

# SIEMENS



Manual Collection

This document contains a compilation of all manuals for the ET 200AL system family. Use the bookmarks on the left edge of the screen to navigate.

## SIMATIC

### ET 200AL

ET 200AL distributed I/O system

Edition

10/2021

[support.industry.siemens.com](https://support.industry.siemens.com)

# SIEMENS



System manual

# SIMATIC

## ET 200AL

ET 200AL distributed I/O system

Edition

08/2021

[support.industry.siemens.com](https://support.industry.siemens.com)



## SIMATIC

### ET 200AL Distributed I/O system

#### System Manual

#### Preface

---

#### ET 200AL Documentation Guide

**1**

#### System overview

**2**

#### Application planning

**3**

#### Mounting

**4**

#### Connecting

**5**

#### Configuring

**6**

#### Configuration control (option handling)

**7**

#### Commissioning

**8**

#### Maintenance

**9**

#### Technical specifications

**10**

#### Safety-related shutdown of ET200AL standard modules

**A**

#### Dimension drawings

**B**

#### Accessories/spare parts

**C**

## Legal information

### Warning notice system

This manual contains notices you have to observe in order to ensure your personal safety, as well as to prevent damage to property. The notices referring to your personal safety are highlighted in the manual by a safety alert symbol, notices referring only to property damage have no safety alert symbol. These notices shown below are graded according to the degree of danger.

#### **DANGER**

indicates that death or severe personal injury **will** result if proper precautions are not taken.

#### **WARNING**

indicates that death or severe personal injury **may** result if proper precautions are not taken.

#### **CAUTION**

indicates that minor personal injury can result if proper precautions are not taken.

#### **NOTICE**

indicates that property damage can result if proper precautions are not taken.

If more than one degree of danger is present, the warning notice representing the highest degree of danger will be used. A notice warning of injury to persons with a safety alert symbol may also include a warning relating to property damage.

### Qualified Personnel

The product/system described in this documentation may be operated only by **personnel qualified** for the specific task in accordance with the relevant documentation, in particular its warning notices and safety instructions. Qualified personnel are those who, based on their training and experience, are capable of identifying risks and avoiding potential hazards when working with these products/systems.

### Proper use of Siemens products

Note the following:

#### **WARNING**

Siemens products may only be used for the applications described in the catalog and in the relevant technical documentation. If products and components from other manufacturers are used, these must be recommended or approved by Siemens. Proper transport, storage, installation, assembly, commissioning, operation and maintenance are required to ensure that the products operate safely and without any problems. The permissible ambient conditions must be complied with. The information in the relevant documentation must be observed.

### Trademarks

All names identified by ® are registered trademarks of Siemens AG. The remaining trademarks in this publication may be trademarks whose use by third parties for their own purposes could violate the rights of the owner.

### Disclaimer of Liability

We have reviewed the contents of this publication to ensure consistency with the hardware and software described. Since variance cannot be precluded entirely, we cannot guarantee full consistency. However, the information in this publication is reviewed regularly and any necessary corrections are included in subsequent editions.

# Preface

## Purpose of the documentation

This documentation provides you with important information on how to configure, install, wire and commission the SIMATIC ET 200AL distributed I/O system.

## Changes compared to previous version

This manual contains the following changes compared to the previous version:

- Update of the section Safety-related shutdown of ET200AL standard modules (Page 110)
- Additions to the fail-safe I/O module

## Basic knowledge required

A basic knowledge of automation technology is required to understand the documentation.

## Validity of the documentation

This documentation is valid for the SIMATIC ET 200AL distributed I/O system.

## Conventions

Please observe notes labeled as follows:

---

### Note

A note contains important information on the product described in the documentation and on the handling of the product to which particular attention should be paid.

---



## Special information

---

### Note

#### Important note for maintaining operational safety of your plant

Plants with safety-related features are subject to special operational safety requirements on the part of the operator. The supplier is also obliged to comply with special product monitoring measures. For this reason, we inform you in personal notifications about product developments and features that are (or could be) relevant to the operation of systems from a safety perspective.

You should subscribe to the corresponding notifications in order to obtain the latest information and to allow you to make any necessary modifications to your system.

Log on to Industry Online Support. Follow the links below and click on "Email on update" on the right-hand side in each case:

- SIMATIC S7-300/S7-300F (<https://support.industry.siemens.com/cs/ww/en/ps/13751>)
  - SIMATIC S7-400/S7-400H/S7-400F/FH (<https://support.industry.siemens.com/cs/ww/en/ps/13828>)
  - SIMATIC WinAC RTX (F) (<https://support.industry.siemens.com/cs/ww/en/ps/13915>)
  - SIMATIC S7-1500/SIMATIC S7-1500F (<https://support.industry.siemens.com/cs/ww/en/ps/13716>)
  - SIMATIC S7-1200/SIMATIC S7-1200F (<https://support.industry.siemens.com/cs/ww/en/ps/13683>)
  - Distributed I/O (<https://support.industry.siemens.com/cs/ww/en/ps/14029>)
  - STEP 7 (TIA Portal) (<https://support.industry.siemens.com/cs/ww/en/ps/14667>)
- 

### Note

When using F-CPU's in safety mode and fail-safe modules, observe the description of the SIMATIC Industrial Software SIMATIC Safety - Configuring and Programming (<https://support.industry.siemens.com/cs/ww/de/view/54110126/en>) fail-safe system.

---

## Recycling and disposal

For ecologically sustainable recycling and disposal of your old device, contact a certificated disposal service for electronic scrap and dispose of the device in accordance with the regulations in your country.

## Additional support

- Information about Technical Support is available in section Siemens Industry Online Support (Page 5).
- The range of technical documentation for the individual SIMATIC products and systems can be found on the Internet (<https://www.siemens.com/simatic-tech-doku-portal>).
- Information about the online catalog and online order system is available in section Industry Mall (Page 6).

## Security information

Siemens provides products and solutions with industrial security functions that support the secure operation of plants, systems, machines and networks.

In order to protect plants, systems, machines and networks against cyber threats, it is necessary to implement – and continuously maintain – a holistic, state-of-the-art industrial security concept. Siemens' products and solutions constitute one element of such a concept.

Customers are responsible for preventing unauthorized access to their plants, systems, machines and networks. Such systems, machines and components should only be connected to an enterprise network or the internet if and to the extent such a connection is necessary and only when appropriate security measures (e.g. firewalls and/or network segmentation) are in place.

For additional information on industrial security measures that may be implemented, please visit (<https://www.siemens.com/industrialsecurity>).

Siemens' products and solutions undergo continuous development to make them more secure. Siemens strongly recommends that product updates are applied as soon as they are available and that the latest product versions are used. Use of product versions that are no longer supported, and failure to apply the latest updates may increase customers' exposure to cyber threats.

To stay informed about product updates, subscribe to the Siemens Industrial Security RSS Feed visit (<https://www.siemens.com/industrialsecurity>).

## Siemens Industry Online Support

You can find current information on the following topics quickly and easily here:

- **Product support**

All the information and extensive know-how on your product, technical specifications, FAQs, certificates, downloads, and manuals.

- **Application examples**

Tools and examples to solve your automation tasks – as well as function blocks, performance information and videos.

- **Services**

Information about Industry Services, Field Services, Technical Support, spare parts and training offers.

- **Forums**

For answers and solutions concerning automation technology.

- **mySupport**

Your personal working area in Industry Online Support for messages, support queries, and configurable documents.

This information is provided by the Siemens Industry Online Support in the Internet (<https://www.siemens.com/automation/service&support>).

## Industry Mall

The Industry Mall is the catalog and order system of Siemens AG for automation and drive solutions on the basis of Totally Integrated Automation (TIA) and Totally Integrated Power (TIP).

You can find catalogs for all automation and drive products on the Internet.

## See also

Industry Mall (<https://mall.industry.siemens.com>)

# Table of contents

|          |                                                                                                 |           |
|----------|-------------------------------------------------------------------------------------------------|-----------|
|          | <b>Preface .....</b>                                                                            | <b>3</b>  |
| <b>1</b> | <b>ET 200AL Documentation Guide .....</b>                                                       | <b>10</b> |
| <b>2</b> | <b>System overview .....</b>                                                                    | <b>14</b> |
| 2.1      | What is the SIMATIC ET 200AL distributed I/O system? .....                                      | 14        |
| 2.2      | What are fail-safe automation systems and fail-safe modules? .....                              | 17        |
| 2.3      | Components .....                                                                                | 19        |
| <b>3</b> | <b>Application planning .....</b>                                                               | <b>21</b> |
| 3.1      | Hardware configuration .....                                                                    | 21        |
| 3.2      | Configuration variants with ET-Connection .....                                                 | 22        |
| 3.2.1    | ET 200AL with ET-Connection .....                                                               | 22        |
| 3.2.2    | Hybrid configuration ET 200AL/ET 200SP with ET-Connection .....                                 | 24        |
| <b>4</b> | <b>Mounting .....</b>                                                                           | <b>26</b> |
| 4.1      | Basics .....                                                                                    | 26        |
| 4.2      | Mounting modules .....                                                                          | 27        |
| <b>5</b> | <b>Connecting .....</b>                                                                         | <b>31</b> |
| 5.1      | Rules and regulations for operation .....                                                       | 31        |
| 5.2      | Additional rules and regulations for the operation of the ET 200AL with fail-safe modules ..... | 35        |
| 5.2.1    | Safety extra-low-voltage (SELV, PELV) for fail-safe modules .....                               | 35        |
| 5.2.2    | Requirements for sensors and actuators for fail-safe modules .....                              | 36        |
| 5.2.3    | Crosstalk of digital input/output signals .....                                                 | 38        |
| 5.3      | Operation of the ET 200AL on grounded/non-grounded infeed .....                                 | 39        |
| 5.4      | Electrical configuration of the ET 200AL .....                                                  | 42        |
| 5.5      | Connecting ET 200AL to functional earth .....                                                   | 47        |
| 5.5.1    | Mounting ET 200AL modules on conductive substrate .....                                         | 47        |
| 5.5.2    | Mounting ET 200AL modules on non-conductive substrate .....                                     | 48        |
| 5.6      | Connecting cables for ET 200AL .....                                                            | 50        |
| 5.7      | Wiring .....                                                                                    | 51        |
| 5.8      | ET 200AL marking .....                                                                          | 56        |
| 5.8.1    | Factory markings .....                                                                          | 56        |
| 5.8.2    | Optional markings .....                                                                         | 57        |
| 5.8.3    | Mounting identification labels .....                                                            | 58        |
| <b>6</b> | <b>Configuring .....</b>                                                                        | <b>59</b> |

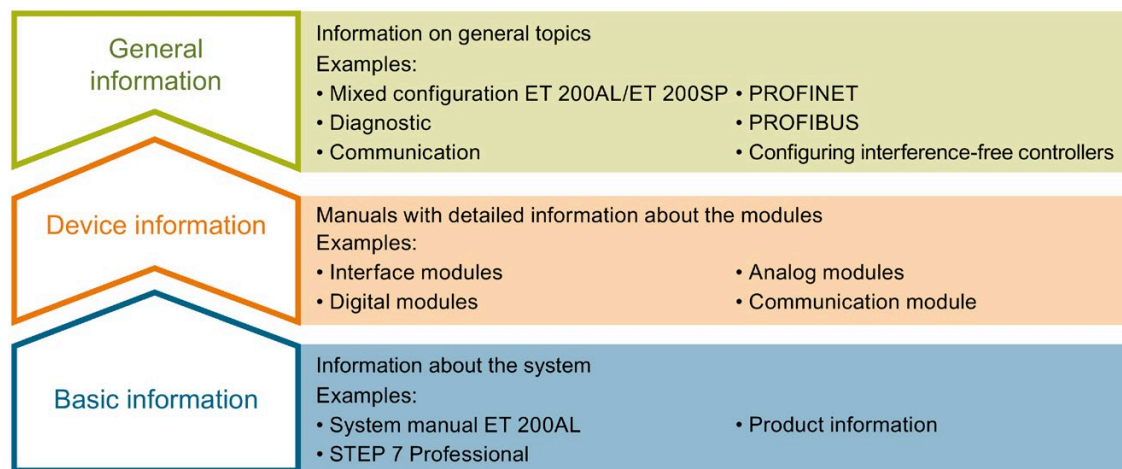
|           |                                                                                       |            |
|-----------|---------------------------------------------------------------------------------------|------------|
| <b>7</b>  | <b>Configuration control (option handling) .....</b>                                  | <b>64</b>  |
| 7.1       | Configuration control .....                                                           | 64         |
| 7.2       | Configuring .....                                                                     | 67         |
| 7.3       | Creating the control data record .....                                                | 69         |
| 7.3.1     | Introduction .....                                                                    | 69         |
| 7.3.2     | Control data record for the ET 200AL distributed I/O system .....                     | 71         |
| 7.3.3     | Feedback data record at the ET200AL distributed I/O system .....                      | 73         |
| 7.3.4     | Example of a configuration control .....                                              | 75         |
| 7.4       | Transferring the control data record in the user program of the CPU .....             | 78         |
| 7.5       | Behavior during operation .....                                                       | 80         |
| <b>8</b>  | <b>Commissioning .....</b>                                                            | <b>81</b>  |
| 8.1       | PROFINET IO .....                                                                     | 81         |
| 8.1.1     | Commissioning ET 200AL on PROFINET IO .....                                           | 81         |
| 8.1.2     | Startup on PROFINET IO .....                                                          | 82         |
| 8.1.3     | PROFenergy .....                                                                      | 84         |
| 8.2       | PROFIBUS DP .....                                                                     | 85         |
| 8.2.1     | Commissioning ET 200AL on PROFIBUS DP .....                                           | 85         |
| 8.2.2     | Startup on PROFIBUS DP .....                                                          | 86         |
| 8.3       | Identification and maintenance data .....                                             | 88         |
| 8.3.1     | Reading out and entering I&M data .....                                               | 88         |
| 8.3.2     | Data record structure for I&M data .....                                              | 90         |
| <b>9</b>  | <b>Maintenance .....</b>                                                              | <b>92</b>  |
| 9.1       | Replacing modules .....                                                               | 92         |
| 9.2       | Firmware update .....                                                                 | 94         |
| 9.3       | Resetting interface module to factory settings (PROFINET) .....                       | 95         |
| 9.4       | Reactions to errors of the F module .....                                             | 97         |
| 9.5       | Cleaning modules .....                                                                | 98         |
| <b>10</b> | <b>Technical specifications .....</b>                                                 | <b>99</b>  |
| 10.1      | Standards and authorizations .....                                                    | 100        |
| 10.2      | Electromagnetic compatibility .....                                                   | 104        |
| 10.3      | Transport and storage conditions .....                                                | 106        |
| 10.4      | Mechanical and climatic ambient conditions .....                                      | 106        |
| 10.5      | Details on insulation, protection class, degree of protection and rated voltage ..... | 108        |
| 10.6      | Safety-related symbols for IP65/IP67 modules .....                                    | 109        |
| <b>A</b>  | <b>Safety-related shutdown of ET200AL standard modules .....</b>                      | <b>110</b> |
| <b>B</b>  | <b>Dimension drawings .....</b>                                                       | <b>113</b> |

|          |                                      |            |
|----------|--------------------------------------|------------|
| <b>C</b> | <b>Accessories/spare parts .....</b> | <b>114</b> |
| C.1      | Accessories/spare parts .....        | 114        |
| C.2      | Cables .....                         | 119        |
| C.3      | Pin assignment and core color.....   | 126        |
|          | <b>Glossary .....</b>                | <b>128</b> |
|          | <b>Index.....</b>                    | <b>138</b> |

# ET 200AL Documentation Guide

The documentation for the SIMATIC ET 200AL distributed I/O system is arranged into three areas.

This arrangement enables you to access the specific content you require.



## Basic information

The System Manual and Getting Started describe in detail the configuration, installation, wiring and commissioning of the SIMATIC ET 200AL distributed I/O system. The STEP 7 online help supports you in the configuration and programming.

## Device information

Product manuals contain a compact description of the module-specific information, such as properties, wiring diagrams, characteristics and technical specifications.

## General information

The function manuals contain detailed descriptions on general topics regarding the SIMATIC ET 200AL distributed I/O system, e.g. diagnostics, communication, Motion Control, Web server.

You can download the documentation free of charge from the Internet (<https://support.industry.siemens.com/cs/ww/en/view/109742667>).

## Manual Collection ET 200AL

The Manual Collection contains the complete documentation on the SIMATIC ET 200AL distributed I/O system gathered together in one file.

You can find the Manual Collection on the Internet (<https://support.automation.siemens.com/WW/view/en/95242965>).

## "mySupport"

With "mySupport", your personal workspace, you make the best out of your Industry Online Support.

In "mySupport", you can save filters, favorites and tags, request CAx data and compile your personal library in the Documentation area. In addition, your data is already filled out in support requests and you can get an overview of your current requests at any time.

You must register once to use the full functionality of "mySupport".

You can find "mySupport" on the Internet (<https://support.industry.siemens.com/My/ww/en>).

## "mySupport" - Documentation

With "mySupport", your personal workspace, you make the best out of your Industry Online Support.

In "mySupport", you can save filters, favorites and tags, request CAx data and compile your personal library in the Documentation area. In addition, your data is already filled out in support requests and you can get an overview of your current requests at any time.

You must register once to use the full functionality of "mySupport".

You can find "mySupport" on the Internet  
(<https://support.industry.siemens.com/My/ww/en/documentation>).

## "mySupport" - CAx data

In the CAx data area of "mySupport", you can access the latest product data for your CAx or CAe system.

You configure your own download package with a few clicks.

In doing so you can select:

- Product images, 2D dimension drawings, 3D models, internal circuit diagrams, EPLAN macro files
- Manuals, characteristics, operating manuals, certificates
- Product master data

You can find "mySupport" - CAx data on the Internet  
(<https://support.industry.siemens.com/my/ww/en/CAxOnline>).

## Application examples

The application examples support you with various tools and examples for solving your automation tasks. Solutions are shown in interplay with multiple components in the system - separated from the focus on individual products.

You will find the application examples on the Internet  
(<https://support.industry.siemens.com/cs/ww/en/ps/ae>).



## TIA Selection Tool

With the TIA Selection Tool, you can select, configure and order devices for Totally Integrated Automation (TIA).

This tool is the successor of the SIMATIC Selection Tool and combines the known configurators for automation technology into one tool.

With the TIA Selection Tool, you can generate a complete order list from your product selection or product configuration.

You can find the TIA Selection Tool on the Internet

(<https://support.industry.siemens.com/cs/ww/en/view/109767888>).

## SIMATIC Automation Tool

You can use the SIMATIC Automation Tool to perform commissioning and maintenance activities simultaneously on various SIMATIC S7 stations as a bulk operation independent of TIA Portal.

The SIMATIC Automation Tool provides a multitude of functions:

- Scanning of a PROFINET/Ethernet system network and identification of all connected CPUs
- Address assignment (IP, subnet, gateway) and station name (PROFINET device) to a CPU
- Transfer of the date and the programming device/PC time converted to UTC time to the module
- Program download to CPU
- RUN/STOP mode switchover
- CPU localization by means of LED flashing
- Reading out of CPU error information
- Reading of the CPU diagnostics buffer
- Reset to factory settings
- Firmware update of the CPU and connected modules

You can find the SIMATIC Automation Tool on the Internet

(<https://support.industry.siemens.com/cs/ww/en/view/98161300>).

## PRONETA

SIEMENS PRONETA (PROFINET network analysis) allows you to analyze the plant network during commissioning. PRONETA features two core functions:

- The topology overview automatically scans the PROFINET and all connected components.
- The IO check is a fast test of the wiring and the module configuration of a plant.

You can find SIEMENS PRONETA on the Internet

(<https://support.industry.siemens.com/cs/ww/en/view/67460624>).

## SINETPLAN

SINETPLAN, the Siemens Network Planner, supports you in planning automation systems and networks based on PROFINET. The tool facilitates professional and predictive dimensioning of your PROFINET installation as early as in the planning stage. In addition, SINETPLAN supports you during network optimization and helps you to exploit network resources optimally and to plan reserves. This helps to prevent problems in commissioning or failures during productive operation even in advance of a planned operation. This increases the availability of the production plant and helps improve operational safety.

The advantages at a glance

- Network optimization thanks to port-specific calculation of the network load
- Increased production availability thanks to online scan and verification of existing systems
- Transparency before commissioning through importing and simulation of existing STEP 7 projects
- Efficiency through securing existing investments in the long term and the optimal use of resources

You can find SINETPLAN on the Internet (<https://www.siemens.com/sinetplan>).

# System overview

## 2.1 What is the SIMATIC ET 200AL distributed I/O system?

### SIMATIC ET 200AL

The SIMATIC ET 200AL distributed I/O system is a scalable and highly flexible, distributed I/O system for connecting process signals to a higher-level control system with a field bus.

### Customer benefits of the system

#### Easy to use

- Easy wiring thanks to color-coded connectors
- CAx compliant labeling of all interfaces
- Fast, convenient configuration and commissioning with STEP 7 (TIA Portal)
- Configuration customizing for future extension through integrated configuration control

#### Energy efficiency

- PROFINET as integrated function

#### Compact design

- High IO configuration limits for module widths of 30 mm or 45 mm and up to 32 modules for each ET 200AL
- High degree of protection IP65/IP67
- Adequate for temperatures from -30 °C/-25 °C to +55 °C and accelerations up to 10g



#### Flexible mounting

- Easy mounting in all mounting positions - even in small spaces
- Spatially separated mounting of the modules by means of a backplane bus designed as a cable (= ET connection)
- Flexible connection to PROFINET, PROFIBUS or integration in SIMATIC ET 200SP
- Integration of sensors and actuators through M8 and M12 connection technology

#### Communication standards

- PROFINET IO
- PROFIBUS DP
- IO-Link
- PROFI-safe

#### Powerful technology

- Module with counting function
- Fail-safe modules

Figure 2-1 ET 200AL benefits

## Area of application

The SIMATIC ET 200AL distributed I/O system is especially well suited for use in tight spaces, moving applications and for assembly and handling technology. Thanks to its scalable construction, you have the option to precisely customize its configuration to your on site needs.

The SIMATIC ET 200AL distributed I/O system features degree of protection IP65/IP67. The I/O modules are suitable for distributed use indoors on a machine or assembly line.

## Setup

The SIMATIC ET 200AL distributed I/O system is made up of the following components:

- Interface modules (PROFINET/PROFIBUS)
- Digital and analog I/O modules
- Communication module

After an interface module you can configure 2 lines (ET-Connection), each with 16 modules.

Alternatively, you can configure a line with 16 I/O modules on the SIMATIC ET 200SP distributed I/O system with BaseUnit BU-Send and the BusAdapter BA-Send 1xFC.

The ET-Connection backplane bus is designed as a cable. This allows you to create spatial distances of up to 15 m between the modules.

## 2.1 What is the SIMATIC ET 200AL distributed I/O system?

### Configuration example

The figure below shows a configuration example of the SIMATIC ET 200AL distributed I/O system with a PROFINET interface module.

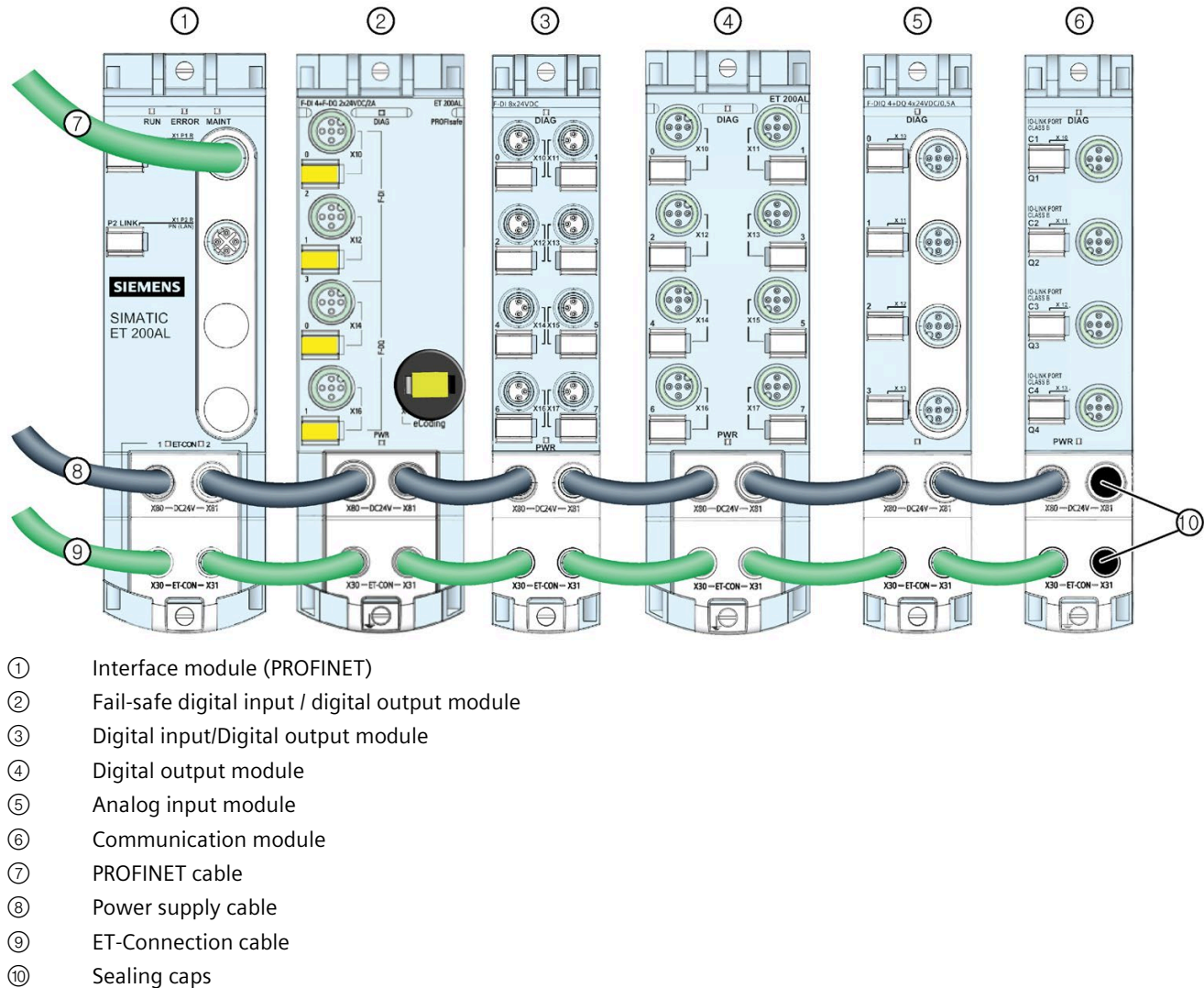


Figure 2-2 Configuration example of the ET 200AL

## 2.2 What are fail-safe automation systems and fail-safe modules?

### Fail-safe automation systems

Fail-safe automation systems are mainly used in applications where failure could have consequences for the safety of people and/or the environment. Fail-safe systems are therefore intended to reduce hazards or failures that could cause physical damage. Their purpose is to ensure a tolerable level of risk.

F-systems are used to control processes and provide a safe operating state when faults are detected. Fault detection is ensured by a very high level of diagnostic coverage. When a fault is detected, appropriate actions are initiated to bring the affected application to a safe state.

F-systems offer improved fault detection and fault localization through detailed diagnostics and diagnostic messages. This is the most important difference between fail-safe systems and standard systems. The use of fail-safe systems should be considered for applications where hazards are inherent and can cause physical damage.

### Safety Integrated

Safety Integrated is the integrated safety concept for automation and drive technology from Siemens.

Proven technologies and systems from automation technology are used for safety systems. Safety Integrated includes the complete safety sequence, ranging from sensor, actuator and fail-safe modules right through to the controller, including safety-related communication via standard fieldbuses. Drives and controllers handle safety tasks in addition to their actual functions.

### Fail-safe modules

The key difference between fail-safe modules (F-modules) and standard modules is that they have an internal two-channel design. This means the two integrated processors monitor each other, automatically test the input and output circuits, and switch the fail-safe module to a safe state in the event of a fault.

The F-CPU communicates with a fail-safe module via the safety-related PROFIsafe bus profile.

### Possible uses of ET 200AL with fail-safe modules

The use of ET 200AL with fail-safe modules makes it possible to replace conventional mounting technology in safety technology with PLC components. This also includes the replacement of switchgear for EMERGENCY STOP, safety door monitoring, ambidextrous operation, etc.

Fail-safe modules for ET 200AL are supported together with the STEP 7 Safety Advanced V17 or higher option package.

F-modules for ET 200AL can be used either with an ET 200AL PROFINET interface module (IM), a direct ET connection to an ET 200SP F-CPU or a direct ET connection to an ET 200SP IM (mixed configuration).

### Use in SIMATIC Safety F-systems

The fail-safe ET 200AL modules can be used with STEP 7 Safety Advanced from V17 with PROFINET and direct ET connection configurations together with an F-CPU.

The fail-safe modules can only be used in safety mode. Fault safe and non-fault safe modules can be combined within one ET 200AL ET connection.

### Achievable safety classes

The fail-safe modules are equipped with integrated safety functions for safety mode.

You can achieve the safety classes of the table below:

- With the appropriate parameter assignment of the safety functions in STEP 7
- With a specific combination of fail-safe and non-fail-safe I/O modules
- With a special arrangement and wiring of the sensors and actuators

Table 2- 1 Safety classes that can be achieved with ET 200AL in safety mode

| Safety class in safety mode |                          |                          |
|-----------------------------|--------------------------|--------------------------|
| According to IEC 61508      | According to ISO 13849-1 |                          |
| SIL2                        | Category 3               | (PL) Performance Level d |
| SIL3                        | Category 3               | (PL) Performance Level e |
| SIL3                        | Category 4               | (PL) Performance Level e |



#### WARNING

**The safety performance of your installation depends on the design and ongoing maintenance of the individual complete safety function.**

SIMATIC fail-safe CPUs and ET 200AL fail-safe modules have logic processing components with certified safety integrity levels, provided they are operated in accordance with classifications, specifications, and instructions.

Failure to adhere to this may cause damage or unpredictable operation, resulting in fatal or serious injury and/or property damage.

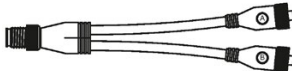
To achieve the level of safety you require, you need to select all components of your plant and construct and maintain them in accordance with accepted safety standards and practices.

## 2.3 Components

### Components of the ET 200AL distributed I/O system

The following table shows and explains the function of the most important components of the ET 200AL distributed I/O system.

Table 2- 2 Components of the ET 200AL distributed I/O system

| Components                       | Function                                                                                                                                                                                                                                                                                                                                                             | View                                                                                  |
|----------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------|
| Interface module for PROFINET IO | <ul style="list-style-type: none"> <li>The interface module connects the ET 200AL distributed I/O system with the IO controller</li> <li>Exchanges data with the I/O modules via ET-Connection</li> </ul>                                                                                                                                                            |    |
| Interface module for PROFIBUS DP | <ul style="list-style-type: none"> <li>The interface module connects the ET 200AL distributed I/O system with the DP master</li> <li>Exchanges data with the I/O modules via ET-Connection</li> </ul>                                                                                                                                                                |   |
| I/O modules                      | <ul style="list-style-type: none"> <li>The I/O modules form the interface to the process</li> <li>Recording and controlling the current process status via the connected sensors and actuators</li> </ul>                                                                                                                                                            |  |
| eCoding plug connector           | Electronic coding element with an overwriteable electronic memory for module-specific fail-safe address data (for example, the F-destination address)                                                                                                                                                                                                                |  |
| Y-cable                          | <p>Y-cable connects multiple actuators or sensors to inputs or outputs. There are two types:</p> <ul style="list-style-type: none"> <li>Y-cable: Connects inputs or outputs of the module to several actuators or sensors.</li> <li>Inverted Y-cable: Connects several fail-safe inputs or outputs of the F-module with one or more sensors and actuators</li> </ul> |  |
| Identification labels            | <ul style="list-style-type: none"> <li>The identification labels come with the module and can be machine printed</li> <li>Can be ordered separately in white or yellow for fail-safe modules</li> </ul>                                                                                                                                                              |  |



## 2.3 Components

| Components                                    | Function                                                        | View                                                                                |
|-----------------------------------------------|-----------------------------------------------------------------|-------------------------------------------------------------------------------------|
| Bus cable and M8 connector for ET-Connection  | The bus cable creates the bus connection between the modules    |  |
| Power cable and M8 connector for power supply | The power cable provides power to the modules                   |  |
| Stripping tool ET-Connection                  | The stripping tool is used to strip the ET-Connection bus cable |  |

## Application planning

### 3.1 Hardware configuration

#### Mechanical maximum configuration

The following tables show the rules of the mechanical configuration. As soon as one of the following rules applies, the maximum configuration has been reached.

Table 3- 1 Maximum mechanical configuration - on ET 200AL interface module

| Properties                                          | Rule (max.)                                     |                                                 |
|-----------------------------------------------------|-------------------------------------------------|-------------------------------------------------|
|                                                     | Interface modules as of firmware version V1.0.0 | Interface modules as of firmware version V1.0.1 |
| Number of ET 200AL I/O modules in the configuration | 32                                              |                                                 |
| Number of ET-Connection outlets                     | 2                                               |                                                 |
| Number of I/O modules per ET-Connection outlet      | 16                                              |                                                 |
| Spatial extension per ET-Connection line            | 160 m                                           | 240 m                                           |
| Cable length between the modules                    | 10 m                                            | 15 m                                            |

Table 3- 2 Maximum mechanical configuration - on ET 200SP with interface module

| Properties                                          | Rule (max.)                                     |                                                 |
|-----------------------------------------------------|-------------------------------------------------|-------------------------------------------------|
|                                                     | Interface modules as of firmware version V3.0.0 | Interface modules as of firmware version V3.3.0 |
| Number of ET 200AL I/O modules in the configuration | 16                                              |                                                 |
| Number of ET-Connection outlets                     | 1                                               |                                                 |
| Spatial extension ET-Connection line                | 160 m                                           | 240 m                                           |
| Cable length between the modules                    | 10 m                                            | 15 m                                            |

Table 3- 3 Maximum mechanical configuration - on ET 200SP with CPU

| Properties                                          | Rule (max.)                             |  |
|-----------------------------------------------------|-----------------------------------------|--|
|                                                     | CPUs with firmware version as of V2.0.0 |  |
| Number of ET 200AL I/O modules in the configuration | 16                                      |  |
| Number of ET-Connection outlets                     | 1                                       |  |
| Spatial extension ET-Connection line                | 240 m                                   |  |
| Cable length between the modules                    | 15 m                                    |  |

## Electrical maximum configuration

The number of usable I/O modules of a potential group is limited by the following points:

- Power requirements of the I/O modules
- Power requirements of the components supplied via these I/O modules

The maximum infeed current of the I/O modules is 4 A with 1L+ supply voltage (non-switched) and 2L+ load voltage (switched). When the maximum infeed current has been reached, you must open a new potential group.

## Reference

You will find more information in the section Connecting cables for ET 200AL (Page 50).

## 3.2 Configuration variants with ET-Connection

### 3.2.1 ET 200AL with ET-Connection

Every ET 200AL interface module has 2 ET-Connection connections

From every ET-Connection, you have the option to set up a line with a maximum of 16 ET 200AL I/O modules.

#### ET-Connection1

The figure below shows a configuration in the IP65/IP67 environment with one ET-Connection line.

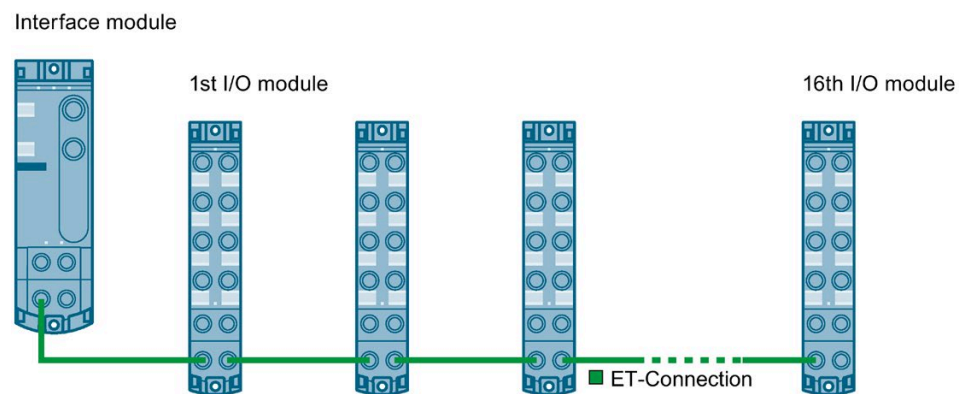


Figure 3-1 ET 200AL with ET-Connection1

## ET-Connection1 and ET-Connection2

The figure below shows a configuration in the IP65/IP67 environment with two ET-Connection lines

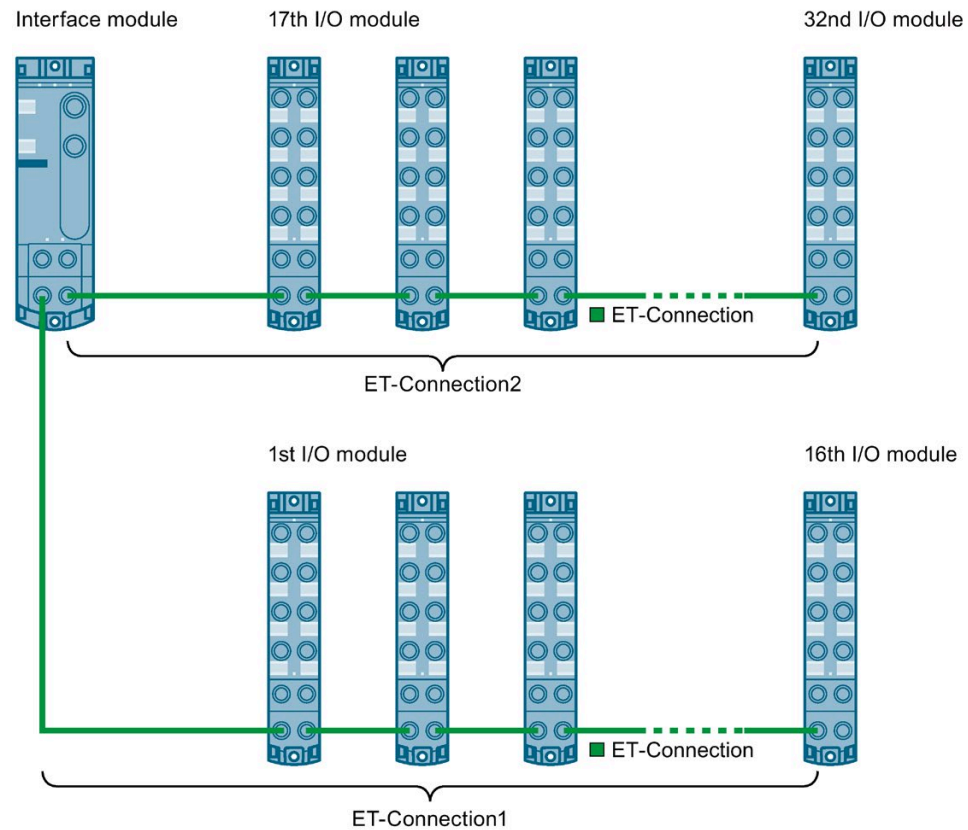


Figure 3-2 ET 200AL with ET-Connection1 and ET-Connection2

### 3.2.2 Hybrid configuration ET 200AL/ET 200SP with ET-Connection

#### Hybrid configuration ET 200AL and ET 200SP

You have the possibility to integrate standard and fail-safe I/O modules of the distributed I/O systems ET 200AL (IP65/IP67) into a configuration of the distributed I/O system ET 200SP (IP20). Fail-safe and non-fail-safe modules may be combined at will in the ET 200AL distributed I/O system.

The figure below shows a combination of the modules of the ET 200AL and ET 200SP distributed I/O systems.

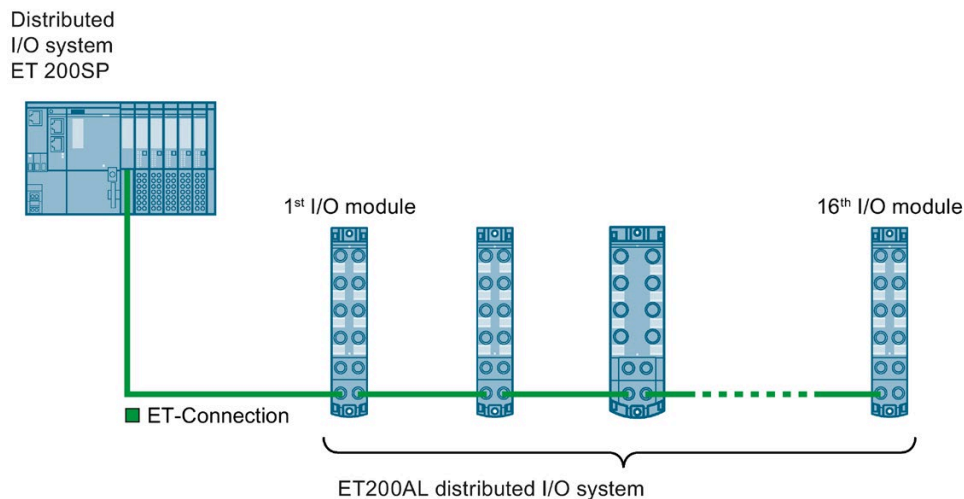


Figure 3-3 Hybrid configuration ET 200SP and ET 200AL with ET-Connection

#### Requirement

For a hybrid configuration, you need at least the following components:

- Interface module or CPU

---

#### Note

##### Use of a F-CPU with F-modules

A fail-safe CPU must also be used when using a fail-safe module in the ET 200AL.

---

- BaseUnit BU-Send with BusAdapter BA-Send 1xFC
- ET-Connection cable pre-assembled on one side
- Power cable pre-assembled on one side

## Rules

When putting together a hybrid configuration, you must observe the following rules:

- The bus length of the ET 200SP distributed I/O system is a maximum of 1 m (excluding interface module/CPU, including BU-Send, BA-Send 1×FC and server module).
- A maximum of 16 ET 200AL I/O modules can be connected to ET-Connection.
- The maximum length of the bus cable for ET-Connection between two modules is 15 m.

## Rules

The following table shows a rough overview of the functions of the ET 200AL I/O modules in combination with the ET 200SP.

| Function              | Hybrid configuration |     |                                       |
|-----------------------|----------------------|-----|---------------------------------------|
|                       | ET 200SP             |     | ET 200AL I/O modules on ET connection |
|                       | IM                   | CPU |                                       |
| Isochronous mode      | ●                    | --  | --                                    |
| Configuration control | ●                    | ●   | ●                                     |
| Shared device         | ●                    | ●   | ●                                     |
| PROFenergy            | ● <sup>1</sup>       | --  | ● <sup>1</sup>                        |
| System redundancy S2  | ● <sup>2</sup>       | --  | ● <sup>2</sup>                        |

<sup>1)</sup> PROFenergy is not supported by fail-safe I/O module F-DI 4+F-DQ 2x24VDC/2A, 4xM12

<sup>2)</sup> With IM 155-6 PN/3 HF and IM 155-6 PN/2 HF as of V4.2

Details on the hybrid configuration are available here

(<https://support.industry.siemens.com/cs/de/en/view/100300517>).

## Procedure

Watch video sequence (<https://support.industry.siemens.com/cs/ww/en/view/95886672>)

Proceed as follows to put together a multi-tier configuration:

1. Mount the BaseUnit BU-Send directly to the right of the ET 200SP interface module or the ET 200SP CPU.
2. Then install the other BaseUnits/I/O modules for the ET 200SP distributed I/O system and the server module.
3. Connect the bus cable for ET-Connection to the BusAdapter BA-Send 1×FC and install it on the BaseUnit BU-Send.
4. Fasten the BusAdapter BA-Send 1×FC with the BaseUnit BU-Send (1 screw with tightening torque of 0.2 Nm). Use a screwdriver with a 3 to 3.5 mm blade to do this.
5. Connect the other end of the bus cable for ET-Connection (with M8 plug) to the first ET 200AL I/O module (socket X30 ET-Connection IN).
6. Connect the supply voltage (24 V DC) to the ET 200AL I/O modules (X80 plug).

# Mounting

## 4.1 Basics

### Introduction

All the modules of the ET 200AL distributed I/O system are designed for the degree of protection IP65/IP67. This means that you can directly mount this system in your plant.

### Installation position

You can mount the ET 200AL distributed I/O system in any position.

### Minimum clearances

At ambient temperatures of 50 °C or higher, please ensure that the module is mounted at a distance of least 1 cm from an adjacent module or another device.

### Mounting rules

When mounting the modules, you do not need to following any special rules.

---

#### Note

#### Mounting of the modules

Mount the ET 200AL distributed I/O system only with disconnected supply voltages.

---

## 4.2 Mounting modules

### Introduction

The modules of the ET 200AL distributed I/O system are designed for installation on a level, firm surface.

Thanks to the axisymmetrical drill holes in the modules, you have the option to fasten the modules on an aluminum profile using tee nuts.

The following images shows the aluminum profile on which you can mount the modules.

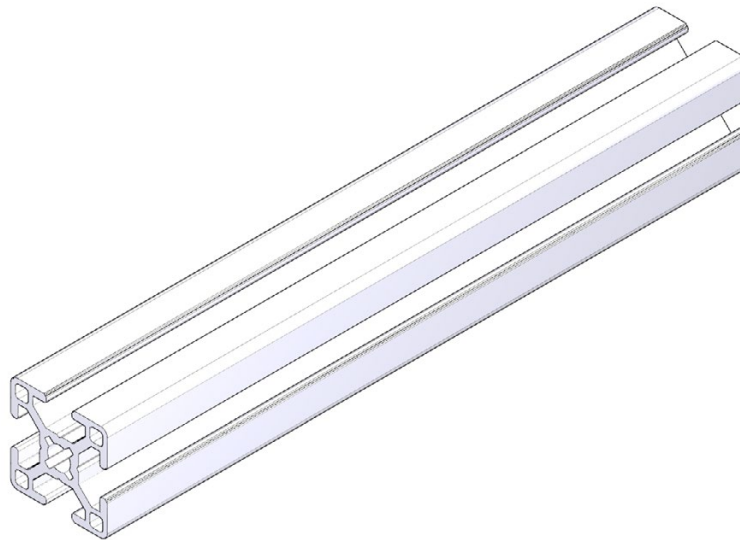


Figure 4-1 Aluminum profile

### Required tools

For installation, you need a screwdriver or an Allen wrench.

### Required screws

The following table shows and explains the screw types required to mount the modules.

Table 4- 1 Recommended screws

| Screw type                                                              | Explanation                                                                                                   |
|-------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------|
| Socket head cap screw M4 according to DIN EN ISO 1207 / DIN EN ISO 1580 | The screw length must be at least 30 mm.<br>If you need washers, use DIN EN ISO 7089/DIN EN ISO 7090 washers. |
| Hexagon socket head cap screw M4 according to DIN EN ISO 4762           |                                                                                                               |



### Drill holes of the modules

All modules of the ET 200AL distributed I/O system feature a uniform drill pattern.

- All module housings are axisymmetrical.
- The distance between the top and bottom drill hole is identical for all modules.

### Mounting interface module and 45 mm I/O modules (front)

Watch video sequence (<https://support.industry.siemens.com/cs/ww/en/view/95886672>)

The interface modules and the 45 mm I/O modules have an attachment point on top and on the bottom.

To mount an interface module or 45 mm I/O module, follow these steps:

1. Drill 2 fastening holes with 4.5 mm diameter at a distance of 149.6 mm.
2. Fasten the interface module or the 45 mm I/O module with the screws to both fastening points (tightening torque 1.2 Nm).

The figure below shows the dimensions for fastening the IM 157-1 PN interface module and the DQ 8x24VDC/2A 8xM12 45 mm I/O module.

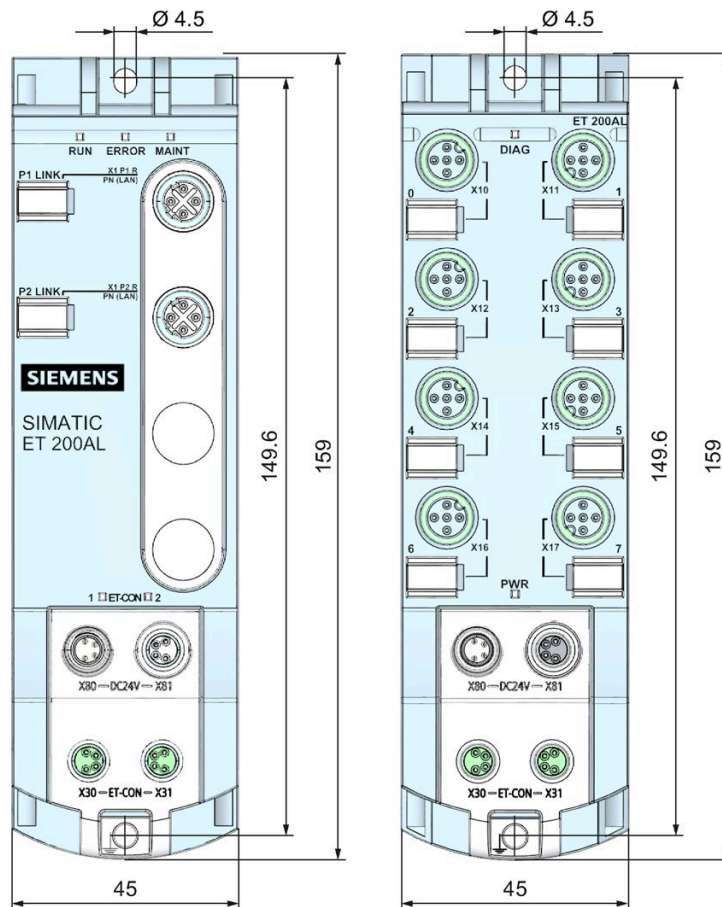


Figure 4-2 Dimensions for mounting interface modules and 45 mm I/O modules

### Mounting 30 mm I/O modules (front or side)

Watch video sequence (<https://support.industry.siemens.com/cs/ww/en/view/95886672>)

The 30 mm I/O modules have an attachment point on top and on the bottom. You also have the option of fastening the 30 mm I/O modules at the side. When fastening them at the side, you must use the supplied spacers.

To mount a 30 mm I/O module, follow these steps:

1. Drill 2 fastening holes with 4.5 mm diameter at a distance of 149.6 mm.
2. Use the supplied spacers for side fastening of the I/O module on the top and bottom (on one side adjacent to the fastening surface).
3. Fasten the I/O module with the screws to both fastening points (tightening torque 1.2 Nm).

The figure below shows the dimensions for fastening the 30 mm I/O modules using the example of the DIQ 4+DQ 4x24VDC/0.5A 8xM8 I/O module.

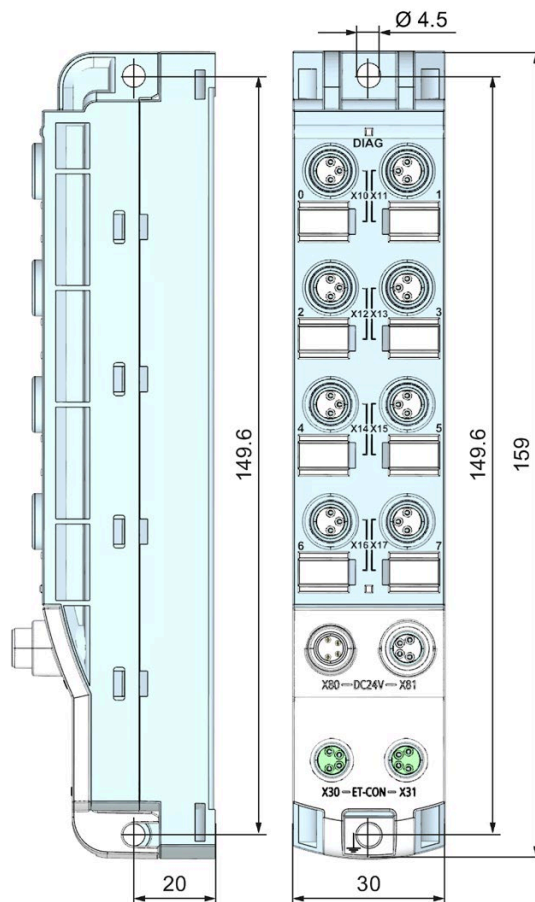


Figure 4-3 Dimensions for mounting 30 mm I/O modules

### Fastening for cable ties

All module of the ET 200AL distributed I/O system have an integrated attachment point for cable ties. The attachment points are found on all four corners of the modules.

The figure below shows the top left attachment point for 2.5 mm wide cable ties for fastening the cables.

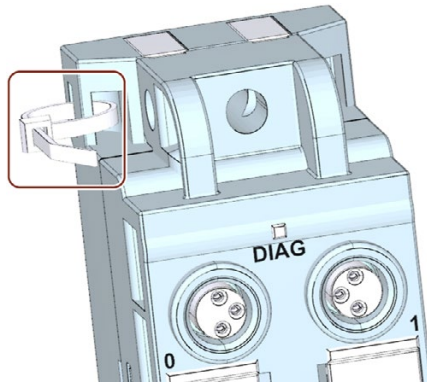


Figure 4-4 Top left attachment point for cable ties

# Connecting

## 5.1 Rules and regulations for operation

### Introduction

Depending on the area of application, the ET 200AL distributed I/O system, as a component of plants and systems, requires that special rules and specifications be followed.

This section gives an overview of the most important rules to be followed for integration of the ET 200AL distributed I/O system in a plant or in a system.

### Specific application

Follow the safety and accident prevention regulations applicable to specific applications, e.g. the machinery directive.

### EMERGENCY-STOP device

EMERGENCY-STOP devices according to IEC 60204 (corresponds to DIN VDE 113) must remain in effect in all operating modes of the plant or system.

### Excluding hazardous system conditions

Hazardous plant states must not occur.

Ensure that dangerous system conditions are excluded, even in the following situations:

- In the event of a voltage dip or power outage
- When the plant restarts after a voltage dip or power outage
- When the ET 200AL distributed I/O system restarts after interruption of PROFINET communication

If necessary, force the EMERGENCY OFF.

An uncontrolled or undefined startup is not permitted after the "EMERGENCY STOP" is unlocked.

### Cables and wires

Make sure that the cables used (incl. connectors) are approved for a continuous operating temperature of at least 70 °C.

### External fuses/switches

External fuses and switches must be installed so that they meet the standards for cable and device protection applicable to your application.

### Line voltage of the SELV/PELV power supply

The following section describes what you need to pay attention to with respect to the line voltage (you will find additional information in the section Information on insulation, protection class, degree of protection, and rated voltage (Page 108)):

- For stationary plants or systems without an all-pole line disconnecter, there must be a disconnecter unit (all-pole) fitted in the building installation.
- For load current supplies, the configured rated voltage range must correspond to the local line voltage.
- For all power circuits of the ET 200AL distributed I/O system, the fluctuation/deviation of the line voltage from the rated value must be within the permitted tolerance.

## 24 V DC supply

Below there is a description of what you need to pay attention to with 24 V DC supply:

- For buildings:  
If there is a danger due to overvoltages, you must take lightning protection measures for external lightning protection (e.g. lightning protection elements).
- With 24 V DC supply lines and signal lines:  
If there is a danger due to overvoltages, you must take lightning protection measures for internal lightning protection (e.g. lightning protection elements. You will find additional information in the Designing interference-free controllers (<https://support.industry.siemens.com/cs/ww/en/view/59193566>) function manual).
- For 24 V DC supply:  
Ensure that there is a safe (electrical) separation of low voltage (SELV/PELV) according to IEC 61010-2-201 or IEC 60950-1.  
You must secure all feeding supply voltages with a UL/IEC approved fuse 24 V DC/4 A (trigger characteristic type B or C).
- Continuous operation of fail-safe modules with more than 28.8 V DC can result in personal injury and equipment damage.

### WARNING

**Continuous operation of fail-safe modules with more than 28.8 V DC can result in personal injury and equipment damage.**

Certain transients from certain source impedances (for example according to EN 61000-4-2, 61000-4-4 and 61000-4-5), as specified in the "Electromagnetic compatibility" section, can act on this voltage without interrupting operation or causing damage.

Operate the fail-safe module within the voltage parameters specified in the technical specifications. This will avoid unacceptable temperature increases and heat damage that will cause the module to lose its functionality.

## Requirements for power supplies in the event of a power interruption

To ensure compliance with IEC 61131-2, use only power supply units/power supplies with a power failure bridging time of at least 20 ms. Observe the relevant requirement in your product standards (e.g. 30 ms for "burners" according to EN 298) with regard to possible voltage interruptions. You can find the latest information on power supply components on the Internet.

### Protection against outside electrical influences

Below is a description of what you must pay attention to in terms of protection against electrical impacts and/or faults:

- For all plants or systems in which the ET 200AL distributed I/O system is integrated, you must ensure that the equipment or system is functionally grounded to discharge electromagnetic interference.
- For supply, signal and bus cables, you must ensure that the cable routing and installation is correct.
- For signal and bus cables, you must ensure that a wire/cable breakage or a cross-wire does not lead to undefined states of the plant or system.

### Reference

Additional information can be found in the function manual Designing interference-free controllers (<https://support.industry.siemens.com/cs/ww/en/view/59193566>).

## 5.2 Additional rules and regulations for the operation of the ET 200AL with fail-safe modules

### 5.2.1 Safety extra-low-voltage (SELV, PELV) for fail-safe modules

|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |
|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|  <b>WARNING</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |
| <p><b>The fail-safe modules must be operated with a safe extra-low voltage (SELV, PELV).</b></p> <p>You can find additional information on safety extra-low voltage (SELV, PELV) in the data sheets of the applicable power supplies, for example.</p> <p>The fail-safe modules operate at a rated voltage of 24 V DC. The tolerance range is 20.4 V DC to 28.8 V DC.</p> <p>Within the overvoltage range from 28.8 V DC to 35 V DC, the F-modules react in a fail-safe manner and the inputs and outputs are passivated. For overvoltages higher than 35 V DC, the F-modules are permanently de-energized.</p> <p>Use a power supply unit that does not exceed <math>U_m = 35</math> V DC even in the event of a fault. For more on this, refer to the information in the data sheet on overvoltage protection in the case of an internal error. Or implement appropriate measures to limit the voltage, e.g. use of an overvoltage protector.</p> <p>All system components that can supply electrical energy in any form whatsoever must fulfill this condition.</p> <p>Each additional circuit (24 V DC) used in the system must have a safety extra-low voltage (SELV, PELV). Refer to the relevant data sheets or contact the manufacturer.</p> <p>Sensors and actuators with an external power supply can also be connected to F-modules. Make sure that power is supplied to these components from safety extra-low voltage (SELV, PELV) as well. The process signal of a 24 V DC digital module must not exceed a fault voltage <math>U_m</math> in the event of a fault.</p> |

|                                                                                                                                                                                                                                                                                                                                                                                                                                                |
|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|  <b>WARNING</b>                                                                                                                                                                                                                                                                                                                                             |
| <p>Even when a fault occurs, the permissible potential difference between the supply of the interface module (bus voltage) and the load voltage must not be exceeded.</p> <p>An external direct electrical connection is one way to meet this requirement. This also prevents potential differences from causing voltage additions at the individual voltage sources, which would cause the fault voltage <math>U_m</math> to be exceeded.</p> |

### Immunity to surge voltages

To meet the product standard for burner controls (EN 298), the wiring must be equipped with external protection against coupled surge voltages caused by lightning. Further information on this can be found in the function manual Designing interference-free controllers (<https://support.industry.siemens.com/cs/ww/en/view/59193566>).



## 5.2.2 Requirements for sensors and actuators for fail-safe modules

### General requirements for sensors and actuators

Note the following important warning regarding safety-related use of sensors and actuators:



#### WARNING

Note that instrumentation with sensors and actuators bears a considerable **safety responsibility**. Also bear in mind that sensors and actuators generally do not have proof-test intervals of 20 years as defined in IEC 61508:2010 without considerable loss of safety.

The probability of hazardous faults and the rate of hazardous faults of safety functions must comply with an SIL-defined high limit. A listing of values achieved by F-modules in the technical specifications of the F-modules is available under "Fail-safe performance characteristics".

To achieve the required safety class, suitably qualified sensors and actuators are necessary.

### Additional sensor requirements

General rule: To achieve SIL3/Cat. 3/PL<sub>e</sub>, a single-channel sensor is adequate. However, to achieve SIL3/Cat. 3/PL<sub>e</sub> with a single-channel sensor, the sensor itself must be SIL3/Cat. 3/PL<sub>e</sub>-capable; otherwise the sensor must be connected by two channels to achieve this safety level.

To achieve SIL3/Cat. 4/PL<sub>e</sub>, sensors must be connected by two channels.



#### WARNING

In the case of fail-safe input modules, the value "0" is output to the F-CPU after detection of faults. You therefore need to make sure that the sensors are implemented in such a way as to ensure the reliable reaction of the safety program when the sensor is in the "0" state.

Example: In its safety program, an EMERGENCY-STOP sensor must achieve the shutdown of the relevant actuator when it is in the "0" state (EMERGENCY-STOP button pressed).

## Duration requirements for sensor signals

### WARNING

Observe the following requirements for sensor signals:

- To ensure the correct detection of the sensor signals via fail-safe modules with inputs, you need to make sure that the sensor signals are output for a minimum duration.
- For pulses to be detected with certainty, the time between two signal changes (pulse duration) must be greater than the PROFIsafe monitoring time.

### Reliable detection by F-modules with inputs

The minimum duration of sensor signals for F-modules with inputs depends on the configured input delay, the parameters of the short circuit test of the sensor supplies, and the configured discrepancy behavior for 1oo2 evaluation. The signal must be greater than the maximum response time of the configured application. Information on calculating the maximum response time can be found in the section "Response times" of the relevant F-module.

The maximum permitted switching frequency of the sensor signals results from the minimum duration.

## Additional requirements for actuators

The fail-safe output modules test the outputs at regular intervals. The F-module briefly switches off the activated outputs and, if necessary, switches on the deactivated outputs. You can assign the maximum duration of the test pulses (dark and light period) with parameters.

Fast reacting actuators may briefly drop out or be activated during the test. If your process does not tolerate this, set the pulse duration of the light or dark test correspondingly or use actuators that have sufficient lag.

### WARNING

If the actuators switch voltages greater than 24 V DC (e.g. 230 V AC), the outputs of a fail-safe output module and the parts carrying a higher voltage must be electrically isolated (in accordance with IEC 60664-1).

This is generally the case for relays and contactors. Particular attention must be paid to this with semiconductor switching devices.

## Technical specifications of sensors and actuators

Refer to the manuals of the fail-safe modules for technical specifications to assist you in selecting sensors and actuators.

### 5.2.3 Crosstalk of digital input/output signals

Readback errors may occur on the F-DQ channels if the fail-safe digital output signals and fail-safe digital input signals are routed through a single cable.

**Cause: capacitive crosstalk**

During the bit pattern test of the outputs or the sensor supply of the inputs, the steep switching edge of the output drivers caused by the coupling capacitance of the line may result in crosstalk to other non-activated output or input channels. This may then lead to a response of the readback circuit in these channels. A cross circuit/short-circuit is detected, which leads to safety-related tripping.

**Remedy:**

- Separate cables for fail-safe DQ modules and non-fail-safe DQ modules
- Separate cables for F-DQ channel and F-DI channels
- Coupling relay or diodes in the outputs
- Disable the sensor supply test if safety class requirements allow it.

**Cause: magnetic crosstalk**

Note that an inductive load connected to the F-DQ channels can induce coupling of a strong magnetic field.

**Remedy:**

- Separate the inductive loads spatially or shield against the magnetic field.
- Configure the readback time to 50 ms or higher.

## 5.3 Operation of the ET 200AL on grounded/non-grounded infeed

### Introduction

Information is provided below on the overall configuration of an ET 200AL distributed I/O system on a grounded incoming supply (TN-S network). The specific subjects discussed are:

- Disconnecting devices, short-circuit and overload protection to IEC 60364 (corresponding to DIN VDE 0100) and IEC 60204 (corresponding to DIN VDE 0113)
- Load current supplies and load circuits
- Supply voltages of the ET 200AL distributed I/O system

### Grounded infeed

In grounded incoming supplies, the neutral conductor of the supply system is grounded. A simple ground fault between a live conductor and ground or a grounded section of the plant causes the protective devices to trip.

### Supply voltages

Provide the ET 200AL distributed I/O devices with a SELV/PELV supply voltage for 1L+. The supplied SELV/PELV load voltage for 2L+ can be switched, depending on the application.

- 1L+: Supply voltage (non-switched)
- 2L+: Load voltage (switched)

### Safe electrical separation (SELV/PELV)

Mains devices/power supply modules with secure electrical separation SELV/PELV are required for the operation of the ET 200AL distributed I/O system. These power supplies/power supply modules must comply with IEC 61010-2-201.

The wiring of SELV/PELV circuits must be separated from the wiring of non-SELV/PELV circuits. Alternatively, the insulation of all conductors must be dimensioned for the higher voltage.

|                                                                                                                  |
|------------------------------------------------------------------------------------------------------------------|
| <b>NOTICE</b>                                                                                                    |
| <b>Operation in damp/wet environments</b>                                                                        |
| When operating in a damp/wet environment, other voltage limits apply for SELV/PELV according to IEC 61010-2-201. |

### Configuring ET 200AL with grounded reference potential

When configuring the ET 200AL distributed I/O system with grounded reference potential, occurring interference currents are discharged into functional earth. The connections must be externally connected (connection between 1M and FE).

### Configuring ET 200AL with ungrounded reference potential

When configuring the ET 200AL distributed I/O system with non-grounded reference potential, occurring interference currents are discharged via an internal RC network to functional earth (no external connection between 1M and FE).

### ET 200AL in the overall configuration

The figure below shows the ET 200AL distributed I/O system in the complete electrical configuration using the example of an interface module.

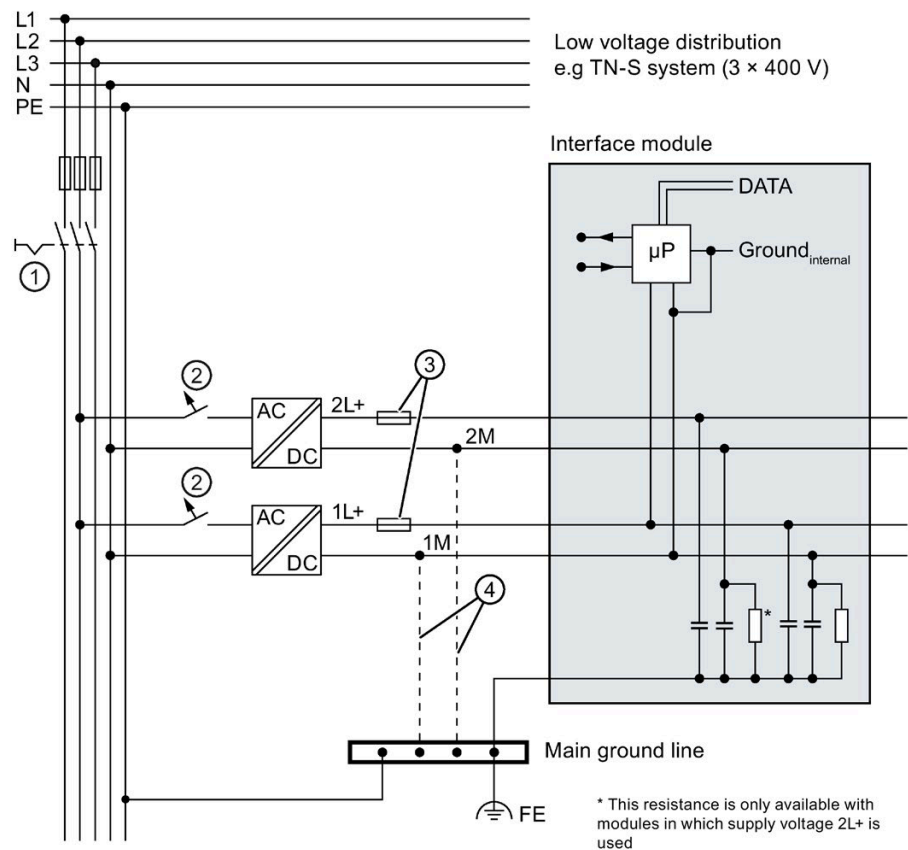


Figure 5-1 Electrical configuration

## Components and protective measures

Various components and protective measures are stipulated for setting up a complete plant. The types of components and the degree to which the protective measures are mandatory depend on the IEC regulation that applies to your plant setup.

The following table shows the components of the electrical configuration with reference to the previous figure and compares the IEC regulations.

Table 5- 1 Components of electrical configuration

|                                                              | Reference to illustration | IEC 60364 (DIN VDE 0100)                                                                                      | IEC 60204 (DIN VDE 0113)                               |
|--------------------------------------------------------------|---------------------------|---------------------------------------------------------------------------------------------------------------|--------------------------------------------------------|
| Disconnection element for controller, sensors, and actuators | ①                         | Main switch                                                                                                   | Disconnecter                                           |
| Short-circuit / over-load protection                         | ②                         | Single-pole protection of circuits<br>Secure all incoming supply cables with a circuit breaker (24 V DC/4 A). | Secure with one pole with a grounded secondary circuit |
| Cable protection                                             | ③                         | Protection of cables and wires against overcurrent                                                            | -                                                      |

## Insulation monitoring

In the following situations, you must provide insulation monitoring.

- When configuring the ET 200AL distributed I/O system with non-grounded reference potential
- When hazardous system conditions may occur due to errors

## 5.4 Electrical configuration of the ET 200AL

### Electrical isolation

When electrically configuring the ET 200AL distributed I/O system, there is electrical isolation between:

- Load voltage 2L+ and all other switching parts
- Communication interfaces (PROFINET/PROFIBUS) of the interface modules and all other switching parts
- ET-Connection and all other switching parts

The following images show the potential conditions of the modules of the ET 200AL distributed I/O system.

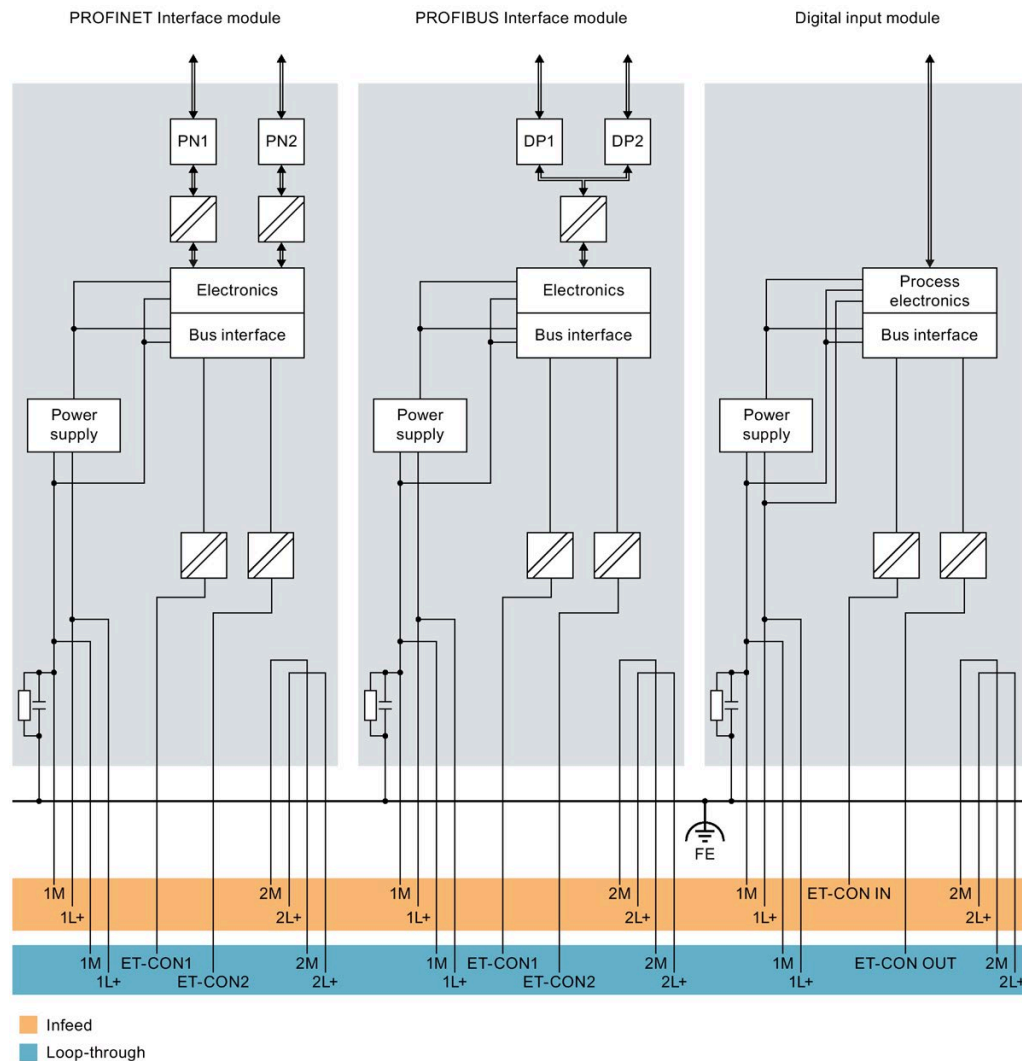


Figure 5-2 Potential conditions of the ET 200AL distributed I/O system (Part 1)

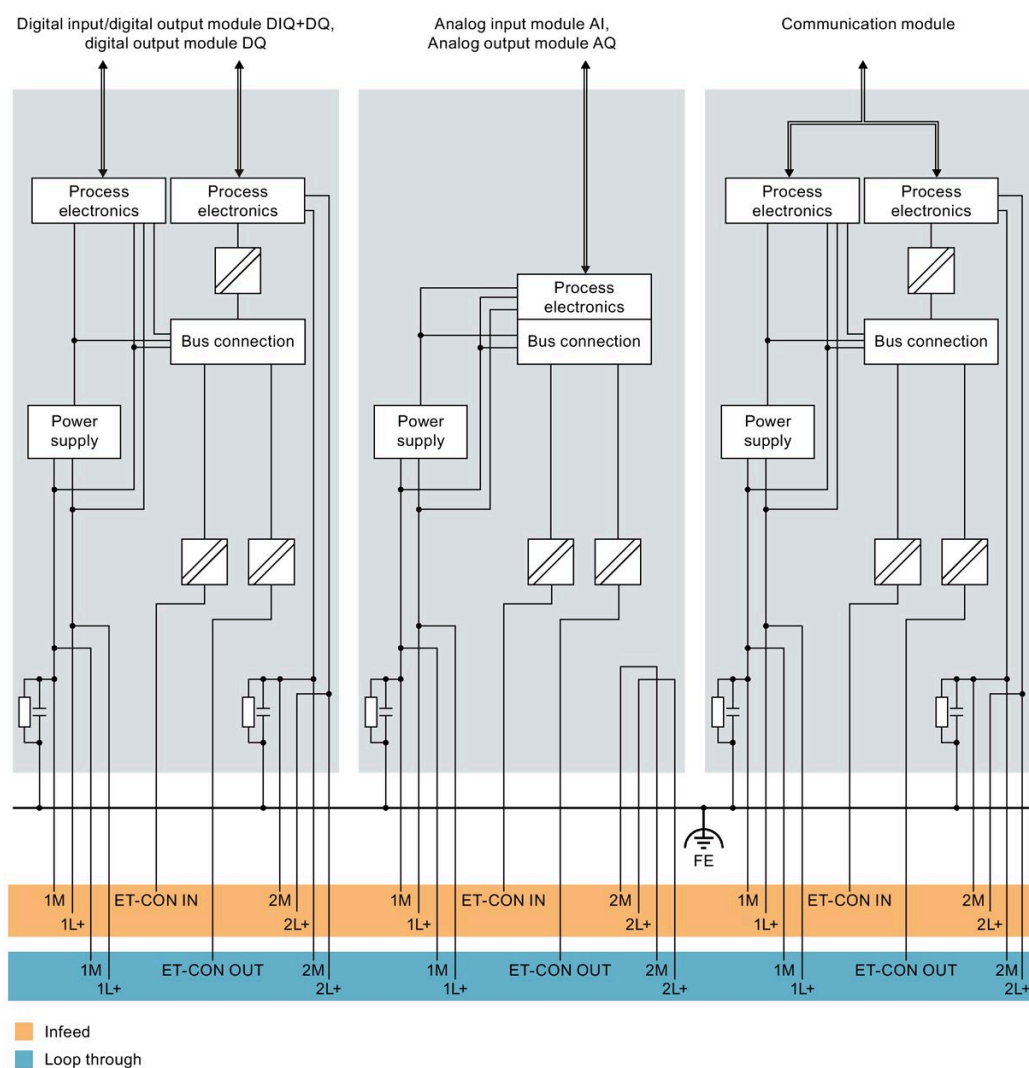


Figure 5-3 Potential conditions of the ET 200AL distributed I/O system (Part 2)



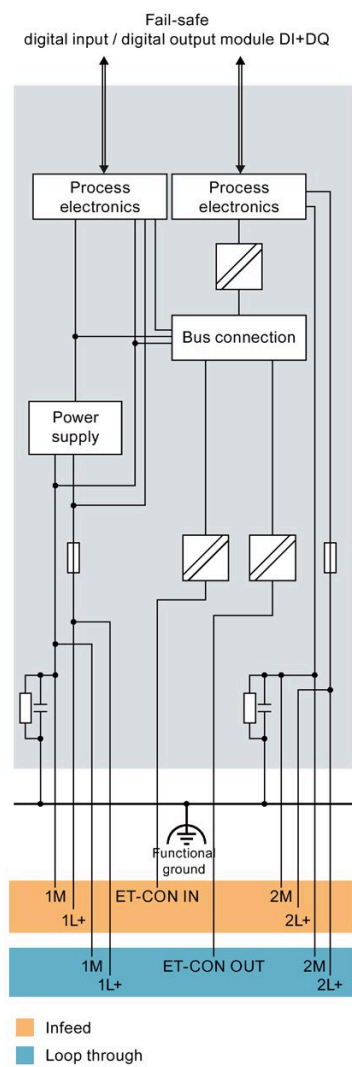


Figure 5-4 Potential conditions of the ET 200AL distributed I/O system (Part 3)

## Connection of a digital output with a digital input

### NOTICE

#### Pay attention to the potential group

When a digital output is connected to a digital input, pay attention to the potential groups. Depending on the configuration, 1M and 2M may then be connected, resulting in elimination of the electrical isolation between 1L+ and 2L+. The possible compensating currents can destroy the digital module.



### WARNING

#### Note potential groups for safety-related shutdown

When a digital output is connected to a digital input, pay attention to the potential groups. Depending on the configuration, 1M and 2M can then be connected, which leads to elimination of the electrical isolation between 1L+ and 2L+. The safety-related shutdown is not permitted if the electrical isolation is eliminated.

## Cable protection

According to IEC 60364, cable protection is required, i.e. you must always secure the incoming lines externally.

You must secure all incoming supply voltages with a UL/IEC approved 24 V DC/4 A fuse (trigger characteristic type B or C).

## Power supply of the configuration

Two voltage groups are available for the distributed I/O system ET 200AL: 1L+ (supply voltage) and 2L+ (load voltage)

A second infeed may be needed to supply all the modules of a configuration with the required voltage. Renewed voltage supply of 1L+ and 2L+ can be necessary to configure different potential groups or because the voltage is not sufficient for all modules due to the voltage drop. Create a power balance for the selection of the infeed point of the voltage.

### Note

#### Turning 1L+ and 2L+ on and off

In contrast to the load voltage 2L+, the operational switching on and off of the supply voltage 1L+ results in a restart of the module.

The figure below shows a configuration with a new voltage infeed for the modules. The different potential groups have a gray background.

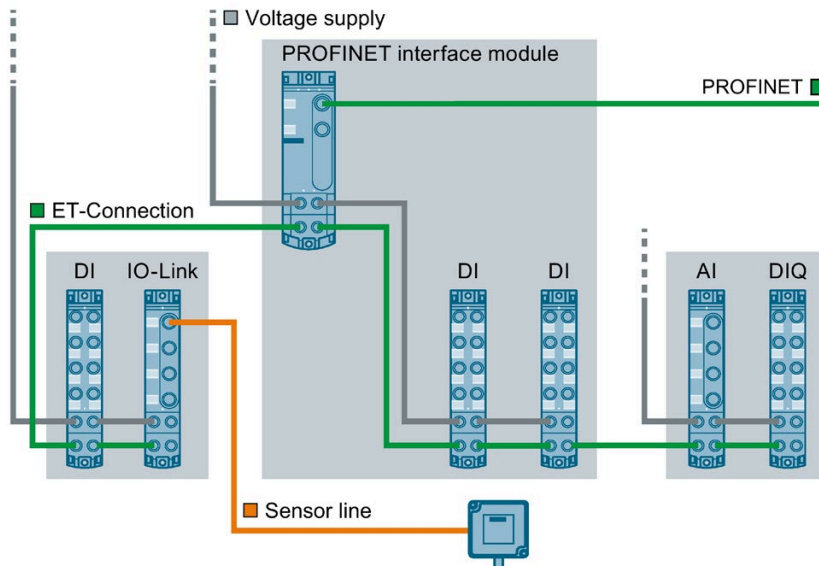


Figure 5-5 Wiring of the power supply

## Reference

You will find additional information on electrical configuration and the voltage drop in the section Connecting cables for ET 200AL (Page 50).

## 5.5 Connecting ET 200AL to functional earth

### Introduction

You must connect the distributed I/O system ET 200AL to functional earth (FE)

### What is functional earth?

All ET 200AL modules feature a functional earth connection. This connection is used to suppress interference sensitivity, but not for protection purposes. With the functional earth connection, you create an electrical connection directly to a point of your system or shielding. This discharges the EMC interference directly into the earth. By discharging the EMC interference, the interference safety of the entire module is increased.

The figure below shows the symbol with which the functional earth connection is identified on the ET 200AL modules.



Figure 5-6 Functional earth

### 5.5.1 Mounting ET 200AL modules on conductive substrate

#### Requirement

Conductive substrate for mounting of the module

#### Required tools

To connect to functional earth, you need the following tools:

- Screwdriver

#### Required accessories:

To connect to functional earth, you need the following accessories:

- 2 x M4 fastening screws.

## Mounting

To connect modules of the ET 200AL distributed I/O system to functional earth with a conductive mounting substrate, proceed as follows:

1. Drill two fastening holes.
2. Screw the module with the M4 fastening screws using a torque of 1.2 Nm.

---

### Note

#### Earthing with conductive mounting substrate

When you fasten a module of the ET 200AL distributed I/O system on a conductive, grounded substrate, the bottom fastening screw provides a conductive connection to the ground potential.

Ensure that there is a low-impedance connection between the module and conductive underground as well as between the conductive underground and functional earth.

---

## Reference

You will find more information on installing the modules in the section Mounting modules (Page 27).

## 5.5.2 Mounting ET 200AL modules on non-conductive substrate

### Requirement

Conductive substrate for mounting of the module

### Required tools

To connect to functional earth, you need the following tools:

- Screwdriver
- Stripping tool
- Crimp tool

### Required accessories:

To connect to functional earth on a non-conductive fastening substrate, you need the following accessories:

- 2 x M4 fastening screws.
- Cable lug suitable for M4 screws
- Grounding cable (braided copper cable) with a minimum cross section of 4 mm<sup>2</sup>

## Mounting

To connect modules of the ET 200AL distributed I/O system to functional earth, proceed as follows:

1. Drill two fastening holes.
2. Strip the grounding cable.
3. Fasten the cable lug to the grounding cable.
4. Screw the module and the cable lug with the M4 fastening screws using a torque of 1.2 Nm.

The figure below shows how to connect functional earth using the example of the IM 157-1 PN interface module.

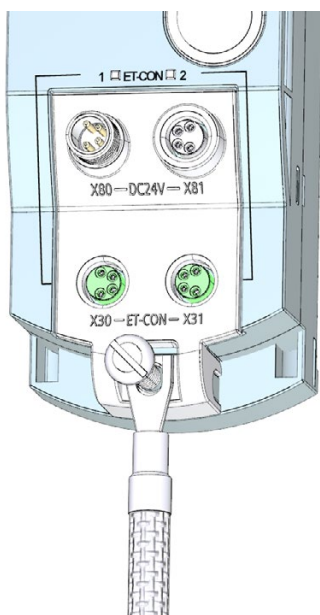


Figure 5-7 Connecting the functional earth

---

### Note

#### Earthing with non-conductive mounting substrate

Make sure there is a low-impedance connection between the module and the functional earth.

---

## Reference

You will find more information on installing the modules in the section Mounting modules (Page 27).

## 5.6 Connecting cables for ET 200AL

### Impact of cable length on the supply voltage

When wiring your configuration, you must take into account the impact of the cable length on the supply voltage of the ET 200AL distributed I/O system.



#### CAUTION

##### Pay attention to maximum incoming currents

For each power supply (1L+, 2L+), you can feed in a maximum of 4A.

If you exceed the maximum incoming currents and do not comply with the required cable cross sections, an increased incoming current could lead to overheating of the cable insulation and the contacts. This could result in damage to the modules.

The figure below shows the voltage drop depending on the cable length for 4 current strengths, using the example of a copper cable with  $\varnothing 0.5 \text{ mm}^2$ .

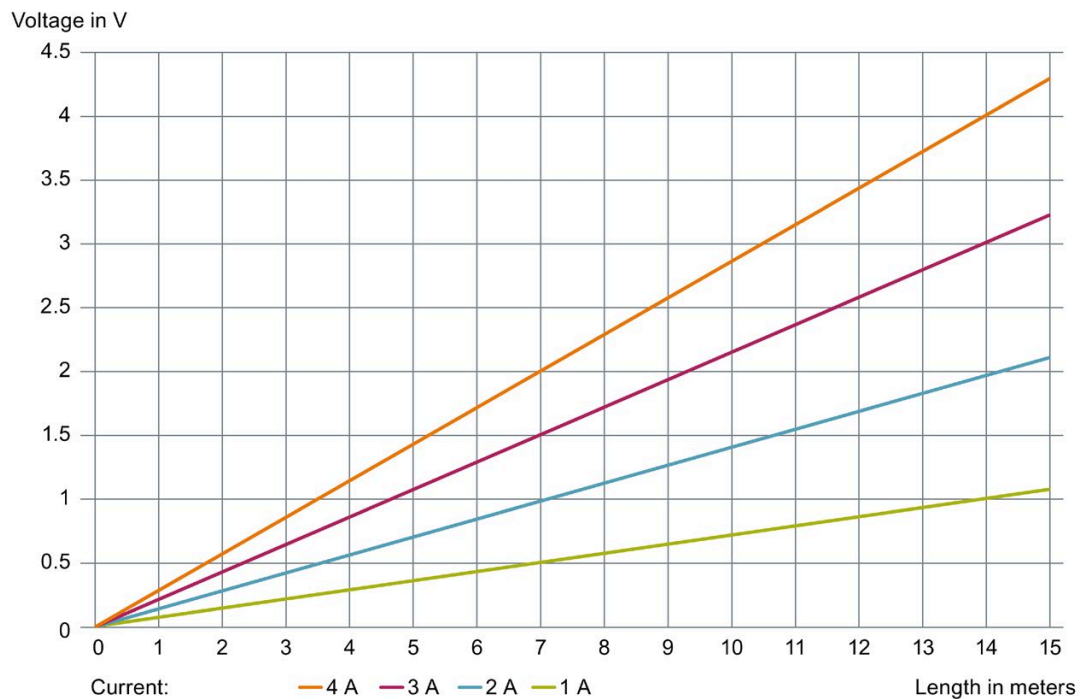


Figure 5-8 Voltage drop with a cable cross-section of  $0.5 \text{ mm}^2$

To estimate the voltage drop in your ET 200AL distributed I/O system, you must add the voltage drops of the different cables. For every module used, you must add an additional voltage drop of around 0.1 V.

### Example

If you have a 7 m power supply cable with  $\varnothing 0.5 \text{ mm}^2$ , the voltage drop is around 1.5 V with a load of 3 A.

## 5.7 Wiring

### Connection

Connect all cables to the front side of the modules:

- Supply voltage and ET-Connection to the 4-pin M8 round sockets and M8 round connectors
- Signal lines to the 3-pin M8 or 4/5-pin M12 round sockets
- Fieldbus lines to the 4/5 pole M12 round sockets and M12 round connectors

---

#### Note

##### Color coding

The sockets for ET-Connection and the power supply of the modules are color-coded. These colors correspond to the colors of the offered cables.

---

### Requirement

Wire the modules with the supply voltage off.

### Required tools

If you are not using pre-assembled cables, you need the following tools:

- Stripping tool
- Screwdriver to wire the connection plugs
- Stripping Tool for ET-Connection

### Required accessories when connecting the supply voltage

You need the following accessories:

- Cables
  - Pre-assembled power cable, M8, 4-pin, or
  - Flexible 4-wire copper cable (wire cross section: 0.25 to 0.5 mm<sup>2</sup>)
- 4-pin M8 connection plug



### Accessories required for the connection of ET-Connection

You need the following accessories:

- ET-Connection cables
- 4-pin M8 connection plug

---

#### Note

##### ET-Connection cables

When connecting ET-Connection **use only** the offered cables.

---

### Connecting M8 plugs

To connect M8 plugs, proceed as follows:

1. Insert the connector in the appropriate round socket on the module.  
Make sure that there is proper locking between the connector and socket.
2. Tighten the connector using the knurled screw with a torque of 0.4 Nm.

The figure below shows the connection of the M8 plugs, using the example of the DIQ 4+DQ 4x24VDC/0.5A 8xM8 digital input / digital output module.

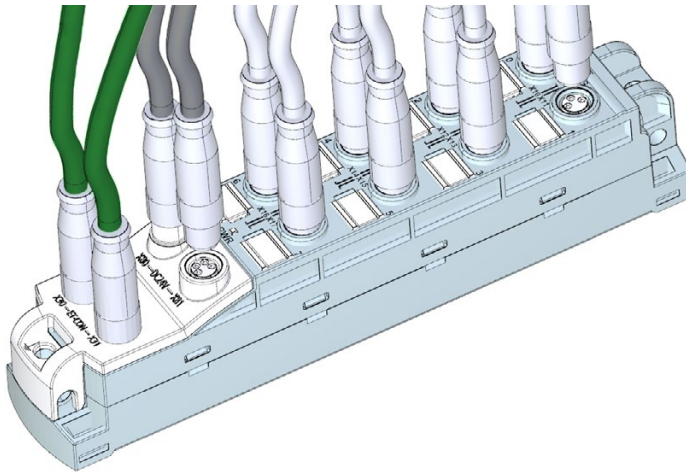


Figure 5-9 Connecting M8 plugs

## Connecting M12 plugs

To connect M12 plugs, proceed as follows:

1. Insert the connector in the appropriate round socket on the module.  
Make sure that there is proper locking between the connector and socket (nut and spring).
2. Tighten the connector using the knurled screw with a torque of 1 Nm.

The figure below shows the connection of the M12 plugs, using the example of the analog input module AI 4xU/I/RTD 4xM12.

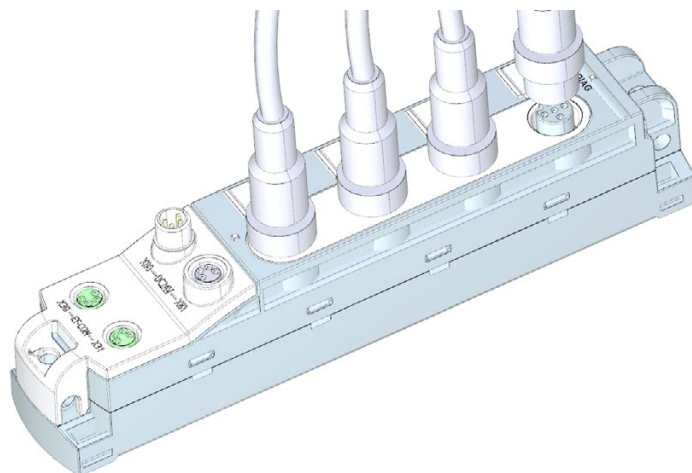


Figure 5-10 Connecting M12 plugs

## Pin assignment of the sockets

The pin assignment of the sockets can be found in the manuals for the interface modules (<https://support.industry.siemens.com/cs/ww/en/ps/14246/man>) and I/O modules (<https://support.industry.siemens.com/cs/ww/en/ps/14247/man>) in the section on pin assignment and on the side surface of the module.

## Y-cable

The Y-cable allows you to connect two actuators or sensors to the inputs or outputs.

The use of a Y-cable is particularly recommended when two channels are occupied for each socket of an I/O device. The Y-cable distributes the channels to two circular connectors.

- Y-cable (6ES7194-6KA00-0XA0) for connecting 2 actuators or sensors for double connection of inputs (also fail-safe inputs) or double connection of outputs with one cable
- Y-cable (6ES7194-6KB00-0XA0) for connecting 2 sensors for double connection F-DI with one cable. Only suitable for use with the F-DI module.

You can find details about connection in the respective user manual of the product.

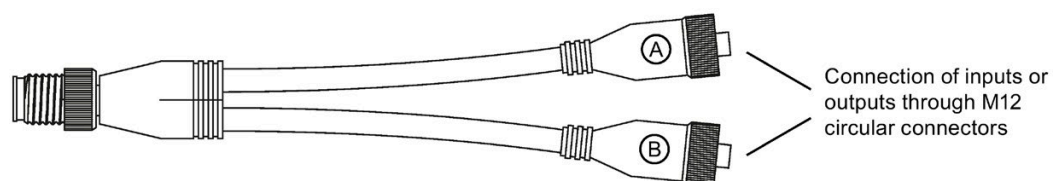
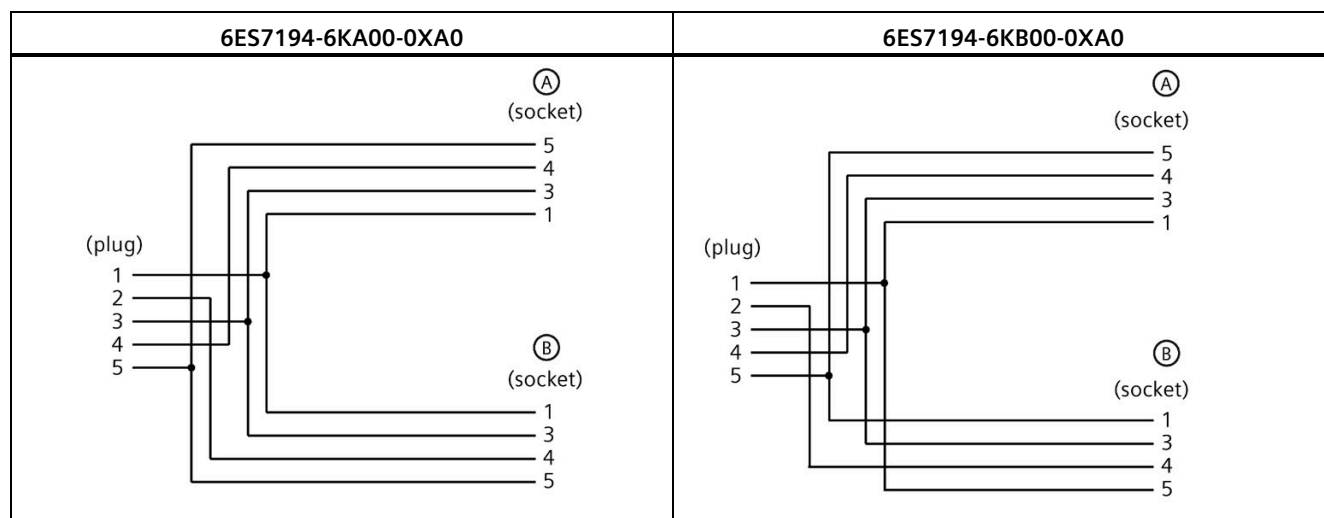


Figure 5-11 Y-cable

The following figure shows the wiring of the Y-cables.



## Inverted Y-cable

The inverted Y-cable enables the connection of fail-safe inputs and a fail-safe output to an I/O device (for example a Siemens SIRIUS safety position switch with interlock) with only one cable.

You can find details about connection in the respective user manual of the product.

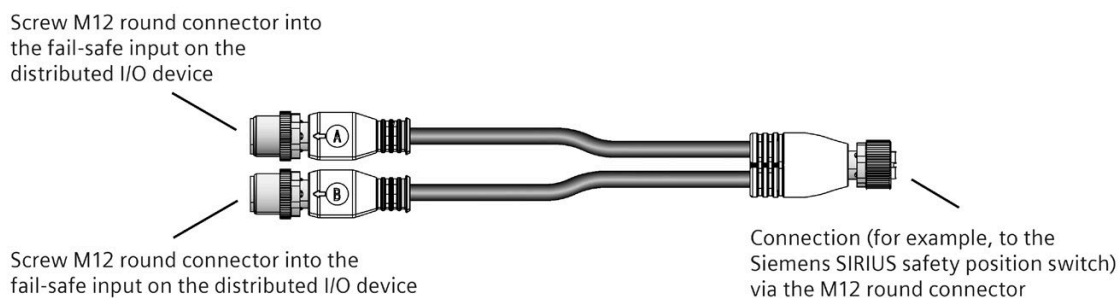


Figure 5-12 Inverted Y-cable

The following figure shows the wiring of the Y-cables.

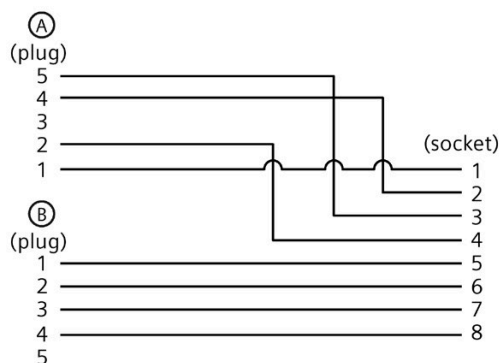


Figure 5-13 Y-cable 6ES7194-6KC00-0XA0

## Sealing of unused sockets

To ensure IP65 or IP67 degree of protection, seal off all unused sockets with sealing caps.

## Article numbers for accessories/spare parts.

You will find the article numbers in the Appendix in section Accessories/spare parts (Page 114).

## 5.8 ET 200AL marking

### 5.8.1 Factory markings

#### Introduction

For better orientation, the ET 200AL distributed I/O system is identified using various markings which will help you when configuring and connecting the modules.

#### Marking of the interfaces

The interfaces of the modules are factory-labeled.

The table below shows the labeling of the interfaces.

Table 5- 2 Interface labeling

| interface                                    | Labeling                             |
|----------------------------------------------|--------------------------------------|
| PROFINET IO interfaces                       | X1 P1 R and X1 P2 R                  |
| PROFIBUS DP interfaces                       | X1 DP1 and X1 DP2                    |
| I/O input and output interfaces              | X10 through X17                      |
| ET-Connection interfaces (interface modules) | X30 (ET-CON1) and X31 (ET-CON2)      |
| ET-Connection interfaces (I/O modules)       | X30 (ET-CON IN) and X31 (ET-CON OUT) |
| Power supply interfaces                      | X80 (IN) and X81 (OUT)               |

#### Note

##### Color coding

The sockets for ET-Connection and the power supply of the modules are color-coded. These colors correspond to the colors of the offered cables.

#### NOTICE

##### ET-Connection/supply voltage

Observe the correct wiring of the M8 sockets for ET-Connection and the supply voltage. Mixing up the ET-Connection connectors and the connectors for the supply voltage can destroy the module.

#### Pin assignment

The pin assignments of the various interfaces are lasered at the factory, on the side of every module.

## 5.8.2 Optional markings

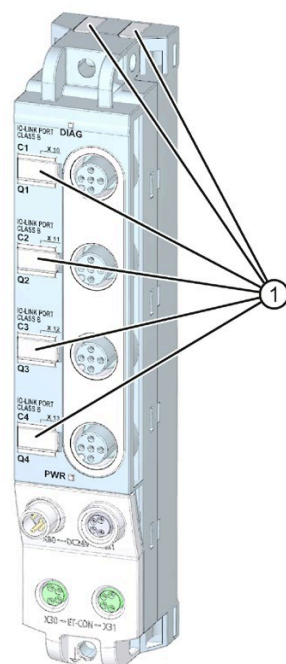
### Introduction

In addition to the factory markings, there are also optional possibilities for labeling and/or identifying interfaces and modules on the ET 200AL distributed I/O system.

### Identification label

The identification labels come with each module as strips and can be machine-printed. A strip has 10 identification labels measuring 10 x 5 mm in the color RAL9016. The identification labels can be inserted into every module at the points provided. The identification labels are used for channel, module and slot labeling.

The figure below shows all points where you can use the identification labels using the example of the IO-Link Master CM 4xIO-Link 4xM12 communication module.



① Identification labels

Figure 5-14 Optional marking

### 5.8.3 Mounting identification labels

#### Introduction

This section describes how to mount or remove identification labels.

#### Required tools

You need a screwdriver with 3 mm blade width (only to remove identification labels).

#### Mounting procedure

To mount an identification label, proceed as follows:

1. Print the identification label using commercially available marking systems.
2. Press the identification label out of its holder.
3. Stick the identification labels into the cutouts provided, as shown in the figure *Optional marking* (Page 57).

Mounting the identification labels is the same for all modules.

#### Removal procedure

To remove an identification label, proceed as follows:

1. Carefully use a screwdriver to pull out the identification label.

Removing identification labels is the same for all modules.

# Configuring

## Introduction

You configure and assign parameters for the ET 200AL distributed I/O system (interface modules and I/O modules) using STEP 7 or the configuration software of another manufacturer.

## Requirements

Table 6- 1 Configuration software and requirements

| Configuration software                                                                                                                                                                                                                                     | Requirements                                                                                                                                                                                           | Installation information |
|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------|
| STEP 7 Safety (TIA Portal) as of V17 for modules: <ul style="list-style-type: none"> <li>F-DI 4+F-DQ 2x24VDC/2A 4xM12</li> </ul>                                                                                                                           | <ul style="list-style-type: none"> <li>PROFINET-compliant F-CPU (with CP expansion modules)</li> <li>PROFIsafe-compliant F-PLC controller, 2.6.X (RIOforFA safety profile) or PROFIsafe 2.4</li> </ul> | STEP 7 online help       |
| STEP 7 (TIA Portal) as of V14 for modules: <ul style="list-style-type: none"> <li>DIQ 16x24VDC/0.5A 8xM12</li> <li>AQ 4XU/I, 4XM12</li> </ul>                                                                                                              | <ul style="list-style-type: none"> <li>PROFINET IO, PROFIBUS DP: as of Support Package HSP 0194</li> </ul>                                                                                             |                          |
| STEP 7 (TIA Portal) V13 SP1 or higher for modules: <ul style="list-style-type: none"> <li>DI 8x24VDC 4xM12</li> <li>DI 16x24VDC 8xM12</li> </ul>                                                                                                           | <ul style="list-style-type: none"> <li>PROFINET IO, PROFIBUS DP: as of Support Package HSP 0155</li> </ul>                                                                                             |                          |
| STEP 7 (TIA Portal) V13 SP1 or higher for modules: <ul style="list-style-type: none"> <li>DIQ 4+DQ 4x24VDC/0.5A 4xM12</li> <li>DQ 8x24VDC/2A 8xM12</li> </ul>                                                                                              | <ul style="list-style-type: none"> <li>PROFINET IO, PROFIBUS DP: as of Support Package HSP 0156</li> </ul>                                                                                             |                          |
| STEP 7 (TIA Portal) V13 SP1 or higher for modules: <ul style="list-style-type: none"> <li>IM 157-1 PN</li> <li>IM 157-1 DP</li> <li>DI 8x24VDC 8xM8</li> <li>DIQ 4+DQ 4x24VDC/0.5A 8xM8</li> <li>AI 4xU/I/RTD 4xM12</li> <li>CM 4xIO-Link 4xM12</li> </ul> | <ul style="list-style-type: none"> <li>none, integrated in STEP 7</li> </ul>                                                                                                                           |                          |



| Configuration software                                                                                                | Requirements                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            | Installation information   |
|-----------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------|
| STEP 7 as of V5.5 SP4 for modules: <ul style="list-style-type: none"> <li>IM 157-1 PN</li> <li>IM 157-1 DP</li> </ul> | <ul style="list-style-type: none"> <li>PROFINET IO:<br/>as of Support Package HSP 0259</li> <li>PROFIBUS DP:<br/>as of Support Package HSP 0258</li> </ul>                                                                                                                                                                                                                                                                                                                                                                              |                            |
| STEP 7 as of V5.5 SP4 for all IO modules                                                                              | <ul style="list-style-type: none"> <li>PROFINET IO, PROFIBUS DP:<br/>as of Support Package HSP 0260</li> </ul>                                                                                                                                                                                                                                                                                                                                                                                                                          |                            |
| STEP 7 (TIA Portal) as of V13 Update 3<br>Software of third-party manufacturer                                        | <ul style="list-style-type: none"> <li>PROFINET IO<br/>GSD file: GSDML-Vx.y-Siemens-ET200AL-"Date in format yyyyymmdd".xml<br/>(<a href="https://support.industry.siemens.com/cs/ww/en/view/92346477">https://support.industry.siemens.com/cs/ww/en/view/92346477</a>)<br/>for example: GSDML-V2.31-Siemens-ET200AL-20140507.xml</li> <li>PROFIBUS DP<br/>GSD file: siem81A9.gsg<br/>(<a href="https://support.industry.siemens.com/cs/ww/en/view/92346281">https://support.industry.siemens.com/cs/ww/en/view/92346281</a>)</li> </ul> | Manufacturer documentation |

## Configuring the ET 200AL distributed I/O system

See the STEP 7 online help or the documentation of the configuration software manufacturer.

## Configuration - PROFINET maximum configuration

Each of the connections for ET-Connection occupies a slot in the configuration. The slots for ET-Connection1 and ET-Connection2 are specified statically in the PROFINET GSD file. ET-Connection1 is permanently on slot 1 and ET-Connection2 on slot 18.

The fixed slot assignment of ET-Connection1 and ET-Connection2 offers you the following advantages:

- You can expand ET-Connection1 and ET-Connection2 without a high workload
- Transparency in configuration control
- Simplification of diagnostics alarms and troubleshooting

The figure below shows the maximum configuration with modules of the ET 200AL distributed I/O system.

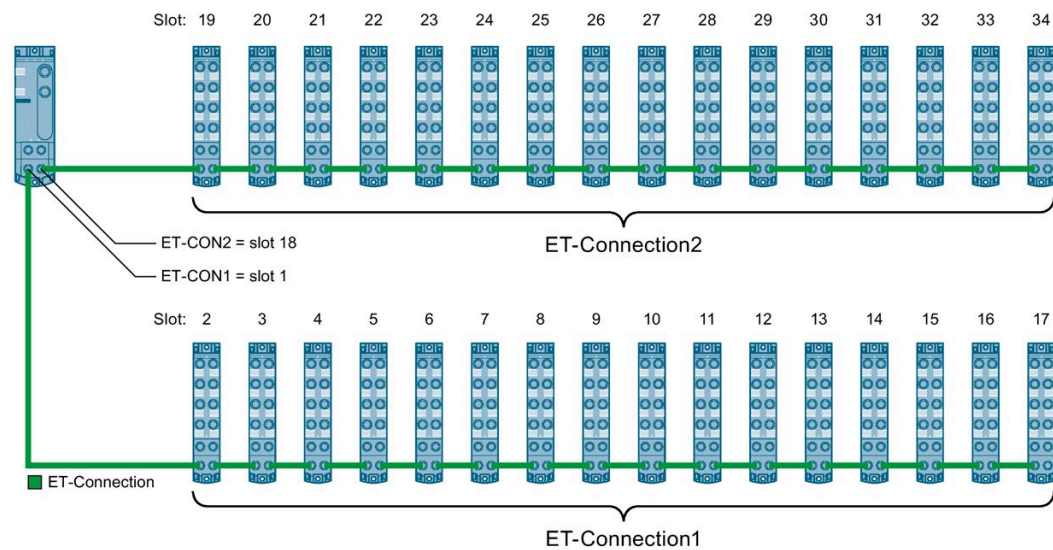


Figure 6-1 PROFINET maximum configuration

## Reference

You can find additional information on this topic in section Configuration control (option handling) (Page 64).

## Configuration - PROFIBUS maximum configuration

Each of the connections for ET-Connection occupies a slot in the configuration. The slot for ET-Connection1 is statically defined in the PROFIBUS GSD file. ET-Connection1 is always permanently installed in slot 1. Always place the topology module for ET-Connection2 on slot 18. You do not need to fill slots in the configuration for ET-Connection1 with dummy modules.

The fixed slot assignment of ET-Connection1 and ET-Connection2 offers you the following advantages:

- You can expand ET-Connection1 and ET-Connection2 without a high workload; for ET-Connection1 you need to remove the placeholder, the I/O module is placeable (no placeholders are needed for ET-Connection2)
- You cannot configure more modules on ET-Connection1 or ET-Connection2 than are allowed.
- Transparency in configuration control
- Simplification of diagnostics alarms and troubleshooting

The figure below shows the maximum configuration with modules of the ET 200AL distributed I/O system.

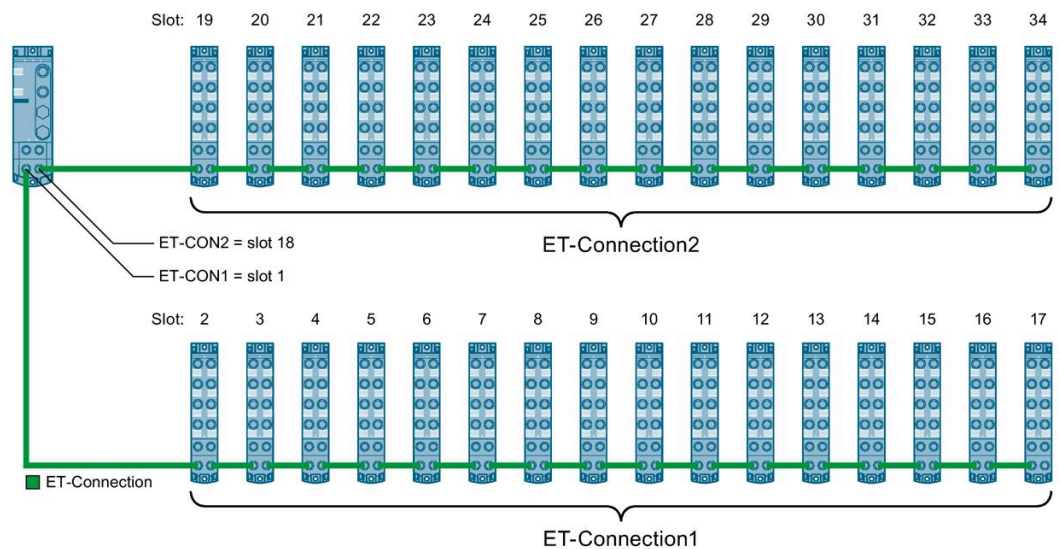


Figure 6-2 PROFIBUS maximum configuration

## Assigning the PROFIsafe addresses

The F-destination address is permanently stored in the eCoding plug connector of the fail-safe ET 200AL I/O modules.

---

### Note

When assigning the PROFIsafe addresses, the F-modules must be supplied with voltage 1L+.

---

### Note

Follow these points in conjunction with the configuration control:

Before you can use the configuration control together with F-modules, the PROFIsafe addresses must be assigned to the F-modules in the designated slots.

For this, each F-module must be plugged into the slot configured for it. The actual configuration may differ from the set configuration.

---

You can find additional information about the assignment of the PROFIsafe addresses in the manual SIMATIC Safety - Configuring and Programming (<https://support.industry.siemens.com/cs/ww/en/view/54110126>).

## Reference

You can find additional information on this topic in section Configuration control (option handling) (Page 64).

# Configuration control (option handling)

## 7.1 Configuration control

### Introduction

With configuration control (option handling), you handle various standard machine configuration levels in one project without having to change the hardware configuration or user program.

### Operating principle of configuration control

You can use configuration control to operate different standard machine configurations with a single configuration of the ET 200AL distributed I/O system.

- A station master (maximum configuration) is configured in a project. The station master comprises all modules needed for all possible equipment components of a modular standard machine.
- Provision is made in the user program of the project for various station options for the different configuration levels of the standard machine and for selection of a station option. A station option uses, for example, only some of the modules of the station master and these modules are not inserted in the configured order.
- Manufacturers of standard machines select a station option for a configuration level of the standard machine. They do not have to change the project or download the modified configuration.

You use a control data record you have programmed to notify the CPU/interface module as to which modules are missing or located on different slots in a station option as compared to the station master. If a module with the configuration control is moved to another slot, it retains its parameter assignment.

The configuration control allows you to flexibly vary the centralized/distributed configuration. As a precondition for this, the station option must be able to be derived from the station master.

The following figure shows 3 configurations of a standard machine with the corresponding station options of the ET 200AL distributed I/O system.

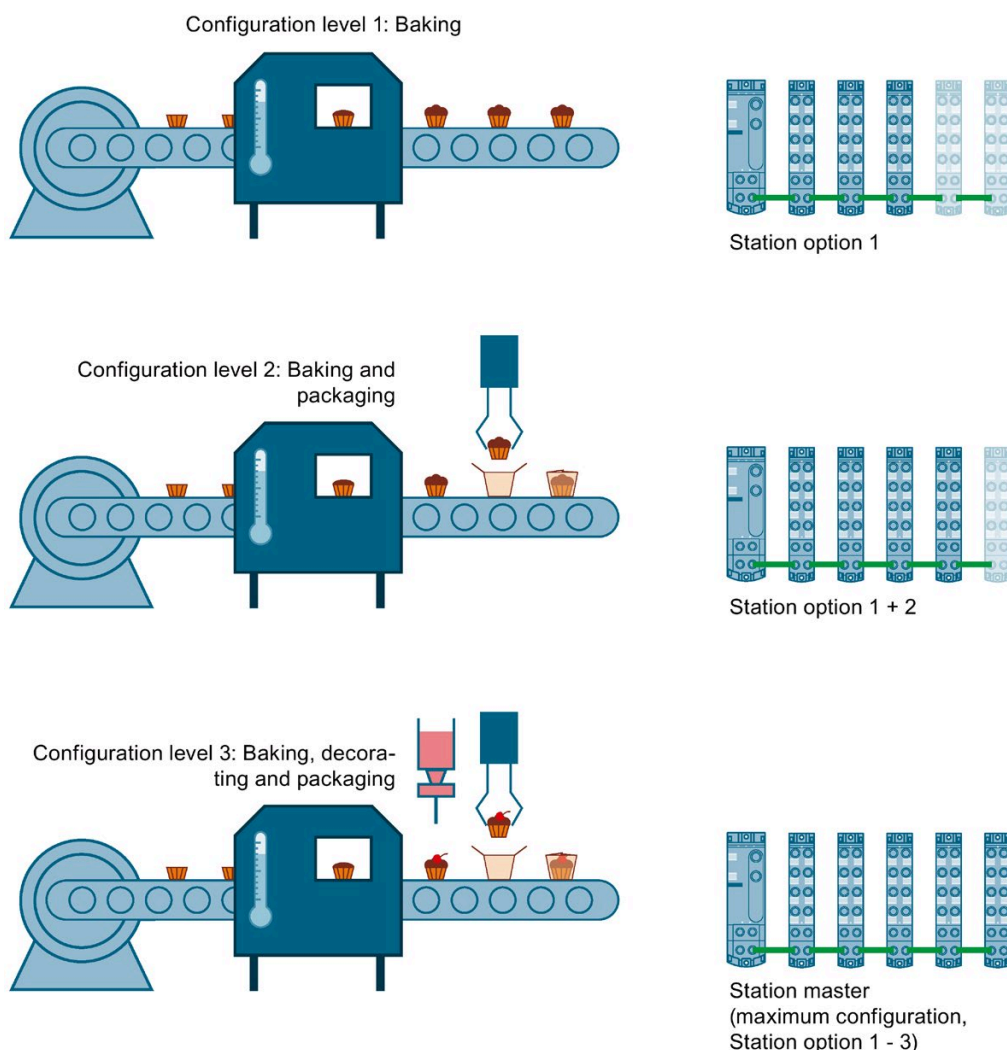


Figure 7-1 Various configuration levels of a standard machine with the corresponding station options of the ET 200AL distributed I/O system.

## Benefits

- Easy project handling and commissioning through use of a single STEP 7 project for all station options.
- Easy handling during maintenance, versioning and upgrades.
- Hardware savings: Only the I/O modules needed for the current station option of the machine are installed.
- Potential savings when building, commissioning and creating documentation for standard machines.

## Procedure

To set up the configuration control, follow these steps in the order given:

| Step | Procedure                              | See...                                                                                |
|------|----------------------------------------|---------------------------------------------------------------------------------------|
| 1    | Enable configuration control in STEP 7 | Section Configuring (Page 67)                                                         |
| 2    | Create control data record             | Section Creating the control data record (Page 69)                                    |
| 3    | Transfer control data record           | Section Transferring the control data record in the user program of the CPU (Page 78) |

## Library for configuration control

A library for configuration control is available for download (<https://support.industry.siemens.com/cs/ww/en/view/29430270>) on the internet. The library contains data types with the structure of the control data records for the ET 200AL distributed I/O system. You can implement your flexible automation solution economically with the help of these data types.

## 7.2 Configuring

### Requirements

Via PROFINET IO:

- Configuration software, for example STEP 7 Professional as of V13
- IM 157-1 PN
- You have assigned the interface module to an IO controller in STEP 7

Via PROFIBUS DP:

- Configuration software, for example STEP 7 Professional as of V13
- IM 157-1 DP
- You have assigned the interface module to an DP master in STEP 7
- The parameter "Operation if preset configuration does not match actual configuration" is activated.  
The parameter "Operation if preset configuration does not match actual configuration" is located in STEP 7 in the properties of the interface module under "Module parameters" > "Start-up".

---

#### Note

##### **Disabled parameter "Startup if preset configuration does not match actual configuration"**

If an I/O module is missing or an incorrect or additional I/O module is plugged in and the "Startup if preset configuration does not match actual configuration" parameter is disabled, the ET 200AL distributed I/O system does not start up.

The diagnostic "Slot x no module" or "Slot x wrong module" is generated.

If the IM 157-1 DP interface module does not start up in this status, the RUN and ERROR LEDs on the interface module flash red. The DIAG LEDs flash green on all I/O modules as well.

---

---

#### Note

Follow these points in conjunction with the configuration control:

Before you can use the configuration control together with F-modules, the PROFIsafe addresses must be assigned to the F-modules in the designated slots.

For this, each F-module must be plugged into the slot configured for it. The actual configuration may differ from the set configuration.

---



## Required steps

Enable the "Allow to reconfigure the device via the user program" parameter when configuring the interface module.

- The parameter "Enable reconfiguration of device via user program" is located in the properties of the interface module under "Module parameters" > "Configuration control".

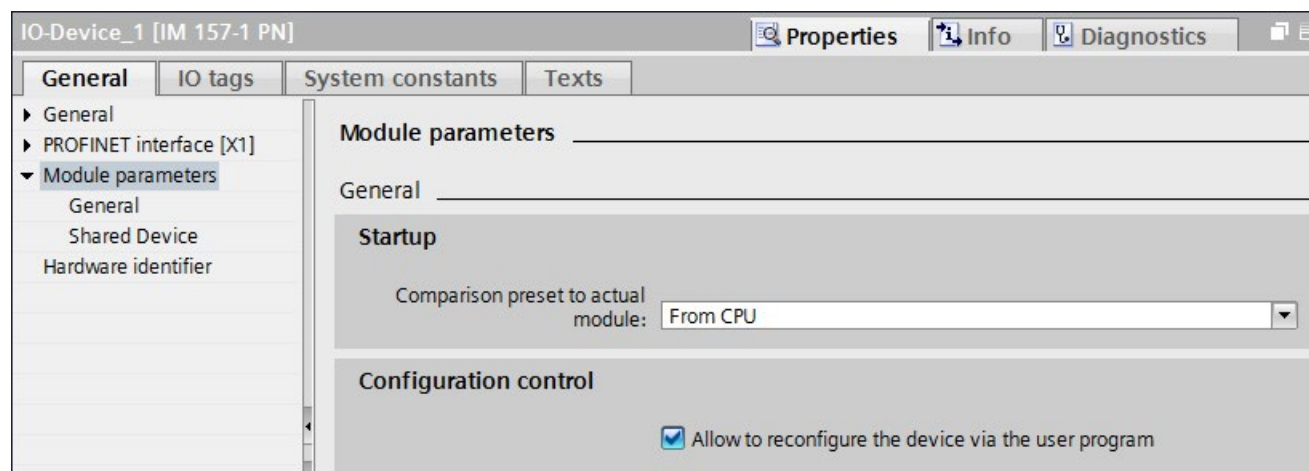


Figure 7-2 Enabling configuration control using the IM 157-1 PN as an example

## 7.3 Creating the control data record

### 7.3.1 Introduction

#### Required steps

The following description shows as an example how you can create a control data record for the configuration control in STEP 7 (TIA Portal).

To create a control data record for the configuration control, follow these steps:

1. Create a PLC data type that contains the structure of the control data record for an ET 200AL interface module.

You can find the structure of the control data record in section Control data record for the ET 200AL distributed I/O system (Page 71)

| CTR_REC |                 |           |               |                                     |                                     |                                     |                          |                                |  |
|---------|-----------------|-----------|---------------|-------------------------------------|-------------------------------------|-------------------------------------|--------------------------|--------------------------------|--|
|         | Name            | Data type | Default value | A...                                | W...                                | V...                                | S...                     | Comment                        |  |
| 1       | Block_Lenght    | USInt     | 76            | <input checked="" type="checkbox"/> | <input checked="" type="checkbox"/> | <input checked="" type="checkbox"/> | <input type="checkbox"/> |                                |  |
| 2       | Block_ID        | USInt     | 196           | <input checked="" type="checkbox"/> | <input checked="" type="checkbox"/> | <input checked="" type="checkbox"/> | <input type="checkbox"/> |                                |  |
| 3       | Version         | USInt     | 2             | <input checked="" type="checkbox"/> | <input checked="" type="checkbox"/> | <input checked="" type="checkbox"/> | <input type="checkbox"/> |                                |  |
| 4       | Subversion      | USInt     | 1             | <input checked="" type="checkbox"/> | <input checked="" type="checkbox"/> | <input checked="" type="checkbox"/> | <input type="checkbox"/> |                                |  |
| 5       | ET-Connection1  | Struct    |               | <input checked="" type="checkbox"/> | <input checked="" type="checkbox"/> | <input checked="" type="checkbox"/> | <input type="checkbox"/> | ET-Connection1 slots 2-17      |  |
| 6       | Topology module | USInt     | 1             | <input checked="" type="checkbox"/> | <input checked="" type="checkbox"/> | <input checked="" type="checkbox"/> | <input type="checkbox"/> | ET-Connection1 topology module |  |
| 7       | Reserved 1      | USInt     | 0             | <input checked="" type="checkbox"/> | <input checked="" type="checkbox"/> | <input checked="" type="checkbox"/> | <input type="checkbox"/> |                                |  |
| 8       | Slot 2          | USInt     | 2             | <input checked="" type="checkbox"/> | <input checked="" type="checkbox"/> | <input checked="" type="checkbox"/> | <input type="checkbox"/> | assigned "real" slot           |  |
| 9       | Reserved 2      | USInt     | 0             | <input checked="" type="checkbox"/> | <input checked="" type="checkbox"/> | <input checked="" type="checkbox"/> | <input type="checkbox"/> |                                |  |
| 10      | Slot 3          | USInt     | 3             | <input checked="" type="checkbox"/> | <input checked="" type="checkbox"/> | <input checked="" type="checkbox"/> | <input type="checkbox"/> | assigned "real" slot           |  |
| 11      | Reserved 3      | USInt     | 0             | <input checked="" type="checkbox"/> | <input checked="" type="checkbox"/> | <input checked="" type="checkbox"/> | <input type="checkbox"/> |                                |  |
| 12      | Slot 4          | USInt     | 4             | <input checked="" type="checkbox"/> | <input checked="" type="checkbox"/> | <input checked="" type="checkbox"/> | <input type="checkbox"/> | assigned "real" slot           |  |
| 13      | Reserved 4      | USInt     | 0             | <input checked="" type="checkbox"/> | <input checked="" type="checkbox"/> | <input checked="" type="checkbox"/> | <input type="checkbox"/> |                                |  |
| 14      | Slot 5          | USInt     | 5             | <input checked="" type="checkbox"/> | <input checked="" type="checkbox"/> | <input checked="" type="checkbox"/> | <input type="checkbox"/> | assigned "real" slot           |  |
| 15      | Reserved 5      | USInt     | 0             | <input checked="" type="checkbox"/> | <input checked="" type="checkbox"/> | <input checked="" type="checkbox"/> | <input type="checkbox"/> |                                |  |
|         |                 | USInt     | 6             | <input checked="" type="checkbox"/> | <input checked="" type="checkbox"/> | <input checked="" type="checkbox"/> | <input type="checkbox"/> | assigned "real" slot           |  |

Figure 7-3 Creating control data record 196

2. Create a global data block.

### 7.3 Creating the control data record

3. Create an array of the data type of the above created PLC data type in the data block.

The following figure shows a data block containing the control data records for an ET200AL interface module. In this example the data block contains three control data records.

| ConfDB |                  |                          |             |                                     |                                     |                                     |                          |                     |  |
|--------|------------------|--------------------------|-------------|-------------------------------------|-------------------------------------|-------------------------------------|--------------------------|---------------------|--|
|        | Name             | Data type                | Start value | R...                                | A...                                | V...                                | S...                     | Comment             |  |
| 1      | Static           |                          |             | <input type="checkbox"/>            | <input type="checkbox"/>            | <input type="checkbox"/>            | <input type="checkbox"/> |                     |  |
| 2      | Option           | Int                      | 0           | <input checked="" type="checkbox"/> | <input checked="" type="checkbox"/> | <input checked="" type="checkbox"/> | <input type="checkbox"/> | Selection of record |  |
| 3      | ConfigControl    | Array[0..2] of "CTR_REC" |             | <input type="checkbox"/>            | <input checked="" type="checkbox"/> | <input checked="" type="checkbox"/> | <input type="checkbox"/> |                     |  |
| 4      | ConfigControl[0] | "CTR_REC"                |             | <input type="checkbox"/>            | <input checked="" type="checkbox"/> | <input checked="" type="checkbox"/> | <input type="checkbox"/> |                     |  |
| 5      | ConfigControl[1] | "CTR_REC"                |             | <input type="checkbox"/>            | <input checked="" type="checkbox"/> | <input checked="" type="checkbox"/> | <input type="checkbox"/> |                     |  |
| 6      | Block_Lenght     | USInt                    | 36          | <input type="checkbox"/>            | <input checked="" type="checkbox"/> | <input checked="" type="checkbox"/> | <input type="checkbox"/> | 4+number of slots   |  |

Figure 7-4 Data block for configuration control

4. In the "Start value" column of the control data records, enter which module is located at which slot.

| ConfDB |                  |                          |            |                                     |                                     |                                     |                          |                                |  |
|--------|------------------|--------------------------|------------|-------------------------------------|-------------------------------------|-------------------------------------|--------------------------|--------------------------------|--|
|        | Name             | Data type                | Start v... | R...                                | ...                                 | ...                                 | ...                      | Comment                        |  |
| 1      | Static           |                          |            | <input type="checkbox"/>            | <input type="checkbox"/>            | <input type="checkbox"/>            | <input type="checkbox"/> |                                |  |
| 2      | Option           | Int                      | 0          | <input checked="" type="checkbox"/> | <input checked="" type="checkbox"/> | <input checked="" type="checkbox"/> | <input type="checkbox"/> | Selection of record            |  |
| 3      | ConfigControl    | Array[0..2] of "CTR_REC" |            | <input type="checkbox"/>            | <input checked="" type="checkbox"/> | <input checked="" type="checkbox"/> | <input type="checkbox"/> |                                |  |
| 4      | ConfigControl[0] | "CTR_REC"                |            | <input type="checkbox"/>            | <input checked="" type="checkbox"/> | <input checked="" type="checkbox"/> | <input type="checkbox"/> |                                |  |
| 5      | Block_Lenght     | USInt                    | 76         | <input type="checkbox"/>            | <input checked="" type="checkbox"/> | <input checked="" type="checkbox"/> | <input type="checkbox"/> |                                |  |
| 6      | Block_ID         | USInt                    | 196        | <input type="checkbox"/>            | <input checked="" type="checkbox"/> | <input checked="" type="checkbox"/> | <input type="checkbox"/> |                                |  |
| 7      | Version          | USInt                    | 2          | <input type="checkbox"/>            | <input checked="" type="checkbox"/> | <input checked="" type="checkbox"/> | <input type="checkbox"/> |                                |  |
| 8      | Subversion       | USInt                    | 1          | <input type="checkbox"/>            | <input checked="" type="checkbox"/> | <input checked="" type="checkbox"/> | <input type="checkbox"/> |                                |  |
| 9      | ET-Connection1   | Struct                   |            | <input type="checkbox"/>            | <input checked="" type="checkbox"/> | <input checked="" type="checkbox"/> | <input type="checkbox"/> | ET-Connection1 slots 2-17      |  |
| 10     | Topology ...     | USInt                    | 1          | <input type="checkbox"/>            | <input checked="" type="checkbox"/> | <input checked="" type="checkbox"/> | <input type="checkbox"/> | ET-Connection1 topology module |  |
| 11     | Reserved 1       | USInt                    | 0          | <input type="checkbox"/>            | <input checked="" type="checkbox"/> | <input checked="" type="checkbox"/> | <input type="checkbox"/> |                                |  |
| 12     | Slot 2           | USInt                    | 0          | <input type="checkbox"/>            | <input checked="" type="checkbox"/> | <input checked="" type="checkbox"/> | <input type="checkbox"/> | assigned "real" slot           |  |
| 13     | Reserved 2       | USInt                    | 0          | <input type="checkbox"/>            | <input checked="" type="checkbox"/> | <input checked="" type="checkbox"/> | <input type="checkbox"/> |                                |  |
| 14     | Slot 3           | USInt                    | 2          | <input type="checkbox"/>            | <input checked="" type="checkbox"/> | <input checked="" type="checkbox"/> | <input type="checkbox"/> | assigned "real" slot           |  |
| 15     | Reserved 3       | USInt                    | 0          | <input type="checkbox"/>            | <input checked="" type="checkbox"/> | <input checked="" type="checkbox"/> | <input type="checkbox"/> |                                |  |
| 16     | Slot 4           | USInt                    | 3          | <input type="checkbox"/>            | <input checked="" type="checkbox"/> | <input checked="" type="checkbox"/> | <input type="checkbox"/> | assigned "real" slot           |  |

Figure 7-5 Assigning slots

## Rules

Observe the following rules:

- Slot entries in the control data record outside the station master are ignored by the interface module.
- The control data record must contain the entries up to the last slot of the station option.
- Each slot of a station option may only be present once in the control data record.
- Each slot of a station option may only be assigned to one slot in the station master.
- The interface module (slot 0) is not an element of the configuration control, but instead controls this.
- The topology modules always have to exist in the data record:
  - The topology module ET-Connection 1 is always located on Slot 1.
  - The topology module ET-Connection 2 is always located on Slot 18.

### 7.3.2 Control data record for the ET 200AL distributed I/O system

#### Slot assignment

##### Note

##### Topology modules ET-Connection1 and ET-Connection2

Both topology modules ET-Connection1 and ET-Connection2 should be treated like real modules during configuration control.

Restriction: ET-Connection1 is always placed in Slot 1 and ET-Connection2 is always placed in Slot 18.

The following table shows the possible slots for the various modules for an ET 200AL interface module:

Table 7- 1 Slot assignment

| Modules                        | Possible slots | Comment                                                          |
|--------------------------------|----------------|------------------------------------------------------------------|
| Topology ET-Connection1        | 1              | The topology module ET-Connection 1 is always located on Slot 1. |
| I/O modules ET-Connection1     | 2-17           | -                                                                |
| Topology module ET-Connection2 | 18             | The topology module ET-Connection2 is always located on Slot 18. |
| I/O modules ET-Connection2     | 19-34          | -                                                                |

## Control data record

For configuration control of the ET 200AL distributed I/O system, you define a control data record 196 V2.1, which contains a slot assignment for the modules. The table below shows the structure of a control data record with explanations of the individual elements.

Table 7- 2 Configuration control: Structure of control data record 196

| Byte                                     | Element                             | Code                                                                  | Explanation                                                                                                                                                                                                                                                                                                                                                                                         |
|------------------------------------------|-------------------------------------|-----------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 0                                        | Block length                        | $4 + (\text{number of slots} \times 2)$                               | Header                                                                                                                                                                                                                                                                                                                                                                                              |
| 1                                        | Block ID                            | 196                                                                   |                                                                                                                                                                                                                                                                                                                                                                                                     |
| 2                                        | Version                             | 2                                                                     |                                                                                                                                                                                                                                                                                                                                                                                                     |
| 3                                        | Subversion                          | 1                                                                     |                                                                                                                                                                                                                                                                                                                                                                                                     |
| 4                                        | Slot topology module ET-Connection1 | 1<br>The topology module ET-Connection 1 is always located on Slot 1. | <b>Control element</b><br>Contains information on which module is inserted in which slot.<br><br>The following rule determines which value you must enter in the respective byte: <ul style="list-style-type: none"> <li>• If the module is included in the station option, enter the slot number of the module.</li> <li>• If the module does not exist in the station option, enter 0.</li> </ul> |
| 5                                        | Reserved                            |                                                                       |                                                                                                                                                                                                                                                                                                                                                                                                     |
| 6                                        | Slot 2 of the station master        | Slot assignment in the station option                                 |                                                                                                                                                                                                                                                                                                                                                                                                     |
| 7                                        | Reserved                            |                                                                       |                                                                                                                                                                                                                                                                                                                                                                                                     |
| :                                        | :                                   | :                                                                     |                                                                                                                                                                                                                                                                                                                                                                                                     |
| 38                                       | Slot topology module ET-Connection2 | 18<br>The topology module ET-Connection2 is always located on Slot 18 |                                                                                                                                                                                                                                                                                                                                                                                                     |
| 39                                       | Reserved                            |                                                                       |                                                                                                                                                                                                                                                                                                                                                                                                     |
| 40                                       | Slot 19 of the station master       | Slot assignment in the station option                                 |                                                                                                                                                                                                                                                                                                                                                                                                     |
| 41                                       | Reserved                            |                                                                       |                                                                                                                                                                                                                                                                                                                                                                                                     |
| :                                        | :                                   | :                                                                     |                                                                                                                                                                                                                                                                                                                                                                                                     |
| $4 + ((\text{max. slot} - 1) \times 2))$ | Maximum slot of the station master  | Slot assignment in the station option                                 |                                                                                                                                                                                                                                                                                                                                                                                                     |
| $5 + ((\text{max. slot} - 1) \times 2))$ | Reserved                            |                                                                       |                                                                                                                                                                                                                                                                                                                                                                                                     |

## Combination of configuration control and shared device (for PROFINET)

The configuration control function in a shared device is therefore only for the I/O modules of the IO controller to which the interface module has subscribed. I/O modules that are assigned to no controller or a different controller behave like a station without activated configuration control.

In the control data record change the slots only for those modules that are assigned to the IO-Controller.

In the control data record do not move modules to slots that are assigned to a different IO controller or no IO controller. The interface module does not check whether a control data record 196 exists for these slots. The interface module assumes a 1-to-1 assignment for these slots.

## Combination of configuration control and PROFlenergy (at PROFINET)

You can use configuration control together with PROFlenergy for the ET 200AL distributed I/O system.

Ensure that you use the slots of the used station option when creating Data record 3. Do not use the slots configured in the station master.

Example: You want to set up PROFlenergy for a DQ module of an IM 157-1 PN that works with configuration control. You have configured the DQ module to Slot 5 in the station master. You have moved the DQ module to Slot 2 in the station option. In order to set up PROFlenergy for this module use Slot 2 in Data record 3.

You can find more information about PROFlenergy in the Interface module IM 157-1 PN (<https://support.industry.siemens.com/cs/ww/en/view/89254863>) Equipment Manual.

### 7.3.3 Feedback data record at the ET200AL distributed I/O system

#### Operating principle

The feedback data record informs you about the accuracy of the module assignment and gives you the option of detecting assignment errors in the control data record. The feedback data record is mapped via a separate data record 197 V2.0.

#### Feedback data record

The feedback data record exists only when configuration control is configured and always refers to the maximum configuration limits **without interface module**, i.e., 34 slots. Partial reading of the feedback data record is possible.

Table 7- 3 Feedback data record

| Byte | Element        | Code | Explanation                                                                                                                                                                                                                                                                                                                          |
|------|----------------|------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 0    | Block length   | 66   | Header                                                                                                                                                                                                                                                                                                                               |
| 1    | Block ID       | 197  |                                                                                                                                                                                                                                                                                                                                      |
| 2    | Version        | 2    |                                                                                                                                                                                                                                                                                                                                      |
| 3    |                | 0    |                                                                                                                                                                                                                                                                                                                                      |
| 4    | Slot 1 status  | 0/1  | Status = 1: <ul style="list-style-type: none"> <li>Module from station master is inserted in the station option</li> <li>Slot is marked as not available in the control data record</li> </ul> Status = 0: <ul style="list-style-type: none"> <li>Module pulled</li> <li>Incorrect module inserted in the station option*</li> </ul> |
| 5    | Reserved       | 0    |                                                                                                                                                                                                                                                                                                                                      |
| 6    | Status slot 2  | 0/1  |                                                                                                                                                                                                                                                                                                                                      |
| 7    | Reserved       | 0    |                                                                                                                                                                                                                                                                                                                                      |
| :    | :              | :    |                                                                                                                                                                                                                                                                                                                                      |
| 70   | Status Slot 34 | 0/1  |                                                                                                                                                                                                                                                                                                                                      |
| 71   | Reserved       | 0    |                                                                                                                                                                                                                                                                                                                                      |

\* Not possible if the slot is marked as not available.

**Note**

The data in the feedback data record is always mapped for all modules. In a Shared Device configuration, it is therefore irrelevant which IO controller the respective modules are assigned to.

As long as no control data record was sent, a one-to-one module assignment is assumed for the compilation of data record 197 (station master → station option).

**Error messages**

In the case of an error when reading the feedback data record, the RDREC instruction returns the following error messages via the STATUS block parameter:

Table 7- 4 Error messages

| Error code        | Meaning                                                                                                                                                                                                                                                                                                                                                       |
|-------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 80B1 <sub>H</sub> | Invalid length; the length information in data record 197 is not correct.                                                                                                                                                                                                                                                                                     |
| 80B5 <sub>H</sub> | Configuration control not configured                                                                                                                                                                                                                                                                                                                          |
| 80B8 <sub>H</sub> | Parameter error<br>The following events cause a parameter error: <ul style="list-style-type: none"><li>• Incorrect block ID in the header (not equal to 197)</li><li>• Invalid version identifier in the header</li><li>• A reserved bit was set</li><li>• Multiple slots in the station master are assigned to the same slot in the station option</li></ul> |

## 7.3.4 Example of a configuration control

### Introduction

Several options/functional variations often exist for machines designed as series products. Or you have a plant that can operate in different modes.

Combine the modules that are needed for a function. With configuration control (option handling), you have the option to switch these functions on and off or expand their configuration.

The following examples show how you can form the control data record for a station option. The station master consists of an interface module IM 157-1 PN and 15 I/O modules in this case.

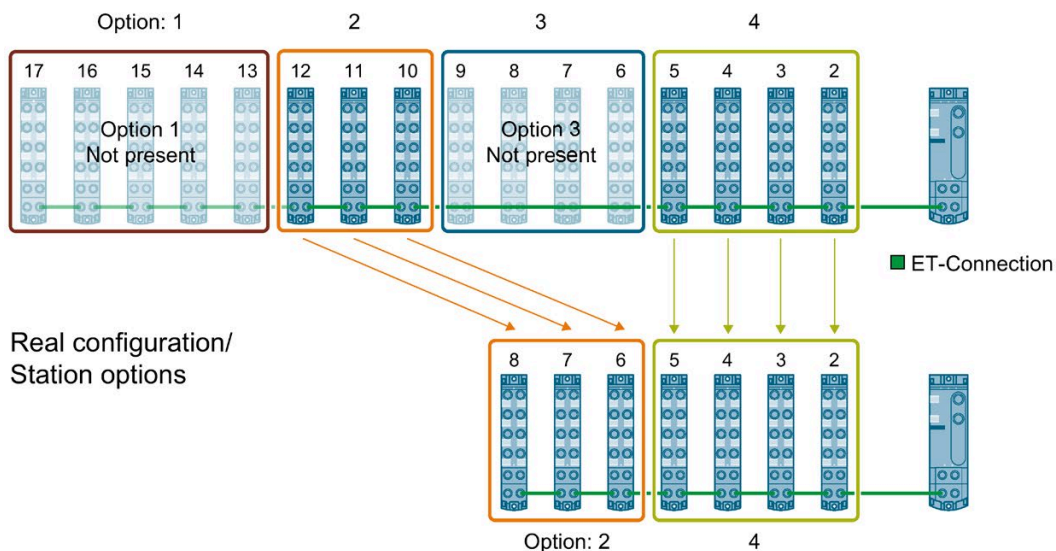
### Station option with associated control data record

The configuration with the station options 2 and 4 differ from the station master as follows:

- The modules for options 1 and 3 do not exist.



## Planned configuration / station master



|    |                |        |   |                                |
|----|----------------|--------|---|--------------------------------|
| 9  | ET-Connection1 | Struct |   | ET-Connection1 slots 2-17      |
| 10 | Topology ...   | USInt  | 1 | ET-Connection1 topology module |
| 11 | Reserved 1     | USInt  | 0 |                                |
| 12 | Slot 2         | USInt  | 2 | assigned "real" slot           |
| 13 | Reserved 2     | USInt  | 0 |                                |
| 14 | Slot 3         | USInt  | 3 | assigned "real" slot           |
| 15 | Reserved 3     | USInt  | 0 |                                |
| 16 | Slot 4         | USInt  | 4 | assigned "real" slot           |
| 17 | Reserved 4     | USInt  | 0 |                                |
| 18 | Slot 5         | USInt  | 5 | assigned "real" slot           |
| 19 | Reserved 5     | USInt  | 0 |                                |
| 20 | Slot 6         | USInt  | 0 | assigned "real" slot           |
| 21 | Reserved 6     | USInt  | 0 |                                |
| 22 | Slot 7         | USInt  | 0 | assigned "real" slot           |
| 23 | Reserved 7     | USInt  | 0 |                                |
| 24 | Slot 8         | USInt  | 0 | assigned "real" slot           |
| 25 | Reserved 8     | USInt  | 0 |                                |
| 26 | Slot 9         | USInt  | 0 | assigned "real" slot           |
| 27 | Reserved 9     | USInt  | 0 |                                |
| 28 | Slot 10        | USInt  | 6 | assigned "real" slot           |
| 29 | Reserved 10    | USInt  | 0 |                                |
| 30 | Slot 11        | USInt  | 7 | assigned "real" slot           |
| 31 | Reserved 11    | USInt  | 0 |                                |
| 32 | Slot 12        | USInt  | 8 | assigned "real" slot           |
| 33 | Reserved 12    | USInt  | 0 |                                |
| 34 | Slot 13        | USInt  | 0 | assigned "real" slot           |
| 35 | Reserved 13    | USInt  | 0 |                                |
| 36 | Slot 14        | USInt  | 0 | assigned "real" slot           |
| 37 | Reserved 14    | USInt  | 0 |                                |
| 38 | Slot 15        | USInt  | 0 | assigned "real" slot           |
| 39 | Reserved 15    | USInt  | 0 |                                |
| 40 | Slot 16        | USInt  | 0 | assigned "real" slot           |
| 41 | Reserved 16    | USInt  | 0 |                                |
| 42 | Slot 17        | USInt  | 0 | assigned "real" slot           |
| 43 | Reserved 17    | USInt  | 0 |                                |

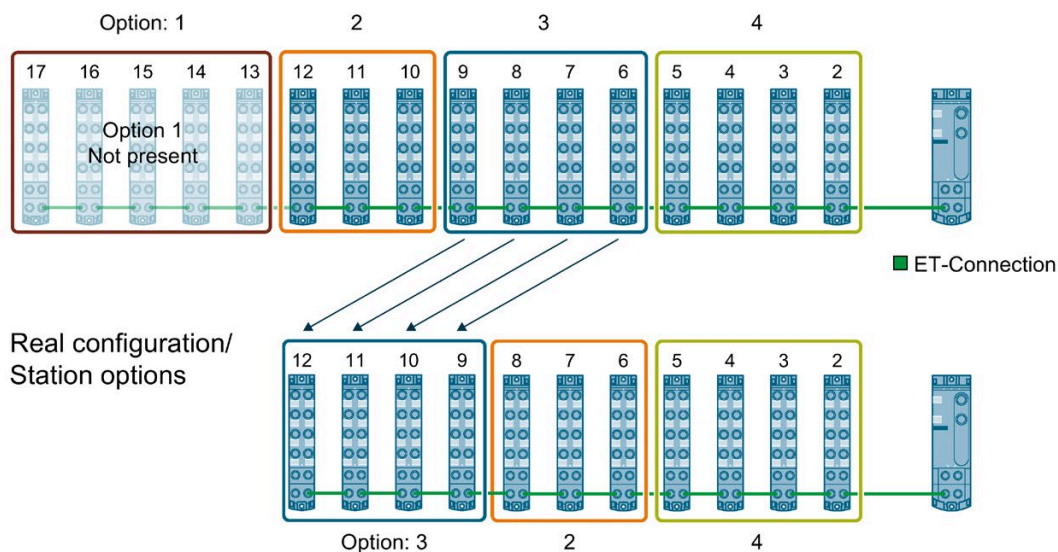
Figure 7-6 Example: Hardware configuration of Station option 2 and 4 with the associated control data record in STEP 7

## Extension by a station option

The following figure shows the configuration with the Station options 2 and 4 that has subsequently been extended by the Station option 3.

The modules of option 3 are added to the modules already existing.

### Planned configuration / station master



|    |                 |        |    |                                |
|----|-----------------|--------|----|--------------------------------|
| 10 | ET-Connection1  | Struct |    | ET-Connection1 slots 2-17      |
| 11 | Topology module | USInt  | 1  | ET-Connection1 topology module |
| 12 | Reserved 1      | USInt  | 0  |                                |
| 13 | Slot 2          | USInt  | 2  | assigned "real" slot           |
| 14 | Reserved 2      | USInt  | 0  |                                |
| 15 | Slot 3          | USInt  | 3  | assigned "real" slot           |
| 16 | Reserved 3      | USInt  | 0  |                                |
| 17 | Slot 4          | USInt  | 4  | assigned "real" slot           |
| 18 | Reserved 4      | USInt  | 0  |                                |
| 19 | Slot 5          | USInt  | 5  | assigned "real" slot           |
| 20 | Reserved 5      | USInt  | 0  |                                |
| 21 | Slot 6          | USInt  | 9  | assigned "real" slot           |
| 22 | Reserved 6      | USInt  | 0  |                                |
| 23 | Slot 7          | USInt  | 10 | assigned "real" slot           |
| 24 | Reserved 7      | USInt  | 0  |                                |
| 25 | Slot 8          | USInt  | 11 | assigned "real" slot           |
| 26 | Reserved 8      | USInt  | 0  |                                |
| 27 | Slot 9          | USInt  | 12 | assigned "real" slot           |
| 28 | Reserved 9      | USInt  | 0  |                                |
| 29 | Slot 10         | USInt  | 6  | assigned "real" slot           |
| 30 | Reserved 10     | USInt  | 0  |                                |
| 31 | Slot 11         | USInt  | 7  | assigned "real" slot           |
| 32 | Reserved 11     | USInt  | 0  |                                |
| 33 | Slot 12         | USInt  | 8  | assigned "real" slot           |
| 34 | Reserved 12     | USInt  | 0  |                                |
| 35 | Slot 13         | USInt  | 4  | assigned "real" slot           |

Figure 7-7 Example: Hardware configuration of station option 2 to 4 with the associated control data record in STEP 7

### Detailed application example

You can find a detailed application example for the configuration control in S7-1500 in here under the keyword "Application example for ET 200SP (PROFINET) and S7-1500 based on the library" on the Internet (<https://support.industry.siemens.com/cs/ww/en/view/29430270>).

## 7.4 Transferring the control data record in the user program of the CPU

### Required steps

Transfer the created control data record 196 to the interface module using the WRREC (Write data record) instruction.

### Parameters of the WRREC instruction

Below, you will find explanations of individual parameters of the WRREC instruction which you must supply with specific values in the configuration control context. You can find additional information on the WRREC instruction in the STEP 7 online help.

|        |                                                                                                                                                                                                                                                                                            |
|--------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| ID     | HW identifier of the interface module.<br>If you have selected the interface module in the network view or device view, the HW identifier is available in the <b>System constants</b> tab of the Inspector window. Use the value of the system constant "<Name_of_interface_module> Head". |
| INDEX  | Data record number: 196 (decimal)                                                                                                                                                                                                                                                          |
| RECORD | Control data record to be transferred.<br>You can find the structure of the control data record in section Control data record for the ET 200AL distributed I/O system (Page 71).                                                                                                          |

### Selection of the station option in the user program

In order for the CPU to know which station option you want to operate, you must set up a possibility to select between the various control data records in the user program. You can implement the selection, for example, via an Int tag that references an array element. Note that the tag used to select the control data record must be stored in the retentive memory area. If the tag is not retentive, it will be initialized during startup of the CPU and will thus be unavailable for selection of the station option.

### Special requirements relating to the transfer of the control data record to the interface module

- If you have enabled configuration control, the ET 200AL station is not ready for operation without a control data record. As long as no valid control data record has been transferred, the I/O modules are considered as failed by the CPU and exhibit substitute value behavior. The interface module continues to exchange data.
- The control data record is stored retentively in the interface module. Note:
  - If the configuration is unchanged, you do not have to rewrite the control data record 196 during restart.
  - If you write a control data record with modified configuration, this will result in a station failure in the distributed I/O system. The original data record 196 is deleted and the new data record 196 is saved retentively. The station will then restart with the modified configuration.

### Error messages

In case of error, the WRREC instruction returns the following error messages via the STATUS block parameter:

Table 7- 5 Error messages

| Error code        | Meaning                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |
|-------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 80B1 <sub>H</sub> | Invalid length; the length information in data record 196 is not correct.                                                                                                                                                                                                                                                                                                                                                                                                                                                      |
| 80B2 <sub>H</sub> | Invalid slot: The configured slot is not assigned                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |
| 80B5 <sub>H</sub> | Configuration control parameters not assigned.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |
| 80B8 <sub>H</sub> | Parameter error<br>Reasons for a parameter error are: <ul style="list-style-type: none"> <li>• Incorrect block ID in the header (not equal to 196)</li> <li>• Invalid version identifier in the header</li> <li>• A reserved bit was set</li> <li>• A station master slot was assigned an invalid slot in the station option</li> <li>• Multiple slots in the station master are assigned to the same slot in the station option</li> <li>• For shared device on submodule level: violation of defined restrictions</li> </ul> |
| 80C5 <sub>H</sub> | DP slave or module not available. Indicates that a data record has not been acknowledged due to the system.                                                                                                                                                                                                                                                                                                                                                                                                                    |

If you receive the error code 80A2<sub>H</sub>, 80B2<sub>H</sub> or 80C5<sub>H</sub> when writing to control data record 196, check whether the required configuration was accepted despite the error code.

## 7.5 Behavior during operation

### Effect of discrepancy between station master and station option

For the online display and for the display in the diagnostics buffer (module OK or module faulty), the station master is always used and not the differing station option.

Example: A module outputs diagnostics data. This module is configured in slot 4 in the station master, but is inserted in slot 3 in the station option (missing module; see example in the next section). The online view (station master) shows an incorrect module in slot 4. In the real configuration, the module in slot 3 indicates an error via an LED display.

### Response to modules that are not present

If modules are entered as not present in the control data record, the automation system behaves as follows:

- Modules designated as not present in the control data record do not supply diagnostics and their status is always OK. The value status is OK.
- Direct writing access to the outputs that are not present or writing access to the process image of outputs that are not present: Remains without effect; no access error is signaled.
- Direct reading access to the inputs that are not present or reading access to the process image of inputs that are not present: Value "0" is supplied; no access error is signaled.
- Write data record to module that is not present: Remains without effect; no error is signaled.
- Read data record from module that is not present: The output parameter STATUS of the instruction RDREC supplies the value 80A3<sub>H</sub> "General CM error".

# Commissioning

## 8.1 PROFINET IO

### 8.1.1 Commissioning ET 200AL on PROFINET IO

#### Introduction

The commissioning of your distributed I/O system depends on the system configuration. The following procedure describes the commissioning of the ET 200AL distributed I/O system on an IO controller.

#### Requirements for the ET 200AL distributed I/O system on the PROFINET IO

##### Note

##### Performing tests

You must ensure the safety of your plant. You therefore need to perform a complete functional test and the necessary safety checks before the final commissioning of a plant.

Also plan the tests to include any possible foreseeable errors. This will allow you to prevent people or plants from being placed in danger during operation.

#### Procedure

The following table shows the chapters/documents in which the required actions are described.

Table 8- 1 Requirements for the ET 200AL distributed I/O system on the PROFINET IO

| Step | Procedure                                                       | See...                                                                                                                                                                        |
|------|-----------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 1    | Mounting the ET 200AL interface module                          | Section Mounting (Page 26)                                                                                                                                                    |
| 2    | Wiring the ET 200AL interface module                            | Section Connecting (Page 31)                                                                                                                                                  |
| 3    | Configuring the ET 200AL interface module                       | Section Configuring (Page 59)                                                                                                                                                 |
| 4    | Turning on the supply voltage for the ET 200AL interface module | IM 157-1 PN interface module ( <a href="https://support.industry.siemens.com/cs/ww/en/view/89254863">https://support.industry.siemens.com/cs/ww/en/view/89254863</a> ) manual |
| 5    | ET 200AL interface module automatically switches to RUN mode    | -                                                                                                                                                                             |

#### Reference

You can find additional information on assigning the PROFINET IO parameters in the PROFINET with STEP 7 V14 (<https://support.industry.siemens.com/cs/ww/en/view/49948856>) function manual.

### 8.1.2 Startup on PROFINET IO

#### Principle of operation

The figure below schematically shows the startup of the ET 200AL distributed I/O system on the PROFINET IO (= IO device) as a flow chart.

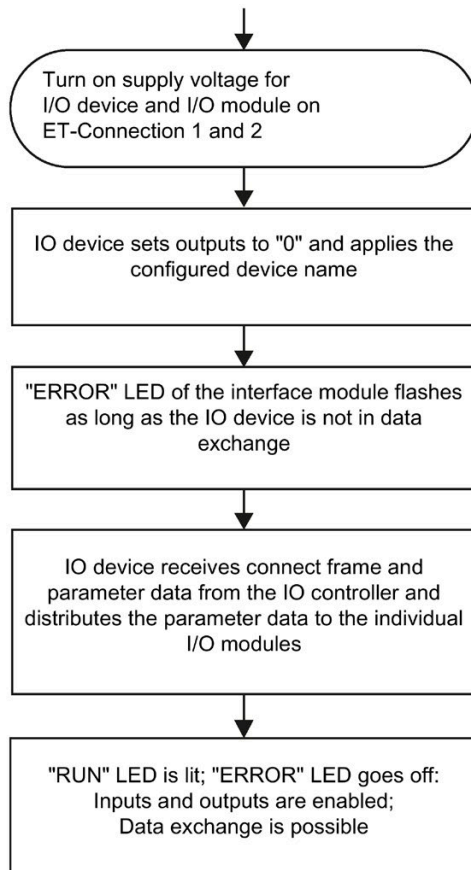


Figure 8-1 Startup of the ET 200AL distributed I/O system on the PROFINET IO

The figure below schematically shows the startup of an ET 200AL I/O module after an ET 200AL PROFINET interface module.

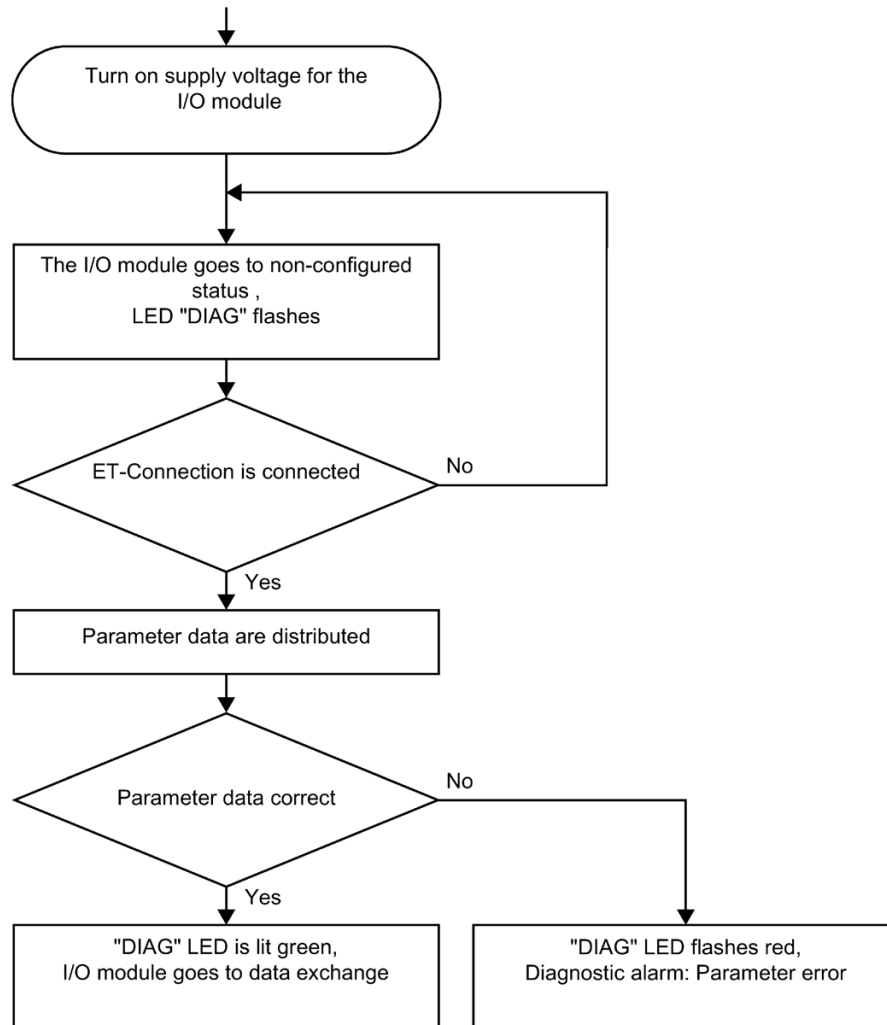


Figure 8-2 Startup of the ET 200AL I/O module



### 8.1.3 PROFlenergy

---

**Note**

PROFlenergy is not supported by fail-safe I/O module F-DI 4+F-DQ 2x24VDC/2A, 4xM12.

---

PROFlenergy (for PROFINET) makes it possible to reduce the energy consumption of the device using the PROFlenergy command during production downtime.

#### Additional information

You will find more information on the Internet (<https://www.profibus.com>) under Common Application Profile PROFlenergy; Technical Specification for PROFINET; as well as in the following documentation:

- IM 157-1 PN interface module  
(<https://support.industry.siemens.com/cs/ww/en/view/89254863>) manual
- I/O modules (<https://support.industry.siemens.com/cs/ww/en/ps/14247/man>) manuals
- PROFINET System Description  
(<https://support.industry.siemens.com/cs/ww/en/view/19292127>) system manual
- PROFINET with STEP 7 V14  
(<https://support.industry.siemens.com/cs/ww/en/view/49948856>), function manual,  
Section: Saving energy with PROFlenergy
- Application guide for implementation of shutdown concepts with PROFlenergy.  
(<https://support.industry.siemens.com/cs/ww/en/view/96837137>)
- Saving energy with SIMATIC S7 (STEP 7 as of V5.5)  
(<https://support.industry.siemens.com/cs/ww/en/view/41986454>)
- Saving energy with SIMATIC S7 and SIMATIC HMI (TIA Portal)  
(<https://support.industry.siemens.com/cs/ww/en/view/58235225>)
- SIMATIC S7 library for simple configuration of PROFlenergy.  
(<https://support.industry.siemens.com/cs/ww/en/view/109478388>)
- You can find additional information on the PROFlenergy FBs ("PE\_START\_END" - FB 815, "PE\_CMD" - FB 816) in the online help for STEP 7 V5.5 as of SP2, Help on system functions/function blocks.

## 8.2 PROFIBUS DP

### 8.2.1 Commissioning ET 200AL on PROFIBUS DP

#### Introduction

The commissioning of your distributed I/O system depends on the system configuration. The following procedure describes the commissioning of the ET 200AL distributed I/O system on a DP master.

#### Requirements for the ET 200AL distributed I/O system on a PROFIBUS DP

##### Note

##### Performing tests

You must ensure the safety of your plant. You therefore need to perform a complete functional test and the necessary safety checks before the final commissioning of a plant.

Also plan the tests to include any possible foreseeable errors. This helps to avoid endangering persons or equipment during operation.

#### Procedure

The following table shows the chapters/documents in which the required actions are described.

Table 8- 2 Requirements for the ET 200AL distributed I/O system on a PROFIBUS DP

| Step | Procedure                                                                 | See...                                                                                                                                                                                                                                        |
|------|---------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 1    | Mounting the ET 200AL interface module                                    | Section Mounting (Page 26)                                                                                                                                                                                                                    |
| 2    | Setting the PROFIBUS DP address on the ET 200AL PROFIBUS interface module | IM 157-1 DP interface module ( <a href="https://support.industry.siemens.com/cs/w/en/view/89255073">https://support.industry.siemens.com/cs/w/en/view/89255073</a> ) manual, section Setting the PROFIBUS DP address and terminating resistor |
| 3    | Wiring the ET 200AL interface module                                      | Section Connecting (Page 31)                                                                                                                                                                                                                  |
| 4    | Configuring the ET 200AL interface module                                 | Section Configuring (Page 59)                                                                                                                                                                                                                 |
| 5    | Switching on the supply voltage for the ET 200AL interface module         | IM 157-1 DP interface module ( <a href="https://support.industry.siemens.com/cs/w/en/view/89255073">https://support.industry.siemens.com/cs/w/en/view/89255073</a> ) manual                                                                   |
| 6    | ET 200AL interface module automatically switches to RUN mode              | -                                                                                                                                                                                                                                             |

## 8.2.2 Startup on PROFIBUS DP

### Principle of operation

The figure below schematically shows the startup of the ET 200AL distributed I/O system on the PROFIBUS DP (= DP slave) as a flow chart.

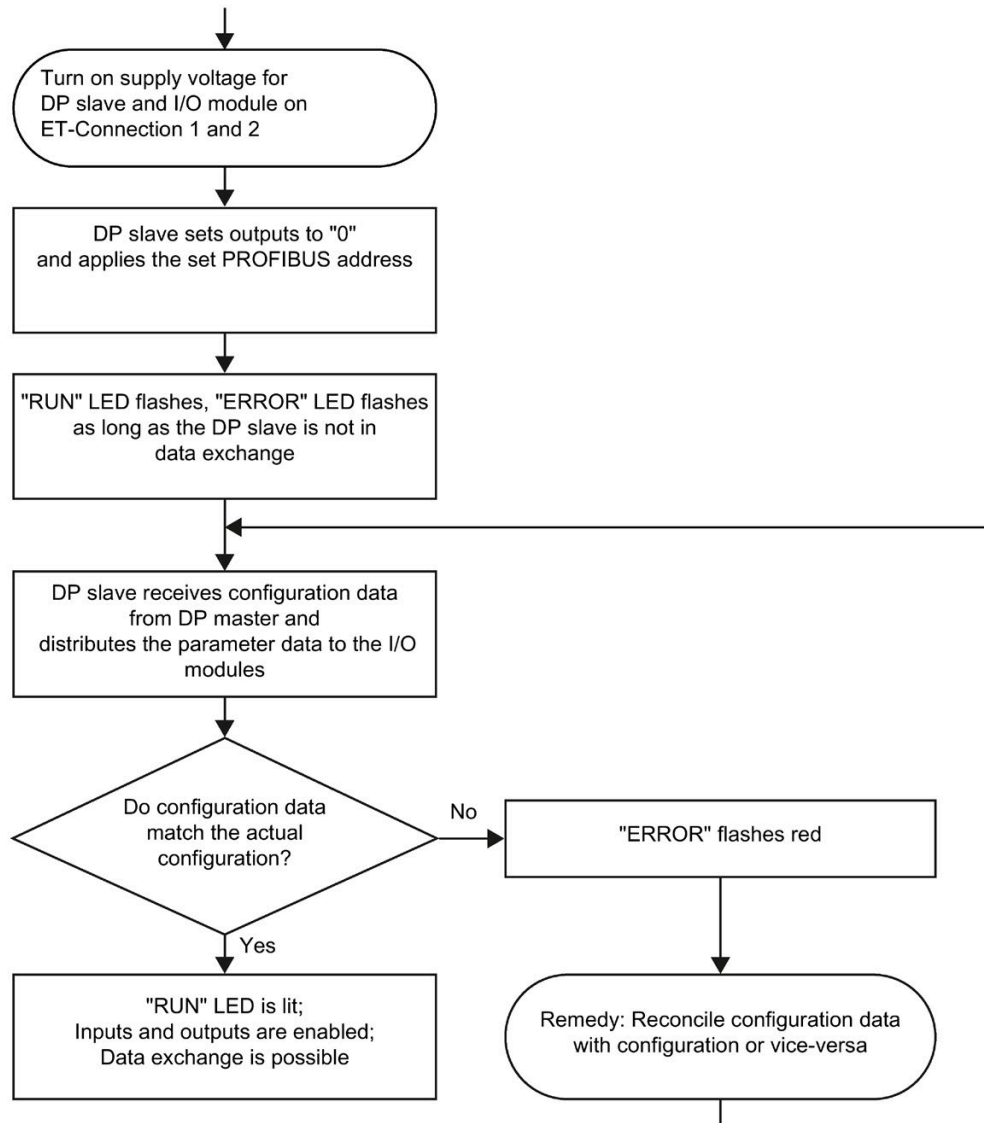


Figure 8-3 Startup of the ET 200AL distributed I/O system on PROFIBUS DP

The figure below schematically shows the startup of an ET 200AL I/O module after an ET 200AL PROFIBUS interface module as flow chart.

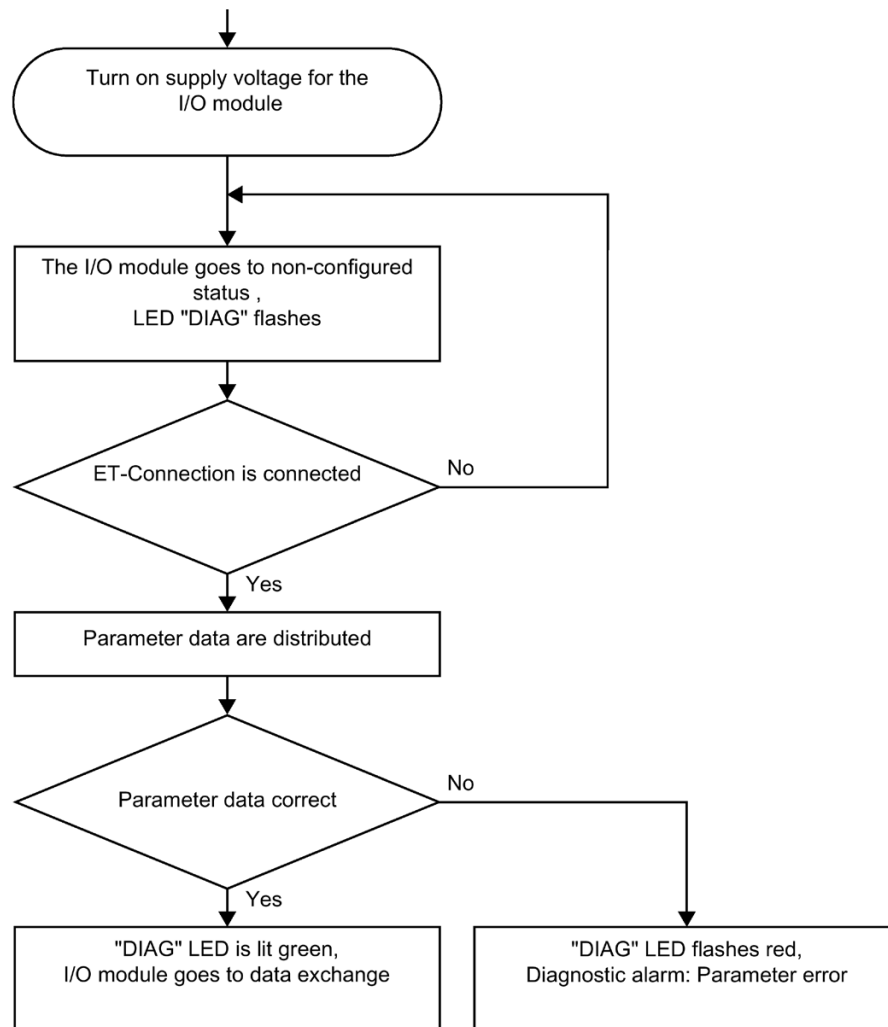


Figure 8-4 Startup of an ET 200AL I/O module

## 8.3 Identification and maintenance data

### 8.3.1 Reading out and entering I&M data

#### Introduction

Identification data I&M is information that is saved either as read-only (I data) or read/write (M data) on the interface module.

**Identification data (I&M0):** Manufacturer information on the module that is read-only and in some cases is also printed on the module housing, for example, article number, serial number and firmware version.

**Maintenance data (I&M1, 2, 3):** Plant-dependent information, e.g. installation location. Maintenance data is created during configuration and written to the module.

All modules of the ET 200AL distributed I/O system support identification data (I&M0 to I&M3).

The I&M identification data supports you in the following activities:

- Checking the plant configuration
- Locating hardware changes in a system
- Correcting errors in a system

With the I&M identification data, you have the option of clearly identifying modules online.

In STEP 7, the identification data is displayed in the "Module status - IM 157" and "Properties..." tabs (see STEP 7 online help).

#### Options for reading out I&M data

You have the following options for reading the I&M data:

- Via the user program
- Via STEP 7 or HMI devices

#### Procedure for reading I&M data by means of the user program

To read the I&M data of the interface module in the user program, use the instruction "RDREC".

#### Procedure for reading the I&M data using STEP 7

Requirement: There must be an online connection to the interface module.

1. In the project navigation, under "Distributed I/O", select the I/O device or the DP slave, e.g. "IM 157-1 PN".
2. Select: **IO device/DP slave > Online & Diagnostics > Identification & Maintenance.**

### Procedure for input of maintenance data using STEP 7

The default module name is assigned by STEP 7. You have the option to enter the following data:

- Plant designation (I&M1)
- Location identifier (I&M1)
- Installation date (I&M2)
- Additional information (I&M3)
- Signature (I&M4), only for PROFINET

To enter the data, follow these steps:

1. In the device view of the STEP 7 hardware network editor, select the interface module, for example.
2. In the properties under "General", select the "Identification & Maintenance" area and enter the data.

During the loading of the hardware configuration, the I&M data are also loaded.

### Reference

You can find additional information on I&M data of the ET 200SP (mixed configuration) in the ET 200SP distributed I/O system  
(<https://support.industry.siemens.com/cs/ww/en/view/58649293>) system manual.

### 8.3.2 Data record structure for I&M data

#### Reading I&M data records (distributed via PROFINET IO)

You can directly access specific identification data by selecting **Read data record** ("RDREC" instruction). You obtain the corresponding part of the identification data under the associated data record index.

The following table shows the principle behind the structure of data records.

Table 8- 3 Basic structure of data records with I&M identification data

| Contents                                 | Length (bytes)             | Coding (hex)                                                                                                                                                 |
|------------------------------------------|----------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Header information</b>                |                            |                                                                                                                                                              |
| BlockType                                | 2                          | I&M0: 0020 <sub>H</sub><br>I&M1: 0021 <sub>H</sub><br>I&M2: 0022 <sub>H</sub><br>I&M3: 0023 <sub>H</sub><br>I&M4: 0024 <sub>H</sub>                          |
| BlockLength                              | 2                          | I&M0: 0038 <sub>H</sub><br>I&M1: 0038 <sub>H</sub><br>I&M2: 0012 <sub>H</sub><br>I&M3: 0038 <sub>H</sub><br>I&M4: 0038 <sub>H</sub>                          |
| BlockVersionHigh                         | 1                          | 01                                                                                                                                                           |
| BlockVersionLow                          | 1                          | 00                                                                                                                                                           |
| <b>Identification data</b>               |                            |                                                                                                                                                              |
| Identification data<br>(see table below) | 54<br>54<br>16<br>54<br>54 | I&M0/Index AFF0 <sub>H</sub><br>I&M1/Index AFF1 <sub>H</sub><br>I&M2/Index AFF2 <sub>H</sub><br>I&M3/Index AFF3 <sub>H</sub><br>I&M4/Index AFF4 <sub>H</sub> |

The following table shows the structure of data records for I&M identification data.

Table 8- 4 Data record structure for I&M identification data

| Identification data                                        | Access                | Default            | Explanation                                                                             |
|------------------------------------------------------------|-----------------------|--------------------|-----------------------------------------------------------------------------------------|
| <b>Identification data 0: (data record index AFF0 hex)</b> |                       |                    |                                                                                         |
| VendorIDHigh                                               | read (1 byte)         | 00H                | This is where the name of the manufacturer is stored (42D = SIEMENS AG).                |
| VendorIDLow                                                | read (1 byte)         | 2AH                |                                                                                         |
| Order_ID                                                   | read (20 bytes)       | 6ES7157-1AB00-0AB0 | Order number of the module (e.g. of PROFINET interface module)                          |
| IM_SERIAL_NUMBER                                           | read (16 bytes)       | -                  | Serial number (device-specific)                                                         |
| IM_HARDWARE_REVISION                                       | read (2 bytes)        | 1                  | Corresponding hardware version                                                          |
| IM_SOFTWARE_REVISION                                       | read                  | Firmware version   | Provides information about the firmware version of the module                           |
| • SWRevisionPrefix                                         | (1 byte)              | V                  |                                                                                         |
| • IM_SWRevision_Functional_Enhancement                     | (1 byte)              | 00 - FFH           |                                                                                         |
| • IM_SWRevision_Bug_Fix                                    | (1 byte)              | 00 - FFH           |                                                                                         |
| • IM_SWRevision_Internal_Change                            | (1 byte)              | 00 - FFH           |                                                                                         |
| IM_REVISION_COUNTER                                        | read (2 bytes)        | 0000H              | provides information about configured changes on the module (not used)                  |
| IM_PROFILE_ID                                              | read (2 bytes)        | 0000H              | Generic device                                                                          |
| IM_PROFILE_SPECIFIC_TYPE                                   | read (2 bytes)        | 0005H              | Interface modules                                                                       |
| IM_VERSION                                                 | read                  | 0101H              | provides information about the version of the identification data (0101H = Version 1.1) |
| • IM_Version_Major                                         | (1 byte)              |                    |                                                                                         |
| • IM_Version_Minor                                         | (1 byte)              |                    |                                                                                         |
| IM_SUPPORTED                                               | read (2 bytes)        | 001EH              | provides information about the existing identification data (I&M1 though I&M4)          |
| <b>Maintenance data 1: (data record index AFF1 hex)</b>    |                       |                    |                                                                                         |
| IM_TAG_FUNCTION                                            | Read/write (32 bytes) | -                  | Enter an identifier for the module here, that is unique plant-wide.                     |
| IM_TAG_LOCATION                                            | Read/write (22 bytes) | -                  | Enter the installation location of the module here.                                     |
| <b>Maintenance data 2: (data record index AFF2 hex)</b>    |                       |                    |                                                                                         |
| IM_DATE                                                    | Read/write (16 bytes) | YYYY-MM-DD HH:MM   | Enter the installation date of the module here.                                         |
| <b>Maintenance data 3: (data record index AFF3 hex)</b>    |                       |                    |                                                                                         |
| IM_DESCRIPTOR                                              | Read/write (54 bytes) | -                  | Enter a comment describing the module.                                                  |

### Reading I&M data records with data record 255 (distributed via PROFIBUS DP)

The modules support standardized access to identification data using DR 255 (index 65000 to 65003). For additional information on the DR 255 data structure, refer to the specifications of the Profile Guideline - Order No. 3.502.



# Maintenance

## 9.1 Replacing modules

### Replacing modules

Replacing a module is not permitted during ongoing operation.



#### **WARNING**

##### **Material damage can occur**

If you remove/insert modules with the power connected, this can lead to undefined states in your system.

Material damage to the ET 200AL distributed I/O system may occur as a result.

Only remove or replace modules when the power is disconnected.

Always comply with the required standards and safety guidelines when configuring a system.



#### **WARNING**

##### **Mixing up ET-Connection1 and ET-Connection2**

When connecting the modules, always ensure that they are properly connected.

If you mix up the lines for ET-Connection1 and ET-Connection2 when connecting the modules, this can lead to undefined states in your system.

### Behavior of ET-Connection

During ongoing operation, a module replacement may be necessary, e.g. because the module is defective. If an I/O module fails in an ET-Connection line, the line remains active up to the failed I/O module. After replacing the I/O module, the ET-Connection line starts up by itself.

## Procedure

To replace a module, proceed as follows:

1. Disconnect the supply voltage to the module to be replaced.
2. Completely remove all cables connected to the module.
3. Completely remove the fixing screws of the module
4. Replace the module.

---

### Note

#### "New" module

The removed module may only be replaced by a module of the same type.

---

5. Fasten the module with a torque of 1.2 Nm.
6. Connect all cables.
7. Turn the supply voltage on.

### WARNING

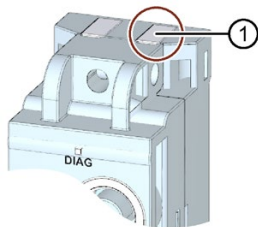
#### Pay attention to the slot number of the module

If you mix up the ET 200AL I/O modules when connecting them, this can cause personal injury and damage to the machine.

The ET 200AL distributed I/O system cannot distinguish between modules of the same type during the actual/target comparison.

We recommend that you clearly label the ET 200AL I/O modules with the slot number.

The figure below shows a recommendation for labeling the ET 200AL I/O modules with the slot number.



- ① Recommendation for labeling the slot number

Figure 9-1 Slot number

## Result

The disconnected I/O module and all downstream I/O modules start up again by themselves.

## 9.2 Firmware update

### Introduction

During operation, it can become necessary to update the firmware (e.g. for function extensions).

Firmware updates are used to update the firmware of the interface module and I/O modules.

---

#### Note

##### Temporary bus interruption

When you perform a firmware update of an ET 200AL I/O module, then the ET-Connection is temporarily interrupted due to the restart of I/O module. All downstream ET 200AL I/O modules report a pull/plug interrupt.

---

### Options for the firmware update

You have the following options to running a firmware update:

- Online via STEP 7, as of V5.5<sup>1</sup>
- Online with STEP 7, TIA Portal V13 or higher
- Embedded web server running on a SIMATIC CPU or a SIMATIC F-CPU with fail-safe modules.
- SIMATIC Automation Tool (SAT)

<sup>1</sup>) Not for use with fail-safe ET 200AL I/O modules

### Reference

You can find additional information on the procedure in the FAQs on the Internet (<https://support.industry.siemens.com/cs/ww/en/view/88778936>) and in the online help for STEP 7.

## 9.3 Resetting interface module to factory settings (PROFINET)

### Introduction

When you "Reset to factory settings", the interface module is reset to the delivery state settings. This means that all information that was saved internally on the interface module is deleted.

### Result after resetting to factory settings

The following table shows an overview of the contents of the memory objects after resetting to factory settings.

Table 9- 1 Result after resetting to factory settings

| Memory object                    | Contents                                                                              |
|----------------------------------|---------------------------------------------------------------------------------------|
| IP address                       | Deleted<br>(configurable when resetting: "Retain IP address"/<br>"Delete IP address") |
| Device name                      | Deleted                                                                               |
| MAC address                      | Is not deleted                                                                        |
| Identification data (I&M0)       | Is not deleted                                                                        |
| Maintenance data (I&M1, 2, 3, 4) | Are deleted (optional)                                                                |
| Firmware version                 | Is not deleted                                                                        |

---

#### Note

##### Failure of downstream stations is possible

Resetting an interface module to factory settings can lead to failure of downstream stations in a line.

---

#### Note

##### Substitute value behavior of I/O modules when resetting to factory settings

When "Resetting to factory settings", the I/O modules in the station take on the non-configured state, which means input data are not entered and output data are not output.

---

### Reset options

There are two ways to reset an interface module to factory settings:

- Online with STEP 7 (TIA Portal)
- Online with STEP 7, V5.5 or higher

## Requirement

You need an online connection to reset an interface module to factory settings.

### Procedure with STEP 7 (TIA Portal)

Connect the PG/PC to the PROFINET IO interface of the ET 200AL distributed I/O system.

Make sure that there is an online connection to the interface module which is to be reset to factory settings.

1. Open the online and diagnostics view of the interface module.
2. In the "Functions" folder, select the "Reset to factory settings" group.
3. Select the "Retain IP address" option button if you want to retain the IP address, or the "Reset IP address" option button if you want to delete the IP address.
4. Click the "Reset" button.
5. Click "OK" in response to the confirmation prompts.

**Result:** The interface module performs the "Reset to factory settings" while the RUN LED flashes yellow. When the RUN LED is lit yellow, the interface module has been reset to factory settings and is in the STOP operating mode. The event "Reset to factory settings" is entered in the diagnostics buffer.

### Procedure with STEP 7 V5.5 or higher

Connect the PG/PC to the PROFINET IO interface of the ET 200AL distributed I/O system.

Make sure that there is an online connection to the interface module which is to be reset to factory settings.

1. Open the SIMATIC Manager.
2. Select accessible devices.
3. Select the interface module.
4. Navigate through "Menu > Options > Edit Ethernet devices > Reset to factor settings > Reset".

**Result:** The interface module performs the "Reset to factory settings" while the RUN LED flashes yellow. When the RUN LED is lit yellow, the interface module has been reset to factory settings and is in the STOP operating mode. The event "Reset to factory settings" is entered in the diagnostics buffer.

## Reference

You will find more information on the procedure in the STEP 7 online help.

## 9.4 Reactions to errors of the F module

### Safe state (safety concept)

The basic principle behind the safety concept is the presence of a safe state for all process tags.

---

#### Note

For digital F-modules, the safe state is "0". The safe state applies to sensors and actuators.

---

### Error reactions and startup of the F-system

In the following situations, the values of the safe state must be connected to the fail-safe channel/channels instead of the process values (passivation of the fail-safe module) due to the safety function:

- When the F-system is started
- When errors are detected in the safety-related communication between the F-CPU and the F-module via the PROFIsafe safety protocol (communication error)
- When errors of the F-I/O or channel errors (e.g. wire break or discrepancy error) are detected

Detected errors are written to the diagnostic buffer of the F-CPU and reported to the safety program in the F-CPU.

F-modules cannot save errors as retentive data. If the system is switched off and then restarted, any pending errors are detected again at startup. However, you can save errors in your safety program.

|                                                                                                    |
|----------------------------------------------------------------------------------------------------|
|  <b>WARNING</b> |
|----------------------------------------------------------------------------------------------------|

|                                                                                                |
|------------------------------------------------------------------------------------------------|
| <b>If channels are set to "disabled", there are no diagnostic or error handling reactions.</b> |
|------------------------------------------------------------------------------------------------|

|                                                                                                                                                                                                                                                            |
|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| For channels that are set to "disabled" in STEP 7, no diagnostic message or error handling is triggered when a channel error occurs. Not even if this channel is indirectly affected by a channel group error ("Channel activated/deactivated" parameter). |
|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|

### Troubleshooting in the F-system

To correct errors in your F-system, proceed as described in IEC 61508-1:2010 section 7.15.2.4 and IEC 61508-2:2010 section 7.6.2.1 e.

Perform the following steps:

1. Rung diagnostics and correct the error
2. Revalidate the safety function
3. Record in the service report

### Fail-safe values for F-modules

For F-modules with inputs, the F-system provides fail-safe values (0) for the safety program when passivated. The fail-safe values are used instead of the process data at the F-DI.

For F-modules with outputs, the F-system transfers the fail-safe values (0) to the fail-safe outputs during passivation. The fail-safe values are used instead of the output values of the safety program. The fail-safe outputs are de-energized. This process is performed even if the F-CPU goes to the STOP operating state.

It is not possible to set the parameters of fail-safe values.

The fail-safe values are used in the following dependencies for the channel involved or all channels of the I/O module involved:

- F-system used
- Type of error occurred
  - Error in the F-I/O
  - Channel fault
  - Communication error

### Re-integration of a fail-safe module or channel

The F-system changes from fail-safe values to process values automatically or after acknowledgment in the safety program by the user. A detailed list of errors can be found in the device manual of the F-module or in the STEP 7 online help.

Procedure after re-integration:

- For an F-module with inputs, the process data pending at the F-DI is provided again to the safety program.
- For an F-module with outputs, the output values provided by the safety program are transferred again to the F-DQs.

### Additional information on passivation and re-integration

For additional information on passivation and reintegration of F-I/O modules, refer to the SIMATIC Safety – Configuring and Programming (<https://support.industry.siemens.com/cs/ww/en/view/54110126>) manual.

### Reaction of the F-module with inputs to communication errors

F-modules with inputs react differently to communication errors than to other errors.

When a communication error is detected, the current process values at the inputs of the F-module remain set. No channels are passivated. The current process values are passivated in the F-CPU.

## 9.5 Cleaning modules

When wired, ET 200AL modules comply with degree of protection IP65/IP67 and do not require any cleaning. If you do have to clean the modules, then use a dry or damp cloth. Please take care to comply with degree of protection IP65/67 when cleaning with liquids.

# Technical specifications

## Introduction

The technical specifications of the system are found in this section:

- The standards and test values that the ET 200AL distributed I/O system complies with and fulfills.
- The test criteria according to which the ET 200AL distributed I/O system was tested.

## Technical specifications for the modules

The technical data of the individual modules can be found in the modules' manuals. If there are discrepancies between the statements in this document and the product manuals, the statements in the product manuals take priority.

## Reference

The certificates for the markings and approvals can be found on the Internet (<https://support.industry.siemens.com>).



## 10.1 Standards and authorizations

### Currently valid markings and authorizations

---

#### Note

#### Details on the components of the ET 200AL distributed I/O system

The currently valid markings and approvals are printed on the components of the ET 200AL distributed I/O system.

---

#### CE mark



The ET 200AL distributed I/O system fulfills the requirements and protection targets of the following directives and complies with the harmonized European standards (ES) which have been promulgated for programmable logic controllers in the official gazettes of the European Community:

- 2014/30/EU "Electromagnetic Compatibility" (EMC Directive)
- 2011/65/EU "Restriction of the use of certain hazardous substances in electrical and electronic equipment" (RoHS Directive)

The fail-safe modules of the ET 200AL distributed I/O system meet the safety requirements and safety objectives of the following EU directives and comply with the harmonized EU standards (EN) for programmable controllers as specified in the official journals of the European Union.

- 2014/30/EU "Electromagnetic Compatibility" (EMC directive)
- 2006/42/EC "Machinery Directive and Supplementary Directive 95/16/EC"
- 2011/65/EU "Restriction of the use of certain hazardous substances in electrical and electronic equipment" (RoHS Directive)

The EU Declarations of Conformity are available for the authorities in charge and are kept at the following address:

SIEMENS AG  
Digital Industries  
DI FA TI COS TT  
P.O. Box 1963  
D-92209 Amberg, Germany

These are also available for download on the Customer Support Internet pages, under the keyword "Declaration of Conformity".

## UL approval



Underwriters Laboratories Inc. in accordance with

- UL 61010-1 and UL 61010-2-201
- CSA C22.2 No. 61010-1 and CSA C22.2 No. 61010-2-201 (Process Control Equipment)

The following table shows the modules that are approved for UL50/NEMA250 Enclosure Type 4X Indoor use only, watertight.

Table 10- 1 Released modules according to UL50/NEMA250 Enclosure Type 4X, Indoor use only, watertight

| Description                       | Article number     |
|-----------------------------------|--------------------|
| <b>Interface modules ET 200AL</b> |                    |
| IM157-1 PN interface module       | 6ES7157-1AB00-0AB0 |
| IM 157-1 DP interface module      | 6ES7157-1AA00-0AB0 |
| <b>DI</b>                         |                    |
| DI 8x24VDC, 8xM8                  | 6ES7141-5BF00-0BA0 |
| DI 8x24VDC, 4xM12                 | 6ES7141-5AF00-0BA0 |
| DI 16x24VDC, 8xM12                | 6ES7141-5AH00-0BA0 |
| <b>DQ</b>                         |                    |
| DQ 8x24VDC/2A, 8xM12              | 6ES7142-5AF00-0BA0 |
| <b>DI/DQ</b>                      |                    |
| DIQ 4+DQ 4x24VDC/0,5A, 8xM8       | 6ES7143-5BF00-0BA0 |
| DIQ 4+DQ 4x24VDC/0,5A, 4xM12      | 6ES7143-5AF00-0BA0 |
| DIQ 16x24VDC/0,5A, 8xM12          | 6ES7143-5AH00-0BA0 |
| <b>AI</b>                         |                    |
| AI 4xU/I/RTD, 4xM12               | 6ES7144-5KD00-0BA0 |
| <b>AQ</b>                         |                    |
| AQ 4xU/I, 4xM12                   | 6ES7145-5ND00-0BA0 |
| <b>Communication modules</b>      |                    |
| CM 4xIO-LINK, 4xM12               | 6ES7147-5JD00-0BA0 |



The following table shows the modules that are approved for UL50/NEMA250 Enclosure Type 1.

Table 10- 2 Released modules according to UL50/NEMA250 Enclosure Type 1

| Description                   | Article number     |
|-------------------------------|--------------------|
| <b>DI/DQ</b>                  |                    |
| F-DI 4+F-DQ 2x24VDC/2A, 4xM12 | 6ES7146-5FF00-0BA0 |

## RCM Declaration of conformity for Australia/New Zealand



The ET 200AL distributed I/O system meets the requirements of EN 61000-6-4:2007 Generic standards – Emission standard for industrial environments.

### Korea Certificate KCC-REM-S49-ET200



Please note that this device corresponds to limit class A with regard to the emission of radio interference. This device can be used in all areas, except residential areas.

이 기기는 업무용(A급) 전자파 적합기기로서 판매자 또는 사용자는 이 점을 주의하시기 바라며 가정 외의 지역에서 사용하는 것을 목적으로 합니다.

### Marking for the Eurasian Customs Union



EAC (Eurasian Conformity)

Customs Union of Russia, Belarus and Kazakhstan

Declaration of conformity with the technical requirements of the Customs Union (TR CU)

### IEC 61131-2

The ET 200AL distributed I/O system fulfills the requirements and criteria of standard IEC 61131-2 (programmable logic controllers, Part 2: Equipment requirements and tests).

### IEC 61010-2-201

The ET 200AL distributed I/O system fulfills the requirements and criteria of standard IEC 61010-2-201.

### PROFINET standard

The interface module IM 157-1 PN based on standard IEC 61158 Type 10.

### PROFIBUS standard

The interface module IM 157-1 DP based on standard IEC 61158 Type 3.

### Marine approval

Classification societies:

- ABS (American Bureau of Shipping)
- BV (Bureau Veritas)
- CCS (China Classification Society)
- Class NK (Nippon Kaiji Kyokai)
- DNV-GL (Det Norske Veritas - Germanischer Lloyd)
- LRS (Lloyds Register of Shipping)

---

#### Note

The fail-safe module F DI 4+F DQ 2x24VDC/2A, 4xM12 of the ET 200AL distributed I/O system does not support the specified marine approvals due to the increased supply voltage requirements.

---

## IO-Link standard

The communication module CM 4xIO-Link 4xM12 based on standard IEC 61131-9.

## Industrial use

The ET 200AL distributed I/O system is suitable for use in industrial environments. It meets the following standards for this type of use:

- Requirements on interference emission EN 61000-6-4: 2007 + A1: 2011
- Requirements on immunity EN 61000-6-2: 2005

### Use in mixed areas

Under specific prerequisites you can use the ET 200AL distributed I/O system in a mixed area. A mixed area is used for residential purposes and for commercial operations that do not significantly impact the residential purpose.

If you want to use the ET 200AL distributed I/O system in mixed areas, you must ensure that its radio frequency interference emission complies with the limit classes of the EN 61000-6-3 generic standard. Suitable measures for observing these limits for use in a mixed area are, for example:

- Installation of the ET 200AL distributed I/O system in grounded control cabinets/control boxes
- Use of filters in supply cables

An additional individual acceptance test is also required.

### Use in residential areas

---

#### Note

#### ET 200AL distributed I/O system not intended for use in residential areas

The ET 200AL distributed I/O system is not intended for use in residential areas. If you are using the ET 200AL distributed I/O system in residential areas, radio and TV reception may be affected.

---

## Use in industrial burner and firing environments.

The fail-safe module F-DI 4+F-DQ 2x24VDC/2A, 4xM12 of the ET 200AL distributed I/O system meets the requirements and criteria of the following standards:

- EN 298 (Automatic burner control systems for burners and appliances burning gaseous or liquid fuels)
- EN 50156-1 (Electrical equipment for furnaces and ancillary equipment)
- EN 50156-2 (Electrical equipment for furnaces and ancillary equipment)

## Reference

The certificates for the markings and approvals can be found on the Internet under Service&Support (<https://support.industry.siemens.com/cs/ww/en/>).

## 10.2 Electromagnetic compatibility

### Definition

Electromagnetic compatibility is the ability of an electrical apparatus to function in a satisfactory manner in its electromagnetic environment without affecting this environment.

An I/O device of the ET 200AL distributed I/O system fulfills the requirements of the EMC law of the European Union. The requirement for this is that an I/O device of the ET 200AL distributed I/O system meets the specifications and guidelines for electrical configuration.

### Pulse-shaped disturbance variables

The table below shows the electromagnetic compatibility of the distributed I/O systems compared to pulse-shaped disturbance variables.

Table 10- 3 Pulse-shaped disturbance variables

| Pulse-shaped disturbance variable                                             | Tested with                                                    | Corresponds to degree of severity |
|-------------------------------------------------------------------------------|----------------------------------------------------------------|-----------------------------------|
| Electrostatic discharge according to IEC 61000-4-2.                           | Air discharge: $\pm 8$ kV                                      | 3                                 |
|                                                                               | Contact discharge: $\pm 4$ kV                                  | 2                                 |
| Burst pulses (rapid transient disturbance values) according to IEC 61000-4-4. | $\pm 2$ kV (power supply cable)                                | 3                                 |
|                                                                               | $\pm 2$ kV (PROFIBUS-/PROFINET line)                           | 4                                 |
|                                                                               | $\pm 1$ kV (signal line <30 m)                                 | 3                                 |
|                                                                               | $\pm 1$ kV (ET-Connection)                                     | 3                                 |
| High-energy surge according to IEC 61000-4-5.                                 |                                                                |                                   |
| • Asymmetrical coupling                                                       | $\pm 2$ kV (24 V DC supply cable) with protective element      | 3                                 |
|                                                                               | $\pm 0.5$ kV (24 V DC supply cable) without protective element | 1                                 |
|                                                                               | $\pm 2$ kV (PROFIBUS/PROFINET line) without protective element | 3                                 |
| • Symmetrical coupling                                                        | $\pm 1$ kV (24 V DC supply cable) with protective element      | 3                                 |
|                                                                               | $\pm 0.5$ kV (24 V DC supply cable) without protective element | 2                                 |

## Sinusoidal disturbance variables

The following tables show the electromagnetic compatibility of the distributed I/O systems to sinusoidal disturbance variables.

Table 10- 4 RF radiation

| RF radiation according to IEC 61000-4-3<br>Electromagnetic RF field, amplitude modulated |        | Corresponds to degree of severity |
|------------------------------------------------------------------------------------------|--------|-----------------------------------|
| 80 MHz to 1000 MHz                                                                       | 10 V/m | 3                                 |
| 1.4 GHz to 6 GHz                                                                         | 3 V/m  | 2                                 |
| 80% AM (1 kHz)                                                                           |        |                                   |

Table 10- 5 RF coupling (signal and supply cables)

| RF coupling according to IEC 61000-4-6. | Corresponds to degree of severity |
|-----------------------------------------|-----------------------------------|
| 0.15 MHz to 80 MHz                      | 3                                 |
| 10 V <sub>rms</sub> unmodulated         |                                   |
| 80% AM (1 kHz)                          |                                   |
| 150 Ω source impedance                  |                                   |

## Emission of radio frequency interference

The following table shows the interference emission of electromagnetic fields according to 55016: limit class A, group 1.

Table 10- 6 Interference emission of electromagnetic fields

| Frequency           | Interference emission | Measuring distance |
|---------------------|-----------------------|--------------------|
| 30 MHz to 230 MHz   | <40 dB (μV/m) Q       | 10 m               |
| 230 MHz to 1000 MHz | <47 dB (μV/m) Q       | 10 m               |
| 1 GHz to 3 GHz      | <76 dB (μV/m) P       | 3 m                |
| 3 GHz to 6 GHz      | <80 dB (μV/m) P       | 3 m                |

## 24 V supply connection

The following table shows measurement ranges for low voltage according to EN 55016.

Table 10- 7 Interference emission from the power supply

| Frequency           | Interference emission        |
|---------------------|------------------------------|
| 0.15 MHz to 0.5 MHz | 79 dB (μV) Q<br>66 dB (μV) M |
| 0.5 MHz to 30 MHz   | 73 dB (μV) Q<br>60 dB (μV) M |

## 10.3 Transport and storage conditions

### Transport and storage conditions

The modules of the ET 200AL distributed I/O system exceed the specifications regarding transport and storage conditions pursuant to IEC 61131-2. The following table shows the conditions that apply to modules transported or stored in their original packaging.

Table 10- 8 Transport and storage conditions

| Type of condition     | Permissible range                                                       |
|-----------------------|-------------------------------------------------------------------------|
| Free fall             | ≤0.3 m                                                                  |
| Temperature           | -40 °C to +70 °C                                                        |
| Temperature variation | 20 K/h                                                                  |
| Barometric pressure   | from 1140 hPa to 660 hPa<br>(corresponds to a height of 1000 to 3500 m) |
| Relative humidity     | from 5 to 95%                                                           |

## 10.4 Mechanical and climatic ambient conditions

### Operating conditions

The ET 200AL distributed I/O system is suitable for use in weather-proof, fixed locations.

- The conditions of use exceed the requirements pursuant to IEC 61131-2
  - Class OTH2

You can find the values for the operating conditions in the technical specifications of the manuals or on the Internet (<https://support.industry.siemens.com/cs/de/en/view/109742718>).

### Tests of mechanical ambient conditions

The following table shows the type and scope of the tests on mechanical ambient conditions.

Table 10- 9 Tests of mechanical ambient conditions

| Condition tested | Test standard                              | Values                                                                                                                                                                                                                                                                       |
|------------------|--------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Vibrations       | Vibration test according to IEC 60068-2-6. | Type of oscillation: Frequency sweeps with a rate of change of 1 octave/minute.<br>5 Hz to 9.1 Hz, constant amplitude 15 mm<br>9.1 Hz to 150 Hz, constant acceleration 10g<br>Duration of oscillation: 10 frequency sweeps per axis at each of three vertically aligned axes |
| Shock            | Shock, tested according to IEC 60068-2-27  | Type of shock: Half-sine<br>Shock intensity: 30g peak value, 18 ms duration<br>Direction of shock: 3 shocks each in ± direction in each of the 3 axes vertical to one another                                                                                                |

## Climatic ambient conditions

The following table shows the type and scope of the tests on climatic ambient conditions.

Table 10- 10 Climatic ambient conditions

| Ambient conditions          | Fields of application                    | Comments                                    |
|-----------------------------|------------------------------------------|---------------------------------------------|
| Temperature                 | -25 °C to 55 °C                          | All installation positions                  |
| Temperature variation       | 10 K/h                                   | -                                           |
| Relative humidity           | From 5 to 100%                           | With condensation                           |
| Barometric pressure         | From 1140 hPa to 795 hPa                 | Corresponds to a height of - 1000 to 2000 m |
| Concentration of pollutants | ANSI/ISA-71.04 severity level G1; G2; G3 | -                                           |

The following table shows the modules with functional versions which are permitted to - 30 °C.

Table 10- 11 Extended temperature range to -30 °C

| Description                       | Article number     | As of functional version |
|-----------------------------------|--------------------|--------------------------|
| <b>Interface modules ET 200AL</b> |                    |                          |
| IM 157-1 DP interface module      | 6ES7157-1AA00-0BA0 | FS02                     |
| <b>DI</b>                         |                    |                          |
| DI 8x24VDC, 8xM8                  | 6ES7141-5BF00-0BA0 | FS03                     |
| DI 8x24VDC, 4xM12                 | 6ES7141-5AF00-0BA0 | FS03                     |
| DI 16x24VDC, 8xM12                | 6ES7141-5AH00-0BA0 | FS03                     |
| <b>DQ</b>                         |                    |                          |
| DQ 8x24VDC/2A, 8xM12              | 6ES7142-5AF00-0BA0 | FS03                     |
| <b>DI/DQ</b>                      |                    |                          |
| DIQ 4+DQ 4x24VDC/0,5A, 8xM8       | 6ES7143-5BF00-0BA0 | FS03                     |
| DIQ 4+DQ 4x24VDC/0,5A, 4xM12      | 6ES7143-5AF00-0BA0 | FS03                     |
| DIQ 16x24VDC/0,5A, 8xM12          | 6ES7143-5AH00-0BA0 | FS03                     |
| <b>AI</b>                         |                    |                          |
| AI 4xU/I/RTD, 4xM12               | 6ES7144-5KD00-0BA0 | FS04                     |
| AI 4xRTD/TC, 4xM12                | 6ES7144-5KD50-0BA0 | FS01                     |
| <b>AQ</b>                         |                    |                          |
| AQ 4xU/I, 4xM12                   | 6ES7145-5ND00-0BA0 | FS03                     |
| <b>Fail-safe modules</b>          |                    |                          |
| F-DI 4+F-DQ 2x24VDC/2A, 4xM12     | 6ES7146-5FF00-0BA0 | FS01                     |
| <b>Communication modules</b>      |                    |                          |
| CM 4xIO-LINK, 4xM12               | 6ES7147-5JD00-0BA0 | FS05                     |



## 10.5 Details on insulation, protection class, degree of protection and rated voltage

### Insulation

The insulation is designed in compliance with the requirements of IEC 61010-2-201.

#### Note

Galvanic isolation with 707 V DC (Type Test) is tested for modules with 24 V DC supply voltage (SELV/PELV).

### Pollution class according to IEC 61010-2-201

- Protection class III

### Severity for voltage interruption

The I/O devices of the distributed I/O system ET 200AL meet the severity class PS1 for voltage interruption (5 ms).

### Pollution degree / overvoltage category pursuant to IEC 61010-2-201

- Pollution degree: 3
- Overvoltage category: II

### Degree of protection IP65 and IP67

Degree of protection IP65 and IP67 according to IEC 60529 for all modules of the ET 200AL distributed I/O system:

- 1. Code number: Dust-proof and complete protection from contact
- 2. Code number: Protection from water
  - IP65: Protection from water jets from any angle  
(The water may not have any damaging effect)
  - IP67: Protection against temporary submersion  
(The water must not enter the enclosure in harmful quantities)

### Rated voltage for operation

The following table shows the nominal voltage and the corresponding tolerance with which the ET 200AL distributed I/O system operates.

Table 10- 12 Rated voltage for operation

| Rated voltage (SELV/PELV) | Tolerance range     |
|---------------------------|---------------------|
| 24 V DC                   | 20.4 V to 28.8 V DC |

## 10.6 Safety-related symbols for IP65/IP67 modules

The following table contains an explanation of the symbols located on your IP65/67 modules, their packaging or in the accompanying documentation.

| Symbol                                                                                                                        | Meaning                                                                                                                                                                                                                                                                |
|-------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|                                              | General warning sign <b>Caution/Notice</b><br>You must read the product documentation. The product documentation contains information about the type of potential hazard and enables you to recognize risks and implement countermeasures.                             |
|                                              | The assigned safety symbols apply to devices <b>with Ex approval</b> .<br>You must read the product documentation. The product documentation contains information about the type of potential hazard and enables you to recognize risks and implement countermeasures. |
|                                              | Read the information provided by the product documentation.<br>ISO 7010 M002                                                                                                                                                                                           |
|                                              | Ensure the device is only installed by an electrically skilled person.<br>IEC 60417 No. 6182                                                                                                                                                                           |
| <br>CABLE SPEC.                             | Note that connected mains lines must be designed according to the expected minimum and maximum ambient temperature.                                                                                                                                                    |
| <br>EMC                                    | Note that the device must be constructed and connected in accordance with EMC regulations.                                                                                                                                                                             |
| <br>230V<br>MODULES                        | Note that a 230 V device can be exposed to electrical voltages which can be dangerous.<br>ANSI Z535.2                                                                                                                                                                  |
| <br>24V<br>MODULES                         | Note that a device of Protection Class III may only be supplied with a protective low voltage according to the standard SELV/PELV.<br>IEC 60417-1-5180 "Class III equipment"                                                                                           |
| <br>INDOOR USE ONLY<br>INDUSTRIAL USE ONLY | Be aware that the device is only approved for the industrial field and only for indoor use.                                                                                                                                                                            |

# Safety-related shutdown of ET200AL standard modules



## Introduction

The diagram below illustrates the fail-safe shutdown of ET 200AL standard modules.

In the configuration shown in the diagram below, all digital outputs that are operated with the 2L+ and 2M supply of the ET 200AL standard modules are switched to the safe OFF state. This step achieves the safety class SIL2/category 3/PLd.

## Principle of operation

The higher-level safety relay (for example: 3SK1) disconnects the 2L+ and 2M supply. This switches all digital outputs operated with the 2L+ and 2M (switched) supply to the safe state. The digital outputs connected to the 1L+ and 1M (non-switched) supply are not intended for functional switching and therefore cannot be shut down safely.

There is no interaction between the outputs supplied by 1L+ and 2L+.

You can also integrate I/O modules that are operated solely at the supply 1L+ and 1M (non-switched) in the structure of your distributed I/O system. These I/O devices must be enabled as reaction-free modules. These I/O modules are not affected by a disconnection, they pass on the supply 2L+ and 2M (switched). The following figure shows this as an example using the DI, AI and AQ modules.

## Block diagram

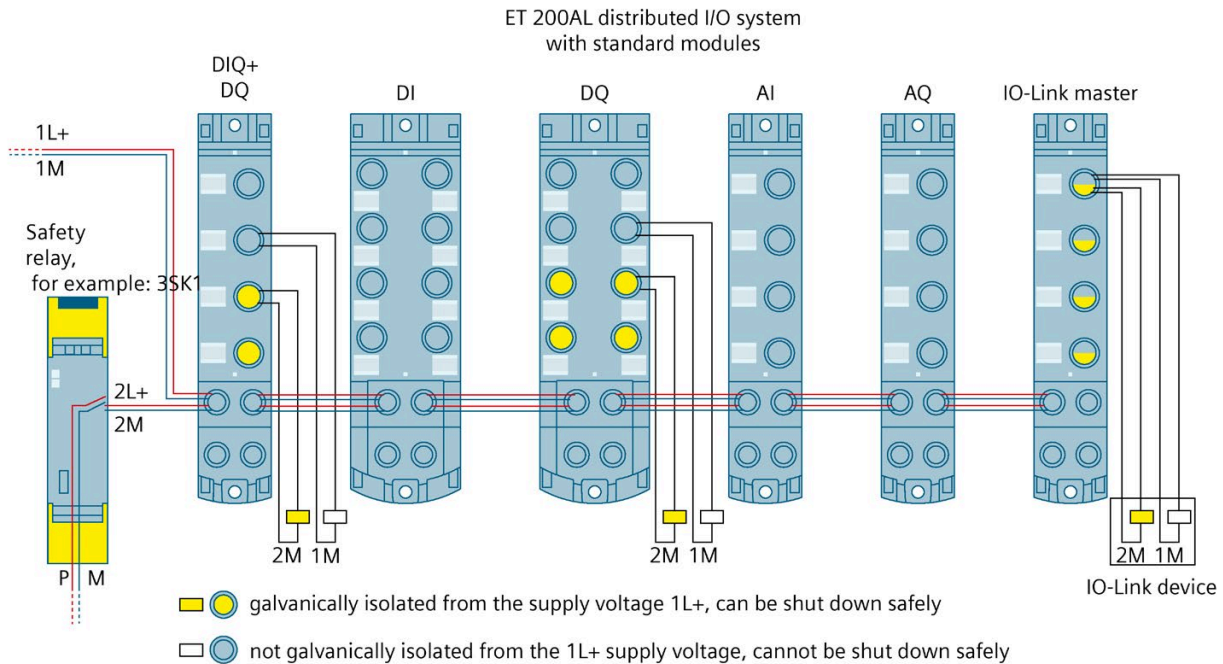


Figure A-1 Higher-level safety circuit with safety relay

### **! WARNING**

#### **Note potential groups for safety-related shutdown**

When a digital output is connected to a digital input, pay attention to the potential groups. Depending on the configuration, 1M and 2M can then be connected, which leads to elimination of the electrical isolation between 1L+ and 2L+. The safety-related shutdown is not permitted if the electrical isolation is eliminated.

#### **Note**

##### **Safe electrical separation**

Maintain safe galvanic isolation for voltages higher than SELV/PELV.

#### **Note**

##### **Safety-related shutdown for the IO-Link master**

For an IO-Link master with IO-Link Port Class B, safety-related shutdown is available for the additional supply (PIN 2 and PIN 5). The other signals at the port are reaction-free.

Please note that the IO-Link device must have corresponding safety characteristics in order to use safety-oriented tripping.

## Limits of the higher-level safety circuit

The ET 200AL standard modules do not fulfill any safety functions. Safety functions are performed by the safety relay to bring the system into a safe state.

Adjust the operation inspection interval of the safety relay with relay output according to the safety class.

Take the following measures if energy that is not provided by the higher-level safety circuit is used to control the safety function.

Cover critical errors in the safety function that are not detected by the higher-level safety circuit (e.g. 3SK1) with suitable safety measures. The "diagnostics" must be performed indirectly via the controlled process.

Specifications for safety-relevant process data:

- Functionally safe
- Read via fail-safe inputs (e.g. F-DI)
- Fail-safe processing unit (e.g. F-CPU) for issuing commands
- Output through fail-safe outputs (e.g. F-DQ) to control the safety function

## Requirements on the power supply

Operation requires a SELV/PELV power supply to limit overvoltages to L+ and M (24 V). This measure prevents possible errors from the power supply side at the same time.

Select the power supply according to the requirements of the respective operating instructions for the shutdown device and for the ET 200AL system.

You can find more information on safe SELV/PELV in the data sheets of the power supplies used.

## FAQ

Read the latest information on safety-related shutdown in the FAQ (<https://support.industry.siemens.com/cs/us/en/view/39198632>).

In this FAQ, you can find the SIMATIC standard modules that are suitable for safety-related shutdown.

## Request German Technical Inspectorate report (Report no. SN89858T)

You can request copies of the German Technical Inspectorate report at the following address:

SIEMENS AG  
Digital Industries  
DI FA TI COS TT  
P.O. Box 1963  
D-92209 Amberg, Germany

## Dimension drawings

2 module widths are available with the distributed I/O system.

The figure below shows the height and width of the modules. The depth of the modules ranges from 40 mm to 46 mm. Detailed information on the dimensions of the individual modules can be found in the manuals for the Interface modules (<https://support.industry.siemens.com/cs/ww/en/ps/14246/man>) and I/O modules (<https://support.industry.siemens.com/cs/ww/en/ps/14247/man>) in the section "Dimension drawing".

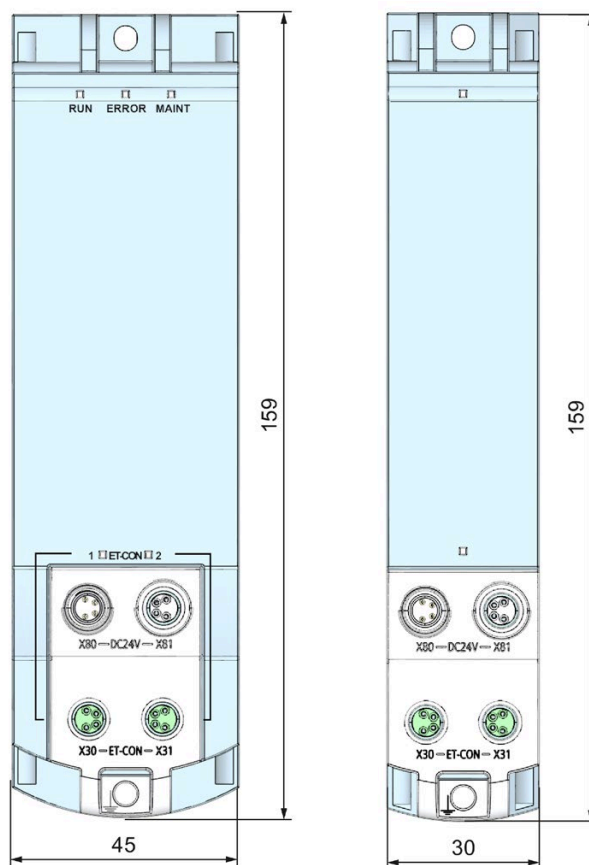


Figure B-1 Module dimension drawings (front view)

# Accessories/spare parts

## C.1 Accessories/spare parts

### Accessories for the ET 200AL distributed I/O system

Table C- 1 Accessories for ET-Connection

| Designation                                                                                                 | Length | Article number     |                    |
|-------------------------------------------------------------------------------------------------------------|--------|--------------------|--------------------|
| Cable                                                                                                       |        | Standard           | PUR                |
| Bus cable for ET-Connection M8, pre-assembled on both sides with 2 x M8 connectors, 4-pin, shielded         | 0.19 m | 6ES7194-2LH02-0AA0 | 6ES7194-2MH02-0AA0 |
|                                                                                                             | 0.3 m  | 6ES7194-2LH03-0AA0 | 6ES7194-2MH03-0AA0 |
|                                                                                                             | 1.0 m  | 6ES7194-2LH10-0AA0 | 6ES7194-2MH10-0AA0 |
|                                                                                                             | 2.0 m  | 6ES7194-2LH20-0AA0 | 6ES7194-2MH20-0AA0 |
|                                                                                                             | 5.0 m  | 6ES7194-2LH50-0AA0 | 6ES7194-2MH50-0AA0 |
|                                                                                                             | 10.0 m | 6ES7194-2LN10-0AA0 | 6ES7194-2MN10-0AA0 |
|                                                                                                             | 15.0 m | 6ES7194-2LN15-0AA0 | 6ES7194-2MN15-0AA0 |
| Bus cable for ET-Connection M8, pre-assembled on both sides with 2 x M8 connectors, angled, 4-pin, shielded | 0.3 m  | 6ES7194-2LH03-0AB0 | 6ES7194-2MH03-0AB0 |
|                                                                                                             | 1.0 m  | 6ES7194-2LH10-0AB0 | 6ES7194-2MH10-0AB0 |
|                                                                                                             | 2.0 m  | 6ES7194-2LH20-0AB0 | 6ES7194-2MH20-0AB0 |
|                                                                                                             | 5.0 m  | 6ES7194-2LH50-0AB0 | 6ES7194-2MH50-0AB0 |
|                                                                                                             | 10.0 m | 6ES7194-2LN10-0AB0 | 6ES7194-2MN10-0AB0 |
|                                                                                                             | 15.0 m | 6ES7194-2LN15-0AB0 | 6ES7194-2MN15-0AB0 |
| Bus cable for ET-Connection M8, pre-assembled on one side with 1 x M8 connector, 4-pin, shielded            | 2.0 m  | 6ES7194-2LH20-0AC0 | 6ES7194-2MH20-0AC0 |
|                                                                                                             | 5.0 m  | 6ES7194-2LH50-0AC0 | 6ES7194-2MH50-0AC0 |
|                                                                                                             | 10.0 m | 6ES7194-2LN10-0AC0 | 6ES7194-2MN10-0AC0 |
|                                                                                                             | 15.0 m | 6ES7194-2LN15-0AC0 | 6ES7194-2MN15-0AC0 |
| Connecting cable for bus cable ET-Connection M8, both ends assembled with 2x M8 socket, 4-pin, shielded     | 0.2 m  | 6ES7194-2LH02-0AD0 | 6ES7194-2MH02-0AD0 |
| Connector                                                                                                   |        |                    |                    |
| M8 connector for ET-Connection, 4-pin, shielded                                                             |        | 6ES7194-2AB00-0AA0 |                    |

Table C- 2 Accessories for power supply

| Designation                                                                                      | Length | Article number     |                    |
|--------------------------------------------------------------------------------------------------|--------|--------------------|--------------------|
| <b>Cable</b>                                                                                     |        | <b>Standard</b>    | <b>PUR</b>         |
| Power cable M8, pre-assembled on both sides with M8 connector and M8 socket, 4-pin               | 0.19 m | 6ES7194-2LH02-1AA0 | 6ES7194-2MH02-1AA0 |
|                                                                                                  | 0.3 m  | 6ES7194-2LH03-1AA0 | 6ES7194-2MH03-1AA0 |
|                                                                                                  | 1.0 m  | 6ES7194-2LH10-1AA0 | 6ES7194-2MH10-1AA0 |
|                                                                                                  | 2.0 m  | 6ES7194-2LH20-1AA0 | 6ES7194-2MH20-1AA0 |
|                                                                                                  | 5.0 m  | 6ES7194-2LH50-1AA0 | 6ES7194-2MH50-1AA0 |
|                                                                                                  | 10.0 m | 6ES7194-2LN10-1AA0 | 6ES7194-2MN10-1AA0 |
|                                                                                                  | 15.0 m | 6ES7194-2LN15-1AA0 | 6ES7194-2MN15-1AA0 |
| Power cable M8, pre-assembled on both sides with angled M8 connector and angled M8 socket, 4-pin | 0.3 m  | 6ES7194-2LH03-1AB0 | 6ES7194-2MH03-1AB0 |
|                                                                                                  | 1.0 m  | 6ES7194-2LH10-1AB0 | 6ES7194-2MH10-1AB0 |
|                                                                                                  | 2.0 m  | 6ES7194-2LH20-1AB0 | 6ES7194-2MH20-1AB0 |
|                                                                                                  | 5.0 m  | 6ES7194-2LH50-1AB0 | 6ES7194-2MH50-1AB0 |
|                                                                                                  | 10.0 m | 6ES7194-2LN10-1AB0 | 6ES7194-2MN10-1AB0 |
|                                                                                                  | 15.0 m | 6ES7194-2LN15-1AB0 | 6ES7194-2MN15-1AB0 |
| Power cable M8, pre-assembled on one side with M8 socket, 4-pin                                  | 2.0 m  | 6ES7194-2LH20-1AC0 | 6ES7194-2MH20-1AC0 |
|                                                                                                  | 5.0 m  | 6ES7194-2LH50-1AC0 | 6ES7194-2MH50-1AC0 |
|                                                                                                  | 10.0 m | 6ES7194-2LN10-1AC0 | 6ES7194-2MN10-1AC0 |
|                                                                                                  | 15.0 m | 6ES7194-2LN15-1AC0 | 6ES7194-2MN15-1AC0 |
| <b>Connector</b>                                                                                 |        |                    |                    |
| M8 power connector, pin insert, 4-pin                                                            |        | 6ES7194-2AA00-0AA0 |                    |
| M8 power connector, socket insert, 4-pin                                                         |        | 6ES7194-2AC00-0AA0 |                    |



Table C- 3 M12 connector

| Designation                                                                       |                  | Article number     |
|-----------------------------------------------------------------------------------|------------------|--------------------|
| <b>Non-preassembled connectors for X1 DP1 (pin)</b>                               |                  |                    |
| PROFIBUS M12 plug connector 180° with female insert                               |                  | 6GK1905-0EB00      |
| PROFIBUS M12 plug connector FastConnect 180° with female insert                   |                  | 6GK1905-0EB10      |
| PROFIBUS M12 plug connector, angled with female insert                            |                  | 3RK1902-1DA00      |
| <b>Non-preassembled connectors for X1 DP2 (socket)</b>                            |                  |                    |
| PROFIBUS M12 plug connector 180° with pin insert                                  |                  | 6GK1905-0EA00      |
| PROFIBUS M12 plug connector FastConnect 180° with pin insert                      |                  | 6GK1905-0EA10      |
| PROFIBUS M12 plug connector angled with pin insert                                |                  | 3RK1902-1BA00      |
| <b>Non-preassembled connectors for X1 P1R PN (LAN) and X1 P2R PN (LAN) socket</b> |                  |                    |
| PROFINET M12 plug connector d-coded with FastConnect connection technology, 180   | 1 unit/<br>pack  | 6GK1901-0DB10-6AA0 |
|                                                                                   | 8 units/<br>pack | 6GK1901-0DB10-6AA8 |
| PROFINET M12 plug connector, D-coded with fast connect technology 180°            | 1 unit/<br>pack  | 6GK1901-0DB20-6AA0 |
|                                                                                   | 8 units/<br>pack | 6GK1901-0DB20-6AA8 |
| PROFINET M12 plug connector, D-coded, angled                                      |                  | 3RK1902-2DA00      |

Table C- 4 Non-preassembled cable M12

| Designation                                                                |  | Article number |
|----------------------------------------------------------------------------|--|----------------|
| <b>Non-preassembled cable for X1 DP1 and X1 DP2</b>                        |  |                |
| PROFIBUS FC Cable                                                          |  |                |
| FC Standard Cable                                                          |  | 6XV1830-0EH10  |
| FC Trailing Cable                                                          |  | 6XV1830-3EH10  |
| FC Food Cable (PE sheath)                                                  |  | 6XV1830-0GH10  |
| FC Robust Cable (PUR sheath)                                               |  | 6XV1830-0JH10  |
| FC FRNC Cable (FRNC sheath)                                                |  | 6XV1830-0LH10  |
| FC Underground Cable                                                       |  | 6XV1830-3FH10  |
| Festoon Cable GP (PVC sheath)                                              |  | 6XV1830-3GH10  |
| FC Flexible Cable GP (PUR sheath)                                          |  | 6XV1831-2K     |
| <b>Non-preassembled connectors for X1 P1R PN (LAN) and X1 P2R PN (LAN)</b> |  |                |
| PROFIBUS FC Cable                                                          |  |                |
| FC Standard Cable                                                          |  | 6XV1840-2AH10  |
| FC TP Trailing Cable                                                       |  | 6XV1840-3AH10  |
| FC TP Trailing Cable GP                                                    |  | 6XV1870-2D     |
| FC TP Marine Cable                                                         |  | 6XV1840-4AH10  |
| FC TP Torsion Cable                                                        |  | 6XV1870-2F     |
| FC TP Flexible Cable GP (PVC sheath)                                       |  | 6XV1870-2B     |
| FC TP FRNC Cable (FRNC sheath)                                             |  | 6XV1871-2F     |
| FC TP Food Cable (PE sheath)                                               |  | 6XV1871-2L     |
| FC TP Festoon Cable GP (PVC sheath)                                        |  | 6XV1871-2S     |

Table C- 5 Pre-assembled cable M12

| Designation                                                                                                                                             |        | Article number     |
|---------------------------------------------------------------------------------------------------------------------------------------------------------|--------|--------------------|
| <b>Pre-assembled cable for X1 DP1 and X1 DP2</b>                                                                                                        |        |                    |
| PROFIBUS M12 connecting cable, trailing cable, pre-assembled on both sides with PROFIBUS M12 connectors, 180° (one end with socket, one end with pin)   | 0.3 m  | 6XV1830-3DE30      |
|                                                                                                                                                         | 0.5 m  | 6XV1830-3DE50      |
|                                                                                                                                                         | 1.0 m  | 6XV1830-3DH10      |
|                                                                                                                                                         | 1.5 m  | 6XV1830-3DH15      |
|                                                                                                                                                         | 2.0 m  | 6XV1830-3DH20      |
|                                                                                                                                                         | 3.0 m  | 6XV1830-3DH30      |
|                                                                                                                                                         | 5.0 m  | 6XV1830-3DH50      |
|                                                                                                                                                         | 10.0 m | 6XV1830-3DN10      |
|                                                                                                                                                         | 15.0 m | 6XV1830-3DN15      |
| PROFIBUS M12 connecting cable, trailing cable, pre-assembled on both sides with PROFIBUS M12 connectors, angled (one end with socket, one end with pin) | 1.5 m  | 6XV1830-3DH15-OSB0 |
|                                                                                                                                                         | 2.0 m  | 6XV1830-3DH20-OSB0 |
|                                                                                                                                                         | 3.0 m  | 3RK1902-1NB30      |
|                                                                                                                                                         | 5.0 m  | 3RK1902-1NB50      |
|                                                                                                                                                         | 10.0 m | 3RK1902-1NC10      |
|                                                                                                                                                         | 15.0 m | 6XV1830-3DN15-OSB0 |
| <b>Pre-assembled cable for X1 P1R PN (LAN) and X1 P2R PN (LAN)</b>                                                                                      |        |                    |
| PROFINET M12 connecting cable, trailing cable, pre-assembled on both ends with M12 connectors 180° (pin)                                                | 0.3 m  | 6XV1870-8AE30      |
|                                                                                                                                                         | 0.5 m  | 6XV1870-8AE50      |
|                                                                                                                                                         | 1.0 m  | 6XV1870-8AH10      |
|                                                                                                                                                         | 1.5 m  | 6XV1870-8AH15      |
|                                                                                                                                                         | 2.0 m  | 6XV1870-8AH20      |
|                                                                                                                                                         | 3.0 m  | 6XV1870-8AH30      |
|                                                                                                                                                         | 5.0 m  | 6XV1870-8AH50      |
|                                                                                                                                                         | 10.0 m | 6XV1870-8AN10      |
|                                                                                                                                                         | 15.0 m | 6XV1870-8AN15      |
| PROFINET M12 connecting cable, trailing cable, pre-assembled on both ends with M12 connectors, angled (pin)                                             | 0.3 m  | 6XV1870-8AE30-OSB0 |
|                                                                                                                                                         | 0.5 m  | 6XV1870-8AE50-OSB0 |
|                                                                                                                                                         | 1.0 m  | 6XV1870-8AH10-OSB0 |
|                                                                                                                                                         | 1.5 m  | 6XV1870-8AH15-OSB0 |
|                                                                                                                                                         | 2.0 m  | 6XV1870-8AH20-OSB0 |
|                                                                                                                                                         | 3.0 m  | 3RK1902-2NB30      |
|                                                                                                                                                         | 5.0 m  | 3RK1902-2NB50      |
|                                                                                                                                                         | 10.0 m | 3RK1902-2NC10      |
|                                                                                                                                                         | 15.0 m | 6XV1870-8AN15-OSB0 |
| PROFINET M12 connecting cable, trailing cable, pre-assembled on both sides with PROFIBUS M12 connectors, angled (one end with pin, one end open)        | 3.0 m  | 3RK1902-2HB30      |
|                                                                                                                                                         | 5.0 m  | 3RK1902-2HB50      |
|                                                                                                                                                         | 10.0 m | 3RK1902-2HC10      |
| PROFINET M12 connecting cable, trailing cable, pre-assembled on one end with M12 connectors 180° (pin), other end with RJ45 plug 145°                   | 2.0 m  | 6XV1871-5TH20      |
|                                                                                                                                                         | 3.0 m  | 6XV1871-5TH30      |
|                                                                                                                                                         | 5.0 m  | 6XV1871-5TH50      |
|                                                                                                                                                         | 10.0 m | 6XV1871-5TN10      |
|                                                                                                                                                         | 15.0 m | 6XV1871-5TN15      |

## C.1 Accessories/spare parts

Table C- 6 Y cable

| Description                                                                                                                                         |       | Article number     |
|-----------------------------------------------------------------------------------------------------------------------------------------------------|-------|--------------------|
| SIMATIC DP, Y-cable for distributed I/Os for double connection of I/Os using single cable, 5-pin, M12                                               | 0.2 m | 6ES7194-6KA00-0XA0 |
| SIMATIC DP, Y-cable, for fail-safe ET 200 distributed I/O, IP 65/67, for connection of single-channel sensors (1oo1 evaluation) 5-pin M12           | 0.2 m | 6ES7194-6KB00-0XA0 |
| SIMATIC DP, Y-cable, for fail-safe distributed I/O ET 200, IP 65/67, for common connection of an F-DQ and F-DI channel by means of 8-pin M12 socket | 0.2 m | 6ES7194-6KC00-0XA0 |

Table C- 7 Additional accessories

| Designation                                                                                                                    | Article number     |
|--------------------------------------------------------------------------------------------------------------------------------|--------------------|
| Identification labels 10 x 5 mm RAL9016, composed of 200 labels on frames, per frame 40 labels                                 | 6ES7194-2BA00-0AA0 |
| Identification labels 10 x 5 mm RAL1018, yellow, consisting of 200 labels on frames, 40 labels per frame                       | 6ES7194-2BB00-0AA0 |
| Identification labels 10 x 7 mm, yellow, consisting of 816 labels on frames, 48 labels per frame (for eCoding plug connectors) | 6ES7194-6HA00-0AA0 |
| Sealing cap M8 for modules IP67                                                                                                | 3RK1901-1PN00      |
| Sealing cap M12 for modules IP67                                                                                               | 3RX9802-0AA00      |
| Bus connection plug PROFIBUS M12, pin insert, 5 units                                                                          | 6GK1905-0EC00      |
| Stripping Tool for ET-Connection                                                                                               | 6ES7194-2KA00-0AA0 |
| Stripping Tool for PROFINET                                                                                                    | 6GK1901-1GA00      |
| Stripping Tool for PROFIBUS                                                                                                    | 6GK1905-6AA00      |
| eCoding plug connector, stores the F-destination addresses and F-source addresses for F-modules                                | 6ES7194-6KB01-0AA0 |

## Online catalog

Other article numbers for the ET 200AL distributed I/O system can be found on the Internet (<https://mall.industry.siemens.com>) in the online catalog and the online order system.

## C.2 Cables

### Cables for ET-Connection standard and PUR cable

The cables for ET-Connection are available in the following versions and lengths:

- Bus cable (4-wire), pre-assembled on both sides with 2 M8 connectors, 4-pole, shielded
  - available lengths: 0.19 m, 0.3 m, 1 m, 2 m, 5 m, 10 m, 15 m
- Bus cable (4-wire), pre-assembled on both sides with 2 M8 connectors, angled, 4-pole, shielded
  - available lengths: 0.3 m, 1 m, 2 m, 5 m, 10 m, 15 m
- Bus cable (4-wire), pre-assembled on one side 1x M8 connector, 4-pole, shielded
  - available lengths: 2 m, 5 m, 10 m, 15 m

The following table shows the technical properties of the bus cable ET-Connection standard.

Table C- 8 Cables for ET-Connection

| General information                              |                                                                                                                                                              |
|--------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Product type designation                         | BUS CABLE ET-CONNECTION                                                                                                                                      |
| Function                                         | To connect ET-CONNECTION devices with degree of protection IP65/IP67                                                                                         |
| Degree of protection and protection class        |                                                                                                                                                              |
| IP65                                             | Yes                                                                                                                                                          |
| IP67                                             | Yes                                                                                                                                                          |
| Ambient conditions                               |                                                                                                                                                              |
| Ambient temperature during mounting              |                                                                                                                                                              |
| minimum                                          | -30 °C                                                                                                                                                       |
| maximum                                          | 80 °C                                                                                                                                                        |
| Storage/transport temperature                    |                                                                                                                                                              |
| Ambient temperature during transport and storage |                                                                                                                                                              |
| minimum                                          | -40 °C                                                                                                                                                       |
| maximum                                          | 80 °C                                                                                                                                                        |
| Cables                                           |                                                                                                                                                              |
| Cable designation                                | 2Y(ST)CY 1x4x0.5/1.0-100-GN                                                                                                                                  |
| Number of electrical wires                       | 4                                                                                                                                                            |
| Design of shielding                              | Overlapped aluminum-lined sheet, coated with shielding made of tin plated copper wires                                                                       |
| Outside diameter of the inner conductor          | 0.5 mm                                                                                                                                                       |
| Outside diameter of the wire insulation          | 1.0 mm                                                                                                                                                       |
| Outside diameter of the cable sheath             | 5 mm                                                                                                                                                         |
| Number of bending cycles                         | 1000000; Trailing-chain suitable for 1 million bending cycles with a bending radius of 100 mm, a velocity of 4 m/s and an acceleration of 4 m/s <sup>2</sup> |
| Permissible bending radius                       |                                                                                                                                                              |
| One time bending, min.                           | 20 mm                                                                                                                                                        |
| Multiple bending, min.                           | 40 mm                                                                                                                                                        |

## C.2 Cables

| General information                            |                                                                |
|------------------------------------------------|----------------------------------------------------------------|
| Constant bending                               | 100 mm                                                         |
| Color of the cable sheath                      | Green                                                          |
| Color of the wire insulation of the data wires | White, yellow, blue, orange                                    |
| Weight per length                              | 34 kg/km                                                       |
| Mechanics/material                             |                                                                |
| Type of cable outlet                           | 180° cable outlet<br>90° cable outlet (with angled connectors) |
| Number of connectors                           | 1 or 2                                                         |
| Connector housing material                     | Metal                                                          |
| Wire insulation material                       | PE                                                             |
| Cable sheath material                          | PVC                                                            |
| Material property halogen free                 | No                                                             |
| Material property silicon free                 | Yes                                                            |

\* = Applies to cable lengths up to 10 meters.

The following table shows the technical properties of the bus cable ET-Connection, PUR cable.

Table C- 9 Cables for ET-Connection, PUR cable

| General information                              |                                                                                                                                                               |
|--------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Product type designation                         | BUS CABLE ET-CONNECTION, PUR CABLE                                                                                                                            |
| Function                                         | To connect ET-CONNECTION devices with degree of protection IP65/IP67                                                                                          |
| Degree of protection and protection class        |                                                                                                                                                               |
| IP65                                             | Yes                                                                                                                                                           |
| IP67                                             | Yes                                                                                                                                                           |
| Ambient conditions                               |                                                                                                                                                               |
| Ambient temperature during mounting              |                                                                                                                                                               |
| minimum                                          | -30 °C                                                                                                                                                        |
| maximum                                          | 80 °C                                                                                                                                                         |
| Storage/transport temperature                    |                                                                                                                                                               |
| Ambient temperature during transport and storage |                                                                                                                                                               |
| minimum                                          | -40 °C                                                                                                                                                        |
| maximum                                          | 80 °C                                                                                                                                                         |
| Cables                                           |                                                                                                                                                               |
| Cable designation                                | 2Y(ST)C11Y 2x2x0.5/1.0-100-GN                                                                                                                                 |
| Number of electrical wires                       | 4                                                                                                                                                             |
| Design of shielding                              | Overlapped aluminum-lined sheet, coated with shielding made of tin plated copper wires                                                                        |
| Outside diameter of the inner conductor          | 0.5 mm                                                                                                                                                        |
| Outside diameter of the wire insulation          | 1.0 mm                                                                                                                                                        |
| Outside diameter of the cable sheath             | 5 mm                                                                                                                                                          |
| Number of bending cycles                         | 1000000*; trailing-chain suitable for 1 million bending cycles with a bending radius of 100 mm, a velocity of 4 m/s and an acceleration of 4 m/s <sup>2</sup> |
| Permissible bending radius                       |                                                                                                                                                               |
| One time bending, min.                           | 20 mm                                                                                                                                                         |

| General information                            |                                                                |
|------------------------------------------------|----------------------------------------------------------------|
| Multiple bending, min.                         | 40 mm                                                          |
| Constant bending                               | 100 mm                                                         |
| Color of the cable sheath                      | Green                                                          |
| Color of the wire insulation of the data wires | White, yellow, blue, orange                                    |
| Weight per length                              | 34 kg/km                                                       |
| Mechanics/material                             |                                                                |
| Type of cable outlet                           | 180° cable outlet<br>90° cable outlet (with angled connectors) |
| Number of connectors                           | 1 or 2                                                         |
| Connector housing material                     | Metal                                                          |
| Wire insulation material                       | PE                                                             |
| Cable sheath material                          | PUR                                                            |
| Material property halogen free                 | Yes                                                            |
| Material property silicon free                 | Yes                                                            |

\* = Applies to cable lengths up to 10 meters.

## Connecting cable for ET-Connection standard and PUR cable

You can use the connecting cable between two cables for ET-Connection.

Typical applications for using connecting cable for ET-Connection are:

- Combination of individual cable lengths by joining multiple pre-assembled cables for ET-Connection.
- Selective installation of disconnection points of cables for ET-Connection (for simple changing of cables and cable sections, e.g. with trailing-cable applications).

You can use a maximum of two connecting cables between the two modules.

The length of the cables for ET-Connection is limited to maximum 10 m when connecting cables are used.

The connecting cable for ET-Connection is available in the following design:

- Connecting cable for bus cable ET-Connection M8, both ends assembled with 2x M8 socket, 4-pole, shielded, length 0.2 m

The following table shows the technical properties of the connecting cable for ET-Connection standard.

Table C- 10 Connecting cables for ET-Connection

|                                                  |                                                                                        |
|--------------------------------------------------|----------------------------------------------------------------------------------------|
| <b>General information</b>                       |                                                                                        |
| Product type designation                         | CONNECTING CABLE FOR BUS CABLE ET-CONNECTION, CABLE 0.2 M                              |
| Function                                         | To connect two bus cables ET-CONNECTION                                                |
| <b>Degree of protection and protection class</b> |                                                                                        |
| IP65                                             | Yes                                                                                    |
| IP67                                             | Yes                                                                                    |
| <b>Ambient conditions</b>                        |                                                                                        |
| Ambient temperature during mounting              |                                                                                        |
| minimum                                          | -30 °C                                                                                 |
| maximum                                          | 80 °C                                                                                  |
| <b>Storage/transport temperature</b>             |                                                                                        |
| Ambient temperature during transport and storage |                                                                                        |
| minimum                                          | -40 °C                                                                                 |
| maximum                                          | 80 °C                                                                                  |
| <b>Cables</b>                                    |                                                                                        |
| Cable designation                                | 2Y(ST)CY 1x4x0.5/1.0-100-GN                                                            |
| Number of electrical wires                       | 4                                                                                      |
| Design of shielding                              | Overlapped aluminum-lined sheet, coated with shielding made of tin plated copper wires |
| Cable length                                     | 0.2 m                                                                                  |
| Outside diameter of the inner conductor          | 0.5 mm                                                                                 |
| Outside diameter of the wire insulation          | 1.0 mm                                                                                 |
| Outside diameter of the cable sheath             | 5 mm                                                                                   |
| Permissible bending radius                       |                                                                                        |
| One time bending, min.                           | 20 mm                                                                                  |
| Multiple bending, min.                           | 40 mm                                                                                  |
| Constant bending                                 | 100 mm                                                                                 |
| Color of the cable sheath                        | Green                                                                                  |
| Color of the wire insulation of the data wires   | White, yellow, blue, orange                                                            |
| Weight per length                                | 34 kg/km                                                                               |
| <b>Mechanics/material</b>                        |                                                                                        |
| Type of cable outlet                             | 180° cable outlet                                                                      |
| Connector housing material                       | Metal                                                                                  |
| Wire insulation material                         | PE                                                                                     |
| Cable sheath material                            | PVC                                                                                    |
| Material property halogen free                   | No                                                                                     |
| Material property silicon free                   | Yes                                                                                    |

The following table shows the technical properties of the connecting cable for ET-Connection, PUR cable.

Table C- 11 Connecting cables for ET-Connection, PUR cable

|                                                  |                                                                                           |
|--------------------------------------------------|-------------------------------------------------------------------------------------------|
| <b>General information</b>                       |                                                                                           |
| Product type designation                         | CONNECTING CABLE FOR BUS CABLE<br>ET-CONNECTION, PUR CABLE 0.2 M                          |
| Function                                         | To connect two bus cables ET-CONNECTION                                                   |
| <b>Degree of protection and protection class</b> |                                                                                           |
| IP65                                             | Yes                                                                                       |
| IP67                                             | Yes                                                                                       |
| <b>Ambient conditions</b>                        |                                                                                           |
| Ambient temperature during mounting              |                                                                                           |
| minimum                                          | -30 °C                                                                                    |
| maximum                                          | 80 °C                                                                                     |
| <b>Storage/transport temperature</b>             |                                                                                           |
| Ambient temperature during transport and storage |                                                                                           |
| minimum                                          | -40 °C                                                                                    |
| maximum                                          | 80 °C                                                                                     |
| <b>Cables</b>                                    |                                                                                           |
| Cable designation                                | 2Y(ST)C11Y 2x2x0.5/1.0-100-GN                                                             |
| Number of electrical wires                       | 4                                                                                         |
| Design of shielding                              | Overlapped aluminum-lined sheet, coated with<br>shielding made of tin plated copper wires |
| Cable length                                     | 0.2 m                                                                                     |
| Outside diameter of the inner conductor          | 0.5 mm                                                                                    |
| Outside diameter of the wire insulation          | 1.0 mm                                                                                    |
| Outside diameter of the cable sheath             | 5 mm                                                                                      |
| Permissible bending radius                       |                                                                                           |
| One time bending, min.                           | 20 mm                                                                                     |
| Multiple bending, min.                           | 40 mm                                                                                     |
| Constant bending                                 | 100 mm                                                                                    |
| Color of the cable sheath                        | Green                                                                                     |
| Color of the wire insulation of the data wires   | White, yellow, blue, orange                                                               |
| Weight per length                                | 34 kg/km                                                                                  |
| <b>Mechanics/material</b>                        |                                                                                           |
| Type of cable outlet                             | 180° cable outlet                                                                         |
| Connector housing material                       | Metal                                                                                     |
| Wire insulation material                         | PE                                                                                        |
| Cable sheath material                            | PUR                                                                                       |
| Material property halogen free                   | Yes                                                                                       |
| Material property silicon free                   | Yes                                                                                       |



## Cables of power supply standard and PUR cable

The cables for the power supply are available in the following versions and lengths:

- Power cable (4-wire), pre-assembled on both sides with a 4-pole M8 pin connector/socket connector
  - available lengths: 0.19 m, 0.3 m, 1 m, 2 m, 5 m, 10 m, 15 m
- Power cable (4-wire), pre-assembled on both sides with a 4-pole M8 pin connector/socket connector, angled
  - available lengths: 0.3 m, 1 m, 2 m, 5 m, 10 m, 15 m
- Power cable (4-wire), pre-assembled on one side with 1x M8 socket connector
  - available lengths: 2 m, 5 m, 10 m, 15 m

The following table shows the technical properties of the power supply cable, standard.

Table C- 12 Cables for power supply

| General information                              |                                                                                                                                                                          |
|--------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Product type designation                         | POWER CABLE M8                                                                                                                                                           |
| Function                                         | For connection of ET 200AL for 24 V DC power supply                                                                                                                      |
| Degree of protection and protection class        |                                                                                                                                                                          |
| IP65                                             | Yes                                                                                                                                                                      |
| IP67                                             | Yes                                                                                                                                                                      |
| Ambient conditions                               |                                                                                                                                                                          |
| Ambient temperature during mounting              |                                                                                                                                                                          |
| minimum                                          | -30 °C                                                                                                                                                                   |
| maximum                                          | 80 °C                                                                                                                                                                    |
| Storage/transport temperature                    |                                                                                                                                                                          |
| Ambient temperature during transport and storage |                                                                                                                                                                          |
| minimum                                          | -40 °C                                                                                                                                                                   |
| maximum                                          | 80 °C                                                                                                                                                                    |
| Cables                                           |                                                                                                                                                                          |
| Cable designation                                | 4 Li9Y 0.50 mm <sup>2</sup> Y                                                                                                                                            |
| Number of electrical wires                       | 4                                                                                                                                                                        |
| Outside diameter of the inner conductor          | 0.8 mm                                                                                                                                                                   |
| Outside diameter of the wire insulation          | 1.46 mm                                                                                                                                                                  |
| Outside diameter of the cable sheath             | 5.2 mm                                                                                                                                                                   |
| Number of bending cycles                         | 2500000; Trailing-chain suitable for 2.5 million bending cycles with a bending radius of 52 mm, a speed of 3 m/s <sup>2</sup> and an acceleration of 10 m/s <sup>2</sup> |
| Permissible bending radius                       |                                                                                                                                                                          |
| One time bending, min.                           | 26 mm                                                                                                                                                                    |
| Multiple bending, min.                           | 52 mm                                                                                                                                                                    |
| Constant bending                                 | 52 mm                                                                                                                                                                    |
| Color of the cable sheath                        | Gray                                                                                                                                                                     |
| Color of the wire insulation of the power wires  | White, brown, blue black                                                                                                                                                 |
| Weight per length                                | 44 kg/km                                                                                                                                                                 |

| General information            |                                                                |
|--------------------------------|----------------------------------------------------------------|
| Mechanics/material             |                                                                |
| Type of cable outlet           | 180° cable outlet<br>90° cable outlet (with angled connectors) |
| Number of connectors           | 1 or 2                                                         |
| Connector housing material     | Plastic                                                        |
| Wire insulation material       | PP                                                             |
| Cable sheath material          | PVC                                                            |
| Material property halogen free | No                                                             |
| Material property silicon free | Yes                                                            |

The following table shows the technical properties of the power supply, PUR cable

Table C- 13 Cables for power supply, PUR cable

| General information                              |                                                                                                                                                             |
|--------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Product type designation                         | POWER CABLE M8, PUR CABLE                                                                                                                                   |
| Function                                         | For connection of ET 200AL for 24 V DC power supply                                                                                                         |
| Degree of protection and protection class        |                                                                                                                                                             |
| IP65                                             | Yes                                                                                                                                                         |
| IP67                                             | Yes                                                                                                                                                         |
| Ambient conditions                               |                                                                                                                                                             |
| Ambient temperature during mounting              |                                                                                                                                                             |
| minimum                                          | -30 °C                                                                                                                                                      |
| maximum                                          | 80 °C                                                                                                                                                       |
| Storage/transport temperature                    |                                                                                                                                                             |
| Ambient temperature during transport and storage |                                                                                                                                                             |
| minimum                                          | -40 °C                                                                                                                                                      |
| maximum                                          | 80 °C                                                                                                                                                       |
| Cables                                           |                                                                                                                                                             |
| Cable designation                                | LIF9Y11YFHF 4x0.50 mm <sup>2</sup>                                                                                                                          |
| Number of electrical wires                       | 4                                                                                                                                                           |
| Outside diameter of the inner conductor          | 1 mm                                                                                                                                                        |
| Outside diameter of the wire insulation          | 1.46 mm                                                                                                                                                     |
| Outside diameter of the cable sheath             | 5.1 mm                                                                                                                                                      |
| Number of bending cycles                         | 2000000; trailing-chain suitable for 2 million bending cycles with a bending radius of 51 mm, a velocity of 5 m/s and an acceleration of 5 m/s <sup>2</sup> |
| Permissible bending radius                       |                                                                                                                                                             |
| One time bending, min.                           | 26 mm                                                                                                                                                       |
| Multiple bending, min.                           | 51 mm                                                                                                                                                       |
| Constant bending                                 | 51 mm                                                                                                                                                       |
| Color of the cable sheath                        | Gray                                                                                                                                                        |
| Color of the wire insulation of the power wires  | White, brown, blue black                                                                                                                                    |
| Weight per length                                | 44 kg/km                                                                                                                                                    |
| Mechanics/material                               |                                                                                                                                                             |

| General information            |                                                                |
|--------------------------------|----------------------------------------------------------------|
| Type of cable outlet           | 180° cable outlet<br>90° cable outlet (with angled connectors) |
| Number of connectors           | 1 or 2                                                         |
| Connector housing material     | Plastic                                                        |
| Wire insulation material       | PP                                                             |
| Cable sheath material          | PE-PUR                                                         |
| Material property halogen free | Yes                                                            |
| Material property silicon free | Yes                                                            |

### C.3 Pin assignment and core color

#### Pin assignment of the sockets for ET-Connection

The tables below shows the pin assignments of the 2 sockets for the connection of ET-Connection.

Table C- 14 Pin assignment for ET-Connection (interface modules)

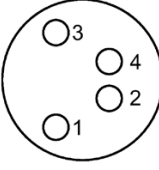
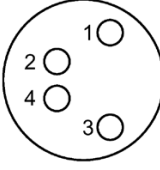
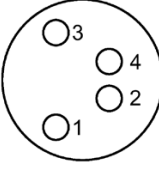
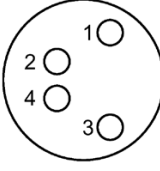
| Pin       | Assignment                  |                             | Assignment of the core color of the bus cable for ET-Connection | Front view of the sockets                                                             |                                                                                       |
|-----------|-----------------------------|-----------------------------|-----------------------------------------------------------------|---------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------|
|           | X30 socket (ET-Connection1) | X31 socket (ET-Connection2) |                                                                 | X30                                                                                   | X31                                                                                   |
| 1         | RXP                         | RXP                         | yellow                                                          |  |  |
| 2         | TXP                         | TXP                         | white                                                           |                                                                                       |                                                                                       |
| 3         | TXN                         | TXN                         | blue                                                            |                                                                                       |                                                                                       |
| 4         | RXN                         | RXN                         | orange                                                          |                                                                                       |                                                                                       |
| Shielding | Functional earth FE         |                             | -                                                               |                                                                                       |                                                                                       |

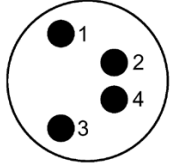
Table C- 15 Pin assignment for ET-Connection (I/O modules)

| Pin       | Assignment                    |                                | Assignment of the core color of the bus cable for ET-Connection | Front view of the sockets                                                             |                                                                                       |
|-----------|-------------------------------|--------------------------------|-----------------------------------------------------------------|---------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------|
|           | X30 socket (ET-Connection IN) | X31 socket (ET-Connection OUT) |                                                                 | X30                                                                                   | X31                                                                                   |
| 1         | TXP                           | RXP                            | yellow                                                          |  |  |
| 2         | RXP                           | TXP                            | white                                                           |                                                                                       |                                                                                       |
| 3         | RXN                           | TXN                            | blue                                                            |                                                                                       |                                                                                       |
| 4         | TXN                           | RXN                            | orange                                                          |                                                                                       |                                                                                       |
| Shielding | Functional earth FE           |                                | -                                                               |                                                                                       |                                                                                       |

### Pin assignment of the connector for infeed of the supply voltage

The table below shows the pin assignment for infeed of the supply voltage.

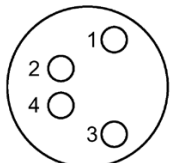
Table C- 16 Pin assignment of the supply voltage connector

| Pin | Assignment                        | Assignment of the core color of the power cable | Front view of the connector                                                         |
|-----|-----------------------------------|-------------------------------------------------|-------------------------------------------------------------------------------------|
|     | X80 connector (power input)       |                                                 |                                                                                     |
| 1   | Supply voltage 1L+ (non-switched) | brown                                           |  |
| 2   | Ground 2M (switched)              | white                                           |                                                                                     |
| 3   | Ground 1M (non-switched)          | blue                                            |                                                                                     |
| 4   | Load voltage 2L+ (switched)       | black                                           |                                                                                     |

### Pin assignment of the socket for loop-through of the supply voltage

The table below shows the pin assignment for loop-through of the supply voltage.

Table C- 17 Pin assignment of the supply voltage socket

| Pin | Assignment                        | Assignment of the core color of the power cable | Front view of the socket                                                              |
|-----|-----------------------------------|-------------------------------------------------|---------------------------------------------------------------------------------------|
|     | X81 Socket (power output)         |                                                 |                                                                                       |
| 1   | Supply voltage 1L+ (non-switched) | brown                                           |  |
| 2   | Ground 2M (switched)              | white                                           |                                                                                       |
| 3   | Ground 1M (non-switched)          | blue                                            |                                                                                       |
| 4   | Load voltage 2L+ (switched)       | black                                           |                                                                                       |

# Glossary

## 1oo1 evaluation

Type of → sensor evaluation – in the case of the 1oo1 evaluation, there → is one sensor with a 1-channel connection to the F module.

## 1oo2 evaluation

Type of → sensor evaluation – in the case of 1oo2 evaluation , two input channels are assigned one two-channel sensor or two one-channel sensors. The input signals are compared internally for equivalence or nonequivalence.

## Access protection

Fail-safe systems must be protected against dangerous, unauthorized access. Access protection for F-systems is achieved by assigning two passwords (for the fail-safe CPU and the safety program).

## Acknowledgment time

During the acknowledgment time, the → F-I/O acknowledge the sign of life specified by the → F-CPU. The acknowledgment time is included in the calculation of the → monitoring time and → response time of the overall fail-safe system.

## Actuator

Actuators are, for example, power relays or contactors for switching on load devices or load devices themselves (e.g. directly controlled solenoid valves).

## Availability

Availability is the probability that a system is functional at a specific point in time. Availability can be increased by redundancy, e.g., by using multiple → sensors at the same measuring point.

## Bus

A common transfer route to which all devices are connected; it has two defined ends.

**Channel**

In IEC 61508 terminology, a channel is a single signal/logic path that supports a safety function. The term 'channel' is used in this sense in the definition of 1oo1 and 1oo2 above. In most cases in this manual, the term 'channel' refers to exactly one process value, which may be implemented as 1oo1 or 1oo2.

**Channel fault**

Channel-specific fault, such as a wire break or short circuit.

In channel-specific passivation, the affected channel is either automatically reintegrated or the fail-safe module must be removed and reinserted after the fault has been eliminated.

**Channel group**

The channels of a module are grouped together in a channel group. Certain parameters in STEP 7 can only be assigned to channel groups, rather than to individual channels.

**Channel number**

Channel numbers are used to uniquely identify the inputs and outputs of a module and to assign channel-specific diagnostic messages.

**Channel-specific passivation**

With this type of passivation, only the affected channel is passivated in the event of a → channel fault. In the event of a → module fault, all channels of the → fail-safe module are passivated.

**Configuration**

Systematic arrangement of individual modules (design).

**Connection plug**

Physical connection between device and cable.

**CRC**

Cyclic Redundancy Check

**CRC signature**

The validity of the process values in the safety frame, the accuracy of the assigned address references, and the safety-related parameters are validated by means of the CRC signature in the safety frame.

## **Dark period**

Dark periods occur during shutdown tests and complete bit pattern tests. The fail-safe output module switches test-related zero signals to the active output. This output is then briefly disabled (= dark period). An adequate carrier → actuator will not respond to this and will remain activated.

## **Device**

Device that can send, receive or amplify data via the bus, e.g. IO device via PROFINET IO.

## **Diagnostics**

Monitoring functions for the detection, localization, classification, display, and further evaluation of errors, faults, and alarms. They run automatically while the system is in operation. This increases the availability of systems by reducing commissioning times and downtimes.

## **Discrepancy analysis**

The discrepancy analysis for equivalence/non-equivalence is used for fail-safe applications to prevent errors from time differences between two signals for the same function. The discrepancy analysis is initiated when different levels are detected in two associated input signals (when testing for non-equivalence: the same levels). A check is performed to determine whether the difference (for nonequivalence testing: the same levels) has disappeared after an assignable time period, the so-called discrepancy time. If not, this means that a discrepancy error exists.

The discrepancy analysis compares the two input signals of the 1oo2 sensor evaluation in the fail-safe input module.

## **Discrepancy time**

Configurable time for the → discrepancy analysis. If the discrepancy time is set too high, the fault detection time and → fault reaction time are extended unnecessarily. If the discrepancy time is set too low, availability is decreased unnecessarily since a discrepancy error is detected when, in reality, no error exists.

## **Distributed I/O system**

System with input and output modules that are configured on a distributed basis, far away from the CPU controlling them.

## **eCoding plug connector**

The eCoding plug connector stores the external addresses of F-source and F-destination of the I/O module. The eCoding plug connector simplifies module replacement.

**ET-Connection**

Backplane bus through which a connection is made. This allows bus participants to be installed several meters from each other.

**Fail-safe**

Ability of a technical system to remain in a safe state or immediately switch to another safe state when certain failures occur.

**Fail-safe modules**

ET 200AL modules with integrated safety functions that can be used for safety-related operation (safety mode).

**Fail-safe systems**

Fail-safe systems (F-systems) remain in a safe state or immediately assume another safe state as soon as particular failures occur.

**Fault reaction time**

The maximum fault reaction time of an F-system defines the interval between the occurrence of any fault and a safe reaction at all affected fail-safe outputs.

**For → F-system overall:** The maximum fault reaction time defines the interval between the occurrence of any fault in any → F-I/O and a safe response at the relevant fail-safe output.

**For digital inputs:** The maximum fault reaction time defines the interval between the occurrence of the fault and the safe reaction on the backplane bus.

**For digital outputs:** The maximum fault reaction time defines the interval between the occurrence of the fault and the safe reaction at the digital output.

**Fault tolerance time**

The fault tolerance time of a process is the time a process can be left unattended without risk to life and limb of the operating personnel, or damage to the environment.

Any type of F-system control is tolerated within this fault tolerance time, i.e. the → F-system can control its processes incorrectly or even not at all. The fault tolerance time depends on the type of process and must be determined on a case-by-case basis.

**F-CPU**

An F-CPU is a central processing unit with fail-safe capability that is permitted for use in SIMATIC Safety. A standard user program can also be run on the F-CPU.



## **F-I/O**

Collective name for fail-safe inputs and outputs available in SIMATIC S7 for integration into the SIMATIC Safety F-system. Available F-I/O modules:

- Fail-safe I/O module for ET 200eco
- Fail-safe signal modules S7-300 (F-SMs)
- Fail-safe modules for ET 200S
- Fail-safe modules for ET 200SP
- Fail-safe modules for ET 200MP
- Fail-safe modules for ET 200AL
- Fail-safe DP standard slaves
- Fail-safe PA field devices
- Fail-safe IO devices

## **Firmware update**

Upgrade of firmware for modules (interface modules, I/O modules etc.), e.g. after functional enhancements, to the newest firmware version (update).

## **F-monitoring time**

→ PROFIsafe monitoring time

## **F-Systems**

→ fail-safe systems

## **Ground**

Conductive earth whose electrical potential can be set equal to zero at any point.

All interconnected, inactive parts of a piece of equipment that cannot accept any dangerous contact voltage, even in the event of a fault.

## **Ground**

Conductive earth whose electrical potential can be set equal to zero at any point.

All interconnected, inactive parts of a piece of equipment that cannot accept any dangerous contact voltage, even in the event of a fault.

## **GSD file**

As a generic station description, this file in XML format has all the properties of a PROFINET or PROFIBUS device that are required for its configuration.

**I/O modules**

All modules that can be operated with a CPU or an interface module.

**Identification data**

Information that is saved in modules and that supports the user in checking the plant configuration and locating hardware changes.

**Interface module**

Module in the distributed I/O system. The interface module connects the distributed I/O system via a field bus with the CPU (I/O) controller and prepared the data for the/from the I/O modules.

**Module fault**

Module faults can be external faults (e.g. missing load voltage) or internal faults (e.g. processor failure). Internal faults always require module replacement.

**Monitoring time**

→ PROFIsafe monitoring time

**M-switch**

Each fail-safe digital output of ET 200AL F-modules consists of a P-switch DO-P<sub>x</sub> (current sourcing) and an M-switch DO-M<sub>x</sub> (current sinking). The load is connected between the P-switch and M-switch. The two switches are always activated so that voltage is applied to the load.

**Nonequivalent sensor**

A nonequivalent → sensor is a two-way switch that is connected to two inputs of an → F-I/O (via 2 channels) in → fail-safe systems (for → 1oo2 evaluation of sensor signals).

**Parameter assignment**

Parameter assignment is the transfer of parameters from the IO controller to the IO device.

## Passivation

If an → F-I/O module detects a fault it switches either the affected channel or all channels to a → safe state, i.e. the channels of this F-I/O module are passivated. The F-I/O module signals the detected faults to the → F-CPU.

When passivating channels at F-I/O with inputs, the → F-System provides fail-safe values for the → safety program instead of the process values pending at the fail-safe inputs.

When passivating channels at F-I/O with outputs, the F-system returns fail-safe values (0) to the fail-safe outputs instead of the output values provided by the safety program.

## PELV

Protective Extra Low Voltage = protective extra-low voltage

## Performance Level

Performance Level (PL) in accordance with ISO 13849-1 or EN ISO 13849-1

## PROFINET

PROcess Field NETwork, open Industrial Ethernet standard, which continues PROFIBUS and Industrial Ethernet. A cross-manufacturer communication, automation and engineering model, defined as an automation standard by PROFIBUS International e.V.

## PROFINET IO controller

Device used to address connected I/O devices (e.g. distributed I/O systems). This means that: The IO controller exchanges input and output signals with assigned I/O devices. The IO controller often corresponds with the CPU in which the automation program is running.

## PROFINET IO device

Distributed field device that can be assigned to one or more IO controllers (e.g. distributed I/O system, valve terminals, frequency converters, switches).

## PROFINET IO

Communication concept for the realization of modular, distributed applications in the framework of PROFINET.

## PROFIsafe

Safety-oriented PROFINET I/O bus profile for communication between the → safety program and the → F-I/O module in a → fail-safe system.

**PROFIsafe address**

The PROFIsafe address (code name according to IEC 61784-3-3: 2010) is used to protect standard addressing mechanisms such as IP addresses. The PROFIsafe address consists of the F-source address and F-destination address. Every → fail-safe module therefore has two address portions, the F-source address and the F-destination address.

The PROFIsafe address must be configured in the hardware and network editor.

**PROFIsafe monitoring time**

Monitoring time for safety-related communication between the F-CPU and F-I/O

**Proof-test interval**

Period after which a component must be forced to fail-safe state, that is, it is either replaced with an unused component, or is proven faultless.

**P-switch**

→ M-switch

**Redundancy, availability-enhancing**

Multiple instances of components with the objective of maintaining component functionality in the event of hardware faults.

**Redundancy, safety-enhancing**

Multiple availability of components with the aim of exposing hardware faults based on comparison; such as → 1oo2 evaluation in → fail-safe modules.

**Reference potential**

Potential from which the voltages of the circuits involved are observed and/or measured.

**Reintegration**

After the elimination of a fault, it is necessary to ensure the reintegration (depassivation) of the → F-I/O. Reintegration (switchover from fail-safe values to process values) occurs either automatically or only after a user acknowledgment in the safety program.

In the case of a fail-safe input module, the process values pending at the fail- safe inputs are made available to the safety program again after reintegration. In the case of a fail-safe output module, the → fail-safe system transfers the output values in the safety program to the fail-safe outputs again.

**RIOforFA-Safety**

Remote IO for Factory Automation with PROFIsafe; Profile for F-I/O

### **Safe Direction (SDI)**

The SDI function (Safe Direction) monitors the direction of the motion.

### **Safe Operating Stop (SOS)**

The SOS function (Safe Operating Stop) protects from unintentional motions.

### **Safe state**

The basic principle of the safety concept in F-systems is the existence of a safe state for all process variables. For the digital F-I/O, for example, the safe state is the value "0".

### **Safety class**

Safety level (Safety Integrity Level) SIL according to IEC 61508:2010. The higher the Safety Integrity Level, the more rigid the measures for prevention of systematic faults and for management of systematic faults and hardware failures.

The fail-safe modules support operation in safety mode up to safety class SIL3.

### **Safety frame**

In safety mode, data are transferred between the → F-CPU and → F-I/O in a safety frame.

### **Safety function**

A mechanism integrated in the → F-CPU and → F-I/O that enables their use in → the fail-safe system SIMATIC Safety.

According to IEC 61508:2010: A safety function is implemented by a safety system in order to maintain or force a system safe state in the event of a specific fault.

### **Safety Limited Speed (SLS)**

The SLS function (Safely Limited Speed) monitors the calculated speeds in both directions.

### **Safety mode**

Operating mode of → F-I/O that enables → safety-related communication via → safety frames.

The → fail-safe modules ET 200AL are designed for safety mode only.

### **Safety program**

Safety-related user program

**Safety-related communication**

Communication used to exchange fail-safe data.

**SELV**

Safety Extra Low Voltage = Safety extra-low voltage

**Sensor evaluation**

There are two types of sensor evaluation:

→ 1oo1 evaluation – sensor signal is read once

→ 1oo2 evaluation – sensor signal is read in twice by the same F-module and compared internally

**Sensors**

Sensors are used for the accurate detection of routes, positions, velocities, rotational speeds, masses, etc. in the form of digital and analog signals.

**Standard mode**

Operating mode of F-I/O in which standard communication is possible by means of → safety frames, but not → safety-related communication.

ET 200AL fail-safe modules are only designed for safety mode.

**TIA Portal**

Totally Integrated Automation Portal

The TIA Portal is the key to the full performance capability of Totally Integrated Automation. The software optimizes operating, machine and process sequences.

**Value status**

Binary additional information for an input signal. This additional information indicates whether or not the input signal is valid. Example: The value of the input signal is invalid if wire break has been detected or flutter monitoring has responded. In this case, exception handling is triggered in an automation function (e.g. with safe substitute value).

# Index

## 2

24 V DC supply, 33

## A

Accessories, 114  
Ambient conditions  
    Climatic, 107  
    Mechanical, 106  
Application, 31  
Approvals, 100

## B

Burst pulses, 104

## C

Cable length, 50  
Cable protection, 45  
Cable ties, 30  
Cables, 31  
    Connecting cable for ET connection, PUR cable, 121  
    Connecting cable for ET-Connection, 121, 122  
    Connecting cable for ET-Connection, PUR cable, 123  
    for ET connection, PUR cable, 119  
    for ET-Connection, 119, 119  
    for power supply, 124  
    for power supply, PUR cable, 124  
    PUR cable for ET-Connection, 120  
Climatic ambient conditions, 107  
Commissioning, 81, 85  
    Startup on PROFIBUS DP, 86  
    Startup with PROFINET IO, 82  
Components, 19  
Configuration  
    connect to functional earth, 47  
    Power supply, 46  
Configuration control, 64  
Configuration software, 59  
Configuration variants  
    ET-Connection1, 22  
    ET-Connection1 and ET-Connection2, 23  
    Hybrid configuration, 24

Configuring, 59  
Connecting  
    Conductive substrate, 48  
    M12 plugs, 53  
    M8 plugs, 52  
    Non-conductive substrate, 49  
Connecting cables, 50

## D

Degree of protection, 108  
Dimension drawing  
    Modules, 113  
Drill holes, 28

## E

eCoding plug connector, 19  
Electrical isolation, 42  
Electromagnetic compatibility, 104  
Electrostatic discharge, 104  
EMC, 104  
EMERGENCY-STOP device, 31  
Emission of radio frequency interference, 105  
ET 200AL  
    Area of application, 15  
    Configuration example, 16  
ET 200AL standard modules  
    safety-related shutdown, 110  
ET-Connection  
    Behavior, 92  
    Bus cable, 20  
    Connector, 20  
    Stripping tool, 20  
Example  
    ET 200AL configuration, 16

## F

Firmware update, 94  
Functional earth, 47  
Fuse, 32

## G

German Technical Inspectorate report, 112

Grounded infeed, 39

## I

- I/O modules, 19
- Identification data, 88
- Identification label, 19, 57
  - Mounting, 58
  - Removing, 58
- Infeed
  - grounded, 39
  - non-grounded, 39
- Installation position, 26
- Insulation, 108
- Insulation monitoring, 41
- Interface module
  - PROFIBUS DP, 19
  - PROFINET IO, 19
  - Wiring, 51
- Interface modules, 19

## L

Line voltage, 32

## M

- M12 plugs, 53
- M8 plugs, 52
- Maintenance, 92
- Maintenance data, 88
- Marking
  - Factory-marked, 56
  - Interfaces, 56
  - Optional, 57
- Maximum configuration
  - Electrical, 22
  - Mechanical, 21
- Mechanical environmental conditions, 106
- Minimum clearances, 26
- Mounting, 27
  - I/O module, 29
  - Interface module, 28

## O

- Option handling, (See configuration control)
- Overall configuration, 40
- Overvoltage category, 108

## P

- PELV, 39
- Pin assignment, 53, 56
- Pollution degree, 108
- Power supply
  - Connector, 20
  - Power cable, 20
- PROFenergy, 84
- PROFINET IO, 81
- Protection class, 108
- Protective measures, 41
- Pulse-shaped disturbance variables, 104

## R

- Radio interference, 103
- Rated voltage, 108
- Reference potential
  - grounded, 39
  - non-grounded, 40

## S

- Safe electrical isolation, 39
- Safety relay, 110
- Screws, 27
- SELV, 39
- Setup, 15
- Shock, 106
- SIMATIC ET 200AL, 14
- Sinusoidal disturbance variables, 105
- Slot number, 93
- Sockets, 55
- Spare parts, 114
- Standards, 100
- Switch, 32
- System conditions, 31
- System configuration
  - Grounded reference potential, 39
  - Protective measures, 41
  - Ungrounded reference potential, 40

## T

- Technical specifications
  - Standards and authorizations, 100
- Test voltage, 108
- TN-S grid, 39
- Tool, 27
- Transport and storage conditions, 106



## **U**

Ungrounded infeed, 39

Use

in industrial environments, 103

in mixed areas, 103

in residential areas, 103

## **V**

Vibrations, 106

## **W**

Wires, 31

## **Y**

Y-cable, 19

# SIEMENS



System manual

# SIMATIC

## ET 200AL

IO-Link I/O modules

Edition

08/2021

[support.industry.siemens.com](https://support.industry.siemens.com)

## SIMATIC

## ET 200AL IO-Link I/O modules

### System Manual

#### Preface

#### ET 200AL IO-Link I/O modules Documentation Guide

**1**

#### System overview

**2**

#### Application planning

**3**

#### Mounting

**4**

#### Connecting

**5**

#### Configuring

**6**

#### Commissioning

**7**

#### Maintenance

**8**

#### Technical specifications

**9**

#### Safety-related shutdown of ET 200AL IO-Link modules

**A**

#### Dimension drawings

**B**

#### Accessories/spare parts

**C**

## Legal information

### Warning notice system

This manual contains notices you have to observe in order to ensure your personal safety, as well as to prevent damage to property. The notices referring to your personal safety are highlighted in the manual by a safety alert symbol, notices referring only to property damage have no safety alert symbol. These notices shown below are graded according to the degree of danger.

#### **DANGER**

indicates that death or severe personal injury **will** result if proper precautions are not taken.

#### **WARNING**

indicates that death or severe personal injury **may** result if proper precautions are not taken.

#### **CAUTION**

indicates that minor personal injury can result if proper precautions are not taken.

#### **NOTICE**

indicates that property damage can result if proper precautions are not taken.

If more than one degree of danger is present, the warning notice representing the highest degree of danger will be used. A notice warning of injury to persons with a safety alert symbol may also include a warning relating to property damage.

### Qualified Personnel

The product/system described in this documentation may be operated only by **personnel qualified** for the specific task in accordance with the relevant documentation, in particular its warning notices and safety instructions. Qualified personnel are those who, based on their training and experience, are capable of identifying risks and avoiding potential hazards when working with these products/systems.

### Proper use of Siemens products

Note the following:

#### **WARNING**

Siemens products may only be used for the applications described in the catalog and in the relevant technical documentation. If products and components from other manufacturers are used, these must be recommended or approved by Siemens. Proper transport, storage, installation, assembly, commissioning, operation and maintenance are required to ensure that the products operate safely and without any problems. The permissible ambient conditions must be complied with. The information in the relevant documentation must be observed.

### Trademarks

All names identified by ® are registered trademarks of Siemens AG. The remaining trademarks in this publication may be trademarks whose use by third parties for their own purposes could violate the rights of the owner.

### Disclaimer of Liability

We have reviewed the contents of this publication to ensure consistency with the hardware and software described. Since variance cannot be precluded entirely, we cannot guarantee full consistency. However, the information in this publication is reviewed regularly and any necessary corrections are included in subsequent editions.

# Preface

## Purpose of the documentation

This documentation provides you with important information on how to configure, install, wire and commission the IO-Link I/O modules of the SIMATIC ET 200AL distributed I/O system.

## Basic knowledge required

A basic knowledge of automation technology is required to understand the documentation.

## Validity of the documentation

This documentation applies to the IO-Link I/O modules of the SIMATIC ET 200AL distributed I/O system.

## Changes compared to the previous version

This manual contains the following changes/additions compared to the previous version:

- Supplement to section Safety-related shutdown of ET 200AL IO-Link modules (Page 61).

## Conventions

Observe the notes labeled as follows:

---

### Note

A note contains important information regarding:

- The product described in the documentation
  - The handling of the product
  - The part of the documentation to which special attention should be paid in order to avoid damage.
- 

## Recycling and disposal

For environmentally compatible recycling and disposal of your electronic waste, contact a company certified for the disposal of electronic waste. Dispose of the equipment according to the applicable regulations in your country.

## Additional support

- Information about Technical Support is available in section Siemens Industry Online Support (Page 5).
- Information about the online catalog and online order system is available in section Industry Mall (Page 5).
- The range of technical documentation for the individual SIMATIC products and systems can be found on the Internet (<http://www.siemens.com/simatic-tech-doku-portal>).

## Security information

Siemens provides products and solutions with industrial security functions that support the secure operation of plants, systems, machines and networks.

In order to protect plants, systems, machines and networks against cyber threats, it is necessary to implement – and continuously maintain – a holistic, state-of-the-art industrial security concept. Siemens' products and solutions constitute one element of such a concept.

Customers are responsible for preventing unauthorized access to their plants, systems, machines and networks. Such systems, machines and components should only be connected to an enterprise network or the internet if and to the extent such a connection is necessary and only when appropriate security measures (e.g. firewalls and/or network segmentation) are in place.

For additional information on industrial security measures that may be implemented, please visit (<https://www.siemens.com/industrialsecurity>).

Siemens' products and solutions undergo continuous development to make them more secure. Siemens strongly recommends that product updates are applied as soon as they are available and that the latest product versions are used. Use of product versions that are no longer supported, and failure to apply the latest updates may increase customers' exposure to cyber threats.

To stay informed about product updates, subscribe to the Siemens Industrial Security RSS Feed visit (<https://www.siemens.com/industrialsecurity>).

## Siemens Industry Online Support

You can find current information on the following topics quickly and easily here:

- **Product support**

All the information and extensive know-how on your product, technical specifications, FAQs, certificates, downloads, and manuals.

- **Application examples**

Tools and examples to solve your automation tasks – as well as function blocks, performance information and videos.

- **Services**

Information about Industry Services, Field Services, Technical Support, spare parts and training offers.

- **Forums**

For answers and solutions concerning automation technology.

- **mySupport**

Your personal working area in Industry Online Support for messages, support queries, and configurable documents.

This information is provided by the Siemens Industry Online Support in the Internet (<https://support.industry.siemens.com/cs/ww/en/>).

## Industry Mall

The Industry Mall is the catalog and order system of Siemens AG for automation and drive solutions on the basis of Totally Integrated Automation (TIA) and Totally Integrated Power (TIP).

You can find catalogs for all automation and drive products on the Internet (<https://mall.industry.siemens.com>) and in the Information and Download Center.

# Table of contents

|          |                                                                           |           |
|----------|---------------------------------------------------------------------------|-----------|
|          | <b>Preface .....</b>                                                      | <b>3</b>  |
| <b>1</b> | <b>ET 200AL IO-Link I/O modules Documentation Guide .....</b>             | <b>8</b>  |
| <b>2</b> | <b>System overview .....</b>                                              | <b>11</b> |
| 2.1      | System overview.....                                                      | 11        |
| 2.2      | What are ET 200AL IO-Link I/O modules? .....                              | 12        |
| 2.3      | Components.....                                                           | 14        |
| <b>3</b> | <b>Application planning .....</b>                                         | <b>15</b> |
| 3.1      | Hardware configuration .....                                              | 15        |
| 3.2      | Configuration of IO-Link I/O modules .....                                | 16        |
| <b>4</b> | <b>Mounting .....</b>                                                     | <b>18</b> |
| 4.1      | Basics .....                                                              | 18        |
| 4.2      | Mounting modules .....                                                    | 19        |
| <b>5</b> | <b>Connecting .....</b>                                                   | <b>24</b> |
| 5.1      | Rules and regulations for operation.....                                  | 24        |
| 5.2      | Operation of the IO-Link I/O modules on a grounded/ungrounded infeed..... | 26        |
| 5.3      | Electrical configuration of the IO-Link I/O modules .....                 | 32        |
| 5.4      | Connecting IO-Link I/O modules to functional ground.....                  | 33        |
| 5.4.1    | Mounting IO-Link I/O modules on a conductive surface.....                 | 34        |
| 5.4.2    | Mounting IO-Link I/O modules on a non-conductive surface .....            | 35        |
| 5.5      | Wiring .....                                                              | 37        |
| 5.6      | Marking of IO-Link I/O modules .....                                      | 40        |
| 5.6.1    | Factory markings .....                                                    | 40        |
| 5.6.2    | Optional markings .....                                                   | 41        |
| 5.6.3    | Mounting identification labels.....                                       | 42        |
| <b>6</b> | <b>Configuring.....</b>                                                   | <b>43</b> |
| 6.1      | Requirements .....                                                        | 43        |
| 6.2      | IODD and Port Configuration Tool - S7-PCT .....                           | 43        |
| <b>7</b> | <b>Commissioning .....</b>                                                | <b>46</b> |
| 7.1      | Startup of the IO-Link I/O module.....                                    | 46        |



---

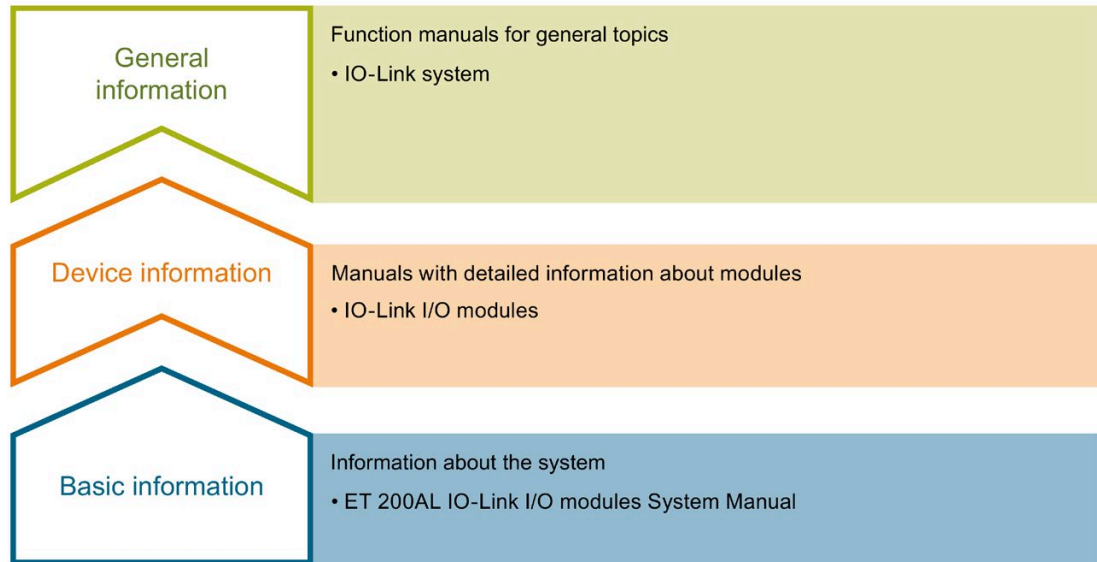
|          |                                                                                      |           |
|----------|--------------------------------------------------------------------------------------|-----------|
| <b>8</b> | <b>Maintenance.....</b>                                                              | <b>47</b> |
| 8.1      | Replacing modules.....                                                               | 47        |
| 8.2      | Firmware update .....                                                                | 49        |
| 8.3      | Resetting a module .....                                                             | 50        |
| 8.4      | Maintaining/cleaning the modules .....                                               | 52        |
| <b>9</b> | <b>Technical specifications.....</b>                                                 | <b>53</b> |
| 9.1      | Standards and authorizations.....                                                    | 53        |
| 9.2      | Electromagnetic compatibility.....                                                   | 56        |
| 9.3      | Transport and storage conditions .....                                               | 57        |
| 9.4      | Mechanical and climatic ambient conditions .....                                     | 58        |
| 9.5      | Details on insulation, protection class, degree of protection and rated voltage..... | 59        |
| 9.6      | Safety-related symbols for IP65/IP67 modules .....                                   | 60        |
| <b>A</b> | <b>Safety-related shutdown of ET 200AL IO-Link modules .....</b>                     | <b>61</b> |
| <b>B</b> | <b>Dimension drawings .....</b>                                                      | <b>65</b> |
| <b>C</b> | <b>Accessories/spare parts .....</b>                                                 | <b>66</b> |
| C.1      | Accessories/spare parts .....                                                        | 66        |
| C.2      | UL-approved cables.....                                                              | 67        |
|          | <b>Glossary .....</b>                                                                | <b>70</b> |
|          | <b>Index.....</b>                                                                    | <b>73</b> |

# ET 200AL IO-Link I/O modules Documentation Guide

# 1

The documentation for the SIMATIC ET 200AL IO-Link I/O modules is arranged into three areas.

This arrangement enables you to access the specific content you require.



## Basic information

The system manual describes in detail the configuration, installation, wiring and commissioning of the distributed I/O system SIMATIC ET 200AL IO-Link I/O modules.

## Device information

Equipment manuals contain a compact description of the module-specific information, such as properties, wiring diagrams, characteristics and technical specifications.

## General information

The function manuals contain detailed descriptions on general topics regarding the SIMATIC IO-Link system.

You can download the documentation free of charge from the Internet (<https://support.industry.siemens.com/cs/ww/en/view/109742667>).

## ET 200AL Manual Collection

The Manual Collection contains the complete documentation on the SIMATIC ET 200AL distributed I/O system gathered together in one file.

You can find the Manual Collection on the Internet (<https://support.automation.siemens.com/WW/view/en/95242965>).

## "mySupport"

With "mySupport", your personal workspace, you make the best out of your Industry Online Support.

In "mySupport", you can save filters, favorites and tags, request CAx data and compile your personal library in the Documentation area. In addition, your data is already filled out in support requests and you can get an overview of your current requests at any time.

You must register once to use the full functionality of "mySupport".

You can find "mySupport" on the Internet (<https://support.industry.siemens.com/My/ww/en>).

## "mySupport" - Documentation

With "mySupport", your personal workspace, you make the best out of your Industry Online Support.

In "mySupport", you can save filters, favorites and tags, request CAx data and compile your personal library in the Documentation area. In addition, your data is already filled out in support requests and you can get an overview of your current requests at any time.

You must register once to use the full functionality of "mySupport".

You can find "mySupport" on the Internet  
(<https://support.industry.siemens.com/My/ww/en/documentation>).

## "mySupport" - CAx data

In the CAx data area of "mySupport", you can access the latest product data for your CAx or CAe system.

You configure your own download package with a few clicks.

You can select:

- Product images, 2D dimension drawings, 3D models, internal circuit diagrams, EPLAN macro files
- Manuals, characteristics, operating manuals, certificates
- Product master data

You can find "mySupport" CAx data on the Internet  
(<https://support.industry.siemens.com/my/ww/en/CAxOnline>).

## Application examples

The application examples support you with various tools and examples for solving your automation tasks. Solutions are shown in interplay with multiple components in the system - separated from the focus on individual products.

You will find the application examples on the Internet  
(<https://support.industry.siemens.com/cs/ww/en/ps/ae>).

## TIA Selection Tool

With the TIA Selection Tool, you can select, configure and order devices for Totally Integrated Automation (TIA).

This tool is the successor of the SIMATIC Selection Tool and combines the known configurators for automation technology into one tool.

With the TIA Selection Tool, you can generate a complete order list from your product selection or product configuration.

You can find the TIA Selection Tool on the Internet

(<https://support.industry.siemens.com/cs/ww/en/view/109767888>).

## PRONETA

SIEMENS PRONETA (PROFINET network analysis) allows you to analyze the plant network during commissioning. PRONETA has two core functions:

- The topology overview automatically scans the PROFINET and all connected components.
- The IO check is a fast test of the wiring and the module configuration of a plant.

You can find SIEMENS PRONETA on the Internet

(<https://support.industry.siemens.com/cs/ww/en/view/67460624>).

## SIMATIC S7-PCT

The Port Configuration Tool ("PCT") is PC-based software for the parameter assignment of Siemens IO-Link master-modules and IO-Link devices from any manufacturer.

The IO-Link devices are integrated using the standardized device description "IODD" that is available from the respective device manufacturer. S7-PCT supports the version 1.0 as well as V1.1 of the IODD.

S7-PCT is called via the hardware configuration of the IO-Link masters from STEP 7; however, it can also be started as "standalone" if the IO-Link master is not operated on a SIMATIC controller or when STEP 7 is not used.

You can find additional information on IO-Link on the Internet

(<https://new.siemens.com/global/en/products/automation/industrial-communication/io-link.html>).

# System overview

## 2.1 System overview

### Introduction

A continuous communication down to the lowest field level ensures enhanced use of the functions and performance capability of sensors and actuators. Enhanced use of sensors and actuators allows you to operate your machines and plants more productively.

No data other than the actual process value can be exchanged via the standard interfaces (digital, analog) used at the sensor/actuator level. Sensors and actuators with integrated intelligence are now used for increasingly complex functions and require a communication interface tailored to these requirements.

### Definition

IO-Link is an innovative, point-to-point communication interface for the sensor/actuator area that is specified in IEC 61131-9.

IO-Link consists of the following system components:

- IO-Link master
- IO-Link device
- Unshielded 3-wire or 5-wire standard cable
- Engineering tool for configuring and assigning parameters of IO-Link

## 2.2 What are ET 200AL IO-Link I/O modules?

### SIMATIC ET 200AL IO-Link I/O modules

SIMATIC ET 200AL IO-Link I/O modules belong to the SIMATIC ET 200AL distributed I/O system.

You can operate the IO-Link I/O modules on any IO-Link master with IP20 or IP67 degree of protection.

### Customer benefits

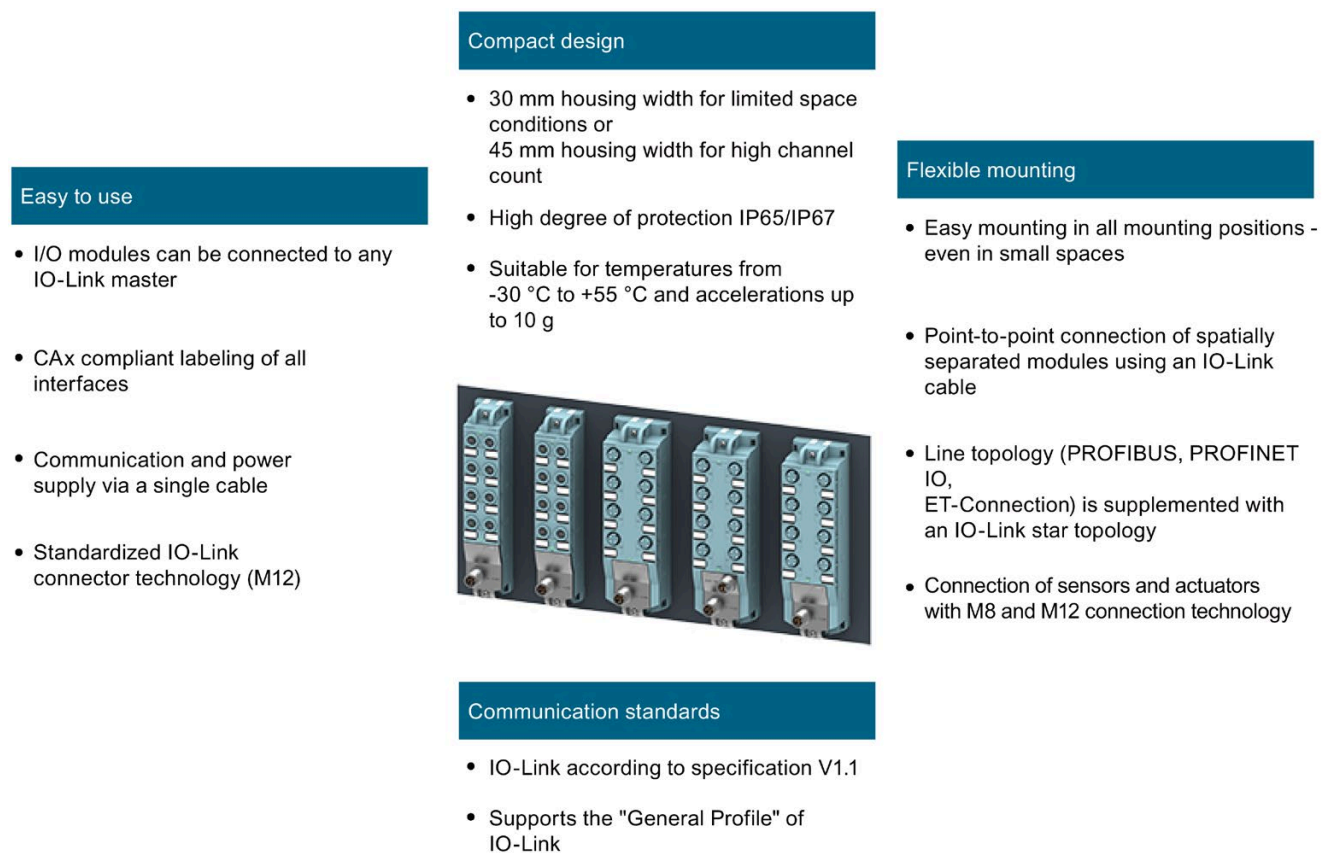


Figure 2-1 Benefits of the ET 200AL IO-Link

## Area of application

The SIMATIC ET 200AL distributed I/O system is especially well-suited for the following application areas:

- Where space is limited
- Moving applications
- Assembly and handling technology

Thanks to its scalable construction, you have the option to precisely customize its configuration to your on site needs.

The SIMATIC ET 200AL distributed I/O system is designed in IP65/IP67 degree of protection. The I/O modules are suited for distributed use indoors on a machine or assembly line.

You can adapt the cable routing optimally to the machine requirements. The combination of a line topology, such as PROFINET IO and ET connection, and the star topology of IO-Link make this easy to implement.

## Configuration

The IO-Link I/O modules of the SIMATIC ET 200AL distributed I/O system are operated on any IO-Link master.

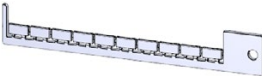
A cable with M12 plug-in connection is used for the communication and power supply.

## 2.3 Components

### Components of the IO-Link I/O modules

The following table shows and explains the function of the components of the IO-Link I/O modules of the ET 200AL distributed I/O system.

Table 2- 1 Components of the IO-Link I/O modules

| Component                    | Function                                                                                                                                                                                                                 | View                                                                                  |
|------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------|
| IO-Link I/O modules          | <ul style="list-style-type: none"> <li>The I/O modules form the interface to the process</li> <li>Recording and controlling the current process status via the connected sensors and actuators</li> </ul>                |    |
| Identification labels        | <ul style="list-style-type: none"> <li>The identification labels come with the module and can be machine printed</li> <li>Can be ordered separately</li> </ul>                                                           |    |
| M12-A connecting cable       | <ul style="list-style-type: none"> <li>Connection of IO-Link I/O module to the master</li> <li>Connection to sensors and actuators</li> </ul>                                                                            |   |
| Power connecting cable M12-L | <ul style="list-style-type: none"> <li>Connection of additional load voltage</li> </ul>                                                                                                                                  |  |
| Sealing cap M8 and M12       | <ul style="list-style-type: none"> <li>Seal for unused connections</li> <li>IP degree of protection is maintained through use</li> </ul>                                                                                 |  |
| Y-cable                      | <ul style="list-style-type: none"> <li>Double connection of actuators or sensors to one socket</li> <li>IP degree of protection class is maintained when two actuators or sensors are connected to one socket</li> </ul> |  |



# Application planning

## 3.1 Hardware configuration

### Basic configuration with IO-Link I/O modules

Connect the IO-Link I/O module to an IO-Link port of the master with an M12-A coded plug.

The maximum cable length between an IO-Link device and an IO-Link master is 20 m.

Power is supplied to the IO-Link I/O modules via the IO-Link master.

You can connect one IO-Link I/O module per IO-Link port to an IO-Link master.

For I/O modules with high power demand, an M12-L power connector is available for an additional supply voltage.

You can find information on the maximum infeed current in the technical specifications of the modules in the respective equipment manuals or on the Internet (<https://support.industry.siemens.com/cs/ww/en/view/109742667>).

## 3.2 Configuration of IO-Link I/O modules

Each ET 200AL IO-Link I/O module has an M12 A-coded plug for connection to an IO-Link master.

When connecting the IO-Link I/O modules to an IP65/67 IO-Link master, pay attention to the required port class (Type A or Type B). You can find the technical specifications in the respective equipment manuals or on the Internet.

### PROFINET IO

The figure shows an IO-Link configuration in combination with a PROFINET IO network. The line topology of PROFINET IO is supplemented with a star topology of IO-Link.

#### Note

#### Configuration variants

The IO-Link I/O modules can also be operated on an IO-Link master in other networks.

### Connection examples

The following figure shows a connection example using an S7-1500 IO-Link master with IP20 degree of protection.

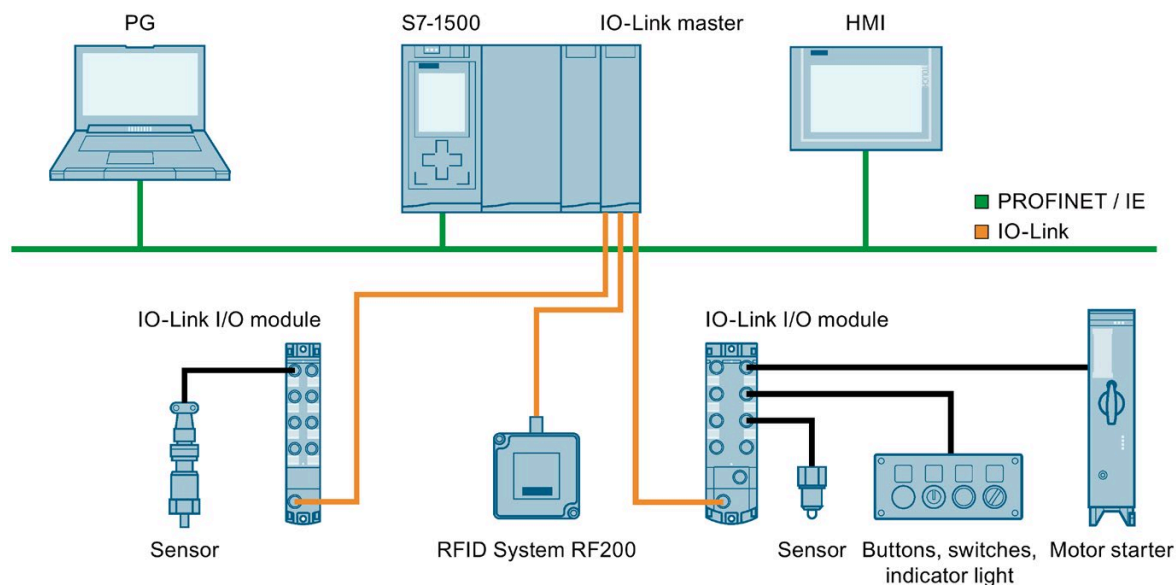


Figure 3-1 Configuration with IP20 IO-Link master

The following figure shows a connection example on an ET 200ecoPN IO-Link master with IP65/67 degree of protection.

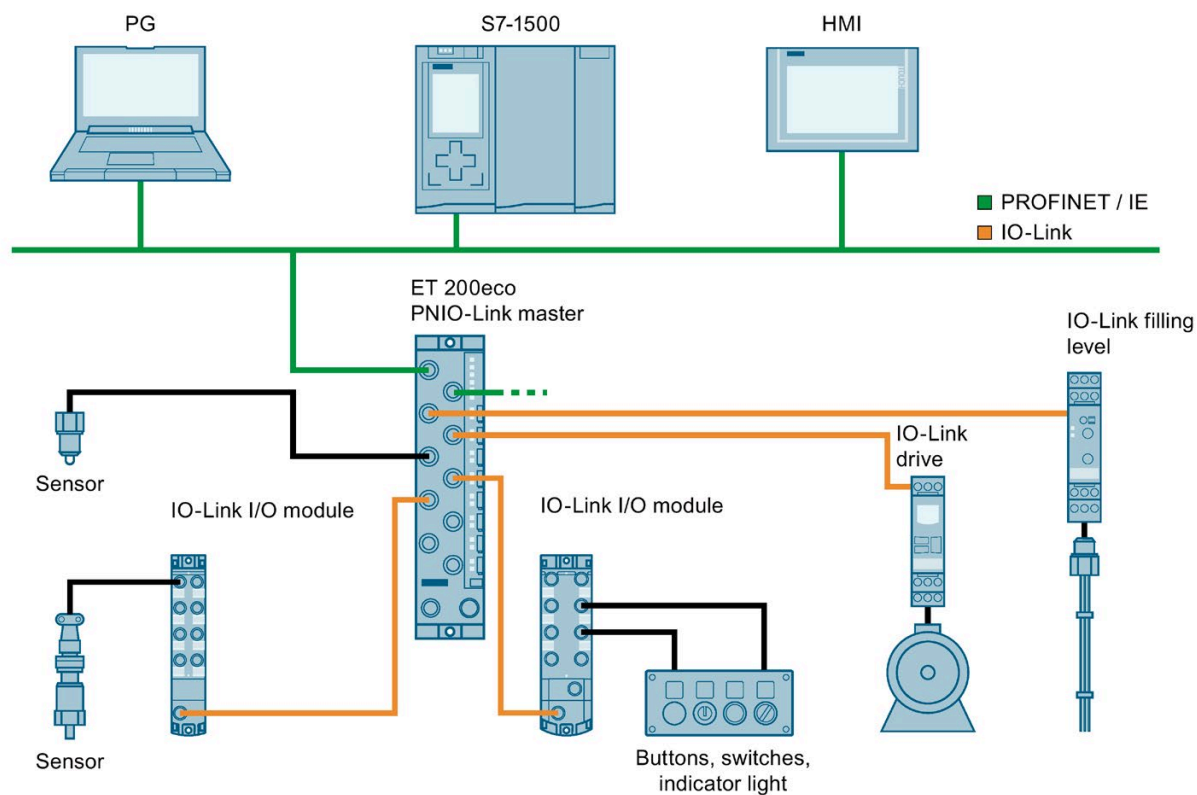


Figure 3-2 Configuration with IP65/67 IO-Link master

# Mounting

## 4.1 Basics

### Introduction

The IO-Link I/O modules are designed for IP65/IP67 degree of protection. This means that you can mount the modules directly in your plant.

### Mounting position

You can mount the IO-Link I/O modules in any mounting position.

### Minimum clearances

Maintain a minimum clearance of 2 cm from adjacent modules or other devices when mounting. The minimum clearance makes it easier to install the connectors.

### Mounting rules

When mounting the modules, you do not need to following any special rules.

---

#### Note

#### Mounting of the modules

Only mount the IO-Link I/O module when the supply voltages are disconnected.

---

## 4.2 Mounting modules

### Introduction

The IO-Link I/O modules are designed for mounting on a level, stable surface.

Thanks to the axisymmetrical drill holes in the modules, you have the option to fasten the modules on an aluminum profile using tee nuts.

The following images shows the aluminum profile on which you can mount the modules.

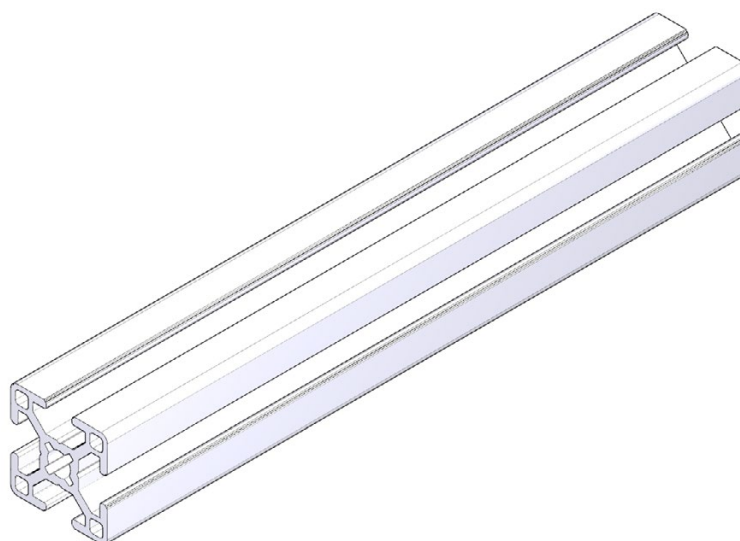


Figure 4-1 Aluminum profile

### Required tool

For installation, you need a screwdriver or an Allen wrench.

### Required screws

The following table shows and explains the screw types required to mount the modules.

Table 4- 1 Recommended screws

| Screw type                                                              | Explanation                                                                                                   |
|-------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------|
| Socket head cap screw M4 according to DIN EN ISO 1207 / DIN EN ISO 1580 | The screw length must be at least 30 mm.<br>If you need washers, use DIN EN ISO 7089/DIN EN ISO 7090 washers. |
| Hexagon socket head cap screw M4 according to DIN EN ISO 4762           |                                                                                                               |

### Drill holes of the modules

All IO-Link I/O modules have a uniform drill pattern.

- All module housings are axisymmetrical.
- The distance between the top and bottom drill hole is identical for all modules.

### Mounting 30 mm wide I/O modules (front or side)

Watch video sequence (<https://support.industry.siemens.com/cs/ww/en/view/95886672>)

The 30 mm I/O modules have a fastening point at the top and bottom. The 30 mm wide I/O modules can also be side-fastened. When fastening them at the side, you must use the supplied spacers.

Follow the steps below to mount a 30 mm wide I/O module:

1. Drill two fastening holes with 4.5 mm diameter spaced 149.6 mm apart.
2. Use the supplied spacers for side fastening of the I/O module on the top and bottom (on one side adjacent to the fastening surface).
3. Fasten the I/O module with the screws to both fastening points (tightening torque 1.2 Nm).

The figure below shows the dimensions for fastening the 30 mm wide I/O modules using the example of the IO-Link I/O module DIQ 4+DQ 4x24VDC/0.5A 8xM8.

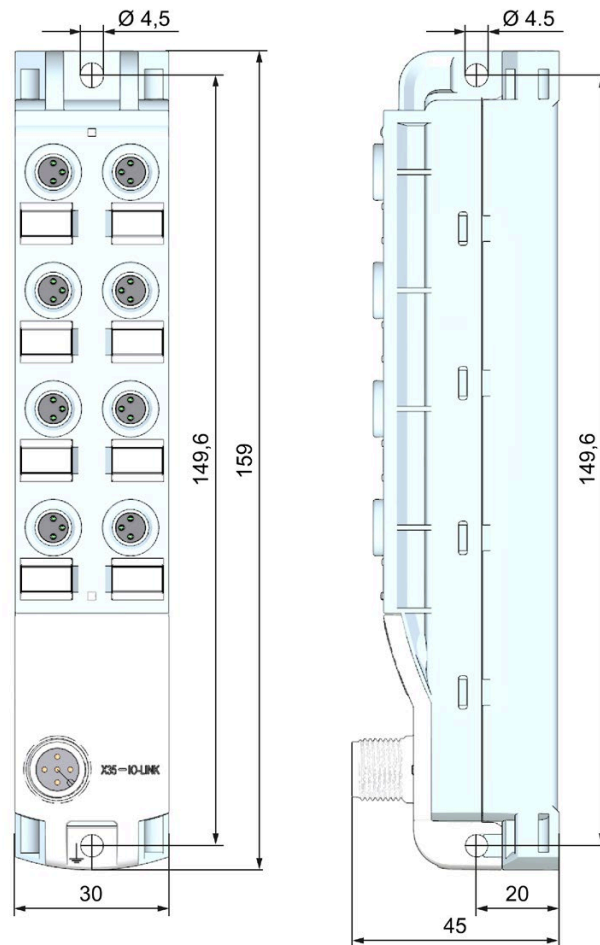


Figure 4-2 Dimensions for mounting 30 mm wide I/O modules

### Mounting 45 mm I/O modules (front mounting)

Watch video sequence (<https://support.industry.siemens.com/cs/ww/en/view/95886672>)

The 45 mm wide I/O modules have a fastening point at the top and bottom.

Follow the steps below to mount a 45 mm wide I/O module:

1. Drill two fastening holes with 4.5 mm diameter spaced 149.6 mm apart.
2. Fasten the I/O module with the screws to both fastening points (tightening torque 1.2 Nm).

The figure below shows the dimensions for fastening using the example of the IO-Link I/O module DI 8x24VDC M12-L 8xM12.

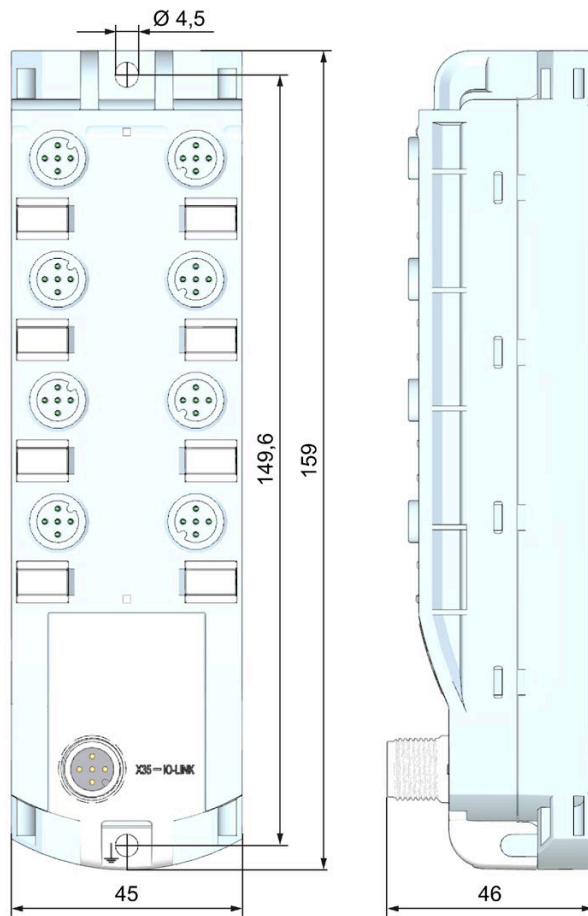


Figure 4-3 Dimensions for mounting 45 mm I/O modules



### Fastening for cable ties

All IO-Link I/O modules have integrated fastening points for cable ties. The fastening points are found on all four corners of the modules.

The figure below shows the top left fastening point for 2.5 mm cable ties for fastening the cables.

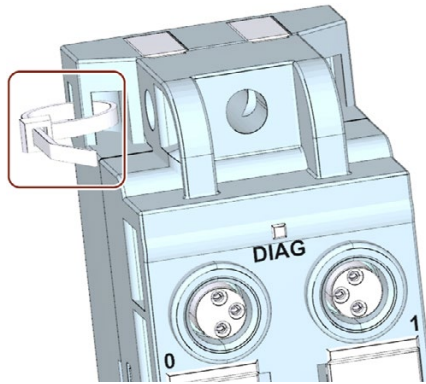


Figure 4-4 Top left fastening point for cable ties

# Connecting

## 5.1 Rules and regulations for operation

### Introduction

Depending on the area of application, the IO-Link I/O modules, as an integral component of a system, must adhere to special rules.

This section gives an overview of the most important rules you must follow when integrating the IO-Link I/O modules in a plant or system.

### Specific application

Observe the safety and accident prevention regulations that are applicable to specific applications, for example, the Machinery Directive.

### EMERGENCY-STOP device

Emergency Stop devices according to IEC 60204-1 (corresponds to DIN VDE 0113-1) must remain effective in all operating modes of the system.

### Excluding hazardous system conditions

Hazardous operating states must not occur in any situation, but especially:

- When the system restarts after a voltage dip or power outage
- When the IO-Link I/O modules start up after interruption of the IO-Link communication

If necessary, force an EMERGENCY STOP.

An uncontrolled or undefined startup is not permitted after the "EMERGENCY STOP" is unlocked.

### Cables and wires

Note that the utilized cables (including plugs) are approved for a continuous operating temperature of 30 °C above the operation temperature of the IO-Link I/O modules.

The cables and wires used must be rated for at least the supply voltage used.

### External fuses/switches

External fuses and switches must be installed so that they meet the standards for cable and device protection applicable to your application.

## Line voltage

For the line voltage, note the following:

- For stationary plants or systems without an all-pole line disconnect, there must be a disconnect unit (all-pole) fitted in the building installation.
- For load current supplies, the configured rated voltage range must correspond to the local line voltage.
- For all electric circuits of the IO-Link I/O modules, the fluctuation/deviation of the supply voltage and load voltage from the rated value must be within the permitted tolerance.

You can find more information in the section Specifications for insulation, protection class, degree of protection and rated voltage (Page 59).

## 24 V supply

For the 24 V supply, note the following:

- For buildings:  
If there is a danger due to overvoltages, you must take lightning protection measures for external lightning protection (e.g. lightning protection elements).
- With 24 V DC supply lines and signal lines:  
If there is a danger due to overvoltages, you must take lightning protection measures for internal lightning protection (e.g. lightning protection elements. You will find additional information in the Designing interference-free controllers (<https://support.industry.siemens.com/cs/ww/en/view/59193566>) function manual).
- For 24 V DC supply:  
Ensure that there is an electrical protective separation of extra-low voltage (SELV/PELV) according to IEC 61010-2-201 or IEC 60950-1.  
1L+ is supplied via the IO-Link master. Observe the requirements of the IO-Link master used.  
2L+ is connected via port Type B or the M12-L power connector. Protect 2L+ with a UL- or IEC-approved fuse (tripping characteristic type B or C). This fuse must conform to the cable cross-section and must not exceed the maximum total current of the IO-Link I/O module. Module-specific specifications can be found in the equipment manuals and on the Internet.

---

### Note

#### Wet environment

If you use IO-Link I/O modules in a wet environment, other limits apply for SELV/PELV.

---

### Protection against outside electrical influences

Below is a description of what you must pay attention to in terms of protection against electrical impacts and/or faults:

- To protect against electromagnetic interference, connect the I/O devices to functional ground.
- Ensure correct installation and routing of the supply, signal and IO-Link cables.
- Configure the plant/system in such a way that an error does not result in undefined states.
  - Line/wire break
  - Cross-circuit in the cable

### Reference

Additional information can be found in the function manual Designing interference-free controllers (<https://support.industry.siemens.com/cs/ww/en/view/59193566>).

## 5.2 Operation of the IO-Link I/O modules on a grounded/ungrounded infeed

### Introduction

Information on the overall configuration of the IO-Link I/O modules on a grounded infeed (TN-S system) is provided below. Statements regarding the TN-S system relate to the upstream 24 V DC power supply that is connected to the TN-S system.

Together, the IO-Link I/O modules and the IO-Link master form a unit. The following items must be noted for the configuration.

- IO-Link voltage supply via IO-Link master port class A
- IO-Link voltage supply via IO-Link master port class B
- Voltage supply for modules with high power demand via the M12-L power connector

The specific subjects discussed are:

- Disconnecting devices, short-circuit and overload protection to IEC 60364 (corresponding to DIN VDE 0100) and IEC 60204 (corresponding to DIN VDE 0113)
- Load current supplies and load circuits
- Supply voltages of the IO-Link I/O modules

### Grounded infeed

In grounded incoming supplies, the neutral conductor of the supply system is grounded. A ground fault between a live conductor and ground or a grounded system component causes the protective devices to trip.

## Supply voltages

Provide the IO-Link master with an SELV/PELV 1L+ supply voltage.

The SELV/PELV 2L+ load voltage is supplied via the M12-A connector with port class B or via the M12-L power connector. The SELV/PELV 2L+ load voltage can be switched depending on the application.

- IO-Link 1L+ supply voltage (non-switched) via M12-A connector port class A.
- IO-Link 2L+ load voltage (switched) via M12-A connector port class B or M12-L power connector.

## Safe electrical isolation (SELV/PELV)

Power packs/power supply modules with safe electrical isolation SELV/PELV are required for operation of the IO-Link I/O modules. These power packs/power supply modules must comply with IEC 61010-2-201.

The wiring of SELV/PELV circuits must be separated from the wiring of non-SELV/PELV circuits. Or the insulation of all conductors must be rated for the higher voltage.

|                                                                                                                        |
|------------------------------------------------------------------------------------------------------------------------|
| <b>NOTICE</b>                                                                                                          |
| <b>Operation in damp / wet environments</b>                                                                            |
| When operating in a damp / wet environment, different voltage limits apply for SELV/PELV according to IEC 61010-2-201. |

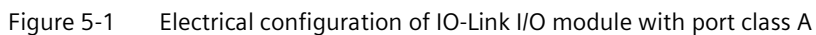
## Configuring IO-Link I/O modules with grounded reference potential

In the configuration of IO-Link I/O modules with grounded reference potential, any interference currents that occur are discharged to functional ground. The connections must be externally connected. Establish a connection between 1M or 2M and functional ground.

## Configuring IO-Link I/O modules with ungrounded reference potential

In the configuration of IO-Link I/O modules with ungrounded reference potential, any interference currents that occur are discharged to functional ground via an internal RC network. You do not need an external connection between 1M, 2M and functional ground.

The figure below shows the overall electrical configuration using the example of an IO-Link I/O module with port class A on an IO-Link master with port class A.



[illegible]

- ① Main switch
- ② Short-circuit and overvoltage protection
- ③ Fuses for cable protection
- ④ In the configuration of the IO-Link system with ungrounded reference potential, the connection between 1M, 2M and functional ground is omitted.

Figure 5-2 Electrical configuration of an IO-Link I/O module with port class A or B on an IO-Link master with port class A.

The figure below shows the overall electrical configuration using the example of an IO-Link I/O module with port class B on an IO-Link master with port class B.

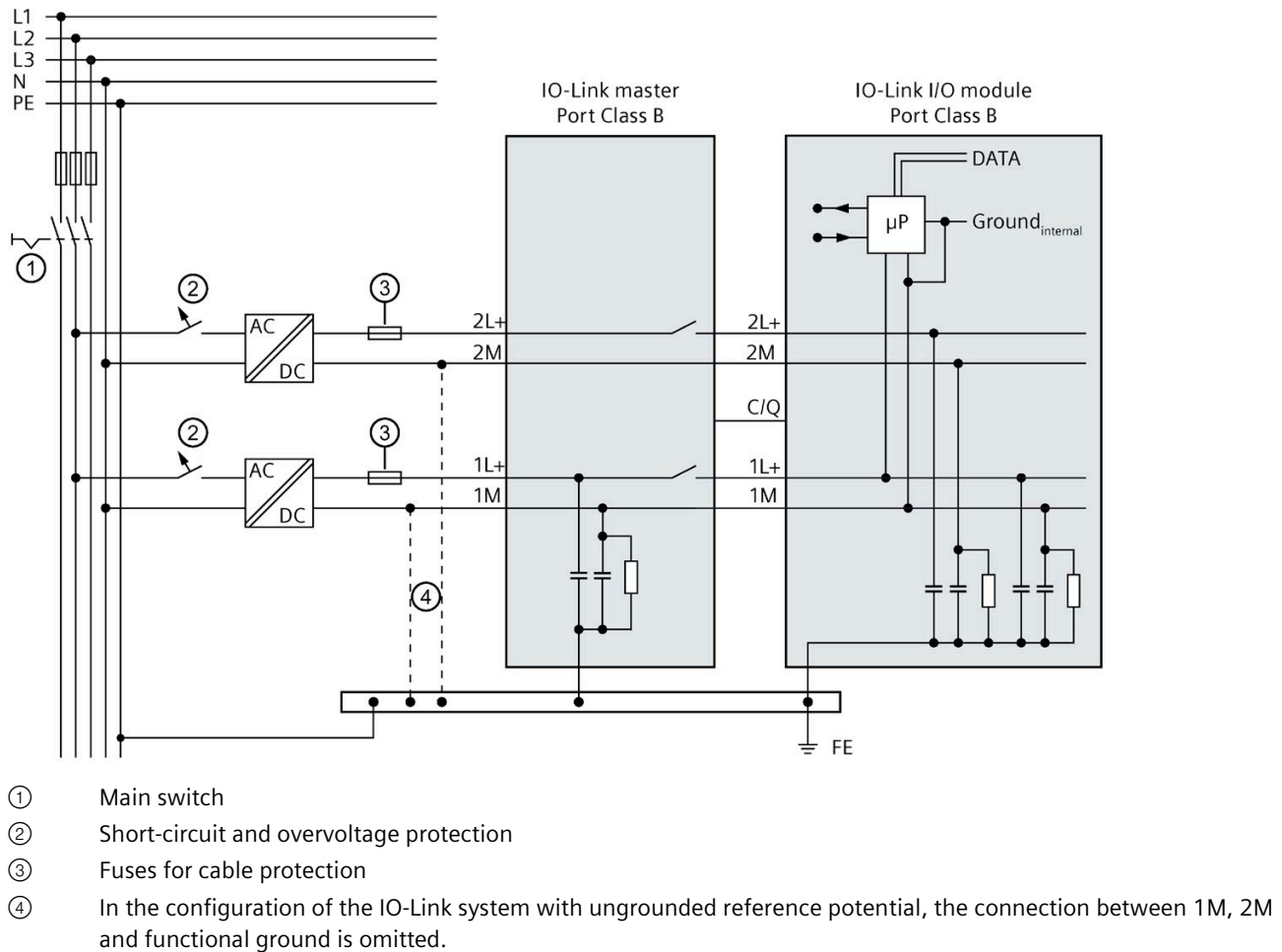


Figure 5-3 Electrical configuration of an IO-Link I/O module with port class B on an IO-Link master with port class B.



## Components and protective measures

Various components and protective measures are stipulated for setting up a complete plant. The types of components and the degree to which the protective measures are mandatory depend on the IEC regulation that applies to your plant setup.

The following table shows the components of the electrical configuration with reference to the previous figure and compares the IEC regulations.

Table 5- 1 Components of electrical configuration

|                                                              | Reference to illustration | IEC 60364 (DIN VDE 0100)                                                                                                       | IEC 60204 (DIN VDE 0113)                                         |
|--------------------------------------------------------------|---------------------------|--------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------|
| Disconnection element for controller, sensors, and actuators | ①                         | ... Part 460: Main switch                                                                                                      | ... Part 1: Disconnectors                                        |
| Short-circuit / over-load protection                         | ②                         | ... Part 725: Single-pole protection of circuits                                                                               | ... Part 1: Single-pole protection of grounded secondary circuit |
| Cable protection                                             | ③                         | ... Part 430: Protection of cables and wires against overcurrent<br>Protect all incoming supply cables with a circuit breaker. | ... Part 1: Overcurrent protection                               |

## Insulation monitoring

You must provide insulation monitoring in the following cases:

- In the configuration of the IO-Link system with ungrounded reference potential
- When hazardous system conditions may occur due to errors

## 5.3 Electrical configuration of the IO-Link I/O modules

### Electrical isolation

In the electrical configuration of the IO-Link I/O modules, there is electrical isolation between:

- IO-Link 1L+: Non-switched supply voltage (electronics/sensor/load supply):  
Electrically isolated from 2L+ (load voltage supply)
- 2L+ port class B or M12-L power connector: Switched supply voltage (load voltage supply):  
Electrically isolated from all other circuit components  
Can be switched off without affecting the IO-Link 1L+

### Connection of a digital output with a digital input

|                                                                                                                                                                                                                                                                                                                                                            |
|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>NOTICE</b>                                                                                                                                                                                                                                                                                                                                              |
| <b>Pay attention to the potential group</b><br>When a digital output is connected to a digital input, pay attention to the potential groups. Depending on the configuration, 1M and 2M may then be connected, resulting in elimination of the electrical isolation between 1L+ and 2L+. The possible compensating currents can destroy the digital module. |



### Cable protection

According to DIN VDE 0100, cable protection is required. Therefore, you must always protect the supply lines externally.

Protect the 24 V DC supply lines against short-circuits and overloads.

Select a protective device that meets the following criteria:

- Suitable for 24 V DC supply voltage
- Suitable for cable cross-section and type of installation
- Suitable for other conditions, such as temperature

## Power supply of the configuration

Up to two voltage groups are available for the ET 200AL distributed I/O system.

- 1L+ via IO-Link (supply voltage / non-switched)
- 2L+ via port class B or M12-L power connector (load voltage / switched)

---

### Note

#### Connecting and disconnecting of 1L+ IO-Link, 2L+ via port class B or M12-L power connector

Unlike the load voltage 2L+ via port class B or the M12-L power connector, the connection and disconnection of the supply voltage 1L+ during operation results in a module restart.

---

## 5.4 Connecting IO-Link I/O modules to functional ground

### Introduction

You must connect the IO-Link I/O modules to functional ground.

### What is functional ground?

All IO-Link I/O modules have a functional ground connection. This connection is used to suppress interference sensitivity, but not for protection purposes. With the functional ground connection, you establish an electrical connection to a point of your system or a shield. Electromagnetic interferences are discharged directly to ground via this connection. By discharging the electromagnetic interference, the interference immunity of the entire module is increased.

The figure below shows the symbol that is used to mark the functional ground connection on the IO-Link I/O modules.



Figure 5-4 Functional ground

### 5.4.1 Mounting IO-Link I/O modules on a conductive surface

#### Requirement

Conductive surface for mounting of the module

#### Required tool

To connect to functional ground, you need the following tool:

- Screwdriver or hexagon socket size 3

#### Required accessories:

To connect to functional ground, you need the following accessories:

- 2 x M4 fastening screws

#### Mounting

To connect the IO-Link I/O modules to functional ground in the case of a conductive mounting surface, proceed as follows:

1. Drill two fastening holes. The dimensions of the module can be found in the section Dimension drawings (Page 65).
2. Screw the module with the M4 fastening screws using a torque of 1.2 Nm.

---

#### Note

##### Grounding in the case of a conductive mounting surface

When you mount an IO-Link I/O module on a conductive, grounded surface, the lower fastening screw establishes a conductive connection to the ground potential.

Ensure that there is a low-impedance connection between the module and conductive surface as well as between the conductive surface and functional ground.

---

#### Reference

You will find more information on installing the modules in the section Mounting modules (Page 19).

## 5.4.2 Mounting IO-Link I/O modules on a non-conductive surface

### Requirement

Non-conductive surface for mounting of the module

### Required tool

To connect to functional ground, you need the following tool:

- Screwdriver or hexagon socket size 3
- Stripping tool
- Crimp tool

### Required accessories:

To connect to functional ground in the case of a non-conductive mounting surface, you need the following accessories:

- 2 x 4 mm fixing screws
- Cable lug, suitable for 4 mm screws
- Grounding cable (braided copper cable) with a minimum cross section of 4 mm<sup>2</sup>

## Mounting

To connect IO-Link I/O modules to functional ground, proceed as follows:

1. Drill two fastening holes.
2. Strip the grounding cable.
3. Fasten the cable lug to the grounding cable.
4. Screw the module and the cable lug with the 4 mm fastening screws using a torque of 1.2 Nm.

The figure below shows how to connect the functional ground.

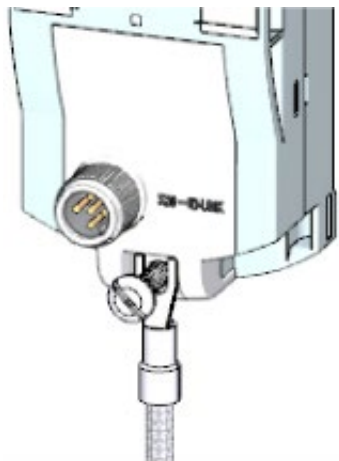


Figure 5-5 Connecting the functional ground

---

### Note

#### Grounding in the case of a non-conductive mounting surface

Make sure there is a low-impedance connection between the module and functional ground.

---

## Reference

You will find more information on installing the modules in the section Mounting modules (Page 19).

## 5.5 Wiring

### Connection

Connect all cables to the front side of the modules:

- IO-Link to the 5-pole M12 connector (A-coded)
- Signal lines to the 3-pole M8 sockets or 4/5-pole M12 sockets (A-coded)
- Additional load voltage to the 5-pole M12 plug (L-coded)

### Requirement

Wire the modules with the supply voltage off.

### Required tool

If you are not using pre-assembled cables, you need the following tool:

- Stripping tool
- Screwdriver to wire the connection plugs

### Accessories required for the connection of IO-Link

You need the following accessories:

- Cables
  - Pre-assembled cable M12, 4-pole or 5-pole, or
  - Flexible 3, 4 or 5-core copper cable (core cross-section: 0.25 to 0.5 mm<sup>2</sup>)
- 5-pole M12-A coded connecting socket

### Accessories required for the connection of additional load voltage

You need the following accessories:

- Pre-assembled power cable M12-L coded, 4-pole or 5-pole
- Flexible 4-core or 5-core copper cable (core cross-section: 0.5 to 2.5 mm<sup>2</sup>)
- 4-pole or 5-pole M12-L coded socket

### Connecting M8 connectors

To connect M8 connectors, proceed as follows:

1. Insert the plug into the respective round socket on the module.  
Ensure the correct alignment between plug and socket.
2. Tighten the connector using the knurled screw with a torque of 0.4 Nm.

The figure below shows the connection of the M8 plugs, using the example of the IO-Link digital input module DI 8x24VDC 8xM8..

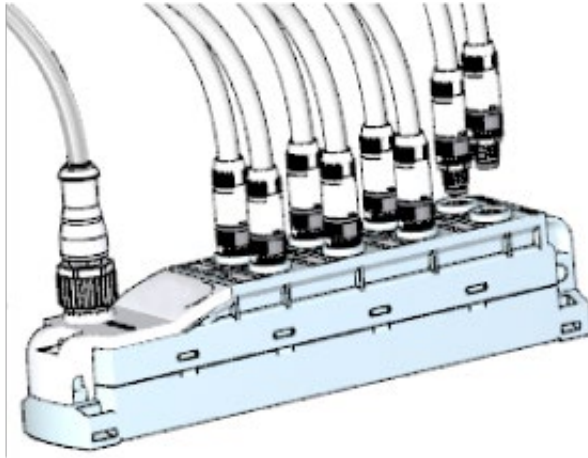


Figure 5-6 Connecting M8 connectors

### Connecting M12 connectors

To connect M12 connectors, proceed as follows:

1. Insert the plug into the respective round socket on the module.  
Ensure the correct alignment between plug and socket (groove and spring).
2. Tighten the connector using the knurled screw with a torque of 1 Nm.

The figure below shows the connection of the M12 plugs, using the example of the IO-Link digital input module DI 16x24VDC 8xM12..

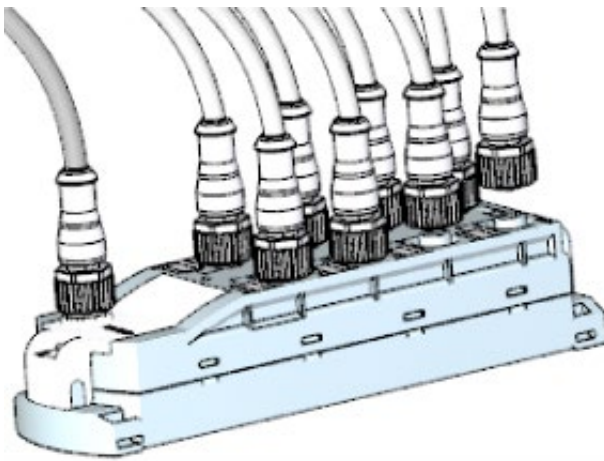


Figure 5-7 Connecting M12 connectors



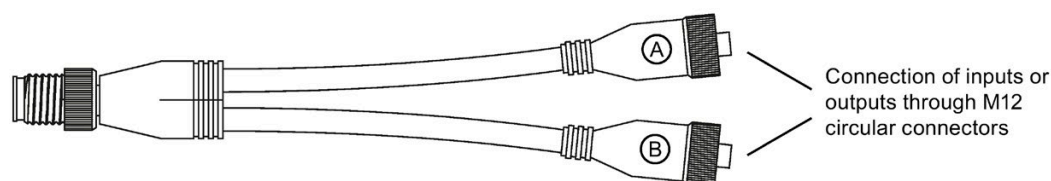
## Pin assignment of the sockets

The pin assignment of the sockets can be found in the equipment manuals of the I/O modules (<https://support.industry.siemens.com/cs/ww/en/ps/14247/man>) in the section on pin assignment and on the side surface of the module.

## Y-cable

The Y-cable allows you to connect two actuators or sensors to the inputs or outputs.

The use of a Y-cable is recommended in particular if two channels are occupied per socket of an I/O module. The Y-cable distributes the channels to two circular connectors.



The figure below shows the wiring of the Y-cable.

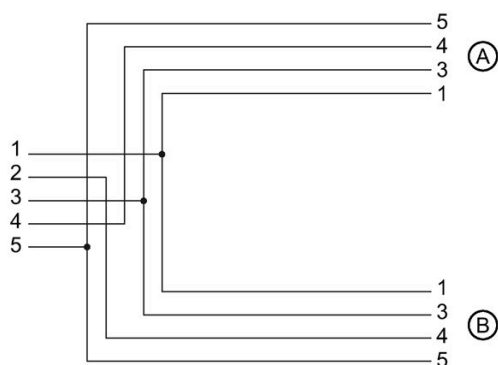


Figure 5-8 Wiring of the Y-cable

## Sealing of unused sockets

To ensure IP65 or IP67 degree of protection, seal off all unused sockets with sealing caps.

## Article numbers for accessories/spare parts.

You will find the article numbers in the Appendix in section Accessories/spare parts (Page 66).

## See also

Interface modules (<https://support.industry.siemens.com/cs/ww/en/ps/14246/man>)

## 5.6 Marking of IO-Link I/O modules

### 5.6.1 Factory markings

#### Introduction

For better orientation, the IO-Link I/O modules are furnished with various markings that support you when configuring and connecting the modules.

#### Marking of the interfaces

The interfaces of the modules are factory-labeled.

The table below shows the labeling of the interfaces.

Table 5- 2     Interface labeling

| interface                       | Labeling      |
|---------------------------------|---------------|
| IO-Link                         | X35 (IO-Link) |
| I/O input and output interfaces | X10 ... X17   |
| Additional power supply         | X80 (DC24V)   |

#### Pin assignment

The pin assignments of the various interfaces are lasered at the factory, on the side of every module.

## 5.6.2 Optional markings

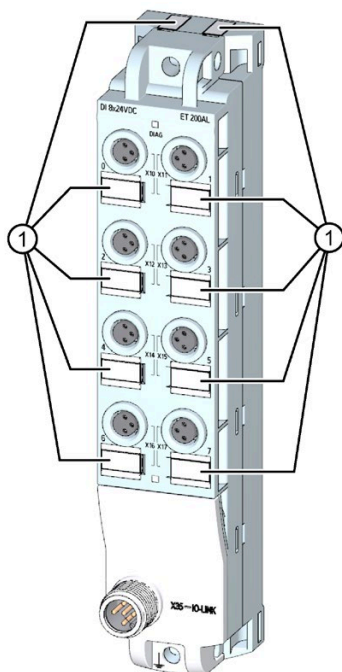
### Introduction

In addition to the factory markings, there are also optional possibilities for labeling or marking interfaces and modules on the IO-Link I/O modules.

### Identification label

The identification labels come with each IO-Link I/O module as strips and can be machine-printed. A strip has 10 identification labels measuring 10 x 5 mm in the color RAL9016. The identification labels can be inserted into every module at the points provided. The identification labels are used for channel and module labeling.

The figure below shows all points where you can use the identification labels using the example of the IO-Link digital input module module DI 8x24VDC 8xM8.



① Identification labels

Figure 5-9 Optional marking

### 5.6.3 Mounting identification labels

#### Introduction

This section describes how to mount or remove identification labels.

#### Required tools

You need a screwdriver with 3 mm blade width (only to remove identification labels).

#### Mounting procedure

To mount an identification label, proceed as follows:

1. Print the identification label using commercially available marking systems.
2. Press the identification label out of its holder.
3. Stick the identification labels into the cutouts provided, as shown in the figure *Optional marking* (Page 41).

Mounting the identification labels is the same for all modules.

#### Removal procedure

To remove an identification label, proceed as follows:

1. Carefully use a screwdriver to pull out the identification label.

Removing identification labels is the same for all modules.

# Configuring

## 6.1 Requirements

### Introduction

Configuration and parameter assignment of the IO-Link I/O modules is carried out with:

- STEP 7 (TIA Portal)
- S7-PCT
- IO-Link configuration software of the IO-Link master manufacturer

### Requirements

Observe the software requirements of the configuration software of the utilized IO-Link master.

Table 6- 1 Hardware requirements

| Hardware       | Requirements       |
|----------------|--------------------|
| IO-Link master | As of IO-Link V1.1 |

## 6.2 IODD and Port Configuration Tool - S7-PCT

### Device description IODD

An electronic device description, the IODD file (IO Device Description), is available for each device. The IODD provides a wealth of information for system integration:

- Communication properties
- Device parameters with value range and default value
- Identification, process and diagnostic data
- Device data
- Text description
- Image of the device
- Manufacturer logo

The structure of the IODD is identical for all devices from all manufacturers. The structure of the IODD is always represented in the same manner by the IO-Link configuration tools of the master manufacturer (for Siemens, S7-PCT). This ensures that the handling is the same for all IO-Link devices regardless of the manufacturer.

## IODDfinder

The IODDfinder is a cross-vendor, central IO-Link database.

This database provides you with the latest IODDs of the device manufacturers and offers an information and download platform.

The IODD finder is available on the Internet (<https://ioddfinder.io-link.com>).

## IO-Link configuration tool

Configuration tools are required to configure the entire IO-Link system. The IO-Link configuration tools of the master manufacturers are able to read IODDs.

The main tasks of the IO-Link configuration tool include:

- Assignment of devices to the master ports
- Address assignment of the ports within the address area of the master
- Parameter assignment of the IO-Link devices

Diagnostics can also be carried out on the connected devices.

This means the IO-Link configuration tool supports the transparent representation of the IO-Link system down to field level.

Siemens provides S7-PCT for engineering of the IO-Link system.

You can find the relevant device description file, software and function manuals in SIOS.  
(<https://support.industry.siemens.com/cs/ww/en/view/109737170>)

## S7-PCT with IODD of an IO-Link I/O module

The following figure shows a section from S7-PCT with IODD of an IO-Link I/O module and the device information contained therein.

Ports | Addresses | Status | I&M | Commands

### General Master Info

Product Name: ET 200eco PN; 4 IO-L; 4xM12 V1.1

Article Number: 6ES7 148-6JD00-0AB0

Comment:

### Port Info

Column Filter

| Port | Autosense                           | Mode    | Name                                | IO-Link Version | Inspection Level | Backup Level   |
|------|-------------------------------------|---------|-------------------------------------|-----------------|------------------|----------------|
| 1    | <input checked="" type="checkbox"/> | IO-Link | ET 200AL DIQ 16x24VDC/0.5A 8xM12    | V1.1            | Type compatible  | Backup&Restore |
| 2    | <input type="checkbox"/>            | IO-Link | ET 200AL DIQ 4+DQ 4x24VDC/0.5A 8xM8 | V1.1            | Type compatible  | Backup&Restore |
| 3    | <input type="checkbox"/>            | IO-Link | ET 200AL DI 16x24VDC 8xM12          | V1.1            | Type compatible  | Backup&Restore |
| 4    | <input type="checkbox"/>            | IO-Link | ET 200AL DI 8x24VDC 8xM8            | V1.1            | Type compatible  | Backup&Restore |

### Details

Vendor Name: SIEMENS AG

Vendor URL: <http://www.siemens.com/io-link>

Device Name: ET 200AL DIQ 16x24VDC/0.5A 8xM12

Description: IO-Link Digital input/output module DIQ 16x24VDC/0.5A 8xM12, Device Family SIMATIC IO Module, Release Date 2020-04-09

Article Number: 6ES7 143-5AH00-0BL0

IODD File Name: Siemens-ET200AL-DIQ16\_8xM12-20200409-IODD1.1.xml

Replaceable Device IDs:

Compatibility: The device is only compatible with the IO-Link revision 1.1.

Comment:



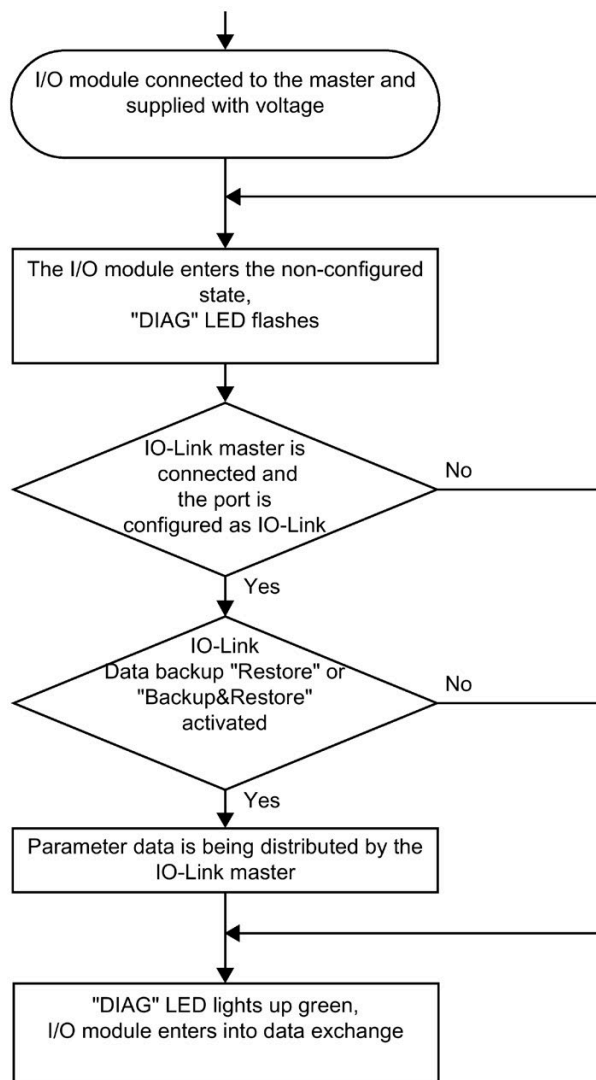

Figure 6-1 S7-PCT with IODD of a device and the device information contained therein

# Commissioning

## 7.1 Startup of the IO-Link I/O module

### Principle of operation

The figure below shows the startup of an IO-Link I/O module on an IO-Link Master schematically as a flow chart.



The "PWR" LED lights up green when the 2L+ voltage is applied.

Figure 7-1 Startup of an ET 200AL IO-Link I/O module



# Maintenance

## 8.1 Replacing modules

### Replacing IO-Link I/O modules

The replacement of a module is not permitted during ongoing operation.



#### **WARNING**

##### **Property damage can occur**

If you remove/insert modules while the power is connected, this can lead to undefined states in your system.

The IO-Link I/O module may be damaged as a result.

Only remove or replace modules when the power is disconnected.

Always comply with the required standards and safety guidelines when configuring a system.

If you use the restore function of the master, the master automatically provides the saved parameters to the new module after module replacement. You have the following setting options for module replacement:

- "Backup&Restore"  
You have set the master port to "Backup&Restore". The new module behaves like the replaced module because the master has saved the last parameter change using the backup function.
- "Restore"  
You have set the master port to "Restore". The new module applies the parameter settings that were saved in the master at the time of the last back-up.

## Procedure

To replace an IO-Link I/O module, follow these steps:

1. Ensure that no current is flowing via the outputs.
2. Completely disconnect all cables connected to the IO-Link I/O module.
3. Completely remove the fixing screws of the module
4. Replace the IO-Link I/O module.

---

### Note

#### "New" IO-Link I/O module

The removed IO-Link I/O module may only be replaced by a module of the same type.

---

5. Fasten the IO-Link I/O module with the screws with a torque of 1.2 Nm.
6. Connect all cables.
7. Turn the supply voltage on.

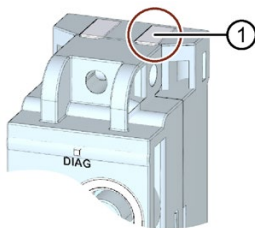
### WARNING

#### Observe the device number of the modules

If you mix up the IO-Link I/O modules when connecting them, this can cause personal injury and property damage.

We recommend that you clearly label the IO-Link I/O modules with the device number.

The figure below shows a recommendation for the marking of the IO-Link I/O modules with the device number.



- ① Recommendation for the marking of device numbers

Figure 8-1 Device number

## Result

The IO-Link I/O module that was out of service starts up again automatically. When data backup is set, the IO-Link master loads the parameter settings to the module.

## 8.2 Firmware update

### Introduction

During operation, it can become necessary to update the firmware (e.g. for function extensions).

You use a firmware update to update the module firmware.

---

**Note****STOP state during the update**

When you perform a firmware update for an IO-Link I/O module, the module goes to STOP state during the update.

---

### Requirement

To perform a FW update, you need an IO-Link master that supports the IO-Link FW update transfer mechanism.

### Option for the firmware update

You have the option of performing a firmware update online via S7-PCT.

### Reference

You will find additional information on the procedure in the "Help" > "Help topics" tab in S7-PCT. Enter "Firmware" in the search field and confirm with Enter.

## 8.3 Resetting a module

### Introduction

With "Restore Factory Setting", the IO-Link I/O module is set to the delivery condition. All information that was saved internally on the IO-Link I/O module is deleted.

### Options for resetting

You can reset the IO-Link I/O module in S7-PCT.  
You have two different possibilities for this.

- "Application Reset"
- "Restore Factory Setting"

### Result after "Application Reset"

The "Application Reset" command resets the application-specific parameters to the default values. The identification parameters of the module remain unchanged.

The command is not followed by a module restart or a communication interruption.

### Result after "Restore Factory Setting"

The "Restore Factory Setting" command causes three different actions. The actions are dependent on the data backup setting on the IO-Link master.

- "None":  
The default parameters of the IO-Link I/O module are loaded. The IO-Link I/O module performs a restart.
- "Restore":  
The saved parameters at the time of the backup are loaded. The IO-Link I/O module performs a restart.
- "Backup&Restore":  
The parameters that were in the IO-Link I/O module before the "Restore Factory Setting" command are loaded. The IO-Link I/O module performs a restart.

### Requirement

An online connection must exist to reset an IO-Link I/O device.

## Procedure using S7-PCT

Connect the PG/PC to the PROFINET IO or PROFIBUS DP interface of the IO-Link master or to your system.

Make sure that an online connection to the IO-Link I/O module exists.

1. Select an IO-Link I/O module in the project tree.
2. Select the "Parameters" tab in the work area.
3. Under "Parameters" > "Parameter Data" > "System command", click on the desired button:

- "Application Reset"
- "Restore Factory Setting"

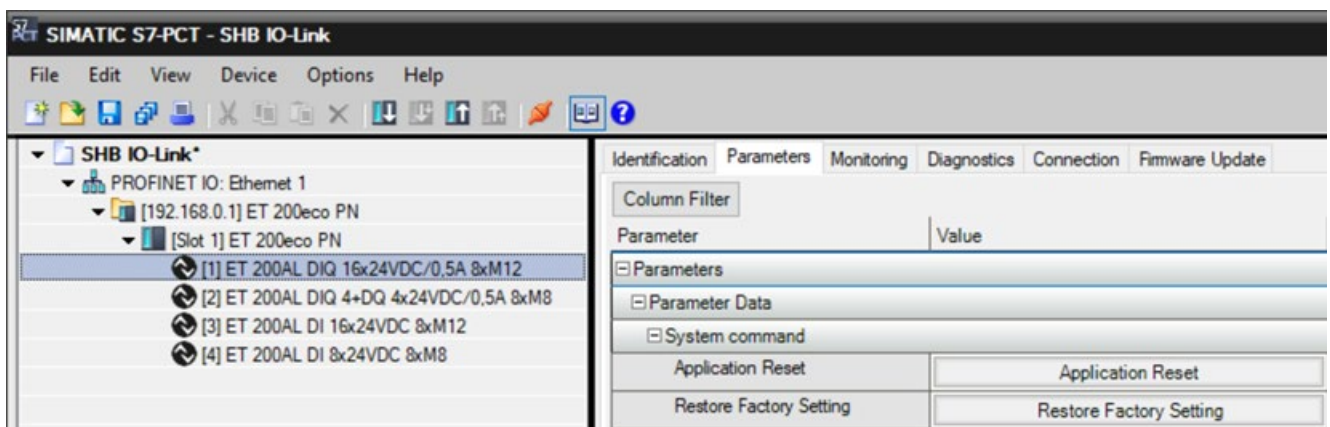


Figure 8-2 Resetting a module

**Result:** The IO-Link I/O module is reset.

## Reference

You can find more information on the procedure in the S7-PCT online help.

## 8.4 Maintaining/cleaning the modules

### Maintenance

The IO-Link I/O modules are maintenance-free.

---

#### Note

#### Repairs

Repairs to an IO-Link I/O module may only be carried out by the manufacturer.

---

### Cleaning

When wired, the IO-Link I/O modules comply with degree of protection IP65/IP67 and do not require any cleaning.

If you want to clean the modules, use a dry or damp cloth. Please take care to comply with degree of protection IP65/67 when cleaning with liquids.

# Technical specifications

## Introduction

The technical specifications of the IO-Link I/O modules are found in this section:

- Standards and test values that the IO-Link I/O modules comply with and fulfill.
- Test criteria by which the IO-Link I/O modules have been tested

## Technical specifications for the modules

The technical data of the individual modules can be found in the modules' manuals. If there are discrepancies between the statements in this document and the product manuals, the statements in the product manuals take priority.

## See also

SIOS (<https://support.industry.siemens.com>)

## 9.1 Standards and authorizations

### Currently valid markings and authorizations

---

#### Note

#### Specifications for the components of the IO-Link I/O modules

The markings and approvals currently valid are printed on the IO-Link I/O modules.

---

### CE mark



The ET 200AL IO-Link I/O modules fulfill the requirements and protection targets of the following directives. They conform to the harmonized European standards (EN) that have been published for programmable logic controllers in the Official Journal of the European Community:

- 2014/30/EU "Electromagnetic Compatibility" (EMC directive)
- 2011/65/EU "Restriction of the use of certain hazardous substances in electrical and electronic equipment" (RoHS Directive)

The EU Declarations of Conformity are available for the authorities in charge and are kept at the following address:

SIEMENS AG  
Digital Industries  
DI FA TI COS TT  
P.O. Box 1963  
D-92209 Amberg, Germany

These files are also available for download on the Customer Support Internet pages, keyword "Declaration of Conformity".

### UL approval



Underwriters Laboratories Inc. in accordance with

- UL 61010-1 and UL 61010-2-201
- CSA C22.2 No. 61010-1 and CSA C22.2 No. 61010-2-201 (Process Control Equipment)

### RCM Declaration of conformity for Australia/New Zealand



The ET 200AL IO-Link I/O modules meet the requirements of EN 61000-6-4:2007.

### Korea Certificate KCC-REM-S49-ET200



Please note that this device corresponds to limit class A with regard to the emission of radio interference. This device can be used in all areas, except residential areas.

이 기기는 업무용(A급) 전자파 적합기기로서 판매자 또는 사용자는 이 점을 주의하시기 바라며 가정 외의 지역에서 사용하는 것을 목적으로 합니다.

### Marking for the Eurasian Customs Union



EAC (Eurasian Conformity)

Customs Union of Russia, Belarus and Kazakhstan

Declaration of conformity with the technical requirements of the Customs Union (TR CU)

### IEC 61010-2-201

The ET 200AL distributed I/O system fulfills the requirements and criteria of IEC 61010-2-201.



## IEC 61131-2

The ET 200AL IO-Link I/O modules fulfill the requirements and criteria of IEC 61131-2.

## IEC 61131-9

The ET 200AL IO-Link I/O modules fulfill the requirements and criteria of the IO-Link standard IEC 61131-9.

## Marine approval

Classification societies:

- ABS (American Bureau of Shipping), coming soon
- BV (Bureau Veritas),
- CCS (China Classification Society), coming soon
- Class NK (Nippon Kaiji Kyokai), coming soon
- DNV-GL (Det Norske Veritas - Germanischer Lloyd), coming soon
- LRS (Lloyds Register of Shipping), coming soon

## Industrial use

The ET 200AL IO-Link I/O modules are designed for the industrial environment. The following standards are met for this:

- Requirements for interference emission EN 61000-6-4
- Requirements for immunity EN 61000-6-2

### Use in mixed areas

Under certain circumstances, you can use the ET 200AL IO-Link I/O modules in a mixed area. A mixed area is used for residential purposes and for commercial operations that do not significantly impact the residential purpose.

If you want to use the ET 200AL IO-Link I/O modules in a mixed area, you must ensure that its radio frequency interference emissions comply with the limits of EN 61000-6-3. Suitable measures for observing these limits for use in a mixed area are, for example:

- Use of filters in supply cables

An additional individual acceptance test is also required.

### Use in residential areas

---

#### Note

#### ET 200AL IO-Link I/O modules are not intended for use in residential areas

The ET 200AL IO-Link I/O modules are not intended for use in residential areas. Using the ET 200AL IO-Link I/O modules in residential areas can affect radio and television reception.

---

## Reference

The certificates for the markings and approvals can be found on the Internet under Service&Support (<http://www.siemens.com/automation/service&support>).

## 9.2 Electromagnetic compatibility

### Definition

Electromagnetic compatibility is the ability of an electrical apparatus to function in a satisfactory manner in its electromagnetic environment without affecting this environment.

The ET 200AL IO-Link I/O modules fulfill the requirements of the EMC law of the European Single Market. The prerequisite for this is that the ET 200AL IO-Link I/O modules comply with the requirements and guidelines regarding the electrical configuration.

### Pulse-shaped disturbance variables

The following table shows the electromagnetic compatibility of the ET 200AL IO-Link I/O modules with respect to pulse-shaped disturbance variables.

Table 9- 1 Pulse-shaped disturbance variables

| Pulse-shaped disturbance variable                                             | Tested with                     | Conforms to degree of severity |
|-------------------------------------------------------------------------------|---------------------------------|--------------------------------|
| Electrostatic discharge according to IEC 61000-4-2.                           | Air discharge: $\pm 8$ kV       | 3                              |
|                                                                               | Contact discharge: $\pm 4$ kV   | 2                              |
| Burst pulses (rapid transient disturbance values) according to IEC 61000-4-4. | $\pm 2$ kV (power supply cable) | 3                              |
|                                                                               | $\pm 1$ kV (signal line <30 m)  | 3                              |

### Sinusoidal disturbance variables

The tables below show the electromagnetic compatibility of the ET 200AL IO-Link I/O modules with respect to sinusoidal disturbance variables.

Table 9- 2 RF radiation

| RF radiation according to IEC 61000-4-3<br>Electromagnetic RF field, amplitude modulated |        | Conforms to degree of severity |
|------------------------------------------------------------------------------------------|--------|--------------------------------|
| 80 ... 1000 MHz                                                                          | 10 V/m | 3                              |
| 1.4 ... 6 GHz                                                                            | 3 V/m  | 2                              |
| 80% AM (1 kHz)                                                                           |        |                                |

Table 9- 3 RF coupling (signal and supply cables)

| RF coupling according to IEC 61000-4-6. | Conforms to degree of severity |
|-----------------------------------------|--------------------------------|
| 0.15 ... 80 MHz                         | 3                              |
| 10 V <sub>rms</sub> unmodulated         |                                |
| 80% AM (1 kHz)                          |                                |
| 150 $\Omega$ source impedance           |                                |

## Emission of radio frequency interference

The table below shows the interference emission of electromagnetic fields according to EN 55011: limit class A, group 1.

Table 9- 4 Interference emission of electromagnetic fields

| Frequency        | Interference emission | Measuring distance |
|------------------|-----------------------|--------------------|
| 30 ... 230 MHz   | <40 dB (μV/m) Q       | 10 m               |
| 230 ... 1000 MHz | <47 dB (μV/m) Q       | 10 m               |
| 1 GHz ... 3 GHz  | <76 dB (μV/m) P       | 3 m                |
| 3 GHz ... 6 GHz  | <80 dB (μV/m) P       | 3 m                |

## 24 V supply connection

The following table shows measurement ranges for low voltage according to EN 55016.

Table 9- 5 Interference emission from the power supply

| Frequency        | Interference emission        |
|------------------|------------------------------|
| 0.15 ... 0.5 MHz | 89 dB (μV) Q<br>76 dB (μV) M |
| 0.5 ... 30 MHz   | 83 dB (μV) Q<br>70 dB (μV) M |

## 9.3 Transport and storage conditions

### Transport and storage conditions

The ET 200AL IO-Link I/O modules surpass the requirements of IEC 61131-2 regarding transport and storage conditions. The following table shows the conditions that apply to modules transported or stored in their original packaging.

Table 9- 6 Transport and storage conditions

| Type of condition     | Permitted range                                                     |
|-----------------------|---------------------------------------------------------------------|
| Free fall             | ≤0.3 m                                                              |
| Temperature           | -40 °C ... +70 °C                                                   |
| Temperature variation | 20 K/h                                                              |
| Barometric pressure   | 1140 ... 660 hPa<br>(corresponds to an altitude of -1000 to 3500 m) |
| Relative humidity     | 5 ... 95%                                                           |

## 9.4 Mechanical and climatic ambient conditions

### Operating conditions

The ET 200AL IO-Link I/O modules are intended for weather-proof, stationary use.

- The operating conditions surpass the requirements of IEC 61131-2:
  - Class OTH2

You can find the values for the operating conditions in the technical specifications of the equipment manuals or on the Internet

(<https://support.industry.siemens.com/cs/de/en/view/109742718>).

### Tests for mechanical ambient conditions

The following table shows the type and scope of the tests for mechanical ambient conditions.

Table 9- 7 Tests for mechanical ambient conditions

| Condition tested | Test standard                              | Values                                                                                                                                                                                                                                                                         |
|------------------|--------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Vibrations       | Vibration test according to IEC 60068-2-6. | Type of oscillation: Frequency sweeps with a rate of change of 1 octave/minute.<br>5 Hz ... 9.1 Hz, constant amplitude 15 mm<br>9.1 Hz ... 150 Hz, constant acceleration 5 g<br>Duration of oscillation: 10 frequency sweeps per axis at each of three vertically aligned axes |
| Shock            | Shock, tested according to IEC 60068-2-27  | Type of shock: Half-sine<br>Shock intensity: 30g peak value, 18 ms duration<br>Direction of shock: 3 shocks each in $\pm$ direction in each of the 3 axes vertical to one another                                                                                              |

### Climatic ambient conditions

The following table shows the type and scope of the tests on climatic ambient conditions.

Table 9- 8 Climatic ambient conditions

| Ambient conditions      | Fields of application                    | Comments                                         |
|-------------------------|------------------------------------------|--------------------------------------------------|
| Temperature             | -30 °C ... 55 °C                         | All installation positions                       |
| Temperature variation   | 10 K/h                                   | -                                                |
| Relative humidity       | 5 ... 100%                               | With condensation                                |
| Barometric pressure     | 1140 ... 795 hPa                         | Corresponds to an altitude of -1000 m ... 2000 m |
| Pollutant concentration | ANSI/ISA-71.04 severity level G1; G2; G3 | -                                                |

## 9.5 Details on insulation, protection class, degree of protection and rated voltage

### Insulation

The insulation is designed in compliance with the requirements of IEC 61010-2-201.

#### Note

For modules with 24 V DC supply voltage (SELV/PELV), electrical isolations are tested with 707 V DC (type test).

### Protection class according to IEC 61010-2-201

- Protection class III

### Degree of severity for direct current-supplied equipment

The IO-Link I/O devices fulfill severity class PS1.

### Pollution degree / overvoltage category according to IEC 61131

- Pollution degree 3
- Overvoltage category: II

### Degree of protection IP65 and IP67

Degree of protection IP65 and IP67 according to IEC 60529 for all ET 200AL IO-Link I/O modules:

- 1. Code number: Dust-proof and complete protection from contact
- 2. Code number: Protection from water
  - IP65: Protection from water jets from any angle  
The water must not have any damaging effect.
  - IP67: Protection against temporary immersion  
The water must not enter the enclosure in harmful quantities.

### Rated voltage for operation

The following table shows the rated voltage and the corresponding tolerance with which the ET 200AL IO-Link I/O modules operate.

Table 9- 9 Rated voltage for operation

| Rated voltage (SELV/PELV) | Tolerance range    |
|---------------------------|--------------------|
| 1L+                       | 18 ... 30 V DC     |
| 2L+                       | 20.4 ... 28.8 V DC |

## 9.6 Safety-related symbols for IP65/IP67 modules

The following table contains an explanation of the symbols located on your IP65/67 modules, their packaging or in the accompanying documentation.

| Symbol                                                                                                                        | Meaning                                                                                                                                                                                                                                                                |
|-------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|                                              | General warning sign <b>Caution/Notice</b><br>You must read the product documentation. The product documentation contains information about the type of potential hazard and enables you to recognize risks and implement countermeasures.                             |
|                                              | The assigned safety symbols apply to devices <b>with Ex approval</b> .<br>You must read the product documentation. The product documentation contains information about the type of potential hazard and enables you to recognize risks and implement countermeasures. |
|                                              | Read the information provided by the product documentation.<br>ISO 7010 M002                                                                                                                                                                                           |
|                                              | Ensure the device is only installed by an electrically skilled person.<br>IEC 60417 No. 6182                                                                                                                                                                           |
| <br>CABLE SPEC.                             | Note that connected mains lines must be designed according to the expected minimum and maximum ambient temperature.                                                                                                                                                    |
| <br>EMC                                    | Note that the device must be constructed and connected in accordance with EMC regulations.                                                                                                                                                                             |
| <br>230V<br>MODULES                        | Note that a 230 V device can be exposed to electrical voltages which can be dangerous.<br>ANSI Z535.2                                                                                                                                                                  |
| <br>24V<br>MODULES                         | Note that a device of Protection Class III may only be supplied with a protective low voltage according to the standard SELV/PELV.<br>IEC 60417-1-5180 "Class III equipment"                                                                                           |
| <br>INDOOR USE ONLY<br>INDUSTRIAL USE ONLY | Be aware that the device is only approved for the industrial field and only for indoor use.                                                                                                                                                                            |

# Safety-related shutdown of ET 200AL IO-Link modules



## Introduction

The following structure describes how to shut down ET 200AL IO-Link modules in a fail-safe manner.

In the configuration shown in the diagram below (e.g. with the safety shutdown device 3SK1), all digital outputs that are connected to the 2L+ and 2M supply (24 V switched) of the ET 200AL IO-Link modules are switched to the safe OFF state. This step achieves the safety class SIL2/Category 3/PL d.

## Principle of operation

The higher-level safety shutdown device (e.g. 3SK1) disconnects the supply 2L+ and 2M switched. The digital outputs of the ET 200AL IO-Link modules operated on the 2L+ and 2M (24 V switched) supply are switched to the safe state.

There are two ways to connect the 2L+ and 2M supply voltage to an IO-Link module.

- Via the IO-Link master Port Class B
- Via the M12-L plug for the supply voltage

## Block diagram

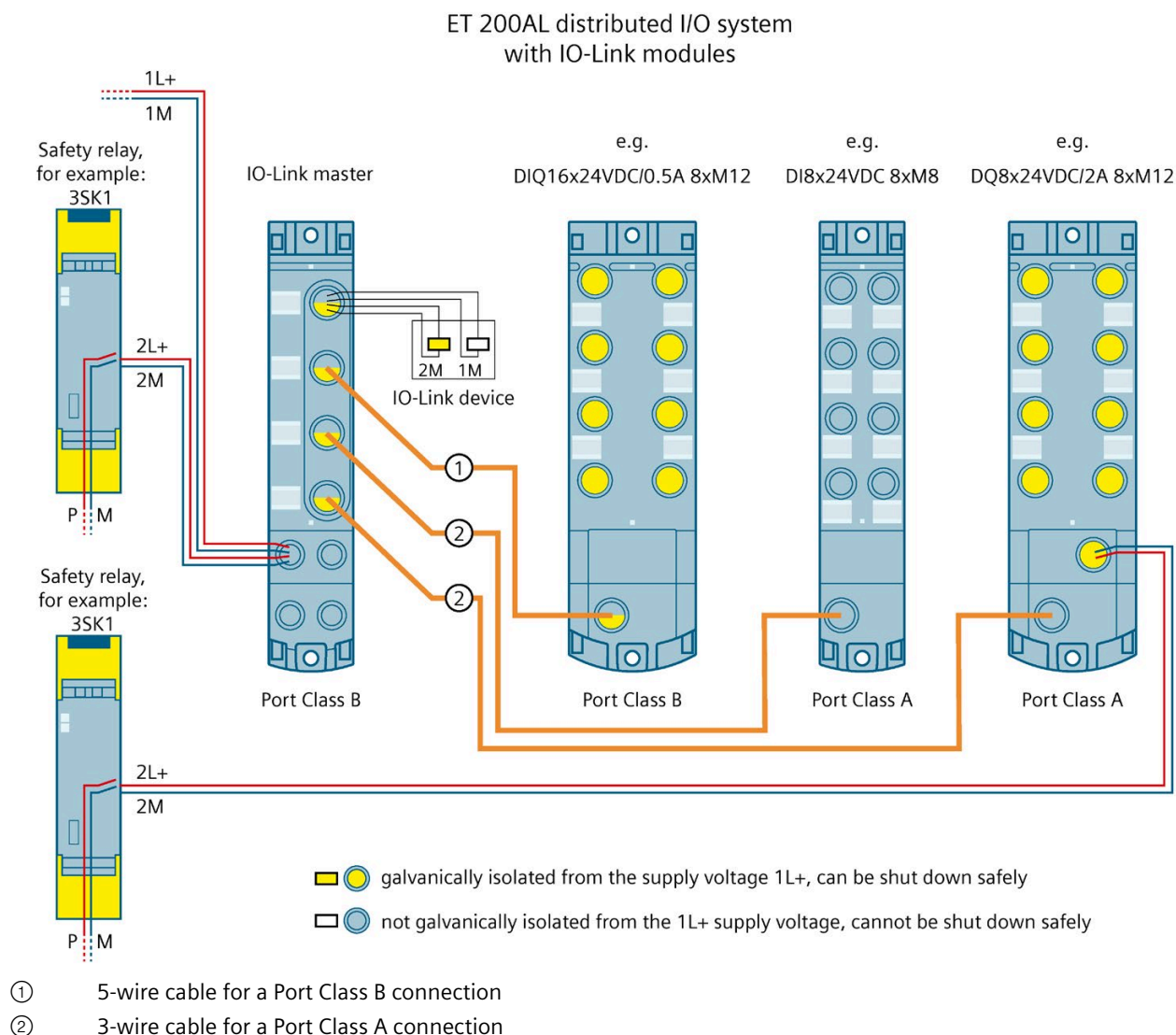


Figure A-1 Higher-level safety circuit of the outputs

### **! WARNING**

#### **Note potential groups for safety-related shutdown**

When a digital output is connected to a digital input, pay attention to the potential groups. Depending on the configuration, 1M and 2M can be connected through this, which leads to cancellation of the electrical isolation between 1L+ and 2L+. The safety-related shutdown is not permitted if the electrical isolation is canceled.



---

**Note****Safe electrical separation**

Maintain safe galvanic isolation for voltages higher than SELV/PELV.

---

---

**Note****Selection of the IO-Link master**

If the safety-related shutdown is performed via the IO-Link master, ensure that the master has the appropriate safety characteristics.

---

---

**Note****IO-Link cable**

Use a 3-wire cable for the connection of an IO-Link master with Port Class B and an IO-Link device with Port Class A.

---

## Limits of the higher-level safety circuit

The ET 200AL IO-Link modules do not perform any safety functions. Safety functions are performed by the safety relay to bring the system into a safe state.

Adjust the operation inspection interval of the safety relay with relay output according to the safety class.

Take the following measures if energy that is not provided by the higher-level safety circuit is used to control the safety function.

Cover critical errors in the safety function that are not detected by the higher-level safety circuit (e.g. 3SK1) with suitable safety measures. The "diagnostics" must be performed indirectly via the controlled process.

Specifications for safety-relevant process data:

- Functionally safe
- Read via fail-safe inputs (e.g. F-DI)
- Fail-safe processing unit (e.g. F-CPU) for issuing commands
- Output through fail-safe outputs (e.g. F-DQ) to control the safety function

## Requirements on the power supply

Operation requires a SELV/PELV power supply to limit overvoltages to L+ and M (24 V). This measure prevents possible errors from the power supply side at the same time.

Select the power supply according to the requirements of the respective operating instructions for the shutdown device and for the ET 200AL system.

You can find more information on safe SELV/PELV in the data sheets of the power supplies used.

## FAQ

Read the latest information on safety-related shutdown in the FAQ (<https://support.industry.siemens.com/cs/us/en/view/39198632>).

In this FAQ, you can find the SIMATIC standard modules that are suitable for safety-related shutdown.

## Request German Technical Inspectorate report (Report no. SN89858T)

You can request copies of the German Technical Inspectorate report at the following address:

SIEMENS AG  
Digital Industries  
DI FA TI COS TT  
P.O. Box 1963  
D-92209 Amberg, Germany

## Dimension drawings

Two module widths are available for the IO-Link I/O modules.

The figure below shows the height and width of the modules. The depth of the modules varies between 40 mm and 45 mm. Detailed information on the dimensions of the individual modules can be found in the equipment manuals for the IO-Link I/O modules in the section "Dimension drawing".

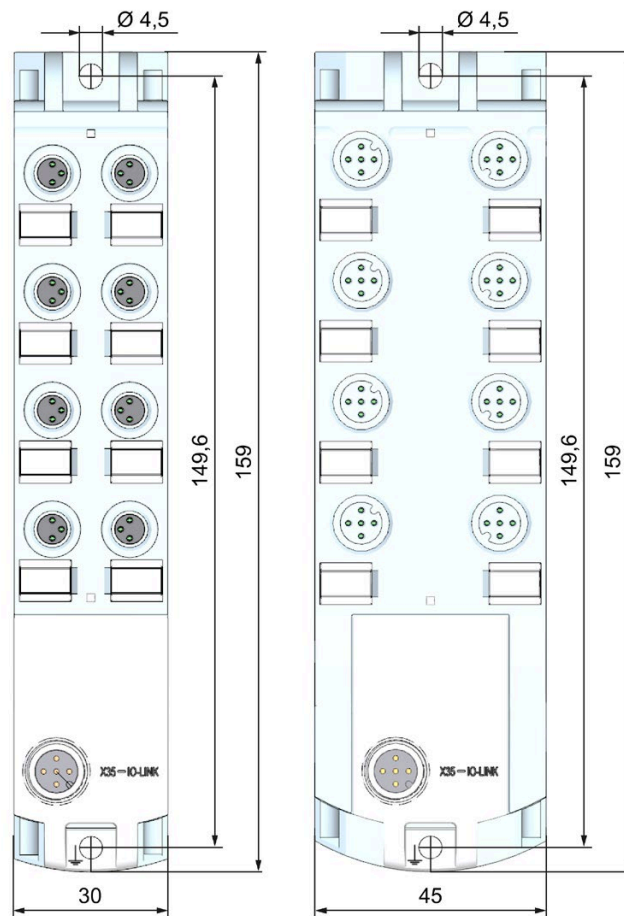


Figure B-1 Module dimension drawings (front view)

# Accessories/spare parts

## C.1 Accessories/spare parts

### Accessories for the ET 200AL IO-Link I/O modules

Table C- 1 Accessories for connection to an IO-Link master

| Designation                                                                                                               | Length | Article number |
|---------------------------------------------------------------------------------------------------------------------------|--------|----------------|
| <b>Cable is pre-assembled</b>                                                                                             |        |                |
| M12 CONNECTING CABLE, A-CODED<br>ET 200<br>Pre-assembled cable with M12 plug and M12 socket,<br>A-coded, 5-pole, 5 x 0.25 | 0.5 m  | 6XV1801-2CE50  |
|                                                                                                                           | 1.0 m  | 6XV1801-2CH10  |
|                                                                                                                           | 1.5 m  | 6XV1801-2CH15  |
|                                                                                                                           | 2.0 m  | 6XV1801-2CH20  |
|                                                                                                                           | 3.0 m  | 6XV1801-2CH30  |
|                                                                                                                           | 5.0 m  | 6XV1801-2CH50  |
|                                                                                                                           | 10.0 m | 6XV1801-2CN10  |
|                                                                                                                           | 15.0 m | 6XV1801-2CN15  |

Table C- 2 Accessories for power supply 2L+ of the DQ 8x24VDC/2A 8xM12

| Designation                                                                                                                                                                   | Length | Article number |
|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------|----------------|
| <b>Cable is pre-assembled</b>                                                                                                                                                 |        |                |
| M12 CONNECTING CABLE, L-CODED<br>Power connecting cable M12-180/M12-180 for power<br>supply of ET 200<br>Pre-assembled cable with M12 plug and M12 socket,<br>L-coded, 4-pole | 0.5 m  | 6XV1801-6DE50  |
|                                                                                                                                                                               | 1.0 m  | 6XV1801-6DH10  |
|                                                                                                                                                                               | 1.5 m  | 6XV1801-6DH15  |
|                                                                                                                                                                               | 2.0 m  | 6XV1801-6DH20  |
|                                                                                                                                                                               | 3.0 m  | 6XV1801-6DH30  |
|                                                                                                                                                                               | 5.0 m  | 6XV1801-6DH50  |
|                                                                                                                                                                               | 10.0 m | 6XV1801-6DN10  |
|                                                                                                                                                                               | 15.0 m | 6XV1801-6DN15  |
| <b>Cable and socket can be assembled in the field</b>                                                                                                                         |        |                |
| Power M12 Cable Connector PRO; M12 connector with female<br>contact insert, 4-pole, L-coded                                                                                   |        | 6GK1906-0EB00  |
| Energy cable 4 x 1.5; power cable (4-wire), by the meter, unas-<br>sembled                                                                                                    |        | 6XV1801-2B     |

Table C- 3 Dual connection

| Designation                                                                                               | Article number              |
|-----------------------------------------------------------------------------------------------------------|-----------------------------|
| SIMATIC DP, Y cable for distributed I/Os for double<br>connection of I/Os using single cable, 5-pole, M12 | 0.2 m<br>6ES7194-6KA00-0XA0 |

Table C- 4 Additional accessories

| Designation                                                                                    | Article number     |
|------------------------------------------------------------------------------------------------|--------------------|
| Identification labels 10 x 5 mm RAL9016, composed of 200 labels on frames, per frame 40 labels | 6ES7194-2BA00-0AA0 |
| Sealing cap M8 for modules IP67                                                                | 3RK1901-1PN00      |
| Sealing cap M12 for modules IP67                                                               | 3RX9802-0AA00      |

## Online catalog

Additional article numbers for the ET 200AL IO-Link I/O modules can be found on the Internet (<https://mall.industry.siemens.com>) in the online catalog and online ordering system.

## C.2 UL-approved cables

### UL-approved cables from PHOENIX CONTACT

In combination with the named cables of the manufacturer PHOENIX CONTACT, the IO-Link I/O modules of the SIMATIC ET 200AL distributed I/O system meet the requirements for UL approval.

Table C- 5 Accessories for connection to an IO-Link master

| Description                                                                                                                                                                      | Length | Designation                    | Article number |
|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------|--------------------------------|----------------|
| <b>Cable: pre-assembled 1.5 mm<sup>2</sup></b>                                                                                                                                   |        |                                |                |
| M12 CONNECTING CABLE, A-CODED<br>Sensor/actuator cable, 5-pole, PUR halogen-free, black gray RAL 7021, shielded, straight plug M12, coding: A, to straight socket M12, coding: A | 0.3 m  | SAC-5P-M12MS/ 0,3-PUR/M12FS SH | 1500884        |
|                                                                                                                                                                                  | 0.6 m  | SAC-5P-M12MS/ 0,6-PUR/M12FS SH | 1500897        |
|                                                                                                                                                                                  | 1.5 m  | SAC-5P-M12MS/ 1,5-PUR/M12FS SH | 1500907        |
|                                                                                                                                                                                  | 3.0 m  | SAC-5P-M12MS/ 3,0-PUR/M12FS SH | 1500910        |
| <b>Cable: Socket - open end 1.5 mm<sup>2</sup></b>                                                                                                                               |        |                                |                |
| M12 CONNECTING CABLE, A-CODED<br>Sensor/actuator cable, 5-pole, PUR halogen-free, black gray RAL 7021, shielded, free cable end, to straight socket M12, coding: A               | 1.5 m  | SAC-5P-1,5-PUR/M12FS SH        | 1682935        |
|                                                                                                                                                                                  | 3.0 m  | SAC-5P-3,0-PUR/M12FS SH        | 1682948        |
|                                                                                                                                                                                  | 5.0 m  | SAC-5P-5,0-PUR/M12FS SH        | 1682951        |
|                                                                                                                                                                                  | 10.0 m | SAC-5P-10,0-PUR/M12FS SH       | 1500758        |

Table C- 6 Accessories for DI/DQ connection

| Description                                                                                                                                    | Length | Designation                 | Article number |
|------------------------------------------------------------------------------------------------------------------------------------------------|--------|-----------------------------|----------------|
| <b>Cable: pre-assembled 0.25 mm<sup>2</sup></b>                                                                                                |        |                             |                |
| M8 CONNECTING CABLE, straight<br>Sensor/actuator cable, 3-pole, PUR halogen-free, black gray RAL 7021, straight plug M8, to straight socket M8 | 0.3 m  | SAC-3P-M 8MS/ 0,3-PUR/M 8FS | 1681907        |
|                                                                                                                                                | 0.6 m  | SAC-3P-M 8MS/ 0,6-PUR/M 8FS | 1681910        |
|                                                                                                                                                | 1.5 m  | SAC-3P-M 8MS/ 1,5-PUR/M 8FS | 1681923        |
|                                                                                                                                                | 3.0 m  | SAC-3P-M 8MS/ 3,0-PUR/M 8FS | 1681936        |

Table C- 7 Accessories for additional power supply

| Description                                                                                                                                                  | Length | Designation               | Article number |
|--------------------------------------------------------------------------------------------------------------------------------------------------------------|--------|---------------------------|----------------|
| <b>Cable: pre-assembled 2.5 mm<sup>2</sup></b>                                                                                                               |        |                           |                |
| M12 CONNECTING CABLE, L-CODED<br>Power cable, 4-pole, PUR halogen-free, black gray RAL 7021, straight plug M12, coding: L, to straight socket M12, coding: L | 0.3 m  | SAC-4P-M12MSL/0,3-PUR/FSL | 1425081        |
|                                                                                                                                                              | 0.6 m  | SAC-4P-M12MSL/0,6-PUR/FSL | 1425082        |
|                                                                                                                                                              | 1.5 m  | SAC-4P-M12MSL/1,5-PUR/FSL | 1425083        |
|                                                                                                                                                              | 3.0 m  | SAC-4P-M12MSL/3,0-PUR/FSL | 1425084        |
| <b>Cable: Socket - open end 2.5 mm<sup>2</sup></b>                                                                                                           |        |                           |                |
| M12 CONNECTING CABLE, L-CODED<br>Power cable, 4-pole, PUR halogen-free, black gray RAL 7021, straight socket M12, coding: L, to free cable end               | 5.0 m  | SAC-4P-5,0-PUR/M12FSL     | 1425075        |
|                                                                                                                                                              | 10.0 m | SAC-4P-10,0-PUR/M12FSL    | 1425076        |
| <b>Cable: pre-assembled 1.5 mm<sup>2</sup></b>                                                                                                               |        |                           |                |
| M12 CONNECTING CABLE, L-CODED<br>Power cable, 4-pole, PUR halogen-free, black gray RAL 7021, straight plug M12, coding: L, to straight socket M12, coding: L | 0.3 m  | SAC-4P-M12MSL/0,3-105/FSL | 1425041        |
|                                                                                                                                                              | 0.6 m  | SAC-4P-M12MSL/0,6-105/FSL | 1425042        |
|                                                                                                                                                              | 1.5 m  | SAC-4P-M12MSL/1,5-105/FSL | 1425043        |
|                                                                                                                                                              | 3.0 m  | SAC-4P-M12MSL/3,0-105/FSL | 1425044        |
| <b>Cable: Socket - open end 1.5 mm<sup>2</sup></b>                                                                                                           |        |                           |                |
| M12 CONNECTING CABLE, L-CODED<br>Power cable, 4-pole, PUR halogen-free, black gray RAL 7021, straight socket M12, coding: L, to free cable end               | 5.0 m  | SAC-4P-5,0-105/M12FSL     | 1425035        |
|                                                                                                                                                              | 10.0 m | SAC-4P-10,0-105/M12FSL    | 1425036        |

## UL-approved cables from Siemens

In combination with the named cables for the connection of DI/DQ of the manufacturer Siemens, the IO-Link I/O modules of the SIMATIC ET 200AL distributed I/O devices meet the requirements for UL approval.

Table C- 8 Accessories for DI/DQ connection

| Designation                                                                                                                                 | Length | Article number |
|---------------------------------------------------------------------------------------------------------------------------------------------|--------|----------------|
| <b>Pre-assembled cables and connectors</b>                                                                                                  |        |                |
| Power connecting cable M12-180/M12-180 for power supply of ET 200, pre-assembled cable with M12 plug and M12 socket, A-coded, 5-pole        | 0.3 m  | 6XV1801-5DE30  |
|                                                                                                                                             | 0.5 m  | 6XV1801-5DE50  |
|                                                                                                                                             | 1.0 m  | 6XV1801-5DH10  |
|                                                                                                                                             | 1.5 m  | 6XV1801-5DH15  |
|                                                                                                                                             | 2.0 m  | 6XV1801-5DH20  |
|                                                                                                                                             | 3.0 m  | 6XV1801-5DH30  |
|                                                                                                                                             | 5.0 m  | 6XV1801-5DH50  |
|                                                                                                                                             | 10.0 m | 6XV1801-5DN10  |
|                                                                                                                                             | 15.0 m | 6XV1801-5DN15  |
| Power connecting cable M12-90/M12-90 for power supply of ET 200, pre-assembled cable with M12 plug and M12 socket, A-coded, 5-pole          | 0.3 m  | 6XV1801-5GE30  |
|                                                                                                                                             | 0.5 m  | 6XV1801-5GE50  |
|                                                                                                                                             | 1.0 m  | 6XV1801-5GH10  |
|                                                                                                                                             | 1.5 m  | 6XV1801-5GH15  |
|                                                                                                                                             | 2.0 m  | 6XV1801-5GH20  |
|                                                                                                                                             | 3.0 m  | 6XV1801-5GH30  |
|                                                                                                                                             | 5.0 m  | 6XV1801-5GH50  |
|                                                                                                                                             | 10.0 m | 6XV1801-5GN10  |
|                                                                                                                                             | 15.0 m | 6XV1801-5GN15  |
| Robust power connecting cable M12-180/M12-180 for power supply of ET 200, pre-assembled cable with M12 plug and M12 socket, A-coded, 5-pole | 1.0 m  | 6XV1801-5AH10  |
|                                                                                                                                             | 2.0 m  | 6XV1801-5AH20  |
|                                                                                                                                             | 3.0 m  | 6XV1801-5AH30  |
|                                                                                                                                             | 5.0 m  | 6XV1801-5AH50  |

# Glossary

## C/Q

IO-Link communication signal / switching signal

## Connection plug

Physical connection between device and cable.

## Device

Device that can send, receive or amplify data via the bus, e.g. IO device via PROFINET IO.

## Diagnostics

Monitoring functions for the detection, localization, classification, display, and further evaluation of errors, faults, and alarms. They run automatically while the system is in operation. This increases the availability of systems by reducing commissioning times and downtimes.

## Distributed I/O system

System with input and output modules that are configured on a distributed basis, far away from the CPU controlling them.

## Firmware update

Upgrading the firmware of IO-Link I/O modules, for example, after function extensions, to the latest firmware version (update).

## Ground

Conductive earth whose electrical potential can be set equal to zero at any point.

All interconnected, inactive parts of a piece of equipment that cannot accept any dangerous contact voltage, even in the event of a fault.

## Ground

Conductive earth whose electrical potential can be set equal to zero at any point.

All interconnected, inactive parts of a piece of equipment that cannot accept any dangerous contact voltage, even in the event of a fault.



**Identification data**

Information that is saved in modules and that supports the user in checking the plant configuration and locating hardware changes.

**IO-Link**

Standard for communication of actuators and sensors in the lowest field level.

**IO-Link device**

Distributed field device that is connected to an IO-Link master via an IO-Link cable.

**IO-Link I/O modules**

I/O modules that are connected to an IO-Link master and operated via an IO-Link connection.

**IO-Link master**

The IO-Link master is a module that is connected to the CPU (IO controller) via a fieldbus and to IO-Link devices via IO-Link cables. It prepares the data for/from the IO-Link devices and can back up and restore the parameters.

**Parameter assignment**

Parameter assignment is the transfer of parameters from the IO-Link master to the IO-Link I/O module.

**PELV**

Protective Extra Low Voltage = Extra low voltage connected to protective ground

**PROFINET**

PROcess Field NETwork, open Industrial Ethernet standard, which continues PROFIBUS and Industrial Ethernet. A cross-manufacturer communication, automation and engineering model, defined as an automation standard by PROFIBUS International e.V.

**PROFINET IO controller**

Device used to address connected I/O devices (e.g. distributed I/O systems). This means that: The IO controller exchanges input and output signals with assigned I/O devices. The IO controller often corresponds with the CPU in which the automation program is running.

**PROFINET IO device**

Distributed field device that can be assigned to one or more IO controllers (for example, distributed I/O system, valve terminals, frequency converters, switches).

## **PROFINET IO**

Communication concept for the realization of modular, distributed applications in the framework of PROFINET.

## **Reference potential**

Potential from which the voltages of the circuits involved are observed and/or measured.

## **S7-PCT**

**S7-Port Configuration Tool** = Siemens program for configuring IO-Link devices.

## **SELV**

Safety Extra Low Voltage

## **TIA Portal**

Totally Integrated Automation Portal

The TIA Portal is the key to the full performance capability of Totally Integrated Automation. The software optimizes operating, machine and process sequences.

# Index

## 2

24 V DC supply, 25

## A

Accessories, 66  
Ambient conditions  
    Climatic, 58  
    Mechanical, 58  
Application, 24  
Approvals, 53

## B

Burst pulses, 56

## C

Cable ties, 23  
Cables, 24  
Climatic ambient conditions, 58  
Commissioning  
    Startup on PROFIBUS DP, 46  
Components, 14  
Configuration, 13  
    Functional ground, 33  
    Power supply, 33  
Configuration software, 43  
Configuration variant  
    PROFINET IO, 16  
Configuring, 43  
Connecting  
    Conductive surface, 34  
    M12 connectors, 38  
    M8 connectors, 38  
    Non-conductive surface, 36

## D

Degree of protection, 59  
Device number, 48  
Dimension drawing  
    Modules, 65  
Drill holes, 20

## E

Electrical isolation, 32  
Electromagnetic compatibility, 56  
Electrostatic discharge, 56  
EMC, 56  
EMERGENCY-STOP device, 24  
Emission of radio frequency interference, 57  
ET 200AL  
    Area of application, 13  
ET 200AL IO-Link modules  
    Safety-related shutdown, 61

## F

Firmware update, 49  
Functional ground, 33  
Fuse, 24

## G

German Technical Inspectorate report, 64  
Grounded infeed, 26

## I

Identification label, 14, 41  
    Mounting, 42  
    Removing, 42  
Infeed  
    Grounded, 26  
    Ungrounded, 26  
Insulation, 59  
Insulation monitoring, 31  
Interface module  
    Wiring, 37  
IODD  
    Device description, 43  
IO-Link  
    Configuration tool, 44  
    Definition, 11

## L

Line voltage, 25

## M

- M12 connectors, 38
- M8 connectors, 38
- Maintenance, 47
- Marking
  - Factory, 40
  - Interfaces, 40
  - Optional, 41
- Mechanical ambient conditions, 58
- Minimum clearances, 18
- Mounting, 19
  - I/O module, 20
  - Interface module, 22
- Mounting position, 18

## O

- Overall configuration, 28

## P

- PELV, 27
- Pin assignment, 39, 40
- Port Class
  - Type B, 16
- Port classes
  - Type A, 16
- Protection class, 59
- Protective measures, 31
- Pulse-shaped disturbance variables, 56

## R

- Radio interference, 55
- Rated voltage, 59
- Reference potential
  - Grounded, 27
  - Ungrounded, 27

## S

- Safe electrical isolation, 27
- Screws, 19
- SELV, 27
- Shock, 58
- SIMATIC ET 200AL, 12
- Sinusoidal disturbance variables, 56
- Sockets, 39
- Spare parts, 66
- Standards, 53

- Switch, 24
- System conditions, 24
- System configuration
  - Grounded reference potential, 27
  - Protective measures, 31
  - Ungrounded reference potential, 27

## T

- Technical specifications
  - Standards and authorizations, 53
- Test voltage, 59
- TN-S grid, 26
- Tool, 19
- Transport and storage conditions, 57

## U

- Ungrounded infeed, 26
- Use
  - in industrial environments, 55
  - in mixed areas, 55
  - in residential areas, 55

## V

- Vibrations, 58

## W

- Wires, 24

SIEMENS



Manual

SIMATIC

ET 200SP/ET 200AL

Mixed configuration

Edition

11/2020

[support.industry.siemens.com](https://support.industry.siemens.com)

## SIMATIC

### ET 200SP/ET 200AL Mixed configuration

#### Equipment Manual

|                                 |          |
|---------------------------------|----------|
| <u>Preface</u>                  | <b>1</b> |
| <u>Documentation guide</u>      | <b>2</b> |
| <u>Product overview</u>         | <b>3</b> |
| <u>Application planning</u>     | <b>4</b> |
| <u>Mounting</u>                 | <b>5</b> |
| <u>Connecting</u>               | <b>6</b> |
| <u>Configuring</u>              | <b>7</b> |
| <u>Technical specifications</u> | <b>8</b> |

## Legal information

### Warning notice system

This manual contains notices you have to observe in order to ensure your personal safety, as well as to prevent damage to property. The notices referring to your personal safety are highlighted in the manual by a safety alert symbol, notices referring only to property damage have no safety alert symbol. These notices shown below are graded according to the degree of danger.

|                                                                                                        |
|--------------------------------------------------------------------------------------------------------|
|  <b>DANGER</b>        |
| indicates that death or severe personal injury <b>will</b> result if proper precautions are not taken. |
|  <b>WARNING</b>       |
| indicates that death or severe personal injury <b>may</b> result if proper precautions are not taken.  |
|  <b>CAUTION</b>       |
| indicates that minor personal injury can result if proper precautions are not taken.                   |
| <b>NOTICE</b>                                                                                          |
| indicates that property damage can result if proper precautions are not taken.                         |

If more than one degree of danger is present, the warning notice representing the highest degree of danger will be used. A notice warning of injury to persons with a safety alert symbol may also include a warning relating to property damage.

### Qualified Personnel

The product/system described in this documentation may be operated only by **personnel qualified** for the specific task in accordance with the relevant documentation, in particular its warning notices and safety instructions. Qualified personnel are those who, based on their training and experience, are capable of identifying risks and avoiding potential hazards when working with these products/systems.

### Proper use of Siemens products

Note the following:

|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |
|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|  <b>WARNING</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                   |
| Siemens products may only be used for the applications described in the catalog and in the relevant technical documentation. If products and components from other manufacturers are used, these must be recommended or approved by Siemens. Proper transport, storage, installation, assembly, commissioning, operation and maintenance are required to ensure that the products operate safely and without any problems. The permissible ambient conditions must be complied with. The information in the relevant documentation must be observed. |

### Trademarks

All names identified by ® are registered trademarks of Siemens AG. The remaining trademarks in this publication may be trademarks whose use by third parties for their own purposes could violate the rights of the owner.

### Disclaimer of Liability

We have reviewed the contents of this publication to ensure consistency with the hardware and software described. Since variance cannot be precluded entirely, we cannot guarantee full consistency. However, the information in this publication is reviewed regularly and any necessary corrections are included in subsequent editions.

# Table of contents

|          |                                                        |           |
|----------|--------------------------------------------------------|-----------|
| <b>1</b> | <b>Preface .....</b>                                   | <b>4</b>  |
| <b>2</b> | <b>Documentation guide .....</b>                       | <b>6</b>  |
| <b>3</b> | <b>Product overview .....</b>                          | <b>11</b> |
| 3.1      | BaseUnit BU-Send .....                                 | 11        |
| 3.1.1    | Product overview .....                                 | 11        |
| 3.2      | BusAdapter BA-Send 1xFC .....                          | 13        |
| 3.2.1    | Properties .....                                       | 13        |
| 3.2.2    | Wiring and schematic circuit diagram .....             | 15        |
| 3.2.3    | Diagnostics by means of LED display .....              | 16        |
| <b>4</b> | <b>Application planning .....</b>                      | <b>17</b> |
| <b>5</b> | <b>Mounting .....</b>                                  | <b>21</b> |
| <b>6</b> | <b>Connecting .....</b>                                | <b>22</b> |
| 6.1      | Connecting BaseUnit BU-Send .....                      | 22        |
| <b>7</b> | <b>Configuring .....</b>                               | <b>27</b> |
| <b>8</b> | <b>Technical specifications .....</b>                  | <b>30</b> |
| 8.1      | Technical specifications BaseUnit BU-Send .....        | 30        |
| 8.2      | Technical specifications BusAdapter BA-Send 1xFC ..... | 31        |



# Preface

## Purpose of the documentation

This manual supplements the system manuals ET 200SP distributed I/O system and ET 200AL distributed I/O system.

Functions that generally relate to the system are described in these system manuals.

The information provided in this manual and in the system/function manuals supports you in commissioning the system.

## Conventions

**CPU:** When the term "CPU" is used in the following, it applies to the CPUs of the S7-1500 automation system as well as to the CPUs/interface modules of the ET 200SP and ET 200AL distributed I/O systems.

**STEP 7:** In this documentation, "STEP 7" is used as a synonym for all versions of the configuration and programming software "STEP 7 (TIA Portal)".

Also observe notes marked as follows:

---

### Note

A note contains important information on the product described in the documentation, on the handling of the product and on the section of the documentation to which particular attention should be paid.

---

## Recycling and disposal

For environmentally friendly recycling and disposal of your old equipment, contact a certified electronic waste disposal company and dispose of the equipment according to the applicable regulations in your country.

Siemens provides products and solutions with industrial security functions that support the secure operation of plants, systems, machines and networks.

In order to protect plants, systems, machines and networks against cyber threats, it is necessary to implement – and continuously maintain – a holistic, state-of-the-art industrial security concept. Siemens' products and solutions constitute one element of such a concept.

Customers are responsible for preventing unauthorized access to their plants, systems, machines and networks. Such systems, machines and components should only be connected to an enterprise network or the internet if and to the extent such a connection is necessary and only when appropriate security measures (e.g. firewalls and/or network segmentation) are in place.

For additional information on industrial security measures that may be implemented, please visit (<https://www.siemens.com/industrialsecurity>).

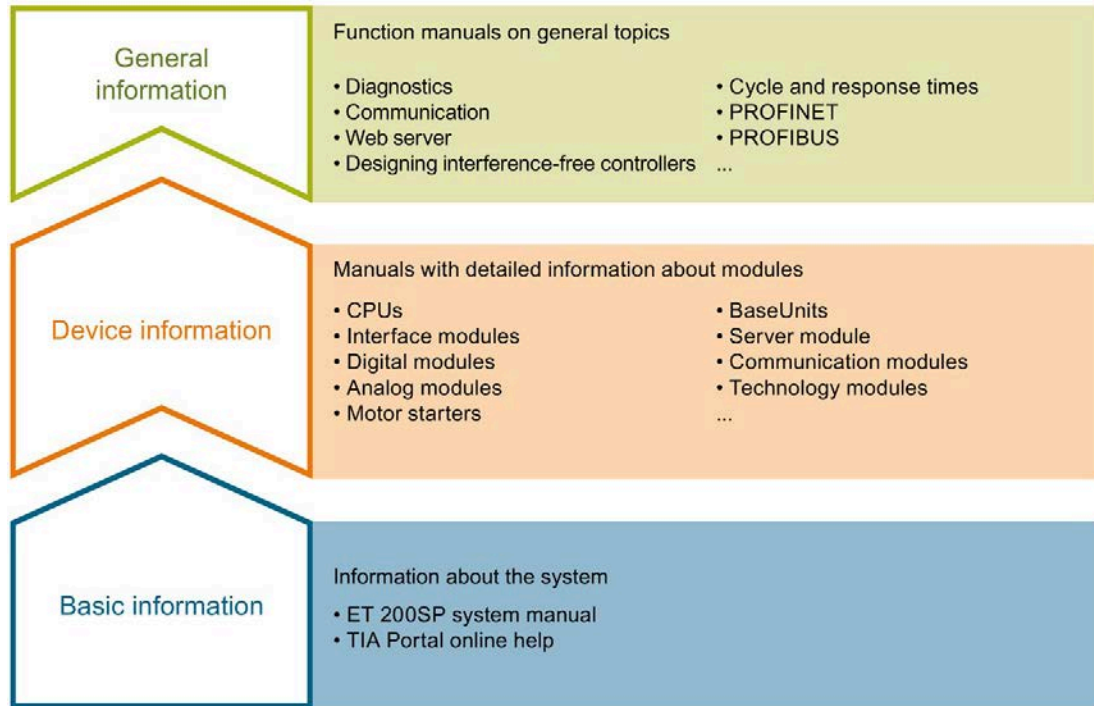
Siemens' products and solutions undergo continuous development to make them more secure. Siemens strongly recommends that product updates are applied as soon as they are available and that the latest product versions are used. Use of product versions that are no longer supported, and failure to apply the latest updates may increase customers' exposure to cyber threats.

To stay informed about product updates, subscribe to the Siemens Industrial Security RSS Feed visit (<https://www.siemens.com/industrialsecurity>).

# Documentation guide

The documentation for the SIMATIC ET 200SP distributed I/O system is arranged into three areas.

This arrangement enables you to access the specific content you require.



## Basic information

The System Manual and Getting Started describe in detail the configuration, installation, wiring and commissioning of the SIMATIC ET 200SP distributed I/O system. The STEP 7 online help supports you in the configuration and programming.

## Device information

Product manuals contain a compact description of the module-specific information, such as properties, wiring diagrams, characteristics and technical specifications.

### General information

The function manuals contain detailed descriptions on general topics regarding the SIMATIC ET 200SP distributed I/O system, e.g. diagnostics, communication, Web server, motion control and OPC UA.

You can download the documentation free of charge from the Internet (<http://w3.siemens.com/mcms/industrial-automation-systems-simatic/en/manual-overview/tech-doc-et200/Pages/Default.aspx>).

Changes and supplements to the manuals are documented in a Product Information.

You can download the product information free of charge from the Internet (<https://support.industry.siemens.com/cs/us/en/view/73021864>).

### Manual Collection ET 200SP

The Manual Collection contains the complete documentation on the SIMATIC ET 200SP distributed I/O system gathered together in one file.

You can find the Manual Collection on the Internet (<http://support.automation.siemens.com/WW/view/en/84133942>).

### "mySupport"

With "mySupport", your personal workspace, you make the best out of your Industry Online Support.

In "mySupport", you can save filters, favorites and tags, request CAx data and compile your personal library in the Documentation area. In addition, your data is already filled out in support requests and you can get an overview of your current requests at any time.

You must register once to use the full functionality of "mySupport".

You can find "mySupport" on the Internet (<https://support.industry.siemens.com/My/ww/en>).

### "mySupport" - Documentation

With "mySupport", your personal workspace, you make the best out of your Industry Online Support.

In "mySupport", you can save filters, favorites and tags, request CAx data and compile your personal library in the Documentation area. In addition, your data is already filled out in support requests and you can get an overview of your current requests at any time.

You must register once to use the full functionality of "mySupport".

You can find "mySupport" on the Internet.

## "mySupport" - CAx data

In the CAx data area of "mySupport", you can access the latest product data for your CAx or CAe system.

You configure your own download package with a few clicks.

In doing so you can select:

- Product images, 2D dimension drawings, 3D models, internal circuit diagrams, EPLAN macro files
- Manuals, characteristics, operating manuals, certificates
- Product master data

You can find "mySupport" - CAx data on the Internet  
(<http://support.industry.siemens.com/my/ww/en/CAxOnline>).

## Application examples

The application examples support you with various tools and examples for solving your automation tasks. Solutions are shown in interplay with multiple components in the system - separated from the focus on individual products.

You will find the application examples on the Internet  
(<https://support.industry.siemens.com/sc/ww/en/sc/2054>).

## TIA Selection Tool

With the TIA Selection Tool, you can select, configure and order devices for Totally Integrated Automation (TIA).

This tool is the successor of the SIMATIC Selection Tool and combines the known configurators for automation technology into one tool.

With the TIA Selection Tool, you can generate a complete order list from your product selection or product configuration.

You can find the TIA Selection Tool on the Internet  
(<http://w3.siemens.com/mcms/topics/en/simatic/tia-selection-tool>).

## SIMATIC Automation Tool

You can use the SIMATIC Automation Tool to perform commissioning and maintenance activities simultaneously on various SIMATIC S7 stations as a bulk operation independent of TIA Portal.

The SIMATIC Automation Tool provides a multitude of functions:

- Scanning of a PROFINET/Ethernet system network and identification of all connected CPUs
- Address assignment (IP, subnet, gateway) and station name (PROFINET device) to a CPU
- Transfer of the date and the programming device/PC time converted to UTC time to the module
- Program download to CPU
- RUN/STOP mode switchover
- CPU localization by means of LED flashing
- Reading out of CPU error information
- Reading of the CPU diagnostics buffer
- Reset to factory settings
- Firmware update of the CPU and connected modules

You can find the SIMATIC Automation Tool on the Internet.

## PRONETA

SIEMENS PRONETA (PROFINET network analysis) allows you to analyze the plant network during commissioning. PRONETA features two core functions:

- The topology overview automatically scans the PROFINET and all connected components.
- The IO check is a fast test of the wiring and the module configuration of a plant.

You can find SIEMENS PRONETA on the Internet.

## SINETPLAN

SINETPLAN, the Siemens Network Planner, supports you in planning automation systems and networks based on PROFINET. The tool facilitates professional and predictive dimensioning of your PROFINET installation as early as in the planning stage. In addition, SINETPLAN supports you during network optimization and helps you to exploit network resources optimally and to plan reserves. This helps to prevent problems in commissioning or failures during productive operation even in advance of a planned operation. This increases the availability of the production plant and helps improve operational safety.

The advantages at a glance

- Network optimization thanks to port-specific calculation of the network load
- Increased production availability thanks to online scan and verification of existing systems
- Transparency before commissioning through importing and simulation of existing STEP 7 projects
- Efficiency through securing existing investments in the long term and the optimal use of resources

You can find SINETPLAN on the Internet.

## See also

My Documentation Manager  
(<http://support.industry.siemens.com/My/ww/en/documentation>)

## Product overview

### 3.1 BaseUnit BU-Send

#### 3.1.1 Product overview

##### Article number

6ES7193-6BN00-0NE0

##### View



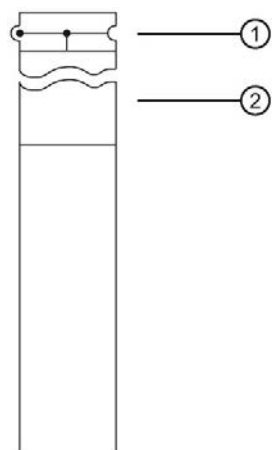
Figure 3-1 BaseUnit BU-Send

##### Properties

BaseUnit suitable for BusAdapter BA-Send 1xFC



### Schematic circuit diagram



- ① Backplane bus
- ② BA-Send 1xFC expansion module

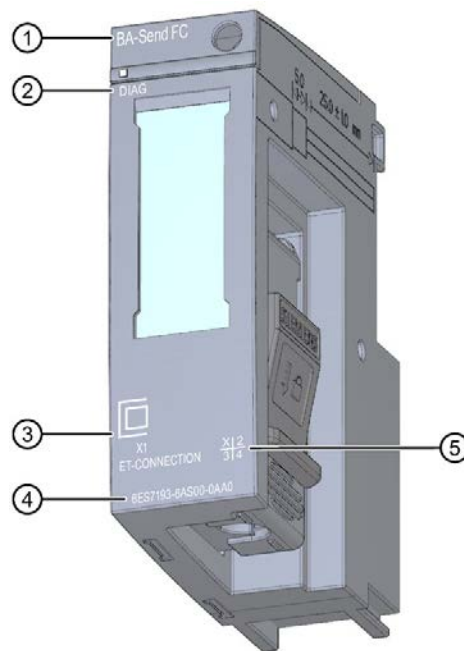
## 3.2 BusAdapter BA-Send 1xFC

### 3.2.1 Properties

#### Article number

6ES7193-6AS00-0AA0

#### View of the module



- ① Module type and name
- ② LED for diagnostics
- ③ Connection for ET-Connection
- ④ Article number
- ⑤ Functional version

Figure 3-2 View of the BusAdapter BA-Send 1xFC

## Properties

The module has the following technical properties:

- BusAdapter for the direct connection of ET-Connection
- Connects the interface module via ET-Connection with the ET 200AL I/O modules
- Supports all ET 200AL I/O modules

The module supports the following functions:

- Identification data I&M 0 to 3. See system manual ET 200SP Distributed I/O System (<https://support.industry.siemens.com/cs/ww/en/view/58649293>).

## Maximum configuration

- 16 ET 200AL I/O modules
- 15 m bus cable between BusAdapter BA Send and the first ET 200AL I/O module and between two ET 200AL I/O modules.
- Supported functions:

| Function              | Mixed configuration |     |                                       |
|-----------------------|---------------------|-----|---------------------------------------|
|                       | ET 200SP            |     | ET 200AL I/O modules on ET-Connection |
|                       | IM                  | CPU |                                       |
| Isochronous mode      | ⑥                   | --  | --                                    |
| Configuration control | ⑥                   | ⑥   | ⑥                                     |
| Shared device         | ⑥                   | ⑥   | ⑥                                     |
| PROFenergy            | ⑥                   | --  | ⑥                                     |
| System redundancy S2  | ● <sup>1</sup>      | --  | ● <sup>1</sup>                        |

<sup>1)</sup> With IM 155-6 PN/3 HF and IM 155-6 PN/2 HF V4.2 or higher

## Accessories

The following components must be ordered separately:

- Labeling strips
- Reference identification label
- Stripping tool for ET-Connection
- Bus cables for ET-Connection

## See also

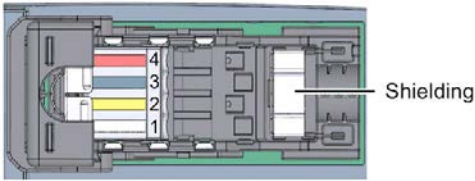
You will find additional information on accessories and the other components in the system manuals ET 200AL Distributed I/O System (<http://support.automation.siemens.com/WW/view/en/89254965>) and the Accessories/Spare parts section of the ET 200SP Distributed I/O System (<https://support.industry.siemens.com/cs/ww/en/view/58649293>) system manual.

### 3.2.2 Wiring and schematic circuit diagram

#### ET-Connection with BusAdapter BA-Send 1xFC

The following table shows the signal names and the designations for the pin assignment of the BusAdapter BA-Send 1xFC.

Table 3- 1 ET-Connection pin assignment with BusAdapter BA-Send 1xFC

| View                                                                                                                              | Signal name |      | Description     |
|-----------------------------------------------------------------------------------------------------------------------------------|-------------|------|-----------------|
| Port 1<br><br>PROFINET IO with BusAdapter BA1xFC | 1           | TD   | Transmit data + |
|                                                                                                                                   | 2           | RD   | Receive data +  |
|                                                                                                                                   | 3           | TD_N | Transmit data – |
|                                                                                                                                   | 4           | RD_N | Receive data -  |

#### Schematic circuit diagram

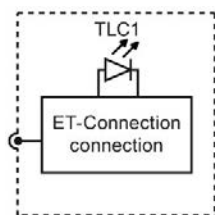


Figure 3-3 Circuit diagram BA-Send 1xFC

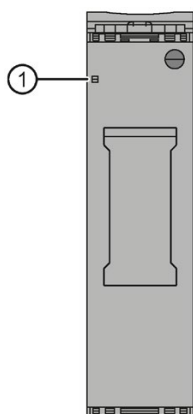
#### Additional information

You can find additional information on connecting the interface module and accessories in the *ET 200SP Distributed I/O System* system manual.

### 3.2.3 Diagnostics by means of LED display

#### LED display

The figure below shows the LED display (status and fault display) of the BusAdapter BA-Send 1xFC.



① DIAG (green/red)

Figure 3-4 LED display

#### Meaning of the LED display

The table below explains the meaning of the status and fault display.

#### DIAG LED

Table 3- 2 Status and fault display DIAG

| DIAG LED             | Meaning                                                                                                            | Remedy                                                                                                                                     |
|----------------------|--------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------|
| <div>□</div> Off     | There is no connection between the ET-Connection interface of the BusAdapter BA-Send 1xFC and the ET 200AL.        | Check whether the bus cable is interrupted.                                                                                                |
|                      | The CPU/interface module does not support the BA-Send 1xFC.                                                        | Run a firmware update.                                                                                                                     |
| <div>■</div> On      | There is a connection between the ET-Connection interface of the BusAdapter BA-Send 1xFC and the ET 200AL.         | ---                                                                                                                                        |
| <div>☀</div> Flashes | There is (at least) one diagnostics alarm of an ET-Connection device. Group error for all ET-Connection bus nodes. | Check the ET-Connection device.                                                                                                            |
|                      | Set configuration does not match the actual configuration on the ET-Connection.                                    | Check the configuration of the ET-Connection to see whether a module is missing or defective, or whether a non-configured module is wired. |

## Application planning

### Mixed configuration ET 200SP and ET 200AL with ET-Connection

You have the option of integrating the I/O modules of the ET 200AL distributed I/O system (IP65/IP67) in a configuration of the ET 200SP distributed I/O system (IP20).

The figure below shows a combination of the modules of the ET 200AL and ET 200SP distributed I/O system.

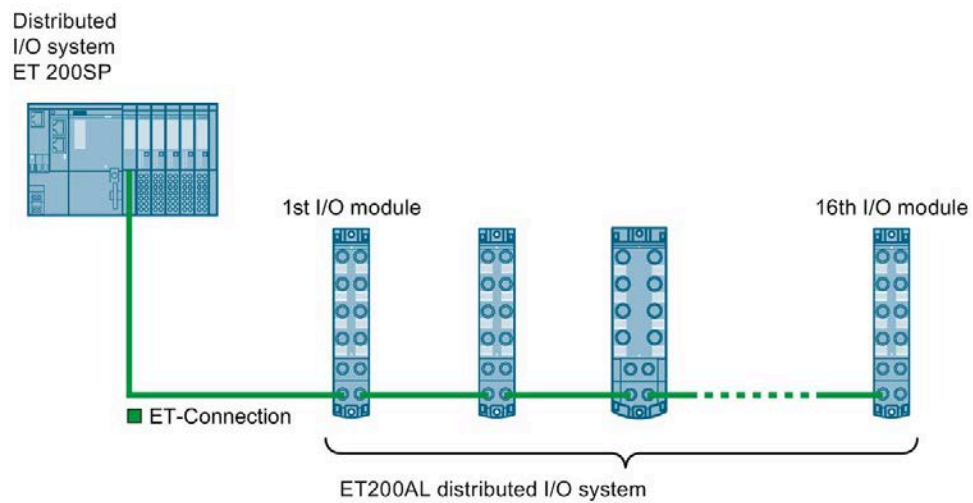


Figure 4-1 Mixed configuration ET 200SP and ET 200AL with ET-Connection

## Requirement

The following components support mixed configuration:

- Interface module
  - IM 155-6 PN HF (V3.0 or higher)
  - IM 155-6 PN/2 HF
  - IM 155-6 PN/3 HF
  - IM 155-6 PN ST (V3.1 or higher)
  - IM 155-6 DP HF (V3.0 or higher)
  - IM 155-6 MF HF
- CPU
  - CPU 1510SP-1 PN (V2.0 or higher)
  - CPU 1510SP F-1 PN (V2.0 or higher)
  - CPU 1512SP-1 PN (V2.0 or higher)
  - CPU 1512SP F-1 PN (V2.0 or higher)
  - CPU 1515SP PC
  - CPU 1515SP PC F
  - CPU 1515SP PC T
  - CPU 1515SP PC2
  - CPU 1515SP PC2 F
  - CPU 1515SP PC2 T
  - CPU 1515SP PC2 TF
- BaseUnit BU-Send with BusAdapter BA-Send 1xFC
- ET-Connection cable
- Power cable

## Rules

You must observe the following rules when assembling a mixed configuration:

- The bus length of the ET 200SP distributed I/O system must not exceed 1 m (without interface module, including BU-Send/BA-Send 1xFC and server module)
- A maximum of 16 ET 200AL I/O modules can be connected to ET-Connection
- The maximum length of the bus cable for ET-Connection between BA-Send and the first module or between two modules is 15 m

The following table shows which firmware versions of your IM or CPU support which maximum bus cable length.

| IM/CPU            | Up to 10 m     | Up to 15 m     |
|-------------------|----------------|----------------|
| IM 155-6 PN HF    | V3.0 or higher | V3.3 or higher |
| IM 155-6 PN ST    | V3.1 or higher | V3.3 or higher |
| IM 155-6 DP HF    | V3.0 or higher | --             |
| CPU 1510SP-1 PN   | V2.0 or higher |                |
| CPU 1510SP F-1 PN |                |                |
| CPU 1512SP-1 PN   |                |                |
| CPU 1512SP F-1 PN |                |                |

## Procedure

To assemble a multi-tier configuration, follow these steps:

1. Switch off the supply voltage for the ET 200SP distributed I/O system.
2. Install the BaseUnit BU-Send to the immediate right of the ET 200SP CPU/interface module. When the BaseUnit BU-Send is used next to the ET 200SP CPU, a CM DP and an Ethernet CP or a maximum of two Ethernet CPs can be inserted between the CPU and BU-Send.
3. Then mount the additional BaseUnits / I/O modules for the ET 200SP distributed I/O system and the server module.
4. Connect the bus cable for ET-Connection to the BusAdapter BA-Send 1xFC and install it on the BaseUnit BU-Send.
5. Fasten the BusAdapter BA-Send 1xFC with the BaseUnit BU-Send (1 screw with tightening torque of 0.2 Nm). To do this, use a screwdriver with a 3 to 3.5 mm blade.
6. Connect the other end of the bus cable for ET-Connection (with M8 connector) to the first ET 200AL I/O module (X30 socket ET-Connection IN).
7. Connect the supply voltage (24 V DC) to the ET 200AL I/O modules (X80 connector).

### Note

#### Firmware update of an ET 200AL I/O module

When you run a firmware update of an ET 200AL I/O module, ET-Connection is briefly interrupted by the restart of the module. All downstream ET 200AL I/O modules report a pull/plug interrupt.



---

**Note**

Insertion of theBusAdapter BA-Send 1xFC during operation leads to a restart of the interface module.

---

# Mounting

## Introduction

For the connection of the ET 200AL I/O module via ET-Connection to the ET 200SP, you require the BaseUnit BU-Send with the BusAdapter BA-Send 1xFC.

## Requirement

- The mounting rail is mounted.
- The interface module is mounted.

## Required tools

3 to 3.5 mm screwdriver (only for dismantling the BusAdapter)

## Mounting BaseUnit BU-Send

To mount the BaseUnit BU-Send, follow these steps:

1. Mount the BaseUnit BU-Send to the right of the CPU/interface module.
2. Swivel the BaseUnit back until you hear the mounting rail release latch into place.
3. Move the BaseUnit to the left until you hear it latch into place on the CPU/interface module.

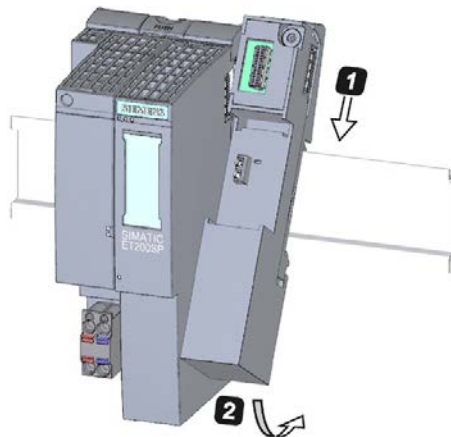


Figure 5-1 Mounting BU-Send

4. Mount the BusAdapter BA-Send 1xFC only after you have connected the bus cable for ET-Connection (see section Connecting).

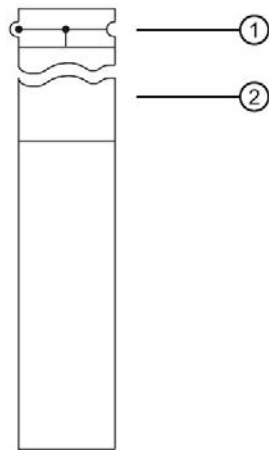
## Connecting

### 6.1 Connecting BaseUnit BU-Send

#### Pin assignment

The BaseUnit BU-Send only has one slot for an expansion module. No other connections are available.

#### Schematic circuit diagram

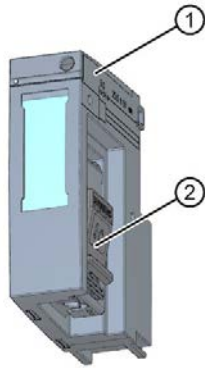


- ① Backplane bus
- ② BA-Send 1xFC expansion module

Figure 6-1 Schematic circuit diagram BU-Send

## Introduction

You connect the ET 200AL I/O modules via the BusAdapter BA-Send 1xFC via ET-Connection.



- ① BusAdapter BA-Send 1xFC
- ② Connection element for ET-Connection bus cable

Figure 6-2 BusAdapter BA-Send 1xFC

## Required tools

Screwdriver with 3 to 3.5 mm blade

## Required accessories

Use the bus cable for ET-Connection as connecting cable between the BusAdapter BA-Send 1xFC and the ET 200AL I/O modules.

We recommend using the Stripping Tool for ET-Connection (6ES7194-2KA00-0AA0) with blade cassette green (6GK1901-1B...). This guarantees fast and safe stripping.

The bus cable is available in the following versions:

### **Bus cable for ET-Connection M8, prefabricated on one side with 1x M8 connector, 4-pole, shielded**

- Length 2 m: 6ES7194-2LH20-0AC0
- Length 5 m: 6ES7194-2LH50-0AC0
- Length 10 m: 6ES7194-2LN10-0AC0
- Length 15 m: 6ES7194-2LN15-0AC0

### **Bus cable for ET-Connection M8, PUR cable, prefabricated on one side with 1x M8 connector, 4-pole, shielded**

- Length 2 m: 6ES7194-2MH20-0AC0
- Length 5 m: 6ES7194-2MH50-0AC0
- Length 10 m: 6ES7194-2MN10-0AC0
- Length 15 m: 6ES7194-2MN15-0AC0

**Procedure**

To connect the BusAdapter BA-Send 1xFC , follow these steps:

1. Strip the sheath of the bus cable at the open end as follows:

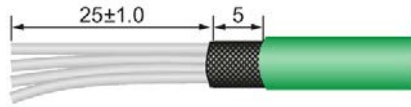
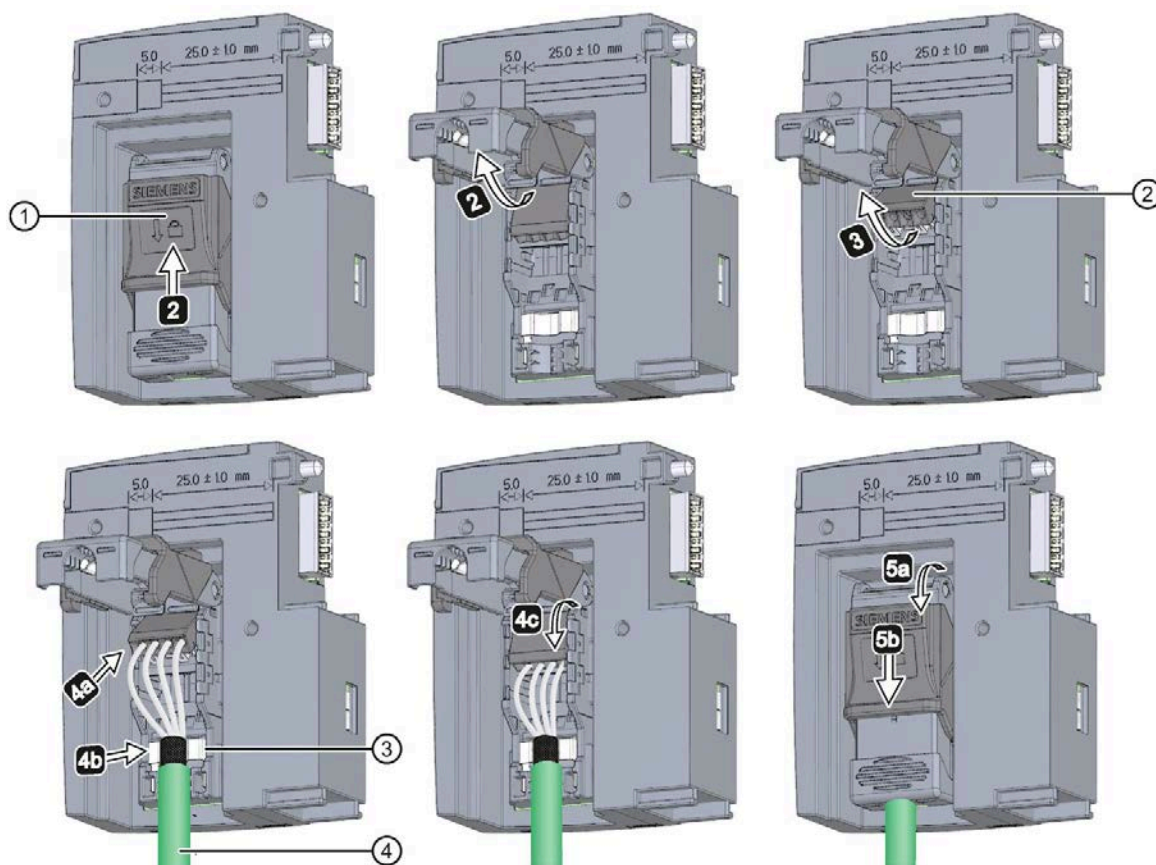


Figure 6-3 Connecting cable

Use the Stripping Tool for ET-Connection to do this. The relevant settings are shown on the tool.

2. Pull back the locking slide of the BusAdapter BA-Send 1xFC and open the cover of the connection element.
3. Lift the cable routing up as far as it will go.
4. Insert the unstripped single cores of the bus cable (according to the imprinted color coding) into the cable routing as far as they will go and press the cable routing down as far as it will go.
5. Close the cover of the connection element and push the locking slide forward.

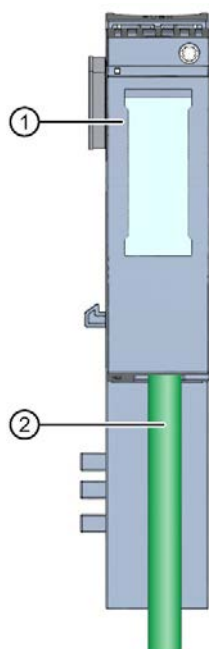
6. Insert and fasten the BusAdapter BA-Send 1xFC with the BaseUnit BU-Send (1 screw with tightening torque of 0.2 Nm). To do this, use a screwdriver with a 3 to 3.5 mm blade.
7. Connect the M8 connector of the bus cable to the first ET 200AL I/O module (socket X30 ET-Connection IN). For more information about wiring the ET 200AL I/O modules, refer to the system manual of the ET 200AL distributed I/O system.



- |   |               |   |                             |
|---|---------------|---|-----------------------------|
| ① | Locking slide | ③ | Shield contact              |
| ② | Cable routing | ④ | Bus cable for ET-Connection |

Figure 6-4 Connection of the BusAdapter BA-Send 1xFC

### BusAdapter BA-Send 1xFC mounted



- ① BusAdapter BA-Send 1xFC
- ② Bus cable for ET-Connection

Figure 6-5 BusAdapter BA-Send 1xFC mounted

# Configuring

## Introduction

The mixed configuration allows the connection of up to 16 ET 200AL I/O modules to the ET 200SP via ET-Connection. The figure below shows the configuration of the ET-Connection and the assignment of the slots.

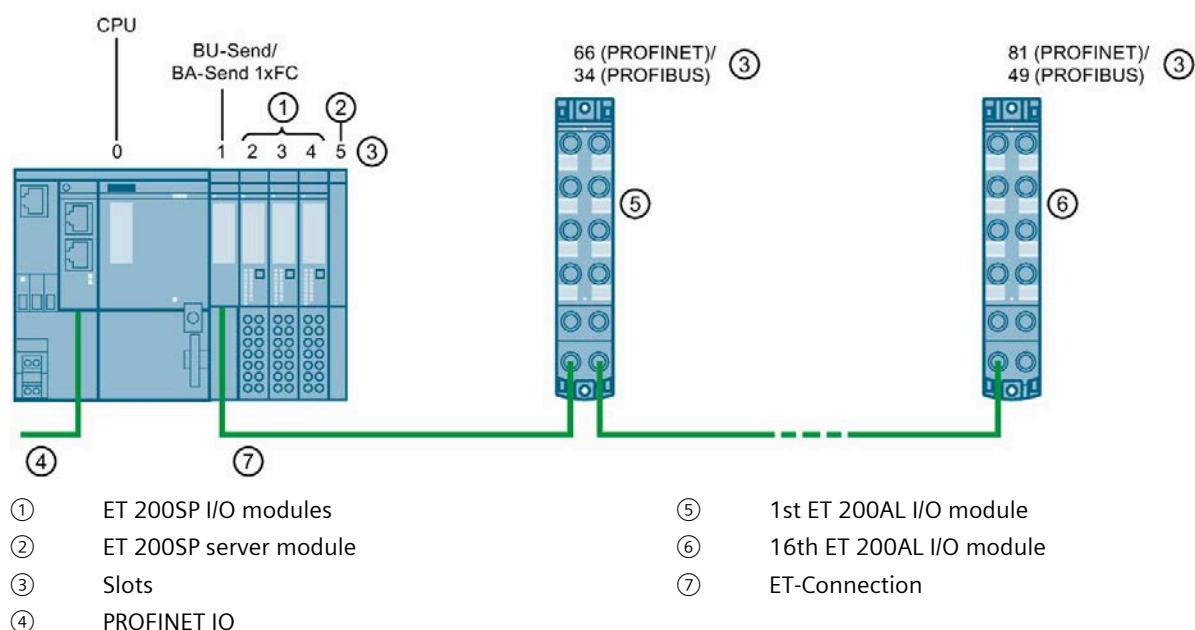


Figure 7-1 Mixed configuration

For more information about connecting ET-Connection, supply voltages, actuators and sensors, refer to the ET 200AL system manual.

## Configuration with a CPU

In a configuration with a CPU, a maximum of 2 slots can be used immediately to the right of the CPU with CM DP module or Ethernet CP. Combinations are also possible, i.e. CM DP module and one Ethernet CP or two Ethernet CPs.

BU-Send and BA-Send should always be inserted to the immediate right of the CM/CP.



## Rules

Observe the following rules when configuring:

- With mixed configurations, the following maximum configuration is possible:
  - 31 slots for ET 200SP modules (IM 155-6 DP HF and IM 155-6 PN ST)
  - 63 slots for ET 200SP modules (IM 155-6 PN HF and CPUs)
  - 16 slots for ET 200AL I/O modules
  - 1 slot for BU-Send/BA-Send 1xFC
  - 1 slot for server module.
- The mixed configuration may contain a maximum of 31 (IM 155-6 DP HF and IM 155-6 PN ST)/63 (IM 155-6 PN HF and CPUs) ET 200SP I/O modules.
- The server module can also be mounted right next to the BU-Send/BA-Send 1xFC.
- Supported functions:

| Function              | Mixed configuration |     |                                       |
|-----------------------|---------------------|-----|---------------------------------------|
|                       | ET 200SP            |     | ET 200AL I/O modules on ET-Connection |
|                       | IM                  | CPU |                                       |
| Isochronous mode      | ●                   | --  | --                                    |
| Configuration control | ●                   | ●   | ●                                     |
| Shared device         | ●                   | ●   | ●                                     |
| PROFenergy            | ●                   | --  | ●                                     |
| System redundancy S2  | ● <sup>1</sup>      | --  | ● <sup>1</sup>                        |

<sup>1)</sup> With IM 155-6 PN/3 HF and IM 155-6 PN/2 HF V4.2 or higher

## Configuring

Observe the following points when configuring:

- BU-Send/BA-Send 1xFC and server module must be configured. There are no parameters for BU-Send/BA-Send 1xFC.
- Arrangement of the modules in the configuration:
  - Configure the BU-Send/BA-Send 1xFC modules downstream from the interface module in slot 1. Position the ET 200SP modules behind it.
  - Configure the ET 200AL I/O modules from slot 66 (PROFINET)/67 (CPU)/34 (PROFIBUS).
- The layout of the modules represents a preset configuration and is independent of the configuration control.
- The system redundancy S2 function is not available in a mixed configuration.

## Configuration example

An example of a mixed configuration is shown below:

### Hardware configuration

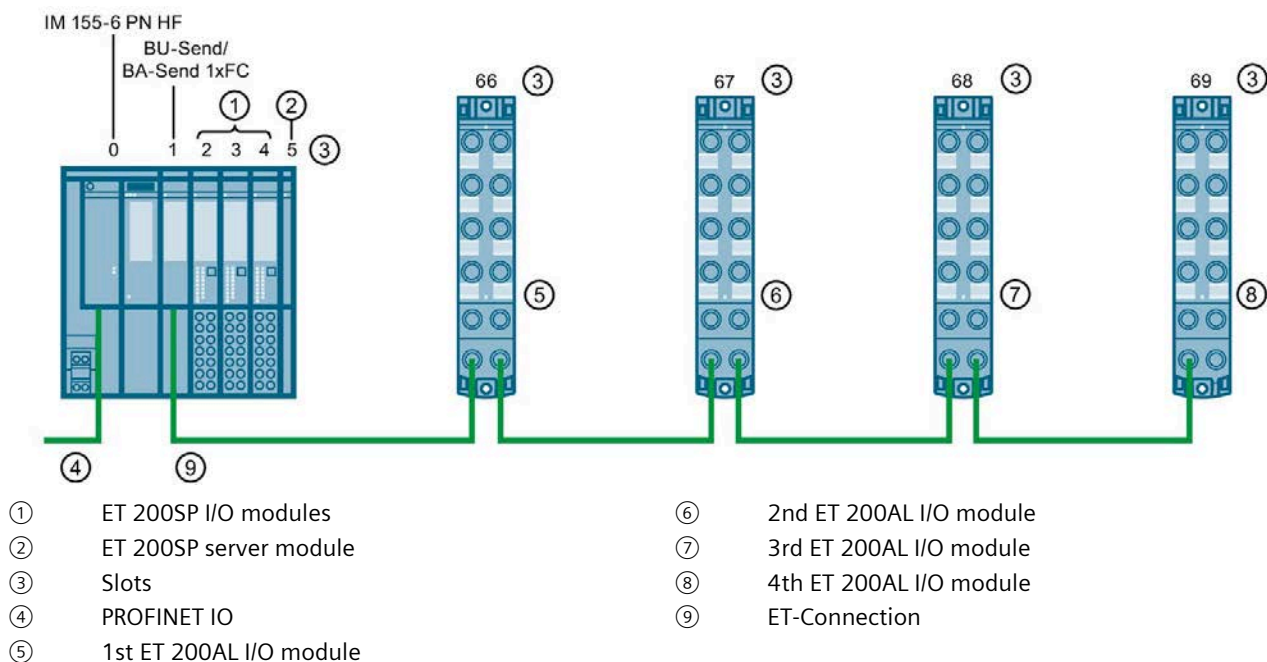


Figure 7-2 Mixed configuration

## Configuring configuration example

Table 7- 1 Overview

| Mixed configuration | Module                     | Slot |
|---------------------|----------------------------|------|
| ET 200SP            | IM 155-6 PN HF             | 0    |
|                     | BA-Send 1xFC               | 1    |
|                     | DI 16x24VDC ST             | 2    |
|                     | DI 16x24VDC ST             | 3    |
|                     | DI 16x24VDC ST             | 4    |
|                     | Server module              | 5    |
| ET 200AL            | DI 8x24VDC 8xM8            | 66   |
|                     | DIQ 4+DQ 4x24VDC/0.5A 8xM8 | 67   |
|                     | AI 4xU/I/RTD 4xM12         | 68   |
|                     | CM 4xIO-Link 4xM12         | 69   |

### Note

#### Configuration using PROFIBUS GSD file

When you use the PROFIBUS GSD file for the configuration, you must configure the gaps between the server module and the first ET 200AL I/O module with BU cover.

## Technical specifications

### 8.1 Technical specifications BaseUnit BU-Send

#### Technical specifications of the BaseUnit BU-Send

|                                                        |                                                                  |
|--------------------------------------------------------|------------------------------------------------------------------|
| Article number                                         | 6ES7193-6BN00-0NE0                                               |
| <b>General information</b>                             |                                                                  |
| HW functional status                                   | from FS04                                                        |
| <b>Ambient conditions</b>                              |                                                                  |
| <b>Ambient temperature during operation</b>            |                                                                  |
| • horizontal installation, min.                        | -30 °C                                                           |
| • horizontal installation, max.                        | 60 °C                                                            |
| • vertical installation, min.                          | -30 °C                                                           |
| • vertical installation, max.                          | 50 °C                                                            |
| <b>Altitude during operation relating to sea level</b> |                                                                  |
| • Installation altitude above sea level, max.          | 2 000 m; On request: Installation altitudes greater than 2 000 m |
| <b>Dimensions</b>                                      |                                                                  |
| Width                                                  | 20 mm                                                            |
| Height                                                 | 117 mm                                                           |
| Depth                                                  | 35 mm                                                            |
| <b>Weights</b>                                         |                                                                  |
| Weight, approx.                                        | 30 g                                                             |

## 8.2 Technical specifications BusAdapter BA-Send 1xFC

### Technical specifications of the BusAdapter BA-Send 1xFC

|                                                        |                                                                                                                   |
|--------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------|
| <b>Article number</b>                                  | <b>6ES7193-6AS00-0AA0</b>                                                                                         |
| <b>General information</b>                             |                                                                                                                   |
| Product type designation                               | BA-Send 1xFC                                                                                                      |
| HW functional status                                   | From FS05                                                                                                         |
| <b>Interfaces</b>                                      |                                                                                                                   |
| <b>Supports protocol for PROFINET IO</b>               |                                                                                                                   |
| <b>Cable length</b>                                    |                                                                                                                   |
| – Cu conductors                                        | 15 m; from IM firmware V3.3: between BA-send and the first ET-CONNECTION bus node and between all other bus nodes |
| <b>ET-Connection</b>                                   |                                                                                                                   |
| • Number of interfaces ET connection                   | 1                                                                                                                 |
| • FC (FastConnect)                                     | Yes                                                                                                               |
| <b>Ambient conditions</b>                              |                                                                                                                   |
| <b>Ambient temperature during operation</b>            |                                                                                                                   |
| • horizontal installation, min.                        | -30 °C                                                                                                            |
| • horizontal installation, max.                        | 60 °C                                                                                                             |
| • vertical installation, min.                          | -30 °C                                                                                                            |
| • vertical installation, max.                          | 50 °C                                                                                                             |
| <b>Altitude during operation relating to sea level</b> |                                                                                                                   |
| • Installation altitude above sea level, max.          | 2 000 m; On request: Installation altitudes greater than 2 000 m                                                  |
| <b>Dimensions</b>                                      |                                                                                                                   |
| Width                                                  | 20 mm                                                                                                             |
| <b>Weights</b>                                         |                                                                                                                   |
| Weight, approx.                                        | 44 g                                                                                                              |

# SIEMENS



Equipment Manual

## SIMATIC

### ET 200AL

Interface module IM 157-1 DP  
(6ES7157-1AA00-0AB0)

Edition

08/2021

[support.industry.siemens.com](https://support.industry.siemens.com)

## SIMATIC

### ET 200AL IM 157-1 DP (6ES7157-1AA00-0AB0)

#### Equipment Manual

#### Preface

#### ET 200AL Documentation Guide

**1**

#### Product overview

**2**

#### Wiring

**3**

#### Parameters

**4**

#### Interrupts, error messages, diagnostics and system alarms

**5**

#### Technical specifications

**6**

#### Dimension drawing

**A**

#### Cycle times

**B**

## Legal information

### Warning notice system

This manual contains notices you have to observe in order to ensure your personal safety, as well as to prevent damage to property. The notices referring to your personal safety are highlighted in the manual by a safety alert symbol, notices referring only to property damage have no safety alert symbol. These notices shown below are graded according to the degree of danger.

#### **DANGER**

indicates that death or severe personal injury **will** result if proper precautions are not taken.

#### **WARNING**

indicates that death or severe personal injury **may** result if proper precautions are not taken.

#### **CAUTION**

indicates that minor personal injury can result if proper precautions are not taken.

#### **NOTICE**

indicates that property damage can result if proper precautions are not taken.

If more than one degree of danger is present, the warning notice representing the highest degree of danger will be used. A notice warning of injury to persons with a safety alert symbol may also include a warning relating to property damage.

### Qualified Personnel

The product/system described in this documentation may be operated only by **personnel qualified** for the specific task in accordance with the relevant documentation, in particular its warning notices and safety instructions. Qualified personnel are those who, based on their training and experience, are capable of identifying risks and avoiding potential hazards when working with these products/systems.

### Proper use of Siemens products

Note the following:

#### **WARNING**

Siemens products may only be used for the applications described in the catalog and in the relevant technical documentation. If products and components from other manufacturers are used, these must be recommended or approved by Siemens. Proper transport, storage, installation, assembly, commissioning, operation and maintenance are required to ensure that the products operate safely and without any problems. The permissible ambient conditions must be complied with. The information in the relevant documentation must be observed.

### Trademarks

All names identified by ® are registered trademarks of Siemens AG. The remaining trademarks in this publication may be trademarks whose use by third parties for their own purposes could violate the rights of the owner.

### Disclaimer of Liability

We have reviewed the contents of this publication to ensure consistency with the hardware and software described. Since variance cannot be precluded entirely, we cannot guarantee full consistency. However, the information in this publication is reviewed regularly and any necessary corrections are included in subsequent editions.

# Preface

## Purpose of the documentation

This manual supplements the ET 200AL distributed I/O system (<https://support.industry.siemens.com/cs/ww/en/view/89254965>) system manual. Functions that are generally applicable to the ET 200AL distributed I/O system are described there.

The information provided in the present manual, the system manual and the function manuals enables you to commission the ET 200AL distributed I/O system.

## Conventions

Please also observe notes marked as follows:

---

### Note

Indicates important product information to which particular attention should be paid.

---

## Security information

Siemens provides products and solutions with industrial security functions that support the secure operation of plants, systems, machines and networks.

In order to protect plants, systems, machines and networks against cyber threats, it is necessary to implement – and continuously maintain – a holistic, state-of-the-art industrial security concept. Siemens' products and solutions constitute one element of such a concept.

Customers are responsible for preventing unauthorized access to their plants, systems, machines and networks. Such systems, machines and components should only be connected to an enterprise network or the internet if and to the extent such a connection is necessary and only when appropriate security measures (e.g. firewalls and/or network segmentation) are in place.

For additional information on industrial security measures that may be implemented, please visit (<https://www.siemens.com/industrialsecurity>).

Siemens' products and solutions undergo continuous development to make them more secure. Siemens strongly recommends that product updates are applied as soon as they are available and that the latest product versions are used. Use of product versions that are no longer supported, and failure to apply the latest updates may increase customers' exposure to cyber threats.

To stay informed about product updates, subscribe to the Siemens Industrial Security RSS Feed visit (<https://www.siemens.com/industrialsecurity>).



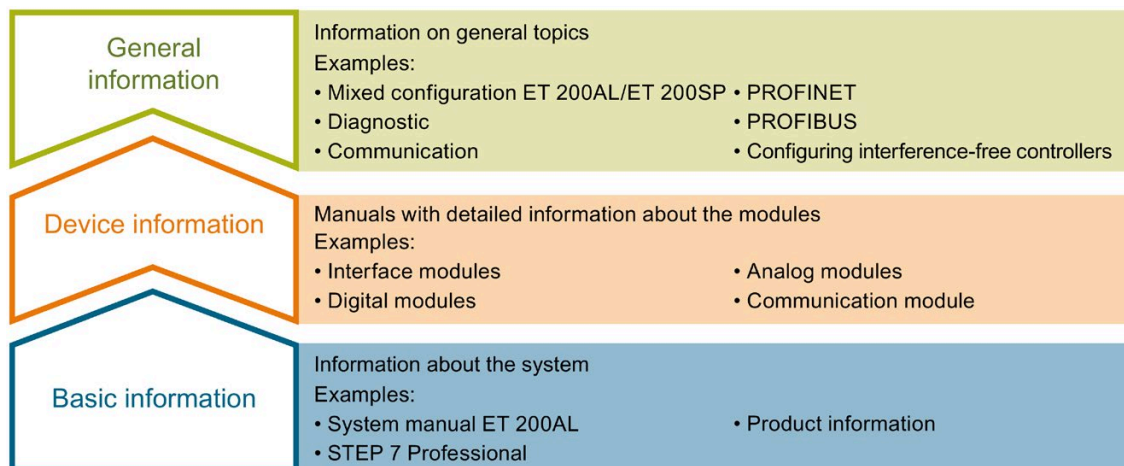
# Table of contents

|          |                                                                        |           |
|----------|------------------------------------------------------------------------|-----------|
|          | <b>Preface</b> .....                                                   | <b>3</b>  |
| <b>1</b> | <b>ET 200AL Documentation Guide</b> .....                              | <b>5</b>  |
| <b>2</b> | <b>Product overview</b> .....                                          | <b>9</b>  |
|          | 2.1 Properties .....                                                   | 9         |
|          | 2.2 Operator controls and display elements .....                       | 11        |
|          | 2.3 Functions .....                                                    | 12        |
|          | 2.3.1 PROFIBUS DP .....                                                | 12        |
|          | 2.3.2 Configuration control (option handling).....                     | 13        |
| <b>3</b> | <b>Wiring</b> .....                                                    | <b>14</b> |
|          | 3.1 Terminal and block diagram .....                                   | 14        |
|          | 3.2 Pin assignment .....                                               | 15        |
|          | 3.3 Configuring PROFIBUS DP address and terminating resistor .....     | 17        |
| <b>4</b> | <b>Parameters</b> .....                                                | <b>20</b> |
|          | 4.1 Parameters .....                                                   | 20        |
|          | 4.2 Explanation of the parameters .....                                | 20        |
| <b>5</b> | <b>Interrupts, error messages, diagnostics and system alarms</b> ..... | <b>22</b> |
|          | 5.1 Status and error displays .....                                    | 22        |
|          | 5.2 Interrupts .....                                                   | 25        |
|          | 5.2.1 Evaluating interrupts .....                                      | 25        |
|          | 5.2.2 Trigger a diagnostics interrupt .....                            | 25        |
|          | 5.2.3 Triggering a hardware interrupt .....                            | 25        |
|          | 5.2.4 Triggering an insert/remove module interrupt .....               | 26        |
|          | 5.2.5 Structure of data records .....                                  | 26        |
|          | 5.3 Alarms.....                                                        | 34        |
|          | 5.3.1 Diagnostics alarms.....                                          | 34        |
|          | 5.3.2 Slave diagnostics .....                                          | 35        |
|          | 5.3.3 Station statuses 1 to 3 .....                                    | 36        |
|          | 5.3.4 Master PROFIBUS address.....                                     | 37        |
|          | 5.3.5 Manufacturer ID .....                                            | 37        |
|          | 5.3.6 Identifier-related diagnostics.....                              | 38        |
|          | 5.3.7 Module status.....                                               | 39        |
|          | 5.3.8 Channel diagnostics.....                                         | 40        |
| <b>6</b> | <b>Technical specifications</b> .....                                  | <b>41</b> |
| <b>A</b> | <b>Dimension drawing</b> .....                                         | <b>44</b> |
| <b>B</b> | <b>Cycle times</b> .....                                               | <b>45</b> |

# ET 200AL Documentation Guide

The documentation for the SIMATIC ET 200AL distributed I/O system is arranged into three areas.

This arrangement enables you to access the specific content you require.



## Basic information

The System Manual and Getting Started describe in detail the configuration, installation, wiring and commissioning of the SIMATIC ET 200AL distributed I/O system. The STEP 7 online help supports you in the configuration and programming.

## Device information

Product manuals contain a compact description of the module-specific information, such as properties, wiring diagrams, characteristics and technical specifications.

## General information

The function manuals contain detailed descriptions on general topics regarding the SIMATIC ET 200AL distributed I/O system, e.g. diagnostics, communication, Motion Control, Web server.

You can download the documentation free of charge from the Internet (<https://support.industry.siemens.com/cs/ww/en/view/109742667>).

## Manual Collection ET 200AL

The Manual Collection contains the complete documentation on the SIMATIC ET 200AL distributed I/O system gathered together in one file.

You can find the Manual Collection on the Internet (<https://support.automation.siemens.com/WW/view/en/95242965>).

## **"mySupport"**

With "mySupport", your personal workspace, you make the best out of your Industry Online Support.

In "mySupport", you can save filters, favorites and tags, request CAx data and compile your personal library in the Documentation area. In addition, your data is already filled out in support requests and you can get an overview of your current requests at any time.

You must register once to use the full functionality of "mySupport".

You can find "mySupport" on the Internet (<https://support.industry.siemens.com/My/ww/en>).

## **"mySupport" - Documentation**

With "mySupport", your personal workspace, you make the best out of your Industry Online Support.

In "mySupport", you can save filters, favorites and tags, request CAx data and compile your personal library in the Documentation area. In addition, your data is already filled out in support requests and you can get an overview of your current requests at any time.

You must register once to use the full functionality of "mySupport".

You can find "mySupport" on the Internet (<https://support.industry.siemens.com/My/ww/en/documentation>).

## **"mySupport" - CAx data**

In the CAx data area of "mySupport", you can access the latest product data for your CAx or CAe system.

You configure your own download package with a few clicks.

In doing so you can select:

- Product images, 2D dimension drawings, 3D models, internal circuit diagrams, EPLAN macro files
- Manuals, characteristics, operating manuals, certificates
- Product master data

You can find "mySupport" - CAx data on the Internet (<https://support.industry.siemens.com/my/ww/en/CAxOnline>).

## **Application examples**

The application examples support you with various tools and examples for solving your automation tasks. Solutions are shown in interplay with multiple components in the system - separated from the focus on individual products.

You will find the application examples on the Internet (<https://support.industry.siemens.com/cs/ww/en/ps/ae>).

## TIA Selection Tool

With the TIA Selection Tool, you can select, configure and order devices for Totally Integrated Automation (TIA).

This tool is the successor of the SIMATIC Selection Tool and combines the known configurators for automation technology into one tool.

With the TIA Selection Tool, you can generate a complete order list from your product selection or product configuration.

You can find the TIA Selection Tool on the Internet

(<https://support.industry.siemens.com/cs/ww/en/view/109767888>).

## SIMATIC Automation Tool

You can use the SIMATIC Automation Tool to perform commissioning and maintenance activities simultaneously on various SIMATIC S7 stations as a bulk operation independent of TIA Portal.

The SIMATIC Automation Tool provides a multitude of functions:

- Scanning of a PROFINET/Ethernet system network and identification of all connected CPUs
- Address assignment (IP, subnet, gateway) and station name (PROFINET device) to a CPU
- Transfer of the date and the programming device/PC time converted to UTC time to the module
- Program download to CPU
- RUN/STOP mode switchover
- CPU localization by means of LED flashing
- Reading out of CPU error information
- Reading of the CPU diagnostics buffer
- Reset to factory settings
- Firmware update of the CPU and connected modules

You can find the SIMATIC Automation Tool on the Internet

(<https://support.industry.siemens.com/cs/ww/en/view/98161300>).

## PRONETA

SIEMENS PRONETA (PROFINET network analysis) allows you to analyze the plant network during commissioning. PRONETA features two core functions:

- The topology overview automatically scans the PROFINET and all connected components.
- The IO check is a fast test of the wiring and the module configuration of a plant.

You can find SIEMENS PRONETA on the Internet

(<https://support.industry.siemens.com/cs/ww/en/view/67460624>).

## SINETPLAN

SINETPLAN, the Siemens Network Planner, supports you in planning automation systems and networks based on PROFINET. The tool facilitates professional and predictive dimensioning of your PROFINET installation as early as in the planning stage. In addition, SINETPLAN supports you during network optimization and helps you to exploit network resources optimally and to plan reserves. This helps to prevent problems in commissioning or failures during productive operation even in advance of a planned operation. This increases the availability of the production plant and helps improve operational safety.

The advantages at a glance

- Network optimization thanks to port-specific calculation of the network load
- Increased production availability thanks to online scan and verification of existing systems
- Transparency before commissioning through importing and simulation of existing STEP 7 projects
- Efficiency through securing existing investments in the long term and the optimal use of resources

You can find SINETPLAN on the Internet (<https://www.siemens.com/sinetplan>).

## Product overview

### 2.1 Properties

#### Article number

6ES7157-1AA00-0AB0

#### View of the module

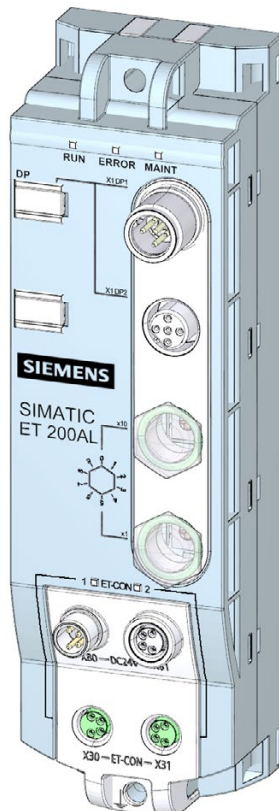


Figure 2-1 View of the IM 157-1 DP interface module

## Properties

The module has the following technical properties:

- Connects the ET 200AL distributed I/O system with PROFIBUS DP
- 24 V DC supply voltage
- Operation as DP1 slave possible
- Direct data exchange (data exchange broadcast)
- Support for 2 ET-Connection lines
- Dimensions: 45 x 159 mm

The functions supported by the module are found in the chapter Functions (Page 12).

## Maximum configuration

The module has the following maximum configuration:

- 244 bytes input data
- 244 bytes output data
- 32 I/O modules, up to 16 I/O modules can be connected for each ET-Connection line

## Accessories

The following component is included with the module in the packaging:

- Identification labels

## Other components

The following component can be ordered as spare part:

- Identification labels

The following components can be ordered as accessories:

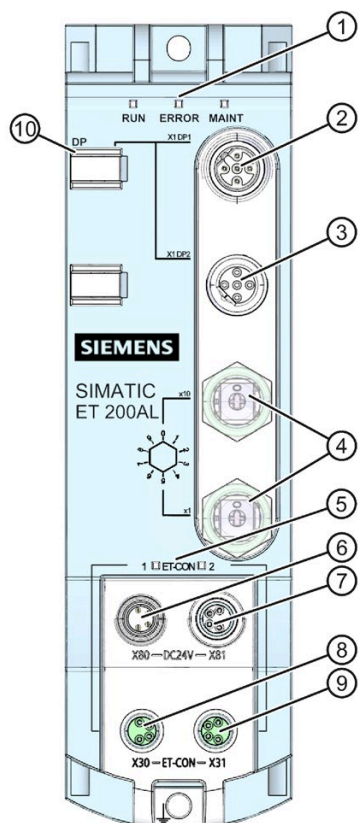
- Connectors
- Cables
- Stripping Tool for PROFIBUS
- Stripping Tool for ET-Connection
- M8 sealing cap
- M12 sealing cap

## See also

You will find additional information on accessories and the other components in the Accessories/Spare parts section of the ET 200AL Distributed I/O System (<http://support.automation.siemens.com/WW/view/en/89254965>) system manual.

## 2.2 Operator controls and display elements

The figure below shows the operator control and display elements of the interface module IM 157-1 DP.



- ① RUN, ERROR, MAINT: LED displays for the current operating status and diagnostics status
- ② X1 DP1: 1st PROFIBUS interface
- ③ X1 DP2: 2nd PROFIBUS interface
- ④ Rotary coding switch for setting the PROFIBUS address
- ⑤ ET-CON1, ET-CON2: LED displays for ET-Connection
- ⑥ X80: Connector for infeed of the supply voltage (POWER input)
- ⑦ X81: Socket for loop-through of the supply voltage (POWER output)
- ⑧ X30: Socket for ET-Connection1
- ⑨ X31: Socket for ET-Connection2
- ⑩ DP: LED displays for the current operating status of the PROFIBUS interfaces

Figure 2-2 Operator controls and display elements



## 2.3 Functions

### 2.3.1 PROFIBUS DP

#### Introduction

The interface module supports the following PROFIBUS DP functions:

- Operation as DPV0 and DPV1 slave
- Identification data I&M0 to I&M3
- Firmware update
- Configuration control by means of the user program

#### PROFIBUS DP

The PROFIBUS DP interface is used for connection to CPUs. With PROFIBUS DP you can set up extended subnets.

PROFIBUS is the network for the cell and field area in the open, manufacturer-independent communication system SIMATIC NET. Physically, PROFIBUS is an electrical network based on a shielded two-wire cable or an optical network based on a fiber optic cable.

Data transmission via PROFIBUS DP features a standardized interface (EN 50170 Vol. 2) for the transmission of process input and process output data between SIMATIC S7 and field devices (DP slaves).

The transmission behavior via PROFIBUS DP is characterized by cyclical data exchange between the DP master and the DP slaves.

#### Reference

You will find more information on PROFIBUS DP in the STEP 7 online help and in the Function Manual PROFIBUS with STEP 7 V13 (<http://support.automation.siemens.com/WW/view/en/59193579>).

## 2.3.2 Configuration control (option handling)

### Properties

Configuration control allows you to prepare your distributed I/O system for future extensions or options. Configuration control means that you can configure the planned maximum configuration of your distributed I/O system in advance and vary it later in a flexible manner by means of the user program.

### Reference

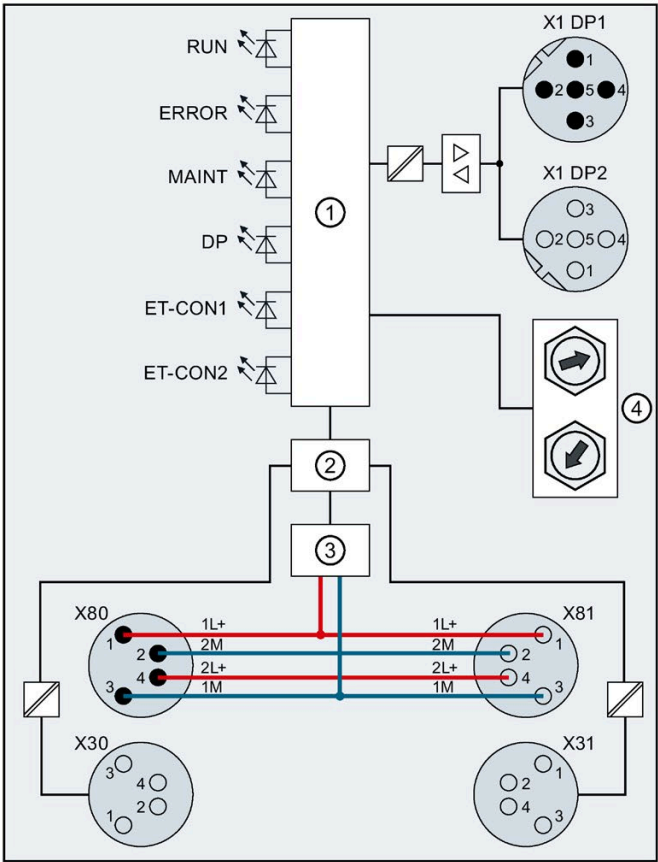
You can find more information on configuration control

- In the system manual ET 200AL Distributed I/O System (<https://support.industry.siemens.com/cs/ww/en/view/89254965>)
- On the Internet under the following link: Application collection (<https://support.industry.siemens.com/cs/ww/en/view/29430270>).
- In the STEP 7 online help.

## Wiring

### 3.1 Terminal and block diagram

The image below shows the terminal and block diagram of the IM 157-1 DP interface module.



|        |                                             |     |                                   |                  |                                 |
|--------|---------------------------------------------|-----|-----------------------------------|------------------|---------------------------------|
| ①      | Electronics                                 | 1L+ | Supply voltage 1L+ (non-switched) | RUN              | LED operating state (green)     |
| ②      | ET-Connection interface                     | 1M  | Ground 1M (non-switched)          | ERROR            | LED diagnostics status (red)    |
| ③      | Internal supply voltage                     | 2L+ | Load voltage 2L+ (switched)       | MAINT            | LED diagnostics status (yellow) |
| ④      | Rotary coding switch for PROFIBUS addresses | 2M  | Ground 2M (switched)              | DP               | PROFIBUS LED (green)            |
| X1 DP1 | 1. PROFIBUS interface                       |     |                                   | ET-CON1, ET-CON2 | ET-Connection LEDs (green)      |
| X1 DP2 | 2. PROFIBUS interface                       |     |                                   |                  |                                 |
| X80    | Infeed of supply voltages                   |     |                                   |                  |                                 |
| X81    | Loop-through of supply voltages             |     |                                   |                  |                                 |
| X30    | Infeed of the ET-Connection                 |     |                                   |                  |                                 |
| X31    | Loop-through of the ET-Connection           |     |                                   |                  |                                 |

Figure 3-1 Terminal and block diagram

## 3.2 Pin assignment

### Note

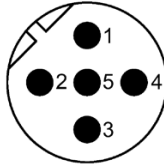
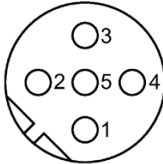
#### Color coding

The sockets for ET-Connection and the power supply of the modules are color-coded. These colors correspond to the colors of the offered cables.

### Pin assignment of the sockets for PROFIBUS

The following table shows the pin assignment of the connectors and sockets for the connection of PROFIBUS.

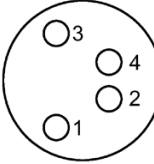
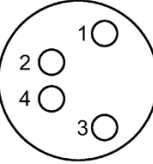
Table 3- 1 Pin assignment for PROFIBUS

| Pin                                                                                                                                                                        | Assignment                    |                                 | Front view of the connector<br>X1 DP1                                                | Front view of the socket<br>X1 DP2                                                   |
|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------|---------------------------------|--------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------|
|                                                                                                                                                                            | X1 DP1 connector<br>(feed in) | X1 DP2 Socket<br>(loop-through) |                                                                                      |                                                                                      |
| 1                                                                                                                                                                          | -                             | Supply plus P5V*                |  |  |
| 2                                                                                                                                                                          | Data cable A                  |                                 |                                                                                      |                                                                                      |
| 3                                                                                                                                                                          | Data reference potential M5*  |                                 |                                                                                      |                                                                                      |
| 4                                                                                                                                                                          | Data cable B                  |                                 |                                                                                      |                                                                                      |
| 5                                                                                                                                                                          | Functional earth FE           |                                 |                                                                                      |                                                                                      |
| Shielding                                                                                                                                                                  | Functional earth FE           |                                 |                                                                                      |                                                                                      |
| * The voltage may only be used for supplying the external terminating resistor. It is not permitted to loop-through the voltage by means of a cable to the next connector. |                               |                                 |                                                                                      |                                                                                      |

### Pin assignment of the sockets for ET-Connection

The table below shows the pin assignments of the 2 sockets for the connection of ET-Connection.

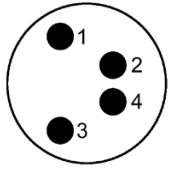
Table 3- 2 Pin assignment for ET-Connection

| Pin       | Assignment                     |                                | Assignment of the wire color of the bus line cable for ET-Connection | Front view of the sockets                                                             |                                                                                       |
|-----------|--------------------------------|--------------------------------|----------------------------------------------------------------------|---------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------|
|           | X30 socket<br>(ET-Connection1) | X31 socket<br>(ET-Connection2) |                                                                      | X30                                                                                   | X31                                                                                   |
| 1         | RXP                            | RXP                            | Yellow                                                               |  |  |
| 2         | TXP                            | TXP                            | White                                                                |                                                                                       |                                                                                       |
| 3         | TXN                            | TXN                            | Blue                                                                 |                                                                                       |                                                                                       |
| 4         | RXN                            | RXN                            | Orange                                                               |                                                                                       |                                                                                       |
| Shielding | Functional earth FE            |                                | -                                                                    |                                                                                       |                                                                                       |

### Pin assignment of the connector for infeed of the supply voltage

The following table shows the pin assignment of the connector for infeed of the supply voltage.

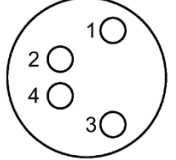
Table 3- 3 Pin assignment of the supply voltage connector

| Pin | Assignment                        | Assignment of the wire color of the power line cable | Front view of the connector                                                         |
|-----|-----------------------------------|------------------------------------------------------|-------------------------------------------------------------------------------------|
|     | X80 connector (power input)       |                                                      |                                                                                     |
| 1   | Supply voltage 1L+ (non-switched) | Brown                                                |  |
| 2   | Ground 2M (switched)              | White                                                |                                                                                     |
| 3   | Ground 1M (non-switched)          | Blue                                                 |                                                                                     |
| 4   | Load voltage 2L+ (switched)       | Black                                                |                                                                                     |

### Pin assignment of the socket for loop-through of the supply voltage

The table below shows the pin assignment of the socket for loop-through of the supply voltage.

Table 3- 4 Pin assignment of the supply voltage socket

| Pin | Assignment                        | Assignment of the wire color of the power line cable | Front view of the socket                                                              |
|-----|-----------------------------------|------------------------------------------------------|---------------------------------------------------------------------------------------|
|     | X81 Socket (power output)         |                                                      |                                                                                       |
| 1   | Supply voltage 1L+ (non-switched) | Brown                                                |  |
| 2   | Ground 2M (switched)              | White                                                |                                                                                       |
| 3   | Ground 1M (non-switched)          | Blue                                                 |                                                                                       |
| 4   | Load voltage 2L+ (switched)       | Black                                                |                                                                                       |

#### NOTICE

##### ET-Connection/supply voltage

Observe the correct wiring of the M8 sockets for ET-Connection and the supply voltage. Mixing up the ET-Connection connectors and the connectors for the supply voltage can destroy the module.

## 3.3 Configuring PROFIBUS DP address and terminating resistor

### Properties

Use the PROFIBUS address to specify at which address the ET 200AL distributed I/O system is addressed on the PROFIBUS DP.

The PROFIBUS DP address is configured for the ET 200AL distributed I/O system with a rotary coding switch on the front of the housing.

### Requirements

The following requirements apply:

- Each address is only assigned once on the PROFIBUS DP.
- The configured PROFIBUS DP address must match the PROFIBUS address defined in the configuration software.
- A change of the PROFIBUS DP address is only valid after POWER ON/POWER OFF on the IM 157-1 DP interface module.

### Required tools

You need the following tools to configure the PROFIBUS DP address:

- 14 mm socket wrench
- 2.5 mm screwdriver

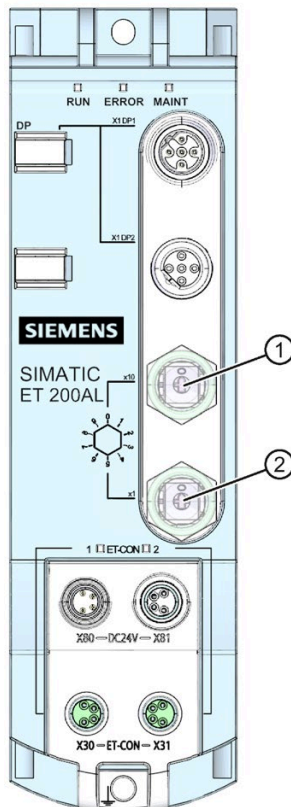
### Setting the PROFIBUS DP address

Configurable PROFIBUS DP addresses are 1 to 99.

Proceed as follows to configure the PROFIBUS DP address:

1. Remove the two M12 sealing caps from the rotary coding switches (use 14 mm socket wrench, if needed).
2. Configure the desired PROFIBUS DP address with a screwdriver on the rotary coding switches.
  - Top rotary coding switch: Tens digit
  - Bottom rotary coding switch: Ones digit
3. Screw the two M12 sealing caps back onto the thread to protect the rotary coding switches (torque: 0.5 to 0.8 Nm).
4. Switch the supply voltage off and on again (POWER OFF/POWER ON).

The figure below shows the rotary coding switches for configuring the PROFIBUS DP address.

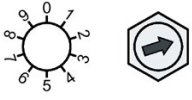
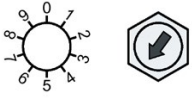


- ① Rotary coding switch for PROFIBUS DP (tens digit)
- ② Rotary coding switch for PROFIBUS DP address (ones digit)

Figure 3-2 Setting the PROFIBUS address

The following table shows how to set PROFIBUS address 26 as an example.

Table 3- 5      Setting of the PROFIBUS address

|                                                                                   |            |            |
|-----------------------------------------------------------------------------------|------------|------------|
|  | Tens digit | Position 2 |
|  | Ones digit | Position 6 |

### Connecting the terminating resistor for PROFIBUS DP

Terminate a PROFIBUS DP segment, on both of its ends, which means on the first and last device of the segment, with its characteristic impedance. There are two different terminating resistors available for this purpose, for sockets and for connectors.

The figure below shows typical use of a terminating resistor.

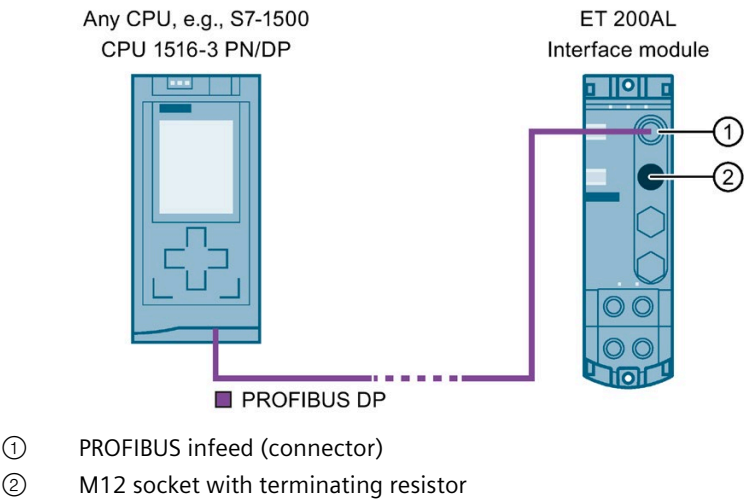


Figure 3-3      Terminating resistor



## Parameters

### 4.1 Parameters

The following table shows the parameters for the IM 157-1 DP interface module.

Table 4- 1 Parameters

| Parameters                                                          | Value range                                                               | Default <sup>2</sup> | Efficiency range |
|---------------------------------------------------------------------|---------------------------------------------------------------------------|----------------------|------------------|
| Configuration control <sup>1</sup>                                  | <ul style="list-style-type: none"> <li>Disable</li> <li>Enable</li> </ul> | Disable              | ET 200AL         |
| Startup if preset configuration does not match actual configuration | <ul style="list-style-type: none"> <li>Disable</li> <li>Enable</li> </ul> | Disable              | ET 200AL         |
| Diagnostics interrupt                                               | <ul style="list-style-type: none"> <li>Disable</li> <li>Enable</li> </ul> | Enable               | ET 200AL         |
| Hardware interrupt                                                  | <ul style="list-style-type: none"> <li>Disable</li> <li>Enable</li> </ul> | Enable               | ET 200AL         |
| Pull/plug module interrupt                                          | <ul style="list-style-type: none"> <li>Disable</li> <li>Enable</li> </ul> | Enable               | ET 200AL         |

<sup>1</sup> Note that the "Startup if preset configuration does not match actual configuration" parameter is always activated when you use configuration control.

<sup>2</sup> The defaults apply to the default startup. If no other parameters are specified by the DP master, the interface module IM 157-1 DP starts up with these parameters.

### 4.2 Explanation of the parameters

#### Configuration control

You can use this parameter to enable the configuration control function in the ET 200AL distributed I/O system.

---

#### Note

##### Configuration control

The configuration control function can only be used if you set the "Startup if preset configuration does not match actual configuration" parameter to "YES".

---

**Note****Configuring the enable**

If you configure the enable, the ET 200AL distributed I/O system requires a control data record 196 from the user program in order for the ET 200AL distributed I/O system to operate the I/O modules.

---

Additional information is available in the section Configuration control (option handling).

**Startup if preset configuration does not match actual configuration****Enabled parameter**

If the preset/actual configuration differ, **a** data exchange occurs between the DP master and the ET 200AL distributed I/O system.

**Disabled parameter**

If the preset/actual configuration differ, **no** data exchange occurs between the DP master and the ET 200AL distributed I/O system.

---

**Note****More than 16 I/O modules in real configuration per ET-Connection line**

The preset/actual configuration do not match parameter is valid for 16 I/O modules per ET-Connection line.

Up to 16 I/O modules are recognized per line. Additional I/O modules are not recognized. A diagnostics alarm is not issued for these I/O modules. All I/O modules in the actual system after the 16th I/O module remain unconfigured (LED DIAG flashes green) and are not involved in the data exchange.

---

**Diagnostics interrupt**

You can use this parameter to enable or disable diagnostics interrupts.

**Hardware interrupt**

You can use this parameter to enable or disable hardware interrupts.

**Pull/plug module interrupt**

You can use this parameter to enable or disable pull/plug module interrupts.

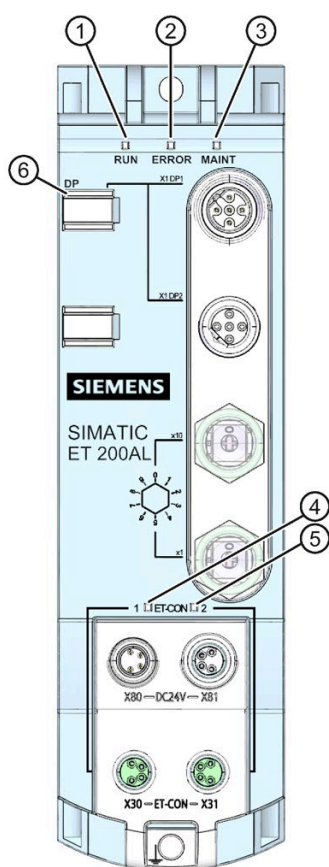
# Interrupts, error messages, diagnostics and system alarms

# 5

## 5.1 Status and error displays

### LED displays

The figure below shows the LED displays (status and error displays) of the IM 157-1 DP interface module.



- |   |         |          |
|---|---------|----------|
| ① | RUN     | (green)  |
| ② | ERROR   | (red)    |
| ③ | MAINT   | (yellow) |
| ④ | ET-CON1 | (green)  |
| ⑤ | ET-CON2 | (green)  |
| ⑥ | DP      | (green)  |

Figure 5-1 LED displays

## Meaning of the LEDs

The following tables set out the meaning of the status and error displays. Corrective measures for diagnostics alarms can be found in the section Diagnostics alarms (Page 34).

### LED RUN, LED ERROR, LED MAINT

Table 5- 1 Status and error displays of the LEDs RUN, ERROR, MAINT

| LEDs                                                                                           |                                                                                                |                                                                                                | Meaning                                                                                                    | Solution                                                                                                                                                        |
|------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------|
| RUN                                                                                            | ERROR                                                                                          | MAINT                                                                                          |                                                                                                            |                                                                                                                                                                 |
| <br>Off       | <br>Off       | <br>Off       | Supply voltage at interface module missing or too low                                                      | Check the supply voltage or switch it on on the interface module.                                                                                               |
| <br>On        | <br>On        | <br>On        | Test of LEDs during startup: The three LEDs light up simultaneously for approximately 0.25 s.              | -                                                                                                                                                               |
| <br>Flashes   | <br>Off       | <br>Off       | Interface module is deactivated.                                                                           | Activate the interface module with the configuration software or the user program.                                                                              |
|                                                                                                |                                                                                                |                                                                                                | Interface module is not configured.                                                                        | Configure the interface module with the configuration software.                                                                                                 |
|                                                                                                |                                                                                                |                                                                                                | ET 200AL starts up.                                                                                        | -                                                                                                                                                               |
|                                                                                                |                                                                                                |                                                                                                | ET 200AL is being assigned parameters.                                                                     | -                                                                                                                                                               |
| <br>On      | Not relevant                                                                                   | Not relevant                                                                                   | ET 200AL is currently exchanging data with the DP master.                                                  | -                                                                                                                                                               |
| Not relevant                                                                                   | <br>Flashes | Not relevant                                                                                   | Group error and group error channels                                                                       | Evaluate the diagnostics and eliminate the error.                                                                                                               |
|                                                                                                |                                                                                                |                                                                                                | The preset configuration does not correspond to the actual configuration of the ET 200AL.                  | Check the configuration of the ET 200AL to see whether a module is missing, defective or if a module that is not configured is connected to ET-CON1 or ET-CON2. |
|                                                                                                |                                                                                                |                                                                                                | Parameter assignment error in the I/O module                                                               | Evaluate the display of the module status in STEP 7 or in STEP 7 (TIA portal) and correct the errors in the I/O module.                                         |
| Not relevant                                                                                   | Not relevant                                                                                   | <br>On      | Maintenance is demanded.                                                                                   | Execute maintenance                                                                                                                                             |
| <br>Flashes | <br>Flashes | <br>Flashes | Hardware or firmware faulty. <sup>1</sup>                                                                  | Replace the interface module.                                                                                                                                   |
| <br>Flashes | Not relevant                                                                                   | Not relevant                                                                                   | Firmware is loading<br>(all LEDs remain in their current state while the firmware update is being written) | ---                                                                                                                                                             |

<sup>1</sup> LED DP off

## 5.1 Status and error displays

### DP LED

Table 5- 2 Status display of the DP LED

| DP LED                                                                                   | Meaning                                                                                                                     | Solution                                                      |
|------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------|
| <br>Off | There is no connection between the PROFIBUS interface of your PROFIBUS device and a communication partner (e.g. DP master). | Check whether the bus cable to the DP master is disconnected. |
| <br>On  | There is no connection between the PROFIBUS interface of your PROFIBUS device and a communication partner (e.g. DP master). | -                                                             |

### LED ET-CON1, LED ET-CON2

Table 5- 3 Status displays of the LEDs ET-CON1 and ET-CON2

| LEDs                                                                                      |         | Meaning                                                                                                       | Solution                                                                         |
|-------------------------------------------------------------------------------------------|---------|---------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------|
| ET-CON1                                                                                   | ET-CON2 |                                                                                                               |                                                                                  |
| <br>Off  |         | There are no I/O modules available at the respective ET-Connection or the modules do not have supply voltage. | Check the wiring for the ET-Connection or the supply voltage for the I/O module. |
| <br>On |         | A communications connection to at least one IO module at the corresponding ET-Connection is available.        | -                                                                                |

## 5.2 Interrupts

### 5.2.1 Evaluating interrupts

#### Introduction

With certain process statuses/errors, the DP slave in each case creates an interrupt block with the corresponding information in the diagnostics frame (DPV1 interrupt mechanism). Regardless of this, the diagnostic status of the DP slave is displayed in the identifier-related diagnostics, in the module status, and in the channel diagnostics.

#### Interrupts in DPV1 mode

The ET 200AL distributed I/O system supports the following interrupts:

- Diagnostics interrupts
- Hardware interrupts
- Pull/plug module interrupt

### 5.2.2 Trigger a diagnostics interrupt

For an incoming or outgoing event (for example, wire break on a channel of an I/O module), the interface module triggers a diagnostics interrupt if the I/O modules were configured accordingly and "Enable:diagnostics interrupt" is set.

The CPU interrupts user program execution and processes the diagnostics interrupt OB (OB 82). The event that triggered the interrupt is entered in the start information of the diagnostics interrupt OB.

### 5.2.3 Triggering a hardware interrupt

When a hardware interrupt occurs, the CPU interrupts execution of the user program and processes the hardware interrupt OB, for example OB 40. The event that triggered the interrupt is entered in the start information of the hardware interrupt OB.

---

#### Note

##### Diagnostics "Hardware interrupt lost" (from I/O module)

Do not use hardware interrupts for technological purposes (e.g., cyclical generation of hardware interrupts).

If the hardware interrupt load is too high, hardware interrupts can get lost depending on the number of I/O modules and the communication load.

---

### 5.2.4 Triggering an insert/remove module interrupt

When an insert/remove module interrupt occurs, the CPU interrupts execution of the user program and processes the insert/remove module interrupt OB (OB 83). The event that triggered the interrupt is entered in the start information of the insert/remove OB.

The pull/plug OB (OB 83) is also triggered for all subsequent I/O modules, because the ET-Connection and/or the power supply is interrupted.

### 5.2.5 Structure of data records

#### Definition

The interrupt section of the slave diagnostics indicates the interrupt type and the event that led to an interrupt being triggered. The interrupt section comprises 62 bytes including an interrupt header.

#### Position in the diagnostics frame

The interrupt section is located after the channel diagnostics.

#### Data records

The diagnostics data of a module are located in the data records 0 and 1:

- Data record 0 contains 4 bytes of diagnostics data that describe the current status of the distributed I/O system. Data record 0 is part of the header information of the OB 82 (local data bytes 8 to 11).
- Data record 1 contains 4 bytes of diagnostics data that are also available in data record 0.

The figure below shows the structure of data record 0.

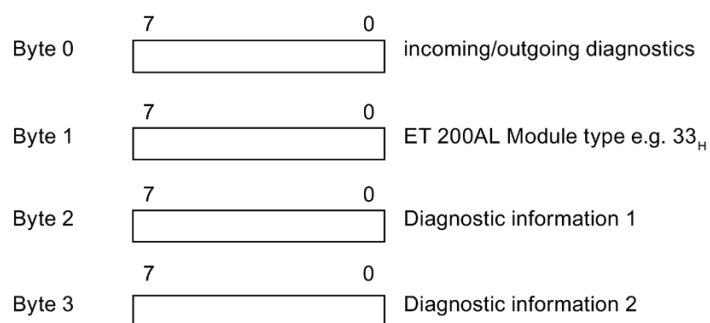


Figure 5-2 Structure of data record 0

The figure below shows the structure of data record 1.

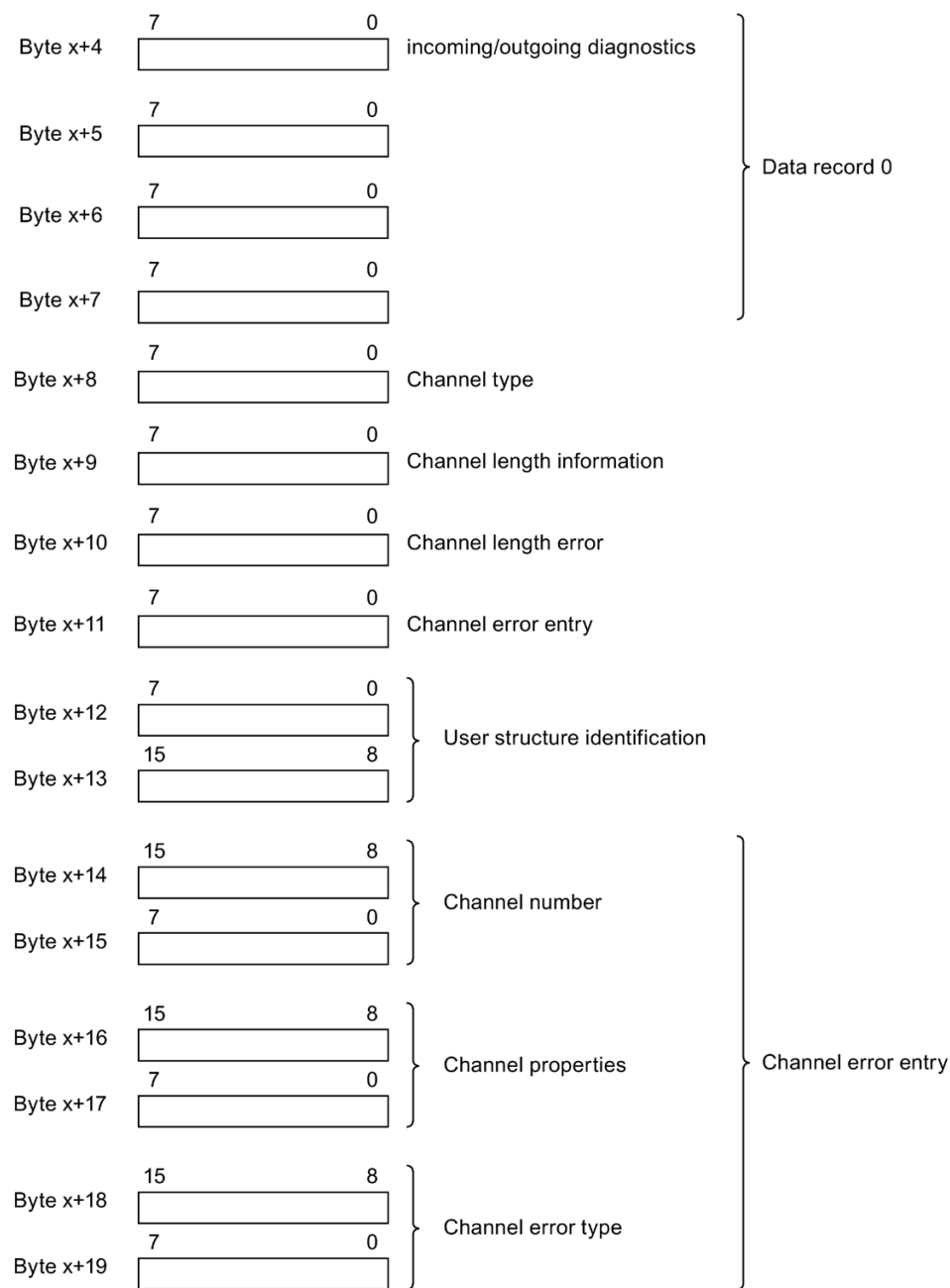


Figure 5-3 Structure of data record 1

## Reading data records

You have the option to read out data records 0 and 1 via SFC 59 (RD\_REC) or SFB 52 (RDREC). The data length of data record 1 is up to 240 bytes. In this case, data record 1 contains up to 38 channel fault entries.

Note the figures below in this section.



## Contents

The contents of the interrupt information depend on the interrupt type:

- In the case of diagnostics interrupts, diagnostics data record 1 (up to 58 bytes) is sent as interrupt status information (starting from byte x+4).
- The length of the interrupt status information for hardware interrupts is 4 bytes.

## Structure of interrupts

The figure below shows the structure of the interrupt section for the ET 200AL distributed I/O system.

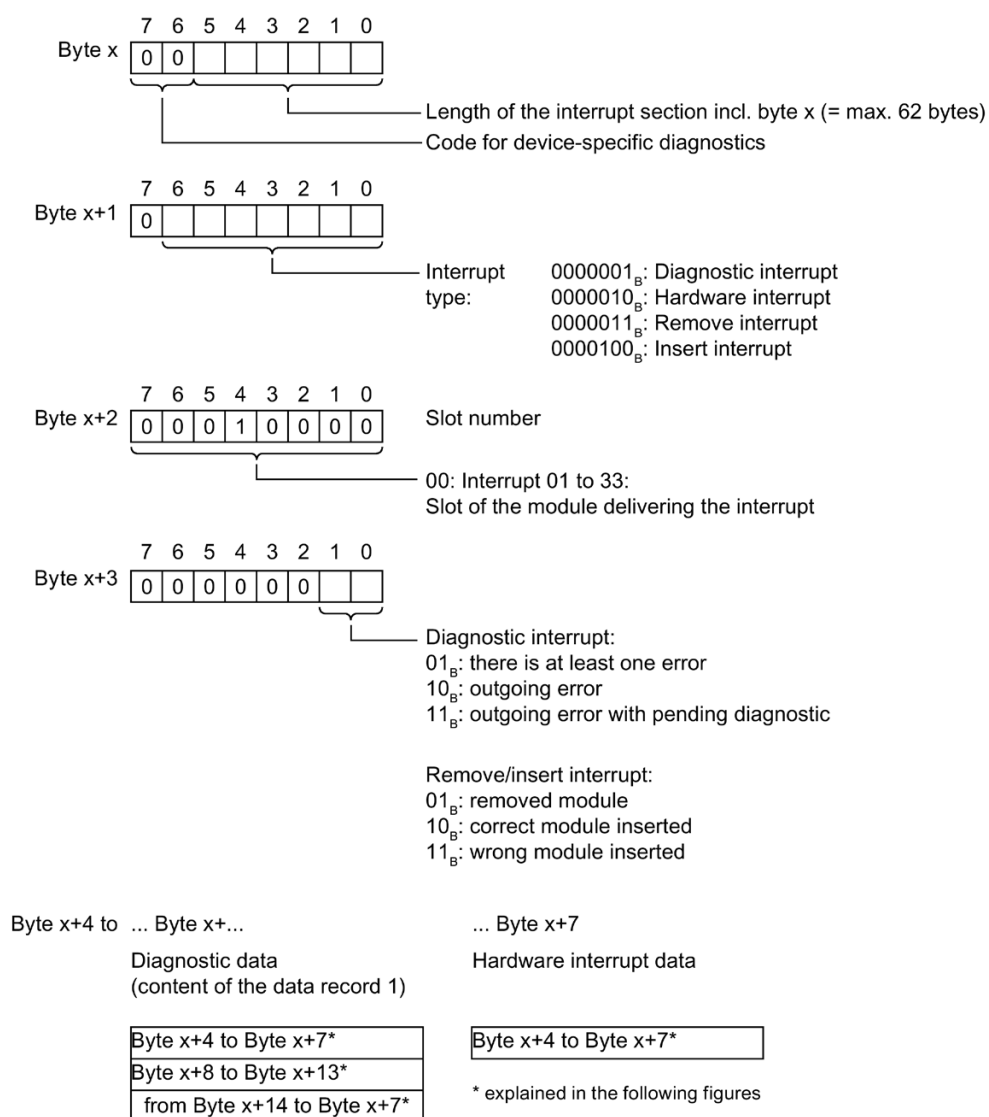


Figure 5-4 Structure of the interrupt status of the interrupt section

## Diagnostics interrupt, byte x+4 to x+7

The figure below shows the structure of the diagnostics interrupt of byte x+4 to byte x+7.

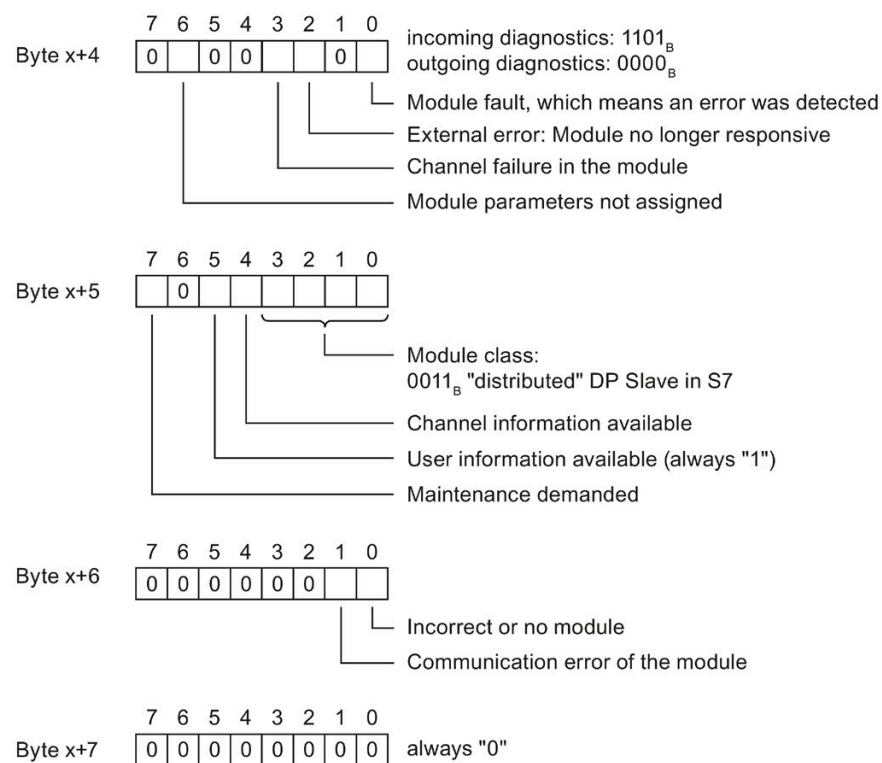


Figure 5-5 Structure of bytes x+4 to x+7 for diagnostics interrupt

**Diagnostics interrupt, starting at byte x+8**

The figure below shows the structure of the diagnostics interrupt starting at byte x+8.

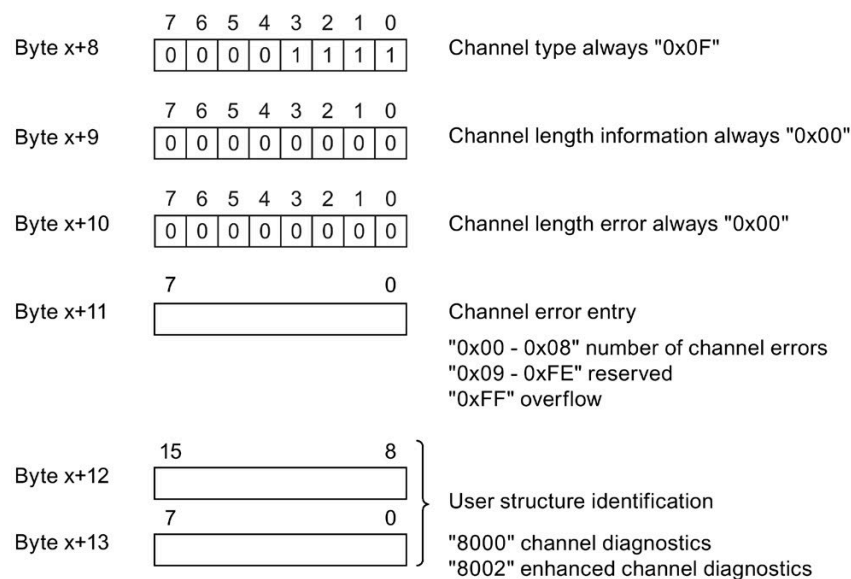


Figure 5-6 Structure starting at byte x+8

**Diagnostics interrupt from the modules, starting at byte x+14**

The channel error entries start from byte x+14. A channel fault entry is 6 bytes long and can follow 8 times starting at byte x+14.

If you read the channel faults with an SFB or SFC, then 38 channel diagnostics are possible.

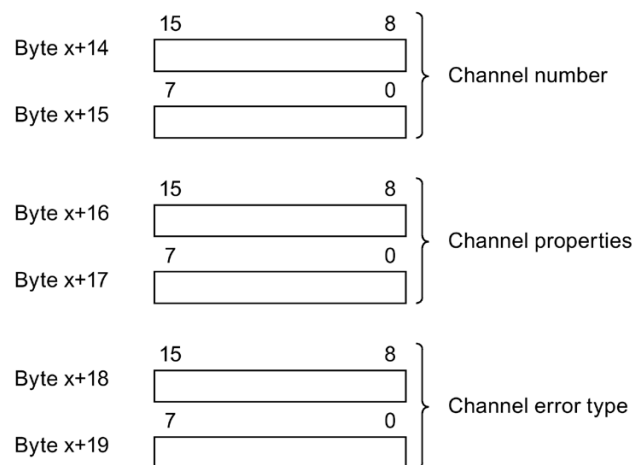


Figure 5-7 Structure starting from byte x+14

The following table is used to explain the channel error entries.

|                    | Description                                                                           |                                                                                                                                                                        |
|--------------------|---------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Channel number     | 0 ... 63: Channel number for channel error<br>0x8000: Entire submodule                |                                                                                                                                                                        |
| Channel properties | Bits 0 to 7                                                                           | 00H: Free data type<br>01H: bit<br>02H: 2 bit<br>03H: 4 bit<br>04H: byte<br>05H: word<br>06H: double word<br>07H to FFH: Reserved                                      |
|                    | Bit 8                                                                                 | 0: Channel<br>1: Channel group                                                                                                                                         |
|                    | Bit 9, 10                                                                             | 00H: Diagnostics<br>01H: Maintenance demanded<br>02H: Maintenance required<br>03H: Reserved                                                                            |
|                    | Bit 11, 12                                                                            | 00H: Channel error-free<br>01H: Incoming diagnostics<br>02H: Outgoing diagnostics<br>03H: Outgoing diagnostics, but other diagnostics are also pending on this channel |
|                    | Bits 13 to 15                                                                         | 00H: Reserved<br>01H: Input channel<br>02H: Output channel<br>03H: Input/output channel                                                                                |
| Channel error type | Explanations are available in the device manuals, in the section "Diagnostic alarms". |                                                                                                                                                                        |

### Example of a diagnostics interrupt

The figure below shows an example of a diagnostics interrupt.

Example:

I/O module AI 4xU/I/RTD reports on channel 1 the diagnostic interrupt

"High limit exceeded"

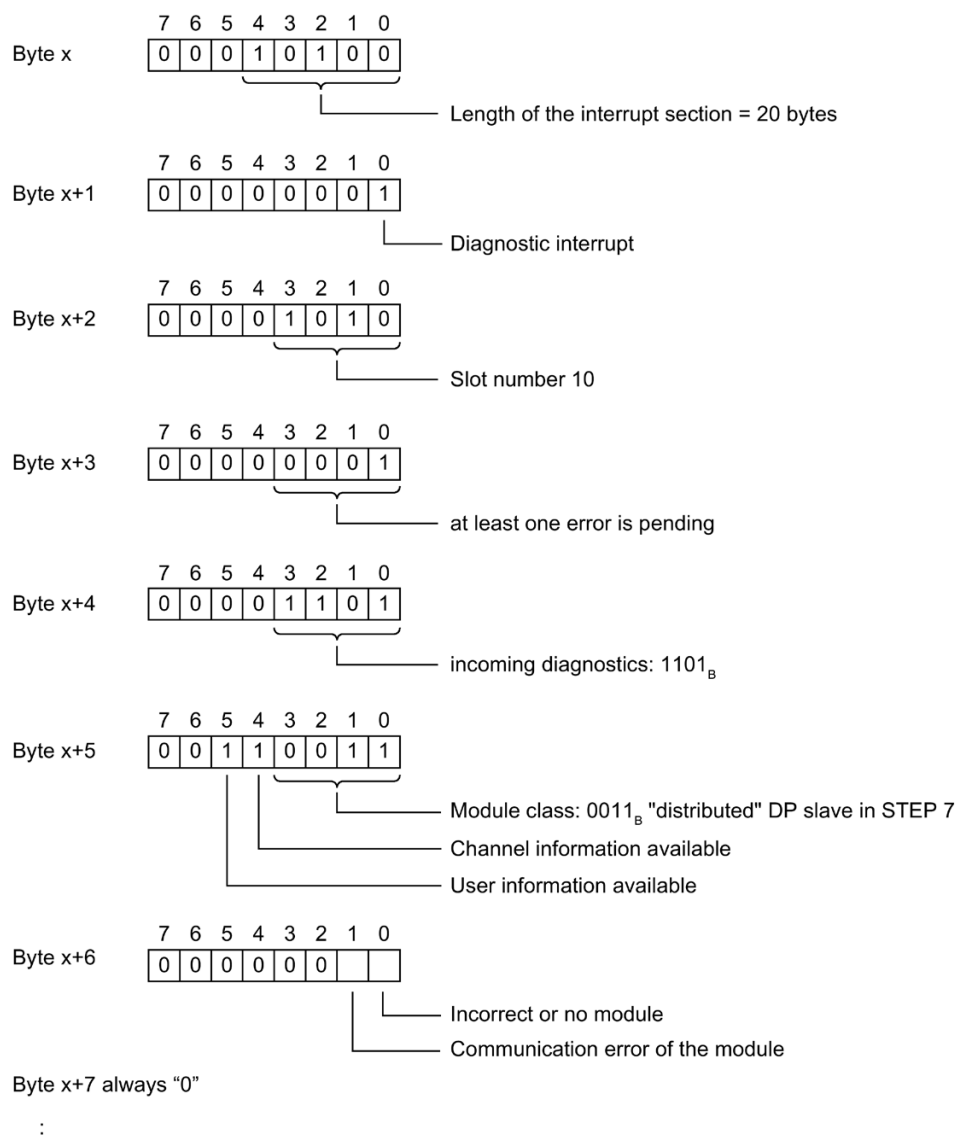


Figure 5-8 Example of a diagnostics interrupt (part 1)

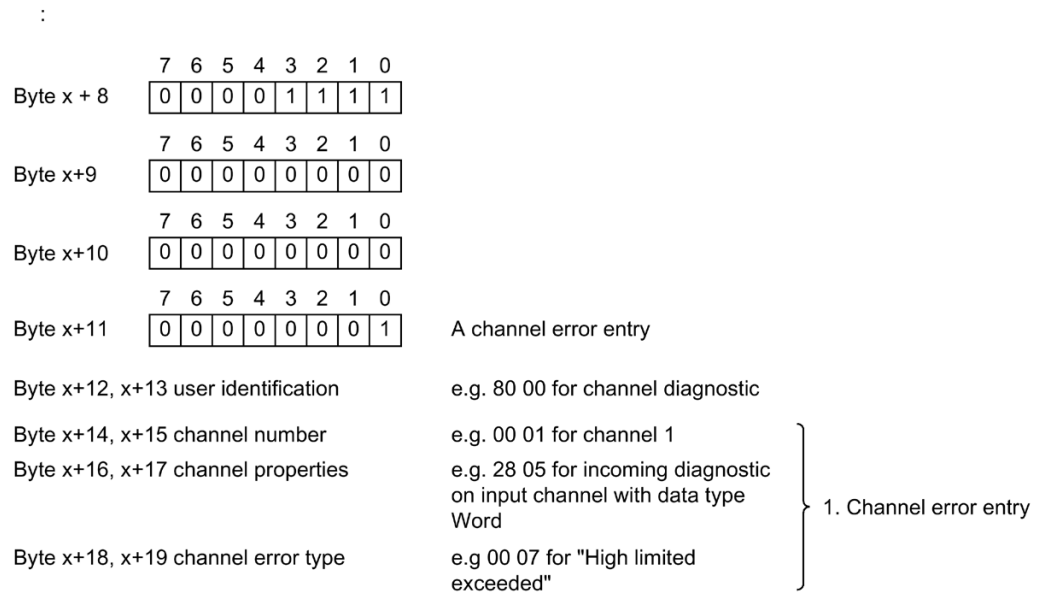


Figure 5-9 Example of a diagnostics interrupt (part 2)

## Hardware interrupt of digital and analog input modules, bytes x+4 to x+7

The figure below shows the structure of a hardware interrupt.

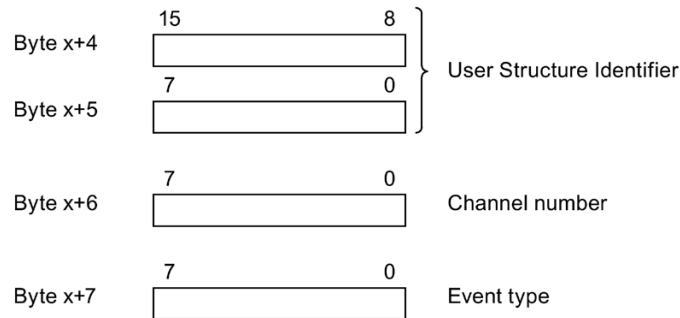


Figure 5-10 Structure as of Byte x+4 for hardware interrupt

### Note

#### Byte x+4

You will find the event type in the device manual of the module that triggered the hardware interrupt.

## 5.3 Alarms

### 5.3.1 Diagnostics alarms

#### Actions after a diagnostics alarm in DPV1 mode

The error is entered in the channel diagnostics in the diagnostics frame:

- In DPV1 mode, diagnostics can be reported as diagnostics interrupts.
- After a diagnostics alarm, this is
  - entered in the diagnostics frame as a diagnostics interrupt block (always only one interrupt).
  - Stored in the diagnostics buffer of the CPU.
- The ERROR LED of the interface module flashes.
- OB 82 is called. If OB 82 is not available, the CPU goes into STOP mode.
- Acknowledgment of the diagnostics interrupt (a new interrupt is possible thereafter).

#### Length of the diagnostics frame

- The maximum frame length for the ET 200AL distributed I/O system with IM157-1 DP interface module (DPV1 mode) is 244 bytes.
- The minimum frame length is 6 bytes.

#### Reading out the diagnostics data

Table 5- 4 Reading the diagnostics with STEP 7

| Automation system with DP master | Application                                                                                                                       | See...                                                              |
|----------------------------------|-----------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------|
| SIMATIC S7/M7                    | Slave diagnostics in plain text in "DP Slave Diagnostics" tab on STEP 7 interface                                                 | "Hardware diagnostics" in STEP 7 online help                        |
|                                  | "DP NRM_DG" instruction (SFC 13)<br>Reading out slave diagnostics (store in the data area of the user program)                    | SFC: see STEP 7 online help                                         |
|                                  | "RD_REC" instruction (SFC 59)<br>Reading out data records of the S7 diagnostics data (store in the data area of the user program) | See System and Standard Functions reference manual                  |
|                                  | "RDREC" instruction (SFC 52)<br>Reading data records from the DP slave                                                            | SFB: refer to STEP 7 online help (system functions/function blocks) |
|                                  | "RALRM" instruction (SFC 54)<br>Receiving interrupts from the interrupt OBs                                                       | SFB: refer to STEP 7 online help (system functions/function blocks) |

### 5.3.2 Slave diagnostics

The figure below shows the structure of the slave diagnostics.

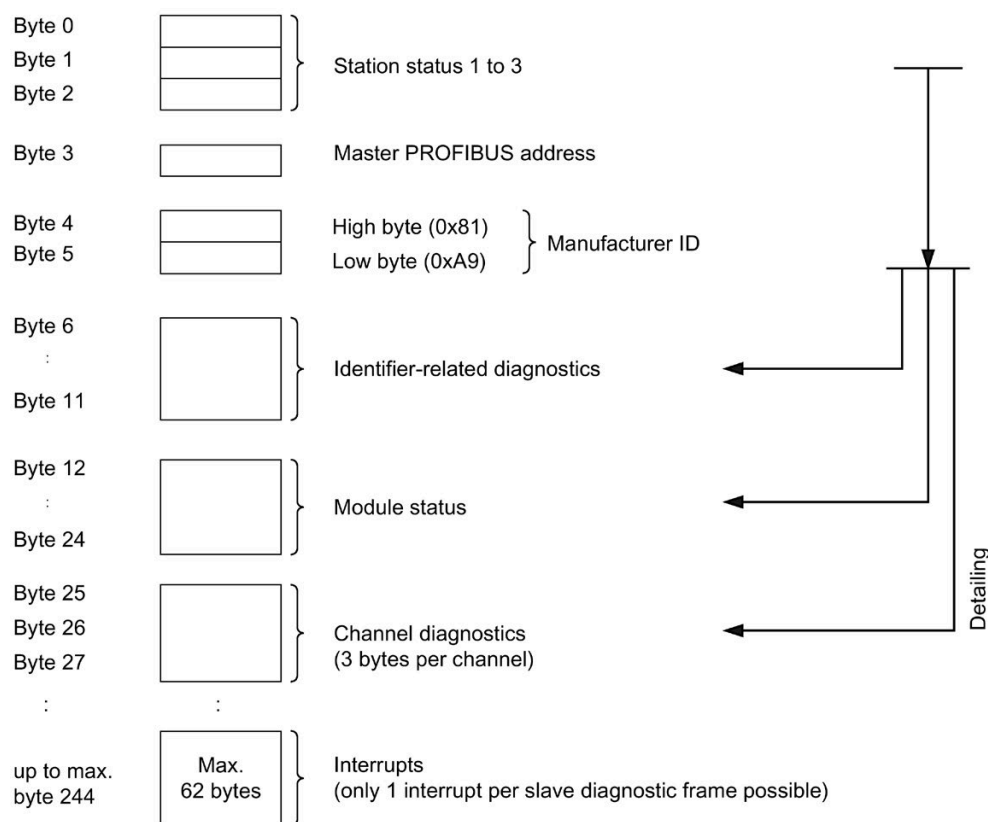


Figure 5-11 Structure of the slave diagnostics

#### Note

The length of the diagnostics frame varies with the IM 157-1 DP (depending on parameter assignment) between 6 and 244 bytes in DPV1 mode.

You can identify the length of the last received diagnostics frame in STEP 7 from the RET\_VAL parameter in SFC 13.



### 5.3.3 Station statuses 1 to 3

The following tables show station status 1 to 3 and provide an overview of the status of a DP slave.

#### Structure of station status 1 (byte 0)

Table 5- 5 Structure of station status 1 (byte 0)

| Bit | Meaning                                                                                                                            | Cause/Solution                                                                                                                                                                                                                                                                                                         |
|-----|------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 0   | 1: The DP slave is not responding to the DP master.                                                                                | <ul style="list-style-type: none"> <li>Correct PROFIBUS address set on the DP slave?</li> <li>Bus connector connected?</li> <li>Is the DP slave connected to the voltage supply?</li> <li>RS485 repeater properly configured?</li> </ul>                                                                               |
| 1   | 1: The DP slave is not yet ready to exchange data.                                                                                 | <ul style="list-style-type: none"> <li>Wait; the DP slave is currently starting up.</li> </ul>                                                                                                                                                                                                                         |
| 2   | 1: The configuration data transferred from the DP master to the DP slave does not match the DP slave configuration.                | <ul style="list-style-type: none"> <li>Has the correct station type or the correct DP slave configuration been entered in the configuration software?</li> </ul>                                                                                                                                                       |
| 3   | 1: External diagnostics is available. (Group diagnostics display)                                                                  | <ul style="list-style-type: none"> <li>Evaluate the ID-specific diagnostics, the module status, and/or the channel diagnostics. As soon as all errors have been eliminated, bit 3 is reset. The bit is set again when there is a new diagnostics alarm in the bytes of the aforementioned diagnostics.</li> </ul>      |
| 4   | 1: The requested function is not supported by the DP slave (e.g. changing the PROFIBUS address using software).                    | <ul style="list-style-type: none"> <li>Check the configuration.</li> </ul>                                                                                                                                                                                                                                             |
| 5   | 1: The DP master cannot interpret the response of the DP slave.                                                                    | <ul style="list-style-type: none"> <li>Check the bus configuration.</li> </ul>                                                                                                                                                                                                                                         |
| 6   | 1: The DP slave type does not match the software configuration.                                                                    | <ul style="list-style-type: none"> <li>Has the correct station type been entered in the configuration software?</li> </ul>                                                                                                                                                                                             |
| 7   | 1: Parameters have been assigned to the DP slave by a different DP master (not the one that currently has access to the DP slave). | <ul style="list-style-type: none"> <li>The bit is always 1, for example, if you access the DP slave with the programming device or another DP master.</li> <li>The PROFIBUS address of the DP master that assigned parameters to the DP slave is located in the "Master PROFIBUS address" diagnostics byte.</li> </ul> |

### Structure of station status 2 (byte 1)

Table 5- 6 Structure of station status 2 (byte 1)

| Bit                                                                             | Meaning |                                                                                                                           |
|---------------------------------------------------------------------------------|---------|---------------------------------------------------------------------------------------------------------------------------|
| 0                                                                               | 1:      | The DP slave parameters need to be reassigned.                                                                            |
| 1                                                                               | 1:      | A diagnostics alarm is pending. The DP slave will not operate until the problem is eliminated (static diagnostics alarm). |
| 2                                                                               | 1:      | The bit on the DP slave is always "1".                                                                                    |
| 3                                                                               | 1:      | The watchdog is activated for this DP slave.                                                                              |
| 4                                                                               | 1:      | The DP slave has received the control command "FREEZE". <sup>1</sup>                                                      |
| 5                                                                               | 1:      | The DP slave has received the control command "SYNC". <sup>1</sup>                                                        |
| 6                                                                               | 0:      | Bit is always "0".                                                                                                        |
| 7                                                                               | 1:      | The DP slave is disabled, that is, it has been removed from the processing in progress.                                   |
| <sup>1</sup> The bit is updated only if another diagnostics alarm also changes. |         |                                                                                                                           |

### Structure of station status 3 (byte 2)

Table 5- 7 Structure of station status 3 (byte 2)

| Bit    | Meaning |                                                                                                                                                                                                                                                         |
|--------|---------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 0 to 6 | 0:      | Bits are always set to "0".                                                                                                                                                                                                                             |
| 7      | 1:      | <ul style="list-style-type: none"> <li>There are more diagnostic alarms pending than the DP slave is able to store.</li> <li>The DP master cannot enter all the diagnostics alarms sent by the DP slave in its (channel) diagnostics buffer.</li> </ul> |

#### 5.3.4 Master PROFIBUS address

The following is stored in the diagnostic byte Master PROFIBUS address:

- The PROFIBUS address of the DP master that assigned the parameters to the DP slave.
- The PROFIBUS address of the DP master that has read and write access to the DP slave.

The master PROFIBUS address is found in byte 3 of the slave diagnostics.

#### 5.3.5 Manufacturer ID

The manufacturer ID contains a code specifying the type of the DP slave.

The following table shows the structure of the manufacturer ID (bytes 4, 5).

Table 5- 8 Description of the manufacturer ID

| Byte 4          | Byte 5          | Manufacturer ID              |
|-----------------|-----------------|------------------------------|
| 81 <sub>H</sub> | A9 <sub>H</sub> | IM 157-1 DP interface module |

### 5.3.6 Identifier-related diagnostics

The identifier-related diagnostics indicates whether modules of the ET 200AL distributed I/O system have errors or not. Identifier-related diagnostics starts at byte 6 and comprises 6 bytes.

The figure below shows how the identifier-related diagnostics for the ET 200AL distributed I/O system is structured with the IM 157-1 DP interface module.

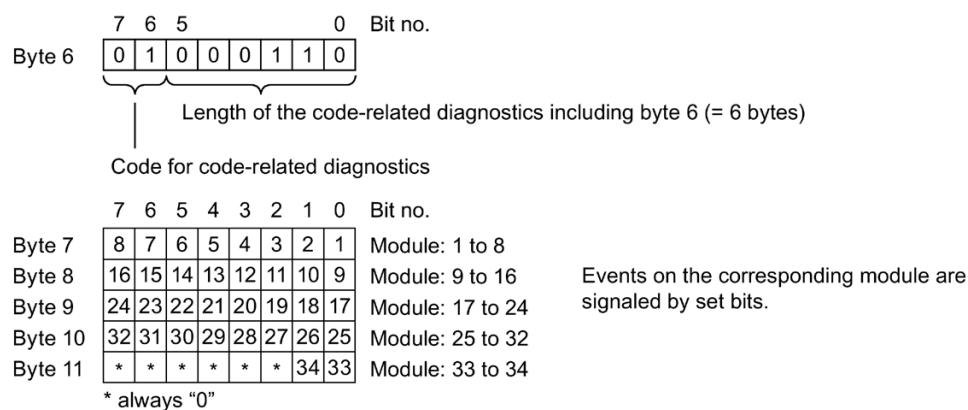


Figure 5-12 Structure of the identifier-related diagnostics

### 5.3.7 Module status

The module status indicates the status of the configured modules and provides more information on the identifier-related diagnostics with respect to the configuration. The module status begins after the identifier-related diagnostics and comprises 13 bytes.

The figure below shows how the module status for the ET 200AL distributed I/O system is structured with the IM 157-1 DP interface module.

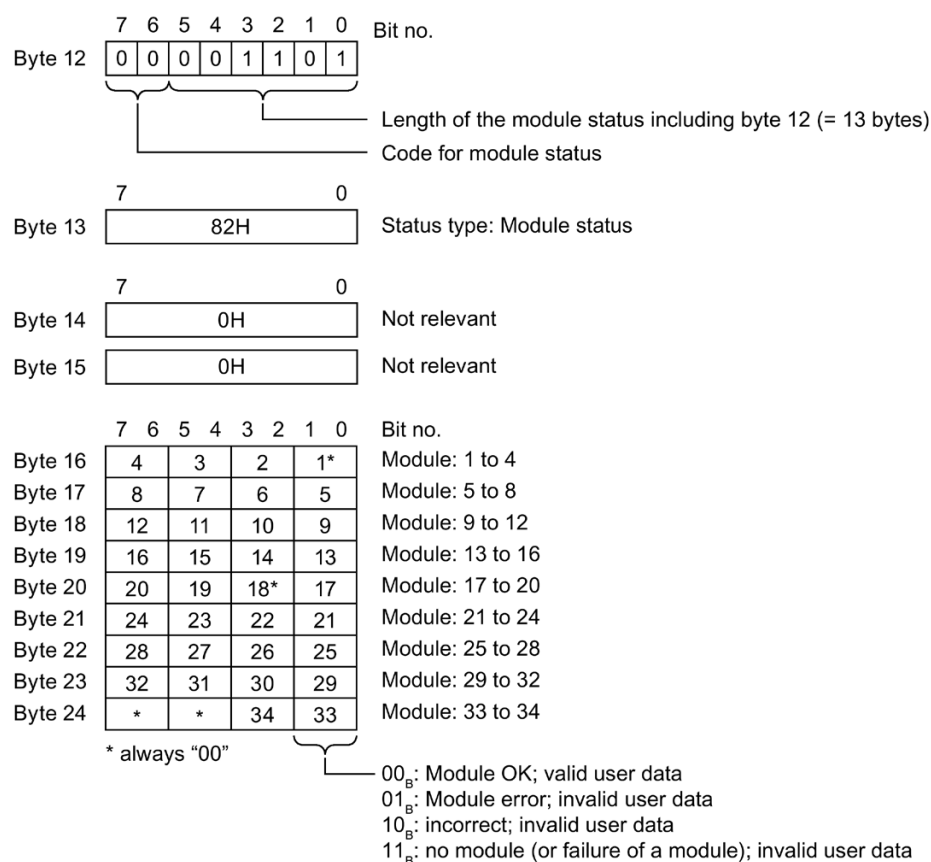


Figure 5-13 Module status structure

### 5.3.8 Channel diagnostics

#### Function

Channel diagnostics provides information about channel errors in modules and details of the identifier-related diagnostics. Channel diagnostics begins after the module status. Channel diagnostics does not affect the module status.

The figure below shows how the channel diagnostics for the ET 200AL distributed I/O system is structured with the IM 157-1 DP interface module.

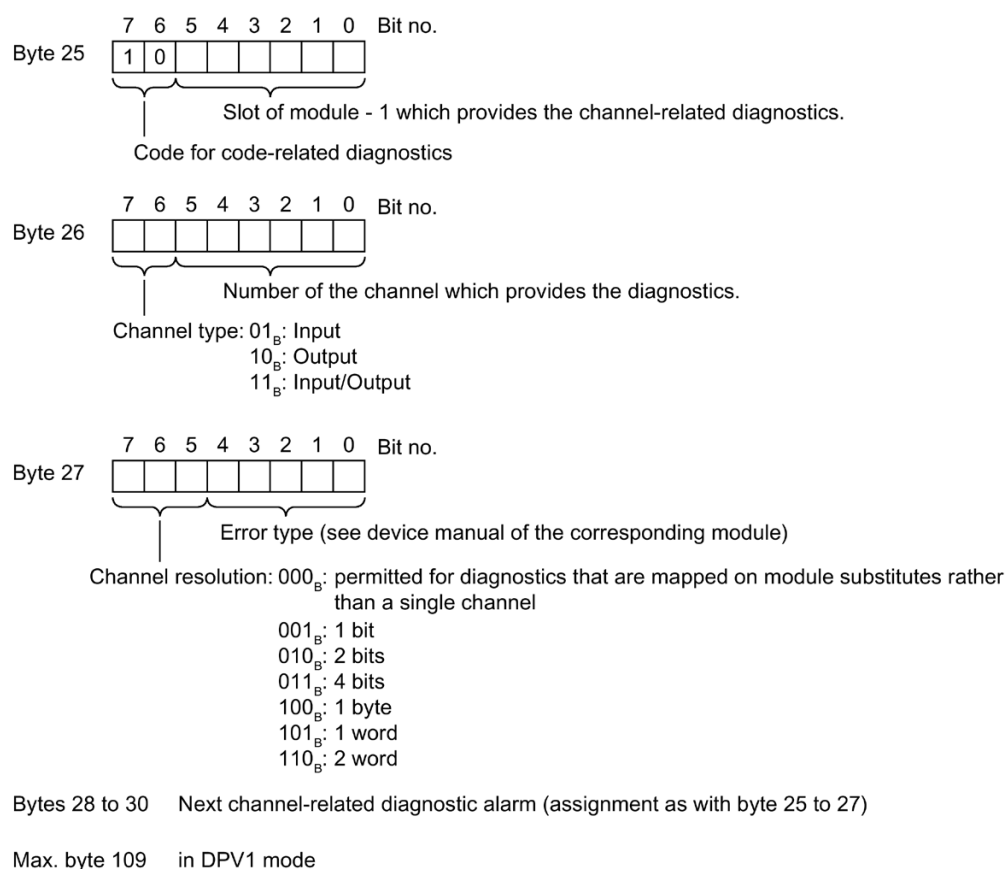


Figure 5-14 Structure of channel diagnostics

# Technical specifications

## Technical specifications of the interface module IM 157-1 DP

The following table shows the technical specifications as of the issue date. You can find a data sheet including daily updated technical specifications on the Internet

(<https://support.industry.siemens.com/cs/ww/en/pv/6ES7157-1AA00-0AB0/td?dl=en>).

|                                                          |                           |
|----------------------------------------------------------|---------------------------|
| <b>Article number</b>                                    | <b>6ES7157-1AA00-0AB0</b> |
| <b>General information</b>                               |                           |
| Product type designation                                 | IM 157-1 DP               |
| HW functional status                                     | FS02                      |
| Firmware version                                         | V1.0.x                    |
| Vendor identification (VendorID)                         | 81A9H                     |
| <b>Product function</b>                                  |                           |
| • I&M data                                               | Yes; I&M0 to I&M3         |
| <b>Engineering with</b>                                  |                           |
| • STEP 7 TIA Portal configurable/integrated from version | STEP 7 V13 SP1 or higher  |
| • STEP 7 configurable/integrated from version            | From V5.5 SP4 Hotfix 3    |
| • PROFIBUS from GSD version/GSD revision                 | GSD as of Revision 5      |
| <b>Configuration control</b>                             |                           |
| via dataset                                              | Yes                       |
| <b>Supply voltage</b>                                    |                           |
| <b>Load voltage 1L+</b>                                  |                           |
| • Rated value (DC)                                       | 24 V                      |
| • permissible range, lower limit (DC)                    | 20.4 V                    |
| • permissible range, upper limit (DC)                    | 28.8 V                    |
| • Reverse polarity protection                            | Yes; against destruction  |
| <b>Input current</b>                                     |                           |
| Current consumption (rated value)                        | 50 mA                     |
| from load voltage 1L+ (unswitched voltage)               | 4 A; Maximum value        |
| from load voltage 2L+, max.                              | 4 A; Maximum value        |
| <b>Power loss</b>                                        |                           |
| Power loss, typ.                                         | 1.7 W                     |
| <b>Address area</b>                                      |                           |
| <b>Address space per station</b>                         |                           |
| • Address space per station, max.                        | 244 byte                  |
| <b>Interfaces</b>                                        |                           |
| Number of PROFIBUS interfaces                            | 1                         |

|                                                          |                           |
|----------------------------------------------------------|---------------------------|
| <b>Article number</b>                                    | <b>6ES7157-1AA00-0AB0</b> |
| <b>1. Interface</b>                                      |                           |
| Interface type                                           | PROFIBUS DP               |
| <b>Interface types</b>                                   |                           |
| • RS 485                                                 | Yes                       |
| • M12 port                                               | Yes; 2x M12 B-coded       |
| <b>Protocols</b>                                         |                           |
| • PROFIBUS DP slave                                      | Yes                       |
| <b>Interface types</b>                                   |                           |
| <b>RS 485</b>                                            |                           |
| • Transmission rate, max.                                | 12 Mbit/s                 |
| <b>PROFIBUS DP</b>                                       |                           |
| <b>Services</b>                                          |                           |
| – SYNC capability                                        | Yes                       |
| – FREEZE capability                                      | Yes                       |
| – Direct data exchange (slave-to-slave communication)    | Yes                       |
| – DPV0                                                   | Yes                       |
| – DPV1                                                   | Yes                       |
| <b>Interrupts/diagnostics/status information</b>         |                           |
| Diagnostics function                                     | Yes                       |
| <b>Alarms</b>                                            |                           |
| • Diagnostic alarm                                       | Yes                       |
| <b>Diagnostics indication LED</b>                        |                           |
| • RUN LED                                                | Yes; green LED            |
| • ERROR LED                                              | Yes; red LED              |
| • MAINT LED                                              | Yes; Yellow LED           |
| • Connection display DP                                  | Yes; green LED            |
| <b>Potential separation</b>                              |                           |
| between the load voltages                                | Yes                       |
| between PROFIBUS DP and all other circuit components     | Yes                       |
| <b>Isolation</b>                                         |                           |
| Isolation tested with                                    | 707 V DC (type test)      |
| <b>Standards, approvals, certificates</b>                |                           |
| Suitable for safety-related tripping of standard modules | Yes; From FS01            |

|                                                                                        |                           |
|----------------------------------------------------------------------------------------|---------------------------|
| <b>Article number</b>                                                                  | <b>6ES7157-1AA00-0AB0</b> |
| <b>Highest safety class achievable for safety-related tripping of standard modules</b> |                           |
| • Performance level according to ISO 13849-1                                           | PL d                      |
| • Category according to ISO 13849-1                                                    | Cat. 3                    |
| • SILCL according to IEC 62061                                                         | SILCL 2                   |
| <b>Ambient conditions</b>                                                              |                           |
| <b>Ambient temperature during operation</b>                                            |                           |
| • min.                                                                                 | -30 °C                    |
| • max.                                                                                 | 55 °C                     |
| <b>Connection method</b>                                                               |                           |
| Design of electrical connection for supply voltage                                     | M8, 4-pole                |
| <b>ET-Connection</b>                                                                   |                           |
| • ET-Connection                                                                        | M8, 4-pin, shielded       |
| <b>Dimensions</b>                                                                      |                           |
| Width                                                                                  | 45 mm                     |
| Height                                                                                 | 159 mm                    |
| Depth                                                                                  | 46 mm                     |
| <b>Weights</b>                                                                         |                           |
| Weight, approx.                                                                        | 211 g                     |



## Dimension drawing

The figure below shows the dimension drawing of the IM 157-1 DP interface module in the front and side view.

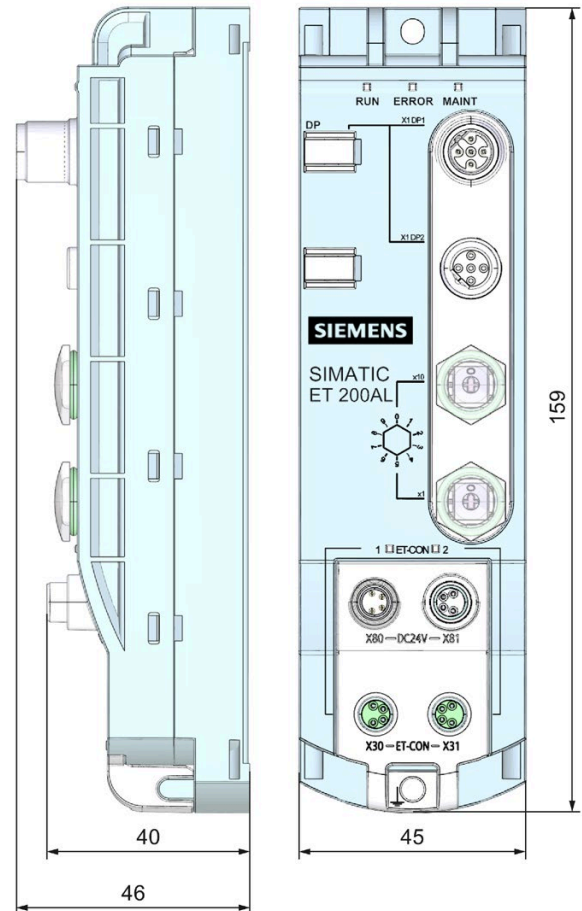


Figure A-1 Dimension drawing

## Cycle times

The following figure shows the cycle times at ET-Connection based on the number of I/O modules.

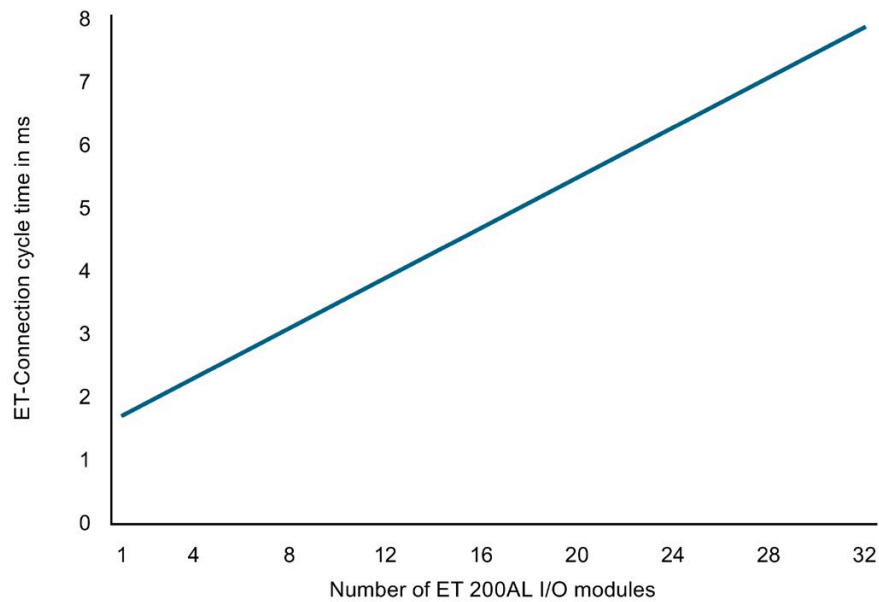


Figure B-1 Cycle times

The cycle time is independent of the PROFIBUS transmission rate.

# SIEMENS



Manual

## SIMATIC

### ET 200AL

Interface module IM 157-1 PN  
(6ES7157-1AB00-0AB0)

Edition

05/2021

[support.industry.siemens.com](https://support.industry.siemens.com)

## SIMATIC

### ET 200AL IM 157-1 PN (6ES7157-1AB00-0AB0)

#### Equipment Manual

#### Preface

---

#### ET 200AL Documentation Guide

**1**

#### Product overview

**2**

#### Wiring

**3**

#### Parameters

**4**

#### Interrupts, error messages, diagnostics and system alarms

**5**

#### Technical specifications

**6**

#### Dimension drawing

**A**

#### Cycle times

**B**

## Legal information

### Warning notice system

This manual contains notices you have to observe in order to ensure your personal safety, as well as to prevent damage to property. The notices referring to your personal safety are highlighted in the manual by a safety alert symbol, notices referring only to property damage have no safety alert symbol. These notices shown below are graded according to the degree of danger.

#### **DANGER**

indicates that death or severe personal injury **will** result if proper precautions are not taken.

#### **WARNING**

indicates that death or severe personal injury **may** result if proper precautions are not taken.

#### **CAUTION**

indicates that minor personal injury can result if proper precautions are not taken.

#### **NOTICE**

indicates that property damage can result if proper precautions are not taken.

If more than one degree of danger is present, the warning notice representing the highest degree of danger will be used. A notice warning of injury to persons with a safety alert symbol may also include a warning relating to property damage.

### Qualified Personnel

The product/system described in this documentation may be operated only by **personnel qualified** for the specific task in accordance with the relevant documentation, in particular its warning notices and safety instructions. Qualified personnel are those who, based on their training and experience, are capable of identifying risks and avoiding potential hazards when working with these products/systems.

### Proper use of Siemens products

Note the following:

#### **WARNING**

Siemens products may only be used for the applications described in the catalog and in the relevant technical documentation. If products and components from other manufacturers are used, these must be recommended or approved by Siemens. Proper transport, storage, installation, assembly, commissioning, operation and maintenance are required to ensure that the products operate safely and without any problems. The permissible ambient conditions must be complied with. The information in the relevant documentation must be observed.

### Trademarks

All names identified by ® are registered trademarks of Siemens AG. The remaining trademarks in this publication may be trademarks whose use by third parties for their own purposes could violate the rights of the owner.

### Disclaimer of Liability

We have reviewed the contents of this publication to ensure consistency with the hardware and software described. Since variance cannot be precluded entirely, we cannot guarantee full consistency. However, the information in this publication is reviewed regularly and any necessary corrections are included in subsequent editions.

# Preface

## Purpose of the documentation

This manual supplements the ET 200AL distributed I/O system (<http://support.automation.siemens.com/WW/view/en/89254965>) system manual. Functions that are generally applicable to the ET 200AL distributed I/O system are described there.

The information provided in the present manual, the system manual and the function manuals enables you to commission the ET 200AL distributed I/O system.

## Changes compared to the previous version

This manual contains the following changes/additions compared to the previous version:

- Supplement to section Cycle times (Page 40)
- Adaptations in the section Technical specifications (Page 36)

## Conventions

Please also observe notes marked as follows:

---

### Note

Indicates important product information to which particular attention should be paid.

---

Siemens provides products and solutions with industrial security functions that support the secure operation of plants, systems, machines and networks.

In order to protect plants, systems, machines and networks against cyber threats, it is necessary to implement – and continuously maintain – a holistic, state-of-the-art industrial security concept. Siemens' products and solutions constitute one element of such a concept.

Customers are responsible for preventing unauthorized access to their plants, systems, machines and networks. Such systems, machines and components should only be connected to an enterprise network or the internet if and to the extent such a connection is necessary and only when appropriate security measures (e.g. firewalls and/or network segmentation) are in place.

For additional information on industrial security measures that may be implemented, please visit (<https://www.siemens.com/industrialsecurity>).

Siemens' products and solutions undergo continuous development to make them more secure. Siemens strongly recommends that product updates are applied as soon as they are available and that the latest product versions are used. Use of product versions that are no longer supported, and failure to apply the latest updates may increase customers' exposure to cyber threats.

To stay informed about product updates, subscribe to the Siemens Industrial Security RSS Feed visit (<https://www.siemens.com/industrialsecurity>).

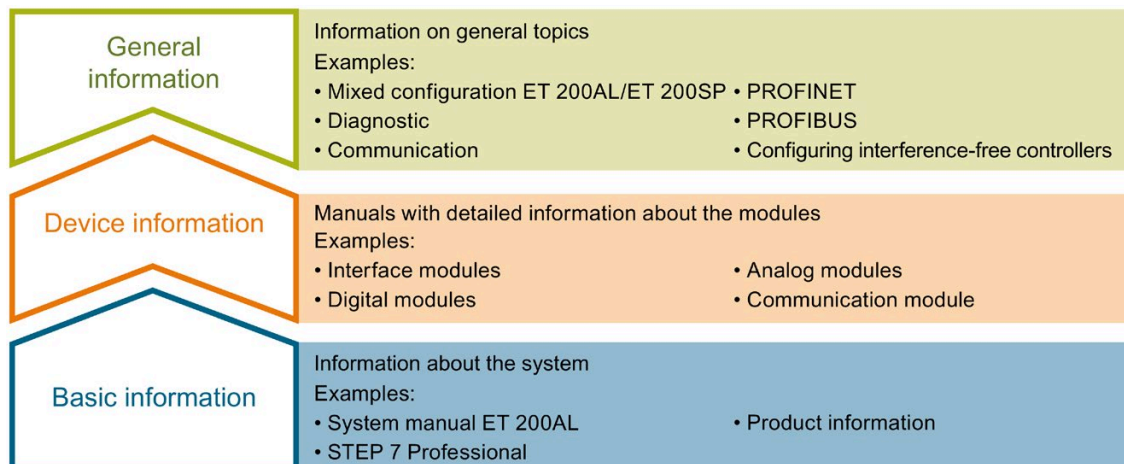
# Table of contents

|          |                                                                         |           |
|----------|-------------------------------------------------------------------------|-----------|
|          | <b>Preface .....</b>                                                    | <b>3</b>  |
| <b>1</b> | <b>ET 200AL Documentation Guide.....</b>                                | <b>5</b>  |
| <b>2</b> | <b>Product overview.....</b>                                            | <b>9</b>  |
|          | 2.1 Properties .....                                                    | 9         |
|          | 2.2 Operator controls and display elements .....                        | 11        |
|          | 2.3 Functions .....                                                     | 12        |
|          | 2.3.1 PROFINET IO .....                                                 | 12        |
|          | 2.3.2 PROFlenergy .....                                                 | 15        |
|          | 2.3.2.1 What is PROFlenergy? .....                                      | 15        |
|          | 2.3.2.2 Principle of operation.....                                     | 17        |
|          | 2.3.2.3 Parameter assignment .....                                      | 19        |
|          | 2.3.2.4 PROFlenergy control data records .....                          | 21        |
|          | 2.3.3 Configuration control (option handling).....                      | 21        |
| <b>3</b> | <b>Wiring .....</b>                                                     | <b>22</b> |
|          | 3.1 Terminal and block diagram .....                                    | 22        |
|          | 3.2 Pin assignment .....                                                | 23        |
| <b>4</b> | <b>Parameters.....</b>                                                  | <b>26</b> |
|          | 4.1 Parameters .....                                                    | 26        |
|          | 4.2 Explanation of the parameters .....                                 | 26        |
| <b>5</b> | <b>Interrupts, error messages, diagnostics and system alarms .....</b>  | <b>27</b> |
|          | 5.1 Status and error displays .....                                     | 27        |
|          | 5.2 Interrupts .....                                                    | 30        |
|          | 5.2.1 Evaluating interrupts .....                                       | 30        |
|          | 5.2.2 Trigger a diagnostics interrupt .....                             | 30        |
|          | 5.2.3 Triggering a hardware interrupt .....                             | 31        |
|          | 5.2.4 Triggering an insert/remove module interrupt .....                | 31        |
|          | 5.3 Alarms.....                                                         | 32        |
|          | 5.3.1 Diagnostics alarms.....                                           | 32        |
|          | 5.3.2 Maintenance events .....                                          | 33        |
|          | 5.3.3 Channel diagnostics.....                                          | 34        |
|          | 5.3.4 Invalid configuration states of ET 200AL on the PROFINET IO ..... | 34        |
|          | 5.3.5 STOP of the IO controller and recovery of the IO device .....     | 35        |
| <b>6</b> | <b>Technical specifications.....</b>                                    | <b>36</b> |
| <b>A</b> | <b>Dimension drawing .....</b>                                          | <b>39</b> |
| <b>B</b> | <b>Cycle times.....</b>                                                 | <b>40</b> |

# ET 200AL Documentation Guide

The documentation for the SIMATIC ET 200AL distributed I/O system is arranged into three areas.

This arrangement enables you to access the specific content you require.



## Basic information

The System Manual and Getting Started describe in detail the configuration, installation, wiring and commissioning of the SIMATIC ET 200AL distributed I/O system. The STEP 7 online help supports you in the configuration and programming.

## Device information

Product manuals contain a compact description of the module-specific information, such as properties, wiring diagrams, characteristics and technical specifications.

## General information

The function manuals contain detailed descriptions on general topics regarding the SIMATIC ET 200AL distributed I/O system, e.g. diagnostics, communication, Motion Control, Web server.

You can download the documentation free of charge from the Internet (<https://support.industry.siemens.com/cs/ww/en/view/109742667>).



## Manual Collection ET 200AL

The Manual Collection contains the complete documentation on the SIMATIC ET 200AL distributed I/O system gathered together in one file.

You can find the Manual Collection on the Internet (<https://support.automation.siemens.com/WW/view/en/95242965>).

## "mySupport"

With "mySupport", your personal workspace, you make the best out of your Industry Online Support.

In "mySupport", you can save filters, favorites and tags, request CAx data and compile your personal library in the Documentation area. In addition, your data is already filled out in support requests and you can get an overview of your current requests at any time.

You must register once to use the full functionality of "mySupport".

You can find "mySupport" on the Internet (<https://support.industry.siemens.com/My/ww/en>).

## "mySupport" - Documentation

With "mySupport", your personal workspace, you make the best out of your Industry Online Support.

In "mySupport", you can save filters, favorites and tags, request CAx data and compile your personal library in the Documentation area. In addition, your data is already filled out in support requests and you can get an overview of your current requests at any time.

You must register once to use the full functionality of "mySupport".

You can find "mySupport" on the Internet (<https://support.industry.siemens.com/My/ww/en/documentation>).

## "mySupport" - CAx data

In the CAx data area of "mySupport", you can access the latest product data for your CAx or CAe system.

You configure your own download package with a few clicks.

In doing so you can select:

- Product images, 2D dimension drawings, 3D models, internal circuit diagrams, EPLAN macro files
- Manuals, characteristics, operating manuals, certificates
- Product master data

You can find "mySupport" - CAx data on the Internet (<https://support.industry.siemens.com/my/ww/en/CAxOnline>).

## Application examples

The application examples support you with various tools and examples for solving your automation tasks. Solutions are shown in interplay with multiple components in the system - separated from the focus on individual products.

You will find the application examples on the Internet  
(<https://support.industry.siemens.com/cs/ww/en/ps/ae>).

## TIA Selection Tool

With the TIA Selection Tool, you can select, configure and order devices for Totally Integrated Automation (TIA).

This tool is the successor of the SIMATIC Selection Tool and combines the known configurators for automation technology into one tool.

With the TIA Selection Tool, you can generate a complete order list from your product selection or product configuration.

You can find the TIA Selection Tool on the Internet  
(<https://support.industry.siemens.com/cs/ww/en/view/109767888>).

## SIMATIC Automation Tool

You can use the SIMATIC Automation Tool to perform commissioning and maintenance activities simultaneously on various SIMATIC S7 stations as a bulk operation independent of TIA Portal.

The SIMATIC Automation Tool provides a multitude of functions:

- Scanning of a PROFINET/Ethernet system network and identification of all connected CPUs
- Address assignment (IP, subnet, gateway) and station name (PROFINET device) to a CPU
- Transfer of the date and the programming device/PC time converted to UTC time to the module
- Program download to CPU
- RUN/STOP mode switchover
- CPU localization by means of LED flashing
- Reading out of CPU error information
- Reading of the CPU diagnostics buffer
- Reset to factory settings
- Firmware update of the CPU and connected modules

You can find the SIMATIC Automation Tool on the Internet  
(<https://support.industry.siemens.com/cs/ww/en/view/98161300>).

## PRONETA

SIEMENS PRONETA (PROFINET network analysis) allows you to analyze the plant network during commissioning. PRONETA features two core functions:

- The topology overview automatically scans the PROFINET and all connected components.
- The IO check is a fast test of the wiring and the module configuration of a plant.

You can find SIEMENS PRONETA on the Internet

(<https://support.industry.siemens.com/cs/ww/en/view/67460624>).

## SINETPLAN

SINETPLAN, the Siemens Network Planner, supports you in planning automation systems and networks based on PROFINET. The tool facilitates professional and predictive dimensioning of your PROFINET installation as early as in the planning stage. In addition, SINETPLAN supports you during network optimization and helps you to exploit network resources optimally and to plan reserves. This helps to prevent problems in commissioning or failures during productive operation even in advance of a planned operation. This increases the availability of the production plant and helps improve operational safety.

The advantages at a glance

- Network optimization thanks to port-specific calculation of the network load
- Increased production availability thanks to online scan and verification of existing systems
- Transparency before commissioning through importing and simulation of existing STEP 7 projects
- Efficiency through securing existing investments in the long term and the optimal use of resources

You can find SINETPLAN on the Internet (<https://www.siemens.com/sinetplan>).

# Product overview

## 2.1 Properties

### Article number

6ES7157-1AB00-0AB0

### View of the module

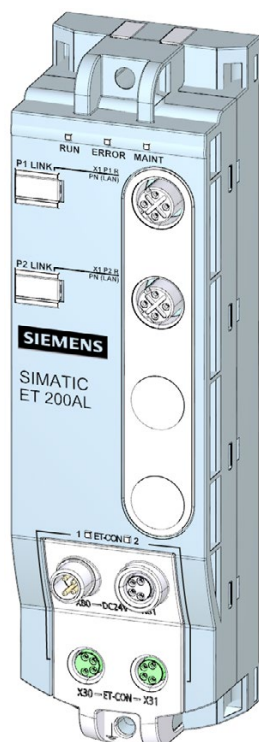


Figure 2-1 View of the IM 157-1 PN interface module

### Properties

The module has the following technical properties:

- Connects the ET 200AL distributed I/O system with PROFINET IO
- 24 V DC supply voltage
- Support for 2 ET-Connection lines
- Dimensions: 45 x 159 mm

The functions supported by the module are found in the chapter Functions (Page 12).

## Maximum configuration

The module has the following maximum configuration:

- 1430 bytes input data
- 1430 bytes output data
- 32 I/O modules, up to 16 I/O modules can be connected for each ET-Connection line

---

### Note

- In the case of a shared device configuration, the sum of the I/O data of all controllers that share the device applies.
  - If more than two (max. four) controllers share the device, the maximum amount of I/O data including user data qualifier is limited to 360 bytes per controller.
- 

## Accessories

The following component is included with the module in the packaging:

- Identification labels

## Other components

The following component can be ordered as spare part:

- Identification labels

The following components can be ordered as accessories:

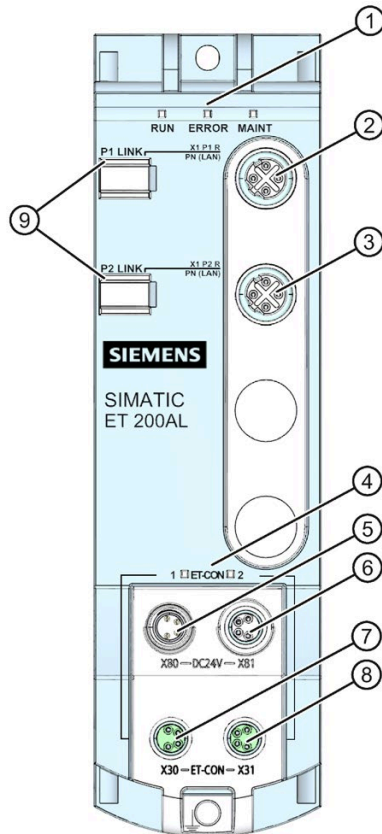
- Connectors
- Cables
- Stripping Tool for PROFINET
- Stripping Tool for ET-Connection
- M8 sealing cap
- M12 sealing cap

## See also

You will find additional information on accessories and the other components in the Accessories/Spare parts section of the ET 200AL Distributed I/O System (<http://support.automation.siemens.com/WW/view/en/89254965>) system manual.

## 2.2 Operator controls and display elements

The figure below shows the operator control and display elements of the interface module IM 157-1 PN.



- ① RUN, ERROR, MAINT: LED displays for the current operating status and diagnostics status
- ② X1 P1 R: 1st PROFINET interface
- ③ X1 P2 R: 2nd PROFINET interface
- ④ ET-CON1, ET-CON2: LED displays for ET-Connection
- ⑤ X80: Connector for infeed of the supply voltage (POWER input)
- ⑥ X81: Socket for loop-through of the supply voltage (POWER output)
- ⑦ X30: Socket for ET-Connection1
- ⑧ X31: Socket for ET-Connection2
- ⑨ P1 LINK, P2 LINK: LED displays for the current operating status of the PROFINET interfaces

Figure 2-2 Operator controls and display elements

## 2.3 Functions

### 2.3.1 PROFINET IO

#### Introduction

The interface module supports the following PROFINET IO functions:

- Integrated switch with 2 ports
- Supported Ethernet services: ping, arp, network diagnostics (SNMP)/MIB-2, LLDP
- Port diagnostics
- Deactivating of ports
- Real-time communication
- Isochronous real-time communication
- Minimum update time 250 µs
- Media redundancy (MRP)
- Media redundancy with planned duplication (MRPD)
- Device replacement with topological configuration
- Device replacement without topological configuration
- Shared Device
- Identification data I&M0 to I&M4
- Firmware update via PROFINET IO
- Reset to factory settings via PROFINET IO
- PROFIenergy
- Configuration control (option handling)
- Value status (of I/O modules)

## Requirements

The following table shows the software requirements for the use of PROFINET IO functions with the IM 157-1 PN interface module.

Table 2- 1 Software requirements for PROFINET IO functions

| PROFINET IO function                          | Configuration software                               |                                                                                                  |
|-----------------------------------------------|------------------------------------------------------|--------------------------------------------------------------------------------------------------|
|                                               | STEP 7 (TIA Portal) V13 or higher<br>(with GSD file) | STEP 7 V5.5 SP4 or higher<br>(with GSD file)/Software from third-party manufacturer <sup>2</sup> |
| Real-time communication                       | X                                                    | X                                                                                                |
| Isochronous real-time communication           | X                                                    | X                                                                                                |
| Device replacement without programming device | X                                                    | X                                                                                                |
| Media redundancy                              | X                                                    | X                                                                                                |
| Shared device                                 | X <sup>1</sup>                                       | X                                                                                                |

<sup>1</sup> Use a S7-1500 CPU as a controller to use a shared device with STEP 7 (TIA Portal).

<sup>2</sup> Systems of third-party manufacturers: Depending on the range of functions of the third-party system

## Real-time communication

A transmission method for PROFINET IO based on a cyclic data exchange with a provider-consumer model.

## Isochronous real-time communication

Synchronized transmission method for cyclic exchange of IRT data between PROFINET devices. A reserved bandwidth within the send clock is available for IRT data. The reserved bandwidth ensures that IRT data can be transferred at reserved synchronized intervals, without being influenced by other higher network loads (e.g., TCP/IP communication, or additional real-time communication).

A topological configuration is required for IRT.

### Note

#### IO controller as sync master with IRT communication

We recommend that you also operate the IO controller as a sync master when configuring IRT communication.

Otherwise IRT and RT configured IO devices may fail if the sync master fails.



### Device replacement without programming device

IO devices with this function can easily be replaced. You do not have to assign the device name with the PG.

The replaced IO device is assigned the device name by the IO controller and not by the programming device. The IO controller uses the configured topology and the neighboring relationships determined by the IO devices for this purpose. To do this, all devices involved must support the LLDP protocol (Link Layer Discovery Protocol). The configured target topology must match the actual topology.

IO devices which were already used in another configuration must be reset to factory settings before being reused.

### Media redundancy

Function for safeguarding communication and plant availability. Redundant transmission lines (ring topology) ensure that another communication path is made available in the event of a transmission section failure.

### Shared device

A shared device is an IO device that provides its data to up to four IO controllers.

The "Shared device" function allows the modules or submodules of an IO device to be divided up among different IO controllers. Thus allowing flexible automation concepts. You have, for example, the possibility of combining I/O modules lying near other into an IO device.

When operating as a shared device, there might be temporary delays in the update of the IO data when establishing or terminating additional communications relationships to an IO controller.

You can find additional information in the STEP 7 online help and the manual and in the function manual PROFINET with STEP 7 V14

(<http://support.automation.siemens.com/WW/view/en/49948856>).

### Cabling with fixed connection setting

If you configure a fixed connection setting for the port in STEP 7, you also have to disable "Autonegotiation/Autocrossover". By disabling "Autonegotiation/Autocrossover" you speed up establishment of the communication path.

## Replacement of an IM 157-1 PN

If you replace an interface module with an interface module that has already been used, you must reset this IO device to the delivery state with "Reset to factory settings".

You will find more information on "Resetting to factory settings" in the ET 200AL Distributed I/O System (<http://support.automation.siemens.com/WW/view/en/89254965>) system manual in the section "Resetting interface module (PROFINET) to factory settings".

## Reference

You will find more information on the PROFINET IO functions in the PROFINET with STEP 7 V14 (<http://support.automation.siemens.com/WW/view/en/49948856>) Function Manual and in the STEP 7 online help.

## 2.3.2 PROFlenergy

### 2.3.2.1 What is PROFlenergy?

#### Introduction

PROFlenergy is a PROFINET-based data interface which makes it possible to switch off consumers in a coordinated and centrally controlled manner during break times regardless of the manufacturer or device. This has the aim that the process is only provided with the energy that is absolutely required. In so doing, the majority of the energy savings come from the process itself; the PROFINET device contributes only a few watts to the possible savings. In PROFlenergy, this operating state is referred to as a "pause".

PROFINET devices are switched off with special commands in the user program of the PROFINET IO controller. Additional hardware is not needed: The PROFlenergy commands are interpreted by the PROFINET devices.

The device which provides PROFlenergy and supports the matching control data record owns the PE-Entity, the access point for these control data records. This PE-Entity represents I/O modules which do not have their own PE-Entity on the interface module. I/O modules that have their own PE-Entity are always addressed directly.

For the ET 200AL distributed I/O system, the PE-Entity is exclusively provided by the PROFINET interface module.

## Procedure

To configure PROFlenergy, follow these steps:

1. Create the parameter data record, Index 3, in STEP 7.
2. Transfer the parameter data record to the interface module with the instruction "WRREC" - SFB 53.
3. Create the user program with the FBs to control the PROFlenergy commands ("PE\_START\_END" - FB 815, "PE\_CMD" - FB 816).
4. Transfer the user program to the CPU.

## Additional information

You will find more information on the Internet (<http://www.profibus.com>) under Common Application Profile PROFlenergy; Technical Specification for PROFINET; as well as in the following documentation:

- System manual ET 200AL Distributed I/O System  
(<https://support.industry.siemens.com/cs/ww/en/view/89254965>)
- Device manuals I/O modules  
(<https://support.industry.siemens.com/cs/ww/en/ps/14247/man>)
- System manual PROFINET System Description  
(<https://support.industry.siemens.com/cs/ww/en/view/19292127>)
- PROFINET with STEP 7 V14  
(<https://support.industry.siemens.com/cs/ww/en/view/49948856>), function manual, section: Saving energy with PROFlenergy
- Application guide for implementation of shutdown concepts with PROFlenergy.  
(<https://support.industry.siemens.com/cs/ww/en/view/96837137>)
- Saving energy with SIMATIC S7 (STEP 7 as of V5.5)  
(<https://support.industry.siemens.com/cs/ww/en/view/41986454>)
- Saving energy with SIMATIC S7 and SIMATIC HMI (TIA Portal)  
(<https://support.industry.siemens.com/cs/ww/en/view/58235225>)
- SIMATIC S7 library for simple configuration of PROFlenergy.  
(<https://support.industry.siemens.com/cs/ww/en/view/109478388>)
- You will find additional information on the PROFlenergy FBs ("PE\_START\_END" - FB 815, "PE\_CMD" - FB 816) in the online help for STEP 7 V5.5 SP2 and higher on System functions/system function blocks.

### 2.3.2.2 Principle of operation

#### "Pause" control and "Pause" behavior

At the beginning/end of pauses, enable/disable the pause function on the system; the IO controller then sends the PROFlenergy command "Start\_Pause" or "End\_Pause" to the modules. The module then interprets the content of the PROFlenergy command and turns it off or on again. The ET 200AL interface module is the PE-Entity for the PROFlenergy-capable I/O modules of the ET 200AL distributed I/O system in this case.

Device information can be called up using additional PROFlenergy commands during the pauses. You can use these commands to transfer the "Start\_Pause" / "End\_Pause" command in good time.

---

**Note**

A complete PROFlenergy sequence consists of the commands "Start\_Pause" and "End\_Pause". Always observe this sequence during programming.

---

#### LED displays

PROFlenergy generally has no effect on the LED display. Exceptions can be found in the device manuals of the I/O modules.

#### Response to error detection

All channels whose pause mode is set to "PE\_MODE\_PROCEED" report errors as in productive operation.

The following rules apply to channels which switch to a pause mode other than "PE\_MODE\_PROCEED":

- All errors that are unrelated to the switch to "Pause" are reported.
- If error recognition is possible during "Pause", these errors continue to be reported.
- All error messages which are caused by the switch to "Pause" are suppressed.
- The following applies if error recognition is not possible during the "Pause":
  - The status of errors already pending before the "Pause" is retained.
  - Incoming and outgoing errors are reported once the "Pause" has been ended.

---

**Note**

Switching to "Pause" and out of "Pause" may cause an error to be reported.

---

## Additional information

Additional information on diagnostics can be found in the I/O module device manuals.

## Hardware interrupt

Ending a "Pause" causes hardware interrupts to be detected again.

## "Pause" behavior under certain operating conditions

A "Pause" is ended in the following cases:

Table 2- 2 Ending a "Pause"

| Ending a "Pause"                                                                                                                                                                                                                                                                                                                 | Explanation                                                                                                                                               |
|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------|
| The supply voltage 1L+ of the interface module module has failed. <ul style="list-style-type: none"><li>• Stop controller<sup>1</sup></li><li>• Controller failure (connection interrupted)<sup>1</sup></li><li>• Firmware update</li><li>• Reset to factory settings</li><li>• Deactivating the IO device<sup>1</sup></li></ul> | The "pause" is exited and can be re-activated by re-sending the PROFlenergy parameter assignment followed by the "Start_Pause" command.                   |
| The I/O module was pulled and plugged                                                                                                                                                                                                                                                                                            |                                                                                                                                                           |
| Station stop <sup>1</sup> <ul style="list-style-type: none"><li>• Removing an I/O module</li></ul>                                                                                                                                                                                                                               | The "pause" is exited , the PROFlenergy parameter assignment is still on the I/O module and the "pause" can be re-activated by the "Start_Pause" command. |
| The supply voltage 1L+ of the I/O module has failed                                                                                                                                                                                                                                                                              |                                                                                                                                                           |
| The parameter settings of the I/O module were changed during operation using data record 128                                                                                                                                                                                                                                     |                                                                                                                                                           |

<sup>1</sup> The substitute value behavior was activated.

### 2.3.2.3 Parameter assignment

#### Parameter assignment

Keep the following points in mind when assigning parameters for PROFlenergy:

- Parameters for PROFlenergy are assigned with the parameter data record (version 2), index 3. The interface module distributes the PROFlenergy parameters to the I/O modules.
- The parameter assignment of an additional pause behavior is possible immediately after the start of the previous "Pause". The required state for the following pause is activated with a new "Start\_Pause" command.
- You can write the parameter assignment as often as needed.
- The interface module checks the distribution of the parameters to the I/O modules and returns the result as a return value of the write job. In the case of a negative return value, there are one or more I/O modules that have not accepted the parameter data record. In this case, the I/O modules respond according to their last PROFlenergy parameter assignment in case of an incoming "Start\_Pause" command. "Start\_Pause"/"End\_Pause" commands can be executed as planned with a positive return value.
- In case of a failure of an I/O module or station outage, you must repeat the parameter assignment using the parameter data record.
- The ET 200AL distributed I/O system supports configuration of the behavior of a "pause". If a different response is required for an additional "Pause", you will have to assign parameters again.

---

**Note**

Effect: The response (switch-off) of the I/O modules to PROFlenergy is related to the slot, which means all channels in the slot behave accordingly.

---

## Parameter data record

You specify in the parameter data record for PROFlenergy which I/O modules (slots) are controlled with the PROFlenergy commands.

The following table shows the content of the parameter data record for PROFlenergy, index 3, which you create yourself and can transfer to the interface module.

Table 2- 3 Parameter data record for PROFlenergy (version 2), index 3

| Byte | Element          |             | Code                                                                                                                                                                                                                                                                                      | Explanation                                                                         |
|------|------------------|-------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------|
| 0    | Version          |             | 02 <sub>D</sub>                                                                                                                                                                                                                                                                           | Cannot be modified                                                                  |
| 1    | Number of blocks |             | 01 <sub>D</sub> to 34 <sub>D</sub>                                                                                                                                                                                                                                                        | Slots 1 to 34 depending on the configuration of the distributed I/O system ET 200AL |
| 2    | Block 1          | Slot number | 00 <sub>D</sub>                                                                                                                                                                                                                                                                           | Not assigned                                                                        |
|      |                  |             | 01 <sub>D</sub> to 34 <sub>D</sub>                                                                                                                                                                                                                                                        | I/O module slot with PROFlenergy                                                    |
| 3    | Block 1          | Mode        | 0 <sub>D</sub> : PE_MODE_PROCEED, proceed at "Pause"<br>1 <sub>D</sub> : PE_MODE_SHUTDOWN, shut down at "Pause" <sup>1</sup><br>3 <sub>D</sub> : PE_MODE_LAST_VALUE, last output or measured value is retained<br>4 <sub>D</sub> : PE_MODE_SUBST_VALUE, substitute value "0" <sup>2</sup> |                                                                                     |
| :    | :                | :           | :                                                                                                                                                                                                                                                                                         |                                                                                     |
| 64   | Block 32         | Slot number | See Block 1                                                                                                                                                                                                                                                                               |                                                                                     |
| 65   |                  | Mode        |                                                                                                                                                                                                                                                                                           |                                                                                     |

<sup>1</sup> The specific behavior depends on the used I/O module (with a digital input module, for example, the sensor supply is turned off or the outputs are without power supply and voltage supply with an analog output module)

<sup>2</sup> An analog output module (e. g. with the output range 0 mA to 20 mA,  $\pm 20$  mA) or a digital output module issues the value "0".

## Error messages

The following table shows which error messages the feedback data record returns, if necessary:

Table 2- 4 Error messages

| Error code        | Meaning                                                                                                                                                                        |                                                                                                                                                                                                                         |
|-------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 80B1 <sub>H</sub> | Impermissible length                                                                                                                                                           | Check the length of the data record                                                                                                                                                                                     |
| 80E0 <sub>H</sub> | Error in header information                                                                                                                                                    | Check the data record header information                                                                                                                                                                                |
| 80E1 <sub>H</sub> | Parameter error <ul style="list-style-type: none"> <li>at least one I/O module does not support PROFlenergy</li> <li>A parameter value has been incorrectly encoded</li> </ul> | Check the content of the data record and correct the parameter assignment error before starting the "Pause". Parameter assignment errors which are not corrected can result in incorrect I/O module shut-down behavior. |

### 2.3.2.4 PROFenergy control data records

#### PROFenergy control data records

The control data record for PROFenergy, Index 80A0H, supports the following services for the IM 157-1 PN interface module:

Table 2- 5 Control data records for PROFenergy

| Service                  | Service ID | Meaning                                                                                                                                                          |
|--------------------------|------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Start pause <sup>1</sup> | 01H        | Assuming the configured Pause behavior, suppressing all associated diagnostics data                                                                              |
| End Pause                | 02H        | Leaving the pause                                                                                                                                                |
| Query Modes              | 03H        | Reads the supported modes <ul style="list-style-type: none"> <li>Request List Energy Saving Modes</li> <li>Request Get Mode (Energy Saving Mode Data)</li> </ul> |
| PEM status               | 04H        | Reading the PROFenergy status                                                                                                                                    |
| PE_Identify              | 05H        | Reading the supported PROFenergy services                                                                                                                        |

<sup>1</sup> The minimum (configurable) pause time for the ET 200AL distributed I/O system is 10 s.

## 2.3.3 Configuration control (option handling)

### Properties

Configuration control allows you to prepare your distributed I/O system for future extensions or options. Configuration control means that you can configure the planned maximum configuration of your distributed I/O system in advance and vary it later in a flexible manner by means of the user program.

### Reference

You can find more information on configuration control

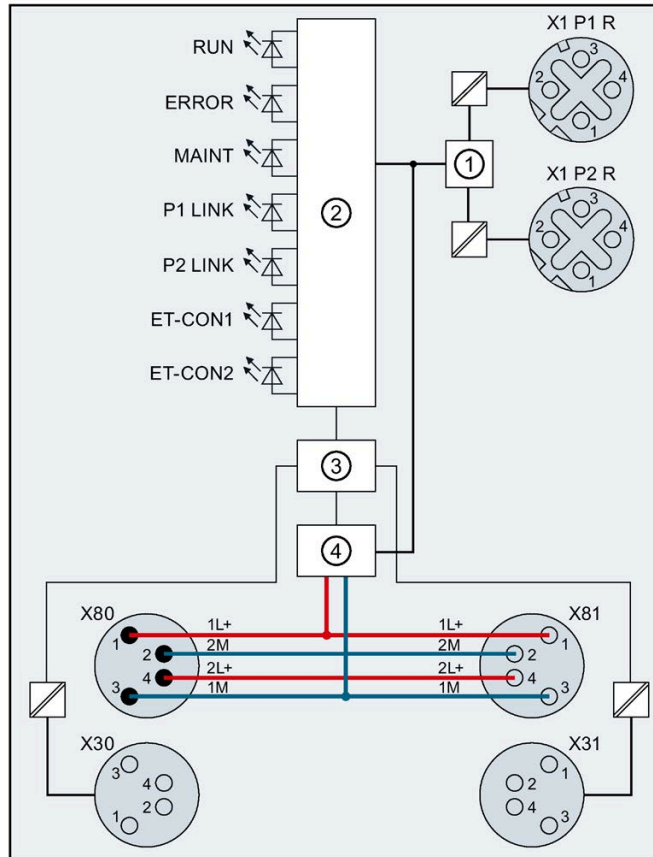
- In the system manual ET 200AL Distributed I/O System (<https://support.industry.siemens.com/cs/ww/en/view/89254965>)
- On the Internet under the following link: Application collection (<https://support.industry.siemens.com/cs/ww/en/view/29430270>).
- In the STEP 7 online help.



## Wiring

### 3.1 Terminal and block diagram

The image below shows the terminal and block diagram of the IM 157-1 PN interface module.



|         |                                   |                  |                                   |
|---------|-----------------------------------|------------------|-----------------------------------|
| ①       | Switch                            | 1L+              | Supply voltage 1L+ (non-switched) |
| ②       | Electronics                       | 1M               | Ground 1M (non-switched)          |
| ③       | ET-Connection interface           | 2L+              | Load voltage 2L+ (switched)       |
| ④       | Internal supply voltage           | 2M               | Ground 2M (switched)              |
| X1 P1 R | 1. PROFINET interface             | RUN              | LED operating state (green)       |
| X1 P2 R | 2. PROFINET interface             | ERROR            | LED diagnostics status (red)      |
| X80     | Infeed of supply voltages         | MAINT            | LED diagnostics status (yellow)   |
| X81     | Loop-through of supply voltages   | P1 LINK, P2 LINK | PROFINET LEDs (green)             |
| X30     | Infeed of the ET-Connection       | ET-CON1, ET-CON2 | ET-Connection LEDs (green)        |
| X31     | Loop-through of the ET-Connection |                  |                                   |

Figure 3-1 Terminal and block diagram

# 3.2 Pin assignment

**Note**

Color coding

The sockets for ET-Connection and the power supply of the modules are color-coded. These colors correspond to the colors of the offered cables.

## Pin assignment of the sockets for PROFINET

The following table shows the pin assignment of the two sockets for PROFINET.

Table 3- 1 Pin assignment of the PROFINET sockets

| Pin       | Assignment          |                | Front view of the sockets |         |
|-----------|---------------------|----------------|---------------------------|---------|
|           | X1 P1 R Socket      | X1 P2 R Socket | X1 P1 R                   | X1 P2 R |
| 1         | TXP                 | RXP            |                           |         |
| 2         | RXP                 | TXP            |                           |         |
| 3         | TXN                 | RXN            |                           |         |
| 4         | RXN                 | TXN            |                           |         |
| Shielding | Functional earth FE |                |                           |         |

**Note**

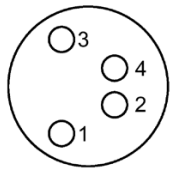
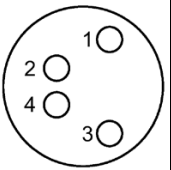
**Pin assignments**

If you disable "Autonegotiation" in STEP 7, you must pay attention to the different pin assignments of X1 P1 R and X1 P2 R.

### Pin assignment of the sockets for ET-Connection

The table below shows the pin assignments of the 2 sockets for the connection of ET-Connection.

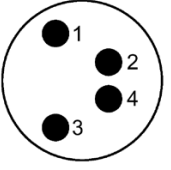
Table 3- 2 Pin assignment for ET-Connection

| Pin       | Assignment                  |                             | Assignment of the wire color of the bus line cable for ET-Connection | Front view of the sockets                                                           |                                                                                     |
|-----------|-----------------------------|-----------------------------|----------------------------------------------------------------------|-------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------|
|           | X30 socket (ET-Connection1) | X31 socket (ET-Connection2) |                                                                      | X30                                                                                 | X31                                                                                 |
| 1         | RXP                         | RXP                         | Yellow                                                               |  |  |
| 2         | TXP                         | TXP                         | White                                                                |                                                                                     |                                                                                     |
| 3         | TXN                         | TXN                         | Blue                                                                 |                                                                                     |                                                                                     |
| 4         | RXN                         | RXN                         | Orange                                                               |                                                                                     |                                                                                     |
| Shielding | Functional earth FE         |                             | -                                                                    |                                                                                     |                                                                                     |

### Pin assignment of the connector for infeed of the supply voltage

The following table shows the pin assignment for infeed of the supply voltage.

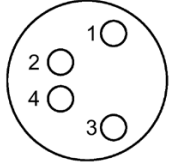
Table 3- 3 Pin assignment of the supply voltage connector

| Pin | Assignment                        | Assignment of the wire color of the power line cable | Front view of the connector                                                           |
|-----|-----------------------------------|------------------------------------------------------|---------------------------------------------------------------------------------------|
|     | X80 connector (power input)       |                                                      |                                                                                       |
| 1   | Supply voltage 1L+ (non-switched) | Brown                                                |  |
| 2   | Ground 2M (switched)              | White                                                |                                                                                       |
| 3   | Ground 1M (non-switched)          | Blue                                                 |                                                                                       |
| 4   | Load voltage 2L+ (switched)       | Black                                                |                                                                                       |

### Pin assignment of the socket for loop-through of the supply voltage

The following table shows the pin assignment for loop-through of the supply voltage.

Table 3- 4 Pin assignment of the supply voltage socket

| Pin | Assignment                        | Assignment of the wire color of the power line cable | Front view of the socket                                                            |
|-----|-----------------------------------|------------------------------------------------------|-------------------------------------------------------------------------------------|
|     | X81 Socket (power output)         |                                                      |                                                                                     |
| 1   | Supply voltage 1L+ (non-switched) | Brown                                                |  |
| 2   | Ground 2M (switched)              | White                                                |                                                                                     |
| 3   | Ground 1M (non-switched)          | Blue                                                 |                                                                                     |
| 4   | Load voltage 2L+ (switched)       | Black                                                |                                                                                     |

#### NOTICE

##### ET-Connection/supply voltage

Observe the correct wiring of the M8 sockets for ET-Connection and the supply voltage.

Mixing up the ET-Connection connectors and the connectors for the supply voltage can destroy the module.

#### CAUTION

##### PROFINET IO

Modules with PROFINET interfaces may only be operated under the following condition:

All connected devices must be equipped with SELV/PELV power supplies.

## Parameters

### 4.1 Parameters

The following table shows the parameters for the IM 157-1 PN interface module.

Table 4- 1 Parameters (GSD file)

| Parameters            | Value range                                                                | Default | Efficiency range |
|-----------------------|----------------------------------------------------------------------------|---------|------------------|
| Configuration control | <ul style="list-style-type: none"><li>• Disable</li><li>• Enable</li></ul> | Disable | ET 200AL         |

### 4.2 Explanation of the parameters

#### Configuration control

You can use this parameter to enable the configuration control function in the ET 200AL distributed I/O system.

---

#### Note

If you configure the enable, the ET 200AL distributed I/O system requires a control data record 196 from the user program in order for the ET 200AL distributed I/O system to operate the I/O modules.

---

#### Reference

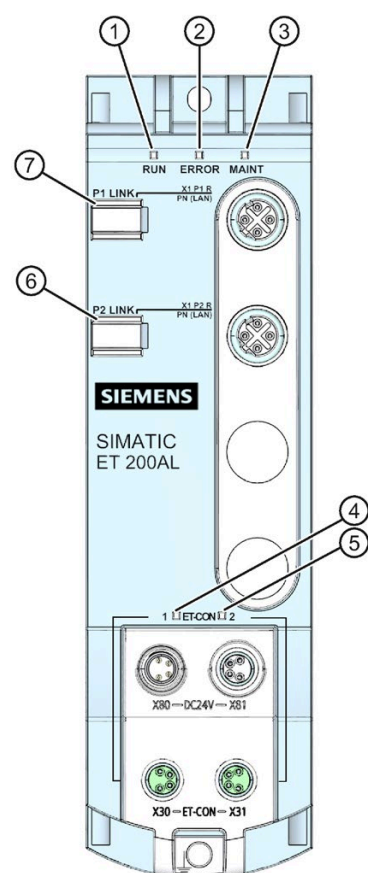
You will find more information in the section Configuration control (option handling) and in the STEP 7 online help.

# Interrupts, error messages, diagnostics and system alarms

## 5.1 Status and error displays

### LED displays

The figure below shows the LED displays (status and error displays) of the interface module IM 157-1 PN.



- |   |         |          |
|---|---------|----------|
| ① | RUN     | (green)  |
| ② | ERROR   | (red)    |
| ③ | MAINT   | (yellow) |
| ④ | ET-CON1 | (green)  |
| ⑤ | ET-CON2 | (green)  |
| ⑥ | P2 LINK | (green)  |
| ⑦ | P1 LINK | (green)  |

Figure 5-1 LED displays

## Meaning of the LEDs

The following tables set out the meaning of the status and error displays. Corrective measures for diagnostics alarms can be found in the section Diagnostics alarms (Page 32).

### LED RUN, LED ERROR, LED MAINT

Table 5- 1 Status and error displays of the LEDs RUN, ERROR, MAINT

| LEDs                                                                                        |                                                                                             |                                                                                             | Meaning                                                                                                 | Solution                                                                                                                                                        |
|---------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------|
| RUN                                                                                         | ERROR                                                                                       | MAINT                                                                                       |                                                                                                         |                                                                                                                                                                 |
|  Off       |  Off       |  Off       | Missing or insufficient supply voltage on interface module.                                             | Check the supply voltage or switch it on on the interface module.                                                                                               |
|  On        |  On        |  On        | Test of LEDs during startup: The three LEDs light up simultaneously for approximately 0.25 s.           | ---                                                                                                                                                             |
|  Flashes   |  Off       |  Off       | Interface module is deactivated.                                                                        | Activate the interface module with the configuration software or the user program.                                                                              |
|                                                                                             |                                                                                             |                                                                                             | Interface module is not configured.                                                                     | Configure the interface module with the configuration software.                                                                                                 |
|                                                                                             |                                                                                             |                                                                                             | ET 200AL starts up.                                                                                     | ---                                                                                                                                                             |
|                                                                                             |                                                                                             |                                                                                             | ET 200AL is being assigned parameters.                                                                  | ---                                                                                                                                                             |
|  On      | Not relevant                                                                                | Not relevant                                                                                | ET 200AL is currently exchanging data with the IO controller.                                           | ---                                                                                                                                                             |
| Not relevant                                                                                |  Flashes | Not relevant                                                                                | Group error                                                                                             | Evaluate the diagnostics and eliminate the error.                                                                                                               |
|                                                                                             |                                                                                             |                                                                                             | The preset configuration does not correspond to the actual configuration of the ET 200AL.               | Check the configuration of the ET 200AL to see whether a module is missing, defective or if a module that is not configured is connected to ET-CON1 or ET-CON2. |
|                                                                                             |                                                                                             |                                                                                             | Parameter assignment error in the I/O module                                                            | Evaluate the display of the module status in STEP 7 or in STEP 7 (TIA portal) and correct the errors in the I/O module.                                         |
| Not relevant                                                                                | Not relevant                                                                                |  On      | Maintenance                                                                                             | See section Maintenance events (Page 33)                                                                                                                        |
|  Flashes |  Flashes |  Flashes | The "Node flash test" is run (the LEDs P1 LINK and P2 LINK of the PROFINET interface also flash).       | ---                                                                                                                                                             |
|                                                                                             |                                                                                             |                                                                                             | Hardware or firmware defective (The LEDs P1 LINK and P2 LINK of the PROFINET interface do not flash).   | Replace the interface module.                                                                                                                                   |
|  Flashes | Not relevant                                                                                | Not relevant                                                                                | Firmware is loading (all LEDs remain in their current state while the firmware update is being written) | ---                                                                                                                                                             |

**LED P1 LINK, LED P2 LINK**

Table 5- 2 Status displays of the LEDs P1 LINK and P2 LINK

| LEDs                                                                                         |         | Meaning                                                                                                                          | Solution                                                                    |
|----------------------------------------------------------------------------------------------|---------|----------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------|
| P1 LINK                                                                                      | P2 LINK |                                                                                                                                  |                                                                             |
| <br>Off     |         | There is no connection between the PROFINET interface of your PROFINET device and a communication partner (e.g., IO controller). | Check whether the bus cable to the switch or IO controller is disconnected. |
| <br>On      |         | There is no connection between the PROFINET interface of your PROFINET device and a communication partner (e.g., IO controller). | -                                                                           |
| <br>Flashes |         | The "Node flash test" is run (the RUN, ERROR and MAINT LEDs also flash).                                                         | -                                                                           |

**LED ET-CON1, LED ET-CON2**

Table 5- 3 Status displays of the LEDs ET-CON1 and ET-CON2

| LEDs                                                                                       |         | Meaning                                                                                                       | Solution                                                                         |
|--------------------------------------------------------------------------------------------|---------|---------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------|
| ET-CON1                                                                                    | ET-CON2 |                                                                                                               |                                                                                  |
| <br>Off |         | There are no I/O modules available at the respective ET-Connection or the modules do not have supply voltage. | Check the wiring for the ET-Connection or the supply voltage for the I/O module. |
| <br>On  |         | A communications connection to at least one IO module at the corresponding ET-Connection is available.        | -                                                                                |



## 5.2 Interrupts

### 5.2.1 Evaluating interrupts

#### Introduction

Interrupts are triggered by the IO device in case of errors. Interrupts are evaluated based on the I/O controller used.

#### Evaluating interrupts with I/O controllers

The ET 200AL distributed I/O system supports the following interrupts:

- Diagnostics interrupts
- Hardware interrupts
- Pull/plug module interrupt

In the event of an interrupt, interrupt OBs are automatically called in the CPU of the IO controller.

Information on the cause and class of the error is already available, based on the OB number and start information.

Detailed information on the error event can be obtained in the error OB using the instruction "RALRM" (read additional interrupt information).

#### System diagnostics

In STEP 7 (TIA Portal), the updated system diagnostic is available for the modules of the S7-1500 automation system (IO controller CPU S7-1500) and ET 200AL (IO device). Independent of the cyclic user program, messages are made available on the display of the CPU S7-1500, the CPU web server and the HMI device.

You will find more information on systemic diagnostics in the Function Manual Diagnostics (<http://support.automation.siemens.com/WW/view/en/59192926>).

### 5.2.2 Trigger a diagnostics interrupt

For an incoming or outgoing event (for example, wire break on a channel of an I/O module), the interface module triggers a diagnostics interrupt if the parameters were assigned accordingly.

The CPU interrupts the processing of the user program and processes the diagnostics interrupt OB (OB 82). The event that triggered the interrupt is entered in the start information of the diagnostics interrupt OB.

### 5.2.3 Triggering a hardware interrupt

During a hardware interrupt, the CPU interrupts the processing of the user program and processes the hardware interrupt OB (e.g., OB 40). The event that triggered the interrupt is entered in the start information of the hardware interrupt OB.

---

**Note****Diagnostics "Hardware interrupt lost" (from I/O module)**

Avoid creating hardware interrupts cyclically.

If the hardware interrupt load is too high, hardware interrupts can get lost depending on the number of I/O modules and the communication load.

---

### 5.2.4 Triggering an insert/remove module interrupt

When an insert/remove module interrupt occurs, the CPU interrupts execution of the user program and processes the insert/remove module interrupt OB (OB 83). The event that triggered the interrupt is entered in the start information of the insert/remove OB.

The pull/plug OB (OB 83) is also triggered for all subsequent I/O modules, because the ET-Connection and/or the power supply is interrupted.

## 5.3 Alarms

### 5.3.1 Diagnostics alarms

#### Actions after a diagnostics alarm

There can be more than one diagnostic alarm at a given time. Actions initiated by diagnostics alarms:

- The ERROR LED of the interface module flashes.
- Diagnostic data is reported as diagnostics interrupts to the CPU of the IO controller and can be read via data records.
- Incoming diagnostics alarms are saved to the diagnostics buffer of the I/O controller.
- OB 82 is called. If OB 82 is not available, the I/O controller goes into STOP mode.

You can find more information on this topic in the STEP 7 online help.

#### Reading out the diagnostics data

Table 5- 4 Reading the diagnostics with STEP 7

| Automation system with IO controller | Application                                                             | See...                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |
|--------------------------------------|-------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| SIMATIC S7                           | Diagnostics as plain text in STEP 7 in online and diagnostics view      | STEP 7 online help <ul style="list-style-type: none"> <li>• STEP 7 V13 and higher Function Manual PROFINET with STEP 7 V13 (<a href="http://support.automation.siemens.com/WW/view/en/49948856">http://support.automation.siemens.com/WW/view/en/49948856</a>)</li> <li>• STEP 7 V5.5 and higher System Manual PROFINET System Description (<a href="http://support.automation.siemens.com/WW/view/en/19292127">http://support.automation.siemens.com/WW/view/en/19292127</a>)</li> </ul> |
|                                      | "RDREC" instruction (SFB 52)<br>Reading data records from the IO device |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |
|                                      | "RALRM" instruction (SFB 54)<br>Receiving alarms from the IO device     |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |

#### Additional information on the data records for PROFINET IO

The structure of the diagnostics data records and programming examples can be found in the Programming Manual From PROFIBUS DP to PROFINET IO (<http://support.automation.siemens.com/WW/view/en/19289930>) and in the Application example (<http://support.automation.siemens.com/WW/view/en/24000238>).

## Causes of error and troubleshooting

Causes of errors and corrective measures of diagnostics alarms are described in the device manuals of the I/O modules

(<http://support.automation.siemens.com/WW/view/en/89013554>) in the section Interrupt, Error and System Messages.

## 5.3.2 Maintenance events

### Triggering of a maintenance event

The PROFINET IO interfaces of the interface module support the diagnostics concept and maintenance concept in PROFINET IO according to standard IEC 61158-6-10. The goal is the early recognition and correction of potential disruptions.

For the interface module, maintenance events signal to the user when a network component must be checked or replaced.

The CPU interrupts user program execution and processes the diagnostic block OB 82. The event that triggered the maintenance event is entered in the start information of the OB 82.

The interface module signals a maintenance event to the higher-level diagnostics system in the case of the following event:

Table 5- 5 Triggering of a maintenance event

| Maintenance alarm                                | Event                | Alarm/Meaning                                                                                                                                                                                                                                                                                                                                                             |
|--------------------------------------------------|----------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Maintenance demanded</b><br>LED MAINT is lit. | Synchronization loss | <ul style="list-style-type: none"> <li>No synchronization frame received.</li> </ul> <p>No synchronization message frame was received by the sync master within the timeout period after parameter assignment or during operation.</p> <ul style="list-style-type: none"> <li>Successive synchronization frames are located outside permitted limits (jitter).</li> </ul> |

### System alarms in STEP 7 (TIA Portal)

The maintenance information is generated in STEP 7 (TIA Portal) V12 SP1 and higher with the following system alarms:

- Maintenance demanded - indicated for each port by a yellow wrench icon  in the device view or in the hardware configuration.

You can find more information on this topic in the STEP 7 online help.

### 5.3.3 Channel diagnostics

#### Function

Channel-related diagnostics provides information about channel faults in modules.

Channel faults are mapped as channel diagnostics data in IO diagnostics data records.

The data record is read with the "RDREC" instruction (SFB 52).

#### Structure of the diagnostics data records

The data records supported by the ET 200AL distributed I/O system are based on the PROFINET IO standard - Application Layer Service definition V2.2.

You can download the standard on the Internet (<http://www.profibus.com>) from home page of the PROFIBUS user organization free of charge.

#### Structure of the manufacturer-specific diagnostics data records

The structure of the diagnostics data records is differentiated by the BlockVersion. The following BlockVersion applies to the IM 157-1 PN interface modules:

Table 5- 6 Structure of the manufacturer-specific diagnostics data records

| IM 157-1 PN interface module | BlockVersion |
|------------------------------|--------------|
| 6ES7157-1AB00-0AB0           | W#16#0101    |

### 5.3.4 Invalid configuration states of ET 200AL on the PROFINET IO

#### Invalid configuration states

If the number of modules exceeds the maximum configuration limit, the extra modules are ignored by the system. No data exchange takes place.

### **5.3.5 STOP of the IO controller and recovery of the IO device**

#### **STOP of the SIMATIC IO controller**

If diagnostics from the IO device are received by the IO controller in the STOP state, these diagnostics do not result in a start of the organization blocks after startup of the IO controller. You must read the data record E00CH in OB 100 with the "RDREC" instruction.

#### **Return of the SIMATIC IO device**

If you want to read out the diagnostics of a station after the station return, you must read the data record E00CH in OB 86 with the "RDREC" instruction.

## Technical specifications

### Technical specifications of the interface module IM 157-1 PN

The following table shows the technical specifications as of 05/2021. You can find a data sheet including daily updated technical specifications on the Internet (<https://support.industry.siemens.com/cs/ww/en/pv/6ES7157-1AB00-0AB0/td?dl=en>).

|                                                          |                           |
|----------------------------------------------------------|---------------------------|
| <b>Article number</b>                                    | <b>6ES7157-1AB00-0AB0</b> |
| <b>General information</b>                               |                           |
| Product type designation                                 | IM 157-1 PN               |
| HW functional status                                     | E01                       |
| Firmware version                                         | V1.0.x                    |
| <b>Product function</b>                                  |                           |
| • I&M data                                               | Yes; I&M0 to I&M4         |
| <b>Engineering with</b>                                  |                           |
| • STEP 7 TIA Portal configurable/integrated from version | STEP 7 V13 SP1 or higher  |
| • STEP 7 configurable/integrated from version            | From V5.5 SP4 Hotfix 3    |
| • PROFINET from GSD version/GSD revision                 | GSDML V2.3.1              |
| <b>Configuration control</b>                             |                           |
| via dataset                                              | Yes                       |
| <b>Supply voltage</b>                                    |                           |
| <b>Load voltage 1L+</b>                                  |                           |
| • Rated value (DC)                                       | 24 V                      |
| • permissible range, lower limit (DC)                    | 20.4 V                    |
| • permissible range, upper limit (DC)                    | 28.8 V                    |
| • Reverse polarity protection                            | Yes; against destruction  |
| <b>Input current</b>                                     |                           |
| Current consumption (rated value)                        | 100 mA                    |
| from load voltage 1L+ (unswitched voltage)               | 4 A; Maximum value        |
| from load voltage 2L+, max.                              | 4 A; Maximum value        |
| <b>Power loss</b>                                        |                           |
| Power loss, typ.                                         | 2.9 W                     |
| <b>Address area</b>                                      |                           |
| <b>Address space per station</b>                         |                           |
| • Address space per station, max.                        | 1 430 byte                |
| <b>Interfaces</b>                                        |                           |
| Number of PROFINET interfaces                            | 1                         |
| <b>1. Interface</b>                                      |                           |

|                                                     |                                                                          |
|-----------------------------------------------------|--------------------------------------------------------------------------|
| <b>Article number</b>                               | <b>6ES7157-1AB00-0AB0</b>                                                |
| <b>Interface types</b>                              |                                                                          |
| • M12 port                                          | Yes; 2x M12 D-coded                                                      |
| • integrated switch                                 | Yes                                                                      |
| <b>Protocols</b>                                    |                                                                          |
| • PROFINET IO Device                                | Yes                                                                      |
| • Open IE communication                             | Yes                                                                      |
| <b>M12 port</b>                                     |                                                                          |
| • Transmission procedure                            | PROFINET with 100 Mbit/s full duplex (100BASE-TX)                        |
| • 10 Mbps                                           | Yes; for Ethernet services                                               |
| • 100 Mbps                                          | Yes; PROFINET with 100 Mbit/s full duplex (100BASE-TX)                   |
| • Autonegotiation                                   | Yes                                                                      |
| • Autocrossing                                      | Yes                                                                      |
| <b>Protocols</b>                                    |                                                                          |
| <b>PROFINET IO Device</b>                           |                                                                          |
| <b>Services</b>                                     |                                                                          |
| – IRT                                               | Yes; 250 µs, 500 µs, 1 ms, 2 ms, 4 ms, 8 ms, 16 ms, 32 ms, 64 ms, 128 ms |
| – PROFinergy                                        | Yes                                                                      |
| – Shared device                                     | Yes                                                                      |
| – Number of IO Controllers with shared device, max. | 4                                                                        |
| <b>Redundancy mode</b>                              |                                                                          |
| <b>Media redundancy</b>                             |                                                                          |
| – MRP                                               | Yes                                                                      |
| – MRPD                                              | Yes                                                                      |
| <b>Open IE communication</b>                        |                                                                          |
| • TCP/IP                                            | Yes                                                                      |
| • SNMP                                              | Yes                                                                      |
| • LLDP                                              | Yes                                                                      |
| <b>Interrupts/diagnostics/status information</b>    |                                                                          |
| Diagnostics function                                | Yes                                                                      |
| <b>Alarms</b>                                       |                                                                          |
| • Diagnostic alarm                                  | Yes                                                                      |
| <b>Diagnostics indication LED</b>                   |                                                                          |
| • RUN LED                                           | Yes; green LED                                                           |
| • ERROR LED                                         | Yes; red LED                                                             |
| • MAINT LED                                         | Yes; Yellow LED                                                          |
| • Connection display LINK TX/RX                     | Yes; 2x green LED                                                        |



|                                                                                                                                                                               |                                   |
|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------|
| <b>Article number</b>                                                                                                                                                         | <b>6ES7157-1AB00-0AB0</b>         |
| <b>Potential separation</b>                                                                                                                                                   |                                   |
| between the load voltages                                                                                                                                                     | Yes                               |
| between PROFINET and all other circuits                                                                                                                                       | Yes                               |
| <b>Isolation</b>                                                                                                                                                              |                                   |
| Isolation tested with                                                                                                                                                         | 707 V DC (type test)              |
| <b>Standards, approvals, certificates</b>                                                                                                                                     |                                   |
| Suitable for safety-related tripping of standard modules                                                                                                                      | Yes; From FS01                    |
| <b>Highest safety class achievable for safety-related tripping of standard modules</b>                                                                                        |                                   |
| <ul style="list-style-type: none"> <li>Performance level according to ISO 13849-1</li> <li>Category according to ISO 13849-1</li> <li>SILCL according to IEC 62061</li> </ul> | PL d<br><br>Cat. 3<br><br>SILCL 2 |
| <b>Ambient conditions</b>                                                                                                                                                     |                                   |
| <b>Ambient temperature during operation</b>                                                                                                                                   |                                   |
| <ul style="list-style-type: none"> <li>min.</li> <li>max.</li> </ul>                                                                                                          | -25 °C<br><br>55 °C               |
| <b>Connection method</b>                                                                                                                                                      |                                   |
| Design of electrical connection for supply voltage                                                                                                                            | M8, 4-pole                        |
| <b>ET-Connection</b>                                                                                                                                                          |                                   |
| <ul style="list-style-type: none"> <li>ET-Connection</li> </ul>                                                                                                               | M8, 4-pin, shielded               |
| <b>Dimensions</b>                                                                                                                                                             |                                   |
| Width                                                                                                                                                                         | 45 mm                             |
| Height                                                                                                                                                                        | 159 mm                            |
| Depth                                                                                                                                                                         | 40 mm                             |
| <b>Weights</b>                                                                                                                                                                |                                   |
| Weight, approx.                                                                                                                                                               | 263 g                             |

## Dimension drawing

The figure below shows the dimension drawing of the IM 157-1 PN interface module in the front and side view.

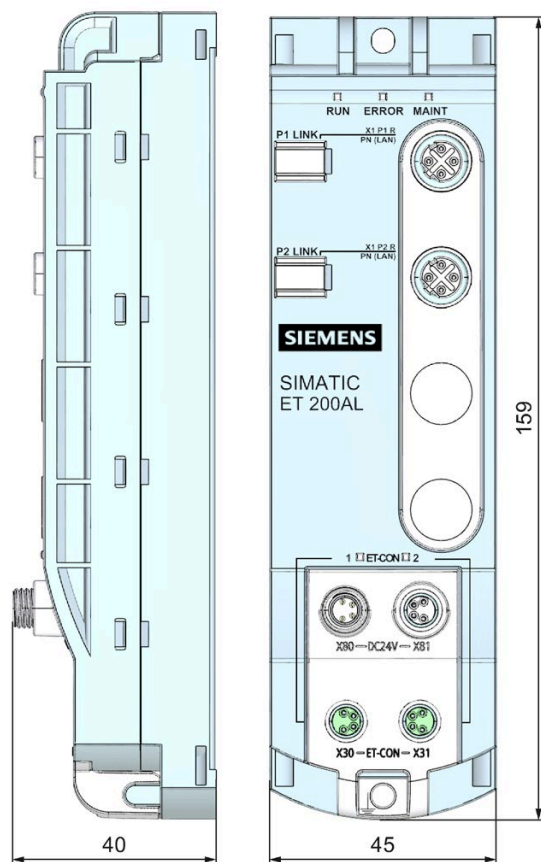


Figure A-1 Dimension drawing

## Cycle times

The figure below shows the cycle times at ET-Connection based on the number of I/O modules with a PN send clock of 0.5 ms.

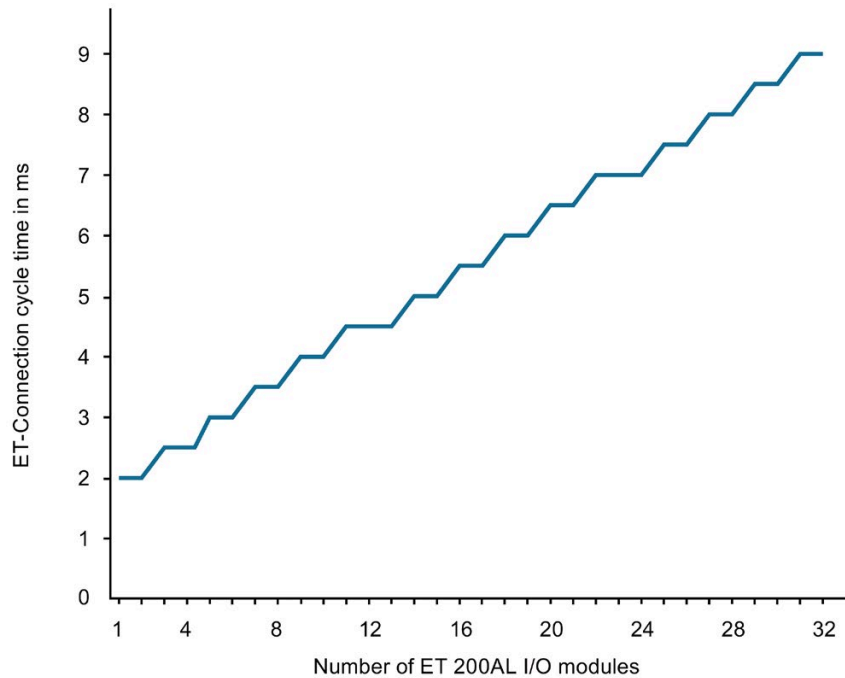


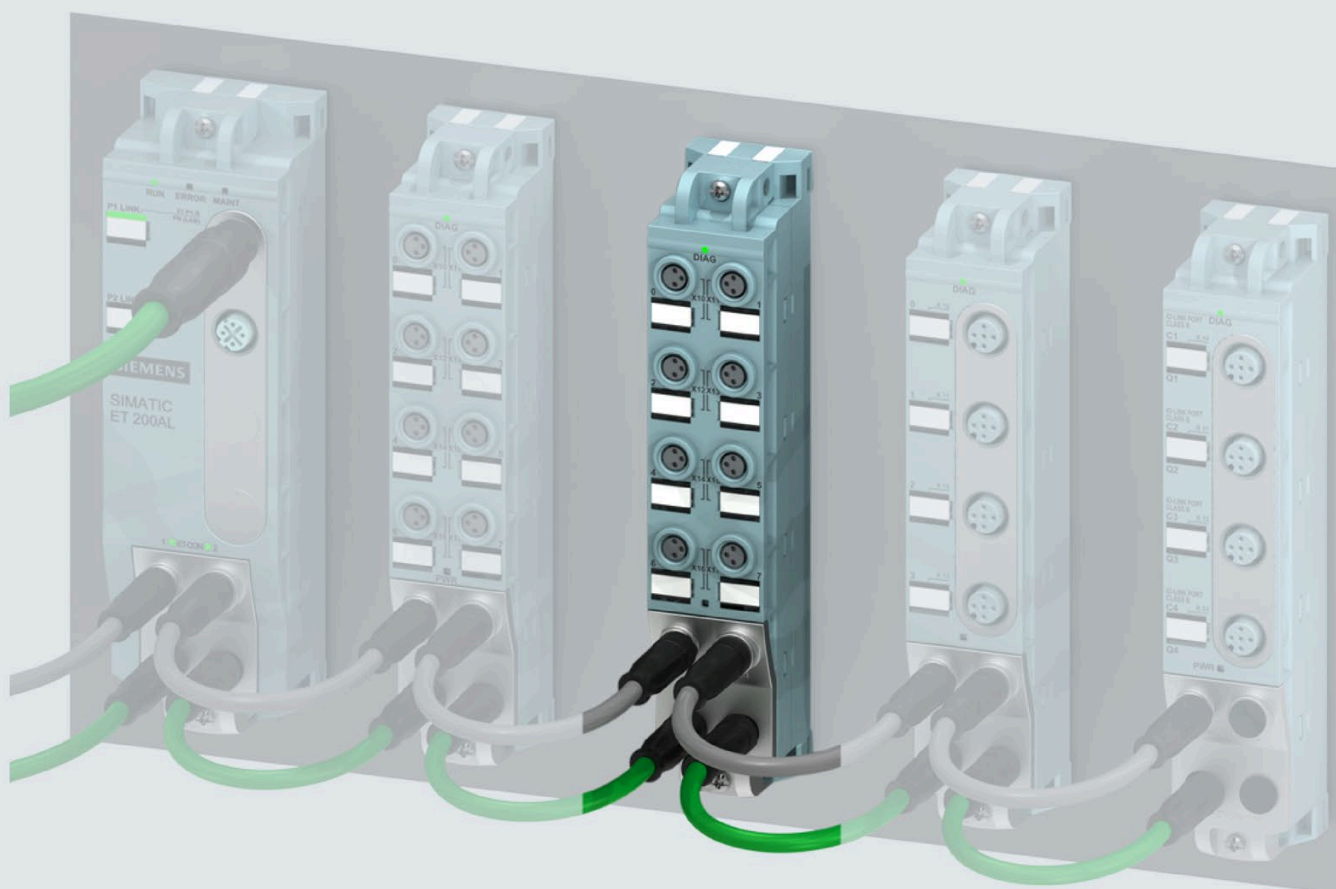
Figure B-1 Cycle times

The cycle time at ET-Connection is synchronized with the PROFINET send clock. This means that the input data of the I/O modules are transmitted via ET-Connection without further delay (wait time in the interface module) via PROFINET. The output data from PROFINET is also transmitted without further delay via ET-Connection to the I/O modules. Thus, the cycle time of the ET-Connection, based on the number of I/O modules, is always a multiple of the configured PROFINET send clock.

The chart shown above shows the trend for a send clock of 0.5 ms. With larger send clocks, the gradation of the trend changes according to the send clock.

When using a larger number of IO-Link masters with a large I/O data configuration (> 32 bytes), there may be a slight increase in the cycle time at the ET-Connection.

# SIEMENS



Equipment Manual

## SIMATIC

### ET 200AL

Digital input module DI 8x24VDC 8xM8  
(6ES7141-5BF00-0BA0)

Edition

08/2021

[support.industry.siemens.com](https://support.industry.siemens.com)

## SIMATIC

### ET 200AL DI 8x24VDC 8xM8 (6ES7141-5BF00-0BA0)

#### Equipment Manual

#### Preface

---

#### ET 200AL Documentation Guide

**1**

#### Product overview

**2**

#### Wiring

**3**

#### Parameters/address space

**4**

#### Interrupts/diagnostics alarms

**5**

#### Technical specifications

**6**

#### PROFenergy

**7**

#### Dimension drawing

**A**

## Legal information

### Warning notice system

This manual contains notices you have to observe in order to ensure your personal safety, as well as to prevent damage to property. The notices referring to your personal safety are highlighted in the manual by a safety alert symbol, notices referring only to property damage have no safety alert symbol. These notices shown below are graded according to the degree of danger.

#### **DANGER**

indicates that death or severe personal injury **will** result if proper precautions are not taken.

#### **WARNING**

indicates that death or severe personal injury **may** result if proper precautions are not taken.

#### **CAUTION**

indicates that minor personal injury can result if proper precautions are not taken.

#### **NOTICE**

indicates that property damage can result if proper precautions are not taken.

If more than one degree of danger is present, the warning notice representing the highest degree of danger will be used. A notice warning of injury to persons with a safety alert symbol may also include a warning relating to property damage.

### Qualified Personnel

The product/system described in this documentation may be operated only by **personnel qualified** for the specific task in accordance with the relevant documentation, in particular its warning notices and safety instructions. Qualified personnel are those who, based on their training and experience, are capable of identifying risks and avoiding potential hazards when working with these products/systems.

### Proper use of Siemens products

Note the following:

#### **WARNING**

Siemens products may only be used for the applications described in the catalog and in the relevant technical documentation. If products and components from other manufacturers are used, these must be recommended or approved by Siemens. Proper transport, storage, installation, assembly, commissioning, operation and maintenance are required to ensure that the products operate safely and without any problems. The permissible ambient conditions must be complied with. The information in the relevant documentation must be observed.

### Trademarks

All names identified by ® are registered trademarks of Siemens AG. The remaining trademarks in this publication may be trademarks whose use by third parties for their own purposes could violate the rights of the owner.

### Disclaimer of Liability

We have reviewed the contents of this publication to ensure consistency with the hardware and software described. Since variance cannot be precluded entirely, we cannot guarantee full consistency. However, the information in this publication is reviewed regularly and any necessary corrections are included in subsequent editions.

# Preface

## Purpose of the documentation

This manual supplements the ET 200AL distributed I/O system (<http://support.automation.siemens.com/WW/view/en/89254965>) system manual. Functions that are generally applicable to the ET 200AL distributed I/O system are described there.

The information provided in the present manual, the system manual and the function manuals enables you to commission the ET 200AL distributed I/O system.

## Conventions

Please also observe notes marked as follows:

---

### Note

Indicates important product information to which particular attention should be paid.

---

## Security information

Siemens provides products and solutions with industrial security functions that support the secure operation of plants, systems, machines and networks.

In order to protect plants, systems, machines and networks against cyber threats, it is necessary to implement – and continuously maintain – a holistic, state-of-the-art industrial security concept. Siemens' products and solutions constitute one element of such a concept.

Customers are responsible for preventing unauthorized access to their plants, systems, machines and networks. Such systems, machines and components should only be connected to an enterprise network or the internet if and to the extent such a connection is necessary and only when appropriate security measures (e.g. firewalls and/or network segmentation) are in place.

For additional information on industrial security measures that may be implemented, please visit (<https://www.siemens.com/industrialsecurity>).

Siemens' products and solutions undergo continuous development to make them more secure. Siemens strongly recommends that product updates are applied as soon as they are available and that the latest product versions are used. Use of product versions that are no longer supported, and failure to apply the latest updates may increase customers' exposure to cyber threats.

To stay informed about product updates, subscribe to the Siemens Industrial Security RSS Feed visit (<https://www.siemens.com/industrialsecurity>).

# Table of contents

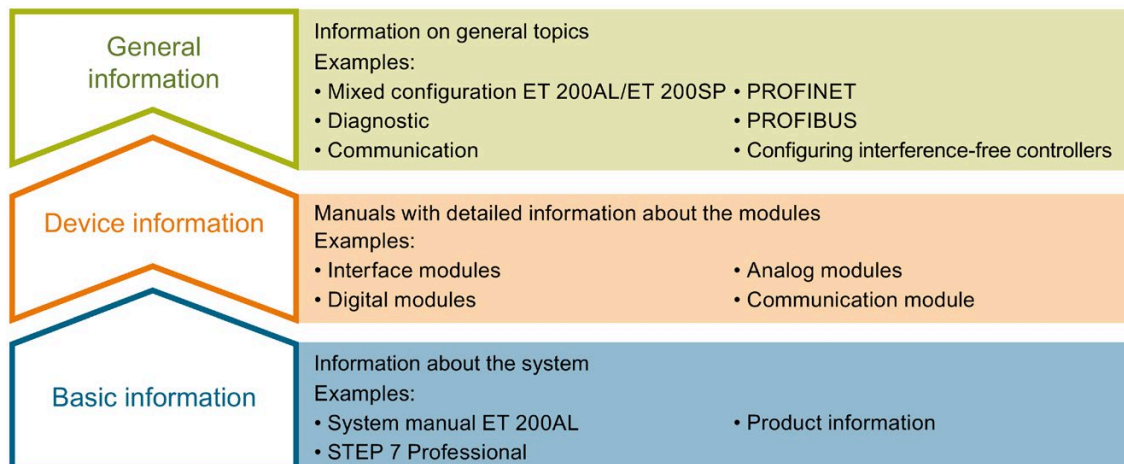
|          |                                                  |           |
|----------|--------------------------------------------------|-----------|
|          | <b>Preface .....</b>                             | <b>3</b>  |
| <b>1</b> | <b>ET 200AL Documentation Guide.....</b>         | <b>5</b>  |
| <b>2</b> | <b>Product overview.....</b>                     | <b>9</b>  |
|          | 2.1 Properties .....                             | 9         |
|          | 2.2 Operator controls and display elements ..... | 11        |
| <b>3</b> | <b>Wiring .....</b>                              | <b>12</b> |
|          | 3.1 Terminal and block diagram .....             | 12        |
|          | 3.2 Pin assignment .....                         | 13        |
| <b>4</b> | <b>Parameters/address space .....</b>            | <b>16</b> |
|          | 4.1 Parameters .....                             | 16        |
|          | 4.2 Explanation of the parameters .....          | 16        |
|          | 4.3 Address space.....                           | 17        |
| <b>5</b> | <b>Interrupts/diagnostics alarms .....</b>       | <b>18</b> |
|          | 5.1 Status and error displays .....              | 18        |
|          | 5.2 Interrupts .....                             | 20        |
|          | 5.3 Diagnostics alarms .....                     | 20        |
| <b>6</b> | <b>Technical specifications.....</b>             | <b>21</b> |
| <b>7</b> | <b>PROFenergy .....</b>                          | <b>24</b> |
|          | 7.1 Pause function.....                          | 24        |
|          | 7.2 Behavior of the digital input module .....   | 25        |
| <b>A</b> | <b>Dimension drawing .....</b>                   | <b>27</b> |



# ET 200AL Documentation Guide

The documentation for the SIMATIC ET 200AL distributed I/O system is arranged into three areas.

This arrangement enables you to access the specific content you require.



## Basic information

The System Manual and Getting Started describe in detail the configuration, installation, wiring and commissioning of the SIMATIC ET 200AL distributed I/O system. The STEP 7 online help supports you in the configuration and programming.

## Device information

Product manuals contain a compact description of the module-specific information, such as properties, wiring diagrams, characteristics and technical specifications.

## General information

The function manuals contain detailed descriptions on general topics regarding the SIMATIC ET 200AL distributed I/O system, e.g. diagnostics, communication, Motion Control, Web server.

You can download the documentation free of charge from the Internet (<https://support.industry.siemens.com/cs/ww/en/view/109742667>).

## Manual Collection ET 200AL

The Manual Collection contains the complete documentation on the SIMATIC ET 200AL distributed I/O system gathered together in one file.

You can find the Manual Collection on the Internet (<https://support.automation.siemens.com/WW/view/en/95242965>).

## **"mySupport"**

With "mySupport", your personal workspace, you make the best out of your Industry Online Support.

In "mySupport", you can save filters, favorites and tags, request CAx data and compile your personal library in the Documentation area. In addition, your data is already filled out in support requests and you can get an overview of your current requests at any time.

You must register once to use the full functionality of "mySupport".

You can find "mySupport" on the Internet (<https://support.industry.siemens.com/My/ww/en>).

## **"mySupport" - Documentation**

With "mySupport", your personal workspace, you make the best out of your Industry Online Support.

In "mySupport", you can save filters, favorites and tags, request CAx data and compile your personal library in the Documentation area. In addition, your data is already filled out in support requests and you can get an overview of your current requests at any time.

You must register once to use the full functionality of "mySupport".

You can find "mySupport" on the Internet (<https://support.industry.siemens.com/My/ww/en/documentation>).

## **"mySupport" - CAx data**

In the CAx data area of "mySupport", you can access the latest product data for your CAx or CAe system.

You configure your own download package with a few clicks.

In doing so you can select:

- Product images, 2D dimension drawings, 3D models, internal circuit diagrams, EPLAN macro files
- Manuals, characteristics, operating manuals, certificates
- Product master data

You can find "mySupport" - CAx data on the Internet (<https://support.industry.siemens.com/my/ww/en/CAxOnline>).

## **Application examples**

The application examples support you with various tools and examples for solving your automation tasks. Solutions are shown in interplay with multiple components in the system - separated from the focus on individual products.

You will find the application examples on the Internet (<https://support.industry.siemens.com/cs/ww/en/ps/ae>).

## TIA Selection Tool

With the TIA Selection Tool, you can select, configure and order devices for Totally Integrated Automation (TIA).

This tool is the successor of the SIMATIC Selection Tool and combines the known configurators for automation technology into one tool.

With the TIA Selection Tool, you can generate a complete order list from your product selection or product configuration.

You can find the TIA Selection Tool on the Internet

(<https://support.industry.siemens.com/cs/ww/en/view/109767888>).

## SIMATIC Automation Tool

You can use the SIMATIC Automation Tool to perform commissioning and maintenance activities simultaneously on various SIMATIC S7 stations as a bulk operation independent of TIA Portal.

The SIMATIC Automation Tool provides a multitude of functions:

- Scanning of a PROFINET/Ethernet system network and identification of all connected CPUs
- Address assignment (IP, subnet, gateway) and station name (PROFINET device) to a CPU
- Transfer of the date and the programming device/PC time converted to UTC time to the module
- Program download to CPU
- RUN/STOP mode switchover
- CPU localization by means of LED flashing
- Reading out of CPU error information
- Reading of the CPU diagnostics buffer
- Reset to factory settings
- Firmware update of the CPU and connected modules

You can find the SIMATIC Automation Tool on the Internet

(<https://support.industry.siemens.com/cs/ww/en/view/98161300>).

## PRONETA

SIEMENS PRONETA (PROFINET network analysis) allows you to analyze the plant network during commissioning. PRONETA features two core functions:

- The topology overview automatically scans the PROFINET and all connected components.
- The IO check is a fast test of the wiring and the module configuration of a plant.

You can find SIEMENS PRONETA on the Internet

(<https://support.industry.siemens.com/cs/ww/en/view/67460624>).

## SINETPLAN

SINETPLAN, the Siemens Network Planner, supports you in planning automation systems and networks based on PROFINET. The tool facilitates professional and predictive dimensioning of your PROFINET installation as early as in the planning stage. In addition, SINETPLAN supports you during network optimization and helps you to exploit network resources optimally and to plan reserves. This helps to prevent problems in commissioning or failures during productive operation even in advance of a planned operation. This increases the availability of the production plant and helps improve operational safety.

The advantages at a glance

- Network optimization thanks to port-specific calculation of the network load
- Increased production availability thanks to online scan and verification of existing systems
- Transparency before commissioning through importing and simulation of existing STEP 7 projects
- Efficiency through securing existing investments in the long term and the optimal use of resources

You can find SINETPLAN on the Internet (<https://www.siemens.com/sinetplan>).

## Product overview

### 2.1 Properties

#### Article number

6ES7141-5BF00-0BA0

#### View of the module

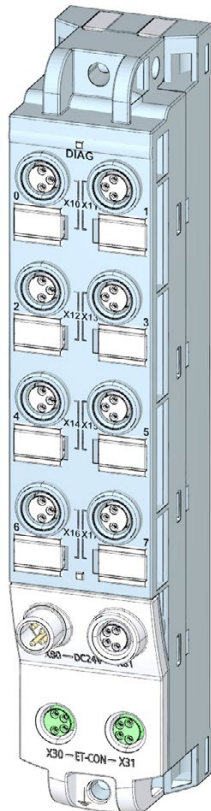


Figure 2-1 View of the DI 8x24VDC 8xM8 digital input module

## 2.1 Properties

### Properties

The module has the following technical properties:

- 8 digital inputs
- M8 sockets for connection of sensors
- 24 V DC supply voltage
- Configurable diagnostics can be set for each module
- Typical input delay of 3 ms
- Suitable for switches and proximity switches
- Dimensions 30 x 159 mm

The module supports the following functions:

- Firmware update
- Identification and maintenance data I&M0 to I&M3
- Value status (Quality Information)
- PROFIenergy

### Accessories

The following components are included in the module package:

- Identification labels
- Spacers

### Other components

The following component can be ordered as spare part:

- Identification labels

The following components can be ordered as accessories:

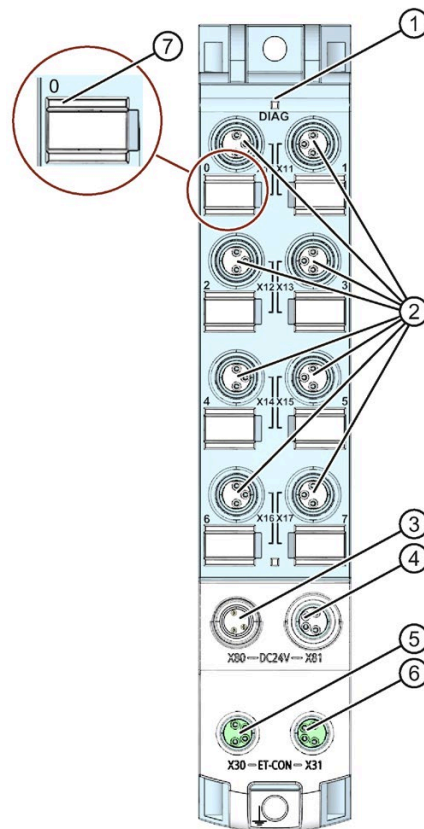
- Connectors
- Cables
- Stripping Tool for ET-Connection
- M8 sealing cap

### See also

You can find more information on accessories in the Accessories/spare parts section of the ET 200AL distributed I/O system (<http://support.automation.siemens.com/WW/view/en/89254965>) system manual.

## 2.2 Operator controls and display elements

The following figure shows the operator controls and display elements of the DI 8x24VDC 8xM8 digital input module.



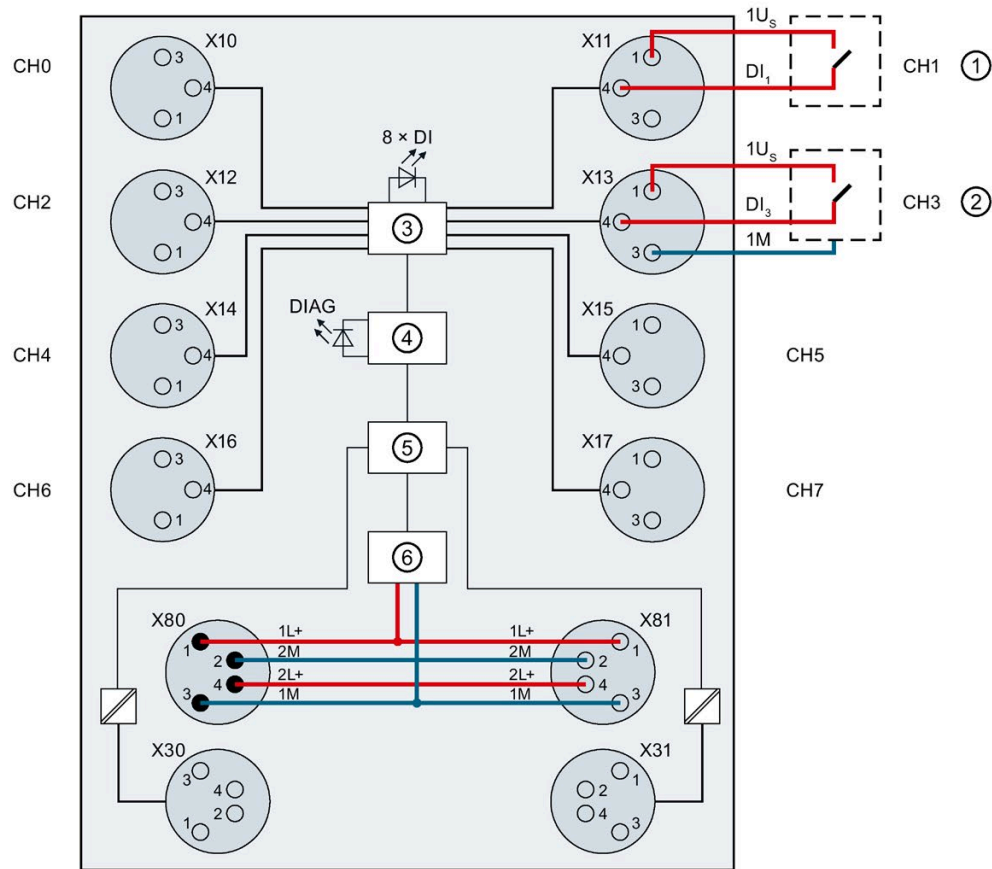
- ① DIAG: LED display for the diagnostic status
- ② X10 to X17: Sockets for the input signal
- ③ X80: Connector for infeed of the supply voltage (POWER input)
- ④ X81: Socket for loop-through of the supply voltage (POWER output)
- ⑤ X30: Socket for ET-Connection IN
- ⑥ X31: Socket for ET-Connection OUT
- ⑦ LED displays 0 to 7 for the channel status

Figure 2-2 Operator controls and display elements

# Wiring

## 3.1 Terminal and block diagram

The following figure shows an example of the pin assignment of signal outputs with 2- and 3-wire connection.



|            |                                 |                 |                                      |
|------------|---------------------------------|-----------------|--------------------------------------|
| ①          | 2-wire connection               | X30             | Infeed of the ET-Connection          |
| ②          | 3-wire connection               | X31             | Loop-through of the ET-Connection    |
| ③          | DI circuit                      | 1L+             | Supply voltage 1L+ (non-switched)    |
| ④          | Microcontroller                 | 1M              | Ground 1M (non-switched)             |
| ⑤          | ET-Connection interface         | 2L+             | Load voltage 2L+ (switched)          |
| ⑥          | Internal supply voltage         | 2M              | Ground 2M (switched)                 |
| X10 to X17 | Channels 0 to 7                 | 1U <sub>s</sub> | 24 V encoder supply                  |
| X80        | Infeed of supply voltages       | DI <sub>n</sub> | Input signal                         |
| X81        | Loop-through of supply voltages | DI              | Channel status LEDs (0 to 7) (green) |
|            |                                 | DIAG            | LED diagnostic status (red/green)    |

Figure 3-1 Terminal and block diagram



## 3.2 Pin assignment

### Note

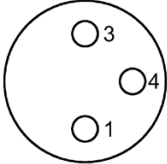
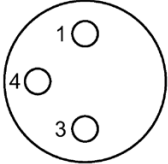
Color coding

The sockets for ET-Connection and the power supply of the modules are color-coded. These colors correspond to the colors of the offered cables.

### Pin assignment of the sockets for digital inputs

The table below shows the pin assignment of the 8 sockets for the connection of digital inputs.

Table 3- 1 Pin assignment for digital inputs

| Pin | Assignment                                                                                                                                                                                                                                                                           | Front view of the sockets                                                            |                                                                                      |
|-----|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------|
|     | X10 to X17 sockets for digital inputs                                                                                                                                                                                                                                                | X10, X12, X14, X16                                                                   | X11, X13, X15, X17                                                                   |
| 1   | 24 V encoder supply 1Us<br>(derived from 1L+ non-switched)                                                                                                                                                                                                                           |  |  |
| 3   | Encoder supply ground 1M                                                                                                                                                                                                                                                             |                                                                                      |                                                                                      |
| 4   | Input signal DI0: Connector X10<br>Input signal DI1: Connector X11<br>Input signal DI2: Connector X12<br>Input signal DI3: Connector X13<br>Input signal DI4: Connector X14<br>Input signal DI5: Connector X15<br>Input signal DI6: Connector X16<br>Input signal DI7: Connector X17 |                                                                                      |                                                                                      |

### NOTICE

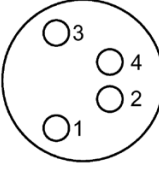
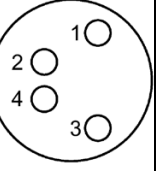
#### 24 V encoder supply 1Us

Use only the 24 V encoder supply 1Us provided by the digital input module to supply power to the encoder.

### Pin assignment of the sockets for ET-Connection

The table below shows the pin assignments of the 2 sockets for the connection of ET-Connection.

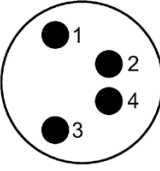
Table 3- 2 Pin assignment for ET-Connection

| Pin       | Assignment                    |                                | Assignment of the wire color of the bus line cable for ET-Connection | Front view of the sockets                                                           |                                                                                     |
|-----------|-------------------------------|--------------------------------|----------------------------------------------------------------------|-------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------|
|           | X30 socket (ET-Connection IN) | X31 socket (ET-Connection OUT) |                                                                      | X30                                                                                 | X31                                                                                 |
| 1         | TXP                           | RXP                            | Yellow                                                               |  |  |
| 2         | RXP                           | TXP                            | White                                                                |                                                                                     |                                                                                     |
| 3         | RXN                           | TXN                            | Blue                                                                 |                                                                                     |                                                                                     |
| 4         | TXN                           | RXN                            | Orange                                                               |                                                                                     |                                                                                     |
| Shielding | Functional earth FE           |                                | -                                                                    |                                                                                     |                                                                                     |

### Pin assignment of the connector for infeed of the supply voltage

The table below shows the pin assignment of the connector for infeed of the supply voltage.

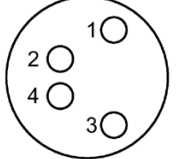
Table 3- 3 Pin assignment of the supply voltage connector

| Pin | Assignment                        | Assignment of the wire color of the power line cable | Front view of the connector                                                           |
|-----|-----------------------------------|------------------------------------------------------|---------------------------------------------------------------------------------------|
|     | X80 connector (POWER input)       |                                                      |                                                                                       |
| 1   | Supply voltage 1L+ (non-switched) | Brown                                                |  |
| 2   | Ground 2M (switched)              | White                                                |                                                                                       |
| 3   | Ground 1M (non-switched)          | Blue                                                 |                                                                                       |
| 4   | Load voltage 2L+ (switched)       | Black                                                |                                                                                       |

### Pin assignment of the socket for loop-through of the supply voltage

The table below shows the pin assignment of the socket for loop-through of the supply voltage.

Table 3- 4 Pin assignment of the supply voltage socket

| Pin | Assignment                        | Assignment of the wire color of the power line cable | Front view of the socket                                                            |
|-----|-----------------------------------|------------------------------------------------------|-------------------------------------------------------------------------------------|
|     | X81 socket (POWER output)         |                                                      |                                                                                     |
| 1   | Supply voltage 1L+ (non-switched) | Brown                                                |  |
| 2   | Ground 2M (switched)              | White                                                |                                                                                     |
| 3   | Ground 1M (non-switched)          | Blue                                                 |                                                                                     |
| 4   | Load voltage 2L+ (switched)       | Black                                                |                                                                                     |

#### NOTICE

##### ET-Connection/supply voltage

Observe the correct wiring of the M8 sockets for ET-Connection and the supply voltage. Mixing up the ET-Connection connectors and the connectors for the supply voltage can destroy the module.

## Parameters/address space

### 4.1 Parameters

The following table shows the parameters for the DI 8x24VDC 8xM8 digital input module.

Table 4- 1 Parameters

| Parameters                           | Value range                                                                | Default | Scope  |
|--------------------------------------|----------------------------------------------------------------------------|---------|--------|
| Diagnostics: Short-circuit to ground | <ul style="list-style-type: none"><li>• Disable</li><li>• Enable</li></ul> | Disable | Module |

### 4.2 Explanation of the parameters

#### Diagnostics: Short-circuit to ground

Enabling of the diagnostics if a short-circuit of the encoder supply to ground occurs.

## 4.3 Address space

The figure below shows the assignment of the address space for the digital input module DI 8x24VDC 8xM8 with value status (Quality Information, QI). If you are using PROFINET and the value status was enabled, the addresses for the value status are available. The value status is not available for PROFIBUS.

Assignment in the process image input (PII)

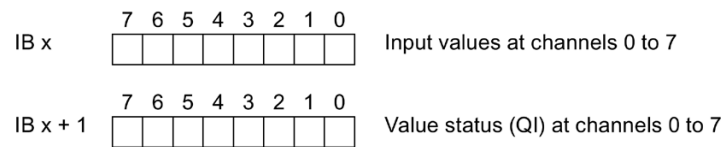


Figure 4-1 Address space

### Configuration options of the DI 8x24VDC 8xM8 digital input module

You have the following configuration options:

- Configuration 1: without value status
- Configuration 2: with value status

### Evaluating the value status

An additional byte is occupied in the input address space if you enable the value status for the digital input module. Bits 0 to 7 in this byte are assigned to a channel and provide information on the validity of the digital input value.

Bit = 1: No error on channel.

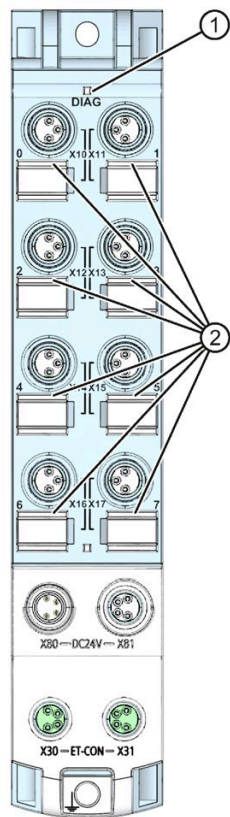
Bit = 0: Error on channel.

## Interrupts/diagnostics alarms

### 5.1 Status and error displays

#### LED displays

The figure below shows the LED displays (status and error displays) of the DI 8x24VDC 8xM8 digital input module.



- ① Diagnostic status (DIAG) (red/green)
- ② Channel status (0 to 7) (green)

Figure 5-1 LED displays

## Meaning of the LEDs

The following tables set out the meaning of the status and error displays. Corrective measures for diagnostics alarms can be found in the section Diagnostics alarms (Page 20).

### DIAG LED

Table 5- 1 Error display of the DIAG LED

| DIAG LED                                                                                     | Meaning                                                                                                                                                                                                                                                                                                     |
|----------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <br>Off     | No supply voltage 1L+                                                                                                                                                                                                                                                                                       |
| <br>Flashes | <ul style="list-style-type: none"> <li>Module parameters not assigned (after switching on the supply voltage 1L+)</li> <li>Loading firmware (while the firmware update is being performed, all LEDs retain their current status)</li> <li>No connection to the ET-Connection and/or the fieldbus</li> </ul> |
| <br>On      | Module parameters assigned and no module diagnostics                                                                                                                                                                                                                                                        |
| <br>Flashes | Module parameters assigned and module diagnostics                                                                                                                                                                                                                                                           |

### LED channel status

Table 5- 2 LED channel status display

| LED channel status                                                                         | Meaning            |
|--------------------------------------------------------------------------------------------|--------------------|
| <br>Off | Process signal = 0 |
| <br>On  | Process signal = 1 |

## 5.2 Interrupts

The DI 8x24VDC 8xM8 digital input module supports diagnostic interrupts.

### Diagnostic interrupt

The digital input module generates a diagnostic interrupt at the following events:

- Short-circuit of encoder supply to ground

## 5.3 Diagnostics alarms

For each diagnostic event, a diagnostics alarm is issued and the DIAG LED flashes red on the digital input module. You can read out the diagnostics alarms, for example, in the diagnostics buffer of the CPU. You can evaluate the error codes with the user program.

Table 5- 3 Diagnostics alarms, their meanings and corrective measures

| Diagnostics alarm | Error code     | Meaning                                | Remedy                      |
|-------------------|----------------|----------------------------------------|-----------------------------|
| Short-circuit     | 1 <sub>H</sub> | Short-circuit encoder supply to ground | Eliminate the short-circuit |



# Technical specifications

## Technical specifications of the DI 8x24VDC 8xM8 digital input module

The following table shows the technical specifications as of the issue date. You can find a data sheet including daily updated technical specifications on the Internet

(<https://support.industry.siemens.com/cs/ww/en/pv/6ES7141-5BF00-0BA0/td?dl=en>).

|                                                          |                                                                                       |
|----------------------------------------------------------|---------------------------------------------------------------------------------------|
| <b>Article number</b>                                    | <b>6ES7141-5BF00-0BA0</b>                                                             |
| <b>General information</b>                               |                                                                                       |
| Product type designation                                 | DI 8x24VDC                                                                            |
| HW functional status                                     | FS03                                                                                  |
| Firmware version                                         | V1.0.x                                                                                |
| <b>Product function</b>                                  |                                                                                       |
| • I&M data                                               | Yes; I&M0 to I&M3                                                                     |
| <b>Engineering with</b>                                  |                                                                                       |
| • STEP 7 TIA Portal configurable/integrated from version | STEP 7 V13 SP1 or higher                                                              |
| • STEP 7 configurable/integrated from version            | From V5.5 SP4 Hotfix 3                                                                |
| • PROFIBUS from GSD version/GSD revision                 | GSD as of Revision 5                                                                  |
| • PROFINET from GSD version/GSD revision                 | GSDML V2.3.1                                                                          |
| <b>Supply voltage</b>                                    |                                                                                       |
| <b>Load voltage 1L+</b>                                  |                                                                                       |
| • Rated value (DC)                                       | 24 V                                                                                  |
| • permissible range, lower limit (DC)                    | 20.4 V                                                                                |
| • permissible range, upper limit (DC)                    | 28.8 V                                                                                |
| • Reverse polarity protection                            | Yes; Against destruction; encoder power supply outputs applied with reversed polarity |
| <b>Input current</b>                                     |                                                                                       |
| Current consumption (rated value)                        | 25 mA; without load                                                                   |
| from load voltage 1L+ (unswitched voltage)               | 4 A; Maximum value                                                                    |
| from load voltage 2L+, max.                              | 4 A; Maximum value                                                                    |
| <b>Encoder supply</b>                                    |                                                                                       |
| Number of outputs                                        | 8                                                                                     |
| <b>24 V encoder supply</b>                               |                                                                                       |
| • Short-circuit protection                               | Yes; per module, electronic                                                           |
| • Output current, max.                                   | 0.7 A; Total current of all encoders                                                  |
| <b>Power loss</b>                                        |                                                                                       |
| Power loss, typ.                                         | 1.9 W                                                                                 |

|                                                                            |                                           |
|----------------------------------------------------------------------------|-------------------------------------------|
| <b>Article number</b>                                                      | <b>6ES7141-5BF00-0BA0</b>                 |
| <b>Digital inputs</b>                                                      |                                           |
| Number of digital inputs                                                   | 8                                         |
| Input characteristic curve in accordance with IEC 61131, type 3            | Yes                                       |
| <b>Number of simultaneously controllable inputs all mounting positions</b> |                                           |
| – up to 55 °C, max.                                                        | 8                                         |
| <b>Input voltage</b>                                                       |                                           |
| • Rated value (DC)                                                         | 24 V                                      |
| • for signal "0"                                                           | -30 to +5 V                               |
| • for signal "1"                                                           | +11 to +30V                               |
| <b>Input current</b>                                                       |                                           |
| • for signal "1", typ.                                                     | 3.2 mA                                    |
| <b>Input delay (for rated value of input voltage) for standard inputs</b>  |                                           |
| – at "0" to "1", min.                                                      | 1.2 ms                                    |
| – at "0" to "1", max.                                                      | 4.8 ms                                    |
| – at "1" to "0", min.                                                      | 1.2 ms                                    |
| – at "1" to "0", max.                                                      | 4.8 ms                                    |
| <b>Cable length</b>                                                        |                                           |
| • unshielded, max.                                                         | 30 m                                      |
| <b>Encoder</b>                                                             |                                           |
| <b>Connectable encoders</b>                                                |                                           |
| • 2-wire sensor                                                            | Yes                                       |
| – permissible quiescent current (2-wire sensor), max.                      | 1.5 mA                                    |
| <b>Interrupts/diagnostics/status information</b>                           |                                           |
| <b>Alarms</b>                                                              |                                           |
| • Diagnostic alarm                                                         | Yes; Parameterizable                      |
| <b>Diagnoses</b>                                                           |                                           |
| • Short-circuit                                                            | Yes; Sensor supply to M; module by module |
| <b>Diagnostics indication LED</b>                                          |                                           |
| • Channel status display                                                   | Yes; green LED                            |
| • for module diagnostics                                                   | Yes; green/red LED                        |
| <b>Potential separation</b>                                                |                                           |
| between the load voltages                                                  | Yes                                       |

|                                                                                        |                           |
|----------------------------------------------------------------------------------------|---------------------------|
| <b>Article number</b>                                                                  | <b>6ES7141-5BF00-0BA0</b> |
| <b>Potential separation channels</b>                                                   |                           |
| • between the channels                                                                 | No                        |
| • between the channels and backplane bus                                               | Yes                       |
| • between the channels and the power supply of the electronics                         | No                        |
| <b>Isolation</b>                                                                       |                           |
| Isolation tested with                                                                  | 707 V DC (type test)      |
| <b>Standards, approvals, certificates</b>                                              |                           |
| Suitable for safety-related tripping of standard modules                               | Yes; From FS01            |
| <b>Highest safety class achievable for safety-related tripping of standard modules</b> |                           |
| • Performance level according to ISO 13849-1                                           | PL d                      |
| • Category according to ISO 13849-1                                                    | Cat. 3                    |
| • SILCL according to IEC 62061                                                         | SILCL 2                   |
| <b>Ambient conditions</b>                                                              |                           |
| <b>Ambient temperature during operation</b>                                            |                           |
| • min.                                                                                 | -30 °C                    |
| • max.                                                                                 | 55 °C                     |
| <b>Connection method</b>                                                               |                           |
| Design of electrical connection for the inputs and outputs                             | M8, 3-pole                |
| Design of electrical connection for supply voltage                                     | M8, 4-pole                |
| <b>ET-Connection</b>                                                                   |                           |
| • ET-Connection                                                                        | M8, 4-pin, shielded       |
| <b>Dimensions</b>                                                                      |                           |
| Width                                                                                  | 30 mm                     |
| Height                                                                                 | 159 mm                    |
| Depth                                                                                  | 40 mm                     |
| <b>Weights</b>                                                                         |                           |
| Weight, approx.                                                                        | 145 g                     |

# PROFlenergy

## 7.1 Pause function

### Introduction

PROFlenergy is a PROFINET-based data interface for switching off consumers centrally and in a coordinated manner during pause times regardless of the manufacturer or device type. This has the aim that the process is only provided with the energy that is absolutely required. In so doing, the majority of the energy savings come from the process itself; the PROFINET device contributes only a few watts to the possible savings. In PROFlenergy, this operating state is referred to as a "pause".

### Start and end of a pause

You enable and disable the pause function of the system at the beginning and end of pauses, respectively; the IO controller then sends the PROFlenergy command "Start\_Pause" or "End\_Pause" to the modules.

Use the "Start\_Pause" command to start a pause.

Use the "End\_Pause" command to end a pause.

The following conditions will also cause a pause to be ended:

- Reconfiguration in RUN
- Controller failure
- Firmware update
- Station stop
- Restart of the interface module through:
  - POWER OFF/POWER ON of an interface module
  - POWER OFF/POWER ON of an I/O module
  - Termination of ET-Connection1 or ET-Connection2

The specific behavior of the digital input module is explained in the following section.

### Additional information

You can find additional information on working with PROFlenergy in the "PROFlenergy" section of the manual IM 157-1 PN interface module (<http://support.automation.siemens.com/WW/view/en/89254863>) and the "Saving energy with PROFlenergy" section of function manual PROFINET with STEP 7 V13 (<http://support.automation.siemens.com/WW/view/en/49948856>).

Application examples (<http://support.automation.siemens.com/WW/view/en/41986454>) are also available on the Internet.

## 7.2 Behavior of the digital input module

### Requirement

You can use the PROFlenergy function when you use the internal encoder supply.

### Display

The channel status LEDs are directly influenced by the signal level at the socket.  
If the encoder supply is switched off, this causes the channel status LEDs to also switch off.

### Response to error detection

All channels that are in pause mode on "PE\_MODE\_PROCEED" report their diagnostic status as in productive mode.

The following applies for all channels which switch to a different pause mode:

- Encoder supply switch-off upon the start of "pause" does not result in the "Short-circuit" alarms.
- During the "pause", error detection of "Short circuit" is not possible:
  - Alarms for errors already pending before the "pause" are retained.
  - After the "pause" is over, the error status is updated and incoming/outgoing errors are reported correspondingly.

## Mode parameter

The following table shows the "Mode" parameter.

Table 7- 1 Mode parameter

| Element | Code                                 | Explanation                                                                                                                                                                                                                            |
|---------|--------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Mode    | 0 <sub>D</sub> : PE_MODE_PROCEED     | Proceed at "pause"<br><ul style="list-style-type: none"> <li>Value status "GOOD"</li> </ul>                                                                                                                                            |
|         | 1 <sub>D</sub> : PE_MODE_SHUTDOWN    | Switch off at "pause"<br><ul style="list-style-type: none"> <li>Encoder supply U<sub>s</sub> switched off <sup>1</sup></li> <li>Pause substitute value: 0<sub>B</sub></li> <li>Value status "BAD"</li> </ul>                           |
|         | 3 <sub>D</sub> : PE_MODE_LAST_VALUE  | Last value at "pause"<br><ul style="list-style-type: none"> <li>Encoder supply U<sub>s</sub> switched off <sup>1</sup></li> <li>Pause substitute value: Last input value</li> <li>Value status "BAD"</li> </ul>                        |
|         | 4 <sub>D</sub> : PE_MODE_SUBST_VALUE | Substitute value at "pause"<br><ul style="list-style-type: none"> <li>Encoder supply U<sub>s</sub> switched off <sup>1</sup></li> <li>Pause substitute value: Configured pause substitute value</li> <li>Value status "BAD"</li> </ul> |

<sup>1</sup> As there is only one encoder supply U<sub>s</sub> for all channels, the supply can only be switched off at "pause" if no channel is configured in PE\_MODE\_PROCEED.

## Dimension drawing

The figure below shows the dimension drawing of the DI 8x24VDC 8xM8 digital input module in front and side view.

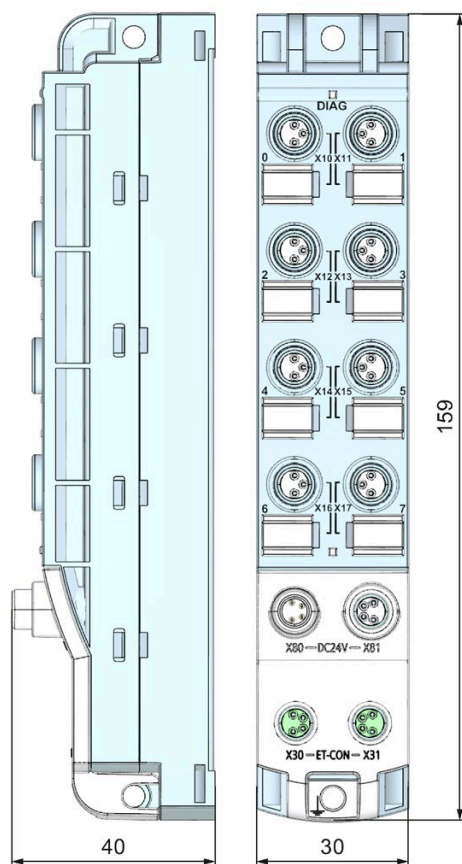
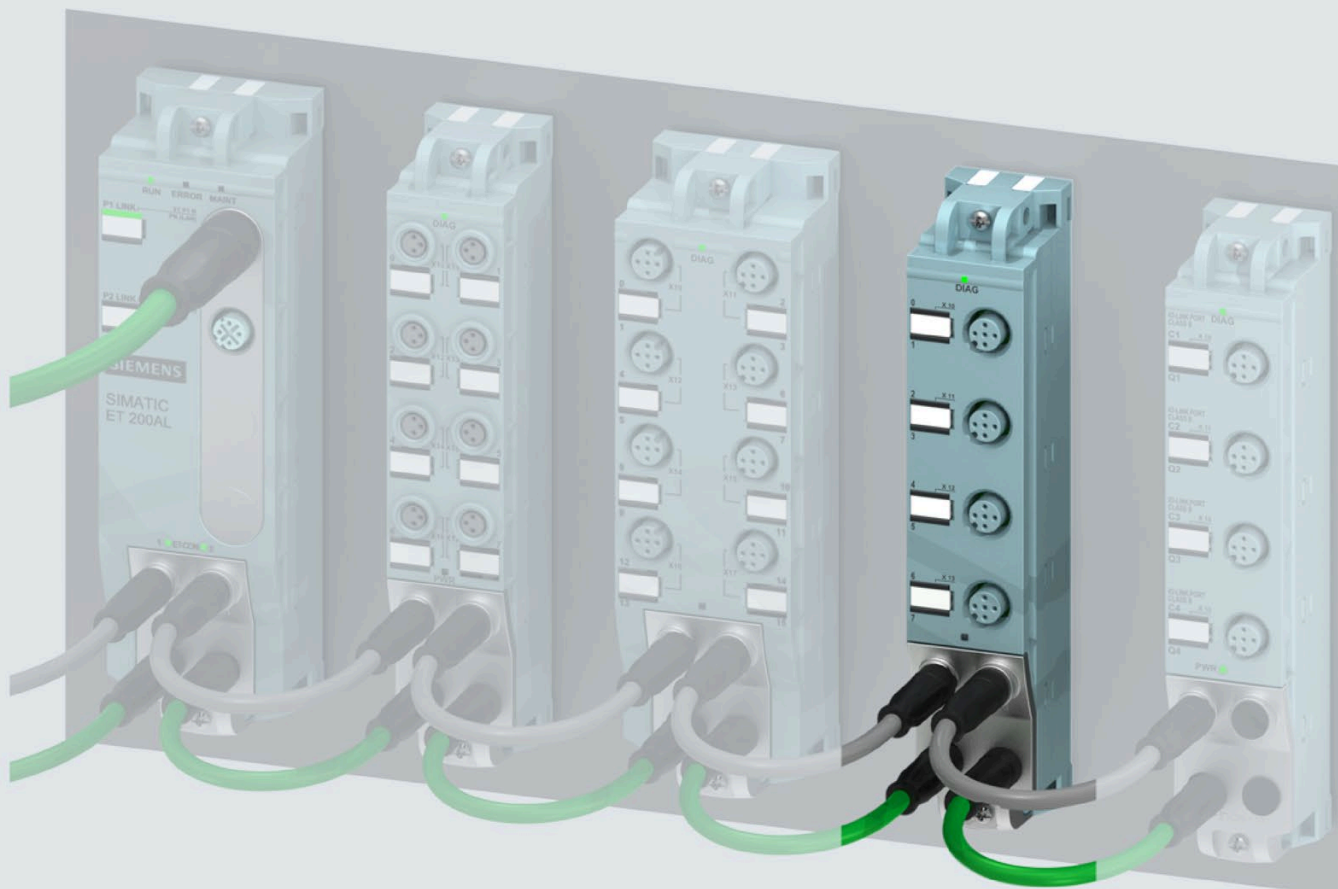


Figure A-1 Dimension drawing

# SIEMENS



Equipment Manual

## SIMATIC

### ET 200AL

Digital input module DI 8x24VDC 4xM12  
(6ES7141-5AF00-0BA0)

Edition

08/2021

[support.industry.siemens.com](https://support.industry.siemens.com)



## SIMATIC

### ET 200AL DI 8x24VDC 4xM12 (6ES7141-5AF00-0BA0)

#### Equipment Manual

#### Preface

---

#### ET 200AL Documentation Guide

**1**

#### Product overview

**2**

#### Wiring

**3**

#### Parameters/address space

**4**

#### Interrupts/diagnostic alarms

**5**

#### Technical specifications

**6**

#### PROFInergy

**7**

#### Dimension drawing

**A**

## Legal information

### Warning notice system

This manual contains notices you have to observe in order to ensure your personal safety, as well as to prevent damage to property. The notices referring to your personal safety are highlighted in the manual by a safety alert symbol, notices referring only to property damage have no safety alert symbol. These notices shown below are graded according to the degree of danger.

#### **DANGER**

indicates that death or severe personal injury **will** result if proper precautions are not taken.

#### **WARNING**

indicates that death or severe personal injury **may** result if proper precautions are not taken.

#### **CAUTION**

indicates that minor personal injury can result if proper precautions are not taken.

#### **NOTICE**

indicates that property damage can result if proper precautions are not taken.

If more than one degree of danger is present, the warning notice representing the highest degree of danger will be used. A notice warning of injury to persons with a safety alert symbol may also include a warning relating to property damage.

### Qualified Personnel

The product/system described in this documentation may be operated only by **personnel qualified** for the specific task in accordance with the relevant documentation, in particular its warning notices and safety instructions. Qualified personnel are those who, based on their training and experience, are capable of identifying risks and avoiding potential hazards when working with these products/systems.

### Proper use of Siemens products

Note the following:

#### **WARNING**

Siemens products may only be used for the applications described in the catalog and in the relevant technical documentation. If products and components from other manufacturers are used, these must be recommended or approved by Siemens. Proper transport, storage, installation, assembly, commissioning, operation and maintenance are required to ensure that the products operate safely and without any problems. The permissible ambient conditions must be complied with. The information in the relevant documentation must be observed.

### Trademarks

All names identified by ® are registered trademarks of Siemens AG. The remaining trademarks in this publication may be trademarks whose use by third parties for their own purposes could violate the rights of the owner.

### Disclaimer of Liability

We have reviewed the contents of this publication to ensure consistency with the hardware and software described. Since variance cannot be precluded entirely, we cannot guarantee full consistency. However, the information in this publication is reviewed regularly and any necessary corrections are included in subsequent editions.

# Preface

## Preface

### Purpose of the documentation

This manual supplements the ET 200AL distributed I/O system (<https://support.industry.siemens.com/cs/us/en/view/89254965>) system manual. Functions that are generally applicable to the ET 200AL distributed I/O system are described there.

The information provided in the present manual, the system manual and the function manuals enables you to commission the ET 200AL distributed I/O system.

### Conventions

Please also observe notes marked as follows:

---

#### Note

Indicates important product information to which particular attention should be paid.

---

### Security information

Siemens provides products and solutions with industrial security functions that support the secure operation of plants, systems, machines and networks.

In order to protect plants, systems, machines and networks against cyber threats, it is necessary to implement – and continuously maintain – a holistic, state-of-the-art industrial security concept. Siemens' products and solutions constitute one element of such a concept.

Customers are responsible for preventing unauthorized access to their plants, systems, machines and networks. Such systems, machines and components should only be connected to an enterprise network or the internet if and to the extent such a connection is necessary and only when appropriate security measures (e.g. firewalls and/or network segmentation) are in place.

For additional information on industrial security measures that may be implemented, please visit (<https://www.siemens.com/industrialsecurity>).

Siemens' products and solutions undergo continuous development to make them more secure. Siemens strongly recommends that product updates are applied as soon as they are available and that the latest product versions are used. Use of product versions that are no longer supported, and failure to apply the latest updates may increase customers' exposure to cyber threats.

To stay informed about product updates, subscribe to the Siemens Industrial Security RSS Feed visit (<https://www.siemens.com/industrialsecurity>).

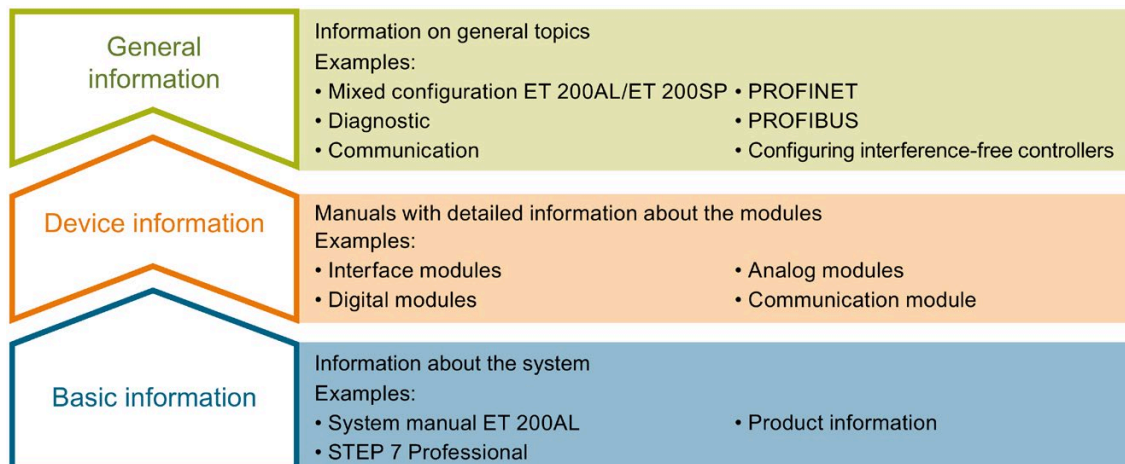
# Table of contents

|          |                                                  |           |
|----------|--------------------------------------------------|-----------|
|          | <b>Preface .....</b>                             | <b>3</b>  |
| <b>1</b> | <b>ET 200AL Documentation Guide.....</b>         | <b>5</b>  |
| <b>2</b> | <b>Product overview.....</b>                     | <b>9</b>  |
|          | 2.1 Properties .....                             | 9         |
|          | 2.2 Operator controls and display elements ..... | 11        |
| <b>3</b> | <b>Wiring .....</b>                              | <b>12</b> |
|          | 3.1 Terminal and block diagram .....             | 12        |
|          | 3.2 Pin assignment .....                         | 13        |
| <b>4</b> | <b>Parameters/address space .....</b>            | <b>16</b> |
|          | 4.1 Parameters .....                             | 16        |
|          | 4.2 Explanation of the parameters .....          | 16        |
|          | 4.3 Address space.....                           | 17        |
| <b>5</b> | <b>Interrupts/diagnostic alarms .....</b>        | <b>18</b> |
|          | 5.1 Status and error displays .....              | 18        |
|          | 5.2 Interrupts .....                             | 20        |
|          | 5.3 Diagnostics alarms .....                     | 20        |
| <b>6</b> | <b>Technical specifications.....</b>             | <b>21</b> |
|          | 6.1 Technical specifications .....               | 21        |
| <b>7</b> | <b>PROFenergy .....</b>                          | <b>24</b> |
|          | 7.1 Pause function.....                          | 24        |
|          | 7.2 Behavior of the digital input module .....   | 25        |
| <b>A</b> | <b>Dimension drawing .....</b>                   | <b>26</b> |

# ET 200AL Documentation Guide

The documentation for the SIMATIC ET 200AL distributed I/O system is arranged into three areas.

This arrangement enables you to access the specific content you require.



## Basic information

The System Manual and Getting Started describe in detail the configuration, installation, wiring and commissioning of the SIMATIC ET 200AL distributed I/O system. The STEP 7 online help supports you in the configuration and programming.

## Device information

Product manuals contain a compact description of the module-specific information, such as properties, wiring diagrams, characteristics and technical specifications.

## General information

The function manuals contain detailed descriptions on general topics regarding the SIMATIC ET 200AL distributed I/O system, e.g. diagnostics, communication, Motion Control, Web server.

You can download the documentation free of charge from the Internet (<https://support.industry.siemens.com/cs/ww/en/view/109742667>).

## Manual Collection ET 200AL

The Manual Collection contains the complete documentation on the SIMATIC ET 200AL distributed I/O system gathered together in one file.

You can find the Manual Collection on the Internet (<https://support.automation.siemens.com/WW/view/en/95242965>).

## "mySupport"

With "mySupport", your personal workspace, you make the best out of your Industry Online Support.

In "mySupport", you can save filters, favorites and tags, request CAx data and compile your personal library in the Documentation area. In addition, your data is already filled out in support requests and you can get an overview of your current requests at any time.

You must register once to use the full functionality of "mySupport".

You can find "mySupport" on the Internet (<https://support.industry.siemens.com/My/ww/en>).

## "mySupport" - Documentation

With "mySupport", your personal workspace, you make the best out of your Industry Online Support.

In "mySupport", you can save filters, favorites and tags, request CAx data and compile your personal library in the Documentation area. In addition, your data is already filled out in support requests and you can get an overview of your current requests at any time.

You must register once to use the full functionality of "mySupport".

You can find "mySupport" on the Internet (<https://support.industry.siemens.com/My/ww/en/documentation>).

## "mySupport" - CAx data

In the CAx data area of "mySupport", you can access the latest product data for your CAx or CAe system.

You configure your own download package with a few clicks.

In doing so you can select:

- Product images, 2D dimension drawings, 3D models, internal circuit diagrams, EPLAN macro files
- Manuals, characteristics, operating manuals, certificates
- Product master data

You can find "mySupport" - CAx data on the Internet (<https://support.industry.siemens.com/my/ww/en/CAxOnline>).

## Application examples

The application examples support you with various tools and examples for solving your automation tasks. Solutions are shown in interplay with multiple components in the system - separated from the focus on individual products.

You will find the application examples on the Internet (<https://support.industry.siemens.com/cs/ww/en/ps/ae>).

## TIA Selection Tool

With the TIA Selection Tool, you can select, configure and order devices for Totally Integrated Automation (TIA).

This tool is the successor of the SIMATIC Selection Tool and combines the known configurators for automation technology into one tool.

With the TIA Selection Tool, you can generate a complete order list from your product selection or product configuration.

You can find the TIA Selection Tool on the Internet

(<https://support.industry.siemens.com/cs/ww/en/view/109767888>).

## SIMATIC Automation Tool

You can use the SIMATIC Automation Tool to perform commissioning and maintenance activities simultaneously on various SIMATIC S7 stations as a bulk operation independent of TIA Portal.

The SIMATIC Automation Tool provides a multitude of functions:

- Scanning of a PROFINET/Ethernet system network and identification of all connected CPUs
- Address assignment (IP, subnet, gateway) and station name (PROFINET device) to a CPU
- Transfer of the date and the programming device/PC time converted to UTC time to the module
- Program download to CPU
- RUN/STOP mode switchover
- CPU localization by means of LED flashing
- Reading out of CPU error information
- Reading of the CPU diagnostics buffer
- Reset to factory settings
- Firmware update of the CPU and connected modules

You can find the SIMATIC Automation Tool on the Internet

(<https://support.industry.siemens.com/cs/ww/en/view/98161300>).

## PRONETA

SIEMENS PRONETA (PROFINET network analysis) allows you to analyze the plant network during commissioning. PRONETA features two core functions:

- The topology overview automatically scans the PROFINET and all connected components.
- The IO check is a fast test of the wiring and the module configuration of a plant.

You can find SIEMENS PRONETA on the Internet

(<https://support.industry.siemens.com/cs/ww/en/view/67460624>).

## SINETPLAN

SINETPLAN, the Siemens Network Planner, supports you in planning automation systems and networks based on PROFINET. The tool facilitates professional and predictive dimensioning of your PROFINET installation as early as in the planning stage. In addition, SINETPLAN supports you during network optimization and helps you to exploit network resources optimally and to plan reserves. This helps to prevent problems in commissioning or failures during productive operation even in advance of a planned operation. This increases the availability of the production plant and helps improve operational safety.

The advantages at a glance

- Network optimization thanks to port-specific calculation of the network load
- Increased production availability thanks to online scan and verification of existing systems
- Transparency before commissioning through importing and simulation of existing STEP 7 projects
- Efficiency through securing existing investments in the long term and the optimal use of resources

You can find SINETPLAN on the Internet (<https://www.siemens.com/sinetplan>).



## Product overview

### 2.1 Properties

#### Article number

6ES7141-5AF00-0BA0

#### View of the module

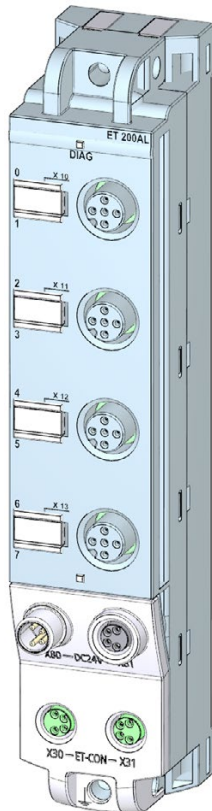


Figure 2-1 View of the DI 8x24VDC 4xM12 digital input module

## 2.1 Properties

### Properties

The module has the following technical properties:

- 8 digital inputs
- M12 sockets for connection of sensors
- 24 V DC supply voltage
- Configurable diagnostics can be set for each module
- Typical input delay of 3 ms
- Suitable for switches and proximity switches
- Dimensions 30 x 159 mm

The module supports the following functions:

- Firmware update
- Identification and maintenance data I&M0 to I&M3
- Value status (Quality Information)
- PROFIenergy

### Accessories

The following components are included in the module package:

- Identification labels
- Spacers

### Other components

The following component can be ordered as spare part:

- Identification labels

The following components can be ordered as accessories:

- Connectors
- Cables
- Stripping Tool for ET-Connection
- M8 sealing cap
- M12 sealing cap

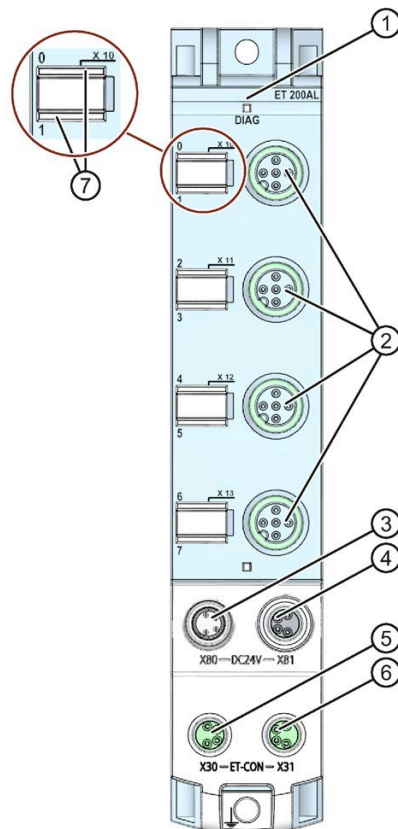
### See also

You can find more information on accessories in the Accessories/spare parts section of the ET 200AL distributed I/O system

(<https://support.industry.siemens.com/cs/us/en/view/89254965>) system manual.

## 2.2 Operator controls and display elements

The figure below shows the operator controls and display elements of the DI 8x24VDC 4xM12 digital input module.



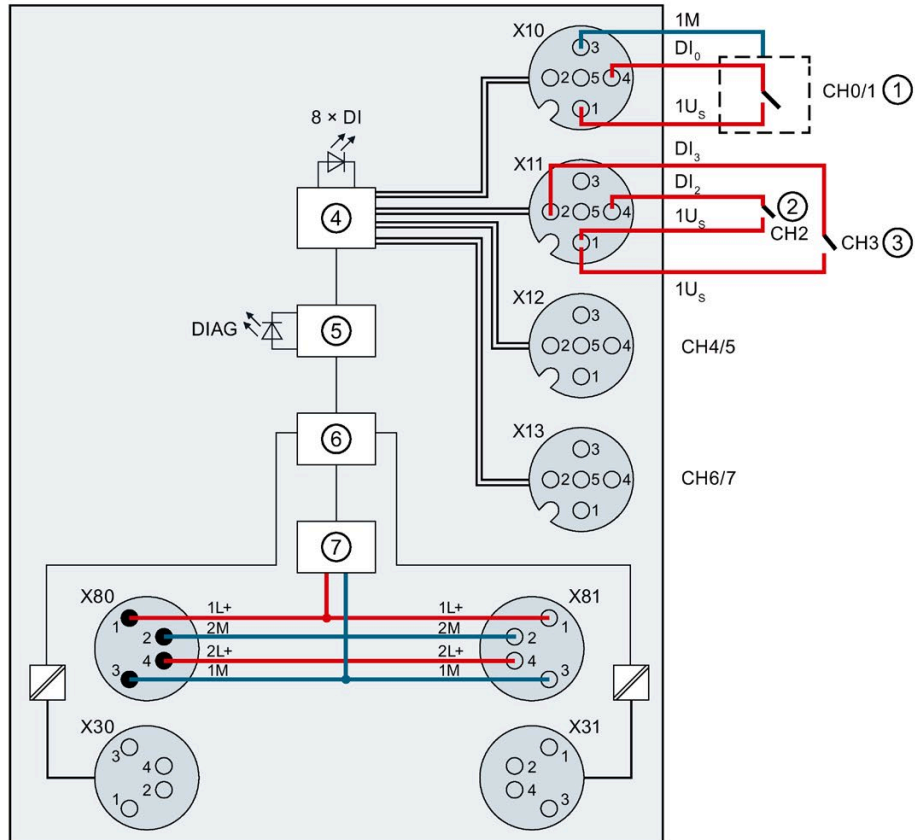
- ① DIAG: LED display for the diagnostic status
- ② X10 to X13: Sockets for the input signal
- ③ X80: Connector for infeed of the supply voltage (POWER input)
- ④ X81: Socket for loop-through of the supply voltage (POWER output)
- ⑤ X30: Socket for ET-Connection IN
- ⑥ X31: Socket for ET-Connection OUT
- ⑦ LED displays 0 to 7 for the channel status

Figure 2-2 Operator controls and display elements

# Wiring

## 3.1 Terminal and block diagram

The figure below shows an example of the pin assignment of signal inputs with 2-wire and 3-wire connection.



|            |                                 |                 |                                      |
|------------|---------------------------------|-----------------|--------------------------------------|
| ①          | 3-wire connection               | X30             | Infeed of the ET-Connection          |
| ②          | 2-wire connection               | X31             | Loop-through of the ET-Connection    |
| ③          | 2-wire connection               | 1L+             | Supply voltage 1L+ (non-switched)    |
| ④          | DI circuit                      | 1M              | Ground 1M (non-switched)             |
| ⑤          | Microcontroller                 | 2L+             | Load voltage 2L+ (switched)          |
| ⑥          | ET-Connection interface         | 2M              | Ground 2M (switched)                 |
| ⑦          | Internal supply voltage         | 1U <sub>s</sub> | 24 V encoder supply                  |
| X10 to X13 | Channels 0 to 7                 | DI <sub>n</sub> | Input signal                         |
| X80        | Infeed of supply voltages       | DI              | Channel status LEDs (0 to 7) (green) |
| X81        | Loop-through of supply voltages | DIAG            | LED diagnostic status (red/green)    |

Figure 3-1 Terminal and block diagram

## 3.2 Pin assignment

### Note

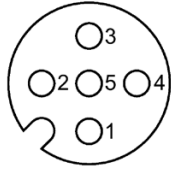
Color coding

The sockets for ET-Connection and the power supply of the modules are color-coded. These colors correspond to the colors of the offered cables.

### Pin assignment of the sockets for digital inputs

The table below shows the pin assignment of the 4 sockets for the connection of digital inputs.

Table 3- 1 Pin assignment for digital inputs

| Pin | Assignment                                                                                                                               | Front view of the sockets                                                            |
|-----|------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------|
|     | <b>X10 to X13 sockets for digital inputs</b>                                                                                             |                                                                                      |
| 1   | 24 V encoder supply 1Us<br>(derived from 1L+ non-switched)                                                                               |  |
| 2   | Input signal DI1: Connector X10<br>Input signal DI3: Connector X11<br>Input signal DI5: Connector X12<br>Input signal DI7: Connector X13 |                                                                                      |
| 3   | Encoder supply ground 1M                                                                                                                 |                                                                                      |
| 4   | Input signal DI0: Connector X10<br>Input signal DI2: Connector X11<br>Input signal DI4: Connector X12<br>Input signal DI6: Connector X13 |                                                                                      |
| 5   | Functional earth FE                                                                                                                      |                                                                                      |

### NOTICE

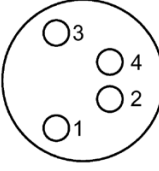
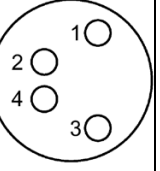
#### 24 V encoder supply 1Us

Use only the 24 V encoder supply 1Us provided by the digital input module to supply power to the encoder.

### Pin assignment of the sockets for ET-Connection

The table below shows the pin assignments of the 2 sockets for the connection of ET-Connection.

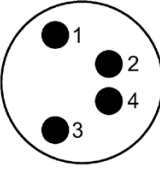
Table 3- 2 Pin assignment for ET-Connection

| Pin       | Assignment                    |                                | Assignment of the wire color of the bus line cable for ET-Connection | Front view of the sockets                                                           |                                                                                     |
|-----------|-------------------------------|--------------------------------|----------------------------------------------------------------------|-------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------|
|           | X30 socket (ET-Connection IN) | X31 socket (ET-Connection OUT) |                                                                      | X30                                                                                 | X31                                                                                 |
| 1         | TXP                           | RXP                            | Yellow                                                               |  |  |
| 2         | RXP                           | TXP                            | White                                                                |                                                                                     |                                                                                     |
| 3         | RXN                           | TXN                            | Blue                                                                 |                                                                                     |                                                                                     |
| 4         | TXN                           | RXN                            | Orange                                                               |                                                                                     |                                                                                     |
| Shielding | Functional earth FE           |                                | -                                                                    |                                                                                     |                                                                                     |

### Pin assignment of the connector for infeed of the supply voltage

The table below shows the pin assignment of the connector for infeed of the supply voltage.

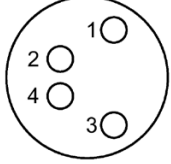
Table 3- 3 Pin assignment of the supply voltage connector

| Pin | Assignment                        | Assignment of the wire color of the power line cable | Front view of the connector                                                           |
|-----|-----------------------------------|------------------------------------------------------|---------------------------------------------------------------------------------------|
|     | X80 connector (POWER input)       |                                                      |                                                                                       |
| 1   | Supply voltage 1L+ (non-switched) | Brown                                                |  |
| 2   | Ground 2M (switched)              | White                                                |                                                                                       |
| 3   | Ground 1M (non-switched)          | Blue                                                 |                                                                                       |
| 4   | Load voltage 2L+ (switched)       | Black                                                |                                                                                       |

### Pin assignment of the socket for loop-through of the supply voltage

The table below shows the pin assignment of the socket for loop-through of the supply voltage.

Table 3- 4 Pin assignment of the supply voltage socket

| Pin | Assignment                        | Assignment of the wire color of the power line cable | Front view of the socket                                                            |
|-----|-----------------------------------|------------------------------------------------------|-------------------------------------------------------------------------------------|
|     | X81 socket (POWER output)         |                                                      |                                                                                     |
| 1   | Supply voltage 1L+ (non-switched) | Brown                                                |  |
| 2   | Ground 2M (switched)              | White                                                |                                                                                     |
| 3   | Ground 1M (non-switched)          | Blue                                                 |                                                                                     |
| 4   | Load voltage 2L+ (switched)       | Black                                                |                                                                                     |

#### NOTICE

##### ET-Connection/supply voltage

Observe the correct wiring of the M8 sockets for ET-Connection and the supply voltage.

Mixing up the ET-Connection connectors and the connectors for the supply voltage can destroy the module.

## Parameters/address space

### 4.1 Parameters

The table below shows the parameters for the DI 8x24VDC 4xM12 digital input module.

Table 4- 1 Parameters

| Parameters                           | Value range                                                                | Default | Scope  |
|--------------------------------------|----------------------------------------------------------------------------|---------|--------|
| Diagnostics: Short-circuit to ground | <ul style="list-style-type: none"><li>• Disable</li><li>• Enable</li></ul> | Disable | Module |

### 4.2 Explanation of the parameters

#### Diagnostics: Short-circuit to ground

Enabling of the diagnostics if a short-circuit of the encoder supply to ground occurs.



## 4.3 Address space

The figure below shows the assignment of the address space for the digital input module DI 8x24VDC 4xM12 with value status (Quality Information, QI).

The address space for the value status is allocated by the module, if the value status is configured using the PROFINET interface module.

Assignment in the process image input (PII)

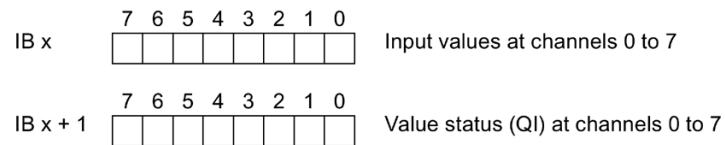


Figure 4-1 Address space

### Configuration options of the DI 8x24VDC 4xM12 digital input module

You have the following configuration options:

- Configuration 1: without value status
- Configuration 2: with value status

### Evaluating the value status

An additional byte is occupied in the input address space if you enable the value status for the digital input module. Bits 0 to 7 in this byte are assigned to a channel and return information about the validity of the digital input value.

Bit = 1: No error on channel.

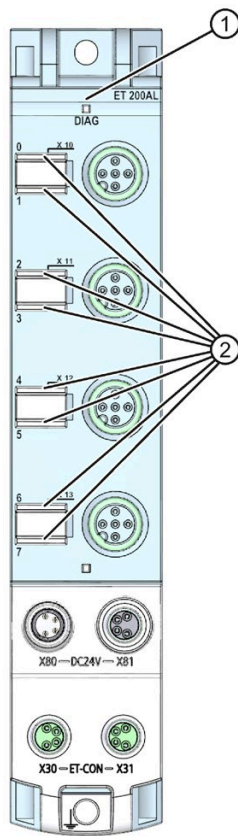
Bit = 0: Error on channel.

## Interrupts/diagnostic alarms

### 5.1 Status and error displays

#### LED displays

The figure below shows the LED displays (status and error displays) of the DI 8x24VDC 4xM12 digital input module.



- ① Diagnostic status (DIAG) (red/green)
- ② Channel status (0 to 7) (green)

Figure 5-1 LED displays

## Meaning of the LEDs

The following tables set out the meaning of the status and error displays. Corrective measures for diagnostics alarms can be found in section Diagnostics alarms (Page 20).

### DIAG LED

Table 5- 1 Error display of the DIAG LED

| DIAG LED                                                                                     | Meaning                                                                                                                                                                                                                                                                                                     |
|----------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <br>Off     | No supply voltage 1L+                                                                                                                                                                                                                                                                                       |
| <br>Flashes | <ul style="list-style-type: none"> <li>Module parameters not assigned (after switching on the supply voltage 1L+)</li> <li>Loading firmware (while the firmware update is being performed, all LEDs retain their current status)</li> <li>No connection to the ET-Connection and/or the fieldbus</li> </ul> |
| <br>On      | Module parameters assigned and no module diagnostics                                                                                                                                                                                                                                                        |
| <br>Flashes | Module parameters assigned and module diagnostics                                                                                                                                                                                                                                                           |

### LED channel status

Table 5- 2 LED channel status display

| LED channel status                                                                         | Meaning            |
|--------------------------------------------------------------------------------------------|--------------------|
| <br>Off | Process signal = 0 |
| <br>On  | Process signal = 1 |

## 5.2 Interrupts

The DI 8x24VDC 4xM12 digital input module supports diagnostic interrupts.

### Diagnostic interrupt

The digital input module generates a diagnostic interrupt at the following events:

- Short-circuit of encoder supply to ground

## 5.3 Diagnostics alarms

For each diagnostic event, a diagnostics alarm is issued and the DIAG LED flashes red on the digital input module. You can read out the diagnostics alarms, for example, in the diagnostics buffer of the CPU. You can evaluate the error codes with the user program.

Table 5- 3     Diagnostics alarms, their meanings and corrective measures

| Diagnostics alarm | Error code     | Meaning                                | Remedy                      |
|-------------------|----------------|----------------------------------------|-----------------------------|
| Short-circuit     | 1 <sub>H</sub> | Short-circuit encoder supply to ground | Eliminate the short-circuit |

# Technical specifications

## 6.1 Technical specifications

### Technical specifications of the DI 8x24VDC 4xM12 digital input module

The following table shows the technical specifications as of the issue date. You can find a data sheet including daily updated technical specifications on the Internet (<https://support.industry.siemens.com/cs/ww/en/pv/6ES7141-5AF00-0BA0/td?dl=en>).

|                                                          |                                                                                       |
|----------------------------------------------------------|---------------------------------------------------------------------------------------|
| <b>Article number</b>                                    | <b>6ES7141-5AF00-0BA0</b>                                                             |
| <b>General information</b>                               |                                                                                       |
| Product type designation                                 | DI 8x24VDC                                                                            |
| HW functional status                                     | FS03                                                                                  |
| Firmware version                                         | V1.0.x                                                                                |
| <b>Product function</b>                                  |                                                                                       |
| • I&M data                                               | Yes; I&M0 to I&M3                                                                     |
| <b>Engineering with</b>                                  |                                                                                       |
| • STEP 7 TIA Portal configurable/integrated from version | STEP 7 V13 SP1 or higher                                                              |
| • STEP 7 configurable/integrated from version            | V5.5 SP4 Hotfix 7 or higher                                                           |
| • PROFIBUS from GSD version/GSD revision                 | GSD as of Revision 5                                                                  |
| • PROFINET from GSD version/GSD revision                 | GSDML V2.3.1                                                                          |
| <b>Supply voltage</b>                                    |                                                                                       |
| <b>Load voltage 1L+</b>                                  |                                                                                       |
| • Rated value (DC)                                       | 24 V                                                                                  |
| • permissible range, lower limit (DC)                    | 20.4 V                                                                                |
| • permissible range, upper limit (DC)                    | 28.8 V                                                                                |
| • Reverse polarity protection                            | Yes; Against destruction; encoder power supply outputs applied with reversed polarity |
| <b>Input current</b>                                     |                                                                                       |
| Current consumption (rated value)                        | 25 mA; without load                                                                   |
| from load voltage 1L+ (unswitched voltage)               | 4 A; Maximum value                                                                    |
| from load voltage 2L+, max.                              | 4 A; Maximum value                                                                    |
| <b>Encoder supply</b>                                    |                                                                                       |
| Number of outputs                                        | 4                                                                                     |
| <b>24 V encoder supply</b>                               |                                                                                       |
| • Short-circuit protection                               | Yes; per module, electronic                                                           |
| • Output current, max.                                   | 0.7 A; Total current of all encoders                                                  |

## 6.1 Technical specifications

|                                                                            |                                           |
|----------------------------------------------------------------------------|-------------------------------------------|
| <b>Article number</b>                                                      | <b>6ES7141-5AF00-0BA0</b>                 |
| <b>Power loss</b>                                                          |                                           |
| Power loss, typ.                                                           | 1.9 W                                     |
| <b>Digital inputs</b>                                                      |                                           |
| Number of digital inputs                                                   | 8                                         |
| Input characteristic curve in accordance with IEC 61131, type 3            | Yes                                       |
| <b>Number of simultaneously controllable inputs all mounting positions</b> |                                           |
| – up to 55 °C, max.                                                        | 8                                         |
| <b>Input voltage</b>                                                       |                                           |
| • Rated value (DC)                                                         | 24 V                                      |
| • for signal "0"                                                           | -30 to +5 V                               |
| • for signal "1"                                                           | +11 to +30V                               |
| <b>Input current</b>                                                       |                                           |
| • for signal "1", typ.                                                     | 3.2 mA                                    |
| <b>Input delay (for rated value of input voltage) for standard inputs</b>  |                                           |
| – at "0" to "1", min.                                                      | 1.2 ms                                    |
| – at "0" to "1", max.                                                      | 4.8 ms                                    |
| – at "1" to "0", min.                                                      | 1.2 ms                                    |
| – at "1" to "0", max.                                                      | 4.8 ms                                    |
| <b>Cable length</b>                                                        |                                           |
| • unshielded, max.                                                         | 30 m                                      |
| <b>Encoder</b>                                                             |                                           |
| <b>Connectable encoders</b>                                                |                                           |
| • 2-wire sensor                                                            | Yes                                       |
| – permissible quiescent current (2-wire sensor), max.                      | 1.5 mA                                    |
| <b>Interrupts/diagnostics/status information</b>                           |                                           |
| <b>Alarms</b>                                                              |                                           |
| • Diagnostic alarm                                                         | Yes; Parameterizable                      |
| <b>Diagnoses</b>                                                           |                                           |
| • Short-circuit                                                            | Yes; Sensor supply to M; module by module |
| <b>Diagnostics indication LED</b>                                          |                                           |
| • Channel status display                                                   | Yes; green LED                            |
| • for module diagnostics                                                   | Yes; green/red LED                        |
| <b>Potential separation</b>                                                |                                           |
| between the load voltages                                                  | Yes                                       |

|                                                                                        |                           |
|----------------------------------------------------------------------------------------|---------------------------|
| <b>Article number</b>                                                                  | <b>6ES7141-5AF00-0BA0</b> |
| <b>Potential separation channels</b>                                                   |                           |
| • between the channels                                                                 | No                        |
| • between the channels and backplane bus                                               | Yes                       |
| • between the channels and the power supply of the electronics                         | No                        |
| <b>Isolation</b>                                                                       |                           |
| Isolation tested with                                                                  | 707 V DC (type test)      |
| <b>Standards, approvals, certificates</b>                                              |                           |
| Suitable for safety-related tripping of standard modules                               | Yes; From FS01            |
| <b>Highest safety class achievable for safety-related tripping of standard modules</b> |                           |
| • Performance level according to ISO 13849-1                                           | PL d                      |
| • Category according to ISO 13849-1                                                    | Cat. 3                    |
| • SILCL according to IEC 62061                                                         | SILCL 2                   |
| <b>Ambient conditions</b>                                                              |                           |
| <b>Ambient temperature during operation</b>                                            |                           |
| • min.                                                                                 | -30 °C                    |
| • max.                                                                                 | 55 °C                     |
| <b>Connection method</b>                                                               |                           |
| Design of electrical connection for the inputs and outputs                             | M12, 5-pole               |
| Design of electrical connection for supply voltage                                     | M8, 4-pole                |
| <b>ET-Connection</b>                                                                   |                           |
| • ET-Connection                                                                        | M8, 4-pin, shielded       |
| <b>Dimensions</b>                                                                      |                           |
| Width                                                                                  | 30 mm                     |
| Height                                                                                 | 159 mm                    |
| Depth                                                                                  | 40 mm                     |
| <b>Weights</b>                                                                         |                           |
| Weight, approx.                                                                        | 145 g                     |

# PROFenergy

## 7.1 Pause function

### Introduction

PROFenergy is a PROFINET-based data interface for switching off consumers centrally and in a coordinated manner during pause times regardless of the manufacturer or device type. This has the aim that the process is only provided with the energy that is absolutely required. The majority of the energy is saved by the process itself; the PROFINET device itself only contributes a few watts of saving potential. In PROFenergy, this operating state is referred to as a "pause".

### Start and end of a pause

You enable and disable the pause function of the system at the beginning and end of pauses, respectively; the IO controller then sends the PROFenergy command "Start\_Pause" or "End\_Pause" to the modules.

Use the "Start\_Pause" command to start a pause.

Use the "End\_Pause" command to end a pause.

The following conditions will also cause a pause to be ended:

- Reconfiguration in RUN
- Controller failure
- Firmware update
- Station stop
- Restart of the interface module through:
  - POWER OFF/POWER ON of an interface module
  - POWER OFF/POWER ON of an I/O module
  - Termination of ET-Connection1 or ET-Connection2

The specific behavior of the digital input module is explained in the following section.

### Additional information

You can find additional information on working with PROFenergy in the "PROFenergy" section of the manual IM 157-1 PN interface module (<https://support.industry.siemens.com/cs/ww/en/view/89254863>) and the "Saving energy with PROFenergy" section of function manual PROFINET with STEP 7 V13 (<https://support.industry.siemens.com/cs/ww/en/view/49948856>).

Application examples (<https://support.industry.siemens.com/cs/ww/en/view/41986454>) are also available on the Internet.



## 7.2 Behavior of the digital input module

### Display

The channel status LEDs are directly influenced by the signal level at the socket.  
If the encoder supply is switched off, this causes the channel status LEDs to also switch off.

### Response to error detection

All channels that are in pause mode on "PE\_MODE\_PROCEED" report their diagnostic status as in productive mode.

The following applies for all channels which switch to a different pause mode:

- Encoder supply switch-off upon the start of "pause" does not result in the "Short-circuit" alarms.
- During the "pause", error detection of "Short circuit" is not possible:
  - Alarms for errors already pending before the "pause" are retained.
  - After the "pause" is over, the error status is updated and incoming/outgoing errors are reported correspondingly.

### Mode parameter

The following table shows the "Mode" parameter.

Table 7- 1 Mode parameter

| Element | Code                    | Explanation                                                                                                                                                         |
|---------|-------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Mode    | 0b: PE_MODE_PROCEED     | Proceed at "pause"<br>• Value status "GOOD"                                                                                                                         |
|         | 1b: PE_MODE_SHUTDOWN    | Switch off at "pause"<br>• Encoder supply Us switched off <sup>1</sup><br>• Pause substitute value: 0b<br>• Value status "BAD"                                      |
|         | 3b: PE_MODE_LAST_VALUE  | Last value at "pause"<br>• Encoder supply Us switched off <sup>1</sup><br>• Pause substitute value: Last input value<br>• Value status "BAD"                        |
|         | 4b: PE_MODE_SUBST_VALUE | Substitute value at "pause"<br>• Encoder supply Us switched off <sup>1</sup><br>• Pause substitute value: Configured pause substitute value<br>• Value status "BAD" |

<sup>1</sup> As there is only one encoder supply Us for all channels, the supply can only be switched off at "pause" if no channel is configured in PE\_MODE\_PROCEED.

## Dimension drawing

The figure below shows the dimension drawing of the DI 8x24VDC 4xM12 digital input module in front and side view.

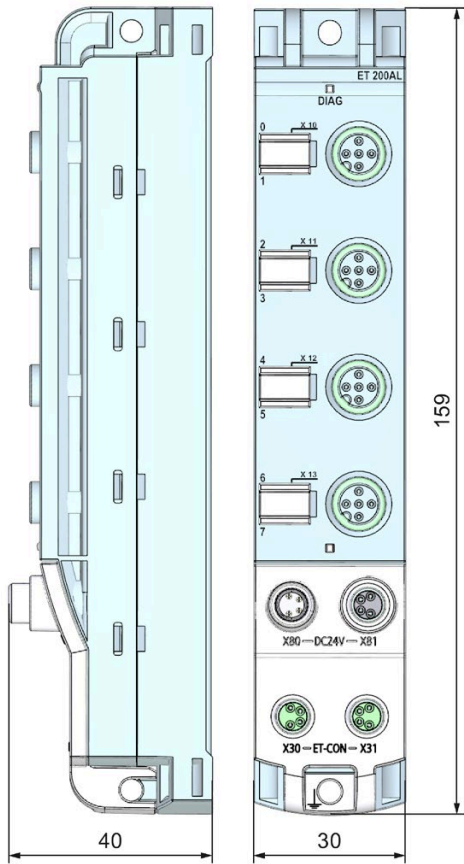
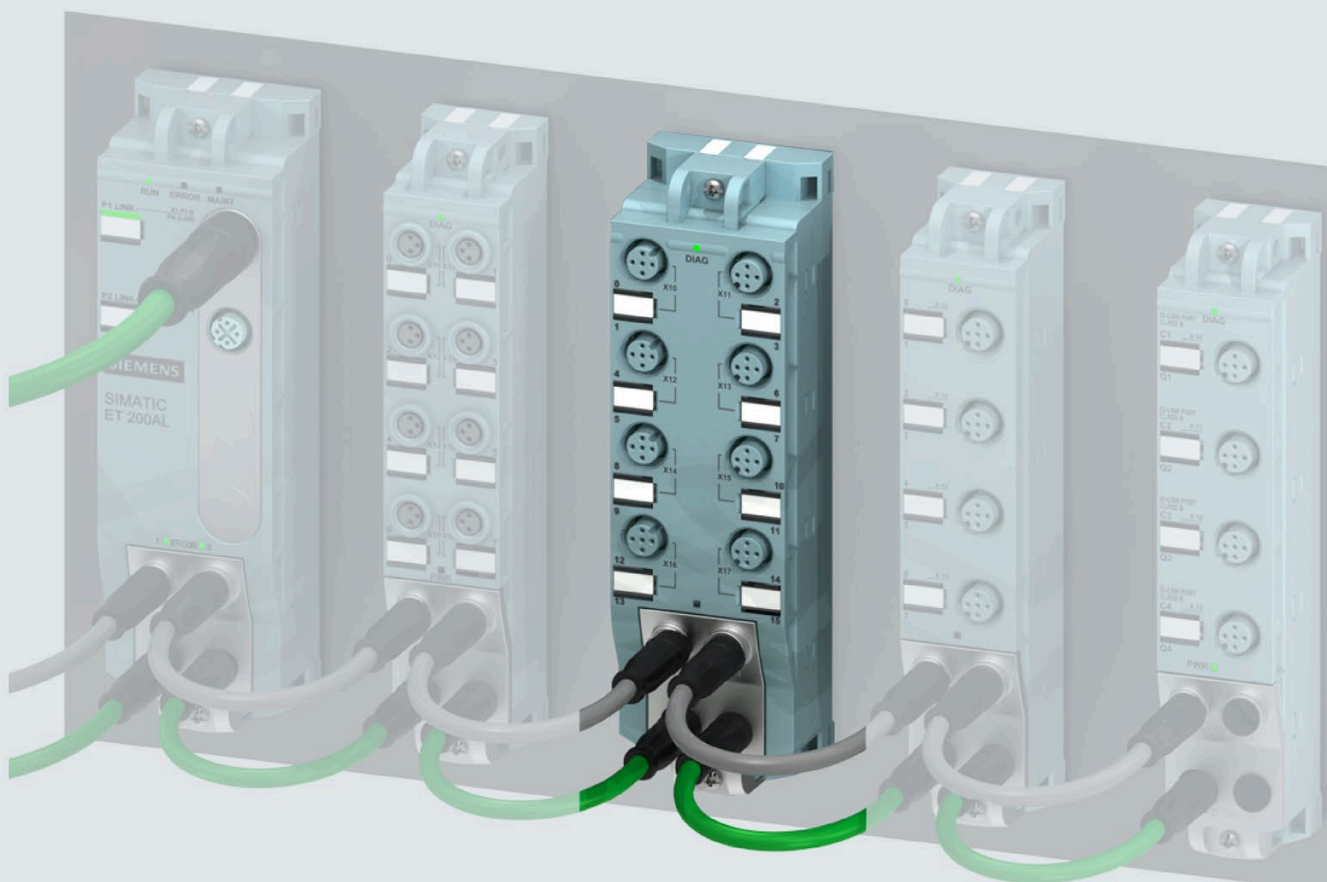


Figure A-1 Dimension drawing

# SIEMENS



Equipment Manual

## SIMATIC

### ET 200AL

Digital input module DI 16x24VDC 8xM12  
(6ES7141-5AH00-0BA0)

Edition

08/2021

[support.industry.siemens.com](https://support.industry.siemens.com)

## SIMATIC

### ET 200AL DI 16x24VDC 8xM12 (6ES7141-5AH00-0BA0)

#### Equipment Manual

#### Preface

---

#### ET 200AL Documentation Guide

**1**

#### Product overview

**2**

#### Wiring

**3**

#### Parameters/address space

**4**

#### Interrupts/diagnostic alarms

**5**

#### Technical specifications

**6**

#### PROFenergy

**7**

#### Dimension drawing

**A**

## Legal information

### Warning notice system

This manual contains notices you have to observe in order to ensure your personal safety, as well as to prevent damage to property. The notices referring to your personal safety are highlighted in the manual by a safety alert symbol, notices referring only to property damage have no safety alert symbol. These notices shown below are graded according to the degree of danger.

#### **DANGER**

indicates that death or severe personal injury **will** result if proper precautions are not taken.

#### **WARNING**

indicates that death or severe personal injury **may** result if proper precautions are not taken.

#### **CAUTION**

indicates that minor personal injury can result if proper precautions are not taken.

#### **NOTICE**

indicates that property damage can result if proper precautions are not taken.

If more than one degree of danger is present, the warning notice representing the highest degree of danger will be used. A notice warning of injury to persons with a safety alert symbol may also include a warning relating to property damage.

### Qualified Personnel

The product/system described in this documentation may be operated only by **personnel qualified** for the specific task in accordance with the relevant documentation, in particular its warning notices and safety instructions. Qualified personnel are those who, based on their training and experience, are capable of identifying risks and avoiding potential hazards when working with these products/systems.

### Proper use of Siemens products

Note the following:

#### **WARNING**

Siemens products may only be used for the applications described in the catalog and in the relevant technical documentation. If products and components from other manufacturers are used, these must be recommended or approved by Siemens. Proper transport, storage, installation, assembly, commissioning, operation and maintenance are required to ensure that the products operate safely and without any problems. The permissible ambient conditions must be complied with. The information in the relevant documentation must be observed.

### Trademarks

All names identified by ® are registered trademarks of Siemens AG. The remaining trademarks in this publication may be trademarks whose use by third parties for their own purposes could violate the rights of the owner.

### Disclaimer of Liability

We have reviewed the contents of this publication to ensure consistency with the hardware and software described. Since variance cannot be precluded entirely, we cannot guarantee full consistency. However, the information in this publication is reviewed regularly and any necessary corrections are included in subsequent editions.

# Preface

## Preface

### Purpose of the documentation

This manual supplements the ET 200AL distributed I/O system (<https://support.industry.siemens.com/cs/us/en/view/89254965>) system manual. Functions that are generally applicable to the ET 200AL distributed I/O system are described there.

The information provided in the present manual, the system manual and the function manuals enables you to commission the ET 200AL distributed I/O system.

### Conventions

Please also observe notes marked as follows:

---

#### Note

Indicates important product information to which particular attention should be paid.

---

### Security information

Siemens provides products and solutions with industrial security functions that support the secure operation of plants, systems, machines and networks.

In order to protect plants, systems, machines and networks against cyber threats, it is necessary to implement – and continuously maintain – a holistic, state-of-the-art industrial security concept. Siemens' products and solutions constitute one element of such a concept.

Customers are responsible for preventing unauthorized access to their plants, systems, machines and networks. Such systems, machines and components should only be connected to an enterprise network or the internet if and to the extent such a connection is necessary and only when appropriate security measures (e.g. firewalls and/or network segmentation) are in place.

For additional information on industrial security measures that may be implemented, please visit (<https://www.siemens.com/industrialsecurity>).

Siemens' products and solutions undergo continuous development to make them more secure. Siemens strongly recommends that product updates are applied as soon as they are available and that the latest product versions are used. Use of product versions that are no longer supported, and failure to apply the latest updates may increase customers' exposure to cyber threats.

To stay informed about product updates, subscribe to the Siemens Industrial Security RSS Feed visit (<https://www.siemens.com/industrialsecurity>).

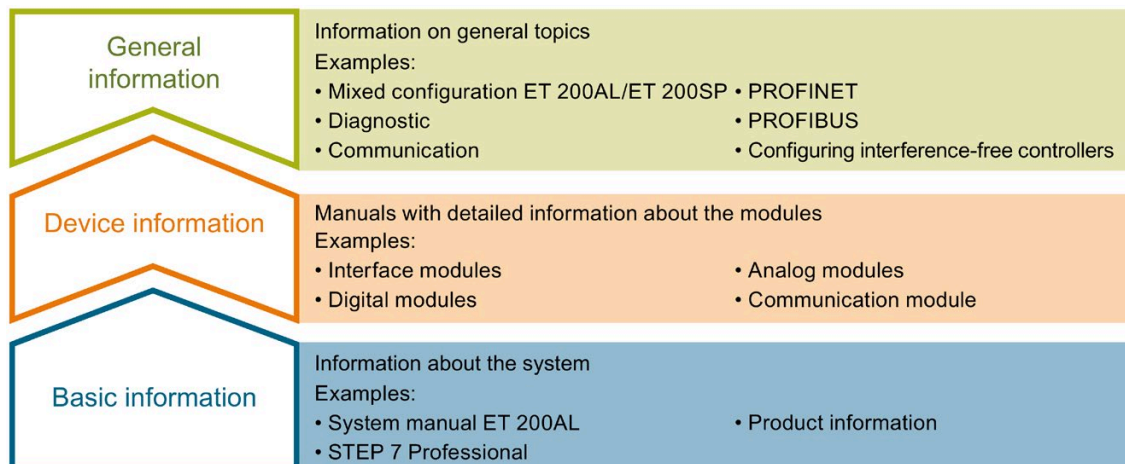
# Table of contents

|          |                                                  |           |
|----------|--------------------------------------------------|-----------|
|          | <b>Preface .....</b>                             | <b>3</b>  |
| <b>1</b> | <b>ET 200AL Documentation Guide.....</b>         | <b>5</b>  |
| <b>2</b> | <b>Product overview.....</b>                     | <b>9</b>  |
|          | 2.1 Properties .....                             | 9         |
|          | 2.2 Operator controls and display elements ..... | 11        |
| <b>3</b> | <b>Wiring .....</b>                              | <b>12</b> |
|          | 3.1 Terminal and block diagram .....             | 12        |
|          | 3.2 Pin assignment .....                         | 13        |
| <b>4</b> | <b>Parameters/address space .....</b>            | <b>16</b> |
|          | 4.1 Parameters .....                             | 16        |
|          | 4.2 Explanation of the parameters .....          | 16        |
|          | 4.3 Address space.....                           | 17        |
| <b>5</b> | <b>Interrupts/diagnostic alarms .....</b>        | <b>18</b> |
|          | 5.1 Status and error displays .....              | 18        |
|          | 5.2 Interrupts .....                             | 20        |
|          | 5.3 Diagnostics alarms .....                     | 20        |
| <b>6</b> | <b>Technical specifications.....</b>             | <b>21</b> |
|          | 6.1 Technical specifications .....               | 21        |
| <b>7</b> | <b>PROFenergy .....</b>                          | <b>24</b> |
|          | 7.1 Pause function.....                          | 24        |
|          | 7.2 Behavior of the digital input module .....   | 25        |
| <b>A</b> | <b>Dimension drawing .....</b>                   | <b>26</b> |

# ET 200AL Documentation Guide

The documentation for the SIMATIC ET 200AL distributed I/O system is arranged into three areas.

This arrangement enables you to access the specific content you require.



## Basic information

The System Manual and Getting Started describe in detail the configuration, installation, wiring and commissioning of the SIMATIC ET 200AL distributed I/O system. The STEP 7 online help supports you in the configuration and programming.

## Device information

Product manuals contain a compact description of the module-specific information, such as properties, wiring diagrams, characteristics and technical specifications.

## General information

The function manuals contain detailed descriptions on general topics regarding the SIMATIC ET 200AL distributed I/O system, e.g. diagnostics, communication, Motion Control, Web server.

You can download the documentation free of charge from the Internet (<https://support.industry.siemens.com/cs/ww/en/view/109742667>).

## Manual Collection ET 200AL

The Manual Collection contains the complete documentation on the SIMATIC ET 200AL distributed I/O system gathered together in one file.

You can find the Manual Collection on the Internet (<https://support.automation.siemens.com/WW/view/en/95242965>).



## **"mySupport"**

With "mySupport", your personal workspace, you make the best out of your Industry Online Support.

In "mySupport", you can save filters, favorites and tags, request CAx data and compile your personal library in the Documentation area. In addition, your data is already filled out in support requests and you can get an overview of your current requests at any time.

You must register once to use the full functionality of "mySupport".

You can find "mySupport" on the Internet (<https://support.industry.siemens.com/My/ww/en>).

## **"mySupport" - Documentation**

With "mySupport", your personal workspace, you make the best out of your Industry Online Support.

In "mySupport", you can save filters, favorites and tags, request CAx data and compile your personal library in the Documentation area. In addition, your data is already filled out in support requests and you can get an overview of your current requests at any time.

You must register once to use the full functionality of "mySupport".

You can find "mySupport" on the Internet (<https://support.industry.siemens.com/My/ww/en/documentation>).

## **"mySupport" - CAx data**

In the CAx data area of "mySupport", you can access the latest product data for your CAx or CAe system.

You configure your own download package with a few clicks.

In doing so you can select:

- Product images, 2D dimension drawings, 3D models, internal circuit diagrams, EPLAN macro files
- Manuals, characteristics, operating manuals, certificates
- Product master data

You can find "mySupport" - CAx data on the Internet (<https://support.industry.siemens.com/my/ww/en/CAxOnline>).

## **Application examples**

The application examples support you with various tools and examples for solving your automation tasks. Solutions are shown in interplay with multiple components in the system - separated from the focus on individual products.

You will find the application examples on the Internet (<https://support.industry.siemens.com/cs/ww/en/ps/ae>).

## TIA Selection Tool

With the TIA Selection Tool, you can select, configure and order devices for Totally Integrated Automation (TIA).

This tool is the successor of the SIMATIC Selection Tool and combines the known configurators for automation technology into one tool.

With the TIA Selection Tool, you can generate a complete order list from your product selection or product configuration.

You can find the TIA Selection Tool on the Internet

(<https://support.industry.siemens.com/cs/ww/en/view/109767888>).

## SIMATIC Automation Tool

You can use the SIMATIC Automation Tool to perform commissioning and maintenance activities simultaneously on various SIMATIC S7 stations as a bulk operation independent of TIA Portal.

The SIMATIC Automation Tool provides a multitude of functions:

- Scanning of a PROFINET/Ethernet system network and identification of all connected CPUs
- Address assignment (IP, subnet, gateway) and station name (PROFINET device) to a CPU
- Transfer of the date and the programming device/PC time converted to UTC time to the module
- Program download to CPU
- RUN/STOP mode switchover
- CPU localization by means of LED flashing
- Reading out of CPU error information
- Reading of the CPU diagnostics buffer
- Reset to factory settings
- Firmware update of the CPU and connected modules

You can find the SIMATIC Automation Tool on the Internet

(<https://support.industry.siemens.com/cs/ww/en/view/98161300>).

## PRONETA

SIEMENS PRONETA (PROFINET network analysis) allows you to analyze the plant network during commissioning. PRONETA features two core functions:

- The topology overview automatically scans the PROFINET and all connected components.
- The IO check is a fast test of the wiring and the module configuration of a plant.

You can find SIEMENS PRONETA on the Internet

(<https://support.industry.siemens.com/cs/ww/en/view/67460624>).

## SINETPLAN

SINETPLAN, the Siemens Network Planner, supports you in planning automation systems and networks based on PROFINET. The tool facilitates professional and predictive dimensioning of your PROFINET installation as early as in the planning stage. In addition, SINETPLAN supports you during network optimization and helps you to exploit network resources optimally and to plan reserves. This helps to prevent problems in commissioning or failures during productive operation even in advance of a planned operation. This increases the availability of the production plant and helps improve operational safety.

The advantages at a glance

- Network optimization thanks to port-specific calculation of the network load
- Increased production availability thanks to online scan and verification of existing systems
- Transparency before commissioning through importing and simulation of existing STEP 7 projects
- Efficiency through securing existing investments in the long term and the optimal use of resources

You can find SINETPLAN on the Internet (<https://www.siemens.com/sinetplan>).

## Product overview

### 2.1 Properties

#### Article number

6ES7141-5AH00-0BA0

#### View of the module

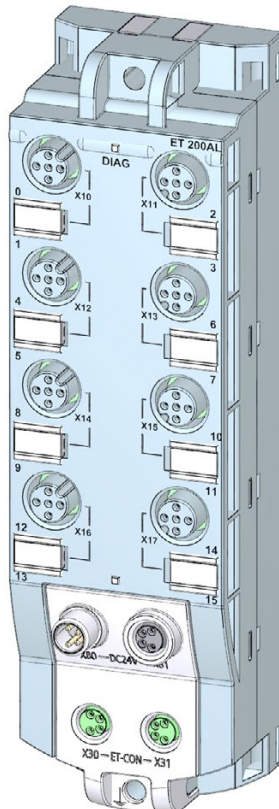


Figure 2-1 View of the DI 16x24VDC 8xM12 digital input module

## 2.1 Properties

### Properties

The module has the following technical properties:

- 16 digital inputs
- M12 sockets for connection of sensors
- 24 V DC supply voltage
- Configurable diagnostics can be set for each module
- Typical input delay of 3 ms
- Suitable for switches and proximity switches
- Dimensions 45 x 159 mm

The module supports the following functions:

- Firmware update
- Identification and maintenance data I&M0 to I&M3
- Value status (Quality Information)
- PROFIenergy

### Accessories

The following components are included in the module package:

- Identification labels

### Other components

The following component can be ordered as spare part:

- Identification labels

The following components can be ordered as accessories:

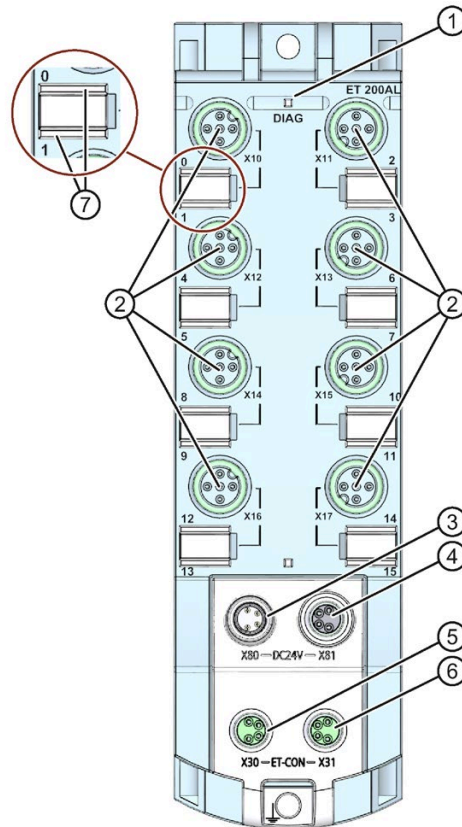
- Connectors
- Cables
- Stripping Tool for ET-Connection
- M8 sealing cap
- M12 sealing cap

### See also

You can find more information on accessories in the Accessories/spare parts section of the ET 200AL distributed I/O system  
(<https://support.industry.siemens.com/cs/us/en/view/89254965>) system manual.

## 2.2 Operator controls and display elements

The figure below shows the operator controls and display elements of the DI 16x24VDC 8xM12 digital input module.



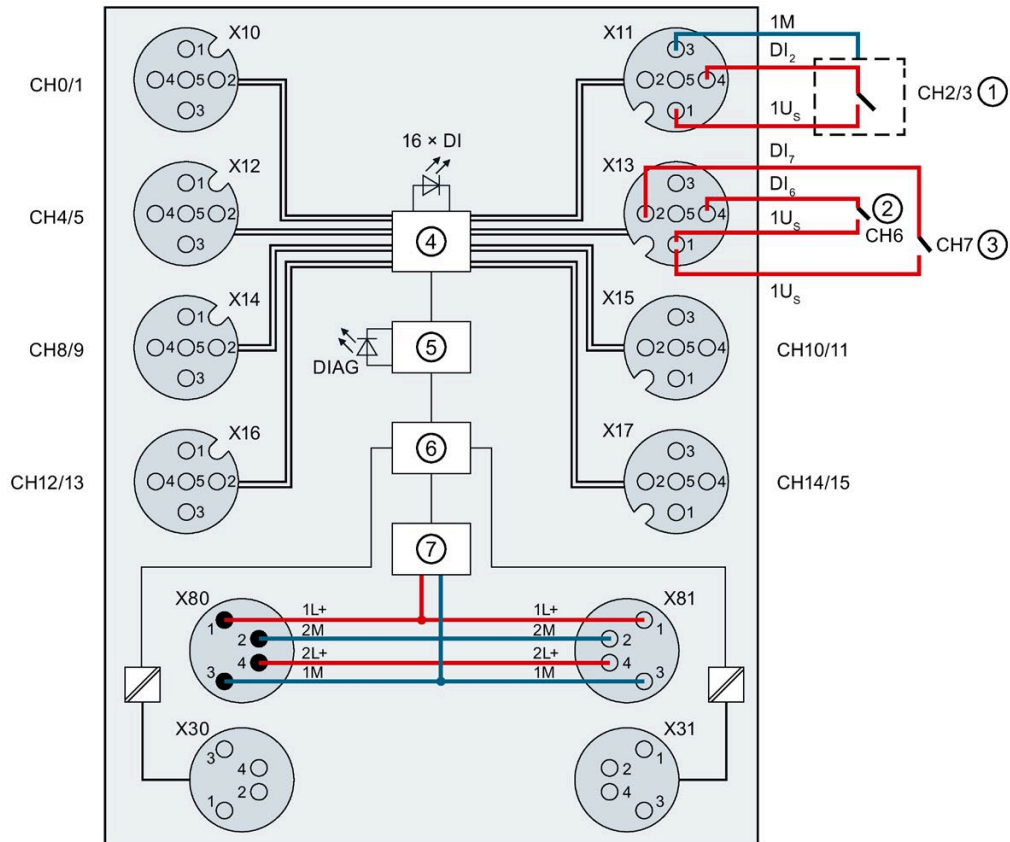
- ① DIAG: LED display for the diagnostic status
- ② X10 to X17: Sockets for the input signal
- ③ X80: Connector for infeed of the supply voltage (POWER input)
- ④ X81: Socket for loop-through of the supply voltage (POWER output)
- ⑤ X30: Socket for ET-Connection IN
- ⑥ X31: Socket for ET-Connection OUT
- ⑦ LED displays 0 to 15 for the channel status

Figure 2-2 Operator controls and display elements

# Wiring

## 3.1 Terminal and block diagram

The figure below shows an example of the pin assignment of signal inputs with 2-wire and 3-wire connection.



|            |                                 |                 |                                       |
|------------|---------------------------------|-----------------|---------------------------------------|
| ①          | 3-wire connection               | X30             | Infeed of the ET-Connection           |
| ②          | 2-wire connection               | X31             | Loop-through of the ET-Connection     |
| ③          | 2-wire connection               | 1L+             | Supply voltage 1L+ (non-switched)     |
| ④          | DI circuit                      | 1M              | Ground 1M (non-switched)              |
| ⑤          | Microcontroller                 | 2L+             | Load voltage 2L+ (switched)           |
| ⑥          | ET-Connection interface         | 2M              | Ground 2M (switched)                  |
| ⑦          | Internal supply voltage         | 1Us             | 24 V encoder supply                   |
| X10 to X17 | Channels 0 to 7                 | DI <sub>n</sub> | Input signal                          |
| X80        | Infeed of supply voltages       | DI              | Channel status LEDs (0 to 15) (green) |
| X81        | Loop-through of supply voltages | DIAG            | LED diagnostic status (red/green)     |

Figure 3-1 Terminal and block diagram

## 3.2 Pin assignment

### Note

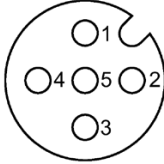
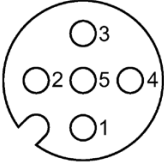
Color coding

The sockets for ET-Connection and the power supply of the modules are color-coded. These colors correspond to the colors of the offered cables.

### Pin assignment of the sockets for digital inputs

The table below shows the pin assignment of the 8 sockets for the connection of digital inputs.

Table 3- 1 Pin assignment for digital inputs

| Pin | Assignment                                                                                                                                                                                                                                                                              | Front view of the sockets                                                            |                                                                                      |
|-----|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------|
|     | X10 to X17 sockets for digital inputs                                                                                                                                                                                                                                                   | X10, X12, X14, X16                                                                   | X11, X13, X15, X17                                                                   |
| 1   | 24 V encoder supply 1Us<br>(derived from 1L+ non-switched)                                                                                                                                                                                                                              |  |  |
| 2   | Input signal DI1: Connector X10<br>Input signal DI3: Connector X11<br>Input signal DI5: Connector X12<br>Input signal DI7: Connector X13<br>Input signal DI9: Connector X14<br>Input signal DI11: Connector X15<br>Input signal DI13: Connector X16<br>Input signal DI15: Connector X17 |                                                                                      |                                                                                      |
| 3   | Encoder supply ground 1M                                                                                                                                                                                                                                                                |                                                                                      |                                                                                      |
| 4   | Input signal DI0: Connector X10<br>Input signal DI2: Connector X11<br>Input signal DI4: Connector X12<br>Input signal DI6: Connector X13<br>Input signal DI8: Connector X14<br>Input signal DI10: Connector X15<br>Input signal DI12: Connector X16<br>Input signal DI14: Connector X17 |                                                                                      |                                                                                      |
| 5   | Functional earth FE                                                                                                                                                                                                                                                                     |                                                                                      |                                                                                      |

### NOTICE

#### 24 V encoder supply 1Us

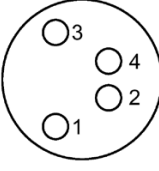
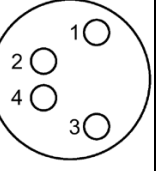
Use only the 24 V encoder supply 1Us provided by the digital input module to supply power to the encoder.



### Pin assignment of the sockets for ET-Connection

The table below shows the pin assignments of the 2 sockets for the connection of ET-Connection.

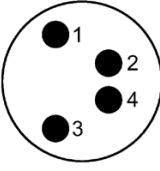
Table 3- 2 Pin assignment for ET-Connection

| Pin       | Assignment                    |                                | Assignment of the wire color of the bus line cable for ET-Connection | Front view of the sockets                                                           |                                                                                     |
|-----------|-------------------------------|--------------------------------|----------------------------------------------------------------------|-------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------|
|           | X30 socket (ET-Connection IN) | X31 socket (ET-Connection OUT) |                                                                      | X30                                                                                 | X31                                                                                 |
| 1         | TXP                           | RXP                            | Yellow                                                               |  |  |
| 2         | RXP                           | TXP                            | White                                                                |                                                                                     |                                                                                     |
| 3         | RXN                           | TXN                            | Blue                                                                 |                                                                                     |                                                                                     |
| 4         | TXN                           | RXN                            | Orange                                                               |                                                                                     |                                                                                     |
| Shielding | Functional earth FE           |                                | -                                                                    |                                                                                     |                                                                                     |

### Pin assignment of the connector for infeed of the supply voltage

The table below shows the pin assignment of the connector for infeed of the supply voltage.

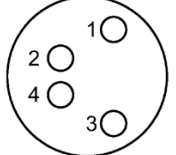
Table 3- 3 Pin assignment of the supply voltage connector

| Pin | Assignment                        | Assignment of the wire color of the power line cable | Front view of the connector                                                           |
|-----|-----------------------------------|------------------------------------------------------|---------------------------------------------------------------------------------------|
|     | X80 connector (POWER input)       |                                                      |                                                                                       |
| 1   | Supply voltage 1L+ (non-switched) | Brown                                                |  |
| 2   | Ground 2M (switched)              | White                                                |                                                                                       |
| 3   | Ground 1M (non-switched)          | Blue                                                 |                                                                                       |
| 4   | Load voltage 2L+ (switched)       | Black                                                |                                                                                       |

### Pin assignment of the socket for loop-through of the supply voltage

The table below shows the pin assignment of the socket for loop-through of the supply voltage.

Table 3- 4 Pin assignment of the supply voltage socket

| Pin | Assignment                        | Assignment of the wire color of the power line cable | Front view of the socket                                                            |
|-----|-----------------------------------|------------------------------------------------------|-------------------------------------------------------------------------------------|
|     | X81 socket (POWER output)         |                                                      |                                                                                     |
| 1   | Supply voltage 1L+ (non-switched) | Brown                                                |  |
| 2   | Ground 2M (switched)              | White                                                |                                                                                     |
| 3   | Ground 1M (non-switched)          | Blue                                                 |                                                                                     |
| 4   | Load voltage 2L+ (switched)       | Black                                                |                                                                                     |

#### NOTICE

##### ET-Connection/supply voltage

Observe the correct wiring of the M8 sockets for ET-Connection and the supply voltage.

Mixing up the ET-Connection connectors and the connectors for the supply voltage can destroy the module.

## Parameters/address space

### 4.1 Parameters

The table below shows the parameters for the DI 16x24VDC 8xM12 digital input module.

Table 4- 1 Parameters

| Parameters                           | Value range                                                                | Default | Scope  |
|--------------------------------------|----------------------------------------------------------------------------|---------|--------|
| Diagnostics: Short-circuit to ground | <ul style="list-style-type: none"><li>• Disable</li><li>• Enable</li></ul> | Disable | Module |

### 4.2 Explanation of the parameters

#### Diagnostics: Short-circuit to ground

Enabling of the diagnostics if a short-circuit of the encoder supply to ground occurs.

## 4.3 Address space

The figure below shows the assignment of the address space for the digital input module DI 16x24VDC 8xM12 with value status (Quality Information, QI).

The address space for the value status is allocated by the module, if the value status is configured using the PROFINET interface module.

Assignment in the process image input (PII)

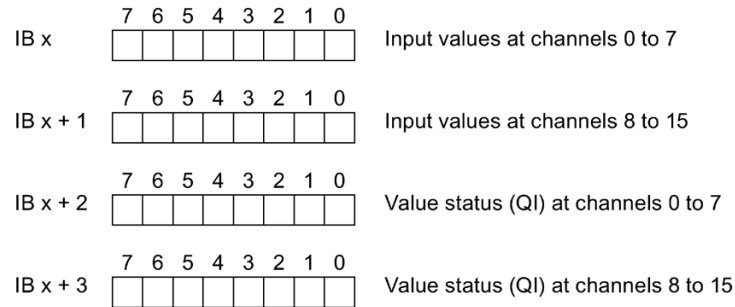


Figure 4-1 Address space

### Configuration options of the DI 16x24VDC 8xM12 digital input module

You have the following configuration options:

- Configuration 1: without value status
- Configuration 2: with value status

### Evaluating the value status

An additional two bytes are occupied in the input address space if you enable the value status for the digital input module. Bits 0 to 7 in these bytes are assigned to a channel and return information about the validity of the digital input value.

Bit = 1: No error on channel.

Bit = 0: Error on channel.

## Interrupts/diagnostic alarms

### 5.1 Status and error displays

#### LED displays

The figure below shows the LED displays (status and error displays) of the DI 16x24VDC 8xM12 digital input module.

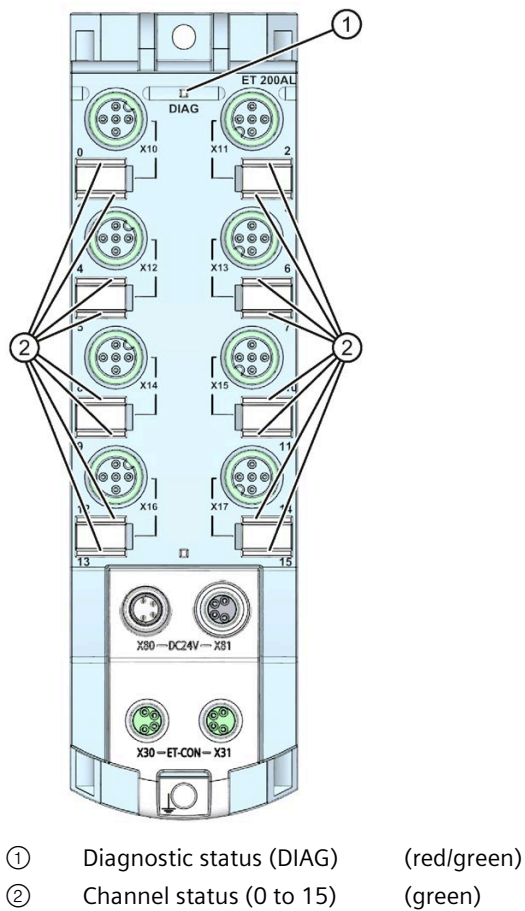


Figure 5-1 LED displays

## Meaning of the LEDs

The following tables set out the meaning of the status and error displays. Corrective measures for diagnostics alarms can be found in section Diagnostics alarms (Page 20).

### DIAG LED

Table 5- 1 Error display of the DIAG LED

| DIAG LED                                                                                     | Meaning                                                                                                                                                                                                                                                                                                     |
|----------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <br>Off     | No supply voltage 1L+                                                                                                                                                                                                                                                                                       |
| <br>Flashes | <ul style="list-style-type: none"> <li>Module parameters not assigned (after switching on the supply voltage 1L+)</li> <li>Loading firmware (while the firmware update is being performed, all LEDs retain their current status)</li> <li>No connection to the ET-Connection and/or the fieldbus</li> </ul> |
| <br>On      | Module parameters assigned and no module diagnostics                                                                                                                                                                                                                                                        |
| <br>Flashes | Module parameters assigned and module diagnostics                                                                                                                                                                                                                                                           |

### LED channel status

Table 5- 2 LED channel status display

| LED channel status                                                                         | Meaning            |
|--------------------------------------------------------------------------------------------|--------------------|
| <br>Off | Process signal = 0 |
| <br>On  | Process signal = 1 |

## 5.2 Interrupts

The DI 16x24VDC 8xM12 digital input module supports diagnostic interrupts.

### Diagnostic interrupt

The digital input module generates a diagnostic interrupt at the following events:

- Short-circuit of encoder supply to ground

## 5.3 Diagnostics alarms

For each diagnostic event, a diagnostics alarm is issued and the DIAG LED flashes red on the digital input module. You can read out the diagnostics alarms, for example, in the diagnostics buffer of the CPU. You can evaluate the error codes with the user program.

Table 5- 3 Diagnostics alarms, their meanings and corrective measures

| Diagnostics alarm | Error code     | Meaning                                | Remedy                      |
|-------------------|----------------|----------------------------------------|-----------------------------|
| Short-circuit     | 1 <sub>H</sub> | Short-circuit encoder supply to ground | Eliminate the short-circuit |

# Technical specifications

## 6.1 Technical specifications

### Technical specifications of the DI 16x24VDC 8xM12 digital input module

The following table shows the technical specifications as of the issue date. You can find a data sheet including daily updated technical specifications on the Internet (<https://support.industry.siemens.com/cs/ww/en/pv/6ES7141-5AH00-0BA0/td?dl=en>).

|                                                          |                                                                                       |
|----------------------------------------------------------|---------------------------------------------------------------------------------------|
| <b>Article number</b>                                    | <b>6ES7141-5AH00-0BA0</b>                                                             |
| <b>General information</b>                               |                                                                                       |
| Product type designation                                 | DI 16x24VDC                                                                           |
| HW functional status                                     | FS03                                                                                  |
| Firmware version                                         | V1.0.x                                                                                |
| <b>Product function</b>                                  |                                                                                       |
| • I&M data                                               | Yes; I&M0 to I&M3                                                                     |
| <b>Engineering with</b>                                  |                                                                                       |
| • STEP 7 TIA Portal configurable/integrated from version | STEP 7 V13 SP1 or higher                                                              |
| • STEP 7 configurable/integrated from version            | V5.5 SP4 Hotfix 7 or higher                                                           |
| • PROFIBUS from GSD version/GSD revision                 | GSD as of Revision 5                                                                  |
| • PROFINET from GSD version/GSD revision                 | GSDML V2.3.1                                                                          |
| <b>Supply voltage</b>                                    |                                                                                       |
| <b>Load voltage 1L+</b>                                  |                                                                                       |
| • Rated value (DC)                                       | 24 V                                                                                  |
| • permissible range, lower limit (DC)                    | 20.4 V                                                                                |
| • permissible range, upper limit (DC)                    | 28.8 V                                                                                |
| • Reverse polarity protection                            | Yes; Against destruction; encoder power supply outputs applied with reversed polarity |
| <b>Input current</b>                                     |                                                                                       |
| Current consumption (rated value)                        | 30 mA; without load                                                                   |
| from load voltage 1L+ (unswitched voltage)               | 4 A; Maximum value                                                                    |
| from load voltage 2L+, max.                              | 4 A; Maximum value                                                                    |
| <b>Encoder supply</b>                                    |                                                                                       |
| Number of outputs                                        | 8                                                                                     |
| <b>24 V encoder supply</b>                               |                                                                                       |
| • Short-circuit protection                               | Yes; per module, electronic                                                           |
| • Output current, max.                                   | 1.4 A; Total current of all encoders                                                  |



## 6.1 Technical specifications

|                                                                            |                                           |
|----------------------------------------------------------------------------|-------------------------------------------|
| <b>Article number</b>                                                      | <b>6ES7141-5AH00-0BA0</b>                 |
| <b>Power loss</b>                                                          |                                           |
| Power loss, typ.                                                           | 2.7 W                                     |
| <b>Digital inputs</b>                                                      |                                           |
| Number of digital inputs                                                   | 16                                        |
| Input characteristic curve in accordance with IEC 61131, type 3            | Yes                                       |
| <b>Number of simultaneously controllable inputs all mounting positions</b> |                                           |
| – up to 55 °C, max.                                                        | 16                                        |
| <b>Input voltage</b>                                                       |                                           |
| • Rated value (DC)                                                         | 24 V                                      |
| • for signal "0"                                                           | -30 to +5 V                               |
| • for signal "1"                                                           | +11 to +30V                               |
| <b>Input current</b>                                                       |                                           |
| • for signal "1", typ.                                                     | 3.2 mA                                    |
| <b>Input delay (for rated value of input voltage) for standard inputs</b>  |                                           |
| – at "0" to "1", min.                                                      | 1.2 ms                                    |
| – at "0" to "1", max.                                                      | 4.8 ms                                    |
| – at "1" to "0", min.                                                      | 1.2 ms                                    |
| – at "1" to "0", max.                                                      | 4.8 ms                                    |
| <b>Cable length</b>                                                        |                                           |
| • unshielded, max.                                                         | 30 m                                      |
| <b>Encoder</b>                                                             |                                           |
| <b>Connectable encoders</b>                                                |                                           |
| • 2-wire sensor                                                            | Yes                                       |
| – permissible quiescent current (2-wire sensor), max.                      | 1.5 mA                                    |
| <b>Interrupts/diagnostics/status information</b>                           |                                           |
| <b>Alarms</b>                                                              |                                           |
| • Diagnostic alarm                                                         | Yes; Parameterizable                      |
| <b>Diagnoses</b>                                                           |                                           |
| • Short-circuit                                                            | Yes; Sensor supply to M; module by module |
| <b>Diagnostics indication LED</b>                                          |                                           |
| • Channel status display                                                   | Yes; green LED                            |
| • for module diagnostics                                                   | Yes; green/red LED                        |
| <b>Potential separation</b>                                                |                                           |
| between the load voltages                                                  | Yes                                       |

|                                                                                        |                           |
|----------------------------------------------------------------------------------------|---------------------------|
| <b>Article number</b>                                                                  | <b>6ES7141-5AH00-0BA0</b> |
| <b>Potential separation channels</b>                                                   |                           |
| • between the channels                                                                 | No                        |
| • between the channels and backplane bus                                               | Yes                       |
| • between the channels and the power supply of the electronics                         | No                        |
| <b>Isolation</b>                                                                       |                           |
| Isolation tested with                                                                  | 707 V DC (type test)      |
| <b>Standards, approvals, certificates</b>                                              |                           |
| Suitable for safety-related tripping of standard modules                               | Yes; From FS01            |
| <b>Highest safety class achievable for safety-related tripping of standard modules</b> |                           |
| • Performance level according to ISO 13849-1                                           | PL d                      |
| • Category according to ISO 13849-1                                                    | Cat. 3                    |
| • SILCL according to IEC 62061                                                         | SILCL 2                   |
| <b>Ambient conditions</b>                                                              |                           |
| <b>Ambient temperature during operation</b>                                            |                           |
| • min.                                                                                 | -30 °C                    |
| • max.                                                                                 | 55 °C                     |
| <b>Connection method</b>                                                               |                           |
| Design of electrical connection for the inputs and outputs                             | M12, 5-pole               |
| Design of electrical connection for supply voltage                                     | M8, 4-pole                |
| <b>ET-Connection</b>                                                                   |                           |
| • ET-Connection                                                                        | M8, 4-pin, shielded       |
| <b>Dimensions</b>                                                                      |                           |
| Width                                                                                  | 45 mm                     |
| Height                                                                                 | 159 mm                    |
| Depth                                                                                  | 40 mm                     |
| <b>Weights</b>                                                                         |                           |
| Weight, approx.                                                                        | 184 g                     |

# PROFlenergy

## 7.1 Pause function

### Introduction

PROFlenergy is a PROFINET-based data interface for switching off consumers centrally and in a coordinated manner during pause times regardless of the manufacturer or device type. This has the aim that the process is only provided with the energy that is absolutely required. In so doing, the majority of the energy savings come from the process itself; the PROFINET device contributes only a few watts to the possible savings. In PROFlenergy, this operating state is referred to as a "pause".

### Start and end of a pause

You enable and disable the pause function of the system at the beginning and end of pauses, respectively; the IO controller then sends the PROFlenergy command "Start\_Pause" or "End\_Pause" to the modules.

Use the "Start\_Pause" command to start a pause.

Use the "End\_Pause" command to end a pause.

The following conditions will also cause a pause to be ended:

- Reconfiguration in RUN
- Controller failure
- Firmware update
- Station stop
- Restart of the interface module through:
  - POWER OFF/POWER ON of an interface module
  - POWER OFF/POWER ON of an I/O module
  - Termination of ET-Connection1 or ET-Connection2

The specific behavior of the digital input module is explained in the following section.

### Additional information

You can find additional information on working with PROFlenergy in the "PROFlenergy" section of the manual IM 157-1 PN interface module (<https://support.industry.siemens.com/cs/ww/en/view/89254863>) and the "Saving energy with PROFlenergy" section of function manual PROFINET with STEP 7 V13 (<https://support.industry.siemens.com/cs/ww/en/view/49948856>).

Application examples (<https://support.industry.siemens.com/cs/ww/en/view/41986454>) are also available on the Internet.

## 7.2 Behavior of the digital input module

### Display

The channel status LEDs are directly influenced by the signal level at the socket.  
If the encoder supply is switched off, this causes the channel status LEDs to also switch off.

### Response to error detection

All channels that are in pause mode on "PE\_MODE\_PROCEED" report their diagnostic status as in productive mode.

The following applies for all channels which switch to a different pause mode:

- Encoder supply switch-off upon the start of "pause" does not result in the "Short-circuit" alarms.
- During the "pause", error detection of "Short circuit" is not possible:
  - Alarms for errors already pending before the "pause" are retained.
  - After the "pause" is over, the error status is updated and incoming/outgoing errors are reported correspondingly.

### Mode parameter

The following table shows the "Mode" parameter.

Table 7- 1 Mode parameter

| Element | Code                    | Explanation                                                                                                                                                         |
|---------|-------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Mode    | 0b: PE_MODE_PROCEED     | Proceed at "pause"<br>• Value status "GOOD"                                                                                                                         |
|         | 1b: PE_MODE_SHUTDOWN    | Switch off at "pause"<br>• Encoder supply Us switched off <sup>1</sup><br>• Pause substitute value: 0b<br>• Value status "BAD"                                      |
|         | 3b: PE_MODE_LAST_VALUE  | Last value at "pause"<br>• Encoder supply Us switched off <sup>1</sup><br>• Pause substitute value: Last input value<br>• Value status "BAD"                        |
|         | 4b: PE_MODE_SUBST_VALUE | Substitute value at "pause"<br>• Encoder supply Us switched off <sup>1</sup><br>• Pause substitute value: Configured pause substitute value<br>• Value status "BAD" |

<sup>1</sup> As there is only one encoder supply Us for all channels, the supply can only be switched off at "pause" if no channel is configured in PE\_MODE\_PROCEED.

## Dimension drawing

The figure below shows the dimension drawing of the DI 16x24VDC 8xM12 digital input module in front and side view.

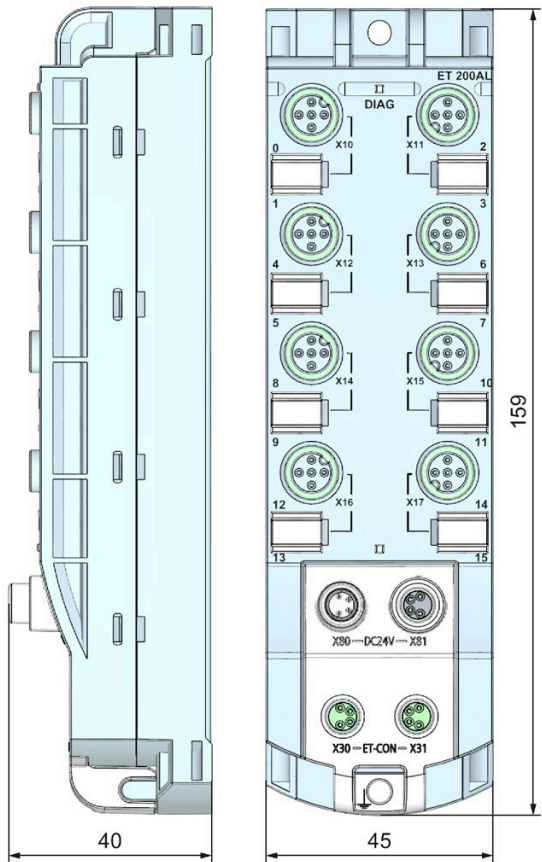


Figure A-1 Dimension drawing

# SIEMENS



Equipment Manual

## SIMATIC

### ET 200AL

Digital input / output module  
DIQ 4+DQ 4x24VDC/0.5A 8xM8  
(6ES7143-5BF00-0BA0)

Edition

08/2021

[support.industry.siemens.com](https://support.industry.siemens.com)

## SIMATIC

### ET 200AL Digital input/digital output module DIQ 4+DQ 4x24VDC/0.5A 8xM8 (6ES7143-5BF00-0BA0)

Equipment Manual

#### Preface

ET 200AL Documentation  
Guide

1

Product overview

2

Wiring

3

Parameters/address space

4

Interrupts/diagnostics  
alarms

5

Technical specifications

6

PROFInergy

7

Dimension drawing

A

## Legal information

### Warning notice system

This manual contains notices you have to observe in order to ensure your personal safety, as well as to prevent damage to property. The notices referring to your personal safety are highlighted in the manual by a safety alert symbol, notices referring only to property damage have no safety alert symbol. These notices shown below are graded according to the degree of danger.

#### **DANGER**

indicates that death or severe personal injury **will** result if proper precautions are not taken.

#### **WARNING**

indicates that death or severe personal injury **may** result if proper precautions are not taken.

#### **CAUTION**

indicates that minor personal injury can result if proper precautions are not taken.

#### **NOTICE**

indicates that property damage can result if proper precautions are not taken.

If more than one degree of danger is present, the warning notice representing the highest degree of danger will be used. A notice warning of injury to persons with a safety alert symbol may also include a warning relating to property damage.

### Qualified Personnel

The product/system described in this documentation may be operated only by **personnel qualified** for the specific task in accordance with the relevant documentation, in particular its warning notices and safety instructions. Qualified personnel are those who, based on their training and experience, are capable of identifying risks and avoiding potential hazards when working with these products/systems.

### Proper use of Siemens products

Note the following:

#### **WARNING**

Siemens products may only be used for the applications described in the catalog and in the relevant technical documentation. If products and components from other manufacturers are used, these must be recommended or approved by Siemens. Proper transport, storage, installation, assembly, commissioning, operation and maintenance are required to ensure that the products operate safely and without any problems. The permissible ambient conditions must be complied with. The information in the relevant documentation must be observed.

### Trademarks

All names identified by ® are registered trademarks of Siemens AG. The remaining trademarks in this publication may be trademarks whose use by third parties for their own purposes could violate the rights of the owner.

### Disclaimer of Liability

We have reviewed the contents of this publication to ensure consistency with the hardware and software described. Since variance cannot be precluded entirely, we cannot guarantee full consistency. However, the information in this publication is reviewed regularly and any necessary corrections are included in subsequent editions.



# Preface

## Purpose of the documentation

This manual supplements the ET 200AL distributed I/O system (<http://support.automation.siemens.com/WW/view/en/89254965>) system manual. Functions that are generally applicable to the ET 200AL distributed I/O system are described there.

The information provided in the present manual, the system manual and the function manuals enables you to commission the ET 200AL distributed I/O system.

## Conventions

Please also observe notes marked as follows:

---

### Note

Indicates important product information to which particular attention should be paid.

---

## Security information

Siemens provides products and solutions with industrial security functions that support the secure operation of plants, systems, machines and networks.

In order to protect plants, systems, machines and networks against cyber threats, it is necessary to implement – and continuously maintain – a holistic, state-of-the-art industrial security concept. Siemens' products and solutions constitute one element of such a concept.

Customers are responsible for preventing unauthorized access to their plants, systems, machines and networks. Such systems, machines and components should only be connected to an enterprise network or the internet if and to the extent such a connection is necessary and only when appropriate security measures (e.g. firewalls and/or network segmentation) are in place.

For additional information on industrial security measures that may be implemented, please visit (<https://www.siemens.com/industrialsecurity>).

Siemens' products and solutions undergo continuous development to make them more secure. Siemens strongly recommends that product updates are applied as soon as they are available and that the latest product versions are used. Use of product versions that are no longer supported, and failure to apply the latest updates may increase customers' exposure to cyber threats.

To stay informed about product updates, subscribe to the Siemens Industrial Security RSS Feed visit (<https://www.siemens.com/industrialsecurity>).

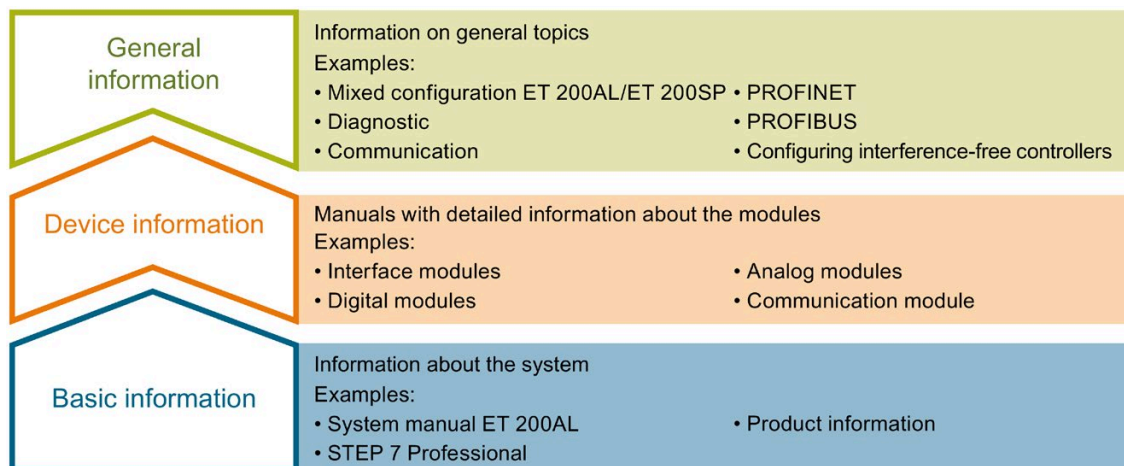
# Table of contents

|          |                                                  |           |
|----------|--------------------------------------------------|-----------|
|          | <b>Preface</b> .....                             | <b>3</b>  |
| <b>1</b> | <b>ET 200AL Documentation Guide</b> .....        | <b>5</b>  |
| <b>2</b> | <b>Product overview</b> .....                    | <b>9</b>  |
|          | 2.1 Properties .....                             | 9         |
|          | 2.2 Operator controls and display elements ..... | 12        |
| <b>3</b> | <b>Wiring</b> .....                              | <b>13</b> |
|          | 3.1 Terminal and block diagram .....             | 13        |
|          | 3.2 Pin assignment .....                         | 14        |
| <b>4</b> | <b>Parameters/address space</b> .....            | <b>17</b> |
|          | 4.1 Parameters .....                             | 17        |
|          | 4.2 Explanation of the parameters .....          | 18        |
|          | 4.3 Address space.....                           | 19        |
| <b>5</b> | <b>Interrupts/diagnostics alarms</b> .....       | <b>21</b> |
|          | 5.1 Status and error displays.....               | 21        |
|          | 5.2 Interrupts .....                             | 23        |
|          | 5.3 Diagnostics alarms.....                      | 23        |
| <b>6</b> | <b>Technical specifications</b> .....            | <b>24</b> |
| <b>7</b> | <b>PROFenergy</b> .....                          | <b>28</b> |
|          | 7.1 Pause function.....                          | 28        |
|          | 7.2 DI operating mode.....                       | 29        |
|          | 7.3 DQ operating mode .....                      | 30        |
| <b>A</b> | <b>Dimension drawing</b> .....                   | <b>31</b> |

# ET 200AL Documentation Guide

The documentation for the SIMATIC ET 200AL distributed I/O system is arranged into three areas.

This arrangement enables you to access the specific content you require.



## Basic information

The System Manual and Getting Started describe in detail the configuration, installation, wiring and commissioning of the SIMATIC ET 200AL distributed I/O system. The STEP 7 online help supports you in the configuration and programming.

## Device information

Product manuals contain a compact description of the module-specific information, such as properties, wiring diagrams, characteristics and technical specifications.

## General information

The function manuals contain detailed descriptions on general topics regarding the SIMATIC ET 200AL distributed I/O system, e.g. diagnostics, communication, Motion Control, Web server.

You can download the documentation free of charge from the Internet (<https://support.industry.siemens.com/cs/ww/en/view/109742667>).

## Manual Collection ET 200AL

The Manual Collection contains the complete documentation on the SIMATIC ET 200AL distributed I/O system gathered together in one file.

You can find the Manual Collection on the Internet (<https://support.automation.siemens.com/WW/view/en/95242965>).

## "mySupport"

With "mySupport", your personal workspace, you make the best out of your Industry Online Support.

In "mySupport", you can save filters, favorites and tags, request CAx data and compile your personal library in the Documentation area. In addition, your data is already filled out in support requests and you can get an overview of your current requests at any time.

You must register once to use the full functionality of "mySupport".

You can find "mySupport" on the Internet (<https://support.industry.siemens.com/My/ww/en>).

## "mySupport" - Documentation

With "mySupport", your personal workspace, you make the best out of your Industry Online Support.

In "mySupport", you can save filters, favorites and tags, request CAx data and compile your personal library in the Documentation area. In addition, your data is already filled out in support requests and you can get an overview of your current requests at any time.

You must register once to use the full functionality of "mySupport".

You can find "mySupport" on the Internet (<https://support.industry.siemens.com/My/ww/en/documentation>).

## "mySupport" - CAx data

In the CAx data area of "mySupport", you can access the latest product data for your CAx or CAe system.

You configure your own download package with a few clicks.

In doing so you can select:

- Product images, 2D dimension drawings, 3D models, internal circuit diagrams, EPLAN macro files
- Manuals, characteristics, operating manuals, certificates
- Product master data

You can find "mySupport" - CAx data on the Internet (<https://support.industry.siemens.com/my/ww/en/CAxOnline>).

## Application examples

The application examples support you with various tools and examples for solving your automation tasks. Solutions are shown in interplay with multiple components in the system - separated from the focus on individual products.

You will find the application examples on the Internet (<https://support.industry.siemens.com/cs/ww/en/ps/ae>).

## TIA Selection Tool

With the TIA Selection Tool, you can select, configure and order devices for Totally Integrated Automation (TIA).

This tool is the successor of the SIMATIC Selection Tool and combines the known configurators for automation technology into one tool.

With the TIA Selection Tool, you can generate a complete order list from your product selection or product configuration.

You can find the TIA Selection Tool on the Internet

(<https://support.industry.siemens.com/cs/ww/en/view/109767888>).

## SIMATIC Automation Tool

You can use the SIMATIC Automation Tool to perform commissioning and maintenance activities simultaneously on various SIMATIC S7 stations as a bulk operation independent of TIA Portal.

The SIMATIC Automation Tool provides a multitude of functions:

- Scanning of a PROFINET/Ethernet system network and identification of all connected CPUs
- Address assignment (IP, subnet, gateway) and station name (PROFINET device) to a CPU
- Transfer of the date and the programming device/PC time converted to UTC time to the module
- Program download to CPU
- RUN/STOP mode switchover
- CPU localization by means of LED flashing
- Reading out of CPU error information
- Reading of the CPU diagnostics buffer
- Reset to factory settings
- Firmware update of the CPU and connected modules

You can find the SIMATIC Automation Tool on the Internet

(<https://support.industry.siemens.com/cs/ww/en/view/98161300>).

## PRONETA

SIEMENS PRONETA (PROFINET network analysis) allows you to analyze the plant network during commissioning. PRONETA features two core functions:

- The topology overview automatically scans the PROFINET and all connected components.
- The IO check is a fast test of the wiring and the module configuration of a plant.

You can find SIEMENS PRONETA on the Internet

(<https://support.industry.siemens.com/cs/ww/en/view/67460624>).

## SINETPLAN

SINETPLAN, the Siemens Network Planner, supports you in planning automation systems and networks based on PROFINET. The tool facilitates professional and predictive dimensioning of your PROFINET installation as early as in the planning stage. In addition, SINETPLAN supports you during network optimization and helps you to exploit network resources optimally and to plan reserves. This helps to prevent problems in commissioning or failures during productive operation even in advance of a planned operation. This increases the availability of the production plant and helps improve operational safety.

The advantages at a glance

- Network optimization thanks to port-specific calculation of the network load
- Increased production availability thanks to online scan and verification of existing systems
- Transparency before commissioning through importing and simulation of existing STEP 7 projects
- Efficiency through securing existing investments in the long term and the optimal use of resources

You can find SINETPLAN on the Internet (<https://www.siemens.com/sinetplan>).

## Product overview

### 2.1 Properties

#### Article number

6ES7143-5BF00-0BA0

#### View of the module

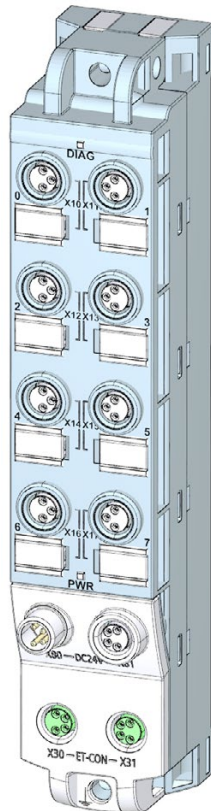


Figure 2-1 View of the DIQ 4+DQ 4x24VDC/0.5A 8xM8 digital input/digital output module

## 2.1 Properties

### Properties

The module has the following technical properties:

- 4 digital inputs or digital outputs and 4 digital outputs, depending on parameter assignment
  - DIQ signals connected to 1L+ (non-switched)
  - DQ signals connected to 2L+ (switched)
- M8 sockets for connection of sensors and actuators
- Digital inputs:
  - 24 V DC supply voltage
  - Configurable diagnostics can be set for each module
  - Typical input delay of 3 ms
  - Suitable for switches and proximity switches
- Digital outputs:
  - Rated load voltage 24 V DC
  - Suitable for solenoid valves, DC contactors, and indicator lights
  - Output current 0.5 A per output
  - Configurable diagnostics can be set for each module
- Dimensions 30 x 159 mm

The module supports the following functions:

- Firmware update
- Identification and maintenance data I&M0 to I&M3
- Value status (Quality Information)
- PROFIenergy

### Accessories

The following components are included in the module package:

- Identification labels
- Spacers



## Other components

The following component can be ordered as spare part:

- Identification labels

The following components can be ordered as accessories:

- Connectors
- Cables
- Stripping Tool for ET-Connection
- M8 sealing cap

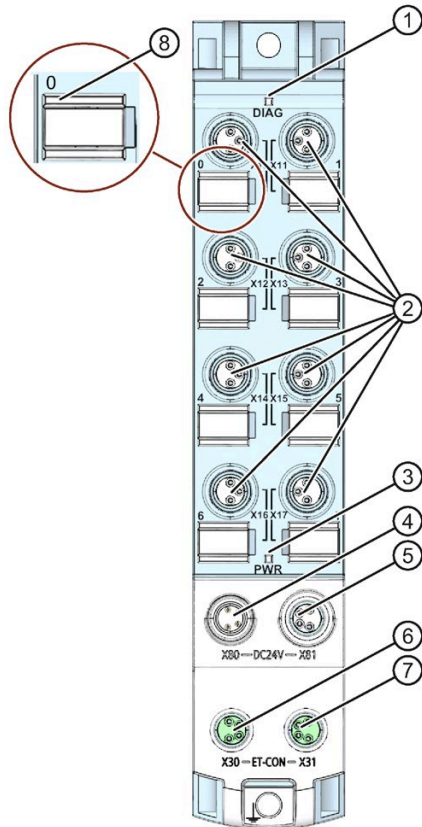
## See also

You can find more information on accessories in the Accessories/spare parts section of the ET 200AL distributed I/O system

(<http://support.automation.siemens.com/WW/view/en/89254965>) system manual.

## 2.2 Operator controls and display elements

The following figure shows the operator controls and display elements of the DIQ 4+DQ 4x24VDC/0.5A 8xM8 digital input/digital output module.



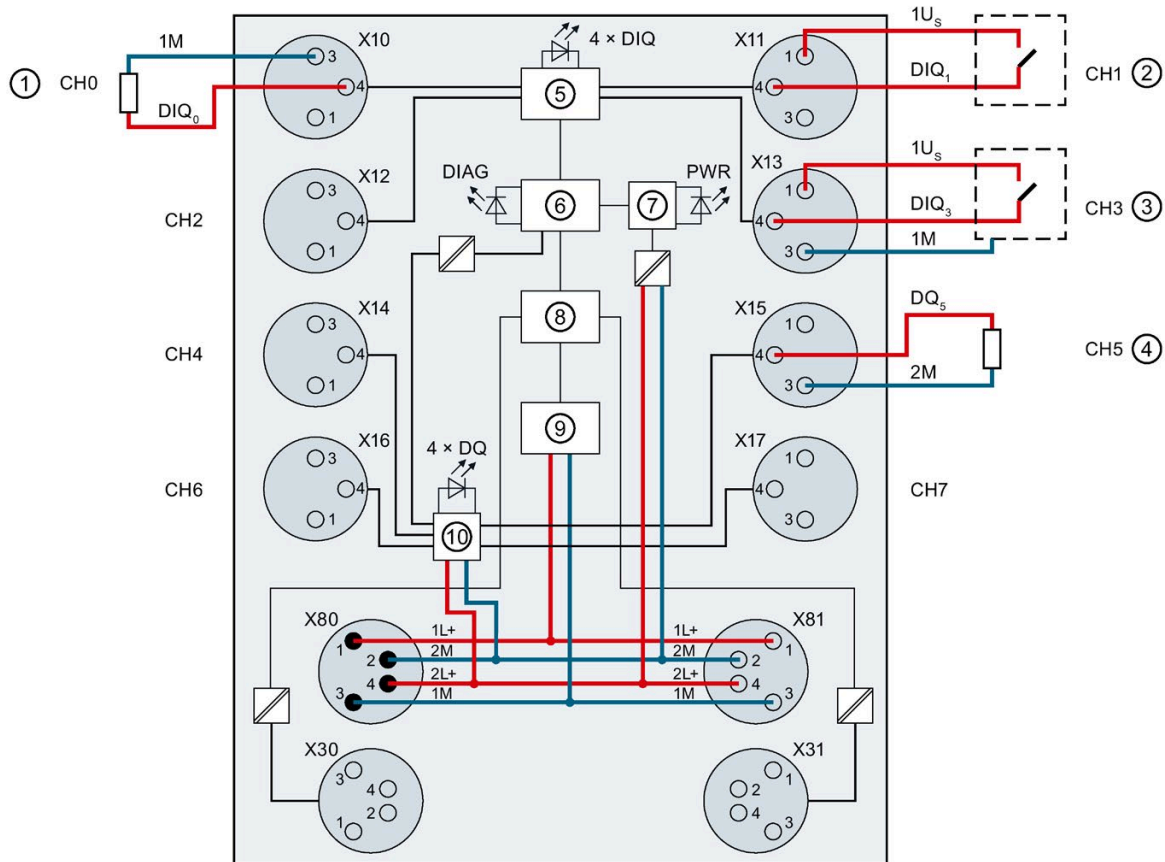
- ① DIAG: LED display for the diagnostic status
- ② X10 to X17: Sockets for the input/output signal
- ③ PWR: LED display for the load voltage 2L+
- ④ X80: Connector for infeed of the supply voltage (POWER input)
- ⑤ X81: Socket for loop-through of the supply voltage (POWER output)
- ⑥ X30: Socket for ET-Connection IN
- ⑦ X31: Socket for ET-Connection OUT
- ⑧ LED displays 0 to 7 for the channel status

Figure 2-2 Operator controls and display elements

# Wiring

### 3.1 Terminal and block diagram

The following figure shows an example of the pin assignment of signal inputs with 2- and 3-wire connection as well as signal outputs.



- |            |                                        |                  |                                             |
|------------|----------------------------------------|------------------|---------------------------------------------|
| ①          | Configured as output                   | X30              | Infeed of the ET-Connection                 |
| ②          | Configured as input: 2-wire connection | X31              | Loop-through of the ET-Connection           |
| ③          | Configured as input: 3-wire connection | 1L+              | Supply voltage 1L+ (non-switched)           |
| ④          | Output                                 | 1M               | Ground 1M (non-switched)                    |
| ⑤          | DI/DQ circuit                          | 2L+              | Load voltage 2L+ (switched)                 |
| ⑥          | Microcontroller                        | 2M               | Ground 2M (switched)                        |
| ⑦          | Monitoring                             | 1Us              | 24 V encoder supply                         |
| ⑧          | ET-Connection interface                | DIQ <sub>n</sub> | Input/output signal                         |
| ⑨          | Internal supply voltage                | DQ <sub>n</sub>  | Output signal                               |
| ⑩          | DQ circuit                             | DIQ              | LEDs channel status (0, 1, 2 and 3) (green) |
| X10 to X17 | Channels 0 to 7                        | DQ               | LEDs channel status (4, 5, 6 and 7) (green) |
| X80        | Infeed of supply voltages              | DIAG             | LED diagnostic status (red/green)           |
| X81        | Loop-through of supply voltages        | PWR              | LED supply voltage 2L+ (green)              |

Figure 3-1 Terminal and block diagram

## 3.2 Pin assignment

### Note

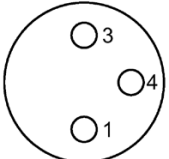
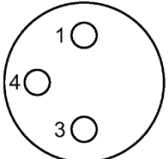
Color coding

The sockets for ET-Connection and the power supply of the modules are color-coded. These colors correspond to the colors of the offered cables.

### Pin assignment of the sockets for digital inputs/digital outputs

The tables below show the pin assignments of the 8 sockets for connection of the digital inputs/digital outputs.

Table 3- 1 Pin assignment for digital inputs/digital outputs

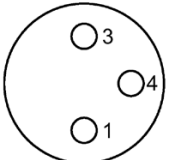
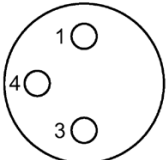
| Pin | Assignment                                                                                                                                                                                                                   | Front view of the sockets                                                            |                                                                                      |
|-----|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------|
|     | X10 to X13 sockets for digital inputs/<br>digital outputs                                                                                                                                                                    | X10, X12                                                                             | X11, X13                                                                             |
| 1   | 24 V encoder supply 1Us<br>(derived from 1L+ non-switched)                                                                                                                                                                   |  |  |
| 3   | Encoder supply ground 1M                                                                                                                                                                                                     |                                                                                      |                                                                                      |
| 4   | Input/output signal DIQ <sub>0</sub> : Connector X10<br>Input/output signal DIQ <sub>1</sub> : Connector X11<br>Input/output signal DIQ <sub>2</sub> : Connector X12<br>Input/output signal DIQ <sub>3</sub> : Connector X13 |                                                                                      |                                                                                      |

### NOTICE

#### 24 V encoder supply 1Us

Use only the 24 V encoder supply 1Us provided by the digital input/digital output module to supply power to the encoder.

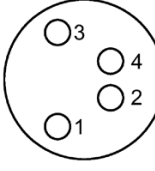
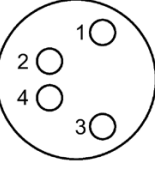
Table 3- 2 Pin assignment for digital outputs

| Pin | Assignment                                                                                                                                                                                       | Front view of the sockets                                                             |                                                                                       |
|-----|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------|
|     | X14 to X17 sockets for digital outputs                                                                                                                                                           | X14, X16                                                                              | X15, X17                                                                              |
| 1   | Unassigned                                                                                                                                                                                       |  |  |
| 3   | Ground 2M                                                                                                                                                                                        |                                                                                       |                                                                                       |
| 4   | Output signal DQ <sub>4</sub> : Connector X14<br>Output signal DQ <sub>5</sub> : Connector X15<br>Output signal DQ <sub>6</sub> : Connector X16<br>Output signal DQ <sub>7</sub> : Connector X17 |                                                                                       |                                                                                       |

### Pin assignment of the sockets for ET-Connection

The table below shows the pin assignments of the 2 sockets for the connection of ET-Connection.

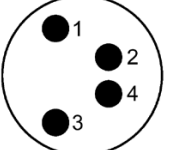
Table 3- 3 Pin assignment for ET-Connection

| Pin       | Assignment                    |                                | Assignment of the wire color of the bus line cable for ET-Connection | Front view of the sockets                                                           |                                                                                     |
|-----------|-------------------------------|--------------------------------|----------------------------------------------------------------------|-------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------|
|           | X30 socket (ET-Connection IN) | X31 socket (ET-Connection OUT) |                                                                      | X30                                                                                 | X31                                                                                 |
| 1         | TXP                           | RXP                            | Yellow                                                               |  |  |
| 2         | RXP                           | TXP                            | White                                                                |                                                                                     |                                                                                     |
| 3         | RXN                           | TXN                            | Blue                                                                 |                                                                                     |                                                                                     |
| 4         | TXN                           | RXN                            | Orange                                                               |                                                                                     |                                                                                     |
| Shielding | Functional earth FE           |                                | -                                                                    |                                                                                     |                                                                                     |

### Pin assignment of the connector for infeed of the supply voltage

The table below shows the pin assignment of the connector for infeed of the supply voltage.

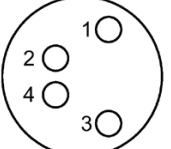
Table 3- 4 Pin assignment of the supply voltage connector

| Pin | Assignment                        | Assignment of the wire color of the power line cable | Front view of the connector                                                           |
|-----|-----------------------------------|------------------------------------------------------|---------------------------------------------------------------------------------------|
|     | X80 connector (POWER input)       |                                                      |                                                                                       |
| 1   | Supply voltage 1L+ (non-switched) | Brown                                                |  |
| 2   | Ground 2M (switched)              | White                                                |                                                                                       |
| 3   | Ground 1M (non-switched)          | Blue                                                 |                                                                                       |
| 4   | Load voltage 2L+ (switched)       | Black                                                |                                                                                       |

### Pin assignment of the socket for loop-through of the supply voltage

The table below shows the pin assignment of the socket for loop-through of the supply voltage.

Table 3- 5 Pin assignment of the supply voltage socket

| Pin | Assignment                        | Assignment of the wire color of the power line cable | Front view of the socket                                                              |
|-----|-----------------------------------|------------------------------------------------------|---------------------------------------------------------------------------------------|
|     | X81 socket (POWER output)         |                                                      |                                                                                       |
| 1   | Supply voltage 1L+ (non-switched) | Brown                                                |  |
| 2   | Ground 2M (switched)              | White                                                |                                                                                       |
| 3   | Ground 1M (non-switched)          | Blue                                                 |                                                                                       |
| 4   | Load voltage 2L+ (switched)       | Black                                                |                                                                                       |

|                                                                                                                                                                                                                                           |
|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>NOTICE</b>                                                                                                                                                                                                                             |
| <b>ET-Connection/supply voltage</b><br>Observe the correct wiring of the M8 sockets for ET-Connection and the supply voltage.<br>Mixing up the ET-Connection connectors and the connectors for the supply voltage can destroy the module. |

## Parameters/address space

### 4.1 Parameters

The following table shows the parameters for the DIQ 4+DQ 4x24VDC/0.5A 8xM8 digital input/digital output module.

Table 4- 1 Parameters

| Parameters                            | Value range                                                                                                                 | Default   | Scope                                                                  |
|---------------------------------------|-----------------------------------------------------------------------------------------------------------------------------|-----------|------------------------------------------------------------------------|
| Diagnostics: Missing load voltage 2L+ | <ul style="list-style-type: none"> <li>• Disable</li> <li>• Enable</li> </ul>                                               | Disable   | Module                                                                 |
| Diagnostics: Short-circuit to ground  | <ul style="list-style-type: none"> <li>• Disable</li> <li>• Enable</li> </ul>                                               | Disable   | Module<br>(Short-circuit of encoder supply or of the output to ground) |
| Freely assignable channel 0 ... 3     | <ul style="list-style-type: none"> <li>• DI</li> <li>• DQ</li> </ul>                                                        | DI        | Channel                                                                |
| Reaction to CPU/master STOP           | <ul style="list-style-type: none"> <li>• Shut down</li> <li>• Keep last value</li> <li>• Output substitute value</li> </ul> | Shut down | Module<br>(digital outputs)                                            |
| Substitute value channel 0 ... 7      | <ul style="list-style-type: none"> <li>• 0</li> <li>• 1</li> </ul>                                                          | 0         | Channel<br>(digital outputs)                                           |

## 4.2 Explanation of the parameters

### **Diagnostics: Missing load voltage 2L+**

Enabling of the diagnostics for missing or insufficient load voltage 2L+.

### **Diagnostics: Short-circuit to ground**

Enabling of the diagnostics for short-circuit of the encoder supply or output to ground.

### **Freely assignable channel n**

With this parameter, you set whether the channel is to be operated as an input or output.

### **Reaction to CPU/master STOP**

With this parameter, you set the reaction of the digital outputs of the digital input/digital output module after a CPU/master STOP:

- Shut down: The digital output is de-energized.
- Keep last value: The last value of the digital output remains activated.
- Output substitute value: The module outputs a configured substitute value.

### **Substitute value channel 0 ... 7**

With this parameter, you set substitute values for the digital outputs.



## 4.3 Address space

The figure below shows the assignment of the address space for the digital input/digital output module DIQ 4+DQ 4x24VDC/0.5A 8xM8 with value status (Quality Information, QI).

The address space for the value status is allocated by the module, if the value status is configured using the PROFINET interface module.

Assignment in the process image input (PII)

|      |   |   |   |   |   |   |   |   |                                 |
|------|---|---|---|---|---|---|---|---|---------------------------------|
|      | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |                                 |
| IB x | 0 | 0 | 0 | 0 |   |   |   |   | Input values at channels 0 to 3 |

|          |   |   |   |   |   |   |   |   |                                                 |
|----------|---|---|---|---|---|---|---|---|-------------------------------------------------|
|          | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |                                                 |
| IB x + 1 | 0 | 0 | 0 | 0 |   |   |   |   | Value status (QI) for inputs at channels 0 to 3 |

|          |   |   |   |   |   |   |   |   |                                                  |
|----------|---|---|---|---|---|---|---|---|--------------------------------------------------|
|          | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |                                                  |
| IB x + 2 |   |   |   |   |   |   |   |   | Value status (QI) for outputs at channels 0 to 7 |

Assignment in the process image output (PIQ)

|      |   |   |   |   |   |   |   |   |                                  |
|------|---|---|---|---|---|---|---|---|----------------------------------|
|      | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |                                  |
| QB x |   |   |   |   |   |   |   |   | Output values at channels 0 to 7 |

Figure 4-1 Address space DIQ 4+DQ 4x24VDC/0.5A 8x8M

### Note

#### Parameter assignment of the channels

Parameters for the first four channels can be freely assigned.

For the channels 0 ... 3 that are configured as input, the corresponding values in the output data do not trigger any reaction.

For the channels 0 ... 3 that are configured as output, the input value in the process image is 0.

### Configuration options of the digital input/digital output module DIQ 4+DQ 4x24VDC/0.5A 8xM8

You have the following configuration options:

- Configuration 1: without value status
- Configuration 2: with value status

### Evaluating the value status

An additional two bytes are occupied in the input address space if you enable the value status for the digital input/digital output module. The value status of the inputs is assigned to bits 0 to 3 in input byte  $x + 1$ . The value status of the outputs is assigned to bits 0 to 7 in input byte  $x + 2$ . This additional information provides information regarding the validity of the digital values or channel status.

Bit = 1: No error on channel.

Bit = 0: Error on channel.

If the channel is configured as input, this means:

- Short-circuit to ground at sensor supply or
- Parameter error

If the channel is configured as output, this means:

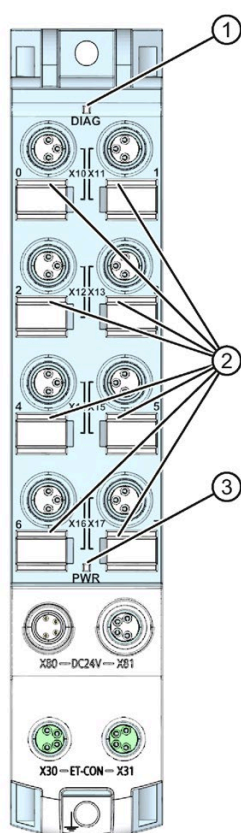
- Short-circuit of output to ground or
- Parameter error or
- For channels 4 ... 7: Missing load voltage 2L+

# Interrupts/diagnostics alarms

## 5.1 Status and error displays

### LED displays

The figure below shows the LED displays (status and error displays) of the digital input/digital output module DIQ 4+DQ 4x24VDC/0.5A 8xM8.



- |   |                          |             |
|---|--------------------------|-------------|
| ① | Diagnostic status (DIAG) | (red/green) |
| ② | Channel status (0 to 7)  | (green)     |
| ③ | Load voltage 2L+ (PWR)   | (green)     |

Figure 5-1 LED displays

## Meaning of the LEDs

The following tables set out the meaning of the status and error displays. Corrective measures for diagnostics alarms can be found in the section Diagnostics alarms (Page 23).

### DIAG LED

Table 5- 1 Error display of the DIAG LED

| DIAG LED                                                                                      | Meaning                                                                                                                                                                                                                                                                                                     |
|-----------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <br>Off      | No supply voltage 1L+                                                                                                                                                                                                                                                                                       |
| <br>Flashes  | <ul style="list-style-type: none"> <li>Module parameters not assigned (after switching on the supply voltage 1L+)</li> <li>Loading firmware (while the firmware update is being performed, all LEDs retain their current status)</li> <li>No connection to the ET-Connection and/or the fieldbus</li> </ul> |
| <br>On       | Module parameters assigned and no module diagnostics                                                                                                                                                                                                                                                        |
| <br>Flashes | Module parameters assigned and module diagnostics                                                                                                                                                                                                                                                           |

### LED channel status

Table 5- 2 LED channel status display

| LED channel status                                                                         | Meaning            |
|--------------------------------------------------------------------------------------------|--------------------|
| <br>Off | Process signal = 0 |
| <br>On  | Process signal = 1 |

### PWR LED

Table 5- 3 Status display of the PWR LED

| PWR LED                                                                                    | Meaning                                |
|--------------------------------------------------------------------------------------------|----------------------------------------|
| <br>Off | Load voltage 2L+ is missing or too low |
| <br>On  | Load voltage 2L+ present               |

## 5.2 Interrupts

The DIQ 4+DQ 4x24VDC/0.5A 8xM8 digital input/digital output module supports diagnostic interrupts.

### Diagnostic interrupt

The digital input/digital output module generates a diagnostic interrupt at the following events:

- Short-circuit of encoder supply to ground
- Short-circuit of outputs to ground
- Load voltage 2L+ missing or too low

## 5.3 Diagnostics alarms

For each diagnostic event, a diagnostics alarm is issued and the DIAG LED flashes red on the digital input/output module.

You can read out the diagnostics alarms, for example, from the diagnostics buffer of the CPU. You can evaluate the error codes with the user program.

Table 5- 4 Diagnostics alarms, their meanings and corrective measures

| Diagnostics alarm                                                                                                                                                                                                                                                                                                                                                  | Error code | Meaning                                | Remedy                                                                                                   |
|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------|----------------------------------------|----------------------------------------------------------------------------------------------------------|
| Short-circuit*                                                                                                                                                                                                                                                                                                                                                     | 1H         | Short-circuit encoder supply to ground | <ul style="list-style-type: none"> <li>• Eliminate the short-circuit</li> </ul>                          |
|                                                                                                                                                                                                                                                                                                                                                                    |            | Short-circuit of outputs to ground     |                                                                                                          |
| Load voltage 2L+ missing**                                                                                                                                                                                                                                                                                                                                         | 11H        | Load voltage 2L+ missing or too low    | <ul style="list-style-type: none"> <li>• Check the supply voltage</li> <li>• Check the module</li> </ul> |
| <p>* If a short-circuit of the encoder supply to ground is detected, the diagnostic alarm "Short-circuit" is always output. This alarm is output even if all channels are configured as outputs.</p> <p>** If you are using ET 200AL modules in connection with the ET 200SP distributed I/O system, the diagnostic alarm "Load voltage missing" is displayed.</p> |            |                                        |                                                                                                          |

### Note

#### Channel type

The digital input/digital output module is always signaled as a mixed module (channel type "Input/Output") in the case of diagnostic events, even if you have configured the digital input/digital output module exclusively as an output module.

## Technical specifications

### Technical specifications of the DIQ 4+DQ 4x24VDC/0.5A 8xM8 digital input/digital output module

The following table shows the technical specifications as of the issue date. You can find a data sheet including daily updated technical specifications on the Internet (<https://support.industry.siemens.com/cs/ww/en/pv/6ES7143-5BF00-0BA0/td?dl=en>).

|                                                          |                                                                                                      |
|----------------------------------------------------------|------------------------------------------------------------------------------------------------------|
| <b>Article number</b>                                    | <b>6ES7143-5BF00-0BA0</b>                                                                            |
| <b>General information</b>                               |                                                                                                      |
| Product type designation                                 | DIQ 4+DQ 4x24VDC/0.5A                                                                                |
| HW functional status                                     | FS03                                                                                                 |
| Firmware version                                         | V1.0.x                                                                                               |
| <b>Product function</b>                                  |                                                                                                      |
| • I&M data                                               | Yes; I&M0 to I&M3                                                                                    |
| <b>Engineering with</b>                                  |                                                                                                      |
| • STEP 7 TIA Portal configurable/integrated from version | STEP 7 V13 SP1 or higher                                                                             |
| • STEP 7 configurable/integrated from version            | From V5.5 SP4 Hotfix 3                                                                               |
| • PROFIBUS from GSD version/GSD revision                 | GSD as of Revision 5                                                                                 |
| • PROFINET from GSD version/GSD revision                 | GSDML V2.3.1                                                                                         |
| <b>Supply voltage</b>                                    |                                                                                                      |
| <b>Load voltage 1L+</b>                                  |                                                                                                      |
| • Rated value (DC)                                       | 24 V                                                                                                 |
| • permissible range, lower limit (DC)                    | 20.4 V                                                                                               |
| • permissible range, upper limit (DC)                    | 28.8 V                                                                                               |
| • Reverse polarity protection                            | Yes; Against destruction; encoder power supply outputs applied with reversed polarity, loads pick up |
| <b>Load voltage 2L+</b>                                  |                                                                                                      |
| • Rated value (DC)                                       | 24 V                                                                                                 |
| • permissible range, lower limit (DC)                    | 20.4 V                                                                                               |
| • permissible range, upper limit (DC)                    | 28.8 V                                                                                               |
| • Reverse polarity protection                            | Yes; against destruction; load increasing                                                            |
| <b>Input current</b>                                     |                                                                                                      |
| Current consumption (rated value)                        | 40 mA; without load                                                                                  |
| from load voltage 1L+ (unswitched voltage)               | 4 A; Maximum value                                                                                   |
| from load voltage 2L+, max.                              | 4 A; Maximum value                                                                                   |

|                                                                            |                                      |
|----------------------------------------------------------------------------|--------------------------------------|
| <b>Article number</b>                                                      | <b>6ES7143-5BF00-0BA0</b>            |
| <b>Encoder supply</b>                                                      |                                      |
| Number of outputs                                                          | 4                                    |
| <b>24 V encoder supply</b>                                                 |                                      |
| • Short-circuit protection                                                 | Yes; per module, electronic          |
| • Output current, max.                                                     | 0.7 A; Total current of all encoders |
| <b>Power loss</b>                                                          |                                      |
| Power loss, typ.                                                           | 2.5 W                                |
| <b>Digital inputs</b>                                                      |                                      |
| Number of digital inputs                                                   | 4; Parameterizable as DIQ            |
| Input characteristic curve in accordance with IEC 61131, type 3            | Yes                                  |
| <b>Number of simultaneously controllable inputs all mounting positions</b> |                                      |
| – up to 55 °C, max.                                                        | 4                                    |
| <b>Input voltage</b>                                                       |                                      |
| • Rated value (DC)                                                         | 24 V                                 |
| • for signal "0"                                                           | -3 to +5V                            |
| • for signal "1"                                                           | +11 to +30V                          |
| <b>Input current</b>                                                       |                                      |
| • for signal "1", typ.                                                     | 3.2 mA                               |
| <b>Input delay (for rated value of input voltage) for standard inputs</b>  |                                      |
| – at "0" to "1", min.                                                      | 1.2 ms                               |
| – at "0" to "1", max.                                                      | 4.8 ms                               |
| – at "1" to "0", min.                                                      | 1.2 ms                               |
| – at "1" to "0", max.                                                      | 4.8 ms                               |
| <b>Cable length</b>                                                        |                                      |
| • unshielded, max.                                                         | 30 m                                 |
| <b>Digital outputs</b>                                                     |                                      |
| Number of digital outputs                                                  | 8; 4 DQ fixed, 4 DIQ parameterizable |
| • in groups of                                                             | 4; 2 load groups for 4 outputs each  |
| Short-circuit protection                                                   | Yes; per channel, electronic         |
| • Response threshold, typ.                                                 | 0.7 A                                |
| Limitation of inductive shutdown voltage to                                | 2L+ (-47 V)                          |
| <b>Switching capacity of the outputs</b>                                   |                                      |
| • on lamp load, max.                                                       | 5 W                                  |
| <b>Load resistance range</b>                                               |                                      |
| • lower limit                                                              | 48 Ω                                 |
| • upper limit                                                              | 4 kΩ                                 |

|                                                                                                                                                                                                                                                 |                                                                                                                                                |
|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Article number</b>                                                                                                                                                                                                                           | <b>6ES7143-5BF00-0BA0</b>                                                                                                                      |
| <b>Output voltage</b> <ul style="list-style-type: none"> <li>for signal "1", min.</li> </ul>                                                                                                                                                    | L+ (-0.8 V)                                                                                                                                    |
| <b>Output current</b> <ul style="list-style-type: none"> <li>for signal "1" rated value</li> <li>for signal "0" residual current, max.</li> </ul>                                                                                               | 0.5 A<br>0.5 mA                                                                                                                                |
| <b>Switching frequency</b> <ul style="list-style-type: none"> <li>with resistive load, max.</li> <li>with inductive load, max.</li> <li>on lamp load, max.</li> </ul>                                                                           | 100 Hz<br>0.5 Hz<br>1 Hz                                                                                                                       |
| <b>Total current of the outputs</b> <ul style="list-style-type: none"> <li>Current per group, max.</li> </ul>                                                                                                                                   | 2 A                                                                                                                                            |
| <b>Cable length</b> <ul style="list-style-type: none"> <li>unshielded, max.</li> </ul>                                                                                                                                                          | 30 m                                                                                                                                           |
| <b>Encoder</b>                                                                                                                                                                                                                                  |                                                                                                                                                |
| <b>Connectable encoders</b> <ul style="list-style-type: none"> <li>2-wire sensor <ul style="list-style-type: none"> <li>permissible quiescent current (2-wire sensor), max.</li> </ul> </li> </ul>                                              | Yes<br>1.5 mA                                                                                                                                  |
| <b>Interrupts/diagnostics/status information</b>                                                                                                                                                                                                |                                                                                                                                                |
| Substitute values connectable                                                                                                                                                                                                                   | Yes; channel by channel, parameterizable                                                                                                       |
| <b>Alarms</b> <ul style="list-style-type: none"> <li>Diagnostic alarm</li> </ul>                                                                                                                                                                | Yes; Parameterizable                                                                                                                           |
| <b>Diagnoses</b> <ul style="list-style-type: none"> <li>Short-circuit</li> </ul>                                                                                                                                                                | Yes; Outputs to M; encoder supply to M; module by module                                                                                       |
| <b>Diagnostics indication LED</b> <ul style="list-style-type: none"> <li>Channel status display</li> <li>for module diagnostics</li> <li>For load voltage monitoring</li> </ul>                                                                 | Yes; green LED<br>Yes; green/red LED<br>Yes; green LED                                                                                         |
| <b>Potential separation</b> <ul style="list-style-type: none"> <li>between the load voltages</li> </ul>                                                                                                                                         | Yes                                                                                                                                            |
| <b>Potential separation channels</b> <ul style="list-style-type: none"> <li>between the channels, in groups of</li> <li>between the channels and backplane bus</li> <li>between the channels and the power supply of the electronics</li> </ul> | 4; DIQ channels are isolated from DQ channels<br>Yes<br>No; DIQ channels are non-isolated and DQ channels are isolated from supply voltage 1L+ |
| <b>Isolation</b> <ul style="list-style-type: none"> <li>Isolation tested with</li> </ul>                                                                                                                                                        | 707 V DC (type test)                                                                                                                           |
| <b>Degree and class of protection</b> <ul style="list-style-type: none"> <li>IP degree of protection</li> </ul>                                                                                                                                 | IP65/67                                                                                                                                        |



|                                                                                        |                           |
|----------------------------------------------------------------------------------------|---------------------------|
| <b>Article number</b>                                                                  | <b>6ES7143-5BF00-0BA0</b> |
| <b>Standards, approvals, certificates</b>                                              |                           |
| Suitable for safety-related tripping of standard modules                               | Yes; From FS01            |
| <b>Highest safety class achievable for safety-related tripping of standard modules</b> |                           |
| • Performance level according to ISO 13849-1                                           | PL d                      |
| • Category according to ISO 13849-1                                                    | Cat. 3                    |
| • SILCL according to IEC 62061                                                         | SILCL 2                   |
| <b>Ambient conditions</b>                                                              |                           |
| <b>Ambient temperature during operation</b>                                            |                           |
| • min.                                                                                 | -30 °C                    |
| • max.                                                                                 | 55 °C                     |
| <b>Connection method</b>                                                               |                           |
| Design of electrical connection for the inputs and outputs                             | M8, 3-pole                |
| Design of electrical connection for supply voltage                                     | M8, 4-pole                |
| <b>ET-Connection</b>                                                                   |                           |
| • ET-Connection                                                                        | M8, 4-pin, shielded       |
| <b>Dimensions</b>                                                                      |                           |
| Width                                                                                  | 30 mm                     |
| Height                                                                                 | 159 mm                    |
| Depth                                                                                  | 40 mm                     |
| <b>Weights</b>                                                                         |                           |
| Weight, approx.                                                                        | 145 g                     |

# PROFenergy

## 7.1 Pause function

### Introduction

PROFenergy is a PROFINET-based data interface for switching off consumers centrally and in a coordinated manner during pause times regardless of the manufacturer or device type. This has the aim that the process is only provided with the energy that is absolutely required. In so doing, the majority of the energy savings come from the process itself; the PROFINET device contributes only a few watts to the possible savings. In PROFenergy, this operating state is referred to as a "pause".

### Start and end of a pause

You enable and disable the pause function of the system at the beginning and end of pauses, respectively; the IO controller then sends the PROFenergy command "Start\_Pause" or "End\_Pause" to the modules.

Use the "Start\_Pause" command to start a pause.

Use the "End\_Pause" command to end a pause.

The following conditions will also cause a pause to be ended:

- Reconfiguration in RUN
- Controller failure
- Firmware update
- Station stop
- Restart of the interface module through:
  - POWER OFF/POWER ON of an interface module
  - POWER OFF/POWER ON of an I/O module
  - Termination of ET-Connection1 or ET-Connection2

The specific behavior of the digital input/digital output module is explained in the following sections.

### Additional information

You can find additional information on working with PROFenergy in the "PROFenergy" section of the manual IM 157-1 PN interface module (<http://support.automation.siemens.com/WW/view/en/89254863>) and the "Saving energy with PROFenergy" section of function manual PROFINET with STEP 7 V13 (<http://support.automation.siemens.com/WW/view/en/49948856>).

Application examples (<http://support.automation.siemens.com/WW/view/en/58235225>) are also available on the Internet.

## 7.2 DI operating mode

### Display

The channel status LEDs are directly influenced by the signal level at the socket.  
If the encoder supply is switched off, this causes the channel status LEDs to also switch off.

### Response to error detection

All channels that are in pause mode on "PE\_MODE\_PROCEED" report their diagnostic status as in productive mode.

The following applies for all channels which switch to a different pause mode:

- Encoder supply switch-off upon the start of "pause" does not result in the "Short-circuit" alarms.
- During the "pause", error detection of "Short circuit" is not possible:
  - Alarms for errors already pending before the "pause" are retained.
  - After the "pause" is over, the error status is updated and incoming/outgoing errors are reported correspondingly.

### Mode parameter

The following table shows the "Mode" parameter.

Table 7- 1 Mode parameter

| Element | Code                    | Explanation                                                                                                                                                            |
|---------|-------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Mode    | 0b: PE_MODE_PROCEED     | Proceed at "pause"<br>• Value status "GOOD"                                                                                                                            |
|         | 1b: PE_MODE_SHUTDOWN    | Switch off at "pause"<br>• Supply voltage $U_s$ switched off <sup>1</sup><br>• Pause substitute value: 0b<br>• Value status "BAD"                                      |
|         | 3b: PE_MODE_LAST_VALUE  | Last value at "pause"<br>• Supply voltage $U_s$ switched off <sup>1</sup><br>• Pause substitute value: Last input value<br>• Value status "BAD"                        |
|         | 4b: PE_MODE_SUBST_VALUE | Substitute value at "pause"<br>• Supply voltage $U_s$ switched off <sup>1</sup><br>• Pause substitute value: Configured pause substitute value<br>• Value status "BAD" |

<sup>1</sup> As there is only one encoder supply  $U_s$  for all channels, the supply can only be switched off at "pause" if all channels are configured to switch off.

## 7.3 DQ operating mode

### Display

The channel status LEDs are directly affected by the signal level at the socket.

### Response to error detection

All channels that are in pause mode on "PE\_MODE\_PROCEED" report their diagnostic status as in productive mode.

The following applies for all channels which switch to a different pause mode:

- During the "pause", error detection of "Short circuit" is not possible:
  - Alarms for errors already pending before the "pause" are retained.
  - After the "pause" is over, the error status is updated and incoming/outgoing errors are reported correspondingly.

### Mode parameter

The following table shows the "Mode" parameter.

Table 7- 2 Mode parameter

| Element | Code                    | Explanation                                                                                                                                                                       |
|---------|-------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Mode    | 0D: PE_MODE_PROCEED     | Proceed at "pause" <ul style="list-style-type: none"> <li>• Value status "GOOD"</li> </ul>                                                                                        |
|         | 1D: PE_MODE_SHUTDOWN    | Switch off at "pause" <ul style="list-style-type: none"> <li>• Pause substitute value: 0B</li> <li>• Value status "BAD"</li> </ul>                                                |
|         | 3D: PE_MODE_LAST_VALUE  | Last value at "pause" <ul style="list-style-type: none"> <li>• Pause substitute value: Last output value is maintained</li> <li>• Value status "BAD"</li> </ul>                   |
|         | 4D: PE_MODE_SUBST_VALUE | Substitute value at "pause" <ul style="list-style-type: none"> <li>• Pause substitute value: Configured pause substitute value is output</li> <li>• Value status "BAD"</li> </ul> |

## Dimension drawing

The following figure shows the dimension drawing of the DIQ 4+DQ 4x24VDC/0.5A 8xM8 digital input/digital output module in front and side views.

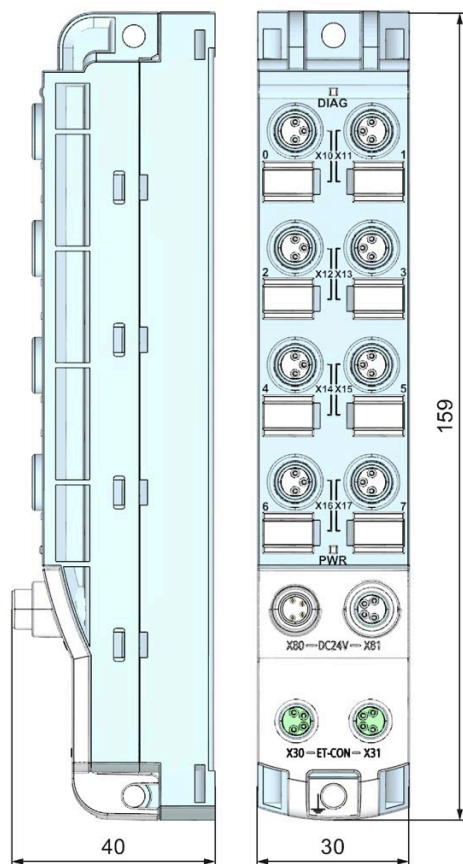
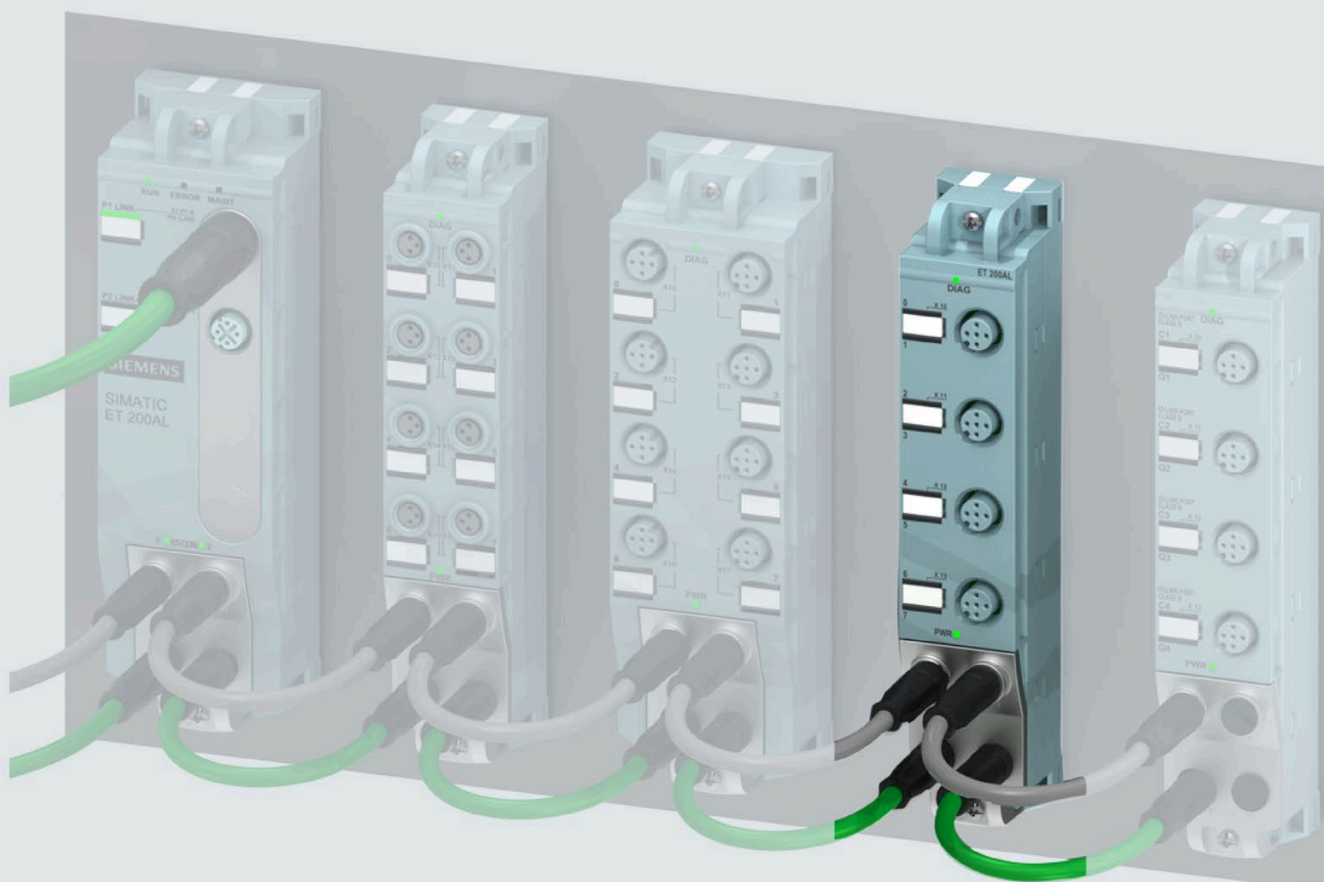


Figure A-1 Dimension drawing

# SIEMENS



Equipment Manual

# SIMATIC

## ET 200AL

Digital input / output module DIQ 4+DQ 4x24VDC/0.5A  
4xM12 (6ES7143-5AF00-0BA0)

Edition

08/2021

[support.industry.siemens.com](https://support.industry.siemens.com)

## SIMATIC

### ET 200AL Digital input/digital output module DIQ 4+DQ 4x24VDC/0.5A 4xM12 (6ES7143-5AF00-0BA0)

#### Equipment Manual

#### Preface

---

#### ET 200AL Documentation Guide

**1**

#### Product overview

**2**

#### Wiring

**3**

#### Parameters/address space

**4**

#### Interrupts/diagnostic alarms

**5**

#### Technical specifications

**6**

#### PROFInergy

**7**

#### Dimension drawing

**A**

## Legal information

### Warning notice system

This manual contains notices you have to observe in order to ensure your personal safety, as well as to prevent damage to property. The notices referring to your personal safety are highlighted in the manual by a safety alert symbol, notices referring only to property damage have no safety alert symbol. These notices shown below are graded according to the degree of danger.

#### **DANGER**

indicates that death or severe personal injury **will** result if proper precautions are not taken.

#### **WARNING**

indicates that death or severe personal injury **may** result if proper precautions are not taken.

#### **CAUTION**

indicates that minor personal injury can result if proper precautions are not taken.

#### **NOTICE**

indicates that property damage can result if proper precautions are not taken.

If more than one degree of danger is present, the warning notice representing the highest degree of danger will be used. A notice warning of injury to persons with a safety alert symbol may also include a warning relating to property damage.

### Qualified Personnel

The product/system described in this documentation may be operated only by **personnel qualified** for the specific task in accordance with the relevant documentation, in particular its warning notices and safety instructions. Qualified personnel are those who, based on their training and experience, are capable of identifying risks and avoiding potential hazards when working with these products/systems.

### Proper use of Siemens products

Note the following:

#### **WARNING**

Siemens products may only be used for the applications described in the catalog and in the relevant technical documentation. If products and components from other manufacturers are used, these must be recommended or approved by Siemens. Proper transport, storage, installation, assembly, commissioning, operation and maintenance are required to ensure that the products operate safely and without any problems. The permissible ambient conditions must be complied with. The information in the relevant documentation must be observed.

### Trademarks

All names identified by ® are registered trademarks of Siemens AG. The remaining trademarks in this publication may be trademarks whose use by third parties for their own purposes could violate the rights of the owner.

### Disclaimer of Liability

We have reviewed the contents of this publication to ensure consistency with the hardware and software described. Since variance cannot be precluded entirely, we cannot guarantee full consistency. However, the information in this publication is reviewed regularly and any necessary corrections are included in subsequent editions.



# Preface

## Preface

### Purpose of the documentation

This manual supplements the ET 200AL distributed I/O system (<https://support.industry.siemens.com/cs/us/en/view/89254965>) system manual. Functions that are generally applicable to the ET 200AL distributed I/O system are described there.

The information provided in the present manual, the system manual and the function manuals enables you to commission the ET 200AL distributed I/O system.

### Conventions

Please also observe notes marked as follows:

---

#### Note

Indicates important product information to which particular attention should be paid.

---

### Security information

Siemens provides products and solutions with industrial security functions that support the secure operation of plants, systems, machines and networks.

In order to protect plants, systems, machines and networks against cyber threats, it is necessary to implement – and continuously maintain – a holistic, state-of-the-art industrial security concept. Siemens' products and solutions constitute one element of such a concept.

Customers are responsible for preventing unauthorized access to their plants, systems, machines and networks. Such systems, machines and components should only be connected to an enterprise network or the internet if and to the extent such a connection is necessary and only when appropriate security measures (e.g. firewalls and/or network segmentation) are in place.

For additional information on industrial security measures that may be implemented, please visit (<https://www.siemens.com/industrialsecurity>).

Siemens' products and solutions undergo continuous development to make them more secure. Siemens strongly recommends that product updates are applied as soon as they are available and that the latest product versions are used. Use of product versions that are no longer supported, and failure to apply the latest updates may increase customers' exposure to cyber threats.

To stay informed about product updates, subscribe to the Siemens Industrial Security RSS Feed visit (<https://www.siemens.com/industrialsecurity>).

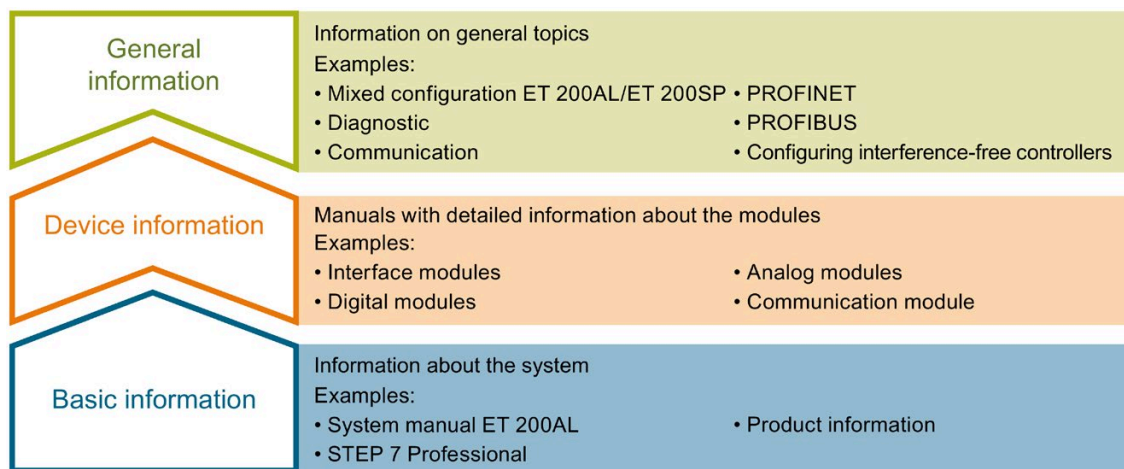
# Table of contents

|          |                                                  |           |
|----------|--------------------------------------------------|-----------|
|          | <b>Preface</b> .....                             | <b>3</b>  |
| <b>1</b> | <b>ET 200AL Documentation Guide</b> .....        | <b>5</b>  |
| <b>2</b> | <b>Product overview</b> .....                    | <b>9</b>  |
|          | 2.1 Properties .....                             | 9         |
|          | 2.2 Operator controls and display elements ..... | 12        |
| <b>3</b> | <b>Wiring</b> .....                              | <b>13</b> |
|          | 3.1 Terminal and block diagram .....             | 13        |
|          | 3.2 Pin assignment .....                         | 14        |
| <b>4</b> | <b>Parameters/address space</b> .....            | <b>17</b> |
|          | 4.1 Parameters .....                             | 17        |
|          | 4.2 Explanation of the parameters .....          | 18        |
|          | 4.3 Address space.....                           | 19        |
| <b>5</b> | <b>Interrupts/diagnostic alarms</b> .....        | <b>21</b> |
|          | 5.1 Status and error displays .....              | 21        |
|          | 5.2 Interrupts .....                             | 23        |
|          | 5.3 Diagnostics alarms.....                      | 23        |
| <b>6</b> | <b>Technical specifications</b> .....            | <b>24</b> |
|          | 6.1 Technical specifications .....               | 24        |
| <b>7</b> | <b>PROFenergy</b> .....                          | <b>28</b> |
|          | 7.1 Pause function.....                          | 28        |
|          | 7.2 DI operating mode.....                       | 29        |
|          | 7.3 DQ operating mode .....                      | 30        |
| <b>A</b> | <b>Dimension drawing</b> .....                   | <b>31</b> |

# ET 200AL Documentation Guide

The documentation for the SIMATIC ET 200AL distributed I/O system is arranged into three areas.

This arrangement enables you to access the specific content you require.



## Basic information

The System Manual and Getting Started describe in detail the configuration, installation, wiring and commissioning of the SIMATIC ET 200AL distributed I/O system. The STEP 7 online help supports you in the configuration and programming.

## Device information

Product manuals contain a compact description of the module-specific information, such as properties, wiring diagrams, characteristics and technical specifications.

## General information

The function manuals contain detailed descriptions on general topics regarding the SIMATIC ET 200AL distributed I/O system, e.g. diagnostics, communication, Motion Control, Web server.

You can download the documentation free of charge from the Internet (<https://support.industry.siemens.com/cs/ww/en/view/109742667>).

## Manual Collection ET 200AL

The Manual Collection contains the complete documentation on the SIMATIC ET 200AL distributed I/O system gathered together in one file.

You can find the Manual Collection on the Internet (<https://support.automation.siemens.com/WW/view/en/95242965>).

## "mySupport"

With "mySupport", your personal workspace, you make the best out of your Industry Online Support.

In "mySupport", you can save filters, favorites and tags, request CAx data and compile your personal library in the Documentation area. In addition, your data is already filled out in support requests and you can get an overview of your current requests at any time.

You must register once to use the full functionality of "mySupport".

You can find "mySupport" on the Internet (<https://support.industry.siemens.com/My/ww/en>).

## "mySupport" - Documentation

With "mySupport", your personal workspace, you make the best out of your Industry Online Support.

In "mySupport", you can save filters, favorites and tags, request CAx data and compile your personal library in the Documentation area. In addition, your data is already filled out in support requests and you can get an overview of your current requests at any time.

You must register once to use the full functionality of "mySupport".

You can find "mySupport" on the Internet (<https://support.industry.siemens.com/My/ww/en/documentation>).

## "mySupport" - CAx data

In the CAx data area of "mySupport", you can access the latest product data for your CAx or CAe system.

You configure your own download package with a few clicks.

In doing so you can select:

- Product images, 2D dimension drawings, 3D models, internal circuit diagrams, EPLAN macro files
- Manuals, characteristics, operating manuals, certificates
- Product master data

You can find "mySupport" - CAx data on the Internet (<https://support.industry.siemens.com/my/ww/en/CAxOnline>).

## Application examples

The application examples support you with various tools and examples for solving your automation tasks. Solutions are shown in interplay with multiple components in the system - separated from the focus on individual products.

You will find the application examples on the Internet (<https://support.industry.siemens.com/cs/ww/en/ps/ae>).

## TIA Selection Tool

With the TIA Selection Tool, you can select, configure and order devices for Totally Integrated Automation (TIA).

This tool is the successor of the SIMATIC Selection Tool and combines the known configurators for automation technology into one tool.

With the TIA Selection Tool, you can generate a complete order list from your product selection or product configuration.

You can find the TIA Selection Tool on the Internet

(<https://support.industry.siemens.com/cs/ww/en/view/109767888>).

## SIMATIC Automation Tool

You can use the SIMATIC Automation Tool to perform commissioning and maintenance activities simultaneously on various SIMATIC S7 stations as a bulk operation independent of TIA Portal.

The SIMATIC Automation Tool provides a multitude of functions:

- Scanning of a PROFINET/Ethernet system network and identification of all connected CPUs
- Address assignment (IP, subnet, gateway) and station name (PROFINET device) to a CPU
- Transfer of the date and the programming device/PC time converted to UTC time to the module
- Program download to CPU
- RUN/STOP mode switchover
- CPU localization by means of LED flashing
- Reading out of CPU error information
- Reading of the CPU diagnostics buffer
- Reset to factory settings
- Firmware update of the CPU and connected modules

You can find the SIMATIC Automation Tool on the Internet

(<https://support.industry.siemens.com/cs/ww/en/view/98161300>).

## PRONETA

SIEMENS PRONETA (PROFINET network analysis) allows you to analyze the plant network during commissioning. PRONETA features two core functions:

- The topology overview automatically scans the PROFINET and all connected components.
- The IO check is a fast test of the wiring and the module configuration of a plant.

You can find SIEMENS PRONETA on the Internet

(<https://support.industry.siemens.com/cs/ww/en/view/67460624>).

## SINETPLAN

SINETPLAN, the Siemens Network Planner, supports you in planning automation systems and networks based on PROFINET. The tool facilitates professional and predictive dimensioning of your PROFINET installation as early as in the planning stage. In addition, SINETPLAN supports you during network optimization and helps you to exploit network resources optimally and to plan reserves. This helps to prevent problems in commissioning or failures during productive operation even in advance of a planned operation. This increases the availability of the production plant and helps improve operational safety.

The advantages at a glance

- Network optimization thanks to port-specific calculation of the network load
- Increased production availability thanks to online scan and verification of existing systems
- Transparency before commissioning through importing and simulation of existing STEP 7 projects
- Efficiency through securing existing investments in the long term and the optimal use of resources

You can find SINETPLAN on the Internet (<https://www.siemens.com/sinetplan>).

## Product overview

### 2.1 Properties

#### Article number

6ES7143-5AF00-0BA0

#### View of the module

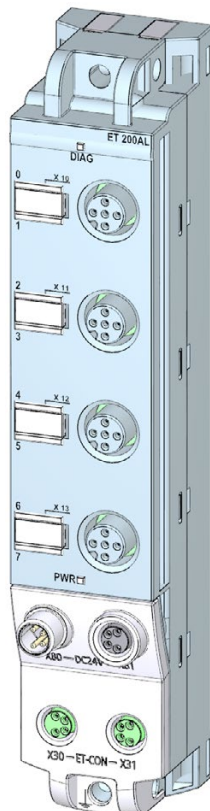


Figure 2-1 View of the DIQ 4+DQ 4x24VDC/0.5A 4xM12 digital input/digital output module

## 2.1 Properties

### Properties

The module has the following technical properties:

- 4 digital inputs or digital outputs and 4 digital outputs, depending on parameter assignment
  - DIQ signals connected to 1L+ (non-switched)
  - DQ signals connected to 2L+ (switched)
- M12 sockets for connection of sensors and actuators
- Digital inputs:
  - 24 V DC supply voltage
  - Configurable diagnostics can be set for each module
  - Typical input delay of 3 ms
  - Suitable for switches and proximity switches
- Digital outputs:
  - Rated load voltage 24 V DC
  - Suitable for solenoid valves, DC contactors, and indicator lights
  - Output current per output 0.5 A
  - Configurable diagnostics can be set for each module
- Dimensions 30 x 159 mm

The module supports the following functions:

- Firmware update
- Identification and maintenance data I&M0 to I&M3
- Value status (Quality Information)
- PROFIenergy

### Accessories

The following components are included in the module package:

- Identification labels
- Spacers



## Other components

The following component can be ordered as spare part:

- Identification labels

The following components can be ordered as accessories:

- Connectors
- Cables
- Stripping Tool for ET-Connection
- M8 sealing cap
- M12 sealing cap

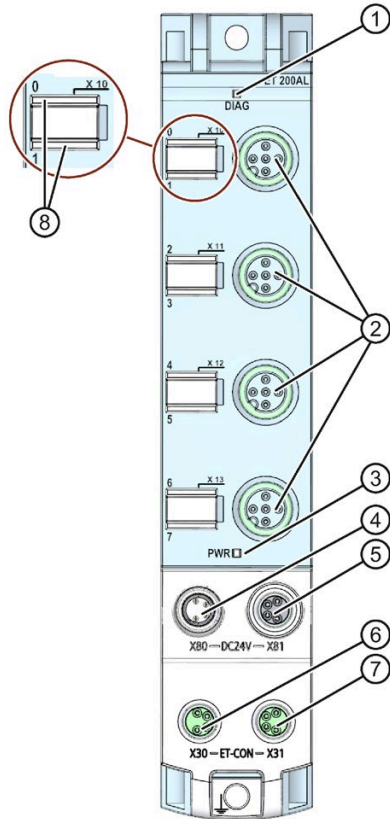
## See also

You can find more information on accessories in the Accessories/spare parts section of the ET 200AL distributed I/O system

(<https://support.industry.siemens.com/cs/us/en/view/89254965>) system manual.

## 2.2 Operator controls and display elements

The figure below shows the operator controls and display elements of the DIQ 4+DQ 4x24VDC/0.5A 4xM12 digital input/digital output module.



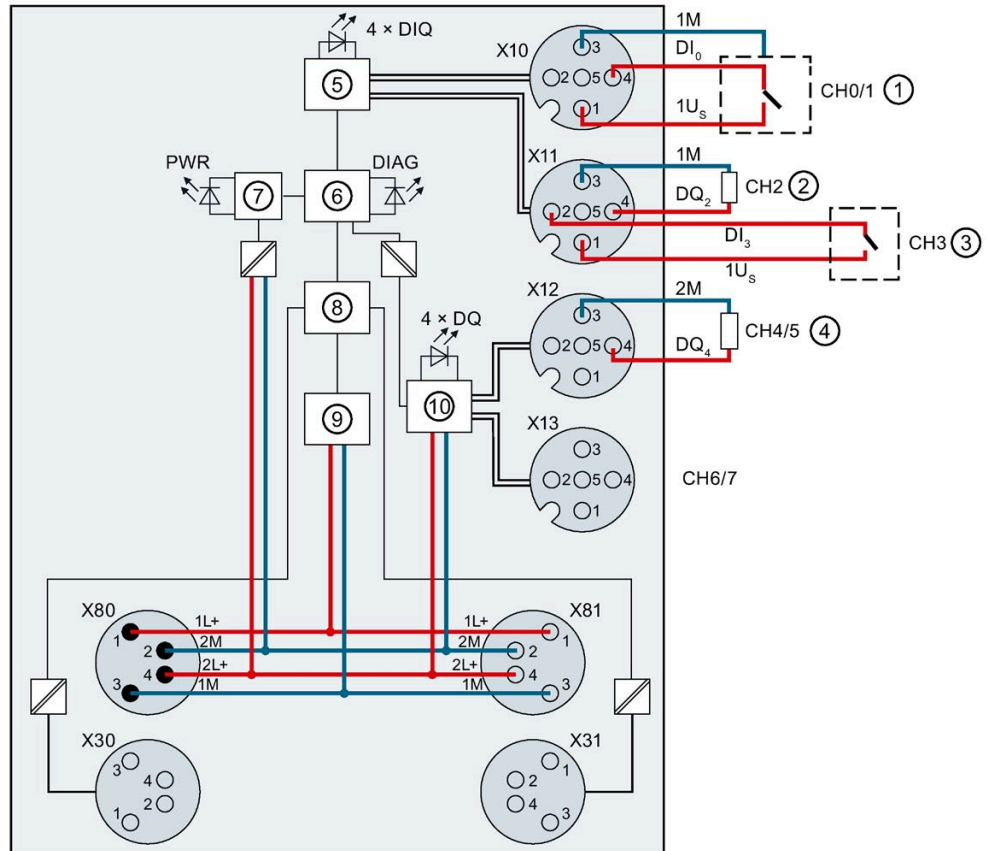
- ① DIAG: LED display for the diagnostic status
- ② X10 to X13: Sockets for the input/output signal
- ③ PWR: LED display for load voltage 2L+
- ④ X80: Connector for infeed of the supply voltage (POWER input)
- ⑤ X81: Socket for loop-through of the supply voltage (POWER output)
- ⑥ X30: Socket for ET-Connection IN
- ⑦ X31: Socket for ET-Connection OUT
- ⑧ LED displays 0 to 7 for the channel status

Figure 2-2 Operator controls and display elements

# Wiring

## 3.1 Terminal and block diagram

The figure below shows an example of the pin assignment of signal inputs with 2-wire and 3-wire connection as well as signal outputs.



|            |                                        |                  |                                             |
|------------|----------------------------------------|------------------|---------------------------------------------|
| ①          | Configured as input: 3-wire connection | X30              | Infeed of the ET-Connection                 |
| ②          | Configured as output                   | X31              | Loop-through of the ET-Connection           |
| ③          | Configured as input: 2-wire connection | 1L+              | Supply voltage 1L+ (non-switched)           |
| ④          | Output                                 | 1M               | Ground 1M (non-switched)                    |
| ⑤          | DI/DQ circuit                          | 2L+              | Load voltage 2L+ (switched)                 |
| ⑥          | Microcontroller                        | 2M               | Ground 2M (switched)                        |
| ⑦          | Monitoring                             | 1U <sub>s</sub>  | 24 V encoder supply                         |
| ⑧          | ET-Connection interface                | DIQ <sub>n</sub> | Input/output signal                         |
| ⑨          | Internal supply voltage                | DQ <sub>n</sub>  | Output signal                               |
| ⑩          | DQ circuit                             | DIQ              | LEDs channel status (0, 1, 2 and 3) (green) |
| X10 to X13 | Channels 0 to 7                        | DQ               | LEDs channel status (4, 5, 6 and 7) (green) |
| X80        | Infeed of supply voltages              | DIAG             | LED diagnostic status (red/green)           |
| X81        | Loop-through of supply voltages        | PWR              | LED supply voltage 2L+ (green)              |

Figure 3-1 Terminal and block diagram

## 3.2 Pin assignment

### Note

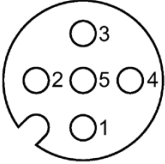
Color coding

The sockets for ET-Connection and the power supply of the modules are color-coded. These colors correspond to the colors of the offered cables.

### Pin assignment of the sockets for digital inputs/digital outputs

The tables below show the pin assignments of the 4 sockets for connection of the digital inputs/digital outputs.

Table 3- 1 Pin assignment for digital inputs/digital outputs

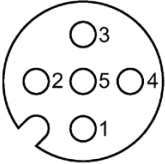
| Pin | Assignment                                                                                                   | Front view of the sockets                                                            |
|-----|--------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------|
|     | <b>X10 and X11 - sockets for digital inputs/digital outputs</b>                                              | <b>X10, X11</b>                                                                      |
| 1   | 24 V encoder supply 1Us<br>(derived from 1L+ non-switched)                                                   |  |
| 2   | Input/output signal DIQ <sub>1</sub> : Connector X10<br>Input/output signal DIQ <sub>3</sub> : Connector X11 |                                                                                      |
| 3   | Encoder supply ground 1M                                                                                     |                                                                                      |
| 4   | Input/output signal DIQ <sub>0</sub> : Connector X10<br>Input/output signal DIQ <sub>2</sub> : Connector X11 |                                                                                      |
| 5   | Functional earth FE                                                                                          |                                                                                      |

### NOTICE

#### 24 V encoder supply 1Us

Use only the 24 V encoder supply 1Us provided by the digital input/digital output module to supply power to the encoder.

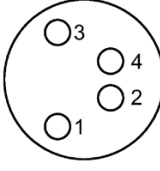
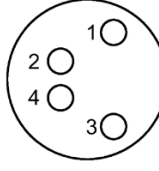
Table 3- 2 Pin assignment for digital outputs

| Pin | Assignment                                                                                     | Front view of the sockets                                                             |
|-----|------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------|
|     | <b>X12 and X13 sockets for digital outputs</b>                                                 | <b>X12, X13</b>                                                                       |
| 1   | Unassigned                                                                                     |  |
| 2   | Output signal DQ <sub>5</sub> : Connector X12<br>Output signal DQ <sub>7</sub> : Connector X13 |                                                                                       |
| 3   | Ground 2M                                                                                      |                                                                                       |
| 4   | Output signal DQ <sub>4</sub> : Connector X12<br>Output signal DQ <sub>6</sub> : Connector X13 |                                                                                       |
| 5   | Functional earth FE                                                                            |                                                                                       |

### Pin assignment of the sockets for ET-Connection

The table below shows the pin assignments of the 2 sockets for the connection of ET-Connection.

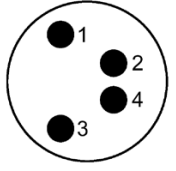
Table 3- 3 Pin assignment for ET-Connection

| Pin       | Assignment                    |                                | Assignment of the wire color of the bus line cable for ET-Connection | Front view of the sockets                                                           |                                                                                     |
|-----------|-------------------------------|--------------------------------|----------------------------------------------------------------------|-------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------|
|           | X30 socket (ET-Connection IN) | X31 socket (ET-Connection OUT) |                                                                      | X30                                                                                 | X31                                                                                 |
| 1         | TXP                           | RXP                            | Yellow                                                               |  |  |
| 2         | RXP                           | TXP                            | White                                                                |                                                                                     |                                                                                     |
| 3         | RXN                           | TXN                            | Blue                                                                 |                                                                                     |                                                                                     |
| 4         | TXN                           | RXN                            | Orange                                                               |                                                                                     |                                                                                     |
| Shielding | Functional earth FE           |                                | -                                                                    |                                                                                     |                                                                                     |

### Pin assignment of the connector for infeed of the supply voltage

The table below shows the pin assignment of the connector for infeed of the supply voltage.

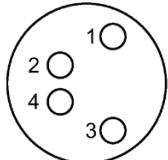
Table 3- 4 Pin assignment of the supply voltage connector

| Pin | Assignment                        | Assignment of the wire color of the power line cable | Front view of the connector                                                           |
|-----|-----------------------------------|------------------------------------------------------|---------------------------------------------------------------------------------------|
|     | X80 connector (POWER input)       |                                                      |                                                                                       |
| 1   | Supply voltage 1L+ (non-switched) | Brown                                                |  |
| 2   | Ground 2M (switched)              | White                                                |                                                                                       |
| 3   | Ground 1M (non-switched)          | Blue                                                 |                                                                                       |
| 4   | Load voltage 2L+ (switched)       | Black                                                |                                                                                       |

### Pin assignment of the socket for loop-through of the supply voltage

The table below shows the pin assignment of the socket for loop-through of the supply voltage.

Table 3- 5 Pin assignment of the supply voltage socket

| Pin | Assignment                        | Assignment of the wire color of the power line cable | Front view of the socket                                                            |
|-----|-----------------------------------|------------------------------------------------------|-------------------------------------------------------------------------------------|
|     | X81 socket (POWER output)         |                                                      |                                                                                     |
| 1   | Supply voltage 1L+ (non-switched) | Brown                                                |  |
| 2   | Ground 2M (switched)              | White                                                |                                                                                     |
| 3   | Ground 1M (non-switched)          | Blue                                                 |                                                                                     |
| 4   | Load voltage 2L+ (switched)       | Black                                                |                                                                                     |

#### NOTICE

##### ET-Connection/supply voltage

Observe the correct wiring of the M8 sockets for ET-Connection and the supply voltage.

Mixing up the ET-Connection connectors and the connectors for the supply voltage can destroy the module.

## Parameters/address space

### 4.1 Parameters

The table below shows the parameters for the DIQ 4+DQ 4x24VDC/0.5A 4xM12 digital input/digital output module.

Table 4- 1 Parameters

| Parameters                            | Value range                                                                                                                 | Default   | Scope                                                                  |
|---------------------------------------|-----------------------------------------------------------------------------------------------------------------------------|-----------|------------------------------------------------------------------------|
| Diagnostics: Missing load voltage 2L+ | <ul style="list-style-type: none"> <li>• Disable</li> <li>• Enable</li> </ul>                                               | Disable   | Module                                                                 |
| Diagnostics: Short-circuit to ground  | <ul style="list-style-type: none"> <li>• Disable</li> <li>• Enable</li> </ul>                                               | Disable   | Module<br>(Short-circuit of encoder supply or of the output to ground) |
| Freely assignable channel 0 ... 3     | <ul style="list-style-type: none"> <li>• DI</li> <li>• DQ</li> </ul>                                                        | DI        | Channel                                                                |
| Reaction to CPU/master STOP           | <ul style="list-style-type: none"> <li>• Shut down</li> <li>• Keep last value</li> <li>• Output substitute value</li> </ul> | Shut down | Module<br>(digital outputs)                                            |
| Substitute value channel 0 ... 7      | <ul style="list-style-type: none"> <li>• 0</li> <li>• 1</li> </ul>                                                          | 0         | Channel<br>(digital outputs)                                           |

## 4.2 Explanation of the parameters

### **Diagnostics: Missing load voltage 2L+**

Enabling of the diagnostics for missing or insufficient load voltage 2L+.

### **Diagnostics: Short-circuit to ground**

Enabling of the diagnostics for short-circuit of the encoder supply or output to ground.

### **Freely assignable channel n**

With this parameter, you set whether the channel is to be operated as an input or output.

### **Reaction to CPU/master STOP**

With this parameter, you set the reaction of the digital outputs of the digital input/digital output module after a CPU/master STOP:

- Shut down: The digital output is de-energized.
- Keep last value: The last value of the digital output remains activated.
- Output substitute value: The module outputs a configured substitute value.

### **Substitute value channel 0 ... 7**

With this parameter, you set substitute values for the digital outputs.



## 4.3 Address space

The figure below shows the assignment of the address space for the digital input/digital output module DIQ 4+DQ 4x24VDC/0.5A 4xM12 with value status (Quality Information, QI).

The address space for the value status is allocated by the module, if the value status is configured using the PROFINET interface module.

Assignment in the process image input (PII)

|      |   |   |   |   |   |   |   |   |                                 |
|------|---|---|---|---|---|---|---|---|---------------------------------|
|      | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |                                 |
| IB x | 0 | 0 | 0 | 0 |   |   |   |   | Input values at channels 0 to 3 |

|          |   |   |   |   |   |   |   |   |                                                 |
|----------|---|---|---|---|---|---|---|---|-------------------------------------------------|
|          | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |                                                 |
| IB x + 1 | 0 | 0 | 0 | 0 |   |   |   |   | Value status (QI) for inputs at channels 0 to 3 |

|          |   |   |   |   |   |   |   |   |                                                  |
|----------|---|---|---|---|---|---|---|---|--------------------------------------------------|
|          | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |                                                  |
| IB x + 2 |   |   |   |   |   |   |   |   | Value status (QI) for outputs at channels 0 to 7 |

Assignment in the process image output (PIQ)

|      |   |   |   |   |   |   |   |   |                                  |
|------|---|---|---|---|---|---|---|---|----------------------------------|
|      | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |                                  |
| QB x |   |   |   |   |   |   |   |   | Output values at channels 0 to 7 |

Figure 4-1 Address space

### Note

#### Parameter assignment of the channels

Parameters for the first four channels can be freely assigned.

For the channels 0 ... 3 that are configured as input, the corresponding values in the output data do not trigger any reaction.

For the channels 0 ... 3 that are configured as output, the input value in the process image is 0.

## Configuration options of the digital input/digital output module DIQ 4+DQ 4x24VDC/0.5A 4xM12

You have the following configuration options:

- Configuration 1: without value status
- Configuration 2: with value status

### Evaluating the value status

An additional two bytes are occupied in the input address space if you enable the value status for the digital input/digital output module. The value status of the inputs is assigned to bits 0 to 3 in input byte  $x + 1$ . The value status of the outputs is assigned to bits 0 to 7 in input byte  $x + 2$ . This additional information provides information regarding the validity of the digital values or channel status.

Bit = 1: No error on channel.

Bit = 0: Error on channel.

If the channel is configured as input, this means:

- Short-circuit to ground at sensor supply or
- Parameter error

If the channel is configured as output, this means:

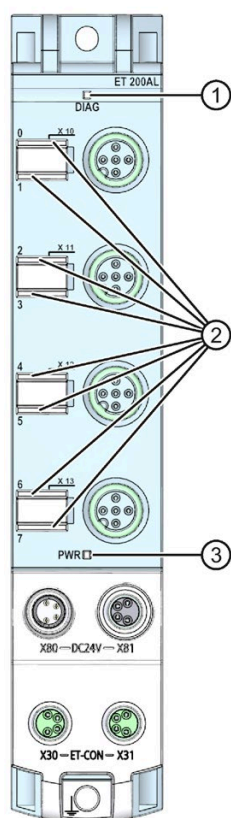
- Short-circuit of output to ground or
- Parameter error or
- For channels 4 ... 7: Missing load voltage 2L+

# Interrupts/diagnostic alarms

## 5.1 Status and error displays

### LED displays

The figure below shows the LED displays (status and error displays) of the digital input/digital output module DIQ 4+DQ 4x24VDC/0.5A 4xM12.



- |   |                          |             |
|---|--------------------------|-------------|
| ① | Diagnostic status (DIAG) | (red/green) |
| ② | Channel status (0 to 7)  | (green)     |
| ③ | Load voltage 2L+ (PWR)   | (green)     |

Figure 5-1 LED displays

## Meaning of the LEDs

The following tables set out the meaning of the status and error displays. Remedial measures for diagnostic alarms can be found in the section Diagnostics alarms (Page 23).

### DIAG LED

Table 5- 1 Error display of the DIAG LED

| DIAG LED                                                                                      | Meaning                                                                                                                                                                                                                                                                                                     |
|-----------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <br>Off      | No supply voltage 1L+                                                                                                                                                                                                                                                                                       |
| <br>Flashes  | <ul style="list-style-type: none"> <li>Module parameters not assigned (after switching on the supply voltage 1L+)</li> <li>Loading firmware (while the firmware update is being performed, all LEDs retain their current status)</li> <li>No connection to the ET-Connection and/or the fieldbus</li> </ul> |
| <br>On       | Module parameters assigned and no module diagnostics                                                                                                                                                                                                                                                        |
| <br>Flashes | Module parameters assigned and module diagnostics                                                                                                                                                                                                                                                           |

### LED channel status

Table 5- 2 LED channel status display

| LED channel status                                                                         | Meaning            |
|--------------------------------------------------------------------------------------------|--------------------|
| <br>Off | Process signal = 0 |
| <br>On  | Process signal = 1 |

### PWR LED

Table 5- 3 Status display of the PWR LED

| PWR LED                                                                                    | Meaning                                |
|--------------------------------------------------------------------------------------------|----------------------------------------|
| <br>Off | Load voltage 2L+ is missing or too low |
| <br>On  | Load voltage 2L+ present               |

## 5.2 Interrupts

The DIQ 4+DQ 4x24VDC/0.5A 4xM12 digital input/digital output module supports diagnostic interrupts.

### Diagnostic interrupt

The digital input/digital output module generates a diagnostic interrupt at the following events:

- Short-circuit of encoder supply to ground
- Short-circuit of outputs to ground
- Load voltage 2L+ missing or too low

## 5.3 Diagnostics alarms

A diagnostic alarm is output for each diagnostic event and the DIAG LED flashes red on the digital input/digital output module.

You can read out the diagnostics alarms, for example, from the diagnostics buffer of the CPU. You can evaluate the error codes with the user program.

Table 5- 4 Diagnostics alarms, their meanings and corrective measures

| Diagnostics alarm                                                                                                                                                                                                                                                                                                                                                  | Error code | Meaning                                | Remedy                                                                                                   |
|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------|----------------------------------------|----------------------------------------------------------------------------------------------------------|
| Short-circuit*                                                                                                                                                                                                                                                                                                                                                     | 1H         | Short-circuit encoder supply to ground | <ul style="list-style-type: none"> <li>• Eliminate the short-circuit</li> </ul>                          |
|                                                                                                                                                                                                                                                                                                                                                                    |            | Short-circuit of outputs to ground     |                                                                                                          |
| Load voltage 2L+ missing**                                                                                                                                                                                                                                                                                                                                         | 11H        | Load voltage 2L+ missing or too low    | <ul style="list-style-type: none"> <li>• Check the supply voltage</li> <li>• Check the module</li> </ul> |
| <p>* If a short-circuit of the encoder supply to ground is detected, the diagnostic alarm "Short-circuit" is always output. This alarm is output even if all channels are configured as outputs.</p> <p>** If you are using ET 200AL modules in connection with the ET 200SP distributed I/O system, the diagnostic alarm "Load voltage missing" is displayed.</p> |            |                                        |                                                                                                          |

### Note

#### Channel type

The digital input/digital output module is always signaled as a mixed module (channel type "Input/Output") in the case of diagnostic events, even if you have configured the digital input/digital output module exclusively as an output module.

## Technical specifications

### 6.1 Technical specifications

#### Technical specifications of the DIQ 4+DQ 4x24VDC/0.5A 4xM12 digital input/digital output module

The following table shows the technical specifications as of the issue date. You can find a data sheet including daily updated technical specifications on the Internet (<https://support.industry.siemens.com/cs/ww/en/pv/6ES7143-5AF00-0BA0/td?dl=en>).

|                                                          |                                                                                                      |
|----------------------------------------------------------|------------------------------------------------------------------------------------------------------|
| <b>Article number</b>                                    | <b>6ES7143-5AF00-0BA0</b>                                                                            |
| <b>General information</b>                               |                                                                                                      |
| Product type designation                                 | DIQ 4+DQ 4x24VDC/0.5A                                                                                |
| HW functional status                                     | FS03                                                                                                 |
| Firmware version                                         | V1.0.x                                                                                               |
| <b>Product function</b>                                  |                                                                                                      |
| • I&M data                                               | Yes; I&M0 to I&M3                                                                                    |
| <b>Engineering with</b>                                  |                                                                                                      |
| • STEP 7 TIA Portal configurable/integrated from version | STEP 7 V13 SP1 or higher                                                                             |
| • STEP 7 configurable/integrated from version            | V5.5 SP4 Hotfix 7 or higher                                                                          |
| • PROFIBUS from GSD version/GSD revision                 | GSD as of Revision 5                                                                                 |
| • PROFINET from GSD version/GSD revision                 | GSDML V2.3.1                                                                                         |
| <b>Supply voltage</b>                                    |                                                                                                      |
| <b>Load voltage 1L+</b>                                  |                                                                                                      |
| • Rated value (DC)                                       | 24 V                                                                                                 |
| • permissible range, lower limit (DC)                    | 20.4 V                                                                                               |
| • permissible range, upper limit (DC)                    | 28.8 V                                                                                               |
| • Reverse polarity protection                            | Yes; Against destruction; encoder power supply outputs applied with reversed polarity, loads pick up |
| <b>Load voltage 2L+</b>                                  |                                                                                                      |
| • Rated value (DC)                                       | 24 V                                                                                                 |
| • permissible range, lower limit (DC)                    | 20.4 V                                                                                               |
| • permissible range, upper limit (DC)                    | 28.8 V                                                                                               |
| • Reverse polarity protection                            | Yes; against destruction; load increasing                                                            |

|                                                                            |                                      |
|----------------------------------------------------------------------------|--------------------------------------|
| <b>Article number</b>                                                      | <b>6ES7143-5AF00-0BA0</b>            |
| <b>Input current</b>                                                       |                                      |
| Current consumption (rated value)                                          | 40 mA; without load                  |
| from load voltage 1L+ (unswitched voltage)                                 | 4 A; Maximum value                   |
| from load voltage 2L+, max.                                                | 4 A; Maximum value                   |
| <b>Encoder supply</b>                                                      |                                      |
| Number of outputs                                                          | 4                                    |
| <b>24 V encoder supply</b>                                                 |                                      |
| • Short-circuit protection                                                 | Yes; per module, electronic          |
| • Output current, max.                                                     | 0.7 A; Total current of all encoders |
| <b>Power loss</b>                                                          |                                      |
| Power loss, typ.                                                           | 2.5 W                                |
| <b>Digital inputs</b>                                                      |                                      |
| Number of digital inputs                                                   | 4; Parameterizable as DIQ            |
| Input characteristic curve in accordance with IEC 61131, type 3            | Yes                                  |
| <b>Number of simultaneously controllable inputs all mounting positions</b> |                                      |
| – up to 55 °C, max.                                                        | 4                                    |
| <b>Input voltage</b>                                                       |                                      |
| • Rated value (DC)                                                         | 24 V                                 |
| • for signal "0"                                                           | -3 to +5V                            |
| • for signal "1"                                                           | +11 to +30V                          |
| <b>Input current</b>                                                       |                                      |
| • for signal "1", typ.                                                     | 3.2 mA                               |
| <b>Input delay (for rated value of input voltage) for standard inputs</b>  |                                      |
| – at "0" to "1", min.                                                      | 1.2 ms                               |
| – at "0" to "1", max.                                                      | 4.8 ms                               |
| – at "1" to "0", min.                                                      | 1.2 ms                               |
| – at "1" to "0", max.                                                      | 4.8 ms                               |
| <b>Cable length</b>                                                        |                                      |
| • unshielded, max.                                                         | 30 m                                 |
| <b>Digital outputs</b>                                                     |                                      |
| Number of digital outputs                                                  | 8; 4 DQ fixed, 4 DIQ parameterizable |
| • in groups of                                                             | 4; 2 load groups for 4 outputs each  |
| Short-circuit protection                                                   | Yes; per channel, electronic         |
| • Response threshold, typ.                                                 | 0.7 A                                |
| <b>Switching capacity of the outputs</b>                                   |                                      |
| • on lamp load, max.                                                       | 5 W                                  |

6.1 Technical specifications

|                                                                |                                                                                        |
|----------------------------------------------------------------|----------------------------------------------------------------------------------------|
| <b>Article number</b>                                          | <b>6ES7143-5AF00-0BA0</b>                                                              |
| <b>Load resistance range</b>                                   |                                                                                        |
| • lower limit                                                  | 48 $\Omega$                                                                            |
| • upper limit                                                  | 4 k $\Omega$                                                                           |
| <b>Output voltage</b>                                          |                                                                                        |
| • for signal "1", min.                                         | L+ (-0.8 V)                                                                            |
| <b>Output current</b>                                          |                                                                                        |
| • for signal "1" rated value                                   | 0.5 A                                                                                  |
| • for signal "0" residual current, max.                        | 0.5 mA                                                                                 |
| <b>Switching frequency</b>                                     |                                                                                        |
| • with resistive load, max.                                    | 100 Hz                                                                                 |
| • with inductive load, max.                                    | 0.5 Hz                                                                                 |
| • on lamp load, max.                                           | 1 Hz                                                                                   |
| <b>Total current of the outputs</b>                            |                                                                                        |
| • Current per group, max.                                      | 2 A                                                                                    |
| <b>Cable length</b>                                            |                                                                                        |
| • unshielded, max.                                             | 30 m                                                                                   |
| <b>Encoder</b>                                                 |                                                                                        |
| <b>Connectable encoders</b>                                    |                                                                                        |
| • 2-wire sensor                                                | Yes                                                                                    |
| – permissible quiescent current (2-wire sensor), max.          | 1.5 mA                                                                                 |
| <b>Interrupts/diagnostics/status information</b>               |                                                                                        |
| Substitute values connectable                                  | Yes; channel by channel, parameterizable                                               |
| <b>Alarms</b>                                                  |                                                                                        |
| • Diagnostic alarm                                             | Yes; Parameterizable                                                                   |
| <b>Diagnoses</b>                                               |                                                                                        |
| • Short-circuit                                                | Yes; Outputs to M; encoder supply to M; module by module                               |
| <b>Diagnostics indication LED</b>                              |                                                                                        |
| • Channel status display                                       | Yes; green LED                                                                         |
| • for module diagnostics                                       | Yes; green/red LED                                                                     |
| • For load voltage monitoring                                  | Yes; green LED                                                                         |
| <b>Potential separation</b>                                    |                                                                                        |
| between the load voltages                                      | Yes                                                                                    |
| <b>Potential separation channels</b>                           |                                                                                        |
| • between the channels, in groups of                           | 4; DIQ channels are isolated from DQ channels                                          |
| • between the channels and backplane bus                       | Yes                                                                                    |
| • between the channels and the power supply of the electronics | No; DIQ channels are non-isolated and DQ channels are isolated from supply voltage 1L+ |



|                                                                                        |                           |
|----------------------------------------------------------------------------------------|---------------------------|
| <b>Article number</b>                                                                  | <b>6ES7143-5AF00-0BA0</b> |
| <b>Isolation</b>                                                                       |                           |
| Isolation tested with                                                                  | 707 V DC (type test)      |
| <b>Standards, approvals, certificates</b>                                              |                           |
| Suitable for safety-related tripping of standard modules                               | Yes; From FS01            |
| <b>Highest safety class achievable for safety-related tripping of standard modules</b> |                           |
| • Performance level according to ISO 13849-1                                           | PL d                      |
| • Category according to ISO 13849-1                                                    | Cat. 3                    |
| • SILCL according to IEC 62061                                                         | SILCL 2                   |
| <b>Ambient conditions</b>                                                              |                           |
| <b>Ambient temperature during operation</b>                                            |                           |
| • min.                                                                                 | -30 °C                    |
| • max.                                                                                 | 55 °C                     |
| <b>Connection method</b>                                                               |                           |
| Design of electrical connection for the inputs and outputs                             | M12, 5-pole               |
| Design of electrical connection for supply voltage                                     | M8, 4-pole                |
| <b>ET-Connection</b>                                                                   |                           |
| • ET-Connection                                                                        | M8, 4-pin, shielded       |
| <b>Dimensions</b>                                                                      |                           |
| Width                                                                                  | 30 mm                     |
| Height                                                                                 | 159 mm                    |
| Depth                                                                                  | 40 mm                     |
| <b>Weights</b>                                                                         |                           |
| Weight, approx.                                                                        | 145 g                     |

# PROFlenergy

## 7.1 Pause function

### Introduction

PROFlenergy is a PROFINET-based data interface for switching off consumers centrally and in a coordinated manner during pause times regardless of the manufacturer or device type. This has the aim that the process is only provided with the energy that is absolutely required. In so doing, the majority of the energy savings come from the process itself; the PROFINET device contributes only a few watts to the possible savings. In PROFlenergy, this operating state is referred to as a "pause".

### Start and end of a pause

You enable and disable the pause function of the system at the beginning and end of pauses, respectively; the IO controller then sends the PROFlenergy command "Start\_Pause" or "End\_Pause" to the modules.

Use the "Start\_Pause" command to start a pause.

Use the "End\_Pause" command to end a pause.

The following conditions will also cause a pause to be ended:

- Reconfiguration in RUN
- Controller failure
- Firmware update
- Station stop
- Restart of the interface module through:
  - POWER OFF/POWER ON of an interface module
  - POWER OFF/POWER ON of an I/O module
  - Termination of ET-Connection1 or ET-Connection2

The specific behavior of the digital input/digital output module is explained in the following sections.

### Additional information

You can find additional information on working with PROFlenergy in the "PROFlenergy" section of the manual IM 157-1 PN interface module (<https://support.industry.siemens.com/cs/ww/en/view/89254863>) and the "Saving energy with PROFlenergy" section of function manual PROFINET with STEP 7 V13 (<https://support.industry.siemens.com/cs/ww/en/view/49948856>).

Application examples (<https://support.industry.siemens.com/cs/ww/en/view/41986454>) are also available on the Internet.

## 7.2 DI operating mode

### Display

The channel status LEDs are directly influenced by the signal level at the socket.  
If the encoder supply is switched off, this causes the channel status LEDs to also switch off.

### Response to error detection

All channels that are in pause mode on "PE\_MODE\_PROCEED" report their diagnostic status as in productive mode.

The following applies for all channels which switch to a different pause mode:

- Encoder supply switch-off upon the start of "pause" does not result in the "Short-circuit" alarms.
- During the "pause", error detection of "Short circuit" is not possible:
  - Alarms for errors already pending before the "pause" are retained.
  - After the "pause" is over, the error status is updated and incoming/outgoing errors are reported correspondingly.

### Mode parameter

The following table shows the "Mode" parameter.

Table 7- 1 Mode parameter

| Element | Code                    | Explanation                                                                                                                                                            |
|---------|-------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Mode    | 0b: PE_MODE_PROCEED     | Proceed at "pause"<br>• Value status "GOOD"                                                                                                                            |
|         | 1b: PE_MODE_SHUTDOWN    | Switch off at "pause"<br>• Supply voltage $U_s$ switched off <sup>1</sup><br>• Pause substitute value: 0b<br>• Value status "BAD"                                      |
|         | 3b: PE_MODE_LAST_VALUE  | Last value at "pause"<br>• Supply voltage $U_s$ switched off <sup>1</sup><br>• Pause substitute value: Last input value<br>• Value status "BAD"                        |
|         | 4b: PE_MODE_SUBST_VALUE | Substitute value at "pause"<br>• Supply voltage $U_s$ switched off <sup>1</sup><br>• Pause substitute value: Configured pause substitute value<br>• Value status "BAD" |

<sup>1</sup> As there is only one encoder supply  $U_s$  for all channels, the supply can only be switched off at "pause" if all channels are configured to switch off.

## 7.3 DQ operating mode

### Display

The channel status LEDs are directly affected by the signal level at the socket.

### Response to error detection

All channels that are in pause mode on "PE\_MODE\_PROCEED" report their diagnostic status as in productive mode.

The following applies for all channels which switch to a different pause mode:

- During the "pause", error detection of "Short circuit" is not possible:
  - Alarms for errors already pending before the "pause" are retained.
  - After the "pause" is over, the error status is updated and incoming/outgoing errors are reported correspondingly.

### Mode parameter

The following table shows the "Mode" parameter.

Table 7- 2 Mode parameter

| Element | Code                    | Explanation                                                                                                                  |
|---------|-------------------------|------------------------------------------------------------------------------------------------------------------------------|
| Mode    | 0D: PE_MODE_PROCEED     | Proceed at "pause"<br>• Value status "GOOD"                                                                                  |
|         | 1D: PE_MODE_SHUTDOWN    | Switch off at "pause"<br>• Pause substitute value: 0B<br>• Value status "BAD"                                                |
|         | 3D: PE_MODE_LAST_VALUE  | Last value at "pause"<br>• Pause substitute value: Last output value is maintained<br>• Value status "BAD"                   |
|         | 4D: PE_MODE_SUBST_VALUE | Substitute value at "pause"<br>• Pause substitute value: Configured pause substitute value is output<br>• Value status "BAD" |

## Dimension drawing

The figure below shows the dimension drawing of the DIQ 4+DQ 4x24VDC/0.5A 4xM12 digital input/digital output module in front and side views.

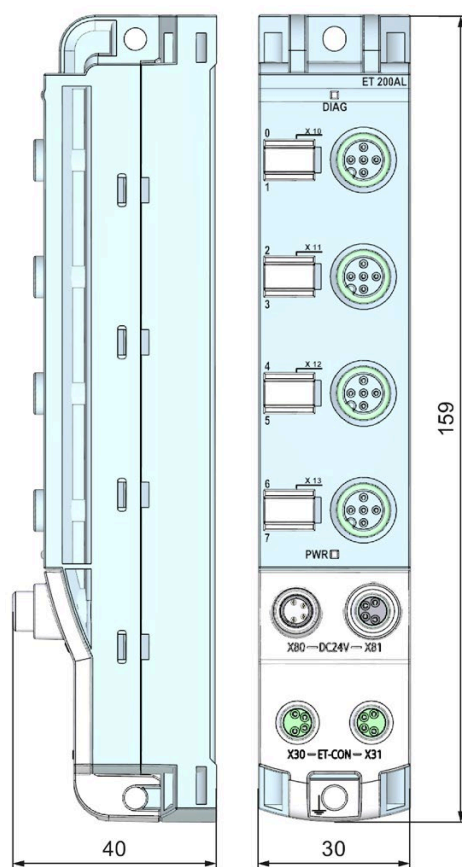
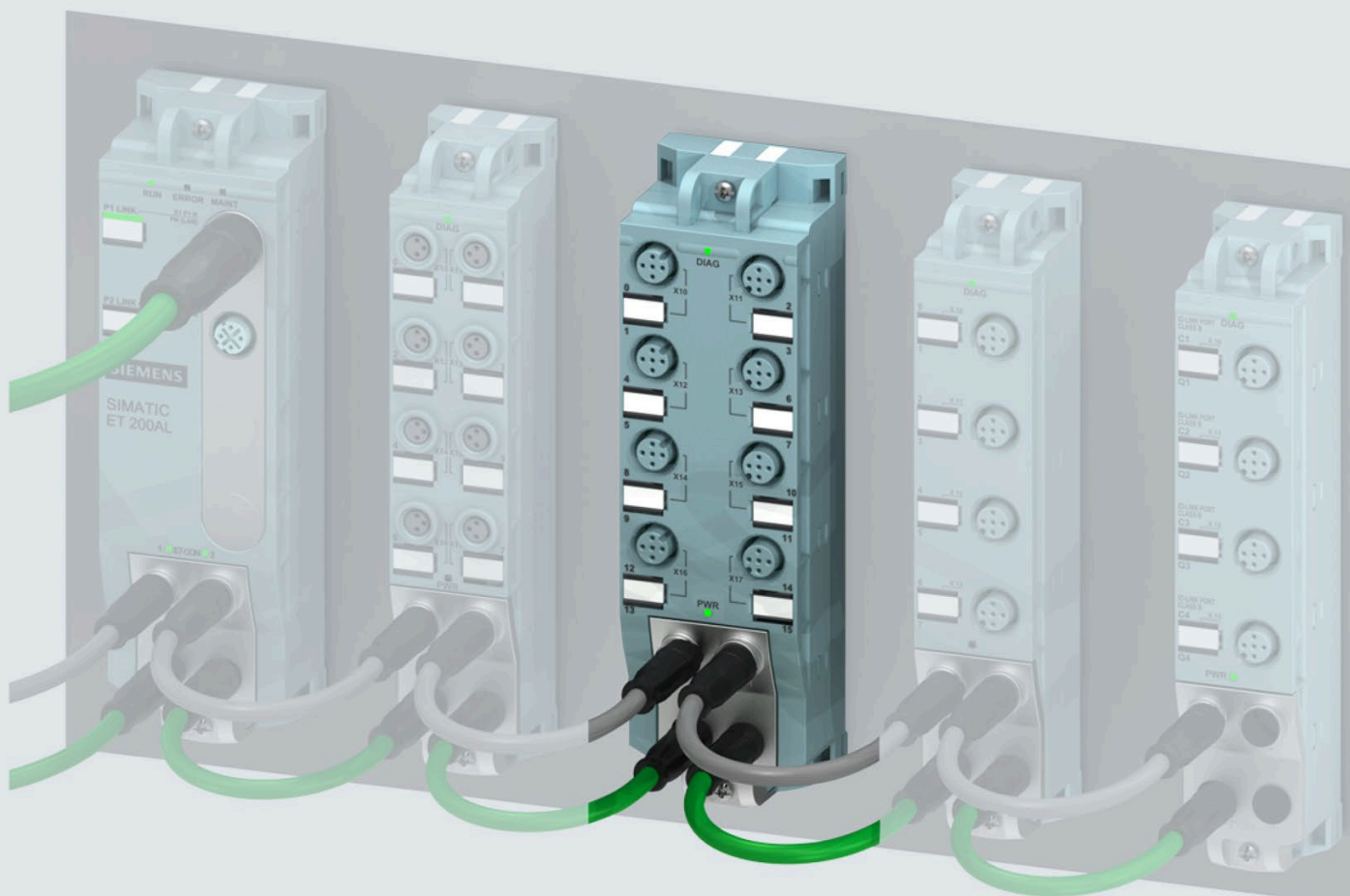


Figure A-1 Dimension drawing

# SIEMENS



Equipment Manual

## SIMATIC

### ET 200AL

Digital input / output module  
DIQ 16x24VDC/0.5A 8xM12  
(6ES7143-5AH00-0BA0)

Edition

08/2021

[support.industry.siemens.com](https://support.industry.siemens.com)

## SIMATIC

### ET 200AL Digital input/Digital output module DIQ 16x24VDC/0.5A 8xM12 (6ES7143-5AH00-0BA0)

#### Equipment Manual

#### Preface

#### ET 200AL Documentation Guide

**1**

#### Product overview

**2**

#### Configuration modes for digital inputs/outputs

**3**

#### Counting

**4**

#### Technical specifications

**5**

#### PROFInergy

**6**

#### Dimension drawing

**A**

## Legal information

### Warning notice system

This manual contains notices you have to observe in order to ensure your personal safety, as well as to prevent damage to property. The notices referring to your personal safety are highlighted in the manual by a safety alert symbol, notices referring only to property damage have no safety alert symbol. These notices shown below are graded according to the degree of danger.

#### **DANGER**

indicates that death or severe personal injury **will** result if proper precautions are not taken.

#### **WARNING**

indicates that death or severe personal injury **may** result if proper precautions are not taken.

#### **CAUTION**

indicates that minor personal injury can result if proper precautions are not taken.

#### **NOTICE**

indicates that property damage can result if proper precautions are not taken.

If more than one degree of danger is present, the warning notice representing the highest degree of danger will be used. A notice warning of injury to persons with a safety alert symbol may also include a warning relating to property damage.

### Qualified Personnel

The product/system described in this documentation may be operated only by **personnel qualified** for the specific task in accordance with the relevant documentation, in particular its warning notices and safety instructions. Qualified personnel are those who, based on their training and experience, are capable of identifying risks and avoiding potential hazards when working with these products/systems.

### Proper use of Siemens products

Note the following:

#### **WARNING**

Siemens products may only be used for the applications described in the catalog and in the relevant technical documentation. If products and components from other manufacturers are used, these must be recommended or approved by Siemens. Proper transport, storage, installation, assembly, commissioning, operation and maintenance are required to ensure that the products operate safely and without any problems. The permissible ambient conditions must be complied with. The information in the relevant documentation must be observed.

### Trademarks

All names identified by ® are registered trademarks of Siemens AG. The remaining trademarks in this publication may be trademarks whose use by third parties for their own purposes could violate the rights of the owner.

### Disclaimer of Liability

We have reviewed the contents of this publication to ensure consistency with the hardware and software described. Since variance cannot be precluded entirely, we cannot guarantee full consistency. However, the information in this publication is reviewed regularly and any necessary corrections are included in subsequent editions.



# Preface

## Preface

### Purpose of the documentation

This manual supplements the ET 200AL distributed I/O system (<https://support.industry.siemens.com/cs/us/en/view/89254965>) system manual. Functions that are generally applicable to the ET 200AL distributed I/O system are described there.

The information provided in the present manual, the system manual and the function manuals enables you to commission the ET 200AL distributed I/O system.

### Conventions

Please also observe notes marked as follows:

---

#### Note

Indicates important product information to which particular attention should be paid.

---

### Security information

Siemens provides products and solutions with industrial security functions that support the secure operation of plants, systems, machines and networks.

In order to protect plants, systems, machines and networks against cyber threats, it is necessary to implement – and continuously maintain – a holistic, state-of-the-art industrial security concept. Siemens' products and solutions constitute one element of such a concept.

Customers are responsible for preventing unauthorized access to their plants, systems, machines and networks. Such systems, machines and components should only be connected to an enterprise network or the internet if and to the extent such a connection is necessary and only when appropriate security measures (e.g. firewalls and/or network segmentation) are in place.

For additional information on industrial security measures that may be implemented, please visit (<https://www.siemens.com/industrialsecurity>).

Siemens' products and solutions undergo continuous development to make them more secure. Siemens strongly recommends that product updates are applied as soon as they are available and that the latest product versions are used. Use of product versions that are no longer supported, and failure to apply the latest updates may increase customers' exposure to cyber threats.

To stay informed about product updates, subscribe to the Siemens Industrial Security RSS Feed visit (<https://www.siemens.com/industrialsecurity>).

# Table of contents

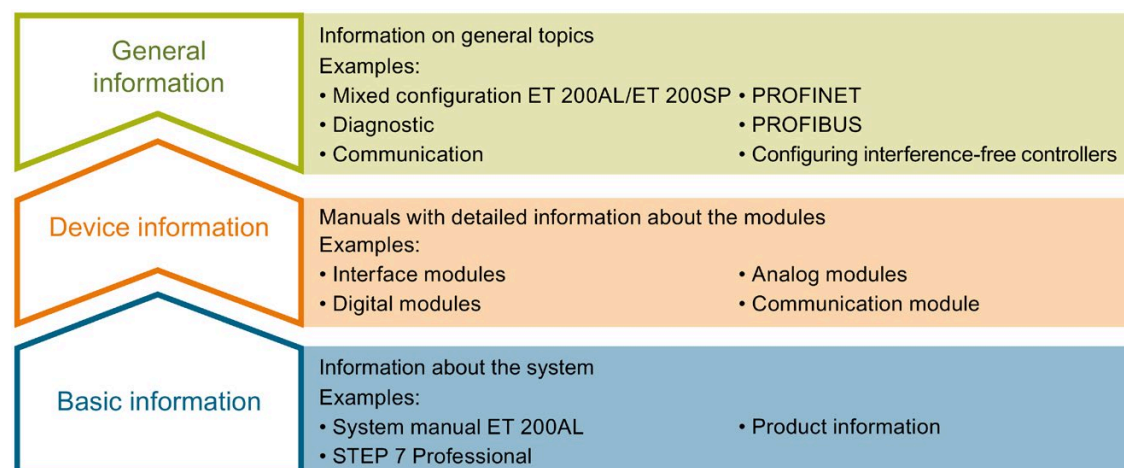
|          |                                                             |           |
|----------|-------------------------------------------------------------|-----------|
|          | <b>Preface</b> .....                                        | <b>3</b>  |
| <b>1</b> | <b>ET 200AL Documentation Guide</b> .....                   | <b>6</b>  |
| <b>2</b> | <b>Product overview</b> .....                               | <b>10</b> |
|          | 2.1 Properties .....                                        | 10        |
|          | 2.2 Operator controls and display elements .....            | 13        |
| <b>3</b> | <b>Configuration modes for digital inputs/outputs</b> ..... | <b>14</b> |
|          | 3.1 Overview .....                                          | 14        |
|          | 3.2 Wiring .....                                            | 15        |
|          | 3.2.1 Terminal and block diagram .....                      | 15        |
|          | 3.2.2 Pin assignment .....                                  | 16        |
|          | 3.3 Parameters/address space .....                          | 22        |
|          | 3.3.1 Parameters .....                                      | 22        |
|          | 3.3.2 Explanation of the parameters .....                   | 23        |
|          | 3.3.3 Address space.....                                    | 24        |
|          | 3.4 Interrupts/diagnostic alarms.....                       | 27        |
|          | 3.4.1 Status and error displays .....                       | 27        |
|          | 3.4.2 Interrupts .....                                      | 29        |
|          | 3.4.3 Diagnostics alarms.....                               | 29        |
| <b>4</b> | <b>Counting</b> .....                                       | <b>30</b> |
|          | 4.1 Configuration method 2xCount.....                       | 32        |
|          | 4.1.1 Wiring .....                                          | 32        |
|          | 4.1.1.1 Terminal and block diagram .....                    | 32        |
|          | 4.1.1.2 Pin assignment .....                                | 33        |
|          | 4.1.2 Parameters/address space .....                        | 36        |
|          | 4.1.2.1 Parameters .....                                    | 36        |
|          | 4.1.2.2 Explanation of the parameters .....                 | 39        |
|          | 4.1.2.3 Assignment of the control interface .....           | 43        |
|          | 4.1.2.4 Explanations on the control interface .....         | 44        |
|          | 4.1.2.5 Assignment of the feedback interface .....          | 44        |
|          | 4.1.2.6 Explanations for the feedback interface.....        | 46        |
|          | 4.1.3 Interrupts/diagnostic alarms.....                     | 48        |
|          | 4.1.3.1 Status and error displays .....                     | 48        |
|          | 4.1.3.2 Interrupts .....                                    | 50        |
|          | 4.1.3.3 Diagnostics alarms.....                             | 51        |

|          |                                                      |           |
|----------|------------------------------------------------------|-----------|
| 4.2      | Configuration method 4xCount.....                    | 52        |
| 4.2.1    | Wiring .....                                         | 52        |
| 4.2.1.1  | Terminal and block diagram.....                      | 52        |
| 4.2.1.2  | Pin assignment .....                                 | 53        |
| 4.2.2    | Parameters/address space .....                       | 56        |
| 4.2.2.1  | Parameters .....                                     | 56        |
| 4.2.2.2  | Explanation of the parameters .....                  | 58        |
| 4.2.2.3  | Assignment of the control interface .....            | 62        |
| 4.2.2.4  | Explanations on the control interface .....          | 63        |
| 4.2.2.5  | Assignment of the feedback interface .....           | 63        |
| 4.2.2.6  | Explanations for the feedback interface.....         | 65        |
| 4.2.3    | Interrupts/diagnostic alarms.....                    | 67        |
| 4.2.3.1  | Status and error displays .....                      | 67        |
| 4.2.3.2  | Interrupts .....                                     | 69        |
| 4.2.3.3  | Diagnostics alarms.....                              | 70        |
| 4.3      | Examples of counting .....                           | 71        |
| <b>5</b> | <b>Technical specifications.....</b>                 | <b>77</b> |
| <b>6</b> | <b>PROFlenergy .....</b>                             | <b>81</b> |
| 6.1      | Pause function.....                                  | 81        |
| 6.2      | Behavior of the digital inputs .....                 | 82        |
| 6.3      | Behavior of the digital outputs .....                | 83        |
| 6.4      | Behavior of the digital inputs of the counters ..... | 84        |
| <b>A</b> | <b>Dimension drawing .....</b>                       | <b>85</b> |

# ET 200AL Documentation Guide

The documentation for the SIMATIC ET 200AL distributed I/O system is arranged into three areas.

This arrangement enables you to access the specific content you require.



## Basic information

The System Manual and Getting Started describe in detail the configuration, installation, wiring and commissioning of the SIMATIC ET 200AL distributed I/O system. The STEP 7 online help supports you in the configuration and programming.

## Device information

Product manuals contain a compact description of the module-specific information, such as properties, wiring diagrams, characteristics and technical specifications.

## General information

The function manuals contain detailed descriptions on general topics regarding the SIMATIC ET 200AL distributed I/O system, e.g. diagnostics, communication, Motion Control, Web server.

You can download the documentation free of charge from the Internet (<https://support.industry.siemens.com/cs/ww/en/view/109742667>).

## Manual Collection ET 200AL

The Manual Collection contains the complete documentation on the SIMATIC ET 200AL distributed I/O system gathered together in one file.

You can find the Manual Collection on the Internet (<https://support.automation.siemens.com/WW/view/en/95242965>).

## **"mySupport"**

With "mySupport", your personal workspace, you make the best out of your Industry Online Support.

In "mySupport", you can save filters, favorites and tags, request CAx data and compile your personal library in the Documentation area. In addition, your data is already filled out in support requests and you can get an overview of your current requests at any time.

You must register once to use the full functionality of "mySupport".

You can find "mySupport" on the Internet (<https://support.industry.siemens.com/My/ww/en>).

## **"mySupport" - Documentation**

With "mySupport", your personal workspace, you make the best out of your Industry Online Support.

In "mySupport", you can save filters, favorites and tags, request CAx data and compile your personal library in the Documentation area. In addition, your data is already filled out in support requests and you can get an overview of your current requests at any time.

You must register once to use the full functionality of "mySupport".

You can find "mySupport" on the Internet (<https://support.industry.siemens.com/My/ww/en/documentation>).

## **"mySupport" - CAx data**

In the CAx data area of "mySupport", you can access the latest product data for your CAx or CAe system.

You configure your own download package with a few clicks.

In doing so you can select:

- Product images, 2D dimension drawings, 3D models, internal circuit diagrams, EPLAN macro files
- Manuals, characteristics, operating manuals, certificates
- Product master data

You can find "mySupport" - CAx data on the Internet (<https://support.industry.siemens.com/my/ww/en/CAxOnline>).

## **Application examples**

The application examples support you with various tools and examples for solving your automation tasks. Solutions are shown in interplay with multiple components in the system - separated from the focus on individual products.

You will find the application examples on the Internet (<https://support.industry.siemens.com/cs/ww/en/ps/ae>).

## TIA Selection Tool

With the TIA Selection Tool, you can select, configure and order devices for Totally Integrated Automation (TIA).

This tool is the successor of the SIMATIC Selection Tool and combines the known configurators for automation technology into one tool.

With the TIA Selection Tool, you can generate a complete order list from your product selection or product configuration.

You can find the TIA Selection Tool on the Internet

(<https://support.industry.siemens.com/cs/ww/en/view/109767888>).

## SIMATIC Automation Tool

You can use the SIMATIC Automation Tool to perform commissioning and maintenance activities simultaneously on various SIMATIC S7 stations as a bulk operation independent of TIA Portal.

The SIMATIC Automation Tool provides a multitude of functions:

- Scanning of a PROFINET/Ethernet system network and identification of all connected CPUs
- Address assignment (IP, subnet, gateway) and station name (PROFINET device) to a CPU
- Transfer of the date and the programming device/PC time converted to UTC time to the module
- Program download to CPU
- RUN/STOP mode switchover
- CPU localization by means of LED flashing
- Reading out of CPU error information
- Reading of the CPU diagnostics buffer
- Reset to factory settings
- Firmware update of the CPU and connected modules

You can find the SIMATIC Automation Tool on the Internet

(<https://support.industry.siemens.com/cs/ww/en/view/98161300>).

## PRONETA

SIEMENS PRONETA (PROFINET network analysis) allows you to analyze the plant network during commissioning. PRONETA features two core functions:

- The topology overview automatically scans the PROFINET and all connected components.
- The IO check is a fast test of the wiring and the module configuration of a plant.

You can find SIEMENS PRONETA on the Internet

(<https://support.industry.siemens.com/cs/ww/en/view/67460624>).

## SINETPLAN

SINETPLAN, the Siemens Network Planner, supports you in planning automation systems and networks based on PROFINET. The tool facilitates professional and predictive dimensioning of your PROFINET installation as early as in the planning stage. In addition, SINETPLAN supports you during network optimization and helps you to exploit network resources optimally and to plan reserves. This helps to prevent problems in commissioning or failures during productive operation even in advance of a planned operation. This increases the availability of the production plant and helps improve operational safety.

The advantages at a glance

- Network optimization thanks to port-specific calculation of the network load
- Increased production availability thanks to online scan and verification of existing systems
- Transparency before commissioning through importing and simulation of existing STEP 7 projects
- Efficiency through securing existing investments in the long term and the optimal use of resources

You can find SINETPLAN on the Internet (<https://www.siemens.com/sinetplan>).

## Product overview

### 2.1 Properties

#### Article number

6ES7143-5AH00-0BA0

#### View of the module

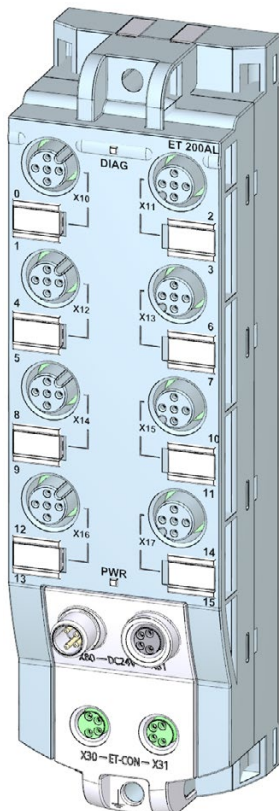


Figure 2-1 View of the digital input/digital output module DIQ 16x24VDC/0.5A 8xM12



## Properties

The module has the following technical properties:

- 16 digital inputs or digital outputs, depending on configuration and parameter assignment
  - 8 DIQ signals connected to 1L+ (non-switched)
  - 8 DQ signals connected to 2L+ (switched)
- M12 sockets for connection of sensors and actuators
- Digital inputs:
  - 24 V DC supply voltage
  - Suitable for switches and proximity switches
  - Input delay configurable
  - Configurable diagnostics can be set for each module
- Digital outputs:
  - Rated load voltage 24 V DC
  - Suitable for solenoid valves, DC contactors, and indicator lights
  - Output current per output 0.5 A
  - Configurable diagnostics can be set for each module
- Counters:
  - Configuration method 2xCount or 4xCount with 2 or 4 counters
  - Counting frequency 2 kHz
  - Counting width 32 bits
  - Counting direction parameterizable or controllable via direction input
  - GATE function controllable via the control interface or via control input
  - Configurable diagnostics and hardware interrupts can be set for each module
  - Input delay configurable
- Dimensions 45 x 159 mm

The module supports the following functions:

- Firmware update
- Identification and maintenance data I&M0 to I&M3
- Value status (Quality Information)
- PROFIenergy

## Accessories

The following components are included in the module package:

- Identification labels

## Other components

The following component can be ordered as spare part:

- Identification labels

The following components can be ordered as accessories:

- Connectors
- Cables
- Stripping Tool for ET-Connection
- M8 sealing cap
- M12 sealing cap

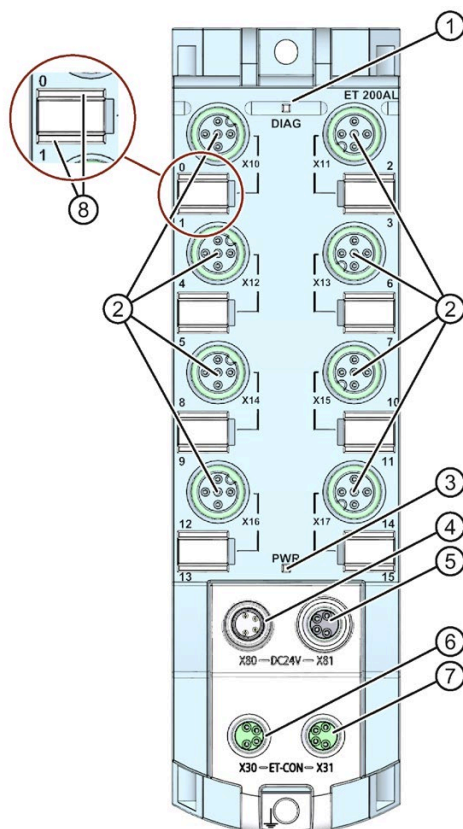
## See also

You can find more information on accessories in the Accessories/spare parts section of the ET 200AL distributed I/O system

(<https://support.industry.siemens.com/cs/us/en/view/89254965>) system manual.

## 2.2 Operator controls and display elements

The following figure shows the operator controls and display elements of the digital input/digital output module DIQ 16x24VDC/0.5A 8xM12.



- ① DIAG: LED display for the diagnostic status
- ② X10 to X17: Sockets for the input/output signal
- ③ PWR: LED display for load voltage 2L+
- ④ X80: Connector for infeed of the supply voltage (POWER input)
- ⑤ X81: Socket for loop-through of the supply voltage (POWER output)
- ⑥ X30: Socket for ET-Connection IN
- ⑦ X31: Socket for ET-Connection OUT
- ⑧ LED displays 0 to 15 for the channel status

Figure 2-2 Operator controls and display elements

# Configuration modes for digital inputs/outputs

## 3.1 Overview

### Introduction

With the configuration modes for digital inputs and outputs, you can configure each channel of the module as an input or output consistent with your application.

You use the available configuration modes to specify how the channels will be used:

- **DIQ:**  
You can use each channel as an input or output through a corresponding parameter assignment.
- **DIQ with value status:**  
You can use each channel as an input or output through a corresponding parameter assignment. Additionally, the value status gives you information about the validity of the digital values and the channel status.
- **DQ16:**  
All channels (0..15) are configured as outputs.
- **DI8/DQ8:**  
Channels 0..7 are configured as inputs, and channels 8..15 are configured as outputs.
- **DIQ MIX:**  
The channels 0, 2, 4, 6, 8, 10, 12, 14 and 16 have a fixed configuration as outputs, the channels 1, 3, 5, 7, 9, 11, 13 and 15 have a fixed configuration as inputs.

---

#### Note

##### Project engineering configuration mode DIQ MIX

Note that you can only use the configuration mode DIQ MIX when configuring via GSD file and in connection with the interface modules IM 157-1 PN and IM 157-1 DP.

---

### Benefits

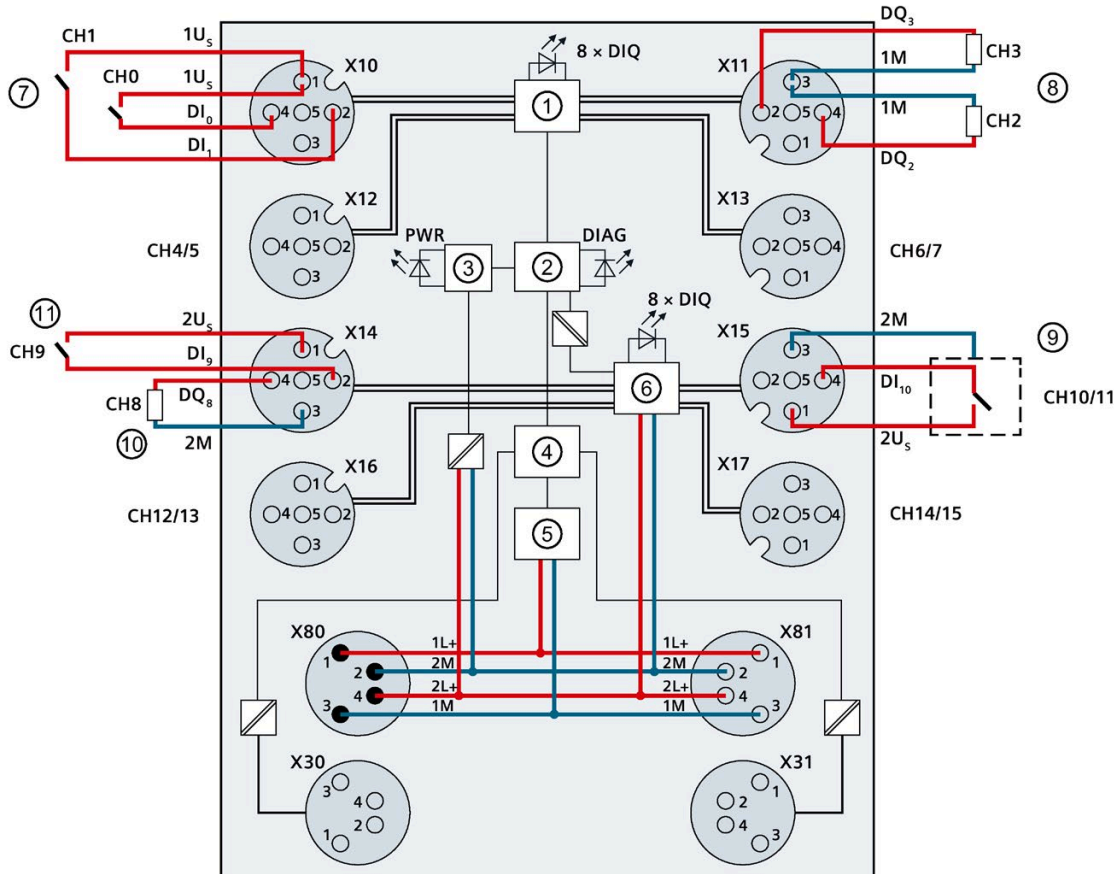
The address space occupied by the module is significantly reduced in the DQ16, DI8/DQ8 and DIQ MIX configuration modes compared with the DIQ configuration modes.

This reduction offers you advantages if you have already assigned the available address space of your plant for other processes.

## 3.2 Wiring

### 3.2.1 Terminal and block diagram

The figure below shows an example of the pin assignment of signal inputs with 2-wire and 3-wire connection and of signal outputs in the configuration modes for digital inputs and outputs.



|            |                                            |                  |                                     |
|------------|--------------------------------------------|------------------|-------------------------------------|
| ①          | DI/DQ circuit (1L+ non-switched)           | X81              | Loop-through of supply voltages     |
| ②          | Microcontroller                            | X30              | Infeed of the ET-Connection         |
| ③          | Monitoring                                 | X31              | Loop-through of the ET-Connection   |
| ④          | ET-Connection interface                    | 1L+              | Supply voltage 1L+ (non-switched)   |
| ⑤          | Internal supply voltage                    | 1M               | Ground 1M (non-switched)            |
| ⑥          | DI/DQ circuit (2L+ switched)               | 2L+              | Load voltage 2L+ (switched)         |
| ⑦          | Parameterized as inputs: 2-wire connection | 2M               | Ground 2M (switched)                |
| ⑧          | Parameterized as outputs                   | 1Us              | 24 V encoder supply                 |
| ⑨          | Configured as input: 3-wire connection     | 2Us              | 24 V encoder supply                 |
| ⑩          | Configured as output                       | DIQ <sub>n</sub> | Input/output signal                 |
| ⑪          | Configured as input: 2-wire connection     | DIQ              | LEDs channel status (0..15) (green) |
| X10 to X17 | Channels 0 to 15                           | DIAG             | Diagnostic status LED (red/green)   |
| X80        | Infeed of supply voltages                  | PWR              | LED supply voltage 2L+ (green)      |

Figure 3-1 Wiring and block diagram of configuration modes for digital inputs and outputs

### 3.2.2 Pin assignment

**Note**

Color coding

The sockets for ET-Connection and the power supply of the modules are color-coded. These colors correspond to the colors of the offered cables.

**NOTICE**
**24 V encoder supply 1Us / 2Us**

Use only the 24 V encoder supplies 1Us and 2Us provided by the digital input/digital output module to supply power to the encoder.

#### Pin assignment of the sockets for digital inputs/digital outputs in the configuration modes DIQ and DIQ with value status

The tables below show the pin assignments of the 8 sockets for connection of the digital inputs/digital outputs.

Table 3- 1 Pin assignment for digital inputs/digital outputs

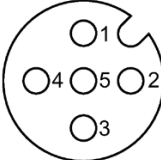
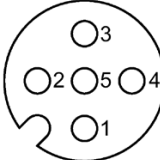
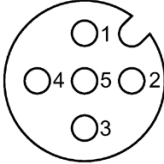
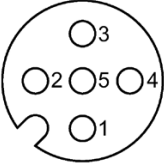
| Pin | Assignment                                                                                                                                                                                                                   | Front view of the sockets                                                             |                                                                                       |
|-----|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------|
|     |                                                                                                                                                                                                                              | X10, X12                                                                              | X11, X13                                                                              |
| 1   | 24 V encoder supply 1Us<br>(derived from 1L+ non-switched)                                                                                                                                                                   |  |  |
| 2   | Input/output signal DIQ <sub>1</sub> : Connector X10<br>Input/output signal DIQ <sub>3</sub> : Connector X11<br>Input/output signal DIQ <sub>5</sub> : Connector X12<br>Input/output signal DIQ <sub>7</sub> : Connector X13 |                                                                                       |                                                                                       |
| 3   | Ground 1M                                                                                                                                                                                                                    |                                                                                       |                                                                                       |
| 4   | Input/output signal DIQ <sub>0</sub> : Connector X10<br>Input/output signal DIQ <sub>2</sub> : Connector X11<br>Input/output signal DIQ <sub>4</sub> : Connector X12<br>Input/output signal DIQ <sub>6</sub> : Connector X13 |                                                                                       |                                                                                       |
| 5   | Functional earth FE                                                                                                                                                                                                          |                                                                                       |                                                                                       |

Table 3- 2 Pin assignment for digital inputs/digital outputs

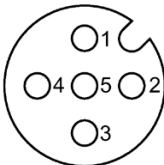
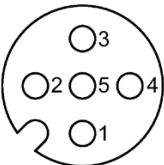
| Pin | Assignment                                                                                                                                                                  | Front view of the sockets                                                           |                                                                                     |
|-----|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------|
|     |                                                                                                                                                                             | X14, X16                                                                            | X15, X17                                                                            |
| 1   | 24 V encoder supply 2Us<br>(derived from 2L+ switched)                                                                                                                      |  |  |
| 2   | Input/output signal DIQ9: Connector X14<br>Input/output signal DIQ11: Connector X15<br>Input/output signal DIQ13: Connector X16<br>Input/output signal DIQ15: Connector X17 |                                                                                     |                                                                                     |
| 3   | Ground 2M                                                                                                                                                                   |                                                                                     |                                                                                     |
| 4   | Input/output signal DIQ8: Connector X14<br>Input/output signal DIQ10: Connector X15<br>Input/output signal DIQ12: Connector X16<br>Input/output signal DIQ14: Connector X17 |                                                                                     |                                                                                     |
| 5   | Functional earth FE                                                                                                                                                         |                                                                                     |                                                                                     |

### Pin assignment of the sockets for digital inputs/digital outputs in the configuration mode DQ16

The tables below show the pin assignments of the 8 sockets for connection of the digital inputs/digital outputs in the configuration mode DQ16.

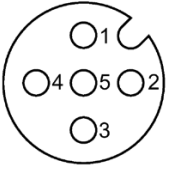
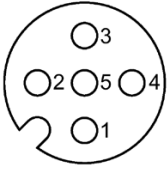
In this configuration mode, socket pins 2 and 4 are always permanently assigned to output signals.

Table 3- 3 Pin assignment for digital inputs/digital outputs

| Pin | Assignment                                                                                                                                   | Front view of the sockets                                                             |                                                                                       |
|-----|----------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------|
|     |                                                                                                                                              | X10, X12                                                                              | X11, X13                                                                              |
| 1   | 24 V encoder supply 1Us<br>(derived from 1L+ non-switched)                                                                                   |  |  |
| 2   | Output signal DQ1: Connector X10<br>Output signal DQ3: Connector X11<br>Output signal DQ5: Connector X12<br>Output signal DQ7: Connector X13 |                                                                                       |                                                                                       |
| 3   | Ground 1M                                                                                                                                    |                                                                                       |                                                                                       |
| 4   | Output signal DQ0: Connector X10<br>Output signal DQ2: Connector X11<br>Output signal DQ4: Connector X12<br>Output signal DQ6: Connector X13 |                                                                                       |                                                                                       |
| 5   | Functional earth FE                                                                                                                          |                                                                                       |                                                                                       |

## 3.2 Wiring

Table 3- 4 Pin assignment for digital inputs/digital outputs

| Pin | Assignment                                                                                                                                                                                          | Front view of the sockets                                                           |                                                                                     |
|-----|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------|
|     | X14 to X17 sockets for digital inputs / outputs                                                                                                                                                     | X14, X16                                                                            | X15, X17                                                                            |
| 1   | 24 V encoder supply 2Us<br>(derived from 2L+ switched)                                                                                                                                              |  |  |
| 2   | Output signal DQ <sub>9</sub> : Connector X14<br>Output signal DQ <sub>11</sub> : Connector X15<br>Output signal DQ <sub>13</sub> : Connector X16<br>Output signal DQ <sub>15</sub> : Connector X17 |                                                                                     |                                                                                     |
| 3   | Ground 2M                                                                                                                                                                                           |                                                                                     |                                                                                     |
| 4   | Output signal DQ <sub>8</sub> : Connector X14<br>Output signal DQ <sub>10</sub> : Connector X15<br>Output signal DQ <sub>12</sub> : Connector X16<br>Output signal DQ <sub>14</sub> : Connector X17 |                                                                                     |                                                                                     |
| 5   | Functional earth FE                                                                                                                                                                                 |                                                                                     |                                                                                     |

### Pin assignment of the sockets for digital inputs/digital outputs in the configuration mode DI8/DQ8

The tables below show the pin assignments of the 8 sockets for connection of the digital inputs/digital outputs in the configuration mode DI8/DQ8.

In this configuration mode, pins 2 and 4 for the sockets X10 to X13 are always permanently assigned to the input signals, pins 2 and 4 for the sockets X14 to X17 are always permanently assigned to the output signals.

Table 3- 5 Pin assignment for digital inputs/digital outputs

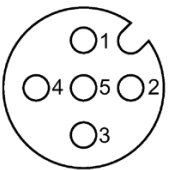
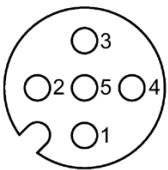
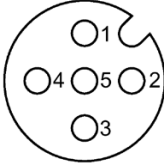
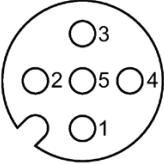
| Pin | Assignment                                                                                                                                                                                   | Front view of the sockets                                                             |                                                                                       |
|-----|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------|
|     | X10 to X13 sockets for digital inputs / outputs                                                                                                                                              | X10, X12                                                                              | X11, X13                                                                              |
| 1   | 24 V encoder supply 1Us<br>(derived from 1L+ non-switched)                                                                                                                                   |  |  |
| 2   | Input signal DI <sub>1</sub> : Connector X10<br>Input signal DI <sub>3</sub> : Connector X11<br>Input signal DI <sub>5</sub> : Connector X12<br>Input signal DI <sub>7</sub> : Connector X13 |                                                                                       |                                                                                       |
| 3   | Ground 1M                                                                                                                                                                                    |                                                                                       |                                                                                       |
| 4   | Input signal DI <sub>0</sub> : Connector X10<br>Input signal DI <sub>2</sub> : Connector X11<br>Input signal DI <sub>4</sub> : Connector X12<br>Input signal DI <sub>6</sub> : Connector X13 |                                                                                       |                                                                                       |
| 5   | Functional earth FE                                                                                                                                                                          |                                                                                       |                                                                                       |



Table 3- 6 Pin assignment for digital inputs/digital outputs

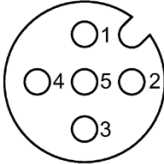
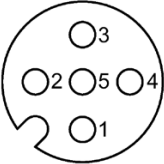
| Pin | Assignment                                                                                                                                      | Front view of the sockets                                                           |                                                                                     |
|-----|-------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------|
|     |                                                                                                                                                 | X14, X16                                                                            | X15, X17                                                                            |
| 1   | 24 V encoder supply 2Us<br>(derived from 2L+ switched)                                                                                          |  |  |
| 2   | Output signal DQ9: Connector X14<br>Output signal DQ11: Connector X15<br>Output signal DQ13: Connector X16<br>Output signal DQ15: Connector X17 |                                                                                     |                                                                                     |
| 3   | Ground 2M                                                                                                                                       |                                                                                     |                                                                                     |
| 4   | Output signal DQ8: Connector X14<br>Output signal DQ10: Connector X15<br>Output signal DQ12: Connector X16<br>Output signal DQ14: Connector X17 |                                                                                     |                                                                                     |
| 5   | Functional earth FE                                                                                                                             |                                                                                     |                                                                                     |

### Pin assignment of the sockets for digital inputs/digital outputs in the configuration mode DIQ MIX

The tables below show the pin assignments of the 8 sockets for connection of the digital inputs/digital outputs in the configuration mode DIQ MIX.

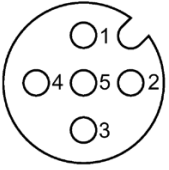
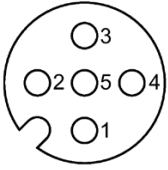
In this configuration mode, socket pin 2 is always permanently assigned to input signals, pin 4 is always permanently assigned to output signals.

Table 3- 7 Pin assignment for digital inputs/digital outputs

| Pin | Assignment                                                                                                                                   | Front view of the sockets                                                             |                                                                                       |
|-----|----------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------|
|     |                                                                                                                                              | X10, X12                                                                              | X11, X13                                                                              |
| 1   | 24 V encoder supply 1Us<br>(derived from 1L+ non-switched)                                                                                   |  |  |
| 2   | Input signal DI1: Connector X10<br>Input signal DI3: Connector X11<br>Input signal DI5: Connector X12<br>Input signal DI7: Connector X13     |                                                                                       |                                                                                       |
| 3   | Ground 1M                                                                                                                                    |                                                                                       |                                                                                       |
| 4   | Output signal DQ0: Connector X10<br>Output signal DQ2: Connector X11<br>Output signal DQ4: Connector X12<br>Output signal DQ6: Connector X13 |                                                                                       |                                                                                       |
| 5   | Functional earth FE                                                                                                                          |                                                                                       |                                                                                       |

## 3.2 Wiring

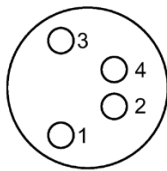
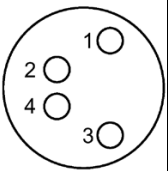
Table 3- 8 Pin assignment for digital inputs/digital outputs

| Pin | Assignment                                                                                                                                                                                          | Front view of the sockets                                                           |                                                                                     |
|-----|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------|
|     | X14 to X17 sockets for digital inputs / outputs                                                                                                                                                     | X14, X16                                                                            | X15, X17                                                                            |
| 1   | 24 V encoder supply 2Us<br>(derived from 2L+ switched)                                                                                                                                              |  |  |
| 2   | Input signal DI <sub>9</sub> : Connector X14<br>Input signal DI <sub>11</sub> : Connector X15<br>Input signal DI <sub>13</sub> : Connector X16<br>Input signal DI <sub>15</sub> : Connector X17     |                                                                                     |                                                                                     |
| 3   | Ground 2M                                                                                                                                                                                           |                                                                                     |                                                                                     |
| 4   | Output signal DQ <sub>8</sub> : Connector X14<br>Output signal DQ <sub>10</sub> : Connector X15<br>Output signal DQ <sub>12</sub> : Connector X16<br>Output signal DQ <sub>14</sub> : Connector X17 |                                                                                     |                                                                                     |
| 5   | Functional earth FE                                                                                                                                                                                 |                                                                                     |                                                                                     |

## Pin assignment of the sockets for ET-Connection

The table below shows the pin assignments of the 2 sockets for the connection of ET-Connection.

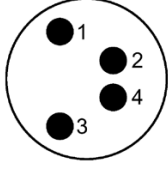
Table 3- 9 Pin assignment for ET-Connection

| Pin       | Assignment                    |                                | Assignment of the wire color of the bus line cable for ET-Connection | Front view of the sockets                                                             |                                                                                       |
|-----------|-------------------------------|--------------------------------|----------------------------------------------------------------------|---------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------|
|           | X30 socket (ET-Connection IN) | X31 socket (ET-Connection OUT) |                                                                      | X30                                                                                   | X31                                                                                   |
| 1         | TXP                           | RXP                            | Yellow                                                               |  |  |
| 2         | RXP                           | TXP                            | White                                                                |                                                                                       |                                                                                       |
| 3         | RXN                           | TXN                            | Blue                                                                 |                                                                                       |                                                                                       |
| 4         | TXN                           | RXN                            | Orange                                                               |                                                                                       |                                                                                       |
| Shielding | Functional earth FE           |                                | -                                                                    |                                                                                       |                                                                                       |

## Pin assignment of the connector for infeed of the supply voltage

The table below shows the pin assignment of the connector for infeed of the supply voltage.

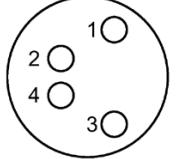
Table 3- 10 Pin assignment of the supply voltage connector

| Pin | Assignment                        | Assignment of the core color of the power cable | Front view of the connector                                                           |
|-----|-----------------------------------|-------------------------------------------------|---------------------------------------------------------------------------------------|
|     | X80 connector (POWER input)       |                                                 |                                                                                       |
| 1   | Supply voltage 1L+ (non-switched) | Brown                                           |  |
| 2   | Ground 2M (switched)              | White                                           |                                                                                       |
| 3   | Ground 1M (non-switched)          | Blue                                            |                                                                                       |
| 4   | Load voltage 2L+ (switched)       | Black                                           |                                                                                       |

### Pin assignment of the socket for loop-through of the supply voltage

The table below shows the pin assignment of the socket for loop-through of the supply voltage.

Table 3- 11 Pin assignment of the supply voltage socket

| Pin | Assignment                        | Assignment of the core color of the power cable | Front view of the socket                                                            |
|-----|-----------------------------------|-------------------------------------------------|-------------------------------------------------------------------------------------|
|     | X81 socket (POWER output)         |                                                 |                                                                                     |
| 1   | Supply voltage 1L+ (non-switched) | Brown                                           |  |
| 2   | Ground 2M (switched)              | White                                           |                                                                                     |
| 3   | Ground 1M (non-switched)          | Blue                                            |                                                                                     |
| 4   | Load voltage 2L+ (switched)       | Black                                           |                                                                                     |

#### NOTICE

##### ET-Connection/supply voltage

Observe the correct wiring of the M8 sockets for ET-Connection and the supply voltage.

Mixing up the ET-Connection connectors and the connectors for the supply voltage can destroy the module.

## 3.3 Parameters/address space

### 3.3.1 Parameters

The following table shows the parameters for the DIQ 16x24VDC/0.5A 8xM12 digital input / digital output module in the configuration modes for digital inputs and outputs.

Table 3- 12 Parameters

| Parameters                            | Value range                                                                                                                                                               | Default   | Scope                                                                  |
|---------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------|------------------------------------------------------------------------|
| Diagnostics: Missing load voltage 2L+ | <ul style="list-style-type: none"> <li>Disable</li> <li>Enable</li> </ul>                                                                                                 | Disable   | Module                                                                 |
| Diagnostics: Short-circuit to ground  | <ul style="list-style-type: none"> <li>Disable</li> <li>Enable</li> </ul>                                                                                                 | Disable   | Module<br>(Short-circuit of encoder supply or of the output to ground) |
| Reaction to CPU/master STOP           | <ul style="list-style-type: none"> <li>Shut down</li> <li>Keep last value</li> <li>Output substitute value</li> </ul>                                                     | Shut down | Module<br>(digital outputs)                                            |
| Freely configurable channel*          | <ul style="list-style-type: none"> <li>DI</li> <li>DQ</li> </ul>                                                                                                          | DI        | Channel                                                                |
| Substitute value channel              | <ul style="list-style-type: none"> <li>0</li> <li>1</li> </ul>                                                                                                            | 0         | Channel<br>(digital outputs)                                           |
| Input delay**                         | <ul style="list-style-type: none"> <li>0.05 ms</li> <li>0.1 ms</li> <li>0.4 ms</li> <li>0.8 ms</li> <li>1.6 ms</li> <li>3.2 ms</li> <li>12.8 ms</li> <li>20 ms</li> </ul> | 3.2 ms    | Channel<br>(Digital inputs)                                            |

\* = Can only be set in DIQ or DIQ with value status configuration mode.

\*\* = Not available in DQ16 mode. Only values starting from 1.6 ms can be configured for the input delay for channels 8..15.

### 3.3.2 Explanation of the parameters

#### Diagnostics: Missing load voltage 2L+

Enabling of the diagnostics for missing or insufficient load voltage 2L+.

#### Diagnostics: Short-circuit to ground

Enabling of the diagnostics, at short-circuit of an encoder supply or of an output to ground.

#### Freely assignable channel

With this parameter, you set whether the channel is to be operated as an input or output. You can only set this parameter in the DIQ and DIQ with value status configuration modes.

#### Reaction to CPU/master STOP

With this parameter, you set the reaction of the channels configured as output of the digital input/output module after a CPU/master STOP:

- Deactivate: The digital output is de-energized.
- Keep last value: The last value of the digital output remains activated.
- Output substitute value: The module outputs a configured substitute value.

#### Substitute value channel

With this parameter, you set substitute values for the digital outputs.

#### Input delay

This parameter can be used to avoid signal faults. Changes to the signal are only detected if they are present and stable for longer than the set input delay time. You cannot set this parameter in DQ16 mode.

### 3.3.3 Address space

The DIQ 16x24VDC/0.5A 8xM12 digital input/output module occupies a different number of bytes in the process image input (PII) or process image output (PIQ), depending on which configuration mode you selected.

The following figures show you the various assignments of the address spaces.

---

#### Note

##### Parameter assignment of the channels

In the configuration modes for digital inputs and outputs, either all channels are user configurable or all channels have a fixed configuration, depending on the configuration.

For the channels that are configured as an input, the corresponding values in the output data do not trigger any reaction.

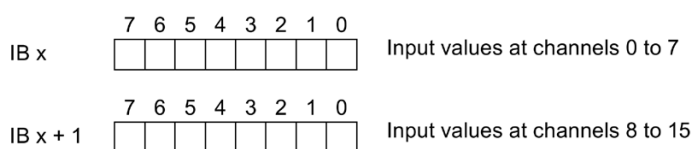
For the channels that are configured as an output, the input value in the process image is 0.

---

#### Configuration mode DIQ without value status

The figure below shows the assignment of the address space for the DIQ 16x24VDC/0.5A 8xM12 digital input / digital output module in the DIQ without value status configuration mode (Quality Information, QI).

Assignment in the process image input (PII)



Assignment in the process image output (PIQ)

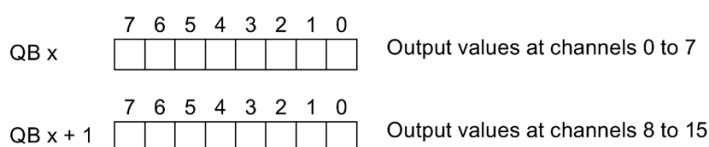


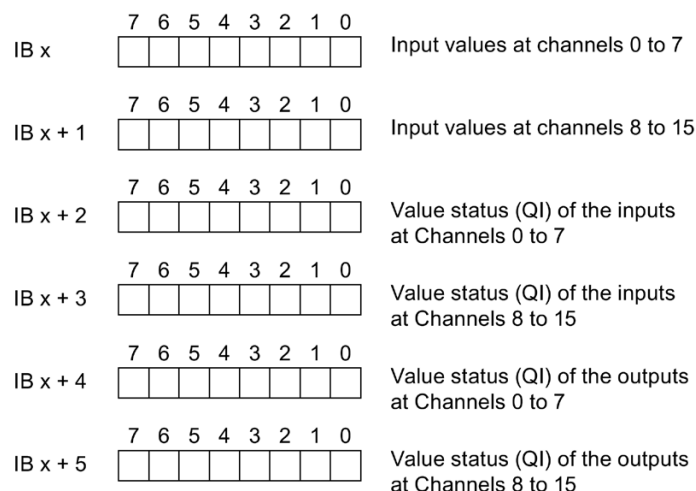
Figure 3-2 Address space in DIQ without value status configuration mode

### Configuration mode DIQ with value status

The figure below shows the assignment of the address space for the digital input/digital output module DIQ 16x24VDC/0.5A 8xM12 with value status (Quality Information, QI) in the configuration method DIQ.

The address space for the value status is allocated by the module, if the value status is configured using the PROFINET interface module.

Assignment in the process image input (PII)



Assignment in the process image output (PIQ)

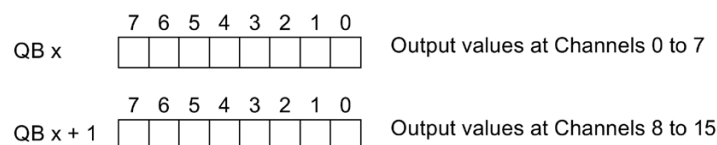


Figure 3-3 Address space in DIQ with value status configuration mode

### Configuration mode DQ16

In DQ16 configuration mode, the address space is reduced by the fixed parameter assignment.

Assignment in the process image output (PIQ)

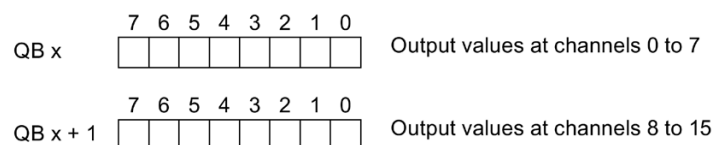
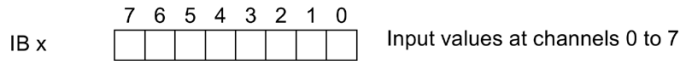


Figure 3-4 Address space in DQ16 configuration mode

### Configuration mode DI8/DQ8

In DI8/DQ8 configuration mode, the address space is reduced by the fixed parameter assignment of the channels.

Assignment in the process image input (PII)



Assignment in the process image output (PIQ)

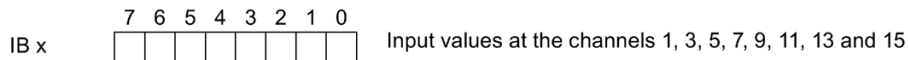


Figure 3-5 Address space in DI8/DQ8 configuration mode

### Configuration mode DIQ MIX

In DIQ MIX configuration mode, the address space is reduced by the fixed parameter assignment of the channels.

Assignment in the process image input (PII)



Assignment in the process image of the outputs (PIQ)

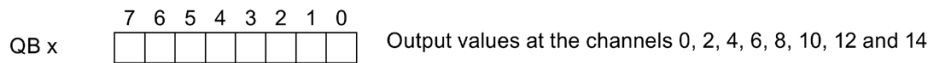


Figure 3-6 Address space in DIQ MIX configuration mode

## Evaluating the value status

An additional four bytes are occupied in the input address space if you enable the value status for the digital input/digital output module. The value status of the inputs is assigned to the input bytes  $x + 2$  and  $x + 3$ . The value status of the outputs is assigned to the input bytes  $x + 4$  and  $x + 5$ . This additional information provides information regarding the validity of the digital values or channel status.

Bit = 1: No error on channel.

Bit = 0: Error on channel.

If the channel is configured as input, this means:

- Short-circuit of an encoder supply to ground, or
- Parameter error, or
- For channels 8 ... 15: Missing load voltage 2L+

If the channel is configured as output, this means:

- Short-circuit of the output to ground, or
- Parameter error, or
- For channels 8 ... 15: Missing load voltage 2L+





## Meaning of the LEDs

The following tables set out the meaning of the status and error displays. Remedial measures for diagnostic reports can be found in chapter Diagnostics alarms (Page 29).

### DIAG LED

Table 3- 13 Error display of the DIAG LED

| DIAG LED                                                                                      | Meaning                                                                                                                                                                                                                                                                                                     |
|-----------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <br>Off      | No supply voltage 1L+                                                                                                                                                                                                                                                                                       |
| <br>Flashes  | <ul style="list-style-type: none"> <li>Module parameters not assigned (after switching on the supply voltage 1L+)</li> <li>Loading firmware (while the firmware update is being performed, all LEDs retain their current status)</li> <li>No connection to the ET-Connection and/or the fieldbus</li> </ul> |
| <br>On       | Module parameters assigned and no module diagnostics                                                                                                                                                                                                                                                        |
| <br>Flashes | Module parameters assigned and module diagnostics                                                                                                                                                                                                                                                           |

### LED channel status

Table 3- 14 LED channel status display

| LED channel status                                                                         | Meaning            |
|--------------------------------------------------------------------------------------------|--------------------|
| <br>Off | Process signal = 0 |
| <br>On  | Process signal = 1 |

### PWR LED

Table 3- 15 Status display of the PWR LED

| PWR LED                                                                                    | Meaning                                |
|--------------------------------------------------------------------------------------------|----------------------------------------|
| <br>Off | Load voltage 2L+ is missing or too low |
| <br>On  | Load voltage 2L+ present               |

### 3.4.2 Interrupts

The digital input / digital output module DIQ 16x24VDC/0.5A 8xM12 in the configuration method DIQ supports diagnostic interrupts.

#### Diagnostic interrupt

The digital input/digital output module generates a diagnostic interrupt at the following events:

- Short-circuit of an encoder supply to ground, or
- Short-circuit of an output to ground
- Load voltage 2L+ missing or too low
- Parameter assignment error

### 3.4.3 Diagnostics alarms

For each diagnostic event, a diagnostics alarm is issued and the LED DIAG flashes red on the digital input/digital output module.

You can read out the diagnostics alarms, for example, from the diagnostics buffer of the CPU. You can evaluate the error codes with the user program.

Table 3- 16 Diagnostics alarms, their meanings and corrective measures

| Diagnostics alarm                                                                                                                                                                                                                                                                                                                                                               | Error code | Meaning                                      | Solution                                                                                                 |
|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------|----------------------------------------------|----------------------------------------------------------------------------------------------------------|
| Short circuit <sup>1</sup>                                                                                                                                                                                                                                                                                                                                                      | 1H         | Short-circuit of an encoder supply to ground | <ul style="list-style-type: none"> <li>• Eliminate the short-circuit</li> </ul>                          |
|                                                                                                                                                                                                                                                                                                                                                                                 |            | Short-circuit of an output to ground         |                                                                                                          |
| Parameter assignment error                                                                                                                                                                                                                                                                                                                                                      | 10H        | Module parameter assignment is faulty        | Correction of the parameter assignment                                                                   |
| Load voltage 2L+ missing <sup>2</sup>                                                                                                                                                                                                                                                                                                                                           | 11H        | Load voltage 2L+ missing or too low          | <ul style="list-style-type: none"> <li>• Check the supply voltage</li> <li>• Check the module</li> </ul> |
| <sup>1</sup> = If a short-circuit of an encoder supply to ground is detected, the diagnostic alarm "Short-circuit" is always output. This alarm is output even if all channels are configured as outputs.<br><sup>2</sup> = If you are using ET 200AL modules in connection with the ET 200SP distributed I/O system, the diagnostic alarm "Load voltage missing" is displayed. |            |                                              |                                                                                                          |

#### Note

##### Channel type

The digital input/digital output module is always signaled as a mixed module (channel type "Input/Output") in the case of diagnostic events, even if you have configured the digital input/digital output module exclusively as an output or input module.

# Counting

## Counting function

Counting refers to the detection and summation of events. The respective counters of the module detect encoder signals and pulses and evaluate them accordingly, for example:

- For counting general piece goods up to a maximum limit
- For applications with recurring counting processes

You can control the counting processes with the digital inputs of the digital input / digital output module belonging to the counter. You can control the digital output belonging to the counter exactly to defined counter values via comparative results independently of the user program.

You can parameterize the behavior of the respective counter by means of the functions described below.

## Counter limits

The counter values define the range of values of the counter value than can be used. The counter limits are configurable and can be modified during runtime using the user program. The maximum adjustable count limit amounts to 2147483647 ( $2^{31}-1$ ). The maximum adjustable count limit amounts to -2147483648 ( $-2^{31}$ ).

You can continue or stop counting (automatic gate stop) on violation of a counting limit. At an overflow or underflow of the count value one event bit is respectively set in the feedback interface. The count value jumps to the respective other counting limit.

## Start value

You can configure a start value within the counter limits. The start value can be modified during runtime with the user program.

## Load value

In addition to the parameterization you can influence the counting behavior additionally via the control interface by means of the load value. Depending on the bit sequence of the load request (LD\_SLOT) contained in the control byte you can load the load value (SLOT) as a current count value, start value, comparative value or count limit.

If you re-parameterize the module, loaded values are overwritten automatically. Therefore, if necessary, carry out the adjustment of the values via the control interface again after a re-parameterization.

## Comparison value

You specify a comparison value that controls the associated count output independently of the user program.

The comparison value can be parameterized and can be changed with the user program during runtime.

## Gate control

Together with the hardware gate the software gate forms the internal gate. The module only counts when the internal gate is open.

You control the HW gate externally via the digital inputs DI<sub>4</sub> and DI<sub>6</sub>. You control the SW gate via the user program. You can activate and use the hardware gate in the 2xCount configuration method by using parameterization.

## Counting direction

The counting direction is specified either by the direction of the respective counter or via the parameter assignment of the counter.

You control the counting direction via the digital inputs DI<sub>5</sub> and DI<sub>7</sub>. You can activate and use the direction inputs in the 2xCount configuration method by using parameterization.

## Overview of configuration methods

The following table shows a list of the channel properties for the configuration methods 2xCount and 4xCount.

You can count with DI<sub>0</sub> and DI<sub>2</sub> (configuration method 2xCount) or respectively with DI<sub>0</sub>, DI<sub>2</sub>, DI<sub>4</sub> and DI<sub>6</sub> (configuration method 4xCount).

Table 4- 1 Configuration methods of the DIQ 16x24VDC/0.5A 8xM12

| Property                                  |         | Configuration method |                    |
|-------------------------------------------|---------|----------------------|--------------------|
|                                           |         | 2xCount (Page 32)    | 4xCount (Page 52)  |
| Number of counters                        |         | 2                    | 4                  |
| Counter width, max. counting frequency    |         | 32 bits, 2 kHz       | 32 bits, 2 kHz     |
| Counter inputs                            |         | Channels 0, 2        | Channel 0, 2, 4, 6 |
| Count outputs                             |         | Channel 1, 3         | Channel 1, 3, 5, 7 |
| Input for gate stop / start <sup>1</sup>  |         | Channel 4, 6         | -                  |
| Input for counting direction <sup>1</sup> |         | Channel 5, 7         | -                  |
| Number of freely parameterizable channels |         | 8                    | 8                  |
| Parameterizable input delay <sup>2</sup>  |         | 0.05 ms .. 20 ms     | 0.05 ms .. 20 ms   |
| Process data length                       | Inputs  | 14 bytes             | 26 bytes           |
|                                           | Outputs | 14 bytes             | 26 bytes           |

<sup>1</sup> = Can also be used as default digital inputs via the parameter assignment as "Digital input without function".

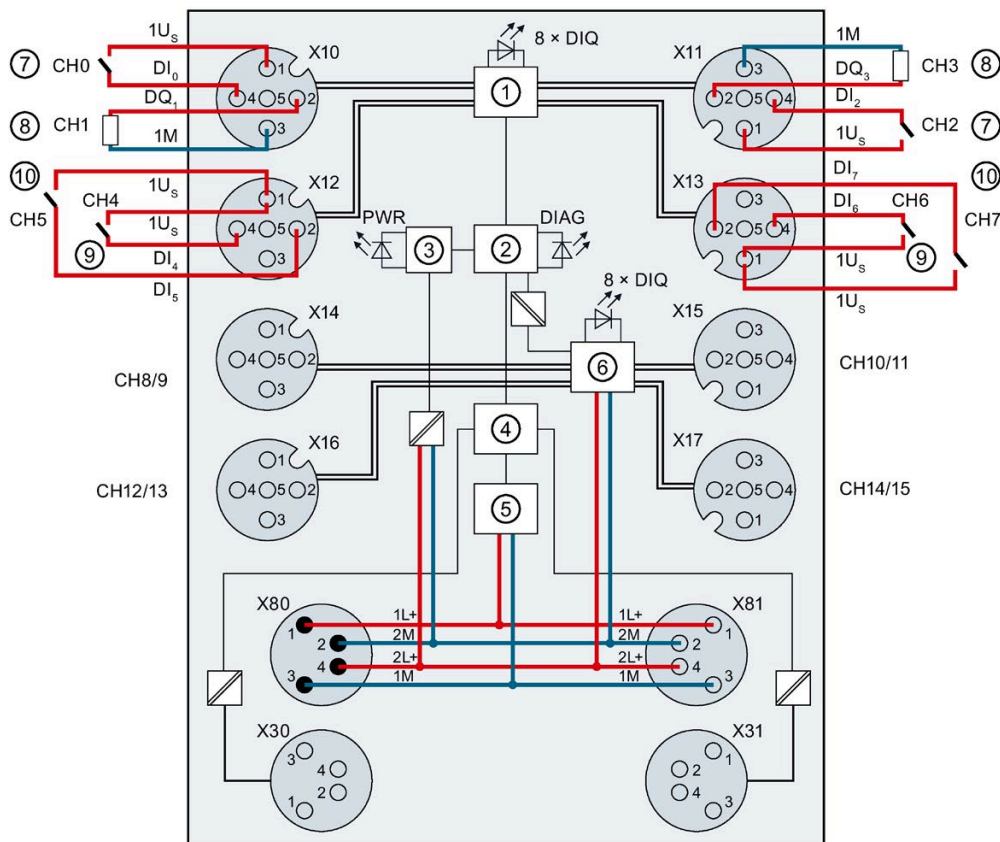
<sup>2</sup> = Only values as of 1.6 ms can be parameterized as the input delay for Channels 8..15.

## 4.1 Configuration method 2xCount

### 4.1.1 Wiring

#### 4.1.1.1 Terminal and block diagram

The following figure shows as an example the pin assignment of the counters in the configuration method Count (2xCount). Connection examples for allocating the freely parameterizable channels 8..15 are available in the section Configuration method DIQ, subsection Terminal and block diagram (Page 15).



|            |                                                                      |                  |                                       |
|------------|----------------------------------------------------------------------|------------------|---------------------------------------|
| ①          | DI/DQ circuit (1L+ non-switched)                                     | X81              | Loop-through of supply voltages       |
| ②          | Microcontroller                                                      | X30              | Infeed of the ET-Connection           |
| ③          | Monitoring                                                           | X31              | Loop-through of the ET-Connection     |
| ④          | ET-Connection interface                                              | 1L+              | Supply voltage 1L+ (non-switched)     |
| ⑤          | Internal supply voltage                                              | 1M               | Ground 1M (non-switched)              |
| ⑥          | DI/DQ circuit (2L+ switched)                                         | 2L+              | Load voltage 2L+ (switched)           |
| ⑦          | Counting input counter                                               | 2M               | Ground 2M (switched)                  |
| ⑧          | DQ for counters                                                      | 1Us              | 24 V encoder supply                   |
| ⑨          | Gate start/stop (level-controlled) or digital input without function | DIQ <sub>n</sub> | Input/output signal                   |
| ⑩          | Counting direction or digital input without function                 | DIQ              | Channel status LEDs (0 to 15) (green) |
| X10 to X17 | Channels 0 to 15                                                     | DIAG             | Diagnostic status LED (red/green)     |
| X80        | Infeed of supply voltages                                            | PWR              | LED supply voltage 2L+ (green)        |

Figure 4-1 Wiring and block diagram configuration method 2xCount

### 4.1.1.2 Pin assignment

#### Note

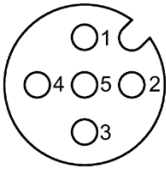
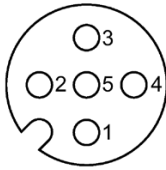
Color coding

The sockets for ET-Connection and the power supply of the modules are color-coded. These colors correspond to the colors of the offered cables.

### Pin assignment of the sockets for counting channels and digital inputs / outputs

The table below shows the pin assignments of the 4 sockets for the connection of the counting channels.

Table 4- 2 Pin assignment for counting channels

| Pin | Assignment                                                                                                                                                                                                                                  | Front view of the sockets                                                            |                                                                                      |
|-----|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------|
|     |                                                                                                                                                                                                                                             | X10, X12                                                                             | X11, X13                                                                             |
| 1   | 24 V encoder supply 1Us<br>(derived from 1L+ non-switched)                                                                                                                                                                                  |  |  |
| 2   | Count output for Counter 0: Connector X10<br>Counting output for Counter 1: Connector X11<br>Counting direction of Counter 0 or<br>Input signal DI5: Connector X12<br>Counting direction of Counter 1 or<br>Input signal DI7: Connector X13 |                                                                                      |                                                                                      |
| 3   | Ground 1M                                                                                                                                                                                                                                   |                                                                                      |                                                                                      |
| 4   | Count input for Counter 0: Connector X10<br>Count input for Counter 1: Connector X11<br>Counting direction of Counter 0 or<br>Input signal DI4: Connector X12<br>Counting direction of Counter 1 or<br>Input signal DI6: Connector X13      |                                                                                      |                                                                                      |
| 5   | Functional earth FE                                                                                                                                                                                                                         |                                                                                      |                                                                                      |

#### NOTICE

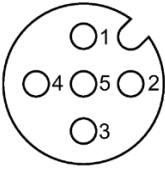
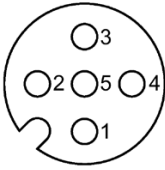
##### 24 V encoder supply 1Us

Use only the 24 V encoder supply 1Us provided by the digital input/digital output module to supply power to the encoder.

## 4.1 Configuration method 2xCount

The table below shows the pin assignments of the 4 sockets for the connection of the digital inputs / digital outputs.

Table 4- 3 Pin assignment for digital inputs/digital outputs

| Pin | Assignment                                                                                                                                                                                                                      | Front view of the sockets                                                           |                                                                                     |
|-----|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------|
|     | X14 to X17 - sockets for digital inputs / outputs                                                                                                                                                                               | X14, X16                                                                            | X15, X17                                                                            |
| 1   | 24 V encoder supply 2Us<br>(derived from 2L+ switched)                                                                                                                                                                          |  |  |
| 2   | Input/output signal DIQ <sub>9</sub> : Connector X14<br>Input/output signal DIQ <sub>11</sub> : Connector X15<br>Input/output signal DIQ <sub>13</sub> : Connector X16<br>Input/output signal DIQ <sub>15</sub> : Connector X17 |                                                                                     |                                                                                     |
| 3   | Ground 2M                                                                                                                                                                                                                       |                                                                                     |                                                                                     |
| 4   | Input/output signal DIQ <sub>8</sub> : Connector X14<br>Input/output signal DIQ <sub>10</sub> : Connector X15<br>Input/output signal DIQ <sub>12</sub> : Connector X16<br>Input/output signal DIQ <sub>14</sub> : Connector X17 |                                                                                     |                                                                                     |
| 5   | Functional earth FE                                                                                                                                                                                                             |                                                                                     |                                                                                     |

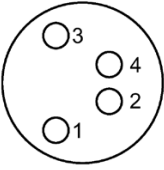
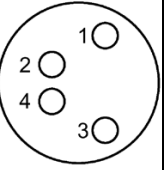
**NOTICE****24 V encoder supply 2Us**

Use only the 24 V encoder supply 2Us provided by the digital input/digital output module to supply power to the encoder.

**Pin assignment of the sockets for ET-Connection**

The table below shows the pin assignments of the 2 sockets for the connection of ET-Connection.

Table 4- 4 Pin assignment for ET-Connection

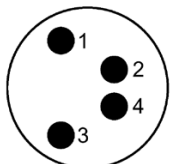
| Pin       | Assignment                    |                                | Assignment of the wire color of the bus line cable for ET-Connection | Front view of the sockets                                                             |                                                                                       |
|-----------|-------------------------------|--------------------------------|----------------------------------------------------------------------|---------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------|
|           | X30 socket (ET-Connection IN) | X31 socket (ET-Connection OUT) |                                                                      | X30                                                                                   | X31                                                                                   |
| 1         | TXP                           | RXP                            | Yellow                                                               |  |  |
| 2         | RXP                           | TXP                            | White                                                                |                                                                                       |                                                                                       |
| 3         | RXN                           | TXN                            | Blue                                                                 |                                                                                       |                                                                                       |
| 4         | TXN                           | RXN                            | Orange                                                               |                                                                                       |                                                                                       |
| Shielding | Functional earth FE           |                                | -                                                                    |                                                                                       |                                                                                       |



### Pin assignment of the connector for infeed of the supply voltage

The table below shows the pin assignment of the connector for infeed of the supply voltage.

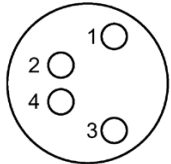
Table 4- 5 Pin assignment of the supply voltage connector

| Pin | Assignment                        | Assignment of the core color of the power cable | Front view of the connector                                                         |
|-----|-----------------------------------|-------------------------------------------------|-------------------------------------------------------------------------------------|
|     | X80 connector (POWER input)       |                                                 |                                                                                     |
| 1   | Supply voltage 1L+ (non-switched) | Brown                                           |  |
| 2   | Ground 2M (switched)              | White                                           |                                                                                     |
| 3   | Ground 1M (non-switched)          | Blue                                            |                                                                                     |
| 4   | Load voltage 2L+ (switched)       | Black                                           |                                                                                     |

### Pin assignment of the socket for loop-through of the supply voltage

The table below shows the pin assignment of the socket for loop-through of the supply voltage.

Table 4- 6 Pin assignment of the supply voltage socket

| Pin | Assignment                        | Assignment of the core color of the power cable | Front view of the socket                                                              |
|-----|-----------------------------------|-------------------------------------------------|---------------------------------------------------------------------------------------|
|     | X81 socket (POWER output)         |                                                 |                                                                                       |
| 1   | Supply voltage 1L+ (non-switched) | Brown                                           |  |
| 2   | Ground 2M (switched)              | White                                           |                                                                                       |
| 3   | Ground 1M (non-switched)          | Blue                                            |                                                                                       |
| 4   | Load voltage 2L+ (switched)       | Black                                           |                                                                                       |

#### NOTICE

##### ET-Connection/supply voltage

Observe the correct wiring of the M8 sockets for ET-Connection and the supply voltage.

Mixing up the ET-Connection connectors and the connectors for the supply voltage can destroy the module.

## 4.1.2 Parameters/address space

### 4.1.2.1 Parameters

In the configuration method 2xCount of the digital input / digital output module DIQ 16x24VDC/0.5A 8xM12 the Channels 0 to 7 are used by the counting function. The Channels 8 to 15 can be parameterized freely.

The following table shows the general parameter of the module.

Table 4- 7 General parameters

| Parameters                            | Value range                                                                                                           | Default   | Scope                                                                  |
|---------------------------------------|-----------------------------------------------------------------------------------------------------------------------|-----------|------------------------------------------------------------------------|
| Diagnostics: Missing load voltage 2L+ | <ul style="list-style-type: none"> <li>Disable</li> <li>Enable</li> </ul>                                             | Disable   | Module                                                                 |
| Diagnostics: Short-circuit to ground  | <ul style="list-style-type: none"> <li>Disable</li> <li>Enable</li> </ul>                                             | Disable   | Module<br>(Short-circuit of encoder supply or of the output to ground) |
| Behavior at CPU/master STOP (8...15)  | <ul style="list-style-type: none"> <li>Shut down</li> <li>Keep last value</li> <li>Output substitute value</li> </ul> | Shut down | Module<br>(digital outputs)                                            |

The following table shows the parameters of Counter 0 and Counter 1.

Table 4- 8 Parameters of Counter 0 and Counter 1

| Parameter                                                 | Value range                                                                                                                                                               | Default          | Scope   |
|-----------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------|---------|
| <b>Counting behavior Counter 0 (DI0), Counter 1 (DI2)</b> |                                                                                                                                                                           |                  |         |
| Input delay DI                                            | <ul style="list-style-type: none"> <li>0.05 ms</li> <li>0.1 ms</li> <li>0.4 ms</li> <li>0.8 ms</li> <li>1.6 ms</li> <li>3.2 ms</li> <li>12.8 ms</li> <li>20 ms</li> </ul> | 0.05 ms          | Counter |
| Counting direction <sup>1</sup>                           | <ul style="list-style-type: none"> <li>Forward</li> <li>Backward</li> </ul>                                                                                               | Forward          | Counter |
| Edge selection                                            | <ul style="list-style-type: none"> <li>On a rising edge</li> <li>On a falling edge</li> </ul>                                                                             | On a rising edge | Counter |

| Parameter                                        | Value range                                                                                                                                                                                     | Default                                                            | Scope   |
|--------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------|---------|
| Behavior when a counting limit is exceeded       | <ul style="list-style-type: none"> <li>Stop counting</li> <li>Continue counting</li> </ul>                                                                                                      | Stop counting                                                      | Counter |
| Comparison value                                 | -<br>2147483648...2147483647                                                                                                                                                                    | 10                                                                 | Counter |
| Start value <sup>2</sup>                         | -<br>2147483648...2147483647                                                                                                                                                                    | 0                                                                  | Counter |
| High count limit                                 | -<br>2147483648...2147483647                                                                                                                                                                    | 2147483647                                                         | Counter |
| Counter low limit <sup>2</sup>                   | -<br>2147483648...2147483647                                                                                                                                                                    | 0                                                                  | Counter |
| <b>Behavior Counter 0 (DQ1), Counter 1 (DQ3)</b> |                                                                                                                                                                                                 |                                                                    |         |
| Behavior DQ                                      | <ul style="list-style-type: none"> <li>Count value between a comparison value and the high counting limit</li> <li>Count value between a comparison value and the low counting limit</li> </ul> | Count value between a comparison value and the high counting limit | Counter |
| Hardware interrupt DQ                            | <ul style="list-style-type: none"> <li>Inactive</li> <li>Comparison event for DQ has occurred</li> </ul>                                                                                        | Inactive                                                           | Counter |
| Behavior at CPU/master STOP for DQ               | <ul style="list-style-type: none"> <li>Continue</li> <li>Output substitute value</li> </ul>                                                                                                     | Continue                                                           | Counter |
| Substitute value DQ                              | <ul style="list-style-type: none"> <li>0</li> <li>1</li> </ul>                                                                                                                                  | 0                                                                  | Counter |
| <b>Behavior Counter 0 (DI4), Counter 1 (DI6)</b> |                                                                                                                                                                                                 |                                                                    |         |
| Behavior DI                                      | <ul style="list-style-type: none"> <li>Digital input without function</li> <li>Gate start/stop (level-controlled)</li> </ul>                                                                    | Digital input without function                                     | Counter |

| Parameter                                        | Value range                                                                                                                                                               | Default                        | Scope   |
|--------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------|---------|
| <b>Behavior Counter 0 (DI5), Counter 1 (DI7)</b> |                                                                                                                                                                           |                                |         |
| Behavior DI                                      | <ul style="list-style-type: none"> <li>Digital input without function</li> <li>Counting direction</li> </ul>                                                              | Digital input without function | Counter |
| Input delay DI                                   | <ul style="list-style-type: none"> <li>0.05 ms</li> <li>0.1 ms</li> <li>0.4 ms</li> <li>0.8 ms</li> <li>1.6 ms</li> <li>3.2 ms</li> <li>12.8 ms</li> <li>20 ms</li> </ul> | 3.2 ms                         | Counter |

<sup>1</sup> = Is ignored if DI5/DI7 is parameterized as the direction input.

<sup>2</sup> = Cannot be parameterized with GSD file

The table below shows the parameters of the freely assignable Channels 8...15.

Table 4- 9 Parameter freely assignable Channels 8..15

| Parameter                 | Value range                                                                                              | Default | Scope                     |
|---------------------------|----------------------------------------------------------------------------------------------------------|---------|---------------------------|
| Freely assignable channel | <ul style="list-style-type: none"> <li>DI</li> <li>DQ</li> </ul>                                         | DI      | Channel                   |
| Substitute value channel  | <ul style="list-style-type: none"> <li>0</li> <li>1</li> </ul>                                           | 0       | Channel (digital outputs) |
| Input delay               | <ul style="list-style-type: none"> <li>1.6 ms</li> <li>3.2 ms</li> <li>12.8 ms</li> <li>20 ms</li> </ul> | 3.2 ms  | Channel (digital inputs)  |

## See also

Pin assignment (Page 33)

### 4.1.2.2 Explanation of the parameters

#### General parameters

**Diagnostics: Missing load voltage 2L+**

Enabling of the diagnostics for missing or insufficient load voltage 2L+.

**Diagnostics: Short circuit to ground**

Enabling of the diagnostics, at short-circuit of an encoder supply or of an output to ground.

**Behavior at CPU/master STOP (8...15)**

With this parameter you set the reaction of the digital outputs of after a CPU/master STOP.

Behavior DQ at freely assignable Channels 8...15:

- Deactivate: The digital output is de-energized.
- Keep last value: The last value of the digital output remains activated.
- Output substitute value: The digital output outputs a configured substitute value.

#### Parameter counting function

**Input delay DI**

This parameter can be used to suppress signal faults. Changes to the signal are only detected if they are constantly pending longer than the set input delay time.

---

**Note****Influences the counting frequency**

When setting the input delay take into account that the counting frequency possible is automatically reduced at higher values.

In order to achieve the maximum counting frequency of 2 kHz select an input delay smaller than 0.4 ms.

---

**Counting direction**

Use this parameter to select the direction in which counting is carried out:

- Forward
- Backward.

---

**Note**

If you have parameterized DI5 or DI7 as the direction input in the respective counter, this parameter is ineffective.

---

**Edge selection**

Use this parameter to select the edge that is counted:

- At rising edge:  
The respective counter counts all the rising edges at the counter input.
- At falling edge:  
The respective counter counts all the falling edges at the counter input.

---

**Note**

If you have parameterized DI<sub>5</sub> or DI<sub>7</sub> as the direction input in the respective counter and the counting direction changes in the process, the count edge is adapted automatically (contrary edges).

---

**Behavior when a counting limit is exceeded**

With this parameter you select the behavior when the high counting limit is violated in the upward direction or the low counting limit is violated in the downward direction:

- Stop counting:  
After a counting limit is violated, the internal gate is closed. This stops the counting process. The counter value is set to the opposite counting limit. To start the counting process again, you must close and reopen the SW gate.
- Continue counting:  
After a counting limit is violated, the counter value is set to the opposite counting limit and counting continues.

**Comparison value**

With this parameter you specify the comparison value.  
The following applies:

- Low counting limit  $\leq$  Comparison value  $\leq$  High counting limit

**Start value**

With this parameter you specify the start value.  
The following applies:

- Low counting limit  $\leq$  Start value  $\leq$  High counting limit

**High counting limit**

With this parameter you specify the high counting limit.  
The following applies:

- Low counting limit  $<$  High counting limit  $\leq 2147483647 (2^{31} - 1)$

**Low counting limit**

With this parameter you specify the low counting limit.  
The following applies:

- High counting limit  $>$  Low counting limit  $\geq -2147483648 (-2^{31})$

**Behavior DQ**

With the "Behavior DQ" you select the counter values at which the count output is set. When the current count value fulfils the parameterized condition, the associated count output is set.

This means the signal state "1" is set at the count output when:

- Count value between a comparison value and the high counting limit:  
Comparison value  $\leq$  Count value  $\leq$  High counting limit

or

- Count value between a comparison value and the low counting limit:  
Low counting limit  $\leq$  Count value  $\leq$  Comparison value.

**Hardware interrupt DQ**

With this parameter you specify whether or not a hardware interrupt is generated by the event "Comparison event occurred for DQ".

**Behavior at CPU/master STOP for DQ**

With this parameter you set the reaction of the count output of a counter after a CPU/master STOP.

Behavior DQ:

- Continue: Signal state of the count output continues to be controlled by comparison conditions.
- Output substitute value: The count output outputs a configured substitute value.

**Note****Count value at CPU/Master STOP**

Independently of the selected reaction of the count output, the count value continues to change during a CPU/Master STOP depending on the input edge, counting continues.

**Substitute value DQ**

With this parameter you set the substitute value of the digital output of a counter if the setting "Output substitute value" has been selected at the parameter "Behavior at CPU/master STOP for DQ".

**Behavior DI (gate control)**

With this parameter you select whether a counting function is assigned to the digital input or whether this functions like a standard digital input:

- Gate start/stop:  
The digital input influences the internal gate of Counter 0 or Counter 1. Signal "1" at the digital input opens the HW gate for the counter. Signal "0" at the digital input closes the HW gate for the counter.
- Digital input without function:  
No counting function is assigned to the digital input. It functions like a standard digital input.

**Behavior DI (direction input)**

With this parameter you select whether a counting function is assigned to the digital input or whether this functions like a standard digital input:

- Counting direction:  
The digital input reverses the counting direction at Counter 0 or Counter 1, in order to adjust it to the process. With signal "0" at the digital input, the counter forwards. With signal "1" at the digital input, the counter counts backwards.
- Digital input without function:  
No counting function is assigned to the digital input. It functions like a standard digital input.

**Parameter freely assignable Channels 8..15**

**Freely assignable channel**

With this parameter, you set whether the channel is to be operated as an input or output.

**Input delay channel**

This parameter can be used to suppress signal interference. Changes to the signal are only detected if they are constantly pending longer than the set input delay time.

**Substitute value channel**

With this parameter, you set substitute values for the digital outputs.

**See also**

Assignment of the feedback interface (Page 44)



### 4.1.2.3 Assignment of the control interface

The user program uses the control interface to influence the behavior of the counters and the channels 8...15 of the module parameterized as an output.

The figure below shows the address assignment of the module in the process image output in the configuration method 2xCount.

At Counter 0 x stands for the output byte QB 2 in this case, at Counter 1 you add 6 bytes to this output byte.

When you assign a different start address to the digital input/digital output module, the byte sequence changes correspondingly.

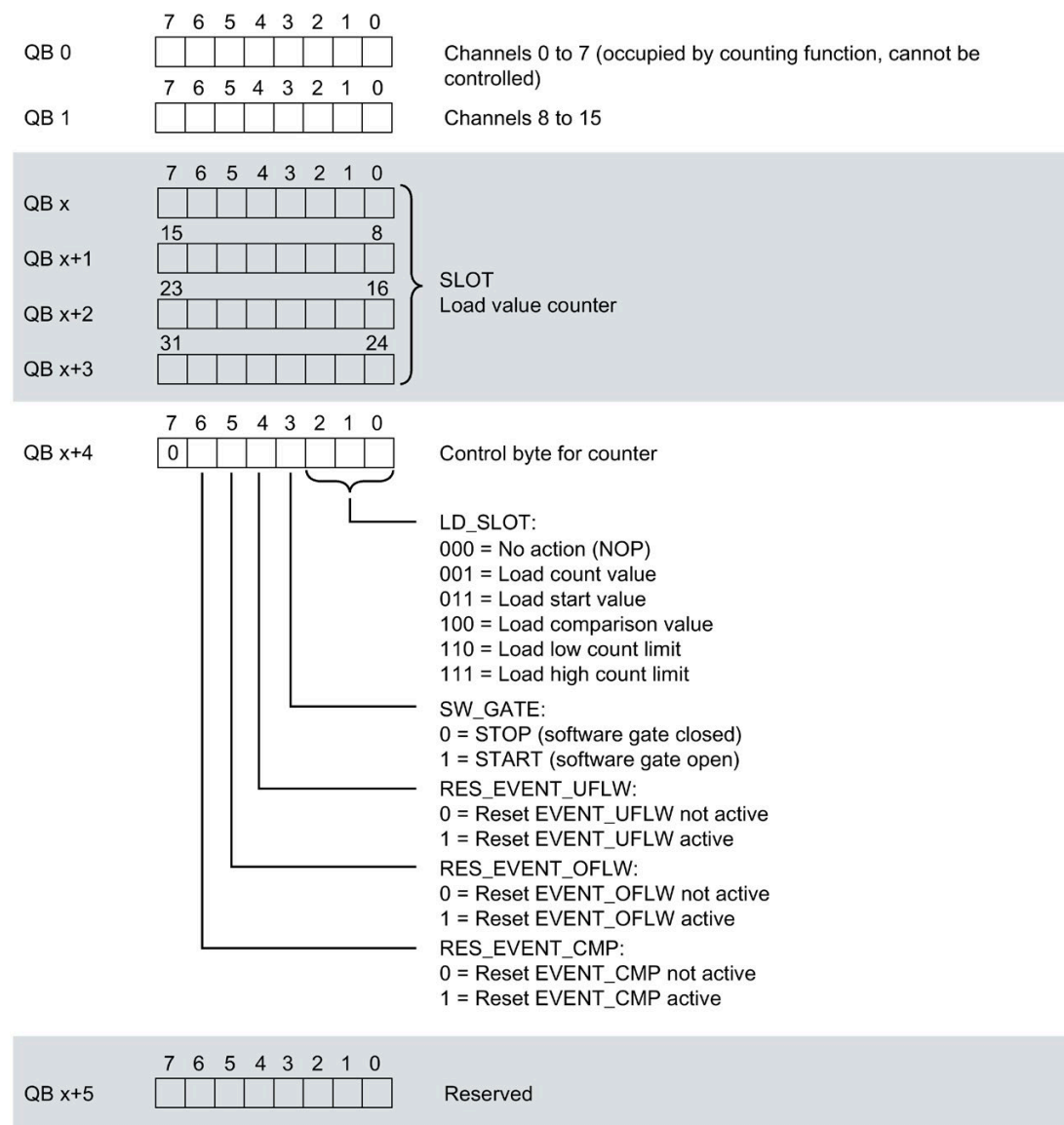


Figure 4-2 Address space control interface configuration method 2xCount

**Note****Parameter assignment of the channels**

The corresponding values in the output data do not trigger any reaction for all the channels that are used as an input.

You cannot control the count outputs via the user program.

#### 4.1.2.4 Explanations on the control interface

Table 4- 10 Explanations on the control bits

| Control bit    | Explanations                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |
|----------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| SLOT           | You specify the load value for the respective counter in these bytes. Through the load request LD_SLOT you load the predefined value into the counter.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |
| LD_SLOT        | With this load request you control for which value of the counter the value specified in SLOT is to be loaded.<br>The counter carries out the respective action as soon as LD_SLOT changes.<br>If you have entered the load request LD_SLOT = 011 <sub>8</sub> open the SW gate, every counting process begins with the value defined in the SLOT as the start value.<br>If you have entered a different load request and open the SW gate, counting is continued with the current count value at every start of the counting process.<br>Both cases also apply at a parameterized HW gate as long as and until the SW gate is closed. |
| SW_GATE        | With this bit you open and close the SW gate of the respective counter.<br>Together with the hardware gate the software gate forms the internal gate. The module only counts when the internal gate is open.<br>0 means: Software gate closed<br>1 means: Software gate open                                                                                                                                                                                                                                                                                                                                                           |
| RES_EVENT_UFLW | With this bit you trigger the resetting of the stored event in the feedback bit EVENT_UFLW for the respective counter.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |
| RES_EVENT_OFLW | With this bit you trigger the resetting of the stored event in the feedback bit EVENT_OFLW for the respective counter.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |
| RES_EVENT_CMP  | With this bit you trigger the resetting of the stored event in the feedback bit EVENT_CMP for the respective counter.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |

#### 4.1.2.5 Assignment of the feedback interface

##### Feedback interface

The user program receives current values and status information from the module via the feedback interface.

The figure below shows the address assignment of the module in the process image input in the configuration method 2xCount.

At Counter 0 x stands for the input byte IB 2 in this case, at Counter 1 you add 6 bytes to this output byte.

When you assign a different start address to the digital input/digital output module, the byte sequence changes correspondingly.

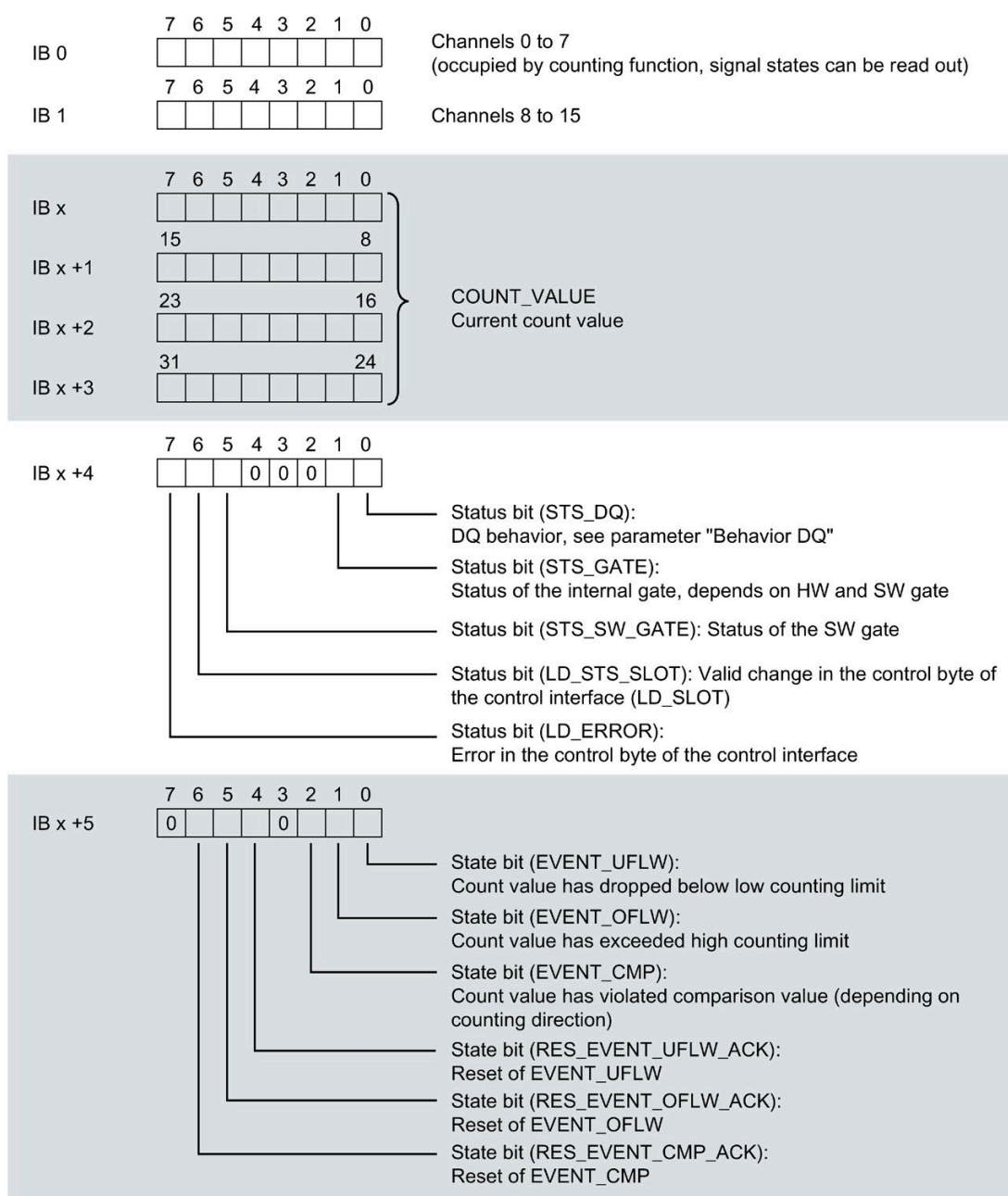


Figure 4-3 Address space feedback interface configuration method 2xCount

### 4.1.2.6 Explanations for the feedback interface

Table 4- 11 Explanations for the feedback bits

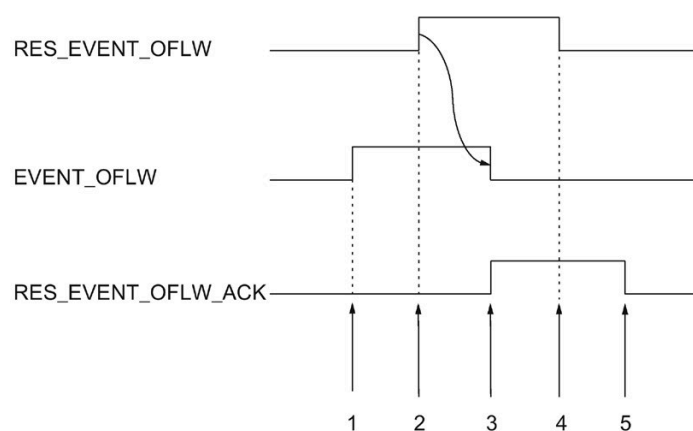
| Feedback bit       | Explanations                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |
|--------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| COUNT_VALUE        | This value supplies the current count value for the respective counter.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |
| STS_DQ             | This bit returns the current signal state of the count output.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |
| STS_GATE           | <p>Together with the hardware gate the software gate forms the internal gate. This bit shows the state of the internal gate for the respective counter. The module only counts when the internal gate is open.</p> <p>0 means: Internal gate closed / counter does not count<br/>1 means: internal Tor open / counter counts</p> <p><b>Note:</b><br/>After a POWER OFF / ON or a change in the parameterization, all the values of the changed counter are transferred again to the module. In the process the internal gate of the respective counter is closed and the count value is set to the start value. Close and open the respective SW gate to restart the counting process.</p> <p><b>Note:</b><br/>When the PROFIBUS interface model is used, the CPU/Master automatically generates the "rising edge" signal after disconnection/reconnection of the communications. This continues the counting process.</p> |
| STS_SW_GATE        | <p>This bit shows the status of the software gate.</p> <p>0 means: Software gate closed<br/>1 means: Software gate open</p>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |
| LD_STS_SLOT        | This bit indicates through a status change (toggling) for the respective counter that loading of the control interface has been carried out successfully.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |
| LD_ERROR           | <p>This bit indicates for the respective counter that an error has occurred during loading of the control interface.</p> <p>The load value was not accepted.</p> <p>One of the following conditions is fulfilled:</p> <ul style="list-style-type: none"> <li>• Low counting limit &gt; Count value</li> <li>• Low counting limit &gt; Start value</li> <li>• Low counting limit &gt; Comparison value</li> <li>• Count value &gt; High counting limit</li> <li>• Start value &gt; High counting limit</li> <li>• Comparison value &gt; High counting limit</li> <li>• Low counting limit <math>\geq</math> High counting limit</li> <li>• No valid load request in LD_SLOT</li> </ul>                                                                                                                                                                                                                                      |
| EVENT_UFLW         | <p>This bit shows for the respective counter whether an underflow (value dropped below the low count limit) has occurred.</p> <p>You reset the state by acknowledging with RES_EVENT_UFLW.</p>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |
| EVENT_OFLW         | <p>This bit shows for the respective counter whether an overflow (value exceeded the high count limit) has occurred.</p> <p>You reset the state by acknowledging with RES_EVENT_OFLW.</p>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |
| EVENT_CMP          | <p>This bit shows for the respective counter whether a comparison event with the comparison value has occurred.</p> <p>You reset the state by acknowledging with RES_EVENT_CMP.</p> <p>The EVENT_CMP bit is not set if the count value is set to the start value.</p>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |
| RES_EVENT_UFLW_ACK | This bit shows for the respective counter whether the resetting of the event bit EVENT_UFLW is active.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |

| Feedback bit       | Explanations                                                                                           |
|--------------------|--------------------------------------------------------------------------------------------------------|
| RES_EVENT_OFLW_ACK | This bit shows for the respective counter whether the resetting of the event bit EVENT_OFLW is active. |
| RES_EVENT_CMP_ACK  | This bit shows for the respective counter whether the resetting of the event bit EVENT_CMP is active.  |

## Complete acknowledgment principle

Storing bits are acknowledged in accordance with the complete acknowledgment principle.

The figure below shows an example for the course of the complete acknowledgment principle at an overflow:



- ① The feedback bit EVENT\_OFLW is set as a storing event at an overflow bit.
- ② The set the control bit RES\_EVENT\_OFLW in order to initiate resetting of EVENT\_OFLW.
- ③ The feedback bit RES\_EVENT\_OFLW\_ACK is set when the resetting of EVENT\_OFLW has been recognized.
- ④ You reset the control bit RES\_EVENT\_OFLW .
- ⑤ The feedback bit RES\_EVENT\_OFLW\_ACK is reset.

Figure 4-4 Acknowledgment principle

### Note

When you have initiated the resetting of an event bit, you have to wait for the respective feedback bit. You can initiate a further reset subsequently.

### Note

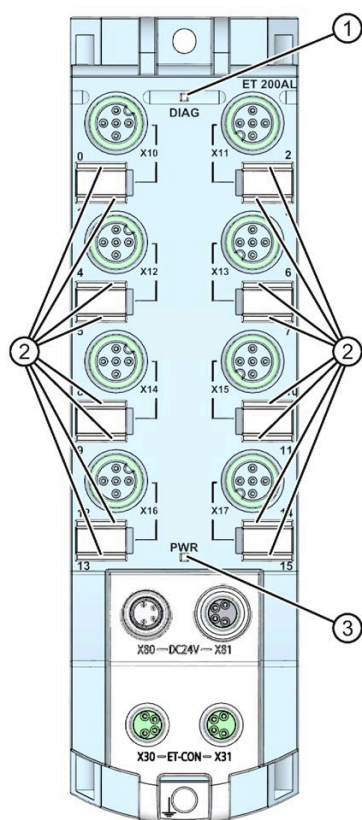
An opening of the SW gate or HW gate (0-1 transition) resets all event bits.

### 4.1.3 Interrupts/diagnostic alarms

#### 4.1.3.1 Status and error displays

##### LED displays

The figure below shows the LED displays (status and error displays) of the digital input module / digital output module DIQ 16x24VDC/0.5A 8xM12.



- ① Diagnostic status (DIAG) (red/green)
- ② Channel status (0 to 15) (green)
- ③ Load voltage 2L+ (PWR) (green)

Figure 4-5 LED displays

## Meaning of the LEDs

The following tables set out the meaning of the status and error displays. Remedial measures for diagnostic reports can be found in chapter Diagnostics alarms (Page 51).

### DIAG LED

Table 4- 12 Error display of the DIAG LED

| DIAG LED                                                                                      | Meaning                                                                                                                                                                                                                                                                                                     |
|-----------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <br>Off      | No supply voltage 1L+                                                                                                                                                                                                                                                                                       |
| <br>Flashes  | <ul style="list-style-type: none"> <li>Module parameters not assigned (after switching on the supply voltage 1L+)</li> <li>Loading firmware (while the firmware update is being performed, all LEDs retain their current status)</li> <li>No connection to the ET-Connection and/or the fieldbus</li> </ul> |
| <br>On       | Module parameters assigned and no module diagnostics                                                                                                                                                                                                                                                        |
| <br>Flashes | Module parameters assigned and module diagnostics                                                                                                                                                                                                                                                           |

### LED channel status

Table 4- 13 LED channel status display

| LED channel status                                                                         | Meaning            |
|--------------------------------------------------------------------------------------------|--------------------|
| <br>Off | Process signal = 0 |
| <br>On  | Process signal = 1 |

### PWR LED

Table 4- 14 Status display of the PWR LED

| PWR LED                                                                                    | Meaning                                |
|--------------------------------------------------------------------------------------------|----------------------------------------|
| <br>Off | Load voltage 2L+ is missing or too low |
| <br>On  | Load voltage 2L+ present               |

### 4.1.3.2 Interrupts

The digital input / digital output module DIQ 16x24VDC/0.5A 8xM12 in the configuration method 2xCount supports diagnostic and hardware interrupts.

#### Diagnostic interrupt

The digital input/digital output module generates a diagnostic interrupt at the following events:

- Short-circuit of an encoder supply to ground, or
- Short-circuit of an output to ground
- Load voltage 2L+ missing or too low
- Parameter assignment error

#### Hardware interrupt

The module generates a hardware interrupt at the following event:

- Comparison event occurred for DQ

For detailed information on the error event, refer to the hardware interrupt organization block with the "RALRM" instruction (read additional interrupt info) and to the STEP 7 online help.

The module channel that triggered the hardware interrupt is entered in the start information of the organization block. The figure below shows the assignment to the bits of the local data double word 8.

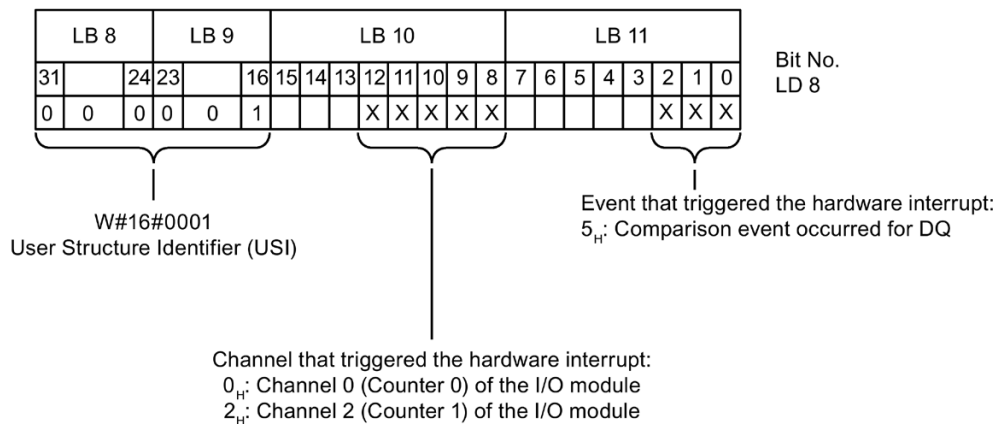


Figure 4-6 Start information of the organization block in the configuration method 2xCount



### 4.1.3.3 Diagnostics alarms

For each diagnostic event, a diagnostics alarm is issued and the LED DIAG flashes red on the digital input/digital output module.

You can read out the diagnostics alarms, for example, from the diagnostics buffer of the CPU. You can evaluate the error codes with the user program.

Table 4- 15 Diagnostics alarms, their meanings and corrective measures

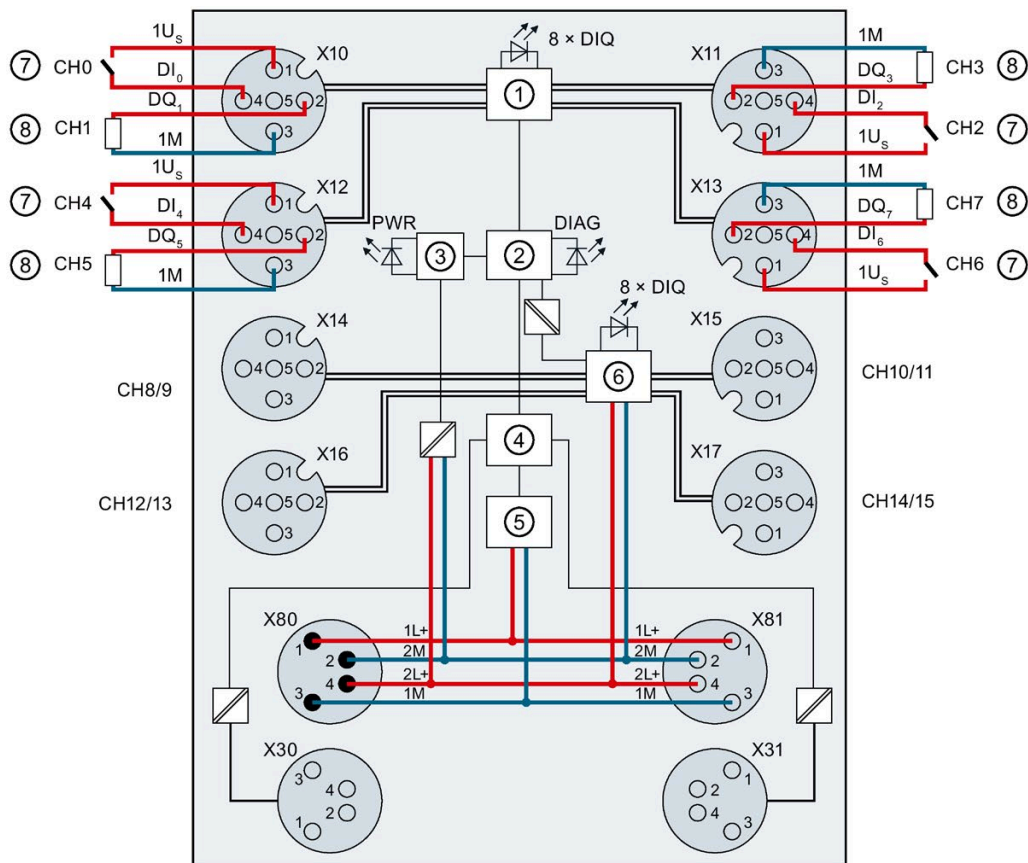
| Diagnostics alarm                                                                                                                                                                                                                                                                                                                                                            | Error code | Meaning                                                                                                 | Solution                                                                                             |
|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------|---------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------|
| Short circuit <sup>1</sup>                                                                                                                                                                                                                                                                                                                                                   | 1H         | Short-circuit of an encoder supply to ground                                                            | <ul style="list-style-type: none"> <li>Eliminate the short-circuit</li> </ul>                        |
|                                                                                                                                                                                                                                                                                                                                                                              |            | Short-circuit of an output to ground                                                                    |                                                                                                      |
| Parameter assignment error                                                                                                                                                                                                                                                                                                                                                   | 10H        | Module parameter assignment is faulty                                                                   | Correction of the parameter assignment                                                               |
| Load voltage 2L+ missing <sup>2</sup>                                                                                                                                                                                                                                                                                                                                        | 11H        | Load voltage 2L+ missing or too low                                                                     | <ul style="list-style-type: none"> <li>Check the supply voltage</li> <li>Check the module</li> </ul> |
| Hardware interrupt lost                                                                                                                                                                                                                                                                                                                                                      | 16H        | At least one hardware interrupt could not be signaled because too many hardware interrupts are pending. | Correct the program or the process                                                                   |
| <sup>1</sup> If a short-circuit of the encoder supply to ground is detected, the diagnostic alarm "Short-circuit" is always output. This alarm is output even if all channels are configured as outputs.<br><sup>2</sup> If you are using ET 200AL modules in connection with the ET 200SP distributed I/O system, the diagnostic alarm "Load voltage missing" is displayed. |            |                                                                                                         |                                                                                                      |

## 4.2 Configuration method 4xCount

### 4.2.1 Wiring

#### 4.2.1.1 Terminal and block diagram

The following figure shows as an example the pin assignment of the counters in the configuration method Count (4xCount). Connection examples for allocating the freely parameterizable channels 8..15 are available in the section Configuration method DIQ, subsection Terminal and block diagram (Page 15).



|            |                                  |                  |                                       |
|------------|----------------------------------|------------------|---------------------------------------|
| ①          | DI/DQ circuit (1L+ non-switched) | X30              | Infeed of the ET-Connection           |
| ②          | Microcontroller                  | X31              | Loop-through of the ET-Connection     |
| ③          | Monitoring                       | 1L+              | Supply voltage 1L+ (non-switched)     |
| ④          | ET-Connection interface          | 1M               | Ground 1M (non-switched)              |
| ⑤          | Internal supply voltage          | 2L+              | Load voltage 2L+ (switched)           |
| ⑥          | DI/DQ circuit (2L+ switched)     | 2M               | Ground 2M (switched)                  |
| ⑦          | Counting input counter           | 1Us              | 24 V encoder supply                   |
| ⑧          | DQ for counters                  | DIQ <sub>n</sub> | Input/output signal                   |
| X10 to X17 | Channels 0 to 15                 | DIQ              | Channel status LEDs (0 to 15) (green) |
| X80        | Infeed of supply voltages        | DIAG             | Diagnostic status LED (red/green)     |
| X81        | Loop-through of supply voltages  | PWR              | LED supply voltage 2L+ (green)        |

Figure 4-7 Wiring and block diagram configuration method 4xCount

### 4.2.1.2 Pin assignment

#### Note

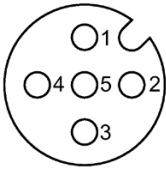
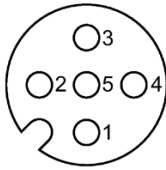
Color coding

The sockets for ET-Connection and the power supply of the modules are color-coded. These colors correspond to the colors of the offered cables.

### Pin assignment of the sockets for counting channels and digital inputs / outputs

The table below shows the pin assignments of the 4 sockets for the connection of the counting channels.

Table 4- 16 Pin assignment for counting channels

| Pin | Assignment                                                                                                                                                                                | Front view of the sockets                                                            |                                                                                      |
|-----|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------|
|     | X10 to X13 - sockets for counting channels                                                                                                                                                | X10, X12                                                                             | X11, X13                                                                             |
| 1   | 24 V encoder supply 1Us<br>(derived from 1L+ non-switched)                                                                                                                                |  |  |
| 2   | Count output for Counter 0: Connector X10<br>Counting output for Counter 1: Connector X11<br>Counting output for Counter 2: Connector X12<br>Counting output for Counter 3: Connector X13 |                                                                                      |                                                                                      |
| 3   | Ground 1M                                                                                                                                                                                 |                                                                                      |                                                                                      |
| 4   | Count input for Counter 0: Connector X10<br>Count input for Counter 1: Connector X11<br>Count input for Counter 2: Connector X12<br>Count input for Counter 3: Connector X13              |                                                                                      |                                                                                      |
| 5   | Functional earth FE                                                                                                                                                                       |                                                                                      |                                                                                      |

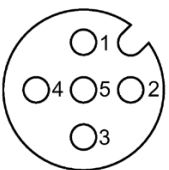
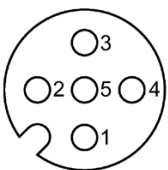
#### NOTICE

##### 24 V encoder supply 1Us

Use only the 24 V encoder supply 1Us provided by the digital input/digital output module to supply power to the encoder.

The table below shows the pin assignments of the 4 sockets for the connection of the digital inputs / digital outputs.

Table 4- 17 Pin assignment for digital inputs/digital outputs

| Pin | Assignment                                                                                                                                                                                                                      | Front view of the sockets                                                           |                                                                                     |
|-----|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------|
|     | X14 to X17 - sockets for digital inputs / outputs                                                                                                                                                                               | X14, X16                                                                            | X15, X17                                                                            |
| 1   | 24 V encoder supply 2Us<br>(derived from 2L+ switched)                                                                                                                                                                          |  |  |
| 2   | Input/output signal DIQ <sub>9</sub> : Connector X14<br>Input/output signal DIQ <sub>11</sub> : Connector X15<br>Input/output signal DIQ <sub>13</sub> : Connector X16<br>Input/output signal DIQ <sub>15</sub> : Connector X17 |                                                                                     |                                                                                     |
| 3   | Ground 2M                                                                                                                                                                                                                       |                                                                                     |                                                                                     |
| 4   | Input/output signal DIQ <sub>8</sub> : Connector X14<br>Input/output signal DIQ <sub>10</sub> : Connector X15<br>Input/output signal DIQ <sub>12</sub> : Connector X16<br>Input/output signal DIQ <sub>14</sub> : Connector X17 |                                                                                     |                                                                                     |
| 5   | Functional earth FE                                                                                                                                                                                                             |                                                                                     |                                                                                     |

#### NOTICE

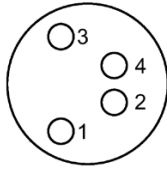
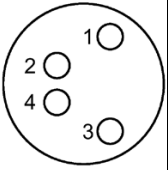
##### 24 V encoder supply 2Us

Use only the 24 V encoder supplies 2Us provided by the digital input/digital output module to supply power to the encoder.

### Pin assignment of the sockets for ET-Connection

The table below shows the pin assignments of the 2 sockets for the connection of ET-Connection.

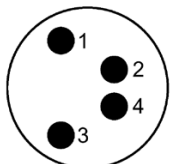
Table 4- 18 Pin assignment for ET-Connection

| Pin       | Assignment                    |                                | Assignment of the wire color of the bus line cable for ET-Connection | Front view of the sockets                                                             |                                                                                       |
|-----------|-------------------------------|--------------------------------|----------------------------------------------------------------------|---------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------|
|           | X30 socket (ET-Connection IN) | X31 socket (ET-Connection OUT) |                                                                      | X30                                                                                   | X31                                                                                   |
| 1         | TXP                           | RXP                            | Yellow                                                               |  |  |
| 2         | RXP                           | TXP                            | White                                                                |                                                                                       |                                                                                       |
| 3         | RXN                           | TXN                            | Blue                                                                 |                                                                                       |                                                                                       |
| 4         | TXN                           | RXN                            | Orange                                                               |                                                                                       |                                                                                       |
| Shielding | Functional earth FE           |                                | -                                                                    |                                                                                       |                                                                                       |

### Pin assignment of the connector for infeed of the supply voltage

The table below shows the pin assignment of the connector for infeed of the supply voltage.

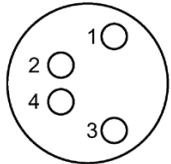
Table 4- 19 Pin assignment of the supply voltage connector

| Pin | Assignment                        | Assignment of the core color of the power cable | Front view of the connector                                                         |
|-----|-----------------------------------|-------------------------------------------------|-------------------------------------------------------------------------------------|
|     | X80 connector (POWER input)       |                                                 |                                                                                     |
| 1   | Supply voltage 1L+ (non-switched) | Brown                                           |  |
| 2   | Ground 2M (switched)              | White                                           |                                                                                     |
| 3   | Ground 1M (non-switched)          | Blue                                            |                                                                                     |
| 4   | Load voltage 2L+ (switched)       | Black                                           |                                                                                     |

### Pin assignment of the socket for loop-through of the supply voltage

The table below shows the pin assignment of the socket for loop-through of the supply voltage.

Table 4- 20 Pin assignment of the supply voltage socket

| Pin | Assignment                        | Assignment of the core color of the power cable | Front view of the socket                                                              |
|-----|-----------------------------------|-------------------------------------------------|---------------------------------------------------------------------------------------|
|     | X81 socket (POWER output)         |                                                 |                                                                                       |
| 1   | Supply voltage 1L+ (non-switched) | Brown                                           |  |
| 2   | Ground 2M (switched)              | White                                           |                                                                                       |
| 3   | Ground 1M (non-switched)          | Blue                                            |                                                                                       |
| 4   | Load voltage 2L+ (switched)       | Black                                           |                                                                                       |

#### NOTICE

##### ET-Connection/supply voltage

Observe the correct wiring of the M8 sockets for ET-Connection and the supply voltage.

Mixing up the ET-Connection connectors and the connectors for the supply voltage can destroy the module.

## 4.2.2 Parameters/address space

### 4.2.2.1 Parameters

In the configuration method 4xCount of the digital input / digital output module DIQ 16x24VDC/0.5A 8xM12 the Channels 0 to 7 are used by the counting function. The Channels 8 to 15 can be parameterized freely.

The following table shows the general parameter of the module.

Table 4- 21 General parameters

| Parameters                            | Value range                                                                                                           | Default   | Scope                                                                      |
|---------------------------------------|-----------------------------------------------------------------------------------------------------------------------|-----------|----------------------------------------------------------------------------|
| Diagnostics: Missing load voltage 2L+ | <ul style="list-style-type: none"> <li>Disable</li> <li>Enable</li> </ul>                                             | Disable   | Module                                                                     |
| Diagnostics: Short-circuit to ground  | <ul style="list-style-type: none"> <li>Disable</li> <li>Enable</li> </ul>                                             | Disable   | Module<br>(Short-circuit of the encoder supply or of the output to ground) |
| Behavior at CPU/master STOP (8...15)  | <ul style="list-style-type: none"> <li>Shut down</li> <li>Keep last value</li> <li>Output substitute value</li> </ul> | Shut down | Module<br>(digital outputs)                                                |

The table below shows the parameters of Counter 0 to Counter 3.

Table 4- 22 Parameters of Counter 0 to Counter 3

| Parameter                                                                                      | Value range                                                                                                                                                               | Default          | Scope   |
|------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------|---------|
| <b>Counting behavior Counter 0 (DI0), Counter 1 (DI2), Counter 2 (DI4) and Counter 3 (DI6)</b> |                                                                                                                                                                           |                  |         |
| Input delay DI                                                                                 | <ul style="list-style-type: none"> <li>0.05 ms</li> <li>0.1 ms</li> <li>0.4 ms</li> <li>0.8 ms</li> <li>1.6 ms</li> <li>3.2 ms</li> <li>12.8 ms</li> <li>20 ms</li> </ul> | 0.05 ms          | Counter |
| Counting direction                                                                             | <ul style="list-style-type: none"> <li>Forward</li> <li>Backward</li> </ul>                                                                                               | Forward          | Counter |
| Edge selection                                                                                 | <ul style="list-style-type: none"> <li>On a rising edge</li> <li>On a falling edge</li> </ul>                                                                             | On a rising edge | Counter |

| Parameter                                                                          | Value range                                                                                                                                                                                     | Default                                                            | Scope   |
|------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------|---------|
| Behavior when a counting limit is exceeded                                         | <ul style="list-style-type: none"> <li>Stop counting</li> <li>Continue counting</li> </ul>                                                                                                      | Stop counting                                                      | Counter |
| Comparison value                                                                   | -<br>2147483648...2147483647                                                                                                                                                                    | 10                                                                 | Counter |
| Start value <sup>1</sup>                                                           | -<br>2147483648...2147483647                                                                                                                                                                    | 0                                                                  | Counter |
| High count limit                                                                   | -<br>2147483648...2147483647                                                                                                                                                                    | 2147483647                                                         | Counter |
| Low counting limit <sup>1</sup>                                                    | -<br>2147483648...2147483647                                                                                                                                                                    | 0                                                                  | Counter |
| <b>Behavior Counter 0 (DQ1), Counter 1 (DQ3), Counter 2 (DQ5), Counter 3 (DQ7)</b> |                                                                                                                                                                                                 |                                                                    |         |
| Behavior DQ                                                                        | <ul style="list-style-type: none"> <li>Count value between a comparison value and the high counting limit</li> <li>Count value between a comparison value and the low counting limit</li> </ul> | Count value between a comparison value and the high counting limit | Counter |
| Hardware interrupt DQ                                                              | <ul style="list-style-type: none"> <li>Inactive</li> <li>Comparison event for DQ has occurred</li> </ul>                                                                                        | Inactive                                                           | Counter |
| Behavior at CPU/master STOP for DQ                                                 | <ul style="list-style-type: none"> <li>Continue</li> <li>Output substitute value</li> </ul>                                                                                                     | Continue                                                           | Counter |
| Substitute value DQ                                                                | <ul style="list-style-type: none"> <li>0</li> <li>1</li> </ul>                                                                                                                                  | 0                                                                  | Counter |

<sup>1</sup> = Cannot be parameterized with GSD file

The table below shows the parameters of the freely assignable Channels 8...15.

Table 4- 23 Parameter freely assignable Channels 8..15

| Parameter                 | Value range                                                                                                      | Default | Scope                        |
|---------------------------|------------------------------------------------------------------------------------------------------------------|---------|------------------------------|
| Freely assignable channel | <ul style="list-style-type: none"> <li>• DI</li> <li>• DQ</li> </ul>                                             | DI      | Channel                      |
| Substitute value channel  | <ul style="list-style-type: none"> <li>• 0</li> <li>• 1</li> </ul>                                               | 0       | Channel<br>(digital outputs) |
| Input delay               | <ul style="list-style-type: none"> <li>• 1.6 ms</li> <li>• 3.2 ms</li> <li>• 12.8 ms</li> <li>• 20 ms</li> </ul> | 3.2 ms  | Channel<br>(digital inputs)  |

## See also

Pin assignment (Page 53)

### 4.2.2.2 Explanation of the parameters

#### General parameters

##### **Diagnostics: Missing load voltage 2L+**

Enabling of the diagnostics for missing or insufficient load voltage 2L+.

##### **Diagnostics: Short circuit to ground**

Enabling of the diagnostics, at short-circuit of an encoder supply or of an output to ground.

##### **Behavior at CPU/master STOP (8...15)**

With this parameter you set the reaction of the digital outputs of after a CPU/master STOP.  
Behavior DQ at freely assignable Channels 8...15:

- Deactivate: The digital output is de-energized.
- Keep last value: The last value of the digital output remains activated.
- Output substitute value: The digital output outputs a configured substitute value.



## Parameter counting function

### Input delay DI

This parameter can be used to suppress signal faults. Changes to the signal are only detected if they are constantly pending longer than the set input delay time.

---

### Note

#### Influences the counting frequency

When setting the input delay take into account that the counting frequency possible is automatically reduced at higher values.

In order to achieve the maximum counting frequency of 2 kHz select an input delay smaller than 0.4 ms.

---

### Counting direction

Use this parameter to select the direction in which counting is carried out:

- Forward
- Backward.

### Edge selection

Use this parameter to select the edge that is counted:

- At rising edge:  
The respective counter counts all the rising edges at the counter input.
- At falling edge:  
The respective counter counts all the falling edges at the counter input.

### Behavior when a counting limit is exceeded

With this parameter you select the behavior when the high counting limit is violated in the upward direction or the low counting limit is violated in the downward direction:

- Stop counting:  
After a counting limit is violated, the internal gate is closed. This stops the counting process. The counter value is set to the opposite counting limit. To start the counting process again, you must close and reopen the SW gate.
- Continue counting:  
After a counting limit is violated, the counter value is set to the opposite counting limit and counting continues.

### Comparison value

With this parameter you specify the comparison value.

The following applies:

- $\text{Low counting limit} \leq \text{Comparison value} \leq \text{High counting limit}$

### Start value

With this parameter you specify the start value.

The following applies:

- $\text{Low counting limit} \leq \text{Start value} \leq \text{High counting limit}$

**High counting limit**

With this parameter you specify the high counting limit.

The following applies:

- Low counting limit < High counting limit  $\leq 2147483647 (2^{31} - 1)$

**Low counting limit**

With this parameter you specify the low counting limit.

The following applies:

- High counting limit > Low counting limit  $\geq -2147483648 (-2^{31})$

**Behavior DQ**

With the "Behavior DQ" you select the counter values at which the count output is set. When the current count value fulfils the parameterized condition, the associated count output is set.

This means the signal state "1" is set at the count output when:

- Count value between a comparison value and the high counting limit:  
Comparison value  $\leq$  Count value  $\leq$  High counting limit

or

- Count value between a comparison value and the low counting limit:  
Low counting limit  $\leq$  Count value  $\leq$  Comparison value.

**Hardware interrupt DQ**

With this parameter you specify whether or not a hardware interrupt is generated by the event "Comparison event occurred for DQ".

**Behavior at CPU/master STOP for DQ**

With this parameter you set the reaction of the count output of a counter after a CPU/master STOP.

Behavior DQ:

- Continue: Signal state of the count output continues to be controlled by comparison conditions.
- Output substitute value: The count output outputs a configured substitute value.

---

**Note****Count value at CPU/Master STOP**

Independently of the selected reaction of the count output, the count value continues to change during a CPU/Master STOP depending on the input edge, counting continues.

---

**Substitute value DQ**

With this parameter you set the substitute value of the digital output of a counter if the setting "Output substitute value" has been selected at the parameter "Behavior at CPU/master STOP for DQ".

**Parameter freely assignable Channels 8..15****Freely assignable channel**

With this parameter, you set whether the channel is to be operated as an input or output.

**Input delay channel**

This parameter can be used to suppress signal interference. Changes to the signal are only detected if they are constantly pending longer than the set input delay time.

**Substitute value channel**

With this parameter, you set substitute values for the digital outputs.

### 4.2.2.3 Assignment of the control interface

The user program uses the control interface to influence the behavior of the counters and the channels 8...15 of the module parameterized as an output.

The figure below shows the address assignment of the module in the process image output in the configuration method 4xCount.

At Counter 0 x stands for the output byte QB 2 in this case, at Counters 1 to 3 you add 6 bytes, 12 bytes and 18 bytes respectively to this output byte.

When you assign a different start address to the digital input/digital output module, the byte sequence changes correspondingly.

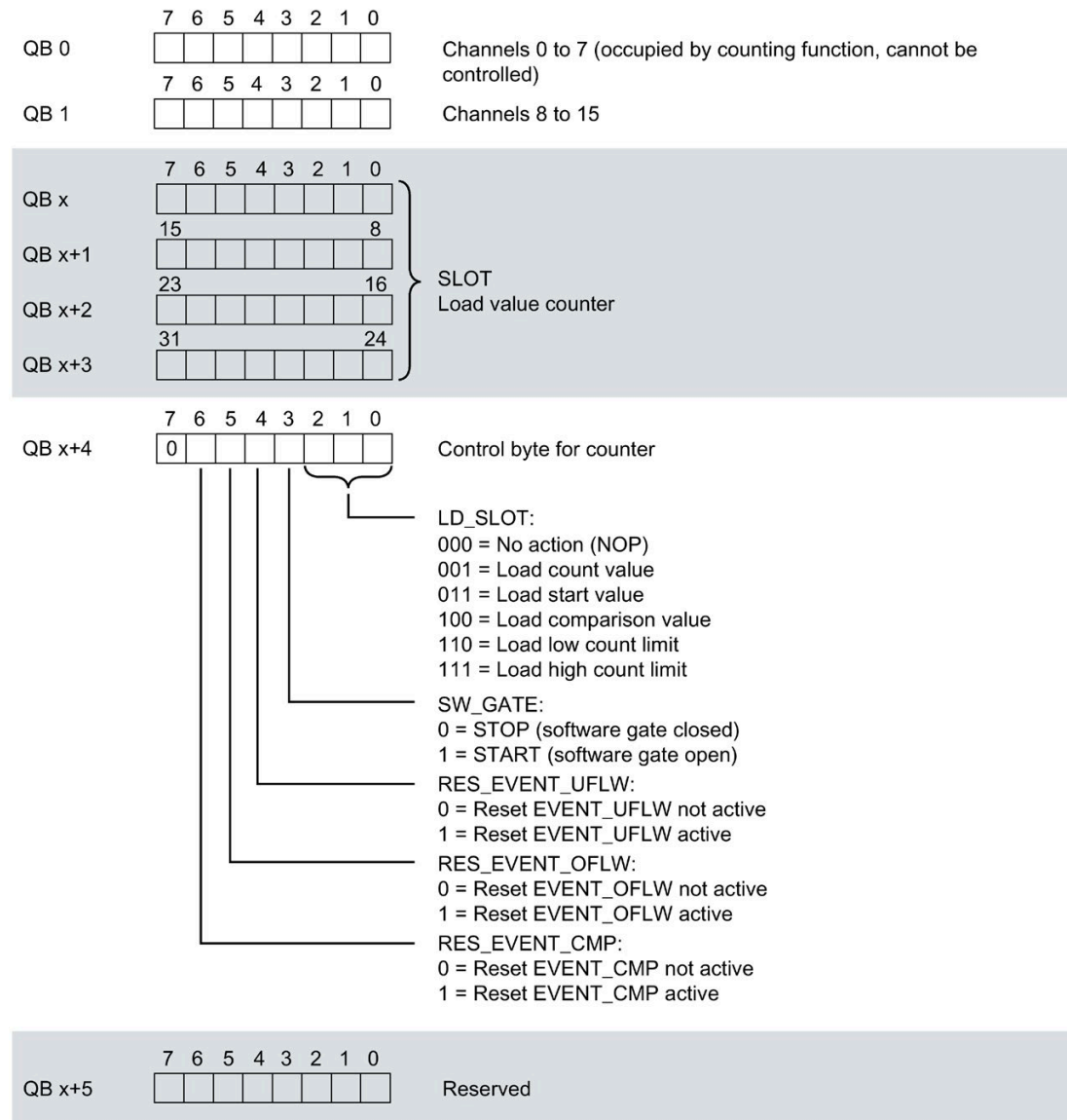


Figure 4-8 Address space control interface configuration method 4xCount

**Note****Parameter assignment of the channels**

The corresponding values in the output data do not trigger any reaction for all the channels that are used as an input.

You cannot control the count outputs via the user program.

#### 4.2.2.4 Explanations on the control interface

Table 4- 24 Explanations on the control bits

| Control bit    | Explanations                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |
|----------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| SLOT           | You specify the load value for the respective counter in these bytes. Through the load request LD_SLOT you load the predefined value into the counter.                                                                                                                                                                                                                                                                                                                                                                                                                                                 |
| LD_SLOT        | With this load request you control for which value of the counter the value specified in SLOT is to be loaded.<br>The counter carries out the respective action as soon as LD_SLOT changes.<br>If you have entered the load request LD_SLOT = 011 <sub>B</sub> open the SW gate, every counting process begins with the value defined in the SLOT as the start value.<br>If you have entered a different load request and open the SW gate, counting is continued with the current count value at every start of the counting process.<br>Both cases apply as long as and until the SW gate is closed. |
| SW_GATE        | With this bit you open and close the SW gate of the respective counter. The module only counts when the software gate is open.<br>0 means: Software gate closed<br>1 means: Software gate open                                                                                                                                                                                                                                                                                                                                                                                                         |
| RES_EVENT_UFLW | With this bit you trigger the resetting of the stored event in the feedback bit EVENT_UFLW for the respective counter.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |
| RES_EVENT_OFLW | With this bit you trigger the resetting of the stored event in the feedback bit EVENT_OFLW for the respective counter.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |
| RES_EVENT_CMP  | With this bit you trigger the resetting of the stored event in the feedback bit EVENT_CMP for the respective counter.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |

#### 4.2.2.5 Assignment of the feedback interface

##### Feedback interface

The user program receives current values and status information from the module via the feedback interface.

The figure below shows the address assignment of the module in the process image input in the configuration method 4xCount.

At Counter 0 x stands for the input byte IB 2 in this case, at Counters 1 to 3 you add 6 bytes, 12 bytes and 18 bytes respectively to this input byte.

When you assign a different start address to the digital input/digital output module, the byte sequence changes correspondingly.

## 4.2 Configuration method 4xCount

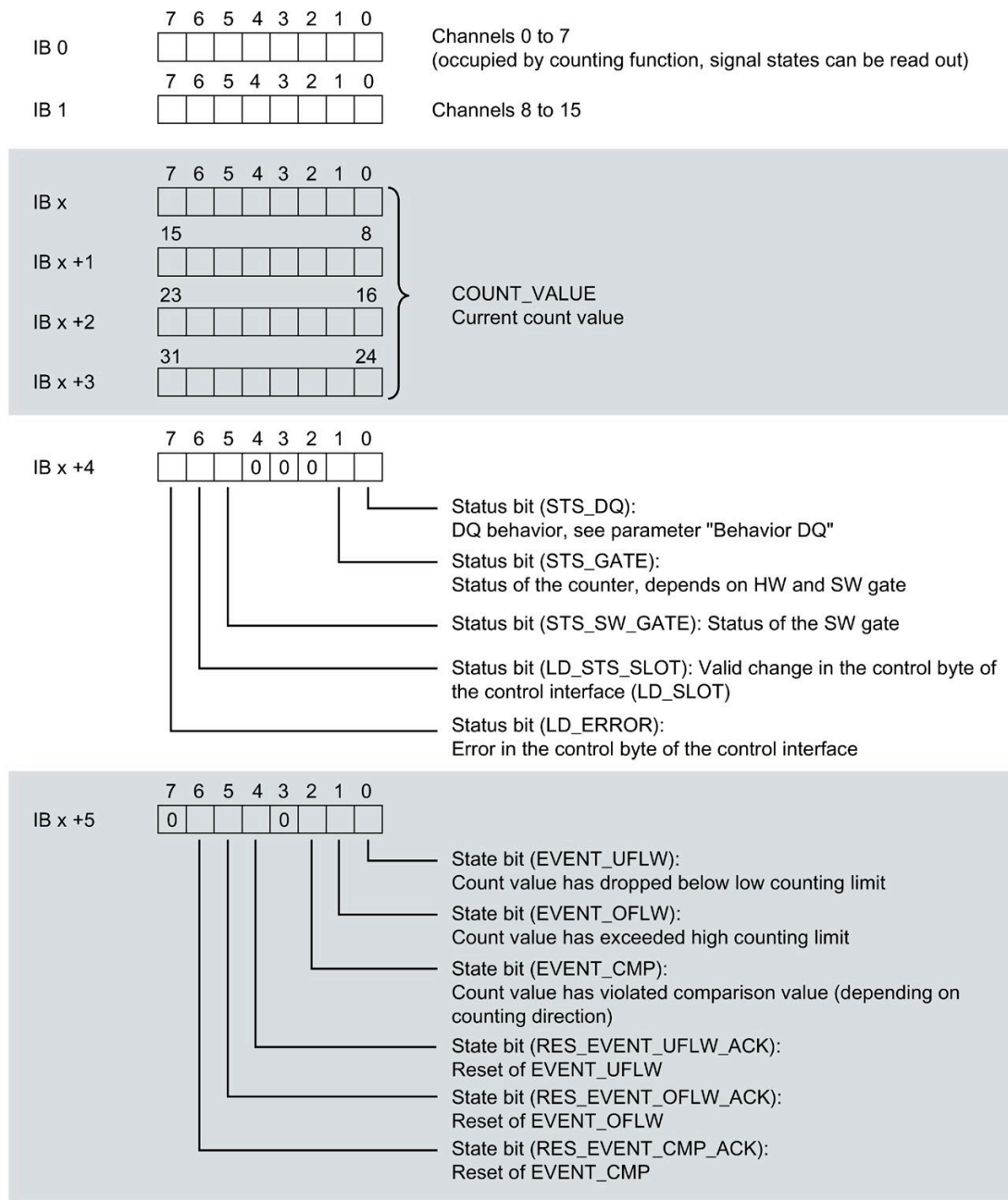


Figure 4-9 Address space feedback interface configuration method 4xCount

### 4.2.2.6 Explanations for the feedback interface

Table 4- 25 Explanations for the feedback bits

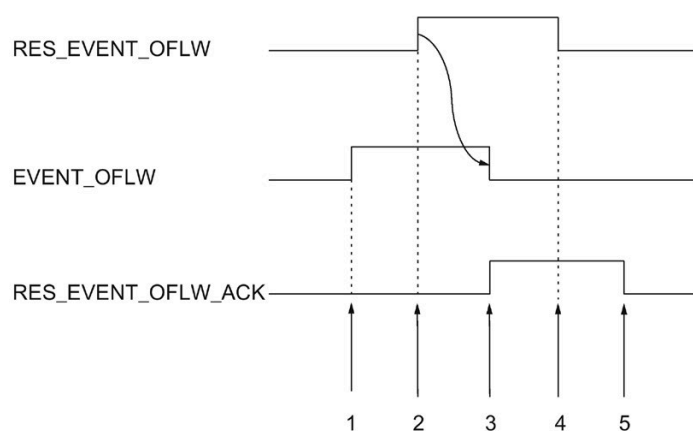
| Feedback bit       | Explanations                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |
|--------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| COUNT_VALUE        | This value supplies the current count value for the respective counter.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |
| STS_DQ             | This bit returns the current signal state of the count output.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |
| STS_GATE           | <p>This bit shows the state of the internal gate for the respective counter. The module only counts when the internal gate is open.</p> <p>0 means: Internal gate closed / counter does not count<br/>1 means: internal Tor open / counter counts</p> <p><b>Note:</b><br/>After a POWER OFF / ON or a change in the parameterization, all the values of the changed counter are transferred again to the module. In the process the internal gate of the respective counter is closed and the count value is set to the start value. Close and open the respective SW gate to restart the counting process.</p> <p><b>Note:</b><br/>When the PROFIBUS interface model is used, the CPU/Master automatically generates the "rising edge" signal after disconnection/reconnection of the communications. This continues the counting process.</p> |
| STS_SW_GATE        | <p>This bit shows the status of the software gate.</p> <p>0 means: Software gate closed<br/>1 means: Software gate open</p>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |
| LD_STS_SLOT        | This bit indicates through a status change (toggling) for the respective counter that loading of the control interface has been carried out successfully.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |
| LD_ERROR           | <p>This bit indicates for the respective counter that an error has occurred during loading of the control interface.</p> <p>The load value was not accepted.</p> <p>One of the following conditions is fulfilled:</p> <ul style="list-style-type: none"> <li>• Low counting limit &gt; Count value</li> <li>• Low counting limit &gt; Start value</li> <li>• Low counting limit &gt; Comparison value</li> <li>• Count value &gt; High counting limit</li> <li>• Start value &gt; High counting limit</li> <li>• Comparison value &gt; High counting limit</li> <li>• Low counting limit <math>\geq</math> High counting limit</li> <li>• No valid load request in LD_SLOT</li> </ul>                                                                                                                                                           |
| EVENT_UFLW         | <p>This bit shows for the respective counter whether an underflow (value dropped below the low count limit) has occurred.</p> <p>You reset the state by acknowledging with RES_EVENT_UFLW.</p>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |
| EVENT_OFLW         | <p>This bit shows for the respective counter whether an overflow (value exceeded the high count limit) has occurred.</p> <p>You reset the state by acknowledging with RES_EVENT_OFLW.</p>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |
| EVENT_CMP          | <p>This bit shows for the respective counter whether a comparison event with the comparison value has occurred.</p> <p>You reset the state by acknowledging with RES_EVENT_CMP.</p> <p>The EVENT_CMP bit is not set if the count value is set to the start value.</p>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |
| RES_EVENT_UFLW_ACK | This bit shows for the respective counter whether the resetting of the event bit EVENT_UFLW is active.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |

| Feedback bit       | Explanations                                                                                           |
|--------------------|--------------------------------------------------------------------------------------------------------|
| RES_EVENT_OFLW_ACK | This bit shows for the respective counter whether the resetting of the event bit EVENT_OFLW is active. |
| RES_EVENT_CMP_ACK  | This bit shows for the respective counter whether the resetting of the event bit EVENT_CMP is active.  |

### Complete acknowledgment principle

Storing bits are acknowledged in accordance with the complete acknowledgment principle.

The figure below shows an example for the course of the complete acknowledgment principle at an overflow:



- ① The feedback bit EVENT\_OFLW is set as a storing event at an overflow bit.
- ② The set the control bit RES\_EVENT\_OFLW in order to initiate resetting of EVENT\_OFLW.
- ③ The feedback bit RES\_EVENT\_OFLW\_ACK is set when the resetting of EVENT\_OFLW has been recognized.
- ④ You reset the control bit RES\_EVENT\_OFLW .
- ⑤ The feedback bit RES\_EVENT\_OFLW\_ACK is reset.

Figure 4-10 Acknowledgment principle

#### Note

When you have initiated the resetting of an event bit, you have to wait for the respective feedback bit. You can initiate a further reset subsequently.

#### Note

An opening of the SW gate or HW gate (0-1 transition) resets all event bits.

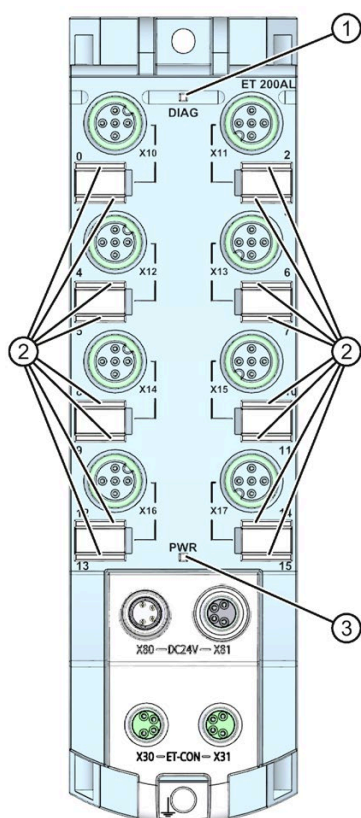


## 4.2.3 Interrupts/diagnostic alarms

### 4.2.3.1 Status and error displays

#### LED displays

The figure below shows the LED displays (status and error displays) of the digital input module / digital output module DIQ 16x24VDC/0.5A 8xM12.



- ① Diagnostic status (DIAG) (red/green)
- ② Channel status (0 to 15) (green)
- ③ Load voltage 2L+ (PWR) (green)

Figure 4-11 LED displays

## Meaning of the LEDs

The following tables set out the meaning of the status and error displays. Remedial measures for diagnostic reports can be found in chapter Diagnostics alarms (Page 70).

### DIAG LED

Table 4- 26 Error display of the DIAG LED

| DIAG LED                                                                                      | Meaning                                                                                                                                                                                                                                                                                                     |
|-----------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <br>Off      | No supply voltage 1L+                                                                                                                                                                                                                                                                                       |
| <br>Flashes  | <ul style="list-style-type: none"> <li>Module parameters not assigned (after switching on the supply voltage 1L+)</li> <li>Loading firmware (while the firmware update is being performed, all LEDs retain their current status)</li> <li>No connection to the ET-Connection and/or the fieldbus</li> </ul> |
| <br>On       | Module parameters assigned and no module diagnostics                                                                                                                                                                                                                                                        |
| <br>Flashes | Module parameters assigned and module diagnostics                                                                                                                                                                                                                                                           |

### LED channel status

Table 4- 27 LED channel status display

| LED channel status                                                                         | Meaning            |
|--------------------------------------------------------------------------------------------|--------------------|
| <br>Off | Process signal = 0 |
| <br>On  | Process signal = 1 |

### PWR LED

Table 4- 28 Status display of the PWR LED

| PWR LED                                                                                    | Meaning                                |
|--------------------------------------------------------------------------------------------|----------------------------------------|
| <br>Off | Load voltage 2L+ is missing or too low |
| <br>On  | Load voltage 2L+ present               |

### 4.2.3.2 Interrupts

The digital input / digital output module DIQ 16x24VDC/0.5A 8xM12 in the configuration method 4xCount supports diagnostic and hardware interrupts.

#### Diagnostic interrupt

The digital input/digital output module generates a diagnostic interrupt at the following events:

- Short-circuit of an encoder supply to ground, or
- Short-circuit of an output to ground
- Load voltage 2L+ missing or too low
- Parameter assignment error

#### Hardware interrupt

The module generates a hardware interrupt at the following event:

- Comparison event occurred for DQ

For detailed information on the error event, refer to the hardware interrupt organization block with the "RALRM" instruction (read additional interrupt info) and to the STEP 7 online help.

The module channel that triggered the hardware interrupt is entered in the start information of the organization block. The figure below shows the assignment to the bits of the local data double word 8.

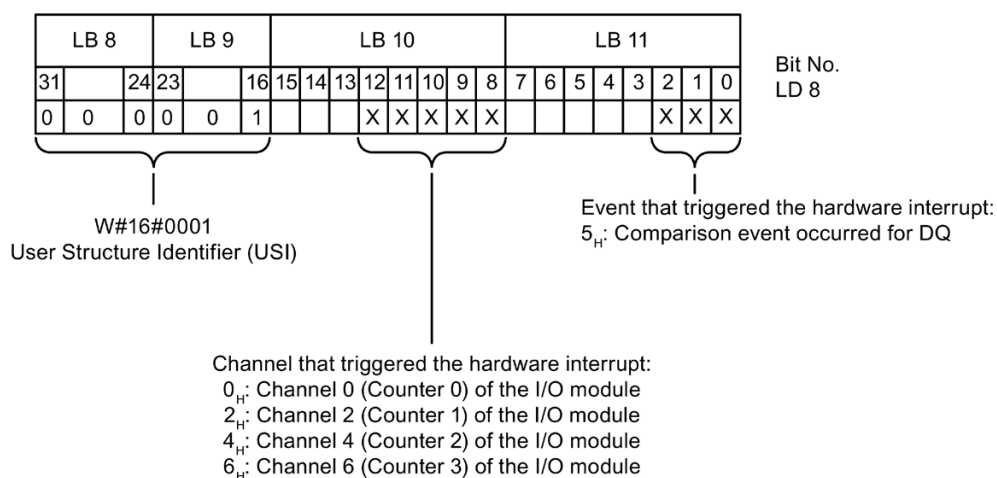


Figure 4-12 Start information of the organization block in the configuration method 4xCount

### 4.2.3.3 Diagnostics alarms

For each diagnostic event, a diagnostics alarm is issued and the LED DIAG flashes red on the digital input/digital output module.

You can read out the diagnostics alarms, for example, from the diagnostics buffer of the CPU. You can evaluate the error codes with the user program.

Table 4- 29 Diagnostics alarms, their meanings and corrective measures

| Diagnostics alarm                                                                                                                                                                                                                                                                                                                                                            | Error code | Meaning                                                                                                 | Solution                                                                                             |
|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------|---------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------|
| Short circuit <sup>1</sup>                                                                                                                                                                                                                                                                                                                                                   | 1H         | Short-circuit of an encoder supply to ground                                                            | <ul style="list-style-type: none"> <li>Eliminate the short-circuit</li> </ul>                        |
|                                                                                                                                                                                                                                                                                                                                                                              |            | Short-circuit of an output to ground                                                                    |                                                                                                      |
| Parameter assignment error                                                                                                                                                                                                                                                                                                                                                   | 10H        | Module parameter assignment is faulty                                                                   | Correction of the parameter assignment                                                               |
| Load voltage 2L+ missing <sup>2</sup>                                                                                                                                                                                                                                                                                                                                        | 11H        | Load voltage 2L+ missing or too low                                                                     | <ul style="list-style-type: none"> <li>Check the supply voltage</li> <li>Check the module</li> </ul> |
| Hardware interrupt lost                                                                                                                                                                                                                                                                                                                                                      | 16H        | At least one hardware interrupt could not be signaled because too many hardware interrupts are pending. | Correct the program or the process                                                                   |
| <sup>1</sup> If a short-circuit of the encoder supply to ground is detected, the diagnostic alarm "Short-circuit" is always output. This alarm is output even if all channels are configured as outputs.<br><sup>2</sup> If you are using ET 200AL modules in connection with the ET 200SP distributed I/O system, the diagnostic alarm "Load voltage missing" is displayed. |            |                                                                                                         |                                                                                                      |

## 4.3 Examples of counting

In this section, you will find examples of the behavior of the counter and how you can specify this behavior. You specify the properties of the counter in the parameter assignment.

The boundary conditions apply for the following examples:

- You set the bit SW\_GATE to "1", the counting process starts.
- If you reset the bit SW\_GATE before a count limit is reached, the counting process stops. Set the bit SW\_GATE to restart the counting process. The value with which the counting process starts again depends on the content of the control interface.

These conditions only apply if you do not use a HW gate (configuration method 2xCount).

### Behavior DQ - Count value between a comparison value and the high counting limit (counting direction forward)

The following section shows the behavior of the count output with the parameter assignment "Set output DQ: Count value between a comparison value and the high counting limit".

The count output is set to "1" if the current values lies between the comparison value and the high count limit.

You can optionally enable a hardware interrupt through the parameterization. This is generated with the rising edge of the count output.

The following figure shows an example of the signal state of the count output depending on the parameterization mentioned above.

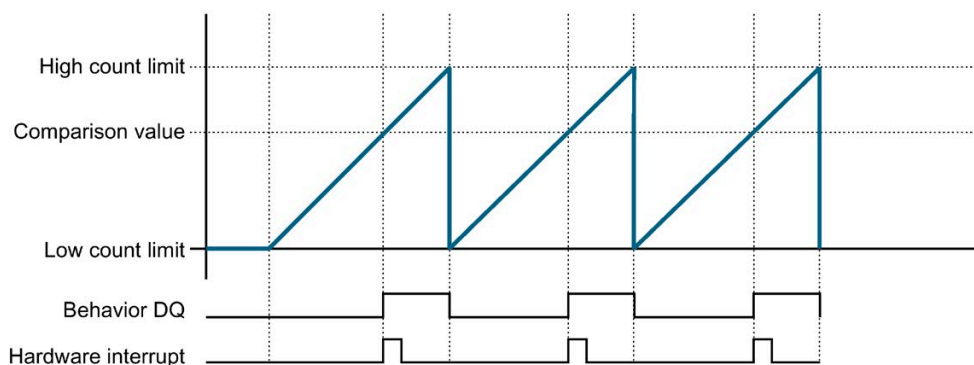


Figure 4-13 Behavior DQ and hardware interrupt

**Behavior DQ - count value between a comparison value and the low counting limit (counting direction backward)**

The following section shows the behavior of the count output with the parameter assignment "Set output DQ: Between a comparison value and the low counting limit".

The count output is set to "1" if the current values lies between the comparison value and the low count limit.

You can optionally enable a hardware interrupt through the parameterization. This is generated with the rising edge of the count output.

The following figure shows an example of the signal state of the count output depending on the parameterization mentioned above.

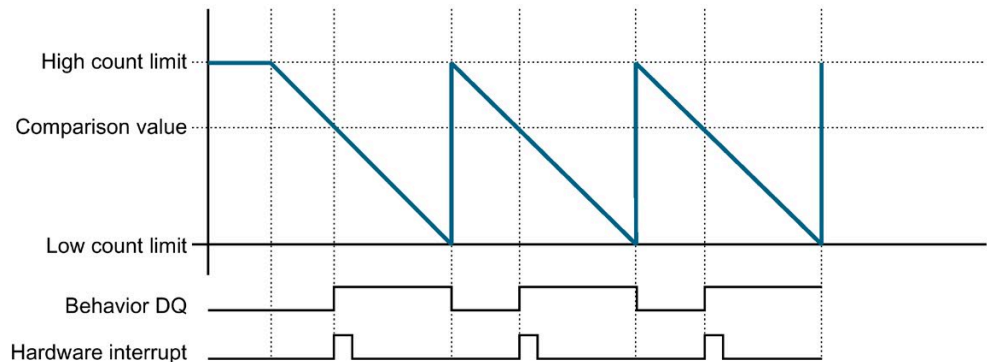


Figure 4-14 Behavior DQ and hardware interrupt

### Start and stop the counting process via the gate control (counting direction forward, configuration method 2xCOUNT)

The following section shows the behavior of the counter depending on the control input at the parameterization "Behavior DI: Gate control in combination with "Behavior when a counting limit is exceeded: Stop counting".

If you set the HW gate to "1" via the control input, the counting process is started. If you set the HW gate to "0", the counting process stops.

Note that the counting process also stops if you close the SW gate while the HW gate is opened.

HW gate and SW gate together form the internal gate. The module only counts when the internal gate is open.

The following figure shows an example of the behavior of the counter at gate control with the principle of stopping counting when a counting limit is exceeded.

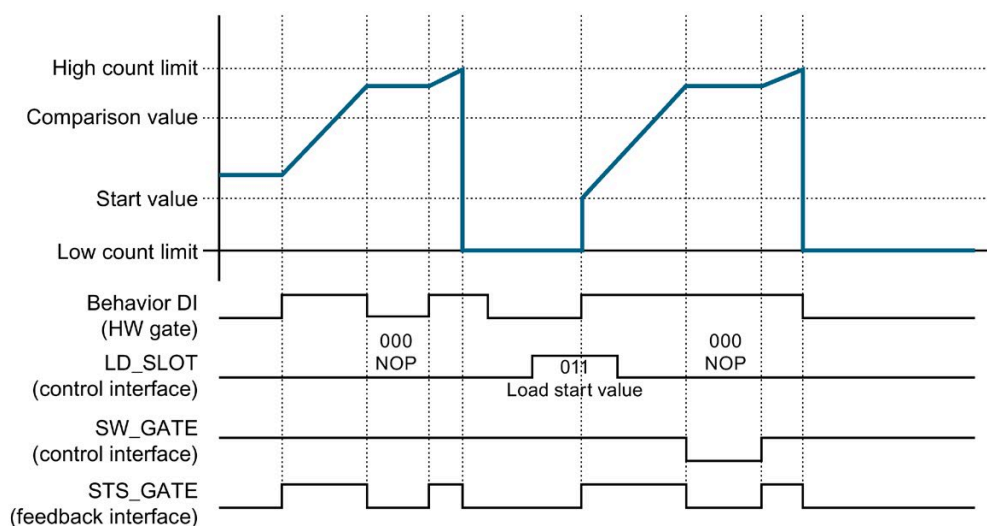


Figure 4-15 Gate control and principle: Stop counting

### Change counting direction via count input and stop counting (configuration method 2xCOUNT)

The following section shows the behavior of the counter depending on the direction input at the parameterization "Behavior DI: Counting direction" in combination with "Behavior when a counting limit is exceeded: Stop counting".

If you have parameterized the digital input of a counter as a direction input, you can change the counting direction via corresponding signals at this input.

Irrespective of the parameterization the counter always forward if the signal state "0" is set at direction input or, respectively backward if the signal state is "1".

If you change the counting direction via a signal change at the direction input, the edge detection (rising / falling edge) is also switched over.

The following figure shows an example of the behavior of the counter at a change in the counting direction with the principle of stopping counting when a counting limit is exceeded.

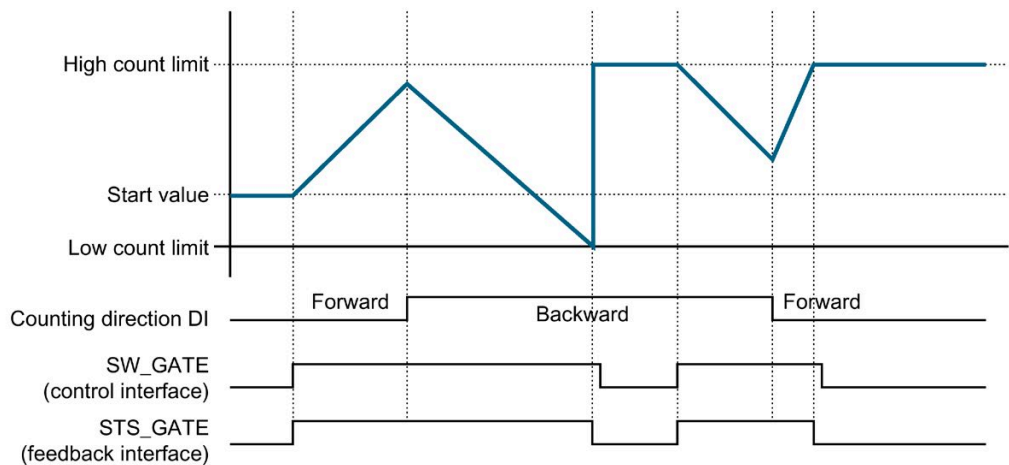


Figure 4-16 Changing the counting direction and principle: Stop counting



### Behavior when a counting limit is exceeded - Stop counting (counting direction forward)

The following section describes the effects of the parameter "Behavior when a counting limit is exceeded: Stop counting" in the counting direction forward. To control the counter, the bits of the control byte of the control interface are used, see the configuration method 2xCount, section Assignment of the control interface (Page 43) and configuration method 4xCount, section Assignment of the control interface (Page 62).

You have entered the bit string 011 in the control byte of the control interface. This bit string loads the value defined in the load value (SLOT) as the start value of the counter via the load request (LD\_SLOT).

After the high counting limit is violated, counting is aborted (counting stops) and the counted value jumps to the low counting limit.

The bit STS\_GATE is reset in the feedback interface, the bit EVENT\_OFLW is set.

The following figure shows an example of the principle of stopping counting when the high count limit is exceeded, counting direction forward.

The behavior "Behavior DQ" is set to "Count value between a comparison value and the high counting limit".

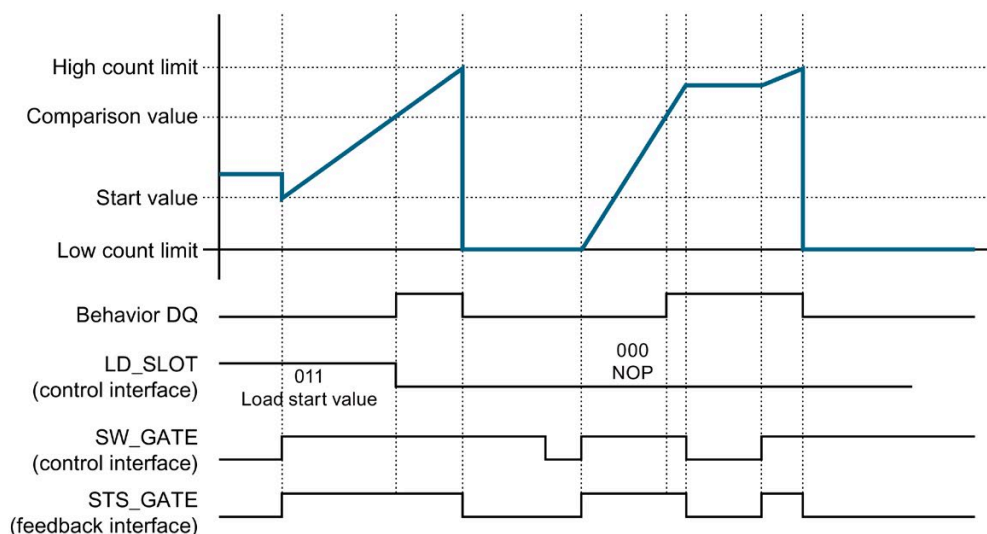


Figure 4-17 Principle: Stop counting (counting direction forward)

You can find additional information on the behavior of the counter at an overflow in the section Explanations for the feedback interface (Page 46).

### Behavior when a counting limit is exceeded - Continue counting (counting direction backward)

The following section describes the effects of the parameter "Behavior when a counting limit is exceeded: Continue counting". To control the counter, the bits of the control byte of the control interface are used, see the configuration method 2xCount, section Assignment of the control interface (Page 43) and configuration method 4xCount, section Assignment of the control interface (Page 62).

After the low counting limit is underpassed, the counted value jumps to the high counting limit and counting is continued.

The bit STS\_GATE is **not** reset when a count limit is exceeded.

The following figure shows an example of the principle of stopping counting when the low count limit is exceeded, counting direction backward.

The behavior "Behavior DQ" is set to "Count value between a comparison value and the high counting limit".

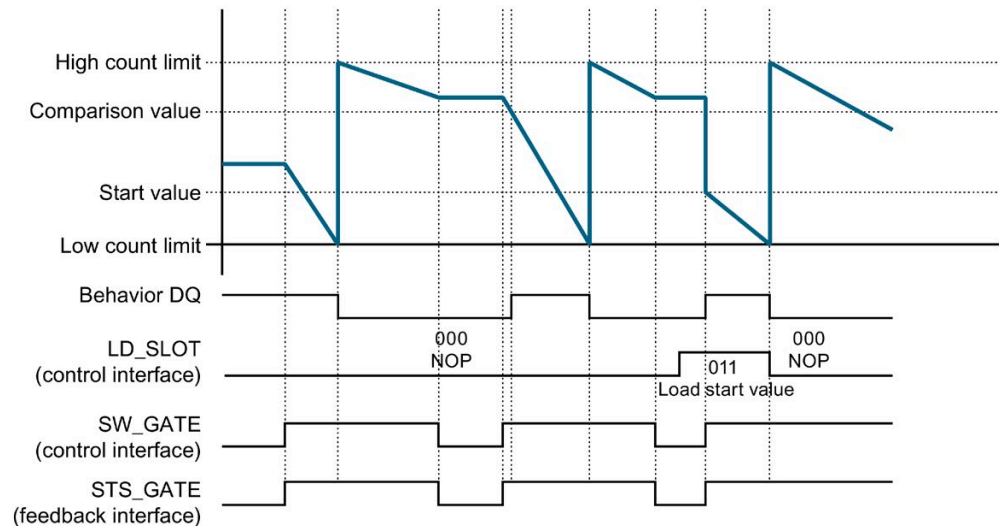


Figure 4-18 Principle: Continue counting (counting direction backward)

### Reference

You will find general information on the counting function in the section Counting (Page 30).

Further information about the pin assignment, parameters, control and feedback interface, etc. is available in the sections Configuration method 2xCount (Page 32) and Configuration method 4xCount (Page 52).

## Technical specifications

### Technical specifications of the DIQ 16x24VDC/0.5A 8xM12 digital input/digital output module

The following table shows the technical specifications as of the issue date. You can find a data sheet including daily updated technical specifications on the Internet (<https://support.industry.siemens.com/cs/ww/en/pv/6ES7143-5AH00-0BA0/td?dl=en>).

|                                                          |                                                                                                      |
|----------------------------------------------------------|------------------------------------------------------------------------------------------------------|
| <b>Article number</b>                                    | <b>6ES7143-5AH00-0BA0</b>                                                                            |
| <b>General information</b>                               |                                                                                                      |
| Product type designation                                 | DIQ 16x24VDC/0.5A                                                                                    |
| HW functional status                                     | FS03                                                                                                 |
| Firmware version                                         | V1.2.x                                                                                               |
| <b>Product function</b>                                  |                                                                                                      |
| • I&M data                                               | Yes; I&M0 to I&M3                                                                                    |
| <b>Engineering with</b>                                  |                                                                                                      |
| • STEP 7 TIA Portal configurable/integrated from version | STEP 7 V14 or higher                                                                                 |
| • STEP 7 configurable/integrated from version            | V5.5 SP4 Hotfix 7 or higher                                                                          |
| • PROFIBUS from GSD version/GSD revision                 | GSD as of Revision 5                                                                                 |
| • PROFINET from GSD version/GSD revision                 | GSDML V2.3.1                                                                                         |
| <b>Operating mode</b>                                    |                                                                                                      |
| • DI                                                     | Yes                                                                                                  |
| • Counter                                                | Yes                                                                                                  |
| • DQ                                                     | Yes                                                                                                  |
| <b>Supply voltage</b>                                    |                                                                                                      |
| <b>Load voltage 1L+</b>                                  |                                                                                                      |
| • Rated value (DC)                                       | 24 V                                                                                                 |
| • permissible range, lower limit (DC)                    | 20.4 V                                                                                               |
| • permissible range, upper limit (DC)                    | 28.8 V                                                                                               |
| • Reverse polarity protection                            | Yes; Against destruction; encoder power supply outputs applied with reversed polarity, loads pick up |
| <b>Load voltage 2L+</b>                                  |                                                                                                      |
| • Rated value (DC)                                       | 24 V                                                                                                 |
| • permissible range, lower limit (DC)                    | 20.4 V                                                                                               |
| • permissible range, upper limit (DC)                    | 28.8 V                                                                                               |
| • Reverse polarity protection                            | Yes; Against destruction; encoder power supply outputs applied with reversed polarity, loads pick up |

|                                                                            |                                                                   |
|----------------------------------------------------------------------------|-------------------------------------------------------------------|
| <b>Article number</b>                                                      | <b>6ES7143-5AH00-0BA0</b>                                         |
| <b>Input current</b>                                                       |                                                                   |
| Current consumption (rated value)                                          | 75 mA; without load                                               |
| from load voltage 1L+ (unswitched voltage)                                 | 4 A; Maximum value                                                |
| from load voltage 2L+, max.                                                | 4 A; Maximum value                                                |
| <b>Encoder supply</b>                                                      |                                                                   |
| Number of outputs                                                          | 8                                                                 |
| <b>24 V encoder supply</b>                                                 |                                                                   |
| • Short-circuit protection                                                 | Yes; Per load voltage, electronic                                 |
| • Output current, max.                                                     | 1.4 A; Total current of all encoders, max. 0.7 A per load voltage |
| <b>Power loss</b>                                                          |                                                                   |
| Power loss, typ.                                                           | 4 W                                                               |
| <b>Digital inputs</b>                                                      |                                                                   |
| Number of digital inputs                                                   | 16; Parameterizable as DIQ                                        |
| Input characteristic curve in accordance with IEC 61131, type 3            | Yes                                                               |
| <b>Number of simultaneously controllable inputs all mounting positions</b> |                                                                   |
| – up to 55 °C, max.                                                        | 16                                                                |
| <b>Digital input functions, parameterizable</b>                            |                                                                   |
| • Freely usable digital input                                              | Yes                                                               |
| • Counter                                                                  | Yes                                                               |
| – Number, max.                                                             | 4                                                                 |
| – Counting frequency, max.                                                 | 2 kHz                                                             |
| – Counting width                                                           | 32 bit; Incl. sign                                                |
| – Counting direction up/down                                               | Yes                                                               |
| <b>Input voltage</b>                                                       |                                                                   |
| • Rated value (DC)                                                         | 24 V                                                              |
| • for signal "0"                                                           | -3 to +5V                                                         |
| • for signal "1"                                                           | +11 to +30V                                                       |
| <b>Input current</b>                                                       |                                                                   |
| • for signal "1", typ.                                                     | 3 mA                                                              |
| <b>Input delay (for rated value of input voltage) for standard inputs</b>  |                                                                   |
| – parameterizable                                                          | Yes                                                               |
| – at "0" to "1", min.                                                      | 0.05 ms; 1.6 ms for channels 8 through 15                         |
| – at "0" to "1", max.                                                      | 20 ms                                                             |
| – at "1" to "0", min.                                                      | 0.05 ms; 1.6 ms for channels 8 through 15                         |
| – at "1" to "0", max.                                                      | 20 ms                                                             |
| <b>for technological functions</b>                                         |                                                                   |
| – parameterizable                                                          | Yes                                                               |

|                                                       |                                          |
|-------------------------------------------------------|------------------------------------------|
| <b>Article number</b>                                 | <b>6ES7143-5AH00-0BA0</b>                |
| <b>Cable length</b>                                   |                                          |
| • unshielded, max.                                    | 30 m                                     |
| <b>Digital outputs</b>                                |                                          |
| Number of digital outputs                             | 16; Parameterizable as DIQ               |
| • in groups of                                        | 8; 2 load groups for 8 outputs each      |
| Short-circuit protection                              | Yes; per channel, electronic             |
| • Response threshold, typ.                            | 0.7 A                                    |
| Limitation of inductive shutdown voltage to           | L+ (-53 V)                               |
| <b>Digital output functions, parameterizable</b>      |                                          |
| • Switching tripped by comparison values              | Yes                                      |
| • Freely usable digital output                        | Yes                                      |
| <b>Switching capacity of the outputs</b>              |                                          |
| • on lamp load, max.                                  | 5 W                                      |
| <b>Load resistance range</b>                          |                                          |
| • lower limit                                         | 48 $\Omega$                              |
| • upper limit                                         | 4 k $\Omega$                             |
| <b>Output voltage</b>                                 |                                          |
| • for signal "1", min.                                | L+ (-0.8 V)                              |
| <b>Output current</b>                                 |                                          |
| • for signal "1" rated value                          | 0.5 A                                    |
| • for signal "0" residual current, max.               | 0.5 mA                                   |
| <b>Switching frequency</b>                            |                                          |
| • with resistive load, max.                           | 100 Hz                                   |
| • with inductive load, max.                           | 0.5 Hz                                   |
| • on lamp load, max.                                  | 1 Hz                                     |
| <b>Total current of the outputs</b>                   |                                          |
| • Current per group, max.                             | 4 A                                      |
| <b>Cable length</b>                                   |                                          |
| • unshielded, max.                                    | 30 m                                     |
| <b>Encoder</b>                                        |                                          |
| <b>Connectable encoders</b>                           |                                          |
| • 2-wire sensor                                       | Yes                                      |
| – permissible quiescent current (2-wire sensor), max. | 1.5 mA                                   |
| <b>Interrupts/diagnostics/status information</b>      |                                          |
| Substitute values connectable                         | Yes; channel by channel, parameterizable |
| <b>Alarms</b>                                         |                                          |
| • Diagnostic alarm                                    | Yes; Parameterizable                     |

|                                                                |                                                                                     |
|----------------------------------------------------------------|-------------------------------------------------------------------------------------|
| <b>Article number</b>                                          | <b>6ES7143-5AH00-0BA0</b>                                                           |
| <b>Diagnoses</b>                                               |                                                                                     |
| • Short-circuit                                                | Yes; Outputs to M; encoder supply to M; module by module                            |
| <b>Diagnostics indication LED</b>                              |                                                                                     |
| • Channel status display                                       | Yes; green LED                                                                      |
| • for module diagnostics                                       | Yes; green/red LED                                                                  |
| • For load voltage monitoring                                  | Yes; green LED                                                                      |
| <b>Potential separation</b>                                    |                                                                                     |
| between the load voltages                                      | Yes                                                                                 |
| <b>Potential separation channels</b>                           |                                                                                     |
| • between the channels, in groups of                           | 8                                                                                   |
| • between the channels and backplane bus                       | Yes                                                                                 |
| • between the channels and the power supply of the electronics | No; 8 channels are non-isolated and 8 channels are isolated from supply voltage 1L+ |
| <b>Isolation</b>                                               |                                                                                     |
| Isolation tested with                                          | 707 V DC (type test)                                                                |
| <b>Degree and class of protection</b>                          |                                                                                     |
| IP degree of protection                                        | IP65/67                                                                             |
| <b>Ambient conditions</b>                                      |                                                                                     |
| <b>Ambient temperature during operation</b>                    |                                                                                     |
| • min.                                                         | -30 °C                                                                              |
| • max.                                                         | 55 °C                                                                               |
| <b>Dimensions</b>                                              |                                                                                     |
| Width                                                          | 45 mm                                                                               |
| Height                                                         | 159 mm                                                                              |
| Depth                                                          | 40 mm                                                                               |
| <b>Weights</b>                                                 |                                                                                     |
| Weight, approx.                                                | 195 g                                                                               |

# PROFlenergy

## 6.1 Pause function

### Introduction

PROFlenergy is a PROFINET-based data interface for switching off consumers centrally and in a coordinated manner during pause times regardless of the manufacturer or device type. This has the aim that the process is only provided with the energy that is absolutely required. In so doing, the majority of the energy savings come from the process itself; the PROFINET device contributes only a few watts to the possible savings. In PROFlenergy, this operating state is referred to as a "pause".

### Start and end of a pause

You enable and disable the pause function of the system at the beginning and end of pauses, respectively; the IO controller then sends the PROFlenergy command "Start\_Pause" or "End\_Pause" to the modules.

Use the "Start\_Pause" command to start a pause.

Use the "End\_Pause" command to end a pause.

The following conditions will also cause a pause to be ended:

- Reconfiguration in RUN
- Controller failure
- Firmware update
- Station stop
- Restart of the interface module through:
  - POWER OFF/POWER ON of an interface module
  - POWER OFF/POWER ON of an I/O module
  - Termination of ET-Connection1 or ET-Connection2

The specific behavior of the digital input/digital output module with counting function is explained in the following sections.

### Additional information

You can find additional information on working with PROFlenergy in the "PROFlenergy" section of the manual IM 157-1 PN interface module (<https://support.industry.siemens.com/cs/ww/en/view/89254863>) and the "Saving energy with PROFlenergy" section of function manual PROFINET with STEP 7 V14 (<https://support.industry.siemens.com/cs/ww/en/view/49948856>).

Application examples (<https://support.industry.siemens.com/cs/ww/en/view/41986454>) are also available on the Internet.

## 6.2 Behavior of the digital inputs

### Display

The channel status LEDs are directly influenced by the signal level at the socket.  
If the encoder supply is switched off, this causes the channel status LEDs to also switch off.

### Response to error detection

All channels that are in pause mode on "PE\_MODE\_PROCEED" report their diagnostic status as in productive mode.

The following applies for all channels which switch to a different pause mode:

- Encoder supply switch-off upon the start of "pause" does not result in the "Short-circuit" alarms.
- During the "pause", error detection of "Short circuit" is not possible:
  - Alarms for errors already pending before the "pause" are retained.
  - After the "pause" is over, the error status is updated and incoming/outgoing errors are reported correspondingly.

### Mode parameter

The following table shows the "Mode" parameter.

Table 6- 1 Mode parameter

| Element | Code                    | Explanation                                                                                                                                                                                                                       |
|---------|-------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Mode    | 0D: PE_MODE_PROCEED     | Proceed at "pause"<br><ul style="list-style-type: none"> <li>• Value status "GOOD"</li> </ul>                                                                                                                                     |
|         | 1D: PE_MODE_SHUTDOWN    | Switch off at "pause"<br><ul style="list-style-type: none"> <li>• Encoder supply Us switched off <sup>1</sup></li> <li>• Pause substitute value: 0B</li> <li>• Value status "BAD"</li> </ul>                                      |
|         | 3D: PE_MODE_LAST_VALUE  | Last value at "pause"<br><ul style="list-style-type: none"> <li>• Encoder supply Us switched off <sup>1</sup></li> <li>• Pause substitute value: Last input value</li> <li>• Value status "BAD"</li> </ul>                        |
|         | 4D: PE_MODE_SUBST_VALUE | Substitute value at "pause"<br><ul style="list-style-type: none"> <li>• Encoder supply Us switched off <sup>1</sup></li> <li>• Pause substitute value: Configured pause substitute value</li> <li>• Value status "BAD"</li> </ul> |

<sup>1</sup> There are two encoder supplies, 1Us for Channels 0 to 7 and 2Us for Channels 8 to 15. At a "Pause" the supplies can only be switched off if no channel is configured in PE\_MODE\_PROCEED.



## 6.3 Behavior of the digital outputs

### Display

The channel status LEDs are directly affected by the signal level at the socket.

### Response to error detection

All channels that are in pause mode on "PE\_MODE\_PROCEED" report their diagnostic status as in productive mode.

The following applies for all channels which switch to a different pause mode:

- During the "pause", error detection of "Short circuit" is not possible:
  - Alarms for errors already pending before the "pause" are retained.
  - After the "pause" is over, the error status is updated and incoming/outgoing errors are reported correspondingly.

### Mode parameter

The following table shows the "Mode" parameter.

Table 6- 2 Mode parameter

| Element | Code                    | Explanation                                                                                                                  |
|---------|-------------------------|------------------------------------------------------------------------------------------------------------------------------|
| Mode    | 0b: PE_MODE_PROCEED     | Proceed at "pause"<br>• Value status "GOOD"                                                                                  |
|         | 1b: PE_MODE_SHUTDOWN    | Switch off at "pause"<br>• Pause substitute value: 0b<br>• Value status "BAD"                                                |
|         | 3b: PE_MODE_LAST_VALUE  | Last value at "pause"<br>• Pause substitute value: Last output value is maintained<br>• Value status "BAD"                   |
|         | 4b: PE_MODE_SUBST_VALUE | Substitute value at "pause"<br>• Pause substitute value: Configured pause substitute value is output<br>• Value status "BAD" |

## 6.4 Behavior of the digital inputs of the counters

### Display

The channel status LEDs are directly influenced by the signal level at the socket.  
If the encoder supply is switched off, this causes the channel status LEDs to also switch off.

### Response to error detection

All channels that are in pause mode on "PE\_MODE\_PROCEED" report their diagnostic status as in productive mode.

The following applies for all channels which switch to a different pause mode:

- Encoder supply switch-off upon the start of "pause" does not result in the "Short-circuit" alarms.
- During the "pause", error detection of "Short circuit" is not possible:
  - Alarms for errors already pending before the "pause" are retained.
  - After the "pause" is over, the error status is updated and incoming/outgoing errors are reported correspondingly.

---

#### Note

##### Channels of a counter

All the channels that belong to a counter must have the same PROFenergy behavior.  
If substitute value behavior is parameterized, this also has to be the same for all channels of a counter.

If the PROFenergy behavior is not the same for all the channels of a counter, the module rejects the PROFenergy parameterization.

Further information on the assignment of the counting channels for the configuration method 2xCount is available in the section Pin assignment (Page 33), for the configuration method 4xCount in the section Pin assignment (Page 53).

---

### Mode parameter

The following table shows the "Mode" parameter.

Table 6- 3 Mode parameter

| Element | Code                    | Explanation                                                                                                                                                                    |
|---------|-------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Mode    | 0D: PE_MODE_PROCEED     | The counter functions as in the normal count mode.<br>The count output depends on the count value.                                                                             |
|         | 1D: PE_MODE_SHUTDOWN    | The count value is no longer updated.<br>The count output is set to 0.                                                                                                         |
|         | 3D: PE_MODE_LAST_VALUE  | The count value is no longer updated (the input does not supply any edges).<br>The count output contains the last value, since the count is no longer updated.                 |
|         | 4D: PE_MODE_SUBST_VALUE | The count value is no longer updated (the input does not supply any edges).<br>The count output is set to the parameterized substitute value, irrespective of the count value. |

## Dimension drawing

The figure below shows the dimension drawing of the DIQ 16x24VDC/0.5A 8xM12 digital input/digital output module in front and side views.

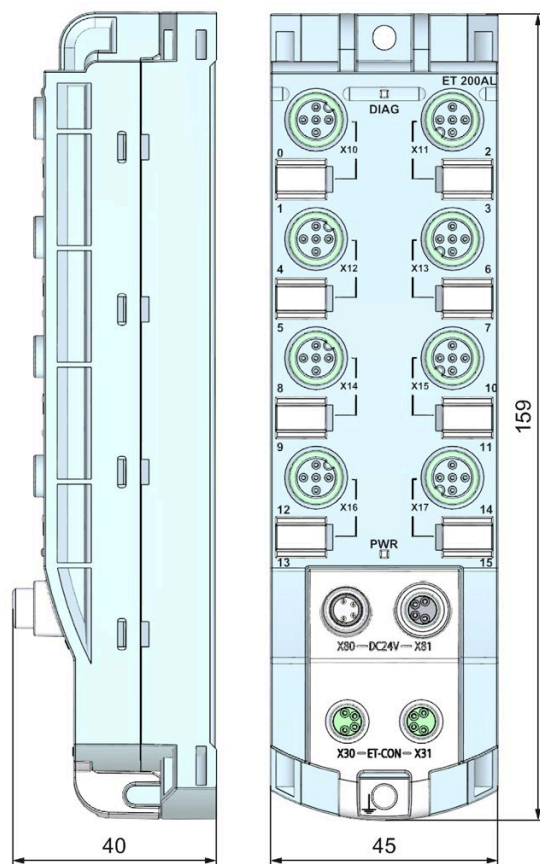
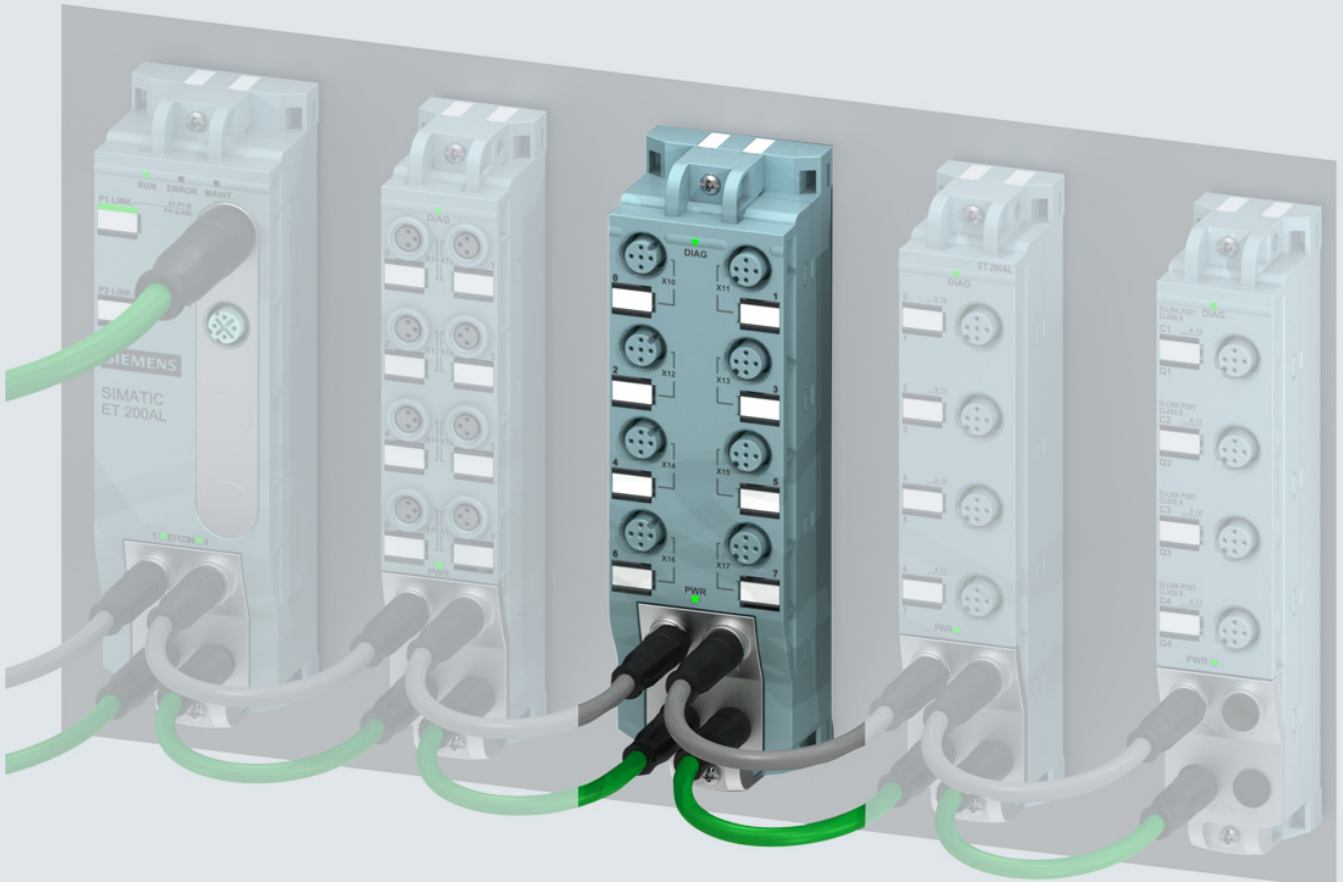


Figure A-1 Dimension drawing

# SIEMENS



Equipment Manual

## SIMATIC

### ET 200AL

Digital output module DQ 8x24VDC/2A 8xM12  
(6ES7142-5AF00-0BA0)

Edition

08/2021

[support.industry.siemens.com](https://support.industry.siemens.com)

## SIMATIC

### ET 200AL Digital output module DQ 8x24VDC/2A 8xM12 (6ES7142-5AF00-0BA0)

Equipment Manual

#### Preface

ET 200AL Documentation  
Guide

**1**

Product overview

**2**

Wiring

**3**

Parameters/address space

**4**

Interrupts/diagnostic  
alarms

**5**

Technical specifications

**6**

PROFInergy

**7**

Dimension drawing

**A**

## Legal information

### Warning notice system

This manual contains notices you have to observe in order to ensure your personal safety, as well as to prevent damage to property. The notices referring to your personal safety are highlighted in the manual by a safety alert symbol, notices referring only to property damage have no safety alert symbol. These notices shown below are graded according to the degree of danger.

#### **DANGER**

indicates that death or severe personal injury **will** result if proper precautions are not taken.

#### **WARNING**

indicates that death or severe personal injury **may** result if proper precautions are not taken.

#### **CAUTION**

indicates that minor personal injury can result if proper precautions are not taken.

#### **NOTICE**

indicates that property damage can result if proper precautions are not taken.

If more than one degree of danger is present, the warning notice representing the highest degree of danger will be used. A notice warning of injury to persons with a safety alert symbol may also include a warning relating to property damage.

### Qualified Personnel

The product/system described in this documentation may be operated only by **personnel qualified** for the specific task in accordance with the relevant documentation, in particular its warning notices and safety instructions. Qualified personnel are those who, based on their training and experience, are capable of identifying risks and avoiding potential hazards when working with these products/systems.

### Proper use of Siemens products

Note the following:

#### **WARNING**

Siemens products may only be used for the applications described in the catalog and in the relevant technical documentation. If products and components from other manufacturers are used, these must be recommended or approved by Siemens. Proper transport, storage, installation, assembly, commissioning, operation and maintenance are required to ensure that the products operate safely and without any problems. The permissible ambient conditions must be complied with. The information in the relevant documentation must be observed.

### Trademarks

All names identified by ® are registered trademarks of Siemens AG. The remaining trademarks in this publication may be trademarks whose use by third parties for their own purposes could violate the rights of the owner.

### Disclaimer of Liability

We have reviewed the contents of this publication to ensure consistency with the hardware and software described. Since variance cannot be precluded entirely, we cannot guarantee full consistency. However, the information in this publication is reviewed regularly and any necessary corrections are included in subsequent editions.

# Preface

## Preface

### Purpose of the documentation

This manual supplements the ET 200AL distributed I/O system (<https://support.industry.siemens.com/cs/us/en/view/89254965>) system manual. Functions that are generally applicable to the ET 200AL distributed I/O system are described there.

The information provided in the present manual, the system manual and the function manuals enables you to commission the ET 200AL distributed I/O system.

### Conventions

Please also observe notes marked as follows:

---

#### Note

Indicates important product information to which particular attention should be paid.

---

### Security information

Siemens provides products and solutions with industrial security functions that support the secure operation of plants, systems, machines and networks.

In order to protect plants, systems, machines and networks against cyber threats, it is necessary to implement – and continuously maintain – a holistic, state-of-the-art industrial security concept. Siemens' products and solutions constitute one element of such a concept.

Customers are responsible for preventing unauthorized access to their plants, systems, machines and networks. Such systems, machines and components should only be connected to an enterprise network or the internet if and to the extent such a connection is necessary and only when appropriate security measures (e.g. firewalls and/or network segmentation) are in place.

For additional information on industrial security measures that may be implemented, please visit (<https://www.siemens.com/industrialsecurity>).

Siemens' products and solutions undergo continuous development to make them more secure. Siemens strongly recommends that product updates are applied as soon as they are available and that the latest product versions are used. Use of product versions that are no longer supported, and failure to apply the latest updates may increase customers' exposure to cyber threats.

To stay informed about product updates, subscribe to the Siemens Industrial Security RSS Feed visit (<https://www.siemens.com/industrialsecurity>).

# Table of contents

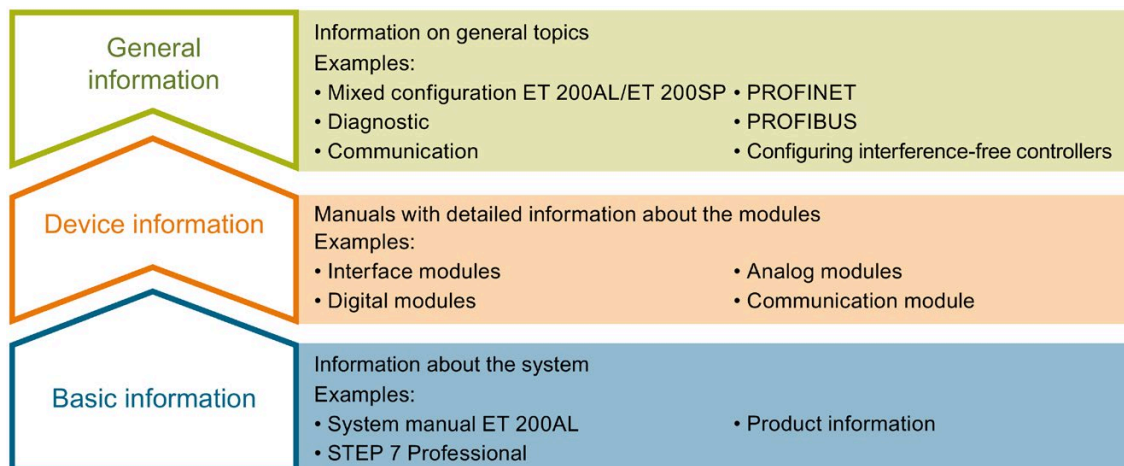
|          |                                                  |           |
|----------|--------------------------------------------------|-----------|
|          | <b>Preface</b> .....                             | <b>3</b>  |
| <b>1</b> | <b>ET 200AL Documentation Guide</b> .....        | <b>5</b>  |
| <b>2</b> | <b>Product overview</b> .....                    | <b>9</b>  |
|          | 2.1 Properties.....                              | 9         |
|          | 2.2 Operator controls and display elements ..... | 11        |
| <b>3</b> | <b>Wiring</b> .....                              | <b>12</b> |
|          | 3.1 Terminal and block diagram .....             | 12        |
|          | 3.2 Pin assignment .....                         | 13        |
| <b>4</b> | <b>Parameters/address space</b> .....            | <b>16</b> |
|          | 4.1 Parameters .....                             | 16        |
|          | 4.2 Explanation of the parameters .....          | 17        |
|          | 4.3 Address space.....                           | 18        |
| <b>5</b> | <b>Interrupts/diagnostic alarms</b> .....        | <b>19</b> |
|          | 5.1 Status and error displays.....               | 19        |
|          | 5.2 Interrupts .....                             | 21        |
|          | 5.3 Diagnostics alarms.....                      | 21        |
| <b>6</b> | <b>Technical specifications</b> .....            | <b>22</b> |
|          | 6.1 Technical specifications .....               | 22        |
| <b>7</b> | <b>PROFenergy</b> .....                          | <b>25</b> |
|          | 7.1 Pause function.....                          | 25        |
|          | 7.2 Behavior of the digital output module .....  | 26        |
| <b>A</b> | <b>Dimension drawing</b> .....                   | <b>27</b> |



# ET 200AL Documentation Guide

The documentation for the SIMATIC ET 200AL distributed I/O system is arranged into three areas.

This arrangement enables you to access the specific content you require.



## Basic information

The System Manual and Getting Started describe in detail the configuration, installation, wiring and commissioning of the SIMATIC ET 200AL distributed I/O system. The STEP 7 online help supports you in the configuration and programming.

## Device information

Product manuals contain a compact description of the module-specific information, such as properties, wiring diagrams, characteristics and technical specifications.

## General information

The function manuals contain detailed descriptions on general topics regarding the SIMATIC ET 200AL distributed I/O system, e.g. diagnostics, communication, Motion Control, Web server.

You can download the documentation free of charge from the Internet (<https://support.industry.siemens.com/cs/ww/en/view/109742667>).

## Manual Collection ET 200AL

The Manual Collection contains the complete documentation on the SIMATIC ET 200AL distributed I/O system gathered together in one file.

You can find the Manual Collection on the Internet (<https://support.automation.siemens.com/WW/view/en/95242965>).

## "mySupport"

With "mySupport", your personal workspace, you make the best out of your Industry Online Support.

In "mySupport", you can save filters, favorites and tags, request CAx data and compile your personal library in the Documentation area. In addition, your data is already filled out in support requests and you can get an overview of your current requests at any time.

You must register once to use the full functionality of "mySupport".

You can find "mySupport" on the Internet (<https://support.industry.siemens.com/My/ww/en>).

## "mySupport" - Documentation

With "mySupport", your personal workspace, you make the best out of your Industry Online Support.

In "mySupport", you can save filters, favorites and tags, request CAx data and compile your personal library in the Documentation area. In addition, your data is already filled out in support requests and you can get an overview of your current requests at any time.

You must register once to use the full functionality of "mySupport".

You can find "mySupport" on the Internet (<https://support.industry.siemens.com/My/ww/en/documentation>).

## "mySupport" - CAx data

In the CAx data area of "mySupport", you can access the latest product data for your CAx or CAe system.

You configure your own download package with a few clicks.

In doing so you can select:

- Product images, 2D dimension drawings, 3D models, internal circuit diagrams, EPLAN macro files
- Manuals, characteristics, operating manuals, certificates
- Product master data

You can find "mySupport" - CAx data on the Internet (<https://support.industry.siemens.com/my/ww/en/CAxOnline>).

## Application examples

The application examples support you with various tools and examples for solving your automation tasks. Solutions are shown in interplay with multiple components in the system - separated from the focus on individual products.

You will find the application examples on the Internet (<https://support.industry.siemens.com/cs/ww/en/ps/ae>).

## TIA Selection Tool

With the TIA Selection Tool, you can select, configure and order devices for Totally Integrated Automation (TIA).

This tool is the successor of the SIMATIC Selection Tool and combines the known configurators for automation technology into one tool.

With the TIA Selection Tool, you can generate a complete order list from your product selection or product configuration.

You can find the TIA Selection Tool on the Internet

(<https://support.industry.siemens.com/cs/ww/en/view/109767888>).

## SIMATIC Automation Tool

You can use the SIMATIC Automation Tool to perform commissioning and maintenance activities simultaneously on various SIMATIC S7 stations as a bulk operation independent of TIA Portal.

The SIMATIC Automation Tool provides a multitude of functions:

- Scanning of a PROFINET/Ethernet system network and identification of all connected CPUs
- Address assignment (IP, subnet, gateway) and station name (PROFINET device) to a CPU
- Transfer of the date and the programming device/PC time converted to UTC time to the module
- Program download to CPU
- RUN/STOP mode switchover
- CPU localization by means of LED flashing
- Reading out of CPU error information
- Reading of the CPU diagnostics buffer
- Reset to factory settings
- Firmware update of the CPU and connected modules

You can find the SIMATIC Automation Tool on the Internet

(<https://support.industry.siemens.com/cs/ww/en/view/98161300>).

## PRONETA

SIEMENS PRONETA (PROFINET network analysis) allows you to analyze the plant network during commissioning. PRONETA features two core functions:

- The topology overview automatically scans the PROFINET and all connected components.
- The IO check is a fast test of the wiring and the module configuration of a plant.

You can find SIEMENS PRONETA on the Internet

(<https://support.industry.siemens.com/cs/ww/en/view/67460624>).

## SINETPLAN

SINETPLAN, the Siemens Network Planner, supports you in planning automation systems and networks based on PROFINET. The tool facilitates professional and predictive dimensioning of your PROFINET installation as early as in the planning stage. In addition, SINETPLAN supports you during network optimization and helps you to exploit network resources optimally and to plan reserves. This helps to prevent problems in commissioning or failures during productive operation even in advance of a planned operation. This increases the availability of the production plant and helps improve operational safety.

The advantages at a glance

- Network optimization thanks to port-specific calculation of the network load
- Increased production availability thanks to online scan and verification of existing systems
- Transparency before commissioning through importing and simulation of existing STEP 7 projects
- Efficiency through securing existing investments in the long term and the optimal use of resources

You can find SINETPLAN on the Internet (<https://www.siemens.com/sinetplan>).

## Product overview

### 2.1 Properties

#### Article number

6ES7142-5AF00-0BA0

#### View of the module

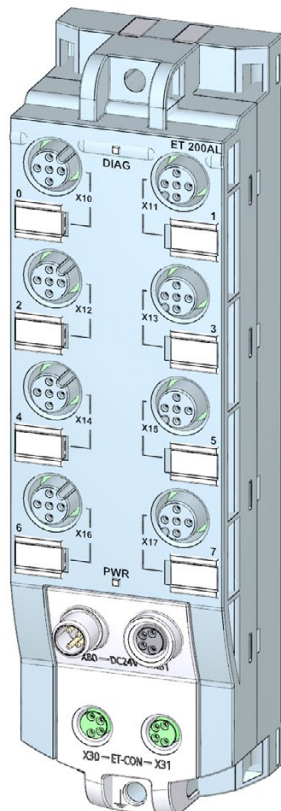


Figure 2-1 View of the DQ 8x24VDC/2A 8xM12 digital output module

## Properties

The module has the following technical properties:

- 8 digital outputs
  - Channels 0 to 3 connected to 1L+ (non-switched)
  - Channels 4 to 7 connected to 2L+ (switched)
- M12 sockets for connection of actuators
- Rated load voltage 24 V DC
- Suitable for solenoid valves, DC contactors, and indicator lights
- Output current per output 2 A
- Configurable diagnostics can be set for each module
- Dimensions 45 x 159 mm

The module supports the following functions:

- Firmware update
- Identification and maintenance data I&M0 to I&M3
- Value status (Quality Information)
- PROFlenergy

## Accessories

The following components are included in the module package:

- Identification labels

## Other components

The following component can be ordered as spare part:

- Identification labels

The following components can be ordered as accessories:

- Connectors
- Cables
- Stripping Tool for ET-Connection
- M8 sealing cap
- M12 sealing cap

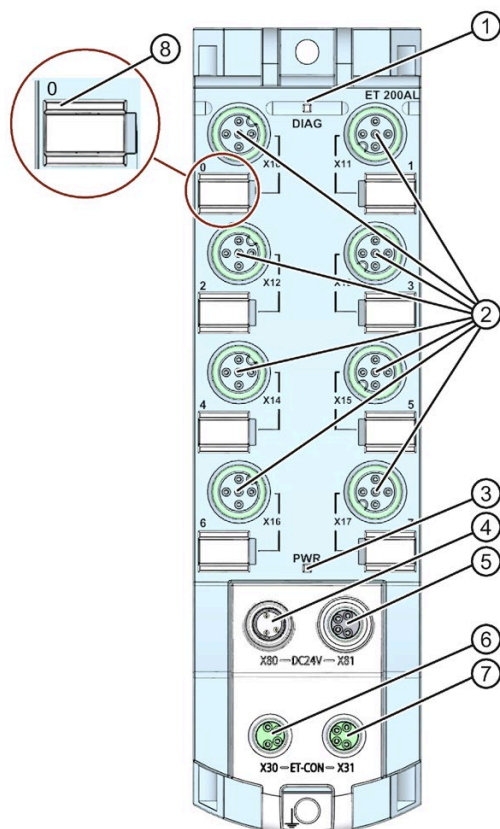
## See also

You can find more information on accessories in the Accessories/spare parts section of the ET 200AL distributed I/O system

(<https://support.industry.siemens.com/cs/us/en/view/89254965>) system manual.

## 2.2 Operator controls and display elements

The figure below shows the operator controls and display elements of the DQ 8x24VDC/2A 8xM12 digital output module.



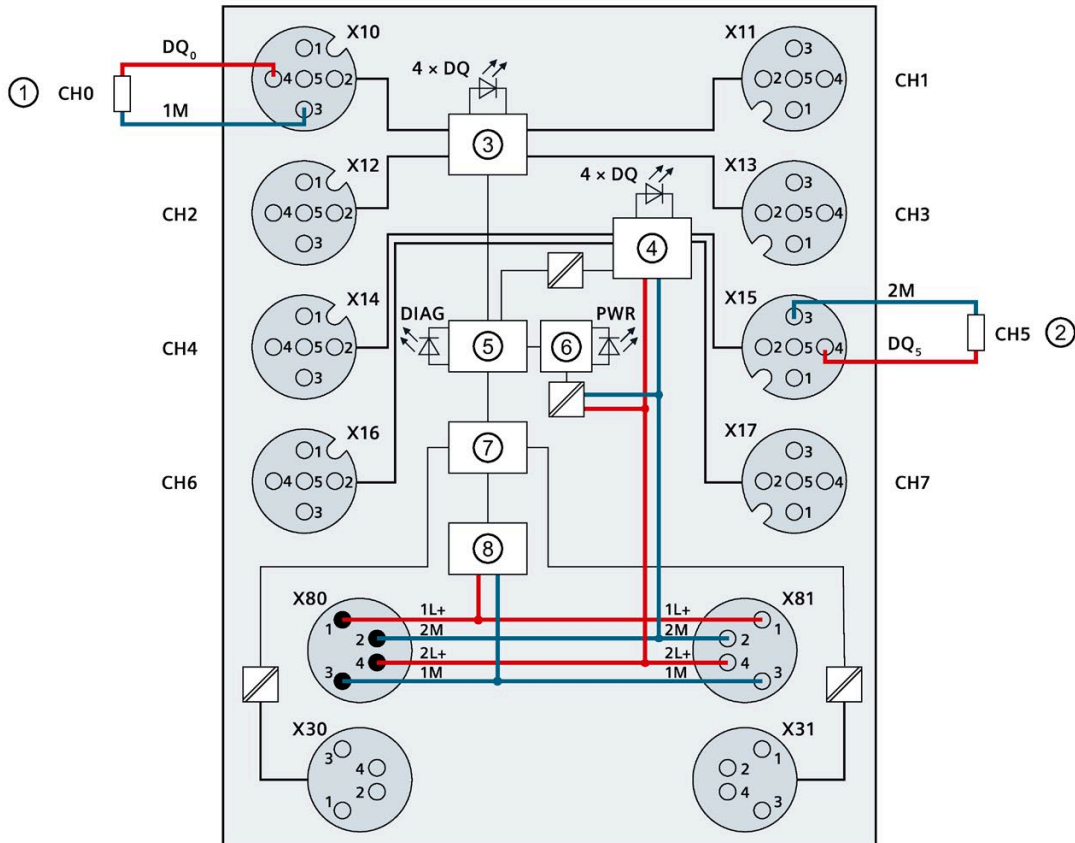
- ① DIAG: LED display for the diagnostic status
- ② X10 to X17: Sockets for the output signal
- ③ PWR: LED display for load voltage 2L+
- ④ X80: Connector for infeed of the supply voltage (POWER input)
- ⑤ X81: Socket for loop-through of the supply voltage (POWER output)
- ⑥ X30: Socket for ET-Connection IN
- ⑦ X31: Socket for ET-Connection OUT
- ⑧ LED displays 0 to 7 for the channel status

Figure 2-2 Operator controls and display elements

## Wiring

### 3.1 Terminal and block diagram

The example in the figure below shows the pin assignment of signal outputs.



|     |                                 |                 |                                      |
|-----|---------------------------------|-----------------|--------------------------------------|
| ①   | Output to 1L+                   | X10 to X17      | Channels 0 to 7                      |
| ②   | Output to 2L+                   | X30             | Infeed of the ET-Connection          |
| ③   | DQ circuit 1L+                  | X31             | Loop-through of the ET-Connection    |
| ④   | DQ circuit 2L+                  | 1L+             | Supply voltage 1L+ (non-switched)    |
| ⑤   | Microcontroller                 | 1M              | Ground 1M (non-switched)             |
| ⑥   | Monitoring                      | 2L+             | Load voltage 2L+ (switched)          |
| ⑦   | ET-Connection interface         | 2M              | Ground 2M (switched)                 |
| ⑧   | Internal supply voltage         | 1Us             | 24 V encoder supply                  |
| X80 | Infeed of supply voltages       | DQ <sub>n</sub> | Output signal                        |
| X81 | Loop-through of supply voltages | DQ              | Channel status LEDs (0 to 7) (green) |

Figure 3-1 Terminal and block diagram



## 3.2 Pin assignment

### Note

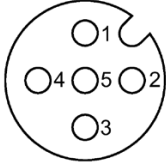
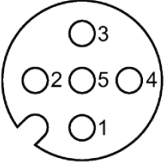
Color coding

The sockets for ET-Connection and the power supply of the modules are color-coded. These colors correspond to the colors of the offered cables.

### Pin assignment of the sockets for digital outputs

The tables below show the pin assignments of the 8 sockets for connection of the digital outputs.

Table 3- 1 Pin assignment for digital outputs

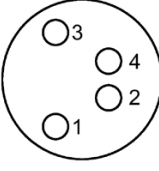
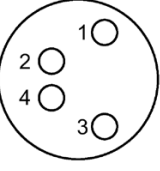
| Pin | Assignment                                                                                                                                                                                                                                                                                   | Front view of the sockets                                                             |                                                                                       |
|-----|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------|
|     | X10 to X17 sockets for digital outputs                                                                                                                                                                                                                                                       | X10, X12, X14, X16                                                                    | X11, X13, X15, X17                                                                    |
| 1   | Unassigned                                                                                                                                                                                                                                                                                   |                                                                                       |                                                                                       |
| 2   | Unassigned                                                                                                                                                                                                                                                                                   |                                                                                       |                                                                                       |
| 3   | X10 - X13: Ground 1M<br>X14 - X17: Ground 2M                                                                                                                                                                                                                                                 |  |  |
| 4 * | Output signal DQ0: Connector X10<br>Output signal DQ1: Connector X11<br>Output signal DQ2: Connector X12<br>Output signal DQ3: Connector X13<br>Output signal DQ4: Connector X14<br>Output signal DQ5: Connector X15<br>Output signal DQ6: Connector X16<br>Output signal DQ7: Connector X17 |                                                                                       |                                                                                       |
| 5   | Functional earth FE                                                                                                                                                                                                                                                                          |                                                                                       |                                                                                       |

\* The outputs DQ<sub>0</sub> to DQ<sub>3</sub> are connected to 1L+; the outputs DQ<sub>4</sub> to DQ<sub>7</sub> are connected to 2L+.

### Pin assignment of the sockets for ET-Connection

The table below shows the pin assignments of the 2 sockets for the connection of ET-Connection.

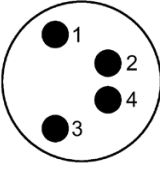
Table 3- 2 Pin assignment for ET-Connection

| Pin       | Assignment                    |                                | Assignment of the wire color of the bus line cable for ET-Connection | Front view of the sockets                                                           |                                                                                     |
|-----------|-------------------------------|--------------------------------|----------------------------------------------------------------------|-------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------|
|           | X30 socket (ET-Connection IN) | X31 socket (ET-Connection OUT) |                                                                      | X30                                                                                 | X31                                                                                 |
| 1         | TXP                           | RXP                            | Yellow                                                               |  |  |
| 2         | RXP                           | TXP                            | White                                                                |                                                                                     |                                                                                     |
| 3         | RXN                           | TXN                            | Blue                                                                 |                                                                                     |                                                                                     |
| 4         | TXN                           | RXN                            | Orange                                                               |                                                                                     |                                                                                     |
| Shielding | Functional earth FE           |                                | -                                                                    |                                                                                     |                                                                                     |

### Pin assignment of the connector for infeed of the supply voltage

The table below shows the pin assignment of the connector for infeed of the supply voltage.

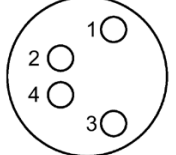
Table 3- 3 Pin assignment of the supply voltage connector

| Pin | Assignment                        | Assignment of the wire color of the power line cable | Front view of the connector                                                           |
|-----|-----------------------------------|------------------------------------------------------|---------------------------------------------------------------------------------------|
|     | X80 connector (POWER input)       |                                                      |                                                                                       |
| 1   | Supply voltage 1L+ (non-switched) | Brown                                                |  |
| 2   | Ground 2M (switched)              | White                                                |                                                                                       |
| 3   | Ground 1M (non-switched)          | Blue                                                 |                                                                                       |
| 4   | Load voltage 2L+ (switched)       | Black                                                |                                                                                       |

### Pin assignment of the socket for loop-through of the supply voltage

The table below shows the pin assignment of the socket for loop-through of the supply voltage.

Table 3- 4 Pin assignment of the supply voltage socket

| Pin | Assignment                        | Assignment of the wire color of the power line cable | Front view of the socket                                                            |
|-----|-----------------------------------|------------------------------------------------------|-------------------------------------------------------------------------------------|
|     | X81 socket (POWER output)         |                                                      |                                                                                     |
| 1   | Supply voltage 1L+ (non-switched) | Brown                                                |  |
| 2   | Ground 2M (switched)              | White                                                |                                                                                     |
| 3   | Ground 1M (non-switched)          | Blue                                                 |                                                                                     |
| 4   | Load voltage 2L+ (switched)       | Black                                                |                                                                                     |

#### NOTICE

##### ET-Connection/supply voltage

Observe the correct wiring of the M8 sockets for ET-Connection and the supply voltage.

Mixing up the ET-Connection connectors and the connectors for the supply voltage can destroy the module.

## Parameters/address space

### 4.1 Parameters

The table below shows the parameters for the DQ 8x24VDC/2A 8xM12 digital output module.

Table 4- 1 Parameters

| Parameters                            | Value range                                                                                                                 | Default   | Scope                                             |
|---------------------------------------|-----------------------------------------------------------------------------------------------------------------------------|-----------|---------------------------------------------------|
| Diagnostics: Missing load voltage 2L+ | <ul style="list-style-type: none"> <li>• Disable</li> <li>• Enable</li> </ul>                                               | Disable   | Module                                            |
| Diagnostics: Short-circuit to ground  | <ul style="list-style-type: none"> <li>• Disable</li> <li>• Enable</li> </ul>                                               | Disable   | Module<br>(Short-circuit of the output to ground) |
| Reaction to CPU/master STOP           | <ul style="list-style-type: none"> <li>• Shut down</li> <li>• Keep last value</li> <li>• Output substitute value</li> </ul> | Shut down | Module                                            |
| Substitute value channel 0 ... 7      | <ul style="list-style-type: none"> <li>• 0</li> <li>• 1</li> </ul>                                                          | 0         | Channel                                           |

## 4.2 Explanation of the parameters

### Diagnostics: Missing load voltage 2L+

Enabling of the diagnostics for missing or insufficient load voltage 2L+.

### Diagnostics: Short-circuit to ground

Enabling of the diagnostics for short-circuit of the output to ground.

### Reaction to CPU/master STOP

With this parameter, you set the reaction of the digital outputs of the module after a CPU/master STOP:

- Shut down: The digital output is de-energized.
- Keep last value: The last value of the digital output remains activated.
- Output substitute value: The module outputs a configured substitute value.

### Substitute value channel 0 ... 7

With this parameter, you set substitute values for the digital outputs.

## 4.3 Address space

The figure below shows the assignment of the address space for the digital output module DQ 8x24VDC/2A 8xM12 with value status (Quality Information, QI).

The address space for the value status is allocated by the module, if the value status is configured using the PROFINET interface module.

Assignment in the process image input (PII)



Assignment in the process image output (PIQ)

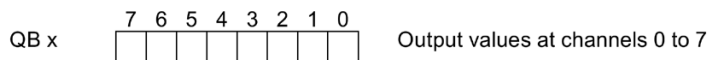


Figure 4-1 Address space

### Configuration options of the digital output module DQ 8x24VDC/2A 8xM12

You have the following configuration options:

- Configuration 1: without value status
- Configuration 2: with value status

### Evaluating the value status

An additional byte is occupied in the input address space if you enable the value status for the digital output module. The value status of the outputs is assigned to bits 0 to 7 in input byte x. This additional information provides information regarding the validity of the digital values or channel status.

Bit = 1: No error on channel.

Bit = 0: Error on channel.

This means:

- Short-circuit of output to ground or
- Parameter error or
- For channels 4 ... 7: Missing load voltage 2L+

# Interrupts/diagnostic alarms

## 5.1 Status and error displays

### LED displays

The figure below shows the LED displays (status and error displays) of the digital output module DQ 8x24VDC/2A 8xM12.

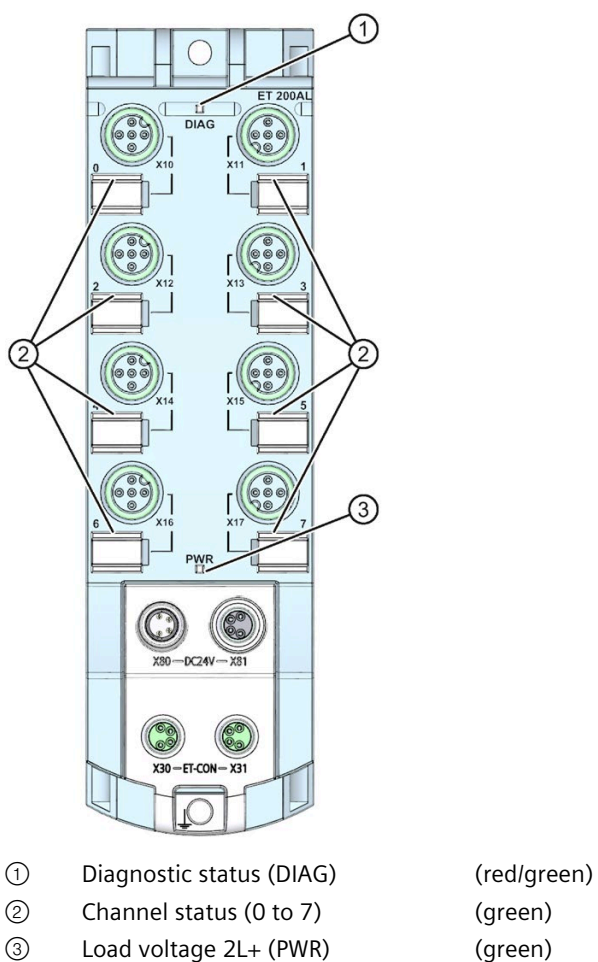


Figure 5-1 LED displays

## Meaning of the LEDs

The following tables set out the meaning of the status and error displays. Remedial measures for diagnostic alarms can be found in the section Diagnostics alarms (Page 21).

### DIAG LED

Table 5- 1 Error display of the DIAG LED

| DIAG LED                                                                                      | Meaning                                                                                                                                                                                                                                                                                                     |
|-----------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <br>Off      | No supply voltage 1L+                                                                                                                                                                                                                                                                                       |
| <br>Flashes  | <ul style="list-style-type: none"> <li>Module parameters not assigned (after switching on the supply voltage 1L+)</li> <li>Loading firmware (while the firmware update is being performed, all LEDs retain their current status)</li> <li>No connection to the ET-Connection and/or the fieldbus</li> </ul> |
| <br>On       | Module parameters assigned and no module diagnostics                                                                                                                                                                                                                                                        |
| <br>Flashes | Module parameters assigned and module diagnostics                                                                                                                                                                                                                                                           |

### LED channel status

Table 5- 2 LED channel status display

| LED channel status                                                                         | Meaning            |
|--------------------------------------------------------------------------------------------|--------------------|
| <br>Off | Process signal = 0 |
| <br>On  | Process signal = 1 |

### PWR LED

Table 5- 3 Status display of the PWR LED

| PWR LED                                                                                    | Meaning                                |
|--------------------------------------------------------------------------------------------|----------------------------------------|
| <br>Off | Load voltage 2L+ is missing or too low |
| <br>On  | Load voltage 2L+ present               |



## 5.2 Interrupts

The digital output module DQ 8x24VDC/2A 8xM12 supports diagnostics interrupts.

### Diagnostic interrupt

The digital output module generates a diagnostic interrupt at the following events:

- Short-circuit of outputs to ground
- Load voltage 2L+ missing or too low

## 5.3 Diagnostics alarms

For each diagnostic event, a diagnostics alarm is issued and the DIAG LED flashes red on the digital output module. You can read out the diagnostics alarms, for example, from the diagnostics buffer of the CPU. You can evaluate the error codes with the user program.

Table 5- 4 Diagnostics alarms, their meanings and corrective measures

| Diagnostics alarm                                                                                                                                      | Error code | Meaning                             | Remedy                                                                                                   |
|--------------------------------------------------------------------------------------------------------------------------------------------------------|------------|-------------------------------------|----------------------------------------------------------------------------------------------------------|
| Short-circuit                                                                                                                                          | 1H         | Short-circuit of outputs to ground  | <ul style="list-style-type: none"> <li>• Eliminate the short-circuit</li> </ul>                          |
| Load voltage 2L+ missing*                                                                                                                              | 11H        | Load voltage 2L+ missing or too low | <ul style="list-style-type: none"> <li>• Check the supply voltage</li> <li>• Check the module</li> </ul> |
| * If you are using ET 200AL modules in connection with the ET 200SP distributed I/O system, the diagnostics alarm "Load voltage missing" is displayed. |            |                                     |                                                                                                          |

## Technical specifications

### 6.1 Technical specifications

#### Technical specifications of the DQ 8x24VDC/2A 8xM12 digital output module

The following table shows the technical specifications as of the issue date. You can find a data sheet including daily updated technical specifications on the Internet (<https://support.industry.siemens.com/cs/ww/en/pv/6ES7142-5AF00-0BA0/td?dl=en>).

|                                                          |                                           |
|----------------------------------------------------------|-------------------------------------------|
| <b>Article number</b>                                    | <b>6ES7142-5AF00-0BA0</b>                 |
| <b>General information</b>                               |                                           |
| Product type designation                                 | DQ 8x24VDC/2A                             |
| HW functional status                                     | FS03                                      |
| Firmware version                                         | V1.0.x                                    |
| <b>Product function</b>                                  |                                           |
| • I&M data                                               | Yes; I&M0 to I&M3                         |
| <b>Engineering with</b>                                  |                                           |
| • STEP 7 TIA Portal configurable/integrated from version | STEP 7 V13 SP1 or higher                  |
| • STEP 7 configurable/integrated from version            | V5.5 SP4 Hotfix 7 or higher               |
| • PROFIBUS from GSD version/GSD revision                 | GSD as of Revision 5                      |
| • PROFINET from GSD version/GSD revision                 | GSDML V2.3.1                              |
| <b>Supply voltage</b>                                    |                                           |
| <b>Load voltage 1L+</b>                                  |                                           |
| • Rated value (DC)                                       | 24 V                                      |
| • permissible range, lower limit (DC)                    | 20.4 V                                    |
| • permissible range, upper limit (DC)                    | 28.8 V                                    |
| • Reverse polarity protection                            | Yes; against destruction; load increasing |
| <b>Load voltage 2L+</b>                                  |                                           |
| • Rated value (DC)                                       | 24 V                                      |
| • permissible range, lower limit (DC)                    | 20.4 V                                    |
| • permissible range, upper limit (DC)                    | 28.8 V                                    |
| • Reverse polarity protection                            | Yes; against destruction; load increasing |
| <b>Input current</b>                                     |                                           |
| Current consumption (rated value)                        | 40 mA; without load                       |
| from load voltage 1L+ (unswitched voltage)               | 4 A; Maximum value                        |
| from load voltage 2L+, max.                              | 4 A; Maximum value                        |

|                                                  |                                                          |
|--------------------------------------------------|----------------------------------------------------------|
| <b>Article number</b>                            | <b>6ES7142-5AF00-0BA0</b>                                |
| <b>Power loss</b>                                |                                                          |
| Power loss, typ.                                 | 4 W                                                      |
| <b>Digital outputs</b>                           |                                                          |
| Number of digital outputs                        | 8                                                        |
| • in groups of                                   | 4; 2 load groups for 4 outputs each                      |
| Short-circuit protection                         | Yes; per channel, electronic                             |
| • Response threshold, typ.                       | 2.8 A                                                    |
| <b>Switching capacity of the outputs</b>         |                                                          |
| • on lamp load, max.                             | 10 W                                                     |
| <b>Load resistance range</b>                     |                                                          |
| • lower limit                                    | 12 Ω                                                     |
| • upper limit                                    | 4 kΩ                                                     |
| <b>Output voltage</b>                            |                                                          |
| • for signal "1", min.                           | L+ (-0.8 V)                                              |
| <b>Output current</b>                            |                                                          |
| • for signal "1" rated value                     | 2 A                                                      |
| • for signal "1" permissible range, max.         | 2 A; with inductive load to IEC 60947-5-1, DC-13 / AC-15 |
| • for signal "0" residual current, max.          | 0.5 mA                                                   |
| <b>Switching frequency</b>                       |                                                          |
| • with resistive load, max.                      | 100 Hz                                                   |
| • with inductive load, max.                      | 0.1 Hz; 0.25 Hz at 25 °C                                 |
| • on lamp load, max.                             | 1 Hz                                                     |
| <b>Total current of the outputs</b>              |                                                          |
| • Current per group, max.                        | 4 A; For inductive load max. 2 channels per group        |
| <b>Cable length</b>                              |                                                          |
| • unshielded, max.                               | 30 m                                                     |
| <b>Interrupts/diagnostics/status information</b> |                                                          |
| Substitute values connectable                    | Yes; channel by channel, parameterizable                 |
| <b>Alarms</b>                                    |                                                          |
| • Diagnostic alarm                               | Yes; Parameterizable                                     |
| <b>Diagnoses</b>                                 |                                                          |
| • Short-circuit                                  | Yes; Outputs to ground; module by module                 |
| <b>Diagnostics indication LED</b>                |                                                          |
| • Channel status display                         | Yes; green LED                                           |
| • for module diagnostics                         | Yes; green/red LED                                       |
| • For load voltage monitoring                    | Yes; green LED                                           |
| <b>Potential separation</b>                      |                                                          |
| between the load voltages                        | Yes                                                      |

6.1 Technical specifications

|                                                                                                                                                                                                            |                                                                                                                |
|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------|
| <b>Article number</b>                                                                                                                                                                                      | <b>6ES7142-5AF00-0BA0</b>                                                                                      |
| <b>Potential separation channels</b>                                                                                                                                                                       |                                                                                                                |
| <ul style="list-style-type: none"> <li>between the channels, in groups of</li> <li>between the channels and backplane bus</li> <li>between the channels and the power supply of the electronics</li> </ul> | <p>4</p> <p>Yes</p> <p>No; 4 channels are non-isolated and 4 channels are isolated from supply voltage 1L+</p> |
| <b>Isolation</b>                                                                                                                                                                                           |                                                                                                                |
| Isolation tested with                                                                                                                                                                                      | 707 V DC (type test)                                                                                           |
| <b>Standards, approvals, certificates</b>                                                                                                                                                                  |                                                                                                                |
| Suitable for safety-related tripping of standard modules                                                                                                                                                   | Yes; From FS01                                                                                                 |
| <b>Highest safety class achievable for safety-related tripping of standard modules</b>                                                                                                                     |                                                                                                                |
| <ul style="list-style-type: none"> <li>Performance level according to ISO 13849-1</li> <li>Category according to ISO 13849-1</li> <li>SILCL according to IEC 62061</li> </ul>                              | <p>PL d</p> <p>Cat. 3</p> <p>SILCL 2</p>                                                                       |
| <b>Ambient conditions</b>                                                                                                                                                                                  |                                                                                                                |
| <b>Ambient temperature during operation</b>                                                                                                                                                                |                                                                                                                |
| <ul style="list-style-type: none"> <li>min.</li> <li>max.</li> </ul>                                                                                                                                       | <p>-30 °C</p> <p>55 °C</p>                                                                                     |
| <b>Connection method</b>                                                                                                                                                                                   |                                                                                                                |
| Design of electrical connection for the inputs and outputs                                                                                                                                                 | M12, 5-pole                                                                                                    |
| Design of electrical connection for supply voltage                                                                                                                                                         | M8, 4-pole                                                                                                     |
| <b>ET-Connection</b>                                                                                                                                                                                       |                                                                                                                |
| <ul style="list-style-type: none"> <li>ET-Connection</li> </ul>                                                                                                                                            | M8, 4-pin, shielded                                                                                            |
| <b>Dimensions</b>                                                                                                                                                                                          |                                                                                                                |
| Width                                                                                                                                                                                                      | 45 mm                                                                                                          |
| Height                                                                                                                                                                                                     | 159 mm                                                                                                         |
| Depth                                                                                                                                                                                                      | 40 mm                                                                                                          |
| <b>Weights</b>                                                                                                                                                                                             |                                                                                                                |
| Weight, approx.                                                                                                                                                                                            | 192 g                                                                                                          |

# PROFlenergy

## 7.1 Pause function

### Introduction

PROFlenergy is a PROFINET-based data interface for switching off consumers centrally and in a coordinated manner during pause times regardless of the manufacturer or device type. This has the aim that the process is only provided with the energy that is absolutely required. In so doing, the majority of the energy savings come from the process itself; the PROFINET device contributes only a few watts to the possible savings. In PROFlenergy, this operating state is referred to as a "pause".

### Start and end of a pause

You enable and disable the pause function of the system at the beginning and end of pauses, respectively; the IO controller then sends the PROFlenergy command "Start\_Pause" or "End\_Pause" to the modules.

Use the "Start\_Pause" command to start a pause.

Use the "End\_Pause" command to end a pause.

The following conditions will also cause a pause to be ended:

- Reconfiguration in RUN
- Controller failure
- Firmware update
- Station stop
- Restart of the interface module through:
  - POWER OFF/POWER ON of an interface module
  - POWER OFF/POWER ON of an I/O module
  - Termination of ET-Connection1 or ET-Connection2

The specific behavior of the digital output module is explained in the following sections.

### Additional information

You can find additional information on working with PROFlenergy in the "PROFlenergy" section of the manual IM 157-1 PN interface module (<https://support.industry.siemens.com/cs/ww/en/view/89254863>) and the "Saving energy with PROFlenergy" section of function manual PROFINET with STEP 7 V13 (<https://support.industry.siemens.com/cs/ww/en/view/49948856>).

Application examples (<https://support.industry.siemens.com/cs/ww/en/view/41986454>) are also available on the Internet.

## 7.2 Behavior of the digital output module

### Display

The channel status LEDs are directly affected by the signal level at the socket.

### Response to error detection

All channels that are in pause mode on "PE\_MODE\_PROCEED" report their diagnostic status as in productive mode.

The following applies for all channels which switch to a different pause mode:

- During the "pause", error detection of "Short circuit" is not possible:
  - Alarms for errors already pending before the "pause" are retained.
  - After the "pause" is over, the error status is updated and incoming/outgoing errors are reported correspondingly.

### Mode parameter

The following table shows the "Mode" parameter.

Table 7- 1 Mode parameter

| Element | Code                    | Explanation                                                                                                                  |
|---------|-------------------------|------------------------------------------------------------------------------------------------------------------------------|
| Mode    | 0D: PE_MODE_PROCEED     | Proceed at "pause"<br>• Value status "GOOD"                                                                                  |
|         | 1D: PE_MODE_SHUTDOWN    | Switch off at "pause"<br>• Pause substitute value: 0b<br>• Value status "BAD"                                                |
|         | 3D: PE_MODE_LAST_VALUE  | Last value at "pause"<br>• Pause substitute value: Last output value is maintained<br>• Value status "BAD"                   |
|         | 4D: PE_MODE_SUBST_VALUE | Substitute value at "pause"<br>• Pause substitute value: Configured pause substitute value is output<br>• Value status "BAD" |

## Dimension drawing

The figure below shows the dimension drawing of the DQ 8x24VDC/2A 8xM12 digital output module in front and side views.

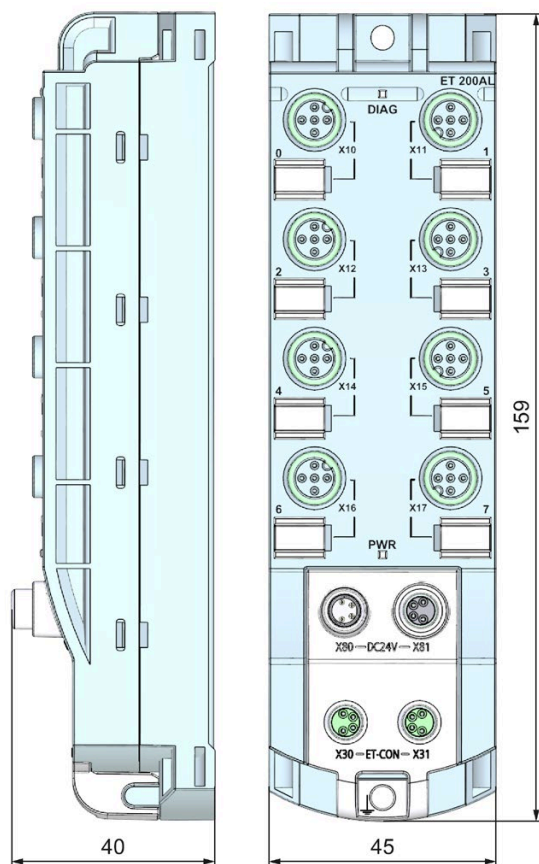


Figure A-1 Dimension drawing

# SIEMENS



Equipment Manual

# SIMATIC

## ET 200AL

Analog input module AI 4xU/I/RTD 4xM12  
(6ES7144-5KD00-0BA0)

Edition

08/2021

[support.industry.siemens.com](https://support.industry.siemens.com)



## SIMATIC

### ET 200AL Analog input module AI 4xU/I/RTD 4xM12 (6ES7144-5KD00-0BA0)

Equipment Manual

#### Preface

---

ET 200AL Documentation  
Guide

1

Product overview

2

Wiring

3

Parameters/address space

4

Interrupts/diagnostics  
alarms

5

Technical specifications

6

PROFInergy

7

Dimension drawing

A

Representation of analog  
values

B

## Legal information

### Warning notice system

This manual contains notices you have to observe in order to ensure your personal safety, as well as to prevent damage to property. The notices referring to your personal safety are highlighted in the manual by a safety alert symbol, notices referring only to property damage have no safety alert symbol. These notices shown below are graded according to the degree of danger.

#### **DANGER**

indicates that death or severe personal injury **will** result if proper precautions are not taken.

#### **WARNING**

indicates that death or severe personal injury **may** result if proper precautions are not taken.

#### **CAUTION**

indicates that minor personal injury can result if proper precautions are not taken.

#### **NOTICE**

indicates that property damage can result if proper precautions are not taken.

If more than one degree of danger is present, the warning notice representing the highest degree of danger will be used. A notice warning of injury to persons with a safety alert symbol may also include a warning relating to property damage.

### Qualified Personnel

The product/system described in this documentation may be operated only by **personnel qualified** for the specific task in accordance with the relevant documentation, in particular its warning notices and safety instructions. Qualified personnel are those who, based on their training and experience, are capable of identifying risks and avoiding potential hazards when working with these products/systems.

### Proper use of Siemens products

Note the following:

#### **WARNING**

Siemens products may only be used for the applications described in the catalog and in the relevant technical documentation. If products and components from other manufacturers are used, these must be recommended or approved by Siemens. Proper transport, storage, installation, assembly, commissioning, operation and maintenance are required to ensure that the products operate safely and without any problems. The permissible ambient conditions must be complied with. The information in the relevant documentation must be observed.

### Trademarks

All names identified by ® are registered trademarks of Siemens AG. The remaining trademarks in this publication may be trademarks whose use by third parties for their own purposes could violate the rights of the owner.

### Disclaimer of Liability

We have reviewed the contents of this publication to ensure consistency with the hardware and software described. Since variance cannot be precluded entirely, we cannot guarantee full consistency. However, the information in this publication is reviewed regularly and any necessary corrections are included in subsequent editions.

# Preface

## Purpose of the documentation

This manual supplements the ET 200AL distributed I/O system (<http://support.automation.siemens.com/WW/view/en/89254965>) system manual. Functions that are generally applicable to the ET 200AL distributed I/O system are described there.

The information provided in the present manual, the system manual and the function manuals enables you to commission the ET 200AL distributed I/O system.

## Changes compared to previous version

Compared to the previous version, this manual contains the following adaptations in the section Technical specifications (Page 38).

## Conventions

Also observe notes marked as follows:

---

### Note

A note contains important information on the product described in the documentation and on the handling of the product to which particular attention should be paid.

---

## See also

Terminal and block diagram (Page 14)

Parameters (Page 21)

ET 200AL Documentation Guide (Page 6)

## Security information

Siemens provides products and solutions with industrial security functions that support the secure operation of plants, systems, machines and networks.

In order to protect plants, systems, machines and networks against cyber threats, it is necessary to implement – and continuously maintain – a holistic, state-of-the-art industrial security concept. Siemens' products and solutions constitute one element of such a concept.

Customers are responsible for preventing unauthorized access to their plants, systems, machines and networks. Such systems, machines and components should only be connected to an enterprise network or the internet if and to the extent such a connection is necessary and only when appropriate security measures (e.g. firewalls and/or network segmentation) are in place.

For additional information on industrial security measures that may be implemented, please visit (<https://www.siemens.com/industrialsecurity>).

Siemens' products and solutions undergo continuous development to make them more secure. Siemens strongly recommends that product updates are applied as soon as they are available and that the latest product versions are used. Use of product versions that are no longer supported, and failure to apply the latest updates may increase customers' exposure to cyber threats.

To stay informed about product updates, subscribe to the Siemens Industrial Security RSS Feed visit (<https://www.siemens.com/industrialsecurity>).

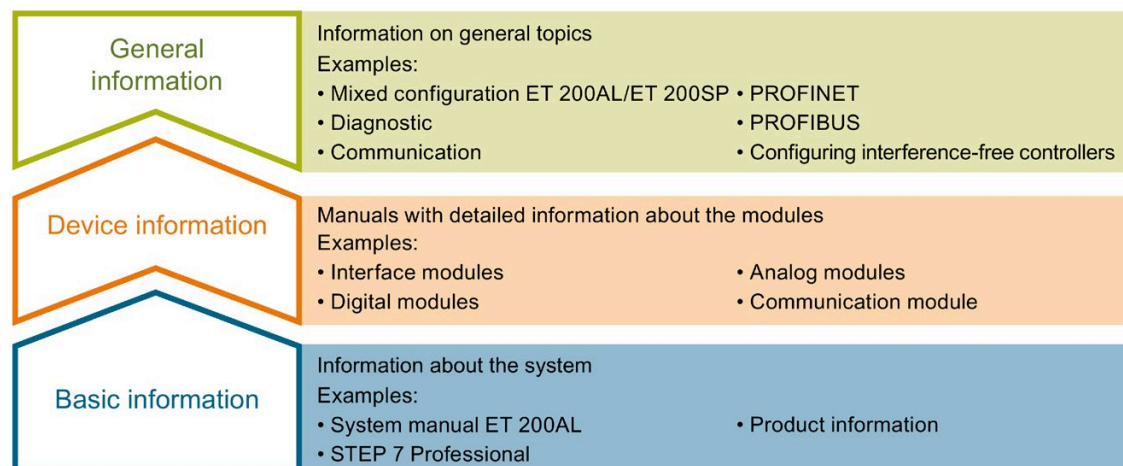
# Table of contents

|          |                                                                   |           |
|----------|-------------------------------------------------------------------|-----------|
|          | <b>Preface .....</b>                                              | <b>3</b>  |
| <b>1</b> | <b>ET 200AL Documentation Guide .....</b>                         | <b>6</b>  |
| <b>2</b> | <b>Product overview .....</b>                                     | <b>10</b> |
| 2.1      | Properties .....                                                  | 10        |
| 2.2      | Operator controls and display elements.....                       | 13        |
| <b>3</b> | <b>Wiring .....</b>                                               | <b>14</b> |
| 3.1      | Terminal and block diagram .....                                  | 14        |
| 3.2      | Pin assignment .....                                              | 16        |
| <b>4</b> | <b>Parameters/address space .....</b>                             | <b>20</b> |
| 4.1      | Measurement types and measuring ranges .....                      | 20        |
| 4.2      | Parameters .....                                                  | 21        |
| 4.3      | Explanation of the parameters .....                               | 26        |
| 4.4      | Address space .....                                               | 29        |
| <b>5</b> | <b>Interrupts/diagnostics alarms .....</b>                        | <b>31</b> |
| 5.1      | Status and error displays .....                                   | 31        |
| 5.2      | Interrupts .....                                                  | 33        |
| 5.3      | Diagnostics alarms.....                                           | 35        |
| <b>6</b> | <b>Technical specifications.....</b>                              | <b>38</b> |
| <b>7</b> | <b>PROFenergy .....</b>                                           | <b>43</b> |
| 7.1      | Pause function.....                                               | 43        |
| 7.2      | Response of the analog input module .....                         | 44        |
| <b>A</b> | <b>Dimension drawing .....</b>                                    | <b>46</b> |
| <b>B</b> | <b>Representation of analog values.....</b>                       | <b>47</b> |
| B.1      | Representation of analog values in voltage measuring ranges ..... | 47        |
| B.2      | Representation of analog values in current measuring ranges.....  | 47        |
| B.3      | Representation of analog values for resistance-based sensors..... | 48        |
| B.4      | Representation of analog values for resistance thermometer .....  | 49        |

# ET 200AL Documentation Guide

The documentation for the SIMATIC ET 200AL distributed I/O system is arranged into three areas.

This arrangement enables you to access the specific content you require.



## Basic information

The System Manual and Getting Started describe in detail the configuration, installation, wiring and commissioning of the SIMATIC ET 200AL distributed I/O system. The STEP 7 online help supports you in the configuration and programming.

## Device information

Product manuals contain a compact description of the module-specific information, such as properties, wiring diagrams, characteristics and technical specifications.

## General information

The function manuals contain detailed descriptions on general topics regarding the SIMATIC ET 200AL distributed I/O system, e.g. diagnostics, communication, Motion Control, Web server.

You can download the documentation free of charge from the Internet (<https://support.industry.siemens.com/cs/ww/en/view/109742667>).

## Manual Collection ET 200AL

The Manual Collection contains the complete documentation on the SIMATIC ET 200AL distributed I/O system gathered together in one file.

You can find the Manual Collection on the Internet (<https://support.automation.siemens.com/WW/view/en/95242965>).

## "mySupport"

With "mySupport", your personal workspace, you make the best out of your Industry Online Support.

In "mySupport", you can save filters, favorites and tags, request CAx data and compile your personal library in the Documentation area. In addition, your data is already filled out in support requests and you can get an overview of your current requests at any time.

You must register once to use the full functionality of "mySupport".

You can find "mySupport" on the Internet (<https://support.industry.siemens.com/My/ww/en>).

## "mySupport" - Documentation

With "mySupport", your personal workspace, you make the best out of your Industry Online Support.

In "mySupport", you can save filters, favorites and tags, request CAx data and compile your personal library in the Documentation area. In addition, your data is already filled out in support requests and you can get an overview of your current requests at any time.

You must register once to use the full functionality of "mySupport".

You can find "mySupport" on the Internet  
(<https://support.industry.siemens.com/My/ww/en/documentation>).

## "mySupport" - CAx data

In the CAx data area of "mySupport", you can access the latest product data for your CAx or CAe system.

You configure your own download package with a few clicks.

In doing so you can select:

- Product images, 2D dimension drawings, 3D models, internal circuit diagrams, EPLAN macro files
- Manuals, characteristics, operating manuals, certificates
- Product master data

You can find "mySupport" - CAx data on the Internet  
(<https://support.industry.siemens.com/my/ww/en/CAxOnline>).

## Application examples

The application examples support you with various tools and examples for solving your automation tasks. Solutions are shown in interplay with multiple components in the system - separated from the focus on individual products.

You will find the application examples on the Internet  
(<https://support.industry.siemens.com/cs/ww/en/ps/ae>).

## TIA Selection Tool

With the TIA Selection Tool, you can select, configure and order devices for Totally Integrated Automation (TIA).

This tool is the successor of the SIMATIC Selection Tool and combines the known configurators for automation technology into one tool.

With the TIA Selection Tool, you can generate a complete order list from your product selection or product configuration.

You can find the TIA Selection Tool on the Internet

(<https://support.industry.siemens.com/cs/ww/en/view/109767888>).

## SIMATIC Automation Tool

You can use the SIMATIC Automation Tool to perform commissioning and maintenance activities simultaneously on various SIMATIC S7 stations as a bulk operation independent of TIA Portal.

The SIMATIC Automation Tool provides a multitude of functions:

- Scanning of a PROFINET/Ethernet system network and identification of all connected CPUs
- Address assignment (IP, subnet, gateway) and station name (PROFINET device) to a CPU
- Transfer of the date and the programming device/PC time converted to UTC time to the module
- Program download to CPU
- RUN/STOP mode switchover
- CPU localization by means of LED flashing
- Reading out of CPU error information
- Reading of the CPU diagnostics buffer
- Reset to factory settings
- Firmware update of the CPU and connected modules

You can find the SIMATIC Automation Tool on the Internet

(<https://support.industry.siemens.com/cs/ww/en/view/98161300>).

## PRONETA

SIEMENS PRONETA (PROFINET network analysis) allows you to analyze the plant network during commissioning. PRONETA features two core functions:

- The topology overview automatically scans the PROFINET and all connected components.
- The IO check is a fast test of the wiring and the module configuration of a plant.

You can find SIEMENS PRONETA on the Internet

(<https://support.industry.siemens.com/cs/ww/en/view/67460624>).



## SINETPLAN

SINETPLAN, the Siemens Network Planner, supports you in planning automation systems and networks based on PROFINET. The tool facilitates professional and predictive dimensioning of your PROFINET installation as early as in the planning stage. In addition, SINETPLAN supports you during network optimization and helps you to exploit network resources optimally and to plan reserves. This helps to prevent problems in commissioning or failures during productive operation even in advance of a planned operation. This increases the availability of the production plant and helps improve operational safety.

The advantages at a glance

- Network optimization thanks to port-specific calculation of the network load
- Increased production availability thanks to online scan and verification of existing systems
- Transparency before commissioning through importing and simulation of existing STEP 7 projects
- Efficiency through securing existing investments in the long term and the optimal use of resources

You can find SINETPLAN on the Internet (<https://www.siemens.com/sinetplan>).

## Product overview

### 2.1 Properties

#### Article number

6ES7144-5KD00-0BA0

#### View of the module

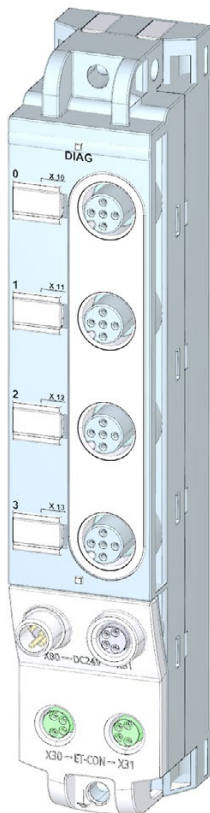


Figure 2-1 View of the analog input module AI 4xU/I/RTD 4xM12

## Properties

The module has the following technical properties:

- 4 analog inputs
- M12 sockets for connection of sensors
- Measurement type can be set for each channel:
  - Voltage
  - Current (2-/4-wire transducers)
  - Resistance (2-/3-wire connection)
  - Resistance thermometer (RTD) (2-/3-wire connection)
- Resolution 16-bit
- Dimensions 30 x 159 mm
- Configurable diagnostics can be set for each channel
- Hardware interrupt on limit violation can be set per channel (two high and two low limits per channel)

The module supports the following functions:

- Firmware update
- Identification and maintenance data I&M0 to I&M3
- Value status (Quality Information)
- PROFIenergy

---

### Note

#### Process values during startup

As long as no parameters have been received by the I/O module, the I/O module returns the process value 7FFF<sub>H</sub>.

---

## Accessories

The following components are included in the module package:

- Identification labels
- Spacers

## Other components

The following component can be ordered as spare part:

- Identification labels

The following components can be ordered as accessories:

- Connectors
- Cables
- Stripping Tool for ET-Connection
- M8 sealing cap
- M12 sealing cap

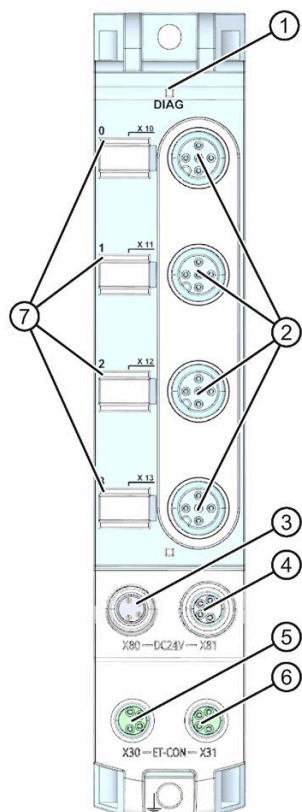
## See also

You can find more information on accessories in the Accessories/spare parts section of the ET 200AL distributed I/O system

(<http://support.automation.siemens.com/WW/view/en/89254965>) system manual.

## 2.2 Operator controls and display elements

The figure below shows the operator controls and display elements of the analog input module AI 4xU/I/RTD 4xM12.



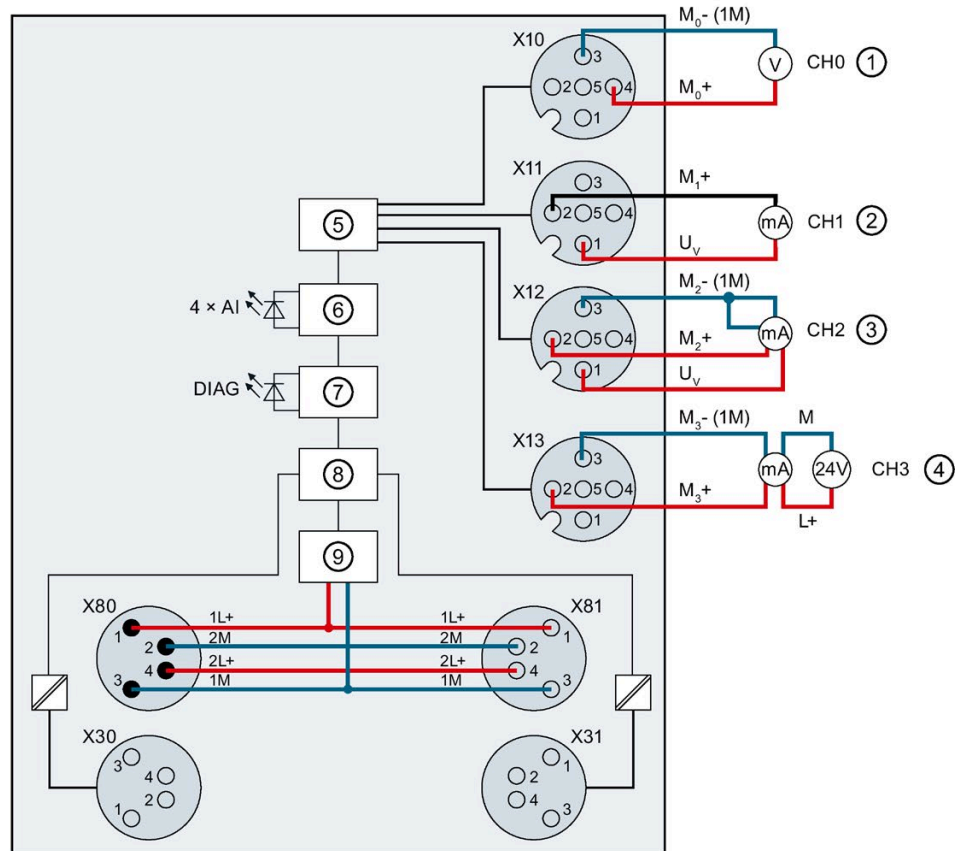
- ① DIAG: LED display for the diagnostic status
- ② X10 to X13: Sockets for the input signal
- ③ X80: Connector for infeed of the supply voltage (POWER input)
- ④ X81: Socket for loop-through of the supply voltage (POWER output)
- ⑤ X30: Socket for ET-Connection IN
- ⑥ X31: Socket for ET-Connection OUT
- ⑦ LED displays 0 to 3 for the channel status

Figure 2-2 Operator controls and display elements

## Wiring

### 3.1 Terminal and block diagram

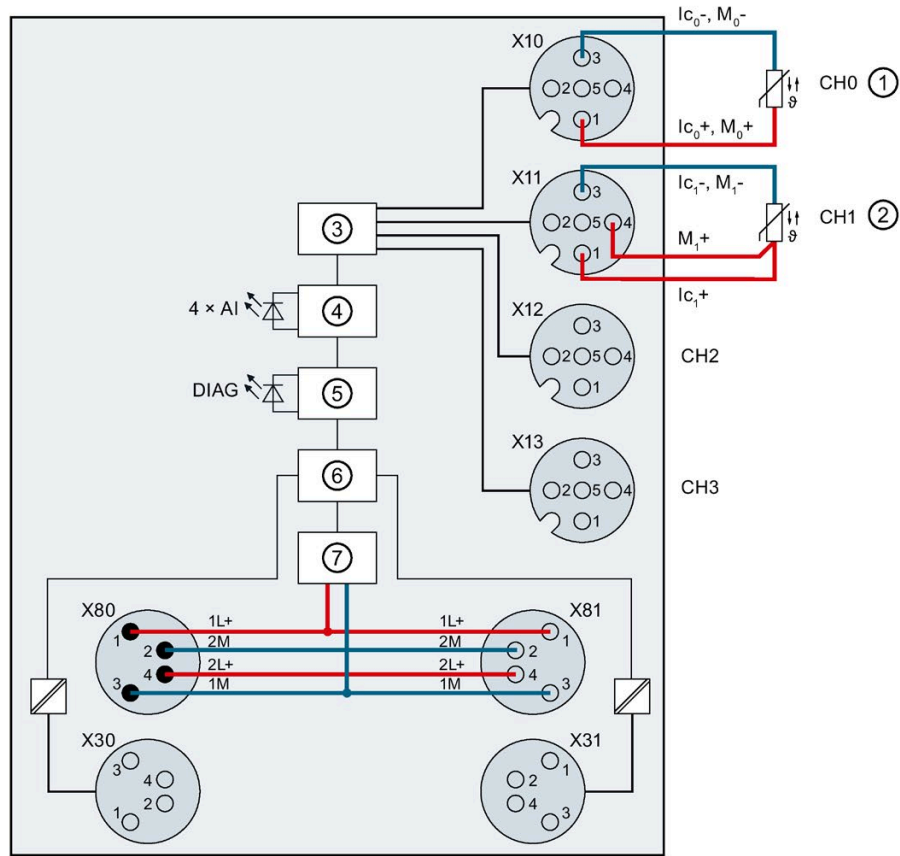
The figure below shows an example of the pin assignment for voltage measurement and current measurement.



|            |                                                         |                  |                                             |
|------------|---------------------------------------------------------|------------------|---------------------------------------------|
| ①          | Voltage measurement                                     | X30              | Infeed of the ET-Connection                 |
| ②          | Current measurement (2 DMU)                             | X31              | Loop-through of the ET-Connection           |
| ③          | Current measurement (4 DMU, with internal power supply) | 1L+              | Supply voltage 1L+ (non-switched)           |
| ④          | Current measurement (4 DMU, with external power supply) | 1M               | Ground 1M (non-switched)                    |
| ⑤          | Multiplexer                                             | 2L+              | Load voltage 2L+ (switched)                 |
| ⑥          | Analog-to-digital converter (ADC)                       | 2M               | Ground 2M (switched)                        |
| ⑦          | Microcontroller                                         | M <sub>n</sub> + | Measuring input positive, channel n         |
| ⑧          | ET-Connection interface                                 | M <sub>n</sub> - | Measuring input negative, channel n         |
| ⑨          | Internal supply voltage                                 | U <sub>v</sub>   | 24 V encoder supply                         |
| X10 to X13 | Channels 0 to 3                                         | AI               | LEDs channel status (0, 1, 2 and 3) (green) |
| X80        | Infeed of supply voltages                               | DIAG             | LED diagnostic status (red/green)           |
| X81        | Loop-through of supply voltages                         |                  |                                             |

Figure 3-1 Terminal and block diagram for voltage and current measurement

The example in the following figure shows the pin assignment for the resistance thermometer.



|            |                                   |            |                                               |
|------------|-----------------------------------|------------|-----------------------------------------------|
| ①          | RTD/R 2-wire connection           | X30        | Infeed of the ET-Connection                   |
| ②          | RTD/R 3-wire connection           | X31        | Loop-through of the ET-Connection             |
| ③          | Multiplexer                       | 1L+        | Supply voltage 1L+ (non-switched)             |
| ④          | Analog-to-digital converter (ADC) | 1M         | Ground 1M (non-switched)                      |
| ⑤          | Microcontroller                   | 2L+        | Load voltage 2L+ (switched)                   |
| ⑥          | ET-Connection interface           | 2M         | Ground 2M (switched)                          |
| ⑦          | Internal supply voltage           | Mn+        | Measuring input positive, channel n           |
| X10 to X13 | Channels 0 to 3                   | Mn-        | Measuring input negative, channel n           |
| X80        | Infeed of supply voltages         | Icn+, Icn- | Current output, current feed, RTD/R channel n |
| X81        | Loop-through of supply voltages   | AI         | LEDs channel status (0, 1, 2 and 3) (green)   |
|            |                                   | DIAG       | LED diagnostic status (red/green)             |

Figure 3-2 Terminal and block diagram for resistance thermometer

## 3.2 Pin assignment

### Note

#### Color coding

The sockets for ET-Connection and the power supply of the modules are color-coded. These colors correspond to the colors of the offered cables.

### Pin assignment of the sockets for analog inputs

The tables below show the pin assignments of the four sockets for connection of the analog inputs.

Table 3- 1 Pin assignment of the sockets for analog inputs (voltage measurement)

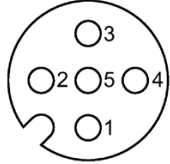
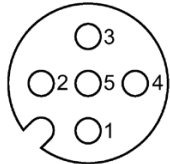
| Pin    | Assignment                                                                                                                                                                                               | Front view of the sockets                                                            |
|--------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------|
|        | <b>X10 to X13 - sockets for analog inputs (voltage measurement)</b>                                                                                                                                      |                                                                                      |
| 1      | 24 V encoder supply 1Us<br>(derived from 1L+ non-switched)                                                                                                                                               |  |
| 2      | Reserved                                                                                                                                                                                                 |                                                                                      |
| 3      | Encoder supply ground 1M                                                                                                                                                                                 |                                                                                      |
| 4      | Measuring input M <sub>0</sub> +: Connector X10<br>Measuring input M <sub>1</sub> +: Connector X11<br>Measuring input M <sub>2</sub> +: Connector X12<br>Measuring input M <sub>3</sub> +: Connector X13 |                                                                                      |
| 5      | Functional earth FE                                                                                                                                                                                      |                                                                                      |
| Shield | Functional earth FE                                                                                                                                                                                      |                                                                                      |

Table 3- 2 Pin assignment of the sockets for analog inputs (current measurement)

| Pin    | Assignment                                                                                                                                                                                               | Front view of the sockets                                                             |
|--------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------|
|        | <b>X10 to X13 sockets for analog inputs (current measurement)</b>                                                                                                                                        |                                                                                       |
| 1      | 24 V encoder supply 1Us<br>(derived from 1L+ non-switched)                                                                                                                                               |  |
| 2      | Measuring input M <sub>0</sub> +: Connector X10<br>Measuring input M <sub>1</sub> +: Connector X11<br>Measuring input M <sub>2</sub> +: Connector X12<br>Measuring input M <sub>3</sub> +: Connector X13 |                                                                                       |
| 3      | Encoder supply ground 1M                                                                                                                                                                                 |                                                                                       |
| 4      | Reserved                                                                                                                                                                                                 |                                                                                       |
| 5      | Functional earth FE                                                                                                                                                                                      |                                                                                       |
| Shield | Functional earth FE                                                                                                                                                                                      |                                                                                       |



**NOTICE****Short-circuit from encoder supply to measuring input**

In the operating mode current measurement a short-circuit from the encoder supply to the measuring input can destroy the input channel.

Table 3- 3 Pin assignment of the sockets for analog inputs (RTD/R 2-wire connection)

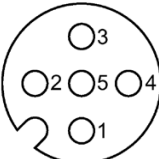
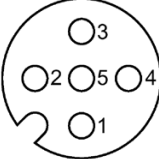
| Pin    | Assignment                                                                                                                                                                                                                           | Front view of the sockets                                                           |
|--------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------|
|        | <b>X10 to X13 sockets for analog inputs<br/>(RTD/R 2-wire connection)</b>                                                                                                                                                            |                                                                                     |
| 1      | Measurement cable $I_{C0+}$ , $M_{0+}$ : Connector X10<br>Measurement cable $I_{C1+}$ , $M_{1+}$ : Connector X11<br>Measurement cable $I_{C2+}$ , $M_{2+}$ : Connector X12<br>Measurement cable $I_{C3+}$ , $M_{3+}$ : Connector X13 |  |
| 2      | Reserved                                                                                                                                                                                                                             |                                                                                     |
| 3      | Measurement cable $I_{C0-}$ , $M_{0-}$ : Connector X10<br>Measurement cable $I_{C1-}$ , $M_{1-}$ : Connector X11<br>Measurement cable $I_{C2-}$ , $M_{2-}$ : Connector X12<br>Measurement cable $I_{C3-}$ , $M_{3-}$ : Connector X13 |                                                                                     |
| 4      | Reserved                                                                                                                                                                                                                             |                                                                                     |
| 5      | Functional earth FE                                                                                                                                                                                                                  |                                                                                     |
| Shield | Functional earth FE                                                                                                                                                                                                                  |                                                                                     |

Table 3- 4 Pin assignment of the sockets for analog inputs (RTD/R 3-wire connection)

| Pin    | Assignment                                                                                                                                                                                                                           | Front view of the sockets                                                             |
|--------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------|
|        | <b>X10 to X13 sockets for analog inputs<br/>(RTD/R 3-wire connection)</b>                                                                                                                                                            |                                                                                       |
| 1      | Constant current cable $I_{C0+}$ : Connector X10<br>Constant current cable $I_{C1+}$ : Connector X11<br>Constant current cable $I_{C2+}$ : Connector X12<br>Constant current cable $I_{C3+}$ : Connector X13                         |  |
| 2      | Reserved                                                                                                                                                                                                                             |                                                                                       |
| 3      | Measurement cable $I_{C0-}$ , $M_{0-}$ : Connector X10<br>Measurement cable $I_{C1-}$ , $M_{1-}$ : Connector X11<br>Measurement cable $I_{C2-}$ , $M_{2-}$ : Connector X12<br>Measurement cable $I_{C3-}$ , $M_{3-}$ : Connector X13 |                                                                                       |
| 4      | Measuring input $M_{0+}$ : Connector X10<br>Measuring input $M_{1+}$ : Connector X11<br>Measuring input $M_{2+}$ : Connector X12<br>Measuring input $M_{3+}$ : Connector X13                                                         |                                                                                       |
| 5      | Functional earth FE                                                                                                                                                                                                                  |                                                                                       |
| Shield | Functional earth FE                                                                                                                                                                                                                  |                                                                                       |

**NOTICE****Incorrect connection of sensors at channel**

If the measurement type current or voltage measurement is configured at the I/O module, a connected resistance thermometer could be destroyed.

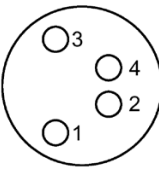
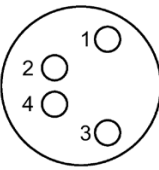
**Note****Coupler plug for RTD measurement**

For RTD measurements, use a coupler plug with gold-plated contacts. Other materials can create contact resistance that can result in incorrect measured values.

**Pin assignment of the sockets for ET-Connection**

The table below shows the pin assignments of the 2 sockets for the connection of ET-Connection.

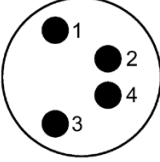
Table 3- 5 Pin assignment for ET-Connection

| Pin    | Assignment                    |                                | Assignment of the core color of the bus cable for ET-Connection | Front view of the sockets                                                             |                                                                                       |
|--------|-------------------------------|--------------------------------|-----------------------------------------------------------------|---------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------|
|        | X30 socket (ET-Connection IN) | X31 socket (ET-Connection OUT) |                                                                 | X30                                                                                   | X31                                                                                   |
| 1      | TXP                           | RXP                            | yellow                                                          |  |  |
| 2      | RXP                           | TXP                            | white                                                           |                                                                                       |                                                                                       |
| 3      | RXN                           | TXN                            | blue                                                            |                                                                                       |                                                                                       |
| 4      | TXN                           | RXN                            | orange                                                          |                                                                                       |                                                                                       |
| Shield | Functional earth FE           |                                | -                                                               |                                                                                       |                                                                                       |

**Pin assignment of the connector for infeed of the supply voltage**

The table below shows the pin assignment of the connector for infeed of the supply voltage.

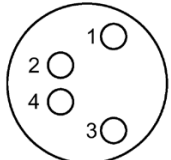
Table 3- 6 Pin assignment of the supply voltage connector

| Pin | Assignment                        | Assignment of the core color of the power cable | Front view of the connector                                                           |
|-----|-----------------------------------|-------------------------------------------------|---------------------------------------------------------------------------------------|
|     | X80 connector (POWER input)       |                                                 |                                                                                       |
| 1   | Supply voltage 1L+ (non-switched) | brown                                           |  |
| 2   | Ground 2M (switched)              | white                                           |                                                                                       |
| 3   | Ground 1M (non-switched)          | blue                                            |                                                                                       |
| 4   | Load voltage 2L+ (switched)       | black                                           |                                                                                       |

### Pin assignment of the socket for loop-through of the supply voltage

The table below shows the pin assignment of the socket for loop-through of the supply voltage.

Table 3- 7 Pin assignment of the supply voltage socket

| Pin | Assignment                        | Assignment of the core color of the power cable | Front view of the socket                                                            |
|-----|-----------------------------------|-------------------------------------------------|-------------------------------------------------------------------------------------|
|     | X81 socket (POWER output)         |                                                 |                                                                                     |
| 1   | Supply voltage 1L+ (non-switched) | brown                                           |  |
| 2   | Ground 2M (switched)              | white                                           |                                                                                     |
| 3   | Ground 1M (non-switched)          | blue                                            |                                                                                     |
| 4   | Load voltage 2L+ (switched)       | black                                           |                                                                                     |

#### NOTICE

##### ET-Connection/supply voltage

Observe the correct wiring of the M8 sockets for ET-Connection and the supply voltage.

Mixing up the connector for ET-Connection and the connector for the supply voltage can destroy the module.

## Parameters/address space

### 4.1 Measurement types and measuring ranges

The table below indicates which measuring range is configurable.

Table 4- 1 Measurement type and measuring ranges

| Measurement type                                                                         | Measuring range                                 | Temperature coefficient                                                              | Resolution             |
|------------------------------------------------------------------------------------------|-------------------------------------------------|--------------------------------------------------------------------------------------|------------------------|
| Deactivated                                                                              | –                                               | –                                                                                    | –                      |
| Voltage                                                                                  | 1 V to 5 V<br>0 V to 10 V                       | –                                                                                    | max. 16-bit            |
| Current (4-wire transducer)                                                              | 0 mA to 20 mA<br>4 mA to 20 mA                  | –                                                                                    | max. 16-bit            |
| Current (2-wire transducer)                                                              | 4 mA to 20 mA                                   | –                                                                                    | max. 16-bit            |
| Resistance (3-wire connection)<br>Resistance (2-wire connection)                         | 150 $\Omega$ , 300 $\Omega$                     | –                                                                                    | max. 15-bit            |
| Resistance thermometer (3-wire connection)<br>Resistance thermometer (2-wire connection) | Pt 100 climatic range/<br>Pt 100 standard range | Pt 0.003850,<br>Pt 0.003916,<br>Pt 0.003902,<br>Pt 0.003920,<br>Pt 0.003851 EN 60751 | max. 16-bit incl. sign |
|                                                                                          | Ni 100 climatic range/<br>Ni 100 standard range | Ni 0.006180,<br>Ni 0.006720                                                          | max. 16-bit incl. sign |

## 4.2 Parameters

### Parameters of the analog input module AI 4xU/I/RTD 4xM12

The table below lists the parameters that can be set. The effective range of the parameters that can be set depends on the type of configuration. The following configurations are possible:

- Distributed operation on PROFINET IO
- Distributed operation with PROFIBUS DP

|                                                                                                                                                                                                                                                                                    |
|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>NOTICE</b>                                                                                                                                                                                                                                                                      |
| <b>Match of encoder and parameters</b><br>The default setting of the analog inputs is voltage measurement (1 V to 5 V).<br>Make sure that the connected encoders and the selected parameters match.<br>The connected encoder can be destroyed in the case of incorrect parameters. |

## 4.2 Parameters

The table below shows the PROFINET and PROFIBUS parameters for the analog input module AI 4xU/I/RTD 4xM12 for configuration with GSD file.

Explanation of abbreviations in table below:

|        |                                          |
|--------|------------------------------------------|
| 4-DMU  | 4-wire transducer                        |
| 2-DMU  | 2-wire transducer                        |
| R-3L   | Resistance 3-wire transducer             |
| R-2L   | Resistance 2-wire transducer             |
| RTD-3L | Resistance thermometer 3-wire transducer |
| RTD-2L | Resistance thermometer 2-wire transducer |

Table 4- 2 Configurable parameters and their defaults

| Parameters                                 | Value range                                                                                                                                                                                                                                                                                 | Default         | GSD file<br>PROFINET IO | GSD file<br>PROFIBUS DP |
|--------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------|-------------------------|-------------------------|
| Temperature unit                           | <ul style="list-style-type: none"> <li>Degrees Celsius</li> <li>Degrees Fahrenheit</li> <li>Kelvin</li> </ul>                                                                                                                                                                               | Degrees Celsius | Module                  | Module                  |
| Measurement type/measuring range channel n | <ul style="list-style-type: none"> <li>Deactivated</li> <li>1 V to 5 V</li> <li>0 V to 10 V</li> <li>0 mA to 20 mA (4-DMU)</li> <li>4 mA to 20 mA (4-DMU)</li> <li>4 mA to 20 mA (2-DMU)</li> <li>R-3L 150 ohm</li> <li>R-3L 300 ohm</li> <li>R-2L 150 ohm</li> <li>R-2L 300 ohm</li> </ul> | 1 V to 5 V      | Channel                 | Channel                 |

| Parameters                                       | Value range                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              | Default    | GSD file<br>PROFINET IO | GSD file<br>PROFIBUS DP |
|--------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------|-------------------------|-------------------------|
| Measurement<br>type/measuring<br>range channel n | <ul style="list-style-type: none"> <li>RTD-3L Pt100 3851 cl.<br/>EN 60751</li> <li>RTD-3L Pt100 3851 std.<br/>EN 60751</li> <li>RTD-3L Pt100 3916 cl.</li> <li>RTD-3L Pt100 3916 std.</li> <li>RTD-3L Pt100 3902 cl.</li> <li>RTD-3L Pt100 3902 std.</li> <li>RTD-3L Pt100 392 cl.</li> <li>RTD-3L Pt100 392 std.</li> <li>RTD-3L Pt100 3850 cl.</li> <li>RTD-3L Pt100 3850 std.</li> <li>RTD-2L Pt100 3851 cl.</li> <li>RTD-2L Pt100 3851 std.</li> <li>RTD-2L Pt100 3916 cl.</li> <li>RTD-2L Pt100 3916 std.</li> <li>RTD-2L Pt100 3902 cl.</li> <li>RTD-2L Pt100 3902 std.</li> <li>RTD-2L Pt100 392 cl.</li> <li>RTD-2L Pt100 392 std.</li> <li>RTD-2L Pt100 3850 cl.</li> <li>RTD-2L Pt100 3850 std.</li> <li>RTD-3L Ni100 618 cl.</li> <li>RTD-3L Ni100 618 std.</li> <li>RTD-3L Ni100 672 cl.</li> <li>RTD-3L Ni100 672 std.</li> <li>RTD-2L Ni100 618 cl.</li> <li>RTD-2L Ni100 618 std.</li> <li>RTD-2L Ni100 672 cl.</li> <li>RTD-2L Ni100 672 std.</li> </ul> | 1 V to 5 V | Channel                 | Channel                 |
| Smoothing channel n                              | <ul style="list-style-type: none"> <li>None</li> <li>Weak</li> <li>Medium</li> <li>Strong</li> </ul>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     | None       | Channel                 | Channel                 |
| Interference fre-<br>quency suppression          | <ul style="list-style-type: none"> <li>3600 Hz</li> <li>60 Hz</li> <li>50 Hz</li> <li>16.67 Hz</li> </ul>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                | 50 Hz      | Channel                 | Module                  |

## 4.2 Parameters

| Parameters                                   | Value range                                                                                                                                          | Default | GSD file<br>PROFINET IO | GSD file<br>PROFIBUS DP |
|----------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------|---------|-------------------------|-------------------------|
| Short-circuit to ground channel n            | <ul style="list-style-type: none"> <li>Disable</li> <li>Enable</li> </ul>                                                                            | Disable | Channel                 | Channel                 |
| Wire break channel n                         | <ul style="list-style-type: none"> <li>Disable</li> <li>Enable</li> </ul>                                                                            | Disable | Channel                 | Channel                 |
| Diagnostics:<br>Overflow/underflow           | <ul style="list-style-type: none"> <li>Disable</li> <li>Enable</li> </ul>                                                                            | Disable | ---                     | Module                  |
| Diagnostics:<br>Underflow channel n          | <ul style="list-style-type: none"> <li>Disable</li> <li>Enable</li> </ul>                                                                            | Disable | Channel                 | ---                     |
| Diagnostics:<br>Overflow channel n           | <ul style="list-style-type: none"> <li>Disable</li> <li>Enable</li> </ul>                                                                            | Disable | Channel                 | ---                     |
| Hardware interrupt<br>high limit 1 channel n | <ul style="list-style-type: none"> <li>Disable</li> <li>Enable</li> </ul>                                                                            | Disable | Channel                 | ---                     |
| Hardware interrupt<br>low limit 1 channel n  | <ul style="list-style-type: none"> <li>Disable</li> <li>Enable</li> </ul>                                                                            | Disable | Channel                 | ---                     |
| Hardware interrupt<br>high limit 2 channel n | <ul style="list-style-type: none"> <li>Disable</li> <li>Enable</li> </ul>                                                                            | Disable | Channel                 | ---                     |
| Hardware interrupt<br>low limit 2 channel n  | <ul style="list-style-type: none"> <li>Disable</li> <li>Enable</li> </ul>                                                                            | Disable | Channel                 | ---                     |
| High limit 1 channel n                       | The value range depends on the measurement type.<br><br>The value range (min./max.) permitted for the measurement type is listed in the table below. |         | Channel                 | ---                     |
| Low limit 1 channel n                        |                                                                                                                                                      |         | Channel                 | ---                     |
| High limit 2 channel n                       |                                                                                                                                                      |         | Channel                 | ---                     |
| Low limit 2 channel n                        |                                                                                                                                                      |         | Channel                 | ---                     |

**Note****Unused channels**

"Deactivate" unused inputs in the parameter assignment to shorten the cycle time of the module.

A deactivated input always returns the value 7FFF<sub>H</sub>.



The table below shows the permitted value ranges for the measurement type.

Table 4- 3 Measuring ranges of the hardware interrupts

| Measure-<br>ment type     | Measuring<br>range | Low limit | High limit | Default   |            | Unit    |
|---------------------------|--------------------|-----------|------------|-----------|------------|---------|
|                           |                    |           |            | Low limit | High limit |         |
| Voltage                   | 1 V to 5 V         | 0.297     | 5.703      | 1         | 5          | V       |
|                           |                    | -4863     | 32510      | 0         | 27648      | Decimal |
|                           | 0 V to 10 V        | -1.758    | 11.758     | 0         | 10         | V       |
|                           |                    | -4863     | 32510      | 0         | 27648      | Decimal |
| Current                   | 0 mA to 20 mA      | -3.51     | 23.51      | 0         | 20         | mA      |
|                           |                    | -4863     | 32510      | 0         | 27648      | Decimal |
|                           | 4 mA to 20 mA      | 1.19      | 22.81      | 4         | 20         | mA      |
|                           |                    | -4863     | 32510      | 0         | 27648      | Decimal |
| Resistance                | 150 ohm            | 0.01      | 176.37     | 0.01      | 150        | Ω       |
|                           |                    | 1         | 32510      | 1         | 27648      | Decimal |
|                           | 300 ohm            | 0.01      | 352.75     | 0.01      | 300        | Ω       |
|                           |                    | 1         | 32510      | 1         | 27648      | Decimal |
| Resistance<br>thermometer | Pt100 cl.          | -144.99   | 154.99     | -120      | 130        | °C      |
|                           |                    | -14499    | 15499      | -12000    | 13000      | Decimal |
|                           |                    | -228.99   | 310.99     | -184      | 266        | F       |
|                           |                    | -22899    | 31099      | -18400    | 26600      | Decimal |
|                           | Ni100 cl.          | -104.99   | 154.99     | -60       | 130        | °C      |
|                           |                    | -10499    | 15499      | -6000     | 13000      | Decimal |
|                           |                    | -156.99   | 310.99     | -76       | 266        | F       |
|                           |                    | -15699    | 31099      | -7600     | 26600      | Decimal |
|                           | Pt100 std.         | -242.9    | 999.9      | -200      | 850        | °C      |
|                           |                    | -2429     | 9999       | -2000     | 8500       | Decimal |
|                           |                    | -405.3    | 1831.9     | -328      | 1562       | F       |
|                           |                    | -4053     | 18319      | -3280     | 15620      | Decimal |
|                           |                    | 30.3      | 1273.1     | 73.2      | 1123.2     | K       |
|                           |                    | 303       | 12731      | 732       | 11232      | Decimal |
|                           | Ni100 std.         | -104.9    | 294.9      | -60       | 250        | °C      |
|                           |                    | -1049     | 2949       | -600      | 2500       | Decimal |
|                           |                    | -156.9    | 562.9      | -76       | 482        | F       |
|                           |                    | -1569     | 5629       | -760      | 4820       | Decimal |
|                           |                    | 168.3     | 568.1      | 213.2     | 523.2      | K       |
|                           |                    | 1683      | 5681       | 2132      | 5232       | Decimal |

## 4.3 Explanation of the parameters

### Temperature unit

You use this parameter to set the temperature unit with which you want to measure the temperature.

### Measurement type/measuring range channel n

You use this parameter to set the measurement type or the measuring range for acquiring the measured values.

---

#### Note

##### Unused channels

"Deactivate" unused channels in the parameter assignment to improve the cycle time of the module.

A deactivated channel always returns the value 7FFF<sub>H</sub>.

---

### Temperature coefficient (for RTD, resistance thermometer)

The temperature coefficient depends on the chemical composition of the material. In Europe, only one value is used per sensor type (default value).

The correction factor for the temperature coefficient ( $\alpha$  value) specifies how much the resistance of a certain material changes when the temperature is raised by 1 °C.

The further values facilitate sensor-specific setting of the temperature coefficient and enhance accuracy.

## Smoothing channel n

The purpose of smoothing is to filter out interferences. The greater the smoothing factor, the better the filter effect. This is technically implemented in the form of a digital filter. The smoothing can be set in 4 levels. The smoothing factor  $k$  is equal to the number of module cycles. The time constant of the smoothing filter is the product of the smoothing factor  $k$  and the cycle time of the I/O module. The greater the smoothing, the greater the time constant of the filter.

Smoothing time = number of module cycles ( $k$ ) × cycle time of the module.

The following figure shows how many module cycles it takes for the smoothed analog value to approach 100%, depending on the configured smoothing. This is valid for all signal changes at the analog input.

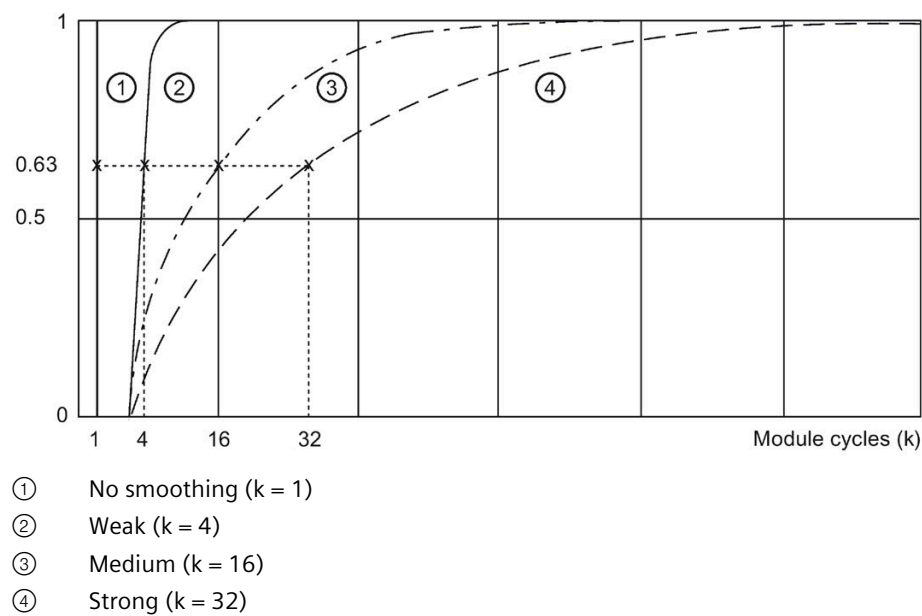


Figure 4-1 Smoothing

## Interference frequency suppression channel n

This parameter suppresses interference for analog input modules which is caused by the frequency of the alternating voltage network in use.

The frequency of the alternating voltage network may negatively affect the measured value, in particular when measuring in the low voltage range and with thermocouples. With this parameter, the user specifies the line frequency that is predominant in the plant.

## Diagnostics: Short-circuit to ground channel n

Enabling of the diagnostics if a short-circuit of the encoder supply to ground occurs.

## 4.3 Explanation of the parameters

**Diagnostics: Wire break channel n**

Enabling of the diagnostics if the analog input module has no current flow or the current is too weak for measurement at the correspondingly configured input.

**Note****Wire break diagnostics**

A wire break diagnostics is not possible for all measuring ranges and measurement types for analog input channels.

The table below shows the rules you must observe in the case of a wire break in the measuring ranges 1 to 5, 4 to 20 mA:

Table 4- 4 Parameters for wire break

| Parameter                                                                                                                                                                                                    | Event      | Measured value    | Explanation                                  |
|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------|-------------------|----------------------------------------------|
| Wire break enabled <sup>1</sup>                                                                                                                                                                              | Wire break | 7FFF <sub>H</sub> | <b>Wire break</b> diagnostics                |
| Wire break disabled <sup>1</sup>                                                                                                                                                                             | Wire break | 8000 <sub>H</sub> | Measured value after leaving the under-range |
| Underflow enabled                                                                                                                                                                                            |            |                   | Diagnostics alarm <b>Low limit violated</b>  |
| Wire break disabled <sup>1</sup><br>Underflow disabled                                                                                                                                                       | Wire break | 8000 <sub>H</sub> | Measured value after leaving the under-range |
| <sup>1</sup> Measuring range limits for detection of wire break and measuring range undershoot: <ul style="list-style-type: none"> <li>1 V to 5 V: at 0.296 V</li> <li>4 mA to 20 mA: at 1.185 mA</li> </ul> |            |                   |                                              |

The table below shows the diagnostics that can occur for wire break with the measurement type RTD/R.

Table 4- 5 Diagnostics with RTD/R

| Diagnostics: Wire break | Diagnostics: Overflow | Diagnostics: Underflow* | Event      | Process data | Diagnostics alarm per channel |
|-------------------------|-----------------------|-------------------------|------------|--------------|-------------------------------|
| activated               | Deactivated           | Deactivated             | Wire break | 0x7FFF       | Wire break                    |
| Deactivated             | Deactivated           | Activated               | Wire break | 0x7FFF       | -                             |
| Deactivated             | Activated             | Deactivated             | Wire break | 0x7FFF       | High limit exceeded           |
| Deactivated             | Activated             | Activated               | Wire break | 0x7FFF       | High limit violated           |
| Deactivated             | Deactivated           | Deactivated             | Wire break | 0x7FFF       | -                             |

\* This column does not apply to the measurement type resistance.

**Diagnostics: Underflow channel n**

Enabling of the diagnostics when the measured value falls below the under-range.

**Diagnostics: Overflow channel n**

Enabling of the diagnostics when the measured value exceeds the overrange.

**Diagnostics: Overflow/Underflow (for PROFIBUS only)**

Enabling of the diagnostics when the measured value exceeds the overrange or falls below the underrange.

The diagnostic enable has an effect on all channels.

**Hardware interrupt high/low limit 1 or 2 channel n**

Enabling of a hardware interrupt when the high limit 1 or 2 or the low limit 1 or 2 is violated.

Requirement: An OB 4x must be assigned to the CPU/device.

Additional information on the structure of hardware interrupts is available in the section Interrupts (Page 33).

**High/low limit 1 or 2 channel n**

Specify a threshold at which a hardware interrupt is triggered when it is exceeded or undershot.

**4.4 Address space**

The figure below shows the assignment of the address space for the analog input module AI 4xU/I/RTD 4xM12 with value status (Quality Information, QI). If you are using PROFINET and the value status was enabled, the addresses for the value status are available. The value status is not available for PROFIBUS.

Assignment in the process image input (PII)

|          | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 | Conne-<br>tor                        | Pin assignment |       |           |             | Channel |
|----------|---|---|---|---|---|---|---|---|--------------------------------------|----------------|-------|-----------|-------------|---------|
|          |   |   |   |   |   |   |   |   |                                      | U              | I     | RTD 2-DMU | RTD 3-DMU   |         |
| EB x     |   |   |   |   |   |   |   |   | X10                                  | Pin 4          | Pin 2 | Pin 1, 3  | Pin 1, 3, 4 | 0       |
| EB x + 1 |   |   |   |   |   |   |   |   | X11                                  | Pin 4          | Pin 2 | Pin 1, 3  | Pin 1, 3, 4 | 1       |
| EB x + 2 |   |   |   |   |   |   |   |   | X12                                  | Pin 4          | Pin 2 | Pin 1, 3  | Pin 1, 3, 4 | 2       |
| EB x + 3 |   |   |   |   |   |   |   |   | X13                                  | Pin 4          | Pin 2 | Pin 1, 3  | Pin 1, 3, 4 | 3       |
| EB x + 4 |   |   |   |   |   |   |   |   |                                      |                |       |           |             |         |
| EB x + 5 |   |   |   |   |   |   |   |   |                                      |                |       |           |             |         |
| EB x + 6 |   |   |   |   |   |   |   |   |                                      |                |       |           |             |         |
| EB x + 7 |   |   |   |   |   |   |   |   |                                      |                |       |           |             |         |
| EB x + 8 | 0 | 0 | 0 | 0 |   |   |   |   | Value status (QI) at channels 0 to 3 |                |       |           |             |         |

Figure 4-2 Address space

### Configuration options of analog input module AI 4xU/I/RTD 4xM12

You have the following configuration options:

- Configuration 1: without value status
- Configuration 2: with value status

### Evaluating the value status

If you enable the value status for the analog input module, a bit is also assigned in the input address space. Bits 0 to 3 in this byte are assigned to a channel and provide information on the validity of the analog value. The value status is independent of whether or not diagnostics was configured.

Bit = 1: No error on channel.

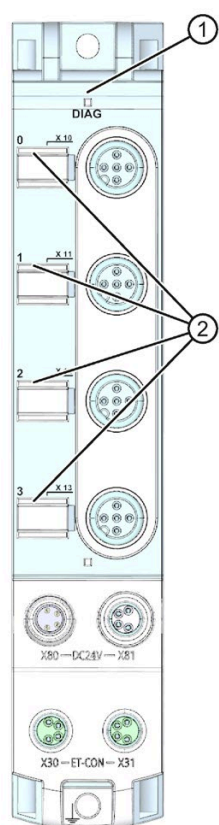
Bit = 0: Error on channel.

# Interrupts/diagnostics alarms

## 5.1 Status and error displays

### LED displays

The figure below shows the LED display (status and error displays) of the analog input module AI 4xU/I/RTD 4xM12.



- ① Diagnostic status (DIAG) (red/green)
- ② Channel status (0, 1, 2 and 3) (green)

Figure 5-1 LED displays

## Meaning of the LEDs

The following tables set out the meaning of the status and error displays. Corrective measures for diagnostics alarms can be found in the section Diagnostics alarms (Page 35).

### DIAG LED

Table 5- 1 Error display of the DIAG LED

| DIAG LED                                                                                      | Meaning                                                                                                                                                                                                                                                                                                     |
|-----------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <br>Off      | No supply voltage 1L+                                                                                                                                                                                                                                                                                       |
| <br>Flashes  | <ul style="list-style-type: none"> <li>Module parameters not assigned (after switching on the supply voltage 1L+)</li> <li>Loading firmware (while the firmware update is being performed, all LEDs retain their current status)</li> <li>No connection to the ET-Connection and/or the fieldbus</li> </ul> |
| <br>On       | Module parameters assigned and no module diagnostics                                                                                                                                                                                                                                                        |
| <br>Flashes | Module parameters assigned and module diagnostics                                                                                                                                                                                                                                                           |

### LED for the channel status

Table 5- 2 Status display of the LEDs 0, 1, 2 and 3

| LED 0, 1, 2 and 3                                                                          | Meaning                                                                                                                                                                        |
|--------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <br>Off | <ul style="list-style-type: none"> <li>Channel deactivated</li> <li>Channel activated and incorrect parameter assignment</li> <li>Parameter error possible with GSD</li> </ul> |
| <br>On  | <ul style="list-style-type: none"> <li>Channel activated and correct parameter assignment</li> </ul>                                                                           |



## 5.2 Interrupts

Analog input module AI 4xU/I/RTD 4xM12 supports the following diagnostic and hardware interrupts.

### Diagnostic interrupt

The table below shows the events for which the analog input module returns a diagnostic interrupt, depending on the parameter assignment.

Table 5- 3 Diagnostic interrupts

| Measure-<br>ment type     | Measuring<br>range        | Diagnostics                    |            |                        |                       |                                     |
|---------------------------|---------------------------|--------------------------------|------------|------------------------|-----------------------|-------------------------------------|
|                           |                           | Short-<br>circuit to<br>ground | Wire break | Underflow <sup>1</sup> | Overflow <sup>1</sup> | Underflow/<br>Overflow <sup>2</sup> |
| Voltage                   | 1 V to 5 V                | x                              | x          | x                      | x                     | x                                   |
|                           | 0 V to 10 V               | x                              | -          | x                      | x                     | x                                   |
| Current                   | 2-DMU<br>4 mA to<br>20 mA | x                              | x          | x                      | x                     | x                                   |
|                           | 4-DMU<br>0 mA to<br>20 mA | x                              | -          | x                      | x                     | x                                   |
|                           | 4-DMU<br>4 mA to<br>20 mA | x                              | x          | x                      | x                     | x                                   |
| Resistance                | 150 Ω                     | -                              | x          | -                      | x                     | x                                   |
|                           | 300 Ω                     | -                              | x          | -                      | x                     | x                                   |
| Resistance<br>thermometer | PT100                     | -                              | x          | x                      | x                     | x                                   |
|                           | Ni100                     | -                              | x          | x                      | x                     | x                                   |

<sup>1</sup> Column valid for configuration with PROFINET GSD file

<sup>2</sup> Column valid for configuration with PROFIBUS GSD file

## Hardware interrupt

The analog input module generates a hardware interrupt with the following events:

- Low limit 1 violated
- High limit 1 violated
- Low limit 2 violated
- High limit 2 violated

Detailed information on the event is available in the hardware interrupt organization block with the instruction "RALRM" (Read additional interrupt information) and in the STEP 7 online help.

The start information of the organization block includes information on which channel of the analog input module triggered the hardware interrupt.

### Note

#### Violation of two limits

If two limits are violated at the same time, limit 1 is always signaled first, followed by limit 2.

The figure below shows the assignment to the bits of the local data double word 8.

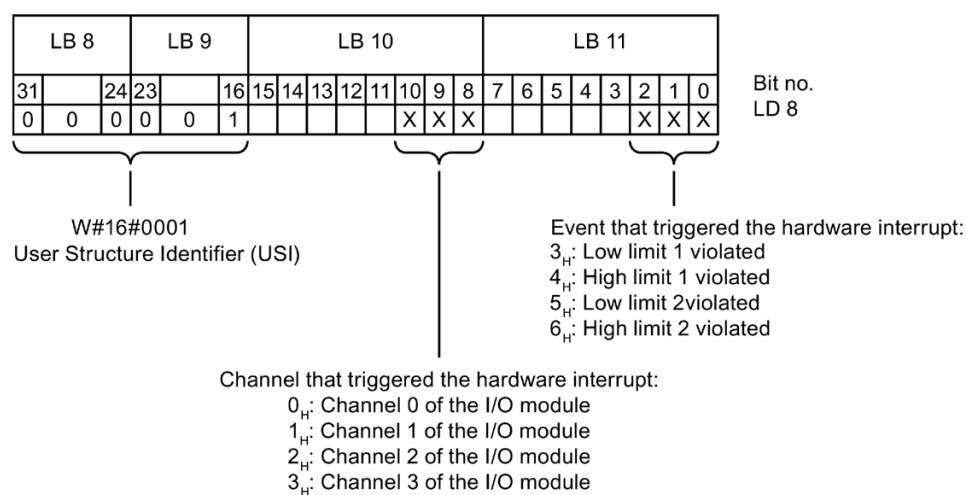


Figure 5-2 Start information of the organization block

## Structure of the additional interrupt information

Table 5- 4 Structure of USI = W#16#0001

| Data block name                                                | Contents           | Comment                                                             | Bytes |
|----------------------------------------------------------------|--------------------|---------------------------------------------------------------------|-------|
| <b>USI</b><br>(User Structure Identifier)                      | W#16#0001          | Additional interrupt info for hardware interrupts of the I/O module | 2     |
| The channel that triggered the hardware interrupt follows.     |                    |                                                                     |       |
| <b>Channel</b>                                                 | B#16#00 to B#16#03 | Number of channel which triggered the event                         | 1     |
| The error event that triggered the hardware interrupt follows. |                    |                                                                     |       |
| <b>Event</b>                                                   | B#16#03            | Low limit 1 violated                                                | 1     |
|                                                                | B#16#04            | High limit 1 violated                                               |       |
|                                                                | B#16#05            | Low limit 2 violated                                                |       |
|                                                                | B#16#06            | High limit 2 violated                                               |       |

## 5.3 Diagnostics alarms

A diagnostics alarm is output for each diagnostic event and the DIAG LED flashes red on the analog input module. You can read out the diagnostics alarms, for example, in the diagnostics buffer of the CPU. You can evaluate the error codes with the user program.

The following tables set out the diagnostics alarms for the set measuring range.

Table 5- 5 Diagnostics alarms - for the measuring range: 1 V to 5 V, 2-DMU 4 mA to 20 mA and 4-DMU 4 mA to 20 mA

| Diagnostics alarm       | Error code      | Meaning                                                                                                 | Remedy                                                                                                                            |
|-------------------------|-----------------|---------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------|
| Short-circuit           | 1 <sub>H</sub>  | Short-circuit encoder supply to ground                                                                  | Correct interplay between module and encoder                                                                                      |
| Wire break              | 6 <sub>H</sub>  | Wire break between the module and sensor                                                                | Connect the cable                                                                                                                 |
|                         |                 | Channel not connected (open)                                                                            | <ul style="list-style-type: none"> <li>Deactivate diagnostics</li> <li>Connect the channel</li> <li>Deactivate channel</li> </ul> |
| High limit violated     | 7 <sub>H</sub>  | Value is above overrange.                                                                               | Correct interplay between module and sensor                                                                                       |
| Low limit violated      | 8 <sub>H</sub>  | Value is below underrange.                                                                              | Correct interplay between module and sensor                                                                                       |
| Error                   | 9 <sub>H</sub>  | Value is significantly above or below underrange/overrange.                                             | Correct interplay between module and sensor                                                                                       |
| Parameter error         | 10 <sub>H</sub> | Module parameter assignment is faulty                                                                   | Correct the parameter assignment                                                                                                  |
| Hardware interrupt lost | 16 <sub>H</sub> | At least one hardware interrupt could not be signaled because too many hardware interrupts are pending. | Correct the program or the process                                                                                                |

## 5.3 Diagnostics alarms

Table 5- 6 Diagnostics alarms - for the measuring range: 0 V to 10 V and 4-DMU 0 mA to 20 mA

| Diagnostics alarm       | Error code      | Meaning                                                                                                 | Remedy                                       |
|-------------------------|-----------------|---------------------------------------------------------------------------------------------------------|----------------------------------------------|
| Short-circuit           | 1 <sub>H</sub>  | Short-circuit encoder supply to ground                                                                  | Correct interplay between module and encoder |
| High limit violated     | 7 <sub>H</sub>  | Value is above overrange.                                                                               | Correct interplay between module and sensor  |
| Low limit violated      | 8 <sub>H</sub>  | Value is below underrange.                                                                              | Correct interplay between module and sensor  |
| Error                   | 9 <sub>H</sub>  | Value is significantly above or below underrange/overrange.                                             | Correct interplay between module and sensor  |
| Parameter error         | 10 <sub>H</sub> | Module parameter assignment is faulty                                                                   | Correct the parameter assignment             |
| Hardware interrupt lost | 16 <sub>H</sub> | At least one hardware interrupt could not be signaled because too many hardware interrupts are pending. | Correct the program or the process           |

Table 5- 7 Diagnostics alarms - for the measuring range: 150 Ω and 300 Ω

| Diagnostics alarm       | Error code      | Meaning                                                                                                 | Remedy                                                                                                                            |
|-------------------------|-----------------|---------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------|
| Wire break              | 6 <sub>H</sub>  | Impedance of encoder circuit too high                                                                   | Use a different encoder type or modify the wiring, for example, using cables with larger cross-section                            |
|                         |                 | Wire break between the module and sensor                                                                | Connect the cable                                                                                                                 |
|                         |                 | Channel not connected (open)                                                                            | <ul style="list-style-type: none"> <li>Deactivate diagnostics</li> <li>Connect the channel</li> <li>Deactivate channel</li> </ul> |
| High limit violated     | 7 <sub>H</sub>  | Value is above overrange.                                                                               | Correct interplay between module and sensor                                                                                       |
| Parameter error         | 10 <sub>H</sub> | Module parameter assignment is faulty                                                                   | Correct the parameter assignment                                                                                                  |
| Hardware interrupt lost | 16 <sub>H</sub> | At least one hardware interrupt could not be signaled because too many hardware interrupts are pending. | Correct the program or the process                                                                                                |

**Note****Measurement type resistor (3-wire terminal)**

A wire break of the M+ cable is not detected with measurement type resistor (3-wire terminal). An incorrect measuring value is output in this case.

Table 5- 8 Diagnostics alarms - for the measuring range: Pt100 and Ni100

| Diagnostics alarm       | Error code | Meaning                                                                                                 | Remedy                                                                                                                                  |
|-------------------------|------------|---------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------|
| Wire break              | 6H         | Impedance of encoder circuit too high                                                                   | Use a different encoder type or modify the wiring, for example, using cables with larger cross-section                                  |
|                         |            | Wire break between the module and sensor                                                                | Connect the cable                                                                                                                       |
|                         |            | Channel not connected (open)                                                                            | <ul style="list-style-type: none"> <li>• Deactivate diagnostics</li> <li>• Connect the channel</li> <li>• Deactivate channel</li> </ul> |
| High limit violated     | 7H         | Value is above overrange.                                                                               | Correct interplay between module and sensor                                                                                             |
| Low limit violated      | 8H         | Value is below underrange.                                                                              | Correct interplay between module and sensor                                                                                             |
| Parameter error         | 10H        | Module parameter assignment is faulty                                                                   | Correct the parameter assignment                                                                                                        |
| Hardware interrupt lost | 16H        | At least one hardware interrupt could not be signaled because too many hardware interrupts are pending. | Correct the program or the process                                                                                                      |

## Technical specifications

### Technical specifications of the analog input module AI 4xU/I/RTD 4xM12

The following table shows the technical specifications as of the issue date. You can find a data sheet including daily updated technical specifications on the Internet (<https://support.industry.siemens.com/cs/ww/en/pv/6ES7144-5KD00-0BA0/td?dl=en>).

|                                                          |                                                            |
|----------------------------------------------------------|------------------------------------------------------------|
| <b>Article number</b>                                    | <b>6ES7144-5KD00-0BA0</b>                                  |
| <b>General information</b>                               |                                                            |
| Product type designation                                 | AI 4xU/I/RTD                                               |
| HW functional status                                     | FS04                                                       |
| Firmware version                                         | V1.0.x                                                     |
| <b>Product function</b>                                  |                                                            |
| • I&M data                                               | Yes; I&M0 to I&M3                                          |
| <b>Engineering with</b>                                  |                                                            |
| • STEP 7 TIA Portal configurable/integrated from version | STEP 7 V13 SP1 or higher                                   |
| • STEP 7 configurable/integrated from version            | From V5.5 SP4 Hotfix 3                                     |
| • PROFIBUS from GSD version/GSD revision                 | GSD as of Revision 5                                       |
| • PROFINET from GSD version/GSD revision                 | GSDML V2.3.1                                               |
| <b>Supply voltage</b>                                    |                                                            |
| <b>Load voltage 1L+</b>                                  |                                                            |
| • Rated value (DC)                                       | 24 V                                                       |
| • permissible range, lower limit (DC)                    | 20.4 V                                                     |
| • permissible range, upper limit (DC)                    | 28.8 V                                                     |
| • Reverse polarity protection                            | Yes; against destruction                                   |
| <b>Input current</b>                                     |                                                            |
| Current consumption (rated value)                        | 35 mA; without load                                        |
| from load voltage 1L+ (unswitched voltage)               | 4 A; Maximum value                                         |
| from load voltage 2L+, max.                              | 4 A; Maximum value                                         |
| <b>Encoder supply</b>                                    |                                                            |
| Number of outputs                                        | 4                                                          |
| <b>24 V encoder supply</b>                               |                                                            |
| • Short-circuit protection                               | Yes; per channel, electronic                               |
| • Output current, max.                                   | 0.5 A; Per channel, total current of all channels max. 1 A |
| <b>Power loss</b>                                        |                                                            |
| Power loss, typ.                                         | 1.5 W                                                      |

|                                                                       |                                                    |
|-----------------------------------------------------------------------|----------------------------------------------------|
| <b>Article number</b>                                                 | <b>6ES7144-5KD00-0BA0</b>                          |
| <b>Analog inputs</b>                                                  |                                                    |
| Number of analog inputs                                               | 4                                                  |
| • For current measurement                                             | 4                                                  |
| • For voltage measurement                                             | 4                                                  |
| • For resistance/resistance thermometer measurement                   | 4                                                  |
| permissible input voltage for voltage input (destruction limit), max. | 30 V                                               |
| permissible input current for current input (destruction limit), max. | 50 mA                                              |
| Cycle time (all channels), min.                                       | 8 ms                                               |
| Technical unit for temperature measurement adjustable                 | Yes; Degrees Celsius / degrees Fahrenheit / Kelvin |
| <b>Input ranges (rated values), voltages</b>                          |                                                    |
| • 0 to +10 V                                                          | Yes                                                |
| – Input resistance (0 to 10 V)                                        | 10 MΩ                                              |
| • 1 V to 5 V                                                          | Yes                                                |
| – Input resistance (1 V to 5 V)                                       | 10 MΩ                                              |
| <b>Input ranges (rated values), currents</b>                          |                                                    |
| • 0 to 20 mA                                                          | Yes                                                |
| – Input resistance (0 to 20 mA)                                       | 50 Ω                                               |
| • 4 mA to 20 mA                                                       | Yes                                                |
| – Input resistance (4 mA to 20 mA)                                    | 50 Ω                                               |
| <b>Input ranges (rated values), resistance thermometer</b>            |                                                    |
| • Ni 100                                                              | Yes; Standard/climate                              |
| – Input resistance (Ni 100)                                           | 10 MΩ                                              |
| • Pt 100                                                              | Yes; Standard/climate                              |
| – Input resistance (Pt 100)                                           | 10 MΩ                                              |
| <b>Input ranges (rated values), resistors</b>                         |                                                    |
| • 0 to 150 ohms                                                       | Yes                                                |
| – Input resistance (0 to 150 ohms)                                    | 10 MΩ                                              |
| • 0 to 300 ohms                                                       | Yes                                                |
| – Input resistance (0 to 300 ohms)                                    | 10 MΩ                                              |
| <b>Cable length</b>                                                   |                                                    |
| • shielded, max.                                                      | 30 m                                               |

|                                                                                                                        |                           |
|------------------------------------------------------------------------------------------------------------------------|---------------------------|
| <b>Article number</b>                                                                                                  | <b>6ES7144-5KD00-0BA0</b> |
| <b>Analog value generation for the inputs</b>                                                                          |                           |
| Measurement principle                                                                                                  | integrating               |
| <b>Integration and conversion time/resolution per channel</b>                                                          |                           |
| <ul style="list-style-type: none"> <li>Resolution with overrange (bit including sign), max.</li> </ul>                 | 16 bit                    |
| <ul style="list-style-type: none"> <li>Integration time, parameterizable</li> </ul>                                    | Yes; channel by channel   |
| <ul style="list-style-type: none"> <li>Integration time (ms)</li> </ul>                                                | 0,3 / 16,7 / 20 / 60      |
| <ul style="list-style-type: none"> <li>Interference voltage suppression for interference frequency f1 in Hz</li> </ul> | 3 600 / 60 / 50 / 16.7    |
| <ul style="list-style-type: none"> <li>Conversion time (per channel)</li> </ul>                                        | 2 / 18 / 21 / 61 ms       |
| <b>Smoothing of measured values</b>                                                                                    |                           |
| <ul style="list-style-type: none"> <li>parameterizable</li> </ul>                                                      | Yes                       |
| <ul style="list-style-type: none"> <li>Step: None</li> </ul>                                                           | Yes; 1x cycle time        |
| <ul style="list-style-type: none"> <li>Step: low</li> </ul>                                                            | Yes; 4x cycle time        |
| <ul style="list-style-type: none"> <li>Step: Medium</li> </ul>                                                         | Yes; 16x cycle time       |
| <ul style="list-style-type: none"> <li>Step: High</li> </ul>                                                           | Yes; 32x cycle time       |
| <b>Encoder</b>                                                                                                         |                           |
| <b>Connection of signal encoders</b>                                                                                   |                           |
| <ul style="list-style-type: none"> <li>for voltage measurement</li> </ul>                                              | Yes                       |
| <ul style="list-style-type: none"> <li>for current measurement as 2-wire transducer</li> </ul>                         | Yes                       |
| <ul style="list-style-type: none"> <li>for current measurement as 4-wire transducer</li> </ul>                         | Yes                       |
| <ul style="list-style-type: none"> <li>for resistance measurement with two-wire connection</li> </ul>                  | Yes                       |
| <ul style="list-style-type: none"> <li>for resistance measurement with three-wire connection</li> </ul>                | Yes                       |
| <b>Errors/accuracies</b>                                                                                               |                           |
| Linearity error (relative to input range), (+/-)                                                                       | 0.025 %                   |
| Temperature error (relative to input range), (+/-)                                                                     | 0.01 %/K                  |
| Crosstalk between the inputs, max.                                                                                     | -70 dB                    |
| Repeat accuracy in steady state at 25 °C (relative to input range), (+/-)                                              | 0.01 %                    |
| <b>Operational error limit in overall temperature range</b>                                                            |                           |
| <ul style="list-style-type: none"> <li>Voltage, relative to input range, (+/-)</li> </ul>                              | 0.35 %                    |
| <ul style="list-style-type: none"> <li>Current, relative to input range, (+/-)</li> </ul>                              | 0.45 %                    |
| <ul style="list-style-type: none"> <li>Resistance, relative to input range, (+/-)</li> </ul>                           | 0.25 %                    |
| <ul style="list-style-type: none"> <li>Resistance thermometer, relative to input range, (+/-)</li> </ul>               | 0.25 %                    |



|                                                                                                                                                                                                                                                                                                                      |                                                                                             |
|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------|
| <b>Article number</b>                                                                                                                                                                                                                                                                                                | <b>6ES7144-5KD00-0BA0</b>                                                                   |
| <b>Basic error limit (operational limit at 25 °C)</b> <ul style="list-style-type: none"> <li>Voltage, relative to input range, (+/-)</li> <li>Current, relative to input range, (+/-)</li> <li>Resistance, relative to input range, (+/-)</li> <li>Resistance thermometer, relative to input range, (+/-)</li> </ul> | 0.25 %<br>0.25 %<br>0.15 %<br>0.15 %                                                        |
| <b>Interference voltage suppression for <math>f = n \times (f_1 \pm 0.5 \%)</math>, <math>f_1</math> = interference frequency</b> <ul style="list-style-type: none"> <li>Series mode interference (peak value of interference &lt; rated value of input range), min.</li> </ul>                                      | 40 dB                                                                                       |
| <b>Interrupts/diagnostics/status information</b>                                                                                                                                                                                                                                                                     |                                                                                             |
| <b>Alarms</b> <ul style="list-style-type: none"> <li>Diagnostic alarm</li> <li>Limit value alarm</li> </ul>                                                                                                                                                                                                          | Yes; Parameterizable<br>Yes; Parameterizable                                                |
| <b>Diagnoses</b> <ul style="list-style-type: none"> <li>Wire-break</li> <li>Short-circuit</li> <li>Overflow/underflow</li> </ul>                                                                                                                                                                                     | Yes; at 4 mA to 20 mA and 1 V to 5 V<br>Yes; Encoder supply to M, channel by channel<br>Yes |
| <b>Diagnostics indication LED</b> <ul style="list-style-type: none"> <li>Channel status display</li> <li>for module diagnostics</li> </ul>                                                                                                                                                                           | Yes; green LED<br>Yes; green/red LED                                                        |
| <b>Potential separation</b>                                                                                                                                                                                                                                                                                          |                                                                                             |
| between the load voltages                                                                                                                                                                                                                                                                                            | Yes                                                                                         |
| <b>Potential separation channels</b>                                                                                                                                                                                                                                                                                 |                                                                                             |
| <ul style="list-style-type: none"> <li>between the channels</li> <li>between the channels and backplane bus</li> <li>between the channels and the power supply of the electronics</li> </ul>                                                                                                                         | No<br>Yes<br>No                                                                             |
| <b>Isolation</b>                                                                                                                                                                                                                                                                                                     |                                                                                             |
| Isolation tested with                                                                                                                                                                                                                                                                                                | 707 V DC (type test)                                                                        |
| <b>Degree and class of protection</b>                                                                                                                                                                                                                                                                                |                                                                                             |
| IP degree of protection                                                                                                                                                                                                                                                                                              | IP65/67                                                                                     |
| <b>Standards, approvals, certificates</b>                                                                                                                                                                                                                                                                            |                                                                                             |
| Suitable for safety-related tripping of standard modules                                                                                                                                                                                                                                                             | Yes; From FS02                                                                              |
| <b>Highest safety class achievable for safety-related tripping of standard modules</b> <ul style="list-style-type: none"> <li>Performance level according to ISO 13849-1</li> <li>Category according to ISO 13849-1</li> <li>SILCL according to IEC 62061</li> </ul>                                                 | PL d<br>Cat. 3<br>SILCL 2                                                                   |

|                                                            |                           |
|------------------------------------------------------------|---------------------------|
| <b>Article number</b>                                      | <b>6ES7144-5KD00-0BA0</b> |
| <b>Ambient conditions</b>                                  |                           |
| <b>Ambient temperature during operation</b>                |                           |
| • min.                                                     | -30 °C                    |
| • max.                                                     | 55 °C                     |
| <b>Connection method</b>                                   |                           |
| Design of electrical connection for the inputs and outputs | M12, 5-pole               |
| Design of electrical connection for supply voltage         | M8, 4-pole                |
| <b>ET-Connection</b>                                       |                           |
| • ET-Connection                                            | M8, 4-pin, shielded       |
| <b>Dimensions</b>                                          |                           |
| Width                                                      | 30 mm                     |
| Height                                                     | 159 mm                    |
| Depth                                                      | 40 mm                     |
| <b>Weights</b>                                             |                           |
| Weight, approx.                                            | 168 g                     |

# PROFlenergy

## 7.1 Pause function

### Introduction

PROFlenergy is a PROFINET-based data interface for switching off consumers centrally and in a coordinated manner during pause times regardless of the manufacturer or device type. This has the aim that the process is only provided with the energy that is absolutely required. In so doing, the majority of the energy savings come from the process itself; the PROFINET device contributes only a few watts to the possible savings. In PROFlenergy, this operating state is referred to as a "pause".

### Start and end of a pause

You enable and disable the pause function of the system at the beginning and end of pauses, respectively; the IO controller then sends the PROFlenergy command "Start\_Pause" or "End\_Pause" to the modules.

Use the "Start\_Pause" command to start a pause.

Use the "End\_Pause" command to end a pause.

The following conditions will also cause a pause to be ended:

- Reconfiguration in RUN
- Controller failure
- Firmware update
- Station stop
- Restart of the interface module through:
  - POWER OFF/POWER ON of an interface module
  - POWER OFF/POWER ON of an I/O module
  - Termination of ET-Connection1 or ET-Connection2

The specific response of the analog input module is explained in the section below.

### Additional information

You can find additional information on working with PROFlenergy in the "PROFlenergy" section of the manual IM 157-1 PN interface module (<http://support.automation.siemens.com/WW/view/en/89254863>) and the "Saving energy with PROFlenergy" section of function manual PROFINET with STEP 7 V13 (<http://support.automation.siemens.com/WW/view/en/49948856>).

Application examples (<http://support.automation.siemens.com/WW/view/en/41986454>) are also available on the Internet.

## 7.2 Response of the analog input module

### Requirement

You can use the PROFenergy function when you use the internal encoder supply.

### Display

The channel status LEDs are not affected by PROFenergy.

### Response to error detection

All channels that are in pause mode on "PE\_MODE\_PROCEED" report their diagnostic status as in productive mode.

The following applies for all channels which switch to a different pause mode:

- Encoder supply switch-off upon the start of "pause" does not result in the alarm "Wire break".
- "Wire break", "Short circuit", "High limit violated" and "Low limit violated" error detection is not possible during the "pause":
  - Alarms for errors already pending before the "pause" are retained.
  - After the "pause" is over, the error status is updated and incoming/outgoing errors are reported correspondingly.
- Hardware interrupts are not signaled.

## Mode parameter

The following table shows the "Mode" parameter.

Table 7- 1 Mode parameter

| Element | Code                    | Explanation                                                                                                                                                                                                                               |
|---------|-------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Mode    | 0b: PE_MODE_PROCEED     | Proceed at "pause"<br><ul style="list-style-type: none"> <li>Value status "GOOD"</li> </ul>                                                                                                                                               |
|         | 1b: PE_MODE_SHUTDOWN    | Switch off at "pause"<br><ul style="list-style-type: none"> <li>Encoder supply <math>U_s</math> switched off <sup>1</sup></li> <li>Pause substitute value: 7FFF<sub>H</sub></li> <li>Value status "BAD"</li> </ul>                        |
|         | 3b: PE_MODE_LAST_VALUE  | Last value at "pause"<br><ul style="list-style-type: none"> <li>Encoder supply <math>U_s</math> switched off <sup>1</sup></li> <li>Pause substitute value: Last input value</li> <li>Value status "BAD"</li> </ul>                        |
|         | 4b: PE_MODE_SUBST_VALUE | Substitute value at "pause"<br><ul style="list-style-type: none"> <li>Encoder supply <math>U_s</math> switched off <sup>1</sup></li> <li>Pause substitute value: Configured pause substitute value</li> <li>Value status "BAD"</li> </ul> |

<sup>1</sup> Encoder supply  $U_s$  is only provided for measurement type current and voltage and can only be deactivated in these measurement types.

## Dimension drawing

The figure below shows the dimension drawing of the AI 4xU//RTD 4xM12 analog input module in front and side view.

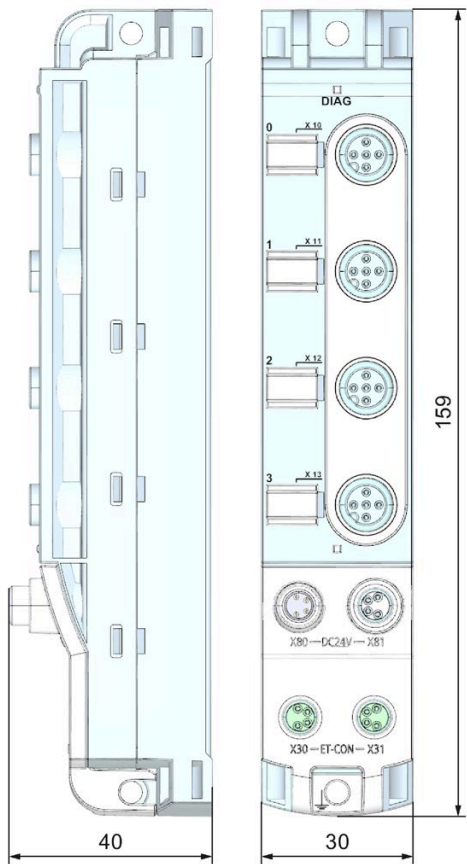


Figure A-1 Dimension drawing

## Representation of analog values

### B.1 Representation of analog values in voltage measuring ranges

Table B- 1 Voltage measuring range 1 V to 5 V and 0 V to 10 V

| Values |      | Voltage measuring range |                     | Range         |
|--------|------|-------------------------|---------------------|---------------|
| Dec.   | Hex. | 1 V to 5 V              | 0 V to 10 V         |               |
| 32767  | 7FFF | >5.704 V                | >11.759 V           | Overflow      |
| 32511  | 7EFF | 5.704 V                 | 11.759 V            | Oerrange      |
| 27649  | 6C01 |                         |                     |               |
| 27648  | 6C00 | 5 V                     | 10 V                |               |
| 20736  | 5100 | 4 V                     | 7.5 V               | Nominal range |
| 1      | 1    | 1 V + 144.7 $\mu$ V     | 0 V + 361.7 $\mu$ V |               |
| 0      | 0    | 1 V                     | 0 V                 |               |
| -1     | FFFF |                         |                     |               |
| -4864  | ED00 | 0.296 V                 | -1.759              | Underrange    |
| -32768 | 8000 | <0.296 V                | < -1.759            | Underflow     |

### B.2 Representation of analog values in current measuring ranges

Table B- 2 Current measuring ranges 0 mA to 20 mA and 4 mA to 20 mA

| Values |      | Current measuring range |                 | Range         |
|--------|------|-------------------------|-----------------|---------------|
| Dec.   | Hex. | 0 mA to 20 mA           | 4 mA to 20 mA   |               |
| 32767  | 7FFF | >23.52 mA               | >22.81 mA       | Overflow      |
| 32511  | 7EFF | 23.52 mA                | 22.81 mA        | Oerrange      |
| 27649  | 6C01 |                         |                 |               |
| 27648  | 6C00 | 20 mA                   | 20 mA           |               |
| 20736  | 5100 | 15 mA                   | 16 mA           | Nominal range |
| 1      | 1    | 723.4 nA                | 4 mA + 578.7 nA |               |
| 0      | 0    | 0 mA                    | 4 mA            |               |
| -1     | FFFF |                         |                 |               |
| -4864  | ED00 | -3.52 mA                | 1.185 mA        | Underrange    |
| -32768 | 8000 | <-3.52 mA               | <1.185 mA       | Underflow     |

## B.3 Representation of analog values for resistance-based sensors

### Resistance-based sensor

Table B- 3 Resistance-based sensor of 150  $\Omega$  and 300  $\Omega$ 

| Values |      | Resistance-based sensor range               |                  | Range                   |
|--------|------|---------------------------------------------|------------------|-------------------------|
| Dec.   | Hex. | 150 $\Omega$                                | 300 $\Omega$     |                         |
| 32767  | 7FFF | >176.38 $\Omega$                            | >352.77 $\Omega$ | Overflow                |
| 32511  | 7EFF | 176.38 $\Omega$                             | 352.77 $\Omega$  | Overrange               |
| 27649  | 6C01 |                                             |                  |                         |
| 27648  | 6C00 | 150 $\Omega$                                | 300 $\Omega$     | Nominal range           |
| 20736  | 5100 | 112.5 $\Omega$                              | 225 $\Omega$     |                         |
| 1      | 1    | 5.43 m $\Omega$                             | 10.85 m $\Omega$ |                         |
| 0      | 0    | 0 $\Omega$                                  | 0 $\Omega$       |                         |
| -1     | FFFF | (negative values are physically impossible) |                  | Underrange <sup>1</sup> |
| :      | :    |                                             |                  |                         |
| -4864  | ED00 |                                             |                  |                         |
| -32768 | 8000 |                                             |                  | Underflow <sup>1</sup>  |

<sup>1</sup> If the sensors are not connected correctly



## B.4 Representation of analog values for resistance thermometer

Table B- 4 Resistance thermometer Pt 100 standard

| Pt x00 standard in °C<br>(1 digit = 0.1°C) | Values |      | Pt x00 standard in °F<br>(1 digit = 0.1 °F) | Values |      | Pt x00 standard in K<br>(1 digit = 0.1 K) | Values |      | Range         |
|--------------------------------------------|--------|------|---------------------------------------------|--------|------|-------------------------------------------|--------|------|---------------|
|                                            | Dec.   | Hex. |                                             | Dec.   | Hex. |                                           | Dec.   | Hex. |               |
| >1000.0                                    | 32767  | 7FFF | >1832.0                                     | 32767  | 7FFF | >1273.2                                   | 32767  | 7FFF | Overflow      |
| 1000.0                                     | 10000  | 2710 | 1832.0                                      | 18320  | 4790 | 1273.2                                    | 12732  | 31BC | Overrange     |
| :                                          | :      | :    | :                                           | :      | :    | :                                         | :      | :    |               |
| 850.1                                      | 8501   | 2135 | 1562.1                                      | 15621  | 3D05 | 1123.3                                    | 11233  | 2BE1 |               |
| 850.0                                      | 8500   | 2134 | 1562.0                                      | 15620  | 3D04 | 1123.2                                    | 11232  | 2BE0 | Nominal range |
| :                                          | :      | :    | :                                           | :      | :    | :                                         | :      | :    |               |
| -200.0                                     | -2000  | F830 | -328.0                                      | -3280  | F330 | 73.2                                      | 732    | 2DC  |               |
| -200.1                                     | -2001  | F82F | -328.1                                      | -3281  | F32F | 73.1                                      | 731    | 2DB  | Underrange    |
| :                                          | :      | :    | :                                           | :      | :    | :                                         | :      | :    |               |
| -243.0                                     | -2430  | F682 | -405.4                                      | -4054  | F02A | 30.2                                      | 302    | 12E  |               |
| <-243.0                                    | -32768 | 8000 | <-405.4                                     | -32768 | 8000 | <30.2                                     | 32768  | 8000 | Underflow     |

Table B- 5 Resistance thermometer Pt 100 climatic

| Pt x00 climatic in °C<br>(1 digit = 0.01 °C) | Values |      | Pt x00 climatic in °F<br>(1 digit = 0.01 °F) | Values |      | Range         |
|----------------------------------------------|--------|------|----------------------------------------------|--------|------|---------------|
|                                              | Dec.   | Hex. |                                              | Dec.   | Hex. |               |
| >155.00                                      | 32767  | 7FFF | >311.00                                      | 32767  | 7FFF | Overflow      |
| 155.00                                       | 15500  | 3C8C | 311.00                                       | 31100  | 797C | Overrange     |
| :                                            | :      | :    | :                                            | :      | :    |               |
| 130.01                                       | 13001  | 32C9 | 266.01                                       | 26601  | 67E9 |               |
| 130.00                                       | 13000  | 32C8 | 266.00                                       | 26600  | 67E8 | Nominal range |
| :                                            | :      | :    | :                                            | :      | :    |               |
| -120.00                                      | -12000 | D120 | -184.00                                      | -18400 | B820 |               |
| -120.01                                      | -12001 | D11F | -184.01                                      | -18401 | B81F | Underrange    |
| :                                            | :      | :    | :                                            | :      | :    |               |
| -145.00                                      | -14500 | C75C | -229.00                                      | -22900 | A68C |               |
| <-145.00                                     | -32768 | 8000 | <-229.00                                     | -32768 | 8000 | Underflow     |

Table B- 6 Resistance thermometer Ni 100 standard

| Ni x00 standard in °C<br>(1 digit = 0.1 °C) | Values |      | Ni x00 standard in °F<br>(1 digit = 0.1 °F) | Values |      | Ni x00 standard in K<br>(1 digit = 0.1 K) | Values |      | Range         |
|---------------------------------------------|--------|------|---------------------------------------------|--------|------|-------------------------------------------|--------|------|---------------|
|                                             | Dec.   | Hex. |                                             | Dec.   | Hex. |                                           | Dec.   | Hex. |               |
| >295.0                                      | 32767  | 7FFF | >563.0                                      | 32767  | 7FFF | >568.2                                    | 32767  | 7FFF | Overflow      |
| 295.0                                       | 2950   | B86  | 563.0                                       | 5630   | 15FE | 568.2                                     | 5682   | 1632 | Overrange     |
| :                                           | :      | :    | :                                           | :      | :    | :                                         | :      | :    |               |
| 250.1                                       | 2501   | 9C5  | 482.1                                       | 4821   | 12D5 | 523.3                                     | 5233   | 1471 | Nominal range |
| 250.0                                       | 2500   | 9C4  | 482.0                                       | 4820   | 12D4 | 523.2                                     | 5232   | 1470 |               |
| :                                           | :      | :    | :                                           | :      | :    | :                                         | :      | :    | Underrange    |
| -60.0                                       | -600   | FDA8 | -76.0                                       | -760   | FD08 | 213.2                                     | 2132   | 854  |               |
| -60.1                                       | -601   | FDA7 | -76.1                                       | -761   | FD07 | 213.1                                     | 2131   | 853  | Underflow     |
| :                                           | :      | :    | :                                           | :      | :    | :                                         | :      | :    |               |
| -105.0                                      | -1050  | FBE6 | -157.0                                      | -1570  | F9DE | 168.2                                     | 1682   | 692  | Underflow     |
| <-105.0                                     | -32768 | 8000 | <-157.0                                     | -32768 | 8000 | <168.2                                    | 32768  | 8000 |               |

Table B- 7 Resistance thermometer Ni 100 climatic

| Ni x00 climatic in °C<br>(1 digit = 0.01 °C) | Values |      | Ni x00 climatic in °F<br>(1 digit = 0.01 °F) | Values |      | Range         |
|----------------------------------------------|--------|------|----------------------------------------------|--------|------|---------------|
|                                              | Dec.   | Hex. |                                              | Dec.   | Hex. |               |
| >155.00                                      | 32767  | 7FFF | >311.00                                      | 32767  | 7FFF | Overflow      |
| 155.00                                       | 15500  | 3C8C | 311.00                                       | 31100  | 797C | Overrange     |
| :                                            | :      | :    | :                                            | :      | :    |               |
| 130.01                                       | 13001  | 32C9 | 266.01                                       | 26601  | 67E9 | Nominal range |
| 130.00                                       | 13000  | 32C8 | 266.00                                       | 26600  | 67E8 |               |
| :                                            | :      | :    | :                                            | :      | :    | Underrange    |
| -60.00                                       | -6000  | E890 | -76.00                                       | -7600  | E250 |               |
| -60.01                                       | -6001  | E88F | -76.01                                       | -7601  | E24F | Underflow     |
| :                                            | :      | :    | :                                            | :      | :    |               |
| -105.00                                      | -10500 | D6FC | -157.00                                      | -15700 | C2AC | Underflow     |
| <-105.00                                     | -32768 | 8000 | <-157.00                                     | -32768 | 8000 |               |

# SIEMENS



Manual

## SIMATIC

### ET 200AL

Analog input module AI 4xRTD/TC 4xM12  
(6ES7144-5KD50-0BA0)

Edition

08/2021

[support.industry.siemens.com](https://support.industry.siemens.com)

## SIMATIC

### ET 200AL Analog input module AI 4xRTD/TC 4xM12 (6ES7144-5KD50-0BA0)

Equipment Manual

#### Preface

---

ET 200AL Documentation  
Guide

1

Product overview

2

Wiring

3

Parameters/address space

4

Interrupts/diagnostics  
alarms

5

Technical specifications

6

Dimension drawing

A

Representation of analog  
values

B

## Legal information

### Warning notice system

This manual contains notices you have to observe in order to ensure your personal safety, as well as to prevent damage to property. The notices referring to your personal safety are highlighted in the manual by a safety alert symbol, notices referring only to property damage have no safety alert symbol. These notices shown below are graded according to the degree of danger.

#### **DANGER**

indicates that death or severe personal injury **will** result if proper precautions are not taken.

#### **WARNING**

indicates that death or severe personal injury **may** result if proper precautions are not taken.

#### **CAUTION**

indicates that minor personal injury can result if proper precautions are not taken.

#### **NOTICE**

indicates that property damage can result if proper precautions are not taken.

If more than one degree of danger is present, the warning notice representing the highest degree of danger will be used. A notice warning of injury to persons with a safety alert symbol may also include a warning relating to property damage.

### Qualified Personnel

The product/system described in this documentation may be operated only by **personnel qualified** for the specific task in accordance with the relevant documentation, in particular its warning notices and safety instructions. Qualified personnel are those who, based on their training and experience, are capable of identifying risks and avoiding potential hazards when working with these products/systems.

### Proper use of Siemens products

Note the following:

#### **WARNING**

Siemens products may only be used for the applications described in the catalog and in the relevant technical documentation. If products and components from other manufacturers are used, these must be recommended or approved by Siemens. Proper transport, storage, installation, assembly, commissioning, operation and maintenance are required to ensure that the products operate safely and without any problems. The permissible ambient conditions must be complied with. The information in the relevant documentation must be observed.

### Trademarks

All names identified by ® are registered trademarks of Siemens AG. The remaining trademarks in this publication may be trademarks whose use by third parties for their own purposes could violate the rights of the owner.

### Disclaimer of Liability

We have reviewed the contents of this publication to ensure consistency with the hardware and software described. Since variance cannot be precluded entirely, we cannot guarantee full consistency. However, the information in this publication is reviewed regularly and any necessary corrections are included in subsequent editions.

# Preface

## Purpose of the documentation

This manual supplements the ET 200AL distributed I/O system (<http://support.automation.siemens.com/WW/view/en/89254965>) system manual. Functions that are generally applicable to the ET 200AL distributed I/O system are described there.

The information provided in the present manual, the system manual and the function manuals enables you to commission the ET 200AL distributed I/O system.

## Changes compared to previous version

Compared to the previous version, this manual contains the following adaptations in the section Technical specifications (Page 39).

## Conventions

Also observe notes marked as follows:

---

### Note

A note contains important information on the product described in the documentation and on the handling of the product to which particular attention should be paid.

---

## Security information

Siemens provides products and solutions with industrial security functions that support the secure operation of plants, systems, machines and networks.

In order to protect plants, systems, machines and networks against cyber threats, it is necessary to implement – and continuously maintain – a holistic, state-of-the-art industrial security concept. Siemens' products and solutions constitute one element of such a concept.

Customers are responsible for preventing unauthorized access to their plants, systems, machines and networks. Such systems, machines and components should only be connected to an enterprise network or the internet if and to the extent such a connection is necessary and only when appropriate security measures (e.g. firewalls and/or network segmentation) are in place.

For additional information on industrial security measures that may be implemented, please visit (<https://www.siemens.com/industrialsecurity>).

Siemens' products and solutions undergo continuous development to make them more secure. Siemens strongly recommends that product updates are applied as soon as they are available and that the latest product versions are used. Use of product versions that are no longer supported, and failure to apply the latest updates may increase customers' exposure to cyber threats.

To stay informed about product updates, subscribe to the Siemens Industrial Security RSS Feed visit (<https://www.siemens.com/industrialsecurity>).

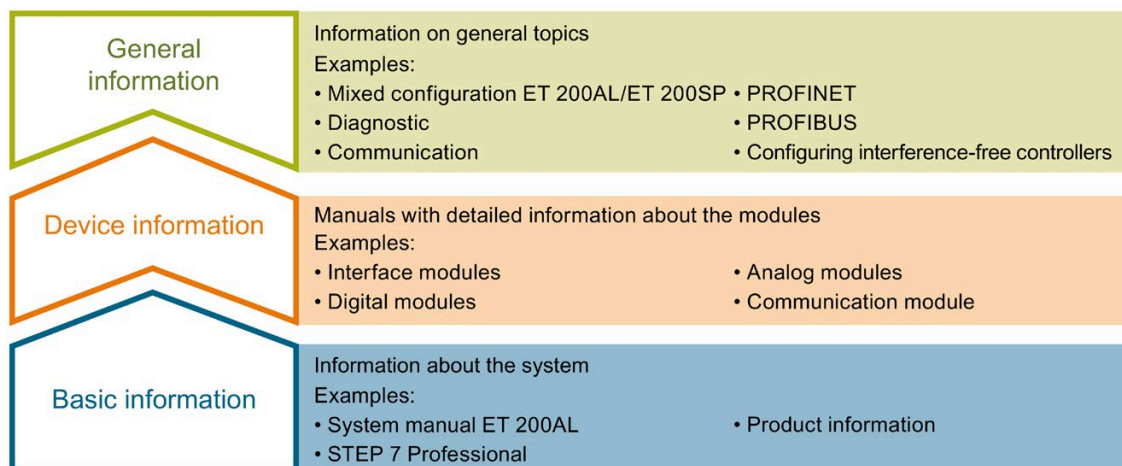
# Table of contents

|          |                                                                        |           |
|----------|------------------------------------------------------------------------|-----------|
|          | <b>Preface</b> .....                                                   | <b>3</b>  |
| <b>1</b> | <b>ET 200AL Documentation Guide</b> .....                              | <b>5</b>  |
| <b>2</b> | <b>Product overview</b> .....                                          | <b>9</b>  |
|          | 2.1 Properties .....                                                   | 9         |
|          | 2.2 Operator controls and display elements .....                       | 12        |
| <b>3</b> | <b>Wiring</b> .....                                                    | <b>13</b> |
|          | 3.1 Terminal and block diagram .....                                   | 13        |
|          | 3.2 Pin assignment .....                                               | 15        |
| <b>4</b> | <b>Parameters/address space</b> .....                                  | <b>19</b> |
|          | 4.1 Measurement types and measuring ranges .....                       | 19        |
|          | 4.2 Parameters .....                                                   | 20        |
|          | 4.3 Explanation of the parameters .....                                | 26        |
|          | 4.4 Structure of a data record for dynamic reference temperature ..... | 31        |
|          | 4.5 Address space.....                                                 | 33        |
| <b>5</b> | <b>Interrupts/diagnostics alarms</b> .....                             | <b>34</b> |
|          | 5.1 Status and error displays .....                                    | 34        |
|          | 5.2 Interrupts .....                                                   | 36        |
|          | 5.3 Diagnostics alarms.....                                            | 38        |
| <b>6</b> | <b>Technical specifications</b> .....                                  | <b>39</b> |
|          | 6.1 Technical specifications .....                                     | 39        |
| <b>A</b> | <b>Dimension drawing</b> .....                                         | <b>45</b> |
|          | A.1 Dimension drawing.....                                             | 45        |
| <b>B</b> | <b>Representation of analog values</b> .....                           | <b>46</b> |
|          | B.1 Representation of analog values in voltage measuring range .....   | 46        |
|          | B.2 Representation of analog values for resistance-based sensors ..... | 47        |
|          | B.3 Representation of analog values for thermal resistors .....        | 48        |
|          | B.4 Representation of analog values for thermocouples .....            | 50        |

# ET 200AL Documentation Guide

The documentation for the SIMATIC ET 200AL distributed I/O system is arranged into three areas.

This arrangement enables you to access the specific content you require.



## Basic information

The System Manual and Getting Started describe in detail the configuration, installation, wiring and commissioning of the SIMATIC ET 200AL distributed I/O system. The STEP 7 online help supports you in the configuration and programming.

## Device information

Product manuals contain a compact description of the module-specific information, such as properties, wiring diagrams, characteristics and technical specifications.

## General information

The function manuals contain detailed descriptions on general topics regarding the SIMATIC ET 200AL distributed I/O system, e.g. diagnostics, communication, Motion Control, Web server.

You can download the documentation free of charge from the Internet (<https://support.industry.siemens.com/cs/ww/en/view/109742667>).

## Manual Collection ET 200AL

The Manual Collection contains the complete documentation on the SIMATIC ET 200AL distributed I/O system gathered together in one file.

You can find the Manual Collection on the Internet (<https://support.automation.siemens.com/WW/view/en/95242965>).



## **"mySupport"**

With "mySupport", your personal workspace, you make the best out of your Industry Online Support.

In "mySupport", you can save filters, favorites and tags, request CAx data and compile your personal library in the Documentation area. In addition, your data is already filled out in support requests and you can get an overview of your current requests at any time.

You must register once to use the full functionality of "mySupport".

You can find "mySupport" on the Internet (<https://support.industry.siemens.com/My/ww/en>).

## **"mySupport" - Documentation**

With "mySupport", your personal workspace, you make the best out of your Industry Online Support.

In "mySupport", you can save filters, favorites and tags, request CAx data and compile your personal library in the Documentation area. In addition, your data is already filled out in support requests and you can get an overview of your current requests at any time.

You must register once to use the full functionality of "mySupport".

You can find "mySupport" on the Internet (<https://support.industry.siemens.com/My/ww/en/documentation>).

## **"mySupport" - CAx data**

In the CAx data area of "mySupport", you can access the latest product data for your CAx or CAe system.

You configure your own download package with a few clicks.

In doing so you can select:

- Product images, 2D dimension drawings, 3D models, internal circuit diagrams, EPLAN macro files
- Manuals, characteristics, operating manuals, certificates
- Product master data

You can find "mySupport" - CAx data on the Internet (<https://support.industry.siemens.com/my/ww/en/CAxOnline>).

## **Application examples**

The application examples support you with various tools and examples for solving your automation tasks. Solutions are shown in interplay with multiple components in the system - separated from the focus on individual products.

You will find the application examples on the Internet (<https://support.industry.siemens.com/cs/ww/en/ps/ae>).

## TIA Selection Tool

With the TIA Selection Tool, you can select, configure and order devices for Totally Integrated Automation (TIA).

This tool is the successor of the SIMATIC Selection Tool and combines the known configurators for automation technology into one tool.

With the TIA Selection Tool, you can generate a complete order list from your product selection or product configuration.

You can find the TIA Selection Tool on the Internet

(<https://support.industry.siemens.com/cs/ww/en/view/109767888>).

## SIMATIC Automation Tool

You can use the SIMATIC Automation Tool to perform commissioning and maintenance activities simultaneously on various SIMATIC S7 stations as a bulk operation independent of TIA Portal.

The SIMATIC Automation Tool provides a multitude of functions:

- Scanning of a PROFINET/Ethernet system network and identification of all connected CPUs
- Address assignment (IP, subnet, gateway) and station name (PROFINET device) to a CPU
- Transfer of the date and the programming device/PC time converted to UTC time to the module
- Program download to CPU
- RUN/STOP mode switchover
- CPU localization by means of LED flashing
- Reading out of CPU error information
- Reading of the CPU diagnostics buffer
- Reset to factory settings
- Firmware update of the CPU and connected modules

You can find the SIMATIC Automation Tool on the Internet

(<https://support.industry.siemens.com/cs/ww/en/view/98161300>).

## PRONETA

SIEMENS PRONETA (PROFINET network analysis) allows you to analyze the plant network during commissioning. PRONETA features two core functions:

- The topology overview automatically scans the PROFINET and all connected components.
- The IO check is a fast test of the wiring and the module configuration of a plant.

You can find SIEMENS PRONETA on the Internet

(<https://support.industry.siemens.com/cs/ww/en/view/67460624>).

## SINETPLAN

SINETPLAN, the Siemens Network Planner, supports you in planning automation systems and networks based on PROFINET. The tool facilitates professional and predictive dimensioning of your PROFINET installation as early as in the planning stage. In addition, SINETPLAN supports you during network optimization and helps you to exploit network resources optimally and to plan reserves. This helps to prevent problems in commissioning or failures during productive operation even in advance of a planned operation. This increases the availability of the production plant and helps improve operational safety.

The advantages at a glance

- Network optimization thanks to port-specific calculation of the network load
- Increased production availability thanks to online scan and verification of existing systems
- Transparency before commissioning through importing and simulation of existing STEP 7 projects
- Efficiency through securing existing investments in the long term and the optimal use of resources

You can find SINETPLAN on the Internet (<https://www.siemens.com/sinetplan>).

## Product overview

### 2.1 Properties

#### Article number

6ES7144-5KD50-0BA0

#### View of the module

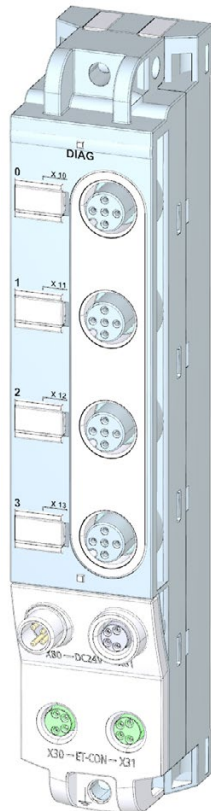


Figure 2-1 View of the analog input module AI 4xRTD/TC 4xM12

## Properties

The module has the following technical properties:

- 4 analog inputs
- M12 sockets for connection of sensors
- Measurement type can be set for each channel:
  - Voltage measurement:  $\pm 80$  mV
  - Resistance measurement: 0-150 Ohm, 0-300 Ohm (2-/3-/4-wire connection)
  - Thermal resistance measurement: Pt/Ni100, Pt/Ni1000 (2-/3-/4-wire connection)
  - Thermocouple measurement: Type B, C, E, J, K, L, N, R, S, T, U
- Connection for isolated/non-isolated thermocouples
- Resolution 16-bit
- Dimensions 30 x 159 x 40 mm
- Accuracy according to AMS2750E
- Configurable diagnostics can be set for each channel
- Hardware interrupt on limit violation can be set per channel (two high and two low limits per channel)
- Various options to compensate for the reference junction temperature

The module supports the following functions:

- Firmware update
- Identification and maintenance data I&M0 to I&M3
- Value status (Quality Information)

---

### Note

#### Process values during startup

As long as no parameters have been received by the I/O module, the I/O module returns the process value 7FFF<sub>H</sub>.

---

## Accessories

The following components are included in the module package:

- Identification labels
- Spacers

## Other components

The following component can be ordered as spare part:

- Identification labels

The following components can be ordered as accessories:

- Connectors
- Cables
- Stripping Tool for ET-Connection
- M8 sealing cap
- M12 sealing cap

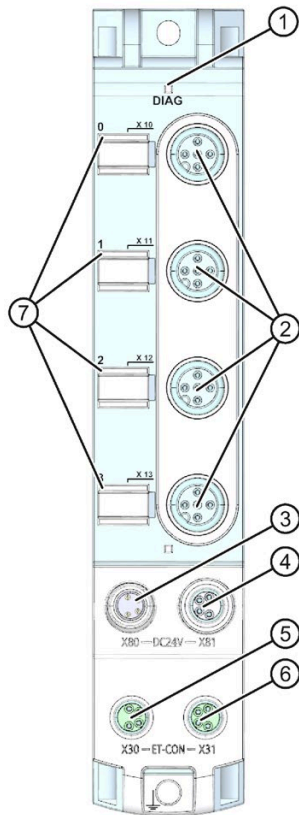
## See also

You can find more information on accessories in the Accessories/spare parts section of the ET 200AL distributed I/O system

(<https://support.industry.siemens.com/cs/ww/en/view/89254965>) system manual.

## 2.2 Operator controls and display elements

The figure below shows the operator control and display elements of the analog input module AI 4xRTD/TC 4xM12.



- ① DIAG: LED display for the diagnostic status
- ② X10 to X13: Sockets for the input signal
- ③ X80: Connector for infeed of the supply voltage (POWER input)
- ④ X81: Socket for loop-through of the supply voltage (POWER output)
- ⑤ X30: Socket for ET-Connection IN
- ⑥ X31: Socket for ET-Connection OUT
- ⑦ LED displays 0 to 3 for the channel status

Figure 2-2 Operator controls and display elements

### 3.1 Terminal and block diagram

[illegible]

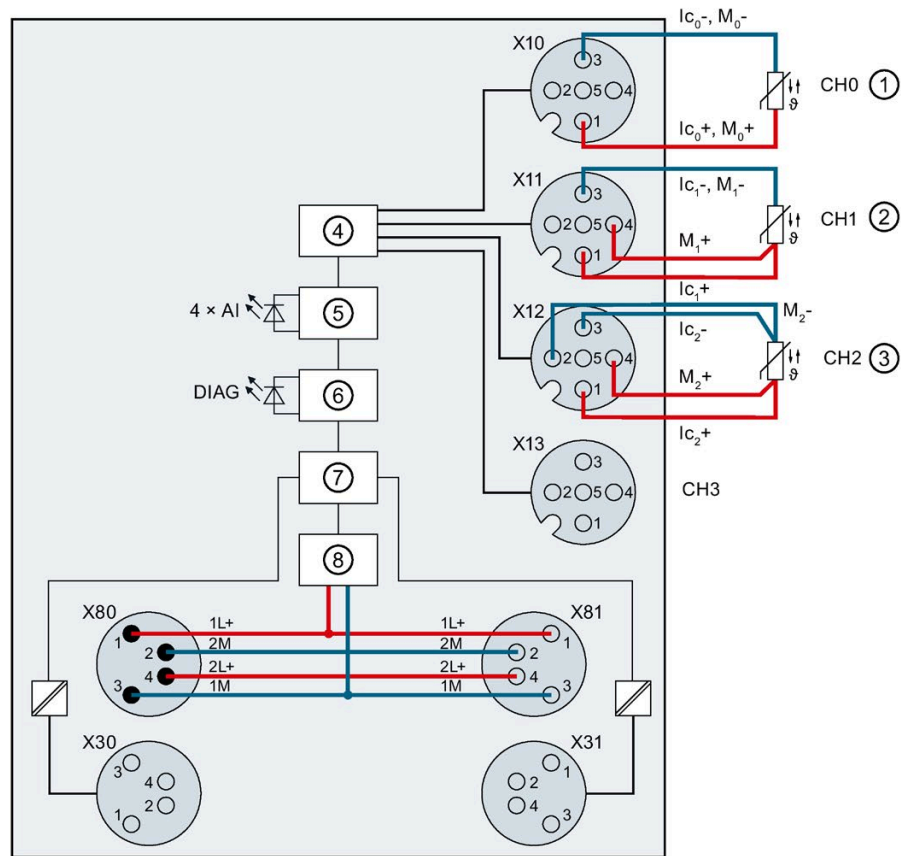
- |             |                                   |                  |                                             |
|-------------|-----------------------------------|------------------|---------------------------------------------|
| ①           | Voltage measurement               | X30              | Infeed of the ET-Connection                 |
| ②           | Thermocouple measurement          | X31              | Loop-through of the ET-Connection           |
| ③           | Multiplexer                       | 1L+              | Supply voltage 1L+ (non-switched)           |
| ④           | Analog-to-digital converter (ADC) | 1M               | Ground 1M (non-switched)                    |
| ⑤           | Microcontroller                   | 2L+              | Load voltage 2L+ (switched)                 |
| ⑥           | ET-Connection interface           | 2M               | Ground 2M (switched)                        |
| ⑦           | Internal supply voltage           | M <sub>n</sub> + | Measuring input positive, channel n         |
| X10 bis X13 | Channels 0 to 3                   | M <sub>n</sub> - | Measuring input negative, channel n         |
| X80         | Infeed of supply voltages         | AI               | Channel status LEDs (0, 1, 2 and 3) (green) |
| X81         | Loop-through of supply voltages   | DIAG             | LED diagnostic status (red/green)           |

Figure 3-1 Example of voltage and thermocouple measurement



## 3.1 Terminal and block diagram

The figure below shows an example of the pin assignment for thermal resistance and resistance measurement.



|            |                                   |            |                                               |
|------------|-----------------------------------|------------|-----------------------------------------------|
| ①          | RTD/R 2-wire connection           | X30        | Infeed of the ET-Connection                   |
| ②          | RTD/R 3-wire connection           | X31        | Loop-through of the ET-Connection             |
| ③          | RTD/R 4-wire connection           | 1L+        | Supply voltage 1L+ (non-switched)             |
| ④          | Multiplexer                       | 1M         | Ground 1M (non-switched)                      |
| ⑤          | Analog-to-digital converter (ADC) | 2L+        | Load voltage 2L+ (switched)                   |
| ⑥          | Microcontroller                   | 2M         | Ground 2M (switched)                          |
| ⑦          | ET-Connection interface           | Mn+        | Measuring input positive, channel n           |
| ⑧          | Internal supply voltage           | Mn-        | Measuring input negative, channel n           |
| X10 to X13 | Channels 0 to 3                   | Icn+, Icn- | Current output, current feed, RTD/R channel n |
| X80        | Infeed of supply voltages         | AI         | Channel status LEDs (0, 1, 2 and 3) (green)   |
| X81        | Loop-through of supply voltages   | DIAG       | LED diagnostic status (red/green)             |

Figure 3-2 Example of resistance and thermal resistance measurement

## 3.2 Pin assignment

### Note

#### Color coding

The sockets for ET-Connection and the power supply of the modules are color-coded. These colors correspond to the colors of the offered cables.

### Pin assignment of the sockets for analog inputs

The tables below show the pin assignments of the four sockets for connection of the analog inputs.

Table 3- 1 Pin assignment for thermocouple + voltage measurement

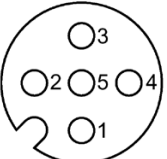
| Pin    | Assignment                                                                                                                                                                                               | Front view of the sockets                                                            |
|--------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------|
|        | <b>X10 ... X13- sockets for analog inputs (thermocouple)</b>                                                                                                                                             |                                                                                      |
| 1      | Reserved                                                                                                                                                                                                 |  |
| 2      | Reserved                                                                                                                                                                                                 |                                                                                      |
| 3      | Measuring input M <sub>0</sub> -: Connector X10<br>Measuring input M <sub>1</sub> -: Connector X11<br>Measuring input M <sub>2</sub> -: Connector X12<br>Measuring input M <sub>3</sub> -: Connector X13 |                                                                                      |
| 4      | Measuring input M <sub>0</sub> +: Connector X10<br>Measuring input M <sub>1</sub> +: Connector X11<br>Measuring input M <sub>2</sub> +: Connector X12<br>Measuring input M <sub>3</sub> +: Connector X13 |                                                                                      |
| 5      | Functional earth FE                                                                                                                                                                                      |                                                                                      |
| Shield | Functional earth FE                                                                                                                                                                                      |                                                                                      |

Table 3- 2 Pin assignment for analog inputs (RTD/R 2-wire connection)

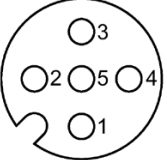
| Pin    | Assignment                                                                                                                                                                                                                                                                                   | Front view of the sockets                                                             |
|--------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------|
|        | <b>X10 ... X13 - sockets for analog inputs (RTD/R 2-wire connection)</b>                                                                                                                                                                                                                     |                                                                                       |
| 1      | Measurement cable I <sub>c0</sub> +, M <sub>0</sub> +: Connector X10<br>Measurement cable I <sub>c1</sub> +, M <sub>1</sub> +: Connector X11<br>Measurement cable I <sub>c2</sub> +, M <sub>2</sub> +: Connector X12<br>Measurement cable I <sub>c3</sub> +, M <sub>3</sub> +: Connector X13 |  |
| 2      | Reserved                                                                                                                                                                                                                                                                                     |                                                                                       |
| 3      | Measurement cable I <sub>c0</sub> -, M <sub>0</sub> -: Connector X10<br>Measurement cable I <sub>c1</sub> -, M <sub>1</sub> -: Connector X11<br>Measurement cable I <sub>c2</sub> -, M <sub>2</sub> -: Connector X12<br>Measurement cable I <sub>c3</sub> -, M <sub>3</sub> -: Connector X13 |                                                                                       |
| 4      | Reserved                                                                                                                                                                                                                                                                                     |                                                                                       |
| 5      | Functional earth FE                                                                                                                                                                                                                                                                          |                                                                                       |
| Shield | Functional earth FE                                                                                                                                                                                                                                                                          |                                                                                       |

Table 3-3 Pin assignment for analog inputs (RTD/R 3-wire connection)

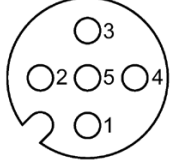
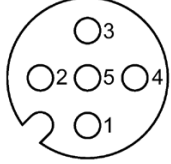
| Pin    | Assignment                                                                                                                                                                                                                           | Front view of the sockets                                                           |
|--------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------|
|        | X10 ... X13 - sockets for analog inputs (RTD/R 3-wire connection)                                                                                                                                                                    |                                                                                     |
| 1      | Constant current cable $I_{c0+}$ : Connector X10<br>Constant current cable $I_{c1+}$ : Connector X11<br>Constant current cable $I_{c2+}$ : Connector X12<br>Constant current cable $I_{c3+}$ : Connector X13                         |  |
| 2      | Reserved                                                                                                                                                                                                                             |                                                                                     |
| 3      | Measurement cable $I_{c0-}$ , $M_{0-}$ : Connector X10<br>Measurement cable $I_{c1-}$ , $M_{1-}$ : Connector X11<br>Measurement cable $I_{c2-}$ , $M_{2-}$ : Connector X12<br>Measurement cable $I_{c3-}$ , $M_{3-}$ : Connector X13 |                                                                                     |
| 4      | Measuring input $M_{0+}$ : Connector X10<br>Measuring input $M_{1+}$ : Connector X11<br>Measuring input $M_{2+}$ : Connector X12<br>Measuring input $M_{3+}$ : Connector X13                                                         |                                                                                     |
| 5      | Functional earth FE                                                                                                                                                                                                                  |                                                                                     |
| Shield | Functional earth FE                                                                                                                                                                                                                  |                                                                                     |

Table 3-4 Pin assignment for analog inputs (RTD/R 4-wire connection)

| Pin    | Assignment                                                                                                                                                                                                   | Front view of the sockets                                                             |
|--------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------|
|        | X10 ... X13 - sockets for analog inputs (RTD/R 4-wire connection)                                                                                                                                            |                                                                                       |
| 1      | Constant current cable $I_{c0+}$ : Connector X10<br>Constant current cable $I_{c1+}$ : Connector X11<br>Constant current cable $I_{c2+}$ : Connector X12<br>Constant current cable $I_{c3+}$ : Connector X13 |  |
| 2      | Measuring line $M_{0-}$ : Connector X10<br>Measuring line $M_{1-}$ : Connector X11<br>Measuring line $M_{2-}$ : Connector X12<br>Measuring line $M_{3-}$ : Connector X13                                     |                                                                                       |
| 3      | Constant current cable $I_{c0-}$ : Connector X10<br>Constant current cable $I_{c1-}$ : Connector X11<br>Constant current cable $I_{c2-}$ : Connector X12<br>Constant current cable $I_{c3-}$ : Connector X13 |                                                                                       |
| 4      | Measuring input $M_{0+}$ : Connector X10<br>Measuring input $M_{1+}$ : Connector X11<br>Measuring input $M_{2+}$ : Connector X12<br>Measuring input $M_{3+}$ : Connector X13                                 |                                                                                       |
| 5      | Functional earth FE                                                                                                                                                                                          |                                                                                       |
| Shield | Functional earth FE                                                                                                                                                                                          |                                                                                       |

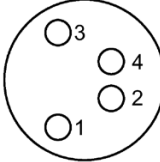
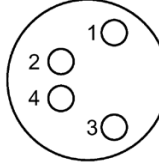
**Note****Coupler plug for RTD measurement**

For RTD measurements, use a coupler plug with gold-plated contacts. Other materials can create contact resistance that can result in incorrect measured values.

### Pin assignment of the sockets for ET-Connection

The table below shows the pin assignments of the 2 sockets for the connection of ET-Connection.

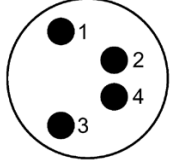
Table 3- 5 Pin assignment for ET-Connection

| Pin    | Assignment                    |                                | Assignment of the core color of the bus cable for ET-Connection | Front view of the sockets                                                           |                                                                                     |
|--------|-------------------------------|--------------------------------|-----------------------------------------------------------------|-------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------|
|        | X30 socket (ET-Connection IN) | X31 socket (ET-Connection OUT) |                                                                 | X30                                                                                 | X31                                                                                 |
| 1      | TXP                           | RXP                            | Yellow                                                          |  |  |
| 2      | RXP                           | TXP                            | White                                                           |                                                                                     |                                                                                     |
| 3      | RXN                           | TXN                            | Blue                                                            |                                                                                     |                                                                                     |
| 4      | TXN                           | RXN                            | Orange                                                          |                                                                                     |                                                                                     |
| Shield | Functional earth FE           |                                | -                                                               |                                                                                     |                                                                                     |

### Pin assignment of the connector for infeed of the supply voltage

The table below shows the pin assignment of the connector for infeed of the supply voltage.

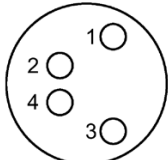
Table 3- 6 Pin assignment of the supply voltage connector

| Pin | Assignment                        | Assignment of the core color of the power cable | Front view of the connector                                                           |
|-----|-----------------------------------|-------------------------------------------------|---------------------------------------------------------------------------------------|
|     | X80 connector (POWER input)       |                                                 |                                                                                       |
| 1   | Supply voltage 1L+ (non-switched) | Brown                                           |  |
| 2   | Ground 2M (switched)              | White                                           |                                                                                       |
| 3   | Ground 1M (non-switched)          | Blue                                            |                                                                                       |
| 4   | Load voltage 2L+ (switched)       | Black                                           |                                                                                       |

### Pin assignment of the socket for loop-through of the supply voltage

The table below shows the pin assignment of the socket for loop-through of the supply voltage.

Table 3- 7 Pin assignment of the supply voltage socket

| Pin | Assignment                        | Assignment of the core color of the power cable | Front view of the socket                                                            |
|-----|-----------------------------------|-------------------------------------------------|-------------------------------------------------------------------------------------|
|     | X81 socket (POWER output)         |                                                 |                                                                                     |
| 1   | Supply voltage 1L+ (non-switched) | Brown                                           |  |
| 2   | Ground 2M (switched)              | White                                           |                                                                                     |
| 3   | Ground 1M (non-switched)          | Blue                                            |                                                                                     |
| 4   | Load voltage 2L+ (switched)       | Black                                           |                                                                                     |

#### NOTICE

##### ET-Connection/supply voltage

Observe the correct wiring of the M8 sockets for ET-Connection and the supply voltage.

Mixing up the connector for ET-Connection and the connector for the supply voltage can destroy the module.

## Parameters/address space

### 4.1 Measurement types and measuring ranges

The table below indicates which measuring range is configurable.

Table 4- 1 Measurement type and measuring ranges

| Measurement type                                                                                                                                                                   | Measuring range                                                                                                                                                        | Temperature coefficient                                                                                                                                    | Resolution             |
|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------|
| Deactivated                                                                                                                                                                        | –                                                                                                                                                                      | –                                                                                                                                                          | –                      |
| Voltage                                                                                                                                                                            | +/- 80 mV                                                                                                                                                              | –                                                                                                                                                          | Max. 16-bit            |
| <ul style="list-style-type: none"> <li>Resistance (2-wire connection)</li> <li>Resistance (3-wire connection)</li> <li>Resistance (4-wire connection)</li> </ul>                   | <ul style="list-style-type: none"> <li>150 <math>\Omega</math></li> <li>300 <math>\Omega</math></li> </ul>                                                             | –                                                                                                                                                          | Max. 15-bit            |
| <ul style="list-style-type: none"> <li>Thermal resistor (2-wire connection)</li> <li>Thermal resistor (3-wire connection)</li> <li>Thermal resistor (4-wire connection)</li> </ul> | <ul style="list-style-type: none"> <li>Pt 100 climatic range</li> <li>Pt 100 standard range</li> <li>Pt 1000 climatic range</li> <li>Pt 1000 standard range</li> </ul> | <ul style="list-style-type: none"> <li>Pt 0.003851 (EN 60751)</li> <li>Pt 0.003916</li> <li>Pt 0.003902</li> <li>Pt 0.00392</li> <li>Pt 0.00385</li> </ul> | Max. 16-bit incl. sign |
|                                                                                                                                                                                    | <ul style="list-style-type: none"> <li>Ni 100 climatic range</li> <li>Ni 100 standard range</li> <li>Ni 1000 climatic range</li> <li>Ni 1000 standard range</li> </ul> | <ul style="list-style-type: none"> <li>Ni 0.00618</li> <li>Ni 0.00672</li> </ul>                                                                           | Max. 16-bit incl. sign |
| Thermocouple                                                                                                                                                                       | Type: B, C, E, J, K, L, N, R, S, T, U                                                                                                                                  | –                                                                                                                                                          | Max. 16-bit incl. sign |

## 4.2 Parameters

### Parameters of the analog input module AI 4xRTD/TC 4xM12

Specify the module properties with the various parameters in the course of the parameter assignment of the module with STEP 7. The following table lists the configurable parameters. The effective range of the configurable parameters depends on the type of configuration. The following configurations are possible:

- Distributed mode on PROFINET IO
- Distributed mode with PROFIBUS DP
- Central operation with an ET 200SP CPU

#### NOTICE

##### Match of encoder and parameters

The default setting of the analog inputs is voltage measurement ( $\pm 80$  mV).

Make sure that the connected encoders and the selected parameters match.

### Parameters and presettings of the analog input module.

The table below shows the PROFINET IO and PROFIBUS DP parameters for the analog input module AI 4xRTD/TC 4xM12 for configuration with GSD file.

Table 4- 2 Configurable parameters and their default (GSD)

| Parameter        | Value range                                                                                                         | Default         | Effective range with configuration software e.g. STEP 7 (TIA Portal) |                      |
|------------------|---------------------------------------------------------------------------------------------------------------------|-----------------|----------------------------------------------------------------------|----------------------|
|                  |                                                                                                                     |                 | GSD file PROFINET IO                                                 | GSD file PROFIBUS DP |
| Temperature unit | <ul style="list-style-type: none"> <li>• Degrees Celsius</li> <li>• Degrees Fahrenheit</li> <li>• Kelvin</li> </ul> | Degrees Celsius | Module                                                               | Module               |

| Parameter                 | Value range                                                                                                                                                                                                                                                                                                                                       | Default                | Effective range with configuration software e.g. STEP 7 (TIA Portal) |         |
|---------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------|----------------------------------------------------------------------|---------|
| Type/range of measurement | <ul style="list-style-type: none"> <li>Disabled</li> </ul>                                                                                                                                                                                                                                                                                        | Voltage $\pm 80$ mV    | Channel                                                              | Channel |
|                           | <ul style="list-style-type: none"> <li>Voltage <math>\pm 80</math> mV</li> </ul>                                                                                                                                                                                                                                                                  |                        |                                                                      |         |
|                           | Resistance (2-, 3-, 4-wire connection) <ul style="list-style-type: none"> <li>150 <math>\Omega</math></li> <li>300 <math>\Omega</math></li> </ul>                                                                                                                                                                                                 |                        |                                                                      |         |
|                           | Thermal resistor (2-, 3-, 4-wire connection) <ul style="list-style-type: none"> <li>Pt 100 climatic range</li> <li>Pt 1000 climatic range</li> <li>Pt 100 standard range</li> <li>Pt 1000 standard range</li> <li>Ni 100 climatic range</li> <li>Ni 1000 climatic range</li> <li>Ni 100 standard range</li> <li>Ni 1000 standard range</li> </ul> |                        |                                                                      |         |
|                           | Thermocouple <ul style="list-style-type: none"> <li>Type B</li> <li>Type N</li> <li>Type E</li> <li>Type R</li> <li>Type S</li> <li>Type J</li> <li>Type L</li> <li>Type T</li> <li>Type K</li> <li>Type U</li> <li>Type C</li> </ul>                                                                                                             |                        |                                                                      |         |
| Temperature coefficient   | <ul style="list-style-type: none"> <li>Pt 0.003851 (EN 60751)</li> <li>Pt 0.003916</li> <li>Pt 0.003902</li> <li>Pt 0.00392</li> <li>Pt 0.00385</li> <li>Ni 0.00618</li> <li>Ni 0.00672</li> </ul>                                                                                                                                                | Pt 0.003851 (EN 60751) | Channel                                                              | Channel |



## 4.2 Parameters

| Parameter                                   | Value range                                                                                                                                                                        | Default                     | Effective range with configuration software e.g. STEP 7 (TIA Portal) |         |
|---------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------|----------------------------------------------------------------------|---------|
| Reference junction                          | <ul style="list-style-type: none"> <li>Fixed reference temperature</li> <li>Dynamic reference temperature</li> <li>Internal reference junction</li> <li>No compensation</li> </ul> | Internal reference junction | Channel                                                              | Channel |
| Fixed reference temperature                 | -2290 ... 3276                                                                                                                                                                     | 0                           | Channel                                                              | Module  |
| Smoothing                                   | <ul style="list-style-type: none"> <li>None</li> <li>Weak</li> <li>Medium</li> <li>Strong</li> </ul>                                                                               | None                        | Channel                                                              | Channel |
| Interference frequency suppression          | <ul style="list-style-type: none"> <li>60 Hz (16.6 ms)</li> <li>50 Hz (20 ms)<sup>1</sup></li> <li>16.6 Hz (60 ms)</li> </ul>                                                      | 50 Hz (20 ms) <sup>1</sup>  | Channel                                                              | Channel |
| Diagnostics: Reference junction             | <ul style="list-style-type: none"> <li>Disable</li> <li>Enable</li> </ul>                                                                                                          | Disable                     | Channel                                                              | Channel |
| Diagnostics: Wire break                     | <ul style="list-style-type: none"> <li>Disable</li> <li>Enable</li> </ul>                                                                                                          | Disable                     | Channel                                                              | Channel |
| Diagnostics: Overflow/underflow diagnostics | <ul style="list-style-type: none"> <li>Disable</li> <li>Enable</li> </ul>                                                                                                          | Disable                     | ---                                                                  | Channel |
| Diagnostics: Underflow                      | <ul style="list-style-type: none"> <li>Disable</li> <li>Enable</li> </ul>                                                                                                          | Disable                     | Channel                                                              | ---     |
| Diagnostics: Overflow                       | <ul style="list-style-type: none"> <li>Disable</li> <li>Enable</li> </ul>                                                                                                          | Disable                     | Channel                                                              | ---     |
| Conductor resistance [mΩ] <sup>2</sup>      | 0 ... 50000 mΩ                                                                                                                                                                     | 0                           | Channel                                                              | ---     |
| Hardware interrupt high limit 1             | <ul style="list-style-type: none"> <li>Disable</li> <li>Enable</li> </ul>                                                                                                          | Disable                     | Channel                                                              | ---     |
| Hardware interrupt low limit 1              | <ul style="list-style-type: none"> <li>Disable</li> <li>Enable</li> </ul>                                                                                                          | Disable                     | Channel                                                              | ---     |
| Hardware interrupt high limit 2             | <ul style="list-style-type: none"> <li>Disable</li> <li>Enable</li> </ul>                                                                                                          | Disable                     | Channel                                                              | ---     |

| Parameter                      | Value range                                                                                                                                                                                    | Default | Effective range with configuration software e.g. STEP 7 (TIA Portal) |     |
|--------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------|----------------------------------------------------------------------|-----|
| Hardware interrupt low limit 2 | <ul style="list-style-type: none"> <li>Disable</li> <li>Enable</li> </ul>                                                                                                                      | Disable | Channel                                                              | --- |
| High limit 1                   | The value range depends on the measurement type.<br>The value range (min./max.) permitted for the measurement type is listed in the table 4-3 <b>Value ranges of the hardware interrupts</b> . | 27648   | Channel                                                              | --- |
| Low limit 1                    |                                                                                                                                                                                                | 0       | Channel                                                              | --- |
| High limit 2                   |                                                                                                                                                                                                | 27648   | Channel                                                              | --- |
| Low limit 2                    |                                                                                                                                                                                                | 0       | Channel                                                              | --- |

<sup>1</sup> Interference frequency suppression: Noise at 400 Hz is automatically included in the filtering at 50 Hz.

<sup>2</sup> For 2-wire connection only

### Note

#### Unused channels

"Deactivate" unused inputs in the parameter assignment to shorten the cycle time of the module.

A deactivated input always returns the value 7FFF<sub>H</sub>.

## Value ranges of the hardware interrupts

The table below shows the permitted value ranges of the hardware interrupts for the measurement type.

Table 4- 3 Value ranges of the hardware interrupts

| Measurement type | Measuring range | Low limit | High limit | Unit    |
|------------------|-----------------|-----------|------------|---------|
| Voltage          | ± 80 mV         | -94.071   | 94.068     | mV      |
|                  |                 | -32511    | 32510      | Decimal |
| Resistance       | 150 ohm         | 0.01      | 176.38     | Ω       |
|                  |                 | 2         | 32510      | Decimal |
|                  | 300 ohm         | 0.01      | 352.76     | Ω       |
|                  |                 | 1         | 32510      | Decimal |

## 4.2 Parameters

| Measurement type   | Measuring range             | Low limit | High limit | Unit    |
|--------------------|-----------------------------|-----------|------------|---------|
| Thermal resistance | Pt 100 Std.<br>Pt 1000 Std. | -242.9    | 999.9      | °C      |
|                    |                             | -2429     | 9999       | Decimal |
|                    |                             | -405.3    | 1831.9     | F       |
|                    |                             | -4053     | 18319      | Decimal |
|                    |                             | 30.3      | 1273.1     | K       |
|                    |                             | 303       | 12731      | Decimal |
|                    | Pt 100 Cl.<br>Pt 1000 Cl.   | -144.99   | 154.99     | °C      |
|                    |                             | -14499    | 15499      | Decimal |
|                    |                             | -228.99   | 310.99     | F       |
|                    |                             | -22899    | 31099      | Decimal |
|                    | Ni 100 Std.<br>Ni 1000 Std. | -104.9    | 294.9      | °C      |
|                    |                             | -1049     | 2949       | Decimal |
|                    |                             | -156.9    | 562.9      | F       |
|                    |                             | -1569     | 5629       | Decimal |
|                    |                             | 168.3     | 568.1      | K       |
|                    |                             | 1683      | 5681       | Decimal |
|                    | Ni 100 Cl.<br>Ni 1000 Cl.   | -104.99   | 154.99     | °C      |
|                    |                             | -10499    | 15499      | Decimal |
|                    |                             | -156.99   | 310.99     | F       |
|                    |                             | -15699    | 31099      | Decimal |
| Thermocouple       | Type B                      | -119.9    | 2069.9     | °C      |
|                    |                             | -1199     | 20699      | Decimal |
|                    |                             | -183.9    | 3276.5     | F       |
|                    |                             | -1839     | 32765      | Decimal |
|                    |                             | 153.3     | 2343.1     | K       |
|                    |                             | 1533      | 23431      | Decimal |
|                    | Type N                      | -269.9    | 1549.9     | °C      |
|                    |                             | -2699     | 15499      | Decimal |
|                    |                             | -453.9    | 2821.9     | F       |
|                    |                             | -4539     | 28219      | Decimal |
|                    |                             | 3.3       | 1823.1     | K       |
|                    |                             | 33        | 18231      | Decimal |
|                    | Type E                      | -269.9    | 1199.9     | °C      |
|                    |                             | -2699     | 11999      | Decimal |
|                    |                             | -453.9    | 2191.9     | F       |
|                    |                             | -4539     | 21919      | Decimal |
|                    |                             | 3.3       | 1473.1     | K       |
|                    |                             | 33        | 14731      | Decimal |
|                    | Types R, S                  | -169.9    | 2018.9     | °C      |
|                    |                             | -1699     | 20189      | Decimal |
|                    |                             | -273.9    | 3276.5     | F       |
|                    |                             | -2739     | 32765      | Decimal |
|                    |                             | 103.3     | 2292.1     | K       |
|                    |                             | 1033      | 22921      | Decimal |
|                    | Type J                      | -209.9    | 1449.9     | °C      |

| Measurement type | Measuring range | Low limit | High limit | Unit    |
|------------------|-----------------|-----------|------------|---------|
|                  |                 | -2099     | 14499      | Decimal |
|                  |                 | -345.9    | 2641.9     | F       |
|                  |                 | -3459     | 26419      | Decimal |
|                  |                 | 63.3      | 1723.1     | K       |
|                  |                 | 633       | 17231      | Decimal |
|                  | Type L          | -199.9    | 1149.9     | °C      |
|                  |                 | -1999     | 11499      | Decimal |
|                  |                 | -327.9    | 2101.9     | F       |
|                  |                 | -3279     | 21019      | Decimal |
|                  |                 | 73.3      | 1423.1     | K       |
|                  |                 | 733       | 14231      | Decimal |
|                  | Type T          | -269.9    | 539.9      | °C      |
|                  |                 | -2699     | 5399       | Decimal |
|                  |                 | -453.9    | 1003.9     | F       |
|                  |                 | -4539     | 10039      | Decimal |
|                  |                 | 3.3       | 813.1      | K       |
|                  |                 | 33        | 8131       | Decimal |
|                  | Type K          | -269.9    | 1621.9     | °C      |
|                  |                 | -2699     | 16219      | Decimal |
|                  |                 | -453.9    | 2951.5     | F       |
|                  |                 | -4539     | 29515      | Decimal |
|                  |                 | 3.3       | 1895.1     | K       |
|                  |                 | 33        | 18951      | Decimal |
|                  | Type U          | -199.9    | 849.9      | °C      |
|                  |                 | -1999     | 8499       | Decimal |
|                  |                 | -327.9    | 1561.9     | F       |
|                  |                 | -3279     | 15619      | Decimal |
|                  |                 | 73.3      | 1123.1     | K       |
|                  |                 | 733       | 11231      | Decimal |
|                  | Type C          | -119.9    | 2499.9     | °C      |
|                  |                 | -1199     | 24999      | Decimal |
|                  |                 | -183.9    | 3276.5     | F       |
|                  |                 | -1839     | 32765      | Decimal |
|                  |                 | 153.3     | 2773.1     | K       |
|                  |                 | 1533      | 27731      | Decimal |

## 4.3 Explanation of the parameters

**"Fixed reference temperature" parameter for thermocouples**

The parameter "Fixed reference temperature" can only be set if you selected = "Fixed Reference Temperature" for the "Reference junction" parameter.

The following table shows the value ranges for the "reference temperature" for thermocouples.

Table 4- 4 Value ranges for the "reference temperature" for thermocouples.

| Temperature unit | Temperature |       | Decimal |      |
|------------------|-------------|-------|---------|------|
|                  | Min.        | Max   | Min.    | Max  |
| Celsius          | -145.0      | 155   | -1450   | 1550 |
| Fahrenheit       | -229.0      | 311.0 | -2290   | 3110 |
| Kelvin           | 128.2       | 327.6 | 1282    | 3276 |

## 4.3 Explanation of the parameters

**Temperature unit**

You use this parameter to set the temperature unit with which you want to measure the temperature.

**Type/range of measurement**

You use this parameter to set the measurement type or the measuring range for acquiring the measured values.

**Note****Unused channels**

"Deactivate" unused channels in the parameter assignment to improve the cycle time of the module.

A deactivated channel always returns the value 7FFF<sub>H</sub>.

**Temperature coefficient (for RTD)**

The temperature coefficient depends on the chemical composition of the material. In Europe, only one value is used per sensor type (default value).

The correction factor for the temperature coefficient ( $\alpha$  value) specifies how much the resistance of a certain material changes when the temperature is raised by 1 °C.

The further values facilitate sensor-specific setting of the temperature coefficient and enhance accuracy.

## Reference junction

If the measuring point is subjected to a different temperature than the reference junction (free ends of the thermocouple at the connection point), a thermal voltage arises between the free ends. The level of the thermal voltage depends:

- On the temperature difference between the measuring point and the free ends
- On the type of material combination of the thermocouple

Since a temperature difference is always detected with a thermocouple, the temperature of the reference junction has to be determined in order to determine the temperature of the measuring point.

The possible compensation types that can be parameterized via the parameter "reference junction" are set out in the table below.

Table 4- 5 Parameterizable compensation types for the "reference junction" parameter

| Compensation type             | Explanation                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |
|-------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Fixed reference temperature   | <p><b>Properties</b></p> <p>With this type of compensation, the reference junction temperature is stored as a fixed value.</p> <p><b>Principle of operation</b></p> <p>The reference junction temperature is specified in the "fixed reference temperature" parameter. The possible value range is displayed in the Table 4-4 Value ranges for the "reference temperature" for thermocouples. (Page 26).</p> <p>The configured reference junction temperature applies to all channels of the module that you have selected for this type of compensation.</p> <p><b>Wiring</b></p> <p>Connect the thermocouples to terminals 3 and 4 from the reference junction with copper cables. If you detect the reference junction temperature directly at the M12 connector of the AI 4xRTD/TC 4xM12, you can also connect the thermocouples directly or with compensating lines.</p>                                                           |
| Dynamic reference temperature | <p><b>Properties</b></p> <p>With this compensation, the reference junction temperature can be measured via an external module of another station.</p> <p><b>Principle of operation</b></p> <p>The reference junction temperature is transferred by means of SFB 53 by the data records 192 - 195 from the CPU to the AI 4xRTD/TC 4xM12 electronic module. Each channel that you select for this type of compensation can have its own reference junction temperature assigned to it via the user program. For more information, see section Structure of a data record for dynamic reference temperature (Page 31).</p> <p><b>Wiring</b></p> <p>Connect the thermocouples to Terminals 3 and 4 from the reference junction with copper cables. If you detect the reference junction temperature directly at the M12 connector of the AI 4xRTD/TC 4xM12, you can also connect the thermocouples directly or with compensating lines.</p> |

## 4.3 Explanation of the parameters

| Compensation type           | Explanation                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |
|-----------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Internal reference junction | <p><b>Properties</b></p> <p>With this compensation type, the reference junction temperature is determined with an internal temperature sensor that is integrated in the AI 4xRTD/TC 4xM12 electronic module.</p> <p>Note: Take the reaction time to changes of the ambient temperature into account.</p> <p><b>Principle of operation</b></p> <p>The reference junction temperature is detected through an internal temperature sensor.</p> <p>All channels of the AI 4xRTD/TC 4xM12 that you select for this type of compensation receive the same reference junction temperature.</p> <p><b>Wiring</b></p> <p>Connect the thermocouples directly or with compensating lines to the AI 4xRTD/TC 4xM12.</p>                                                                |
| No compensation             | <p><b>Properties</b></p> <p>With this compensation type, the reference junction temperature of the thermocouples is measured outside the AI 4xRTD/TC 4xM12 electronic module. You can, for example, connect a compensating box to the thermocouple for this purpose.</p> <p><b>Principle of operation</b></p> <p>The temperature of the reference junction for this type of compensation is specified as 0 °C.</p> <p>This can be achieved by using a compensating box. A separate compensating box is required for each thermocouple.</p> <p><b>Wiring</b></p> <p>Connect the compensating box with the AI 4xRTD/TC 4xM12 with copper cables.</p> <p>Note: Thermocouples of Type B do not require a compensating box up to a reference junction temperature of 50 °C.</p> |

## Smoothing

The purpose of smoothing is to filter out interferences. The greater the smoothing factor, the better the filter effect. This is technically implemented in the form of a digital filter. The smoothing can be set in 4 levels. The smoothing factor  $k$  is equal to the number of module cycles. The time constant of the smoothing filter is the product of the smoothing factor  $k$  and the cycle time of the I/O module. The greater the smoothing, the greater the time constant of the filter.

Smoothing time = number of module cycles ( $k$ )  $\times$  cycle time of the module.

The following figure shows how many module cycles it takes for the smoothed analog value to approach 100%, depending on the configured smoothing. This is valid for all signal changes at the analog input.

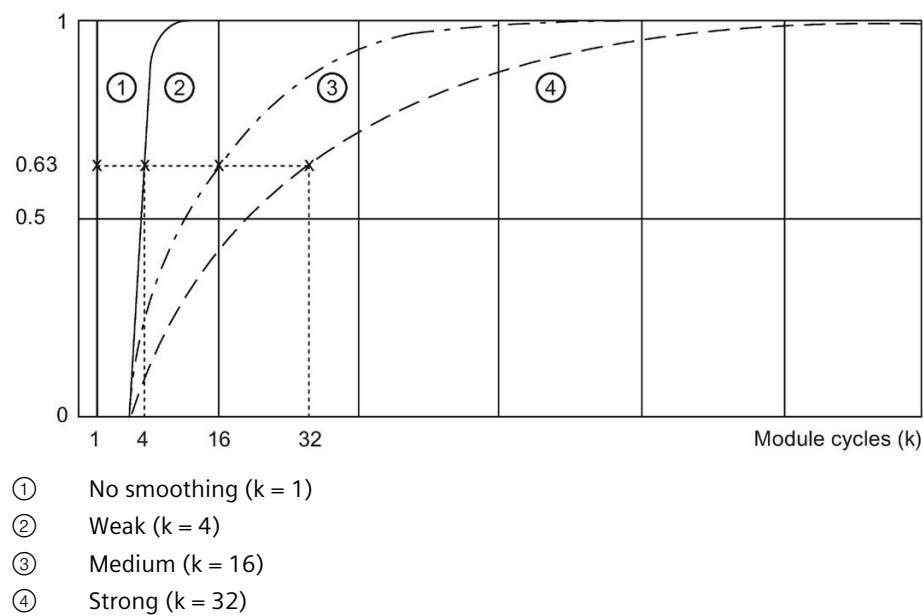


Figure 4-1 Smoothing

## Interference frequency suppression

This parameter suppresses interference for analog input modules which is caused by the frequency of the alternating voltage network in use.

The frequency of the alternating voltage network may negatively affect the measured value, in particular when measuring in the low voltage range and with thermocouples. With this parameter, the user specifies the line frequency that is predominant in the plant.

## Diagnostics: Reference junction

Enabling of the reference junction diagnostics if the reference temperature of the reference junction needs to be determined for the TC channel being operated.



## 4.3 Explanation of the parameters

**Diagnostics: Wire break**

Enabling of the diagnostics if the analog input module has no current flow or the current is too weak for measurement at the correspondingly configured input.

**Note****Wire break diagnostics**

With analog input channels, wire break diagnostics is not possible for the measurement type voltage  $\pm 80$  mV.

The following table shows the diagnostics that may occur on wire break.

Table 4- 6 Diagnostics with RTD/R

| Diagnostics: Wire break | Diagnostics: Overflow | Diagnostics underflow | Event      | Process data | Diagnostics alarm per channel |
|-------------------------|-----------------------|-----------------------|------------|--------------|-------------------------------|
| Enabled                 | Disabled              | Disabled              | Wire break | 0x7FFF       | Wire break                    |
| Disabled                | Disabled              | Enabled               | Wire break | 0x7FFF       | -                             |
| Disabled                | Enabled               | Disabled              | Wire break | 0x7FFF       | High limit violated           |
| Disabled                | Enabled               | Enabled               | Wire break | 0x7FFF       | High limit violated           |
| Disabled                | Disabled              | Disabled              | Wire break | 0x7FFF       | -                             |

**Diagnostics: Overflow/Underflow (for PROFIBUS only)**

Enabling of the diagnostics when the measured value exceeds the overrange or falls below the underrange.

**Diagnostics: Underflow**

Enabling of the diagnostics when the measured value falls below the underrange.

**Diagnostics: Overflow**

Enabling of the diagnostics when the measured value exceeds the overrange.

**Conductor resistance**

Parameters for the measurement types resistor and thermal resistor (2-wire connection).

The parameter is used to compensate the conductor resistance without interfering with the sensor wiring.

**Hardware interrupt high/low limit 1 or 2**

Enabling of a hardware interrupt when the high limit 1 or 2 or the low limit 1 or 2 is violated.

Requirement: An OB 4x must be assigned to the CPU/device.

Additional information on the structure of hardware interrupts is available in the section Interrupts (Page 36).

**High/low limit 1 or 2**

Specify a threshold at which a hardware interrupt is triggered when it is exceeded or undershot.

**See also**

Parameters (Page 20)

**4.4 Structure of a data record for dynamic reference temperature**

The **WRREC** instruction is used to transfer the reference junction temperature via data record 192 to data record 195 to the module.

The description of the WRREC instruction can be found in the online help from STEP 7.

If you have set the "Dynamic reference temperature" value for the "Reference junction" parameter, the module expects a new data record at least every 5 minutes. If the module does not receive a new data record within this time, it generates the "Reference channel error" diagnostics message.

**Assignment of data record and channel**

The assignment of the channels is:

- Data record 192 for channel 0
- Data record 193 for channel 1
- Data record 194 for channel 2
- Data record 195 for channel 3

### Structure of data record 192 for dynamic reference temperature

The following figure shows you an example of the structure of data record 192 for channel 0. The structure for data records 193 to 195 is identical.

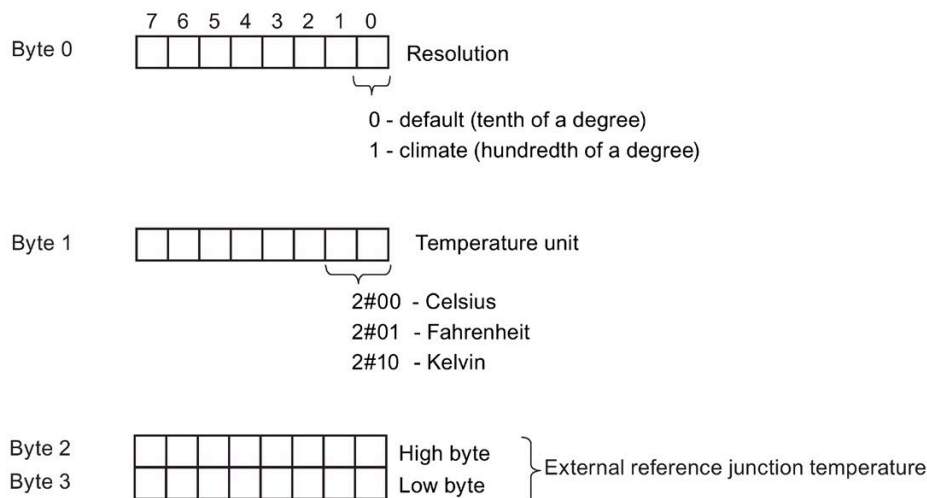


Figure 4-2 Structure of data record 192

### Valid values for fixed temperature compensation

The selectable values must lie within the permitted value range. The resolution of the valid values for temperature compensation is a tenth of a degree

Table 4- 7 Valid values for temperature compensation via data record

| Temperature unit      | Decimal          | Hexadecimal     |
|-----------------------|------------------|-----------------|
| Celsius (default)     | -1450 ... 1550   | FA56H ... 60EH  |
| Fahrenheit (default)  | -2290 ... 3110   | F70EH ... C26H  |
| Kelvin (default)      | 1282 ... 3276    | 502H ... CCH    |
| Celsius (climatic)    | -14500 ... 15500 | C75CH ... 3C8CH |
| Fahrenheit (climatic) | -22900 ... 31100 | A68CH ... 797CH |
| Kelvin (climatic)     | 12820 ... 32760  | 3214H ... 7FF8H |

#### Note

Thanks to the flexible content of the data records DS 192 - DS 195, you can use a separate reference junction for each channel. The channels can also be combined via the user program in such a way that they use the same reference junction. To this end, you need to specify the same temperature value in the data records for all channels operating with the same reference function temperature.

### Additional information

You can find more information on compensation of the reference junction temperature via data record in the function manual SIMATIC analog value processing (<https://support.industry.siemens.com/cs/ww/en/view/67989094>).

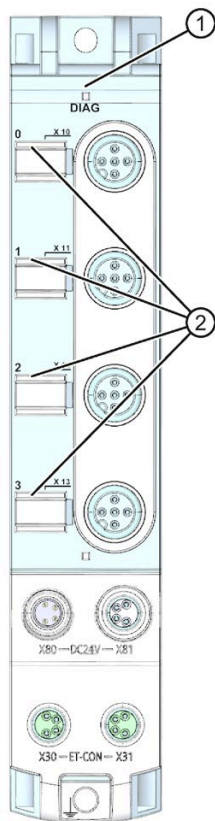


# Interrupts/diagnostics alarms

## 5.1 Status and error displays

### LED displays

The figure below shows the LED display (status and error displays) of the AI 4xRTD/TC 4xM12 analog input module.



- ① Diagnostic status (DIAG) (red/green)
- ② Channel status (0, 1, 2 and 3) (green)

Figure 5-1 LED displays

## Meaning of the LEDs

The following tables set out the meaning of the status and error displays. Corrective measures for diagnostics alarms can be found in the section Diagnostics alarms (Page 38).

### DIAG LED

Table 5- 1 Error display of the DIAG LED

| DIAG LED                                                                                     | Meaning                                                                                                                                                                                                                                                             |
|----------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <br>Off     | No supply voltage 1L+                                                                                                                                                                                                                                               |
| <br>Flashes | <ul style="list-style-type: none"> <li>Module parameters not assigned</li> <li>Loading firmware<br/>(while the firmware update is being performed, all LEDs retain their current status)</li> <li>No connection to the ET connection and/or the fieldbus</li> </ul> |
| <br>On      | Module parameters assigned and no module diagnostics                                                                                                                                                                                                                |
| <br>Flashes | Module parameters assigned and module diagnostics                                                                                                                                                                                                                   |

### LED for the channel status

Table 5- 2 Status display of the LEDs 0, 1, 2 and 3

| LED 0, 1, 2 and 3                                                                          | Meaning                                                                                                                                                                        |
|--------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <br>Off | <ul style="list-style-type: none"> <li>Channel deactivated</li> <li>Channel activated and incorrect parameter assignment</li> <li>Parameter error possible with GSD</li> </ul> |
| <br>On  | <ul style="list-style-type: none"> <li>Channel activated and correct parameter assignment</li> </ul>                                                                           |

## 5.2 Interrupts

The AI 4xRTD/TC 4xM12 analog input module supports diagnostic and hardware interrupts.

### Diagnostic interrupt

The table below shows the events for which the analog input module returns a diagnostic interrupt, depending on the parameter assignment.

Table 5- 3 Diagnostic interrupts

| Measure-<br>ment type | Diagnostics   |                        |                       |       |                                         |                               |                               |
|-----------------------|---------------|------------------------|-----------------------|-------|-----------------------------------------|-------------------------------|-------------------------------|
|                       | Wire<br>break | High limit<br>violated | Low limit<br>violated | Error | Parame-<br>ter as-<br>signment<br>error | Reference<br>channel<br>error | Hardware<br>interrupt<br>lost |
| Voltage               | -             | x                      | x                     | x     | x                                       | -                             | x                             |
| Resistance            | x             | x                      | -                     | x     | x                                       | -                             | x                             |
| Thermal<br>resistor   | x             | x                      | x                     | x     | x                                       | -                             | x                             |
| Thermocou-<br>ple     | x             | x                      | x                     | x     | x                                       | x                             | x                             |

### Hardware interrupt

The analog input module generates a hardware interrupt with the following events:

- Low limit 1 violated
- High limit 1 violated
- Low limit 2 violated
- High limit 2 violated

Detailed information on the event is available in the hardware interrupt organization block with the instruction "RALRM" (Read additional interrupt information) and in the STEP 7 online help.

The start information of the organization block includes information on which channel of the analog input module triggered the hardware interrupt.

---

#### Note

##### High limit violation of 2 limits

If two limits are violated at the same time, limit 1 is always signaled first, followed by limit 2.

---

The figure below shows the assignment to the bits of the local data double word 8.

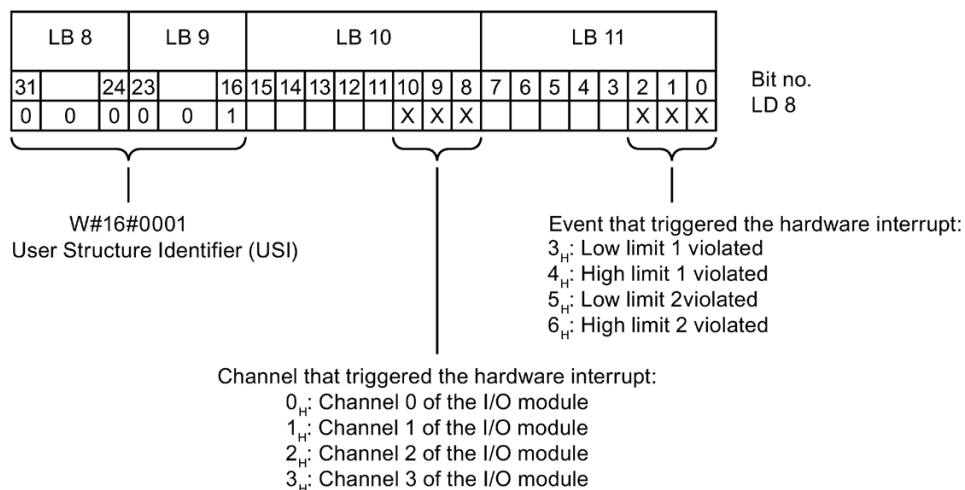


Figure 5-2 Start information of the organization block

## Structure of the additional interrupt information

Table 5- 4 Structure of the additional interrupt information

| Data block name                                                | Contents              | Comment                                                             | Bytes |
|----------------------------------------------------------------|-----------------------|---------------------------------------------------------------------|-------|
| <b>USI</b><br>(User Structure Identifier)                      | W#16#0001             | Additional interrupt info for hardware interrupts of the I/O module | 2     |
| The channel that triggered the hardware interrupt follows.     |                       |                                                                     |       |
| <b>Channel</b>                                                 | B#16#00 to<br>B#16#03 | Number of channel which triggered the event                         | 1     |
| The error event that triggered the hardware interrupt follows. |                       |                                                                     |       |
| <b>Event</b>                                                   | B#16#03               | Low limit 1 violated                                                | 1     |
|                                                                | B#16#04               | High limit 1 violated                                               |       |
|                                                                | B#16#05               | Low limit 2 violated                                                |       |
|                                                                | B#16#06               | High limit 2 violated                                               |       |



## 5.3 Diagnostics alarms

A diagnostics alarm is output for each diagnostics event. The DIAG LED flashes red on the analog output module. The diagnostics alarms are listed in the diagnostics buffer of the CPU. You can evaluate the error codes with the user program.

The following tables set out the diagnostics alarms for the set measuring range.

Table 5- 5 Diagnostics alarms, their meaning and remedies

| Diagnostics alarm                | Error code | Meaning                                                                                                                                                | Remedy                                                                                                                        |
|----------------------------------|------------|--------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------|
| Wire break                       | 6H         | Wire break between the module and sensor                                                                                                               | Connect the cable                                                                                                             |
|                                  |            | Channel not connected (open)                                                                                                                           | <ul style="list-style-type: none"> <li>Deactivate diagnostics</li> <li>Connect channel</li> <li>Deactivate channel</li> </ul> |
| High limit violated <sup>1</sup> | 7H         | Value is above overrange.                                                                                                                              | Correct interplay between module and sensor                                                                                   |
|                                  |            | Wire break <sup>2</sup>                                                                                                                                | See wire break                                                                                                                |
| Low limit violated <sup>1</sup>  | 8H         | Value is below underrange.                                                                                                                             | Correct interplay between module and sensor                                                                                   |
| Error                            | 9H         | Value is significantly above or below underrange/overrange.                                                                                            | Correct interplay between module and sensor                                                                                   |
| Parameter error                  | 10H        | <ul style="list-style-type: none"> <li>The module cannot evaluate parameters for the channel</li> <li>Module parameter assignment is faulty</li> </ul> | Correct the parameter assignment (wire break diagnostics set only with the permitted measuring ranges).                       |
| Reference channel error          | 15H        | Data record 192 ... 195 was not correctly cyclically received within 5 min                                                                             | Write data record 192 ... 195                                                                                                 |
| Hardware interrupt lost          | 16H        | At least one hardware interrupt was not signaled because too many hardware interrupts are pending.                                                     | Correct the program or the process                                                                                            |

<sup>1</sup> = The alarm depends on the configured measuring range.

<sup>2</sup> = For resistor and thermal resistor measuring ranges with deactivated diagnostics for "wire break", this is reported by the "Violation of high limit" diagnostic.

# Technical specifications

## 6.1 Technical specifications

### Technical specifications of the AI 4xRTD/TC 4xM12 analog input module

The following table shows the technical specifications as of the issue date. You will find a data sheet including daily updated technical specifications on the Internet (<https://support.industry.siemens.com/cs/ww/en/pv/6ES7144-5KD50-0BA0/td?dl=en>).

|                                                          |                           |
|----------------------------------------------------------|---------------------------|
| <b>Article number</b>                                    | <b>6ES7144-5KD50-0BA0</b> |
| <b>General information</b>                               |                           |
| Product type designation                                 | AI 4xRTD/TC               |
| HW functional status                                     | FS01                      |
| Firmware version                                         | V1.0.x                    |
| <b>Product function</b>                                  |                           |
| • I&M data                                               | Yes; I&M0 to I&M3         |
| <b>Engineering with</b>                                  |                           |
| • STEP 7 TIA Portal configurable/integrated from version | STEP 7 V16 or higher      |
| • STEP 7 configurable/integrated from version            | V5.5 SP4 and higher       |
| • PROFIBUS from GSD version/GSD revision                 | GSD as of Revision 5      |
| • PROFINET from GSD version/GSD revision                 | GSDML V2.34               |
| <b>Supply voltage</b>                                    |                           |
| <b>Load voltage 1L+</b>                                  |                           |
| • Rated value (DC)                                       | 24 V                      |
| • permissible range, lower limit (DC)                    | 20.4 V                    |
| • permissible range, upper limit (DC)                    | 28.8 V                    |
| • Reverse polarity protection                            | Yes; against destruction  |
| <b>Input current</b>                                     |                           |
| Current consumption (rated value)                        | 25 mA; without load       |
| from load voltage 1L+ (unswitched voltage)               | 4 A; Maximum value        |
| from load voltage 2L+, max.                              | 4 A; Maximum value        |
| <b>Power loss</b>                                        |                           |
| Power loss, typ.                                         | 0.6 W                     |

## 6.1 Technical specifications

| Article number                                                        | 6ES7144-5KD50-0BA0                                 |
|-----------------------------------------------------------------------|----------------------------------------------------|
| <b>Analog inputs</b>                                                  |                                                    |
| Number of analog inputs                                               | 4                                                  |
| • For voltage measurement                                             | 4                                                  |
| • For resistance/resistance thermometer measurement                   | 4                                                  |
| • For thermocouple measurement                                        | 4                                                  |
| permissible input voltage for voltage input (destruction limit), max. | 15 V                                               |
| Constant measurement current for resistance-type transmitter, typ.    | 230 ... 300 µA                                     |
| Cycle time (all channels), min.                                       | 90 ms                                              |
| Technical unit for temperature measurement adjustable                 | Yes; Degrees Celsius / degrees Fahrenheit / Kelvin |
| <b>Input ranges (rated values), voltages</b>                          |                                                    |
| • -80 mV to +80 mV                                                    | Yes; 16 bit incl. sign                             |
| – Input resistance (-80 mV to +80 mV)                                 | 10 MΩ                                              |
| <b>Input ranges (rated values), thermocouples</b>                     |                                                    |
| • Type B                                                              | Yes; 16 bit incl. sign                             |
| – Input resistance (Type B)                                           | 10 MΩ                                              |
| • Type C                                                              | Yes; 16 bit incl. sign                             |
| – Input resistance (Type C)                                           | 10 MΩ                                              |
| • Type E                                                              | Yes; 16 bit incl. sign                             |
| – Input resistance (Type E)                                           | 10 MΩ                                              |
| • Type J                                                              | Yes; 16 bit incl. sign                             |
| – Input resistance (type J)                                           | 10 MΩ                                              |
| • Type K                                                              | Yes; 16 bit incl. sign                             |
| – Input resistance (Type K)                                           | 10 MΩ                                              |
| • Type L                                                              | Yes; 16 bit incl. sign                             |
| – Input resistance (Type L)                                           | 10 MΩ                                              |
| • Type N                                                              | Yes; 16 bit incl. sign                             |
| – Input resistance (Type N)                                           | 10 MΩ                                              |
| • Type R                                                              | Yes; 16 bit incl. sign                             |
| – Input resistance (Type R)                                           | 10 MΩ                                              |
| • Type S                                                              | Yes; 16 bit incl. sign                             |
| – Input resistance (Type S)                                           | 10 MΩ                                              |
| • Type T                                                              | Yes; 16 bit incl. sign                             |
| – Input resistance (Type T)                                           | 10 MΩ                                              |

|                                                                                                             |                                            |
|-------------------------------------------------------------------------------------------------------------|--------------------------------------------|
| <b>Article number</b>                                                                                       | <b>6ES7144-5KD50-0BA0</b>                  |
| <ul style="list-style-type: none"> <li>Type U</li> <li>– Input resistance (Type U)</li> </ul>               | <p>Yes; 16 bit incl. sign</p> <p>10 MΩ</p> |
| <b>Input ranges (rated values), resistance thermometer</b>                                                  |                                            |
| <ul style="list-style-type: none"> <li>Ni 100</li> <li>– Input resistance (Ni 100)</li> </ul>               | <p>Yes; Standard/climate</p> <p>10 MΩ</p>  |
| <ul style="list-style-type: none"> <li>Ni 1000</li> <li>– Input resistance (Ni 1000)</li> </ul>             | <p>Yes; Standard/climate</p> <p>10 MΩ</p>  |
| <ul style="list-style-type: none"> <li>Pt 100</li> <li>– Input resistance (Pt 100)</li> </ul>               | <p>Yes; Standard/climate</p> <p>10 MΩ</p>  |
| <ul style="list-style-type: none"> <li>Pt 1000</li> <li>– Input resistance (Pt 1000)</li> </ul>             | <p>Yes; Standard/climate</p> <p>10 MΩ</p>  |
| <b>Input ranges (rated values), resistors</b>                                                               |                                            |
| <ul style="list-style-type: none"> <li>0 to 150 ohms</li> <li>– Input resistance (0 to 150 ohms)</li> </ul> | <p>Yes</p> <p>10 MΩ</p>                    |
| <ul style="list-style-type: none"> <li>0 to 300 ohms</li> <li>– Input resistance (0 to 300 ohms)</li> </ul> | <p>Yes</p> <p>10 MΩ</p>                    |
| <b>Thermocouple (TC)</b>                                                                                    |                                            |
| <b>Temperature compensation</b>                                                                             |                                            |
| – parameterizable                                                                                           | Yes                                        |
| – internal temperature compensation                                                                         | Yes                                        |
| – external temperature compensation with compensations socket                                               | Yes                                        |
| – dynamic reference temperature value                                                                       | Yes                                        |
| – fixed reference temperature                                                                               | Yes                                        |
| <b>Cable length</b>                                                                                         |                                            |
| <ul style="list-style-type: none"> <li>shielded, max.</li> </ul>                                            | 30 m                                       |

6.1 Technical specifications

|                                                                                                                                                             |                           |
|-------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------|
| <b>Article number</b>                                                                                                                                       | <b>6ES7144-5KD50-0BA0</b> |
| <b>Analog value generation for the inputs</b>                                                                                                               |                           |
| Measurement principle                                                                                                                                       | integrating               |
| <b>Integration and conversion time/resolution per channel</b>                                                                                               |                           |
| <ul style="list-style-type: none"> <li>Resolution with overrange (bit including sign), max.</li> </ul>                                                      | 16 bit                    |
| <ul style="list-style-type: none"> <li>Integration time, parameterizable</li> </ul>                                                                         | Yes; channel by channel   |
| <ul style="list-style-type: none"> <li>Integration time (ms)</li> </ul>                                                                                     | 16.7 / 20 / 60            |
| <ul style="list-style-type: none"> <li>Basic conversion time, including integration time (ms)</li> </ul>                                                    | 18 / 21 / 61 ms           |
| <ul style="list-style-type: none"> <li> <ul style="list-style-type: none"> <li>additional conversion time for wire-break monitoring</li> </ul> </li> </ul>  | 4 ms                      |
| <ul style="list-style-type: none"> <li> <ul style="list-style-type: none"> <li>additional conversion time for resistance measurement</li> </ul> </li> </ul> | 2 ms                      |
| <ul style="list-style-type: none"> <li>Interference voltage suppression for interference frequency f1 in Hz</li> </ul>                                      | 60 / 50 / 16.7            |
| <b>Smoothing of measured values</b>                                                                                                                         |                           |
| <ul style="list-style-type: none"> <li>parameterizable</li> </ul>                                                                                           | Yes                       |
| <ul style="list-style-type: none"> <li>Step: None</li> </ul>                                                                                                | Yes; 1x cycle time        |
| <ul style="list-style-type: none"> <li>Step: low</li> </ul>                                                                                                 | Yes; 4x cycle time        |
| <ul style="list-style-type: none"> <li>Step: Medium</li> </ul>                                                                                              | Yes; 16x cycle time       |
| <ul style="list-style-type: none"> <li>Step: High</li> </ul>                                                                                                | Yes; 32x cycle time       |
| <b>Encoder</b>                                                                                                                                              |                           |
| <b>Connection of signal encoders</b>                                                                                                                        |                           |
| <ul style="list-style-type: none"> <li>for resistance measurement with two-wire connection</li> </ul>                                                       | Yes                       |
| <ul style="list-style-type: none"> <li>for resistance measurement with three-wire connection</li> </ul>                                                     | Yes                       |
| <ul style="list-style-type: none"> <li>for resistance measurement with four-wire connection</li> </ul>                                                      | Yes                       |
| <b>Errors/accuracies</b>                                                                                                                                    |                           |
| Linearity error (relative to input range), (+/-)                                                                                                            | 0.025 %                   |
| Temperature error (relative to input range), (+/-)                                                                                                          | 0.01 %/K                  |
| Crosstalk between the inputs, max.                                                                                                                          | -70 dB                    |
| Repeat accuracy in steady state at 25 °C (relative to input range), (+/-)                                                                                   | 0.01 %; 0.02% for Pt1000  |
| Temperature error of internal compensation                                                                                                                  | ±4 °C                     |

|                                                                                                                                   |                                                                                |
|-----------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------|
| <b>Article number</b>                                                                                                             | <b>6ES7144-5KD50-0BA0</b>                                                      |
| <b>Operational error limit in overall temperature range</b>                                                                       |                                                                                |
| • Voltage, relative to input range, (+/-)                                                                                         | 0.35 %                                                                         |
| • Resistance, relative to input range, (+/-)                                                                                      | 0.25 %                                                                         |
| • Resistance thermometer, relative to input range, (+/-)                                                                          | 0.25 %                                                                         |
| • Thermocouple, relative to input range, (+/-)                                                                                    | TC type E, J, K, N, C, U, L: 0.35 %; TC type R, S, T: 0.4 %; TC type B: 0.45 % |
| <b>Basic error limit (operational limit at 25 °C)</b>                                                                             |                                                                                |
| • Voltage, relative to input range, (+/-)                                                                                         | 0.25 %                                                                         |
| • Resistance, relative to input range, (+/-)                                                                                      | 0.15 %                                                                         |
| • Resistance thermometer, relative to input range, (+/-)                                                                          | 0.15 %                                                                         |
| • Thermocouple, relative to input range, (+/-)                                                                                    | 0.25 %                                                                         |
| <b>Interference voltage suppression for <math>f = n \times (f_1 \pm 0.5 \%)</math>, <math>f_1</math> = interference frequency</b> |                                                                                |
| • Series mode interference (peak value of interference < rated value of input range), min.                                        | 40 dB                                                                          |
| <b>Interrupts/diagnostics/status information</b>                                                                                  |                                                                                |
| <b>Alarms</b>                                                                                                                     |                                                                                |
| • Diagnostic alarm                                                                                                                | Yes; Parameterizable                                                           |
| • Limit value alarm                                                                                                               | Yes; Parameterizable                                                           |
| <b>Diagnoses</b>                                                                                                                  |                                                                                |
| • Wire-break                                                                                                                      | Yes; Not for $\pm 80$ mV                                                       |
| • Overflow/underflow                                                                                                              | Yes                                                                            |
| <b>Diagnostics indication LED</b>                                                                                                 |                                                                                |
| • Channel status display                                                                                                          | Yes; green LED                                                                 |
| • for module diagnostics                                                                                                          | Yes; green/red LED                                                             |
| <b>Potential separation</b>                                                                                                       |                                                                                |
| between the load voltages                                                                                                         | Yes                                                                            |
| <b>Potential separation channels</b>                                                                                              |                                                                                |
| • between the channels                                                                                                            | No                                                                             |
| • between the channels and backplane bus                                                                                          | Yes                                                                            |
| • between the channels and the power supply of the electronics                                                                    | No                                                                             |
| <b>Isolation</b>                                                                                                                  |                                                                                |
| Isolation tested with                                                                                                             | 707 V DC (type test)                                                           |
| <b>Degree and class of protection</b>                                                                                             |                                                                                |
| IP degree of protection                                                                                                           | IP65/67                                                                        |

6.1 Technical specifications

|                                                                                        |                                                                    |
|----------------------------------------------------------------------------------------|--------------------------------------------------------------------|
| <b>Article number</b>                                                                  | <b>6ES7144-5KD50-0BA0</b>                                          |
| <b>Standards, approvals, certificates</b>                                              |                                                                    |
| Suitable for safety-related tripping of standard modules                               | Yes; From FS01                                                     |
| Suitable for applications according to AMS 2750                                        | Yes; Declaration of Conformity, see online support entry 109757262 |
| Suitable for applications according to CQI-9                                           | Yes; Based on AMS 2750 E                                           |
| <b>Highest safety class achievable for safety-related tripping of standard modules</b> |                                                                    |
| • Performance level according to ISO 13849-1                                           | PL d                                                               |
| • Category according to ISO 13849-1                                                    | Cat. 3                                                             |
| • SILCL according to IEC 62061                                                         | SILCL 2                                                            |
| <b>Ambient conditions</b>                                                              |                                                                    |
| <b>Ambient temperature during operation</b>                                            |                                                                    |
| • min.                                                                                 | -30 °C                                                             |
| • max.                                                                                 | 55 °C                                                              |
| <b>Connection method</b>                                                               |                                                                    |
| Design of electrical connection for the inputs and outputs                             | M12, 5-pole                                                        |
| Design of electrical connection for supply voltage                                     | M8, 4-pole                                                         |
| <b>ET-Connection</b>                                                                   |                                                                    |
| • ET-Connection                                                                        | M8, 4-pin, shielded                                                |
| <b>Dimensions</b>                                                                      |                                                                    |
| Width                                                                                  | 30 mm                                                              |
| Height                                                                                 | 159 mm                                                             |
| Depth                                                                                  | 40 mm                                                              |
| <b>Weights</b>                                                                         |                                                                    |
| Weight, approx.                                                                        | 168 g                                                              |

## Dimension drawing

### A.1 Dimension drawing

The figure below shows the dimension drawing of the AI 4xRTD/TC 4xM12 analog input module in the front and side view.

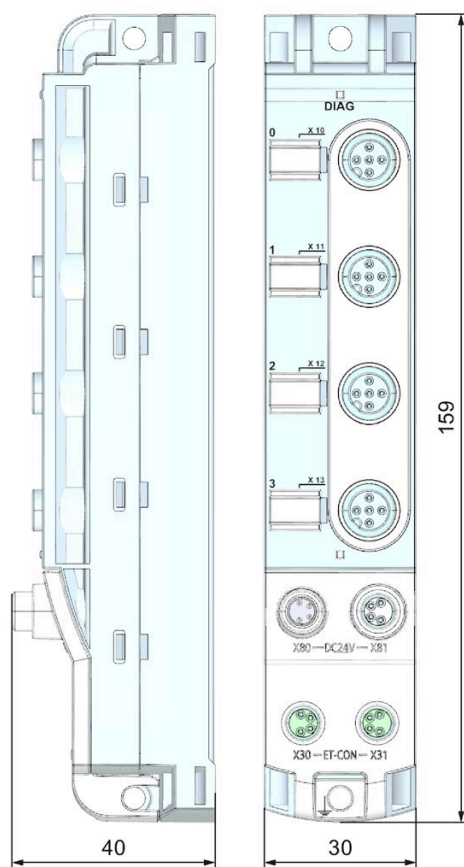


Figure A-1 Dimension drawing



## Representation of analog values

### B.1 Representation of analog values in voltage measuring range

The table below lists the decimal and hexadecimal values (codes) of the voltage measuring range.

Table B- 1 Voltage measuring range  $\pm 80$  mV

| Values |      | Voltage measuring range | Range         |
|--------|------|-------------------------|---------------|
| Dec.   | Hex. | $\pm 80$ mV             |               |
| 32767  | 7FFF | > 94.1 mV               | Overflow      |
| 32511  | 7EFF | 94.1 mV                 | Overrange     |
| 27649  | 6C01 |                         |               |
| 27648  | 6C00 | 80 mV                   | Nominal range |
| 20736  | 5100 | 60 mV                   |               |
| 1      | 1    | 2.89 $\mu$ V            |               |
| 0      | 0    | 0 mV                    |               |
| -1     | FFFF | -2.89 $\mu$ V           |               |
| -20736 | AF00 | -60 mV                  |               |
| -27648 | 9400 | -80 mV                  |               |
| -27649 | 93FF |                         | Underrange    |
| -32512 | 8100 | -94.1 mV                |               |
| -32768 | 8000 | < -94.1 mV              | Underflow     |

## B.2 Representation of analog values for resistance-based sensors

### Resistance-based sensor

The following tables list the decimal and hexadecimal values (codes) of the resistance-based sensor.

Table B- 2 Resistance-based sensor of 150  $\Omega$  and 300  $\Omega$

| Values |      | Resistance-based sensor range |                  | Range         |
|--------|------|-------------------------------|------------------|---------------|
| Dec.   | Hex. | 150 $\Omega$                  | 300 $\Omega$     |               |
| 32767  | 7FFF | >176.38 $\Omega$              | >352.77 $\Omega$ | Overflow      |
| 32511  | 7EFF | 176.38 $\Omega$               | 352.77 $\Omega$  | Overrange     |
| 27649  | 6C01 |                               |                  |               |
| 27648  | 6C00 | 150 $\Omega$                  | 300 $\Omega$     | Nominal range |
| 20736  | 5100 | 112.5 $\Omega$                | 225 $\Omega$     |               |
| 1      | 1    | 5.43 m $\Omega$               | 10.85 m $\Omega$ |               |
| 0      | 0    | 0 $\Omega$                    | 0 $\Omega$       |               |

#### Note

##### Negative value for 2-wire connection

A negative value is possible in these constellations:

- Configured conductor compensation > sum of conductor resistance and resistance
- Short-circuit on the input and configured conductor compensation

With a negative value the value 7FFF<sub>H</sub> is generated. The diagnostic message "Violation of high limit" is signaled for the channel in question.

## B.3 Representation of analog values for thermal resistors

The tables below list the decimal and hexadecimal values (codes) of the thermal resistors.

Table B- 3 Thermal resistor Pt 100, Pt 1000 Standard

| Pt x00<br>Standard<br>in °C<br>(1 digit =<br>0.1°C) | Values |      | Pt x00<br>Standard<br>in °F<br>(1 digit =<br>0.1 °F) | Values |      | Pt x00<br>Standard<br>in K<br>(1 digit =<br>0.1 K) | Values |      | Range         |
|-----------------------------------------------------|--------|------|------------------------------------------------------|--------|------|----------------------------------------------------|--------|------|---------------|
|                                                     | Dec.   | Hex. |                                                      | Dec.   | Hex. |                                                    | Dec.   | Hex. |               |
| >1000.0                                             | 32767  | 7FFF | >1832.0                                              | 32767  | 7FFF | >1273.2                                            | 32767  | 7FFF | Overflow      |
| 1000.0                                              | 10000  | 2710 | 1832.0                                               | 18320  | 4790 | 1273.2                                             | 12732  | 31BC | Overrange     |
| :                                                   | :      | :    | :                                                    | :      | :    | :                                                  | :      | :    |               |
| 850.1                                               | 8501   | 2135 | 1562.1                                               | 15621  | 3D05 | 1123.3                                             | 11233  | 2BE1 | Nominal range |
| 850.0                                               | 8500   | 2134 | 1562.0                                               | 15620  | 3D04 | 1123.2                                             | 11232  | 2BE0 |               |
| :                                                   | :      | :    | :                                                    | :      | :    | :                                                  | :      | :    | Underrange    |
| -200.0                                              | -2000  | F830 | -328.0                                               | -3280  | F330 | 73.2                                               | 732    | 2DC  |               |
| -200.1                                              | -2001  | F82F | -328.1                                               | -3281  | F32F | 73.1                                               | 731    | 2DB  | Underflow     |
| :                                                   | :      | :    | :                                                    | :      | :    | :                                                  | :      | :    |               |
| -243.0                                              | -2430  | F682 | -405.4                                               | -4054  | F02A | 30.2                                               | 302    | 12E  | Underflow     |
| <-243.0                                             | -32768 | 8000 | <-405.4                                              | -32768 | 8000 | <30.2                                              | 32768  | 8000 |               |

Table B- 4 Thermal resistor Pt 100, Pt 1000 Climatic

| Pt x00 Climatic in<br>°C<br>(1 digit = 0.01 °C) | Values |      | Pt x00 Climatic in<br>°F<br>(1 digit = 0.01 °F) | Values |      | Range         |
|-------------------------------------------------|--------|------|-------------------------------------------------|--------|------|---------------|
|                                                 | Dec.   | Hex. |                                                 | Dec.   | Hex. |               |
| >155.00                                         | 32767  | 7FFF | >311.00                                         | 32767  | 7FFF | Overflow      |
| 155.00                                          | 15500  | 3C8C | 311.00                                          | 31100  | 797C | Overrange     |
| :                                               | :      | :    | :                                               | :      | :    |               |
| 130.01                                          | 13001  | 32C9 | 266.01                                          | 26601  | 67E9 | Nominal range |
| 130.00                                          | 13000  | 32C8 | 266.00                                          | 26600  | 67E8 |               |
| :                                               | :      | :    | :                                               | :      | :    | Underrange    |
| -120.00                                         | -12000 | D120 | -184.00                                         | -18400 | B820 |               |
| -120.01                                         | -12001 | D11F | -184.01                                         | -18401 | B81F | Underflow     |
| :                                               | :      | :    | :                                               | :      | :    |               |
| -145.00                                         | -14500 | C75C | -229.00                                         | -22900 | A68C | Underflow     |
| <-145.00                                        | -32768 | 8000 | <-229.00                                        | -32768 | 8000 |               |

## B.3 Representation of analog values for thermal resistors

Table B- 5 Thermal resistor Ni 100, Ni 1000 Standard

| Ni x00<br>Standard in<br>°C<br>(1 digit =<br>0.1 °C) | Values |      | Ni x00<br>Standard in<br>°F<br>(1 digit =<br>0.1 °F) | Values |      | Ni x00<br>Standard in<br>K<br>(1 digit =<br>0.1 K) | Values |      | Range         |
|------------------------------------------------------|--------|------|------------------------------------------------------|--------|------|----------------------------------------------------|--------|------|---------------|
|                                                      | Dec.   | Hex. |                                                      | Dec.   | Hex. |                                                    | Dec.   | Hex. |               |
| > 295.0                                              | 32767  | 7FFF | > 563.0                                              | 32767  | 7FFF | > 568.2                                            | 32767  | 7FFF | Overflow      |
| 295.0                                                | 2950   | B86  | 563.0                                                | 5630   | 15FE | 568.2                                              | 5682   | 1632 | Overrange     |
| :                                                    | :      | :    | :                                                    | :      | :    | :                                                  | :      | :    |               |
| 250.1                                                | 2501   | 9C5  | 482.1                                                | 4821   | 12D5 | 523.3                                              | 5233   | 1471 |               |
| 250.0                                                | 2500   | 9C4  | 482.0                                                | 4820   | 12D4 | 523.2                                              | 5232   | 1470 | Nominal range |
| :                                                    | :      | :    | :                                                    | :      | :    | :                                                  | :      | :    |               |
| -60.0                                                | -600   | FDA8 | -76.0                                                | -760   | FD08 | 213.2                                              | 2132   | 854  |               |
| -60.1                                                | -601   | FDA7 | -76.1                                                | -761   | FD07 | 213.1                                              | 2131   | 853  | Underrange    |
| :                                                    | :      | :    | :                                                    | :      | :    | :                                                  | :      | :    |               |
| -105.0                                               | -1050  | FBE6 | -157.0                                               | -1570  | F9DE | 168.2                                              | 1682   | 692  |               |
| <-105.0                                              | -32768 | 8000 | <-157.0                                              | -32768 | 8000 | < 168.2                                            | 32768  | 8000 | Underflow     |

Table B- 6 Thermal resistor Ni 100, Ni 1000 Climatic

| Ni x00 Climatic in °C<br>(1 digit = 0.01 °C) | Values |      | Ni x00 Climatic in °F<br>(1 digit = 0.01 °F) | Values |      | Range         |
|----------------------------------------------|--------|------|----------------------------------------------|--------|------|---------------|
|                                              | Dec.   | Hex. |                                              | Dec.   | Hex. |               |
| >155.00                                      | 32767  | 7FFF | >311.00                                      | 32767  | 7FFF | Overflow      |
| 155.00                                       | 15500  | 3C8C | 311.00                                       | 31100  | 797C | Overrange     |
| :                                            | :      | :    | :                                            | :      | :    |               |
| 130.01                                       | 13001  | 32C9 | 266.01                                       | 26601  | 67E9 |               |
| 130.00                                       | 13000  | 32C8 | 266.00                                       | 26600  | 67E8 | Nominal range |
| :                                            | :      | :    | :                                            | :      | :    |               |
| -60.00                                       | -6000  | E890 | -76.00                                       | -7600  | E250 |               |
| -60.01                                       | -6001  | E88F | -76.01                                       | -7601  | E24F | Underrange    |
| :                                            | :      | :    | :                                            | :      | :    |               |
| -105.00                                      | -10500 | D6FC | -157.00                                      | -15700 | C2AC |               |
| <-105.00                                     | -32768 | 8000 | <-157.00                                     | -32768 | 8000 | Underflow     |

## B.4 Representation of analog values for thermocouples

The tables below list the decimal and hexadecimal values (codes) of the thermocouples.

Table B- 7 Thermocouple type B

| Type B in °C | Values |      | Type B in °F | Values |      | Type B in K | Values |      | Range         |
|--------------|--------|------|--------------|--------|------|-------------|--------|------|---------------|
|              | Dec.   | Hex. |              | Dec.   | Hex. |             | Dec.   | Hex. |               |
| > 2070.0     | 32767  | 7FFF | > 3276.6     | 32767  | 7FFF | > 2343.2    | 32767  | 7FFF | Overflow      |
| 2070.0       | 20700  | 50DC | 3276.6       | 32766  | 7FFE | 2343.2      | 23432  | 5B88 | Overrange     |
| :            | :      | :    | :            | :      | :    | :           | :      | :    |               |
| 1820.1       | 18201  | 4719 | 2786.6       | 27866  | 6CDA | 2093.3      | 20933  | 51C5 | Nominal range |
| 1820.0       | 18200  | 4718 | 2786.5       | 27865  | 6CD9 | 2093.2      | 20932  | 51C4 |               |
| :            | :      | :    | :            | :      | :    | :           | :      | :    | Underrange    |
| 0.0          | 0      | 0000 | 32.0         | 320    | 0140 | 273.2       | 2732   | 0AAC |               |
| -0.1         | -1     | FFFF | 31.9         | 319    | 013F | 273.1       | 2731   | 0AAB | Underflow     |
| :            | :      | :    | :            | :      | :    | :           | :      | :    |               |
| -120.0       | -1200  | FB50 | -184.0       | -1840  | F8D0 | 153.2       | 1532   | 05FC | Underflow     |
| < -120.0     | -32768 | 8000 | < -184.0     | -32768 | 8000 | < 153.2     | -32768 | 8000 |               |

Table B- 8 Thermocouple type C

| Type C in °C | Values |      | Type C in °F | Values |      | Type C in K | Values |      | Range         |
|--------------|--------|------|--------------|--------|------|-------------|--------|------|---------------|
|              | Dec.   | Hex. |              | Dec.   | Hex. |             | Dec.   | Hex. |               |
| > 2500.0     | 32767  | 7FFF | > 3276.6     | 32767  | 7FFF | > 2773.2    | 32767  | 7FFF | Overflow      |
| 2500.0       | 25000  | 61A8 | 3276.6       | 32766  | 7FFE | 2773.2      | 27732  | 6C54 | Overrange     |
| :            | :      | :    | :            | :      | :    | :           | :      | :    |               |
| 2315.1       | 23151  | 5A6F | 2786.6       | 27866  | 6CDA | 2588.3      | 25883  | 651B | Nominal range |
| 2315.0       | 23150  | 5A6E | 2786.5       | 27865  | 6CD9 | 2588.2      | 25882  | 651A |               |
| :            | :      | :    | :            | :      | :    | :           | :      | :    | Underrange    |
| 0.0          | 0      | 0000 | 32.0         | 320    | 0140 | 273.2       | 2732   | 0AAC |               |
| -0.1         | -1     | FFFF | 31.9         | 319    | 013F | 273.1       | 2731   | 0AAB | Underflow     |
| :            | :      | :    | :            | :      | :    | :           | :      | :    |               |
| -120.0       | -1200  | FB50 | -184.0       | -1840  | F8D0 | 153.2       | 1532   | 05FC | Underflow     |
| < -120.0     | -32768 | 8000 | < -184.0     | -32768 | 8000 | < 153.2     | -32768 | 8000 |               |

Table B- 9 Thermocouple type E

| Type E<br>in °C | Values |      | Type E<br>in °F | Values |      | Type E<br>in K | Values |      | Range         |
|-----------------|--------|------|-----------------|--------|------|----------------|--------|------|---------------|
|                 | Dec.   | Hex. |                 | Dec.   | Hex. |                | Dec.   | Hex. |               |
| > 1200.0        | 32767  | 7FFF | > 2192.0        | 32767  | 7FFF | > 1473.2       | 32767  | 7FFF | Overflow      |
| 1200.0          | 12000  | 2EE0 | 2192.0          | 21920  | 55A0 | 1473.2         | 14732  | 398C | Overrange     |
| :               | :      | :    | :               | :      | :    | :              | :      | :    |               |
| 1000.1          | 10001  | 2711 | 1832.1          | 18321  | 4791 | 1273.3         | 12733  | 31BD | Nominal range |
| 1000.0          | 10000  | 2710 | 1832.0          | 18320  | 4790 | 1273.2         | 12732  | 31BC |               |
| :               | :      | :    | :               | :      | :    | :              | :      | :    |               |
| -270.0          | -2700  | F574 | -454.0          | -4540  | EE44 | 3.2            | 32     | 0020 |               |
| < -270.0        | -32768 | 8000 | < -454.0        | -32768 | 8000 | < 3.2          | -32768 | 8000 | Underflow     |

Table B- 10 Thermocouple type J

| Type J<br>in °C | Values |      | Type J<br>in °F | Values |      | Type J<br>in K | Values |      | Range         |
|-----------------|--------|------|-----------------|--------|------|----------------|--------|------|---------------|
|                 | Dec.   | Hex. |                 | Dec.   | Hex. |                | Dec.   | Hex. |               |
| > 1450.0        | 32767  | 7FFF | > 2642.0        | 32767  | 7FFF | > 1723.2       | 32767  | 7FFF | Overflow      |
| 1450.0          | 14500  | 38A4 | 2642.0          | 26420  | 6734 | 1723.2         | 17232  | 4350 | Overrange     |
| :               | :      | :    | :               | :      | :    | :              | :      | :    |               |
| 1200.1          | 12001  | 2EE1 | 2192.1          | 21921  | 55A1 | 1473.3         | 14733  | 398D | Nominal range |
| 1200.0          | 12000  | 2EE0 | 2192.0          | 21920  | 55A0 | 1473.2         | 14732  | 398C |               |
| :               | :      | :    | :               | :      | :    | :              | :      | :    |               |
| -210.0          | -2100  | F7CC | -346.0          | -3460  | F27C | 63.2           | 632    | 0278 |               |
| < -210.0        | -32768 | 8000 | < -346.0        | -32768 | 8000 | < 63.2         | -32768 | 8000 | Underflow     |

Table B- 11 Thermocouple type K

| Type K<br>in °C | Values |      | Type K<br>in °F | Values |      | Type K<br>in K | Values |      | Range         |
|-----------------|--------|------|-----------------|--------|------|----------------|--------|------|---------------|
|                 | Dec.   | Hex. |                 | Dec.   | Hex. |                | Dec.   | Hex. |               |
| > 1622.0        | 32767  | 7FFF | > 2951.6        | 32767  | 7FFF | > 1895.2       | 32767  | 7FFF | Overflow      |
| 1622.0          | 16220  | 3F5C | 2951.6          | 29516  | 734C | 1895.2         | 18952  | 4A08 | Overrange     |
| :               | :      | :    | :               | :      | :    | :              | :      | :    |               |
| 1372.1          | 13721  | 3599 | 2501.7          | 25017  | 61B9 | 1645.3         | 16453  | 4045 | Nominal range |
| 1372.0          | 13720  | 3598 | 2501.6          | 25016  | 61B8 | 1645.2         | 16452  | 4044 |               |
| :               | :      | :    | :               | :      | :    | :              | :      | :    |               |
| -270.0          | -2700  | F574 | -454.0          | -4540  | EE44 | 3.2            | 32     | 0020 |               |
| < -270.0        | -32768 | 8000 | < -454.0        | -32768 | 8000 | < 3.2          | -32768 | 8000 | Underflow     |

## B.4 Representation of analog values for thermocouples

Table B- 12 Thermocouple type L

| Type L<br>in °C | Values |      | Type L<br>in °F | Values |      | Type L<br>in K | Values |      | Range         |
|-----------------|--------|------|-----------------|--------|------|----------------|--------|------|---------------|
|                 | Dec.   | Hex. |                 | Dec.   | Hex. |                | Dec.   | Hex. |               |
| > 1150.0        | 32767  | 7FFF | > 2102.0        | 32767  | 7FFF | > 1423.2       | 32767  | 7FFF | Overflow      |
| 1150.0          | 11500  | 2CEC | 2102.0          | 21020  | 521C | 1423.2         | 14232  | 3798 | Overrange     |
| :               | :      | :    | :               | :      | :    | :              | :      | :    |               |
| 900.1           | 9001   | 2329 | 1652.1          | 16521  | 4089 | 1173.3         | 11733  | 2DD5 |               |
| 900.0           | 9000   | 2328 | 1652.0          | 16520  | 4088 | 1173.2         | 11732  | 2DD4 | Nominal range |
| :               | :      | :    | :               | :      | :    | :              | :      | :    |               |
| -200.0          | -2000  | F830 | -328.0          | -3280  | F330 | 73.2           | 732    | 02DC |               |
| < -200.0        | -32768 | 8000 | < -328.0        | -32768 | 8000 | < 73.2         | -32768 | 8000 | Underflow     |

Table B- 13 Thermocouple type N

| Type N<br>in °C | Values |      | Type N<br>in °F | Values |      | Type N<br>in K | Values |      | Range         |
|-----------------|--------|------|-----------------|--------|------|----------------|--------|------|---------------|
|                 | Dec.   | Hex. |                 | Dec.   | Hex. |                | Dec.   | Hex. |               |
| > 1550.0        | 32767  | 7FFF | > 2822.0        | 32767  | 7FFF | > 1823.2       | 32767  | 7FFF | Overflow      |
| 1550.0          | 15500  | 3C8C | 2822.0          | 28220  | 6E3C | 1823.2         | 18232  | 4738 | Overrange     |
| :               | :      | :    | :               | :      | :    | :              | :      | :    |               |
| 1300.1          | 13001  | 32C9 | 2372.1          | 23721  | 5CA9 | 1573.3         | 15733  | 3D75 |               |
| 1300.0          | 13000  | 32C8 | 2372.0          | 23720  | 5CA8 | 1573.2         | 15732  | 3D74 | Nominal range |
| :               | :      | :    | :               | :      | :    | :              | :      | :    |               |
| -270.0          | -2700  | F574 | -454.0          | -4540  | EE44 | 3.2            | 32     | 0020 |               |
| < -270.0        | -32768 | 8000 | < -454.0        | -32768 | 8000 | < 3.2          | -32768 | 8000 | Underflow     |

Table B- 14 Thermocouples R and S

| Types R,<br>S in °C | Values |      | Types R,<br>S in °F | Values |      | Types R,<br>S in K | Values |      | Range         |
|---------------------|--------|------|---------------------|--------|------|--------------------|--------|------|---------------|
|                     | Dec.   | Hex. |                     | Dec.   | Hex. |                    | Dec.   | Hex. |               |
| > 2019.0            | 32767  | 7FFF | > 3276.6            | 32767  | 7FFF | > 2292.2           | 32767  | 7FFF | Overflow      |
| 2019.0              | 20190  | 4EDE | 3276.6              | 32766  | 7FFE | 2292.2             | 22922  | 598A | Overrange     |
| :                   | :      | :    | :                   | :      | :    | :                  | :      | :    |               |
| 1769.1              | 17691  | 451B | 3216.3              | 32163  | 7DA3 | 2042.3             | 20423  | 4FC7 |               |
| 1769.0              | 17690  | 451A | 3216.2              | 32162  | 7DA2 | 2042.2             | 20422  | 4FC6 | Nominal range |
| :                   | :      | :    | :                   | :      | :    | :                  | :      | :    |               |
| -50.0               | -500   | FE0C | -58.0               | -580   | FDBC | 223.2              | 2232   | 08B8 |               |
| -50.1               | -501   | FE0B | -58.1               | -581   | FDBB | 223.1              | 2231   | 08B7 | Underrange    |
| :                   | :      | :    | :                   | :      | :    | :                  | :      | :    |               |
| -170.0              | -1700  | F95C | -274.0              | -2740  | F54C | 103.2              | 1032   | 0408 |               |
| < -170.0            | -32768 | 8000 | < -274.0            | -32768 | 8000 | < 103.2            | < 1032 | 8000 | Underflow     |

## B.4 Representation of analog values for thermocouples

Table B- 15 Thermocouple type T

| Type T<br>in °C | Values |      | Type T<br>in °F | Values |      | Type T<br>in K | Values |      | Range         |
|-----------------|--------|------|-----------------|--------|------|----------------|--------|------|---------------|
|                 | Dec.   | Hex. |                 | Dec.   | Hex. |                | Dec.   | Hex. |               |
| > 540.0         | 32767  | 7FFF | > 1004.0        | 32767  | 7FFF | > 813.2        | 32767  | 7FFF | Overflow      |
| 540.0           | 5400   | 1518 | 1004.0          | 10040  | 2738 | 813.2          | 8132   | 1FC4 | Overrange     |
| :               | :      | :    | :               | :      | :    | :              | :      | :    |               |
| 400.1           | 4001   | 0FA1 | 752.1           | 7521   | 1D61 | 673.3          | 6733   | 1AAD | Nominal range |
| 400.0           | 4000   | 0FA0 | 752.0           | 7520   | 1D60 | 673.2          | 6732   | 1AAC |               |
| :               | :      | :    | :               | :      | :    | :              | :      | :    |               |
| -270.0          | -2700  | F574 | -454.0          | -4540  | EE44 | 3.2            | 32     | 0020 |               |
| < -270.0        | -32768 | 8000 | < -454.0        | -32768 | 8000 | < 3.2          | -32768 | 8000 | Underflow     |

Table B- 16 Thermocouple type U

| Type U<br>in °C | Values |      | Type U<br>in °F | Values |        | Type U<br>in K | Values |      | Range         |
|-----------------|--------|------|-----------------|--------|--------|----------------|--------|------|---------------|
|                 | Dec.   | Hex. |                 | Dec.   | Hex.   |                | Dec.   | Hex. |               |
| > 850.0         | 32767  | 7FFF | > 1562.0        | 32767  | 7FFF   | > 1123.2       | 32767  | 7FFF | Overflow      |
| 850.0           | 8500   | 2134 | 1562.0          | 15620  | 2738.0 | 1123.2         | 11232  | 2BE0 | Overrange     |
| :               | :      | :    | :               | :      | :      | :              | :      | :    |               |
| 600.1           | 6001   | 1771 | 1112.1          | 11121  | 2B71   | 873.3          | 8733   | 221D | Nominal range |
| 600.0           | 6000   | 1770 | 1112.0          | 11120  | 2B70   | 873.2          | 8732   | 221C |               |
| :               | :      | :    | :               | :      | :      | :              | :      | :    |               |
| -200.0          | -2000  | F830 | -328.0          | -3280  | F330   | 73.2           | 732    | 02DC |               |
| < -200.0        | -32768 | 8000 | < -328.0        | -32768 | 8000   | < 73.2         | -32768 | 8000 | Underflow     |



# SIEMENS



Manual

## SIMATIC

### ET 200AL

Analog output module AQ 4xU/I 4xM12  
(6ES7145-5ND00-0BA0)

Edition

08/2021

[support.industry.siemens.com](https://support.industry.siemens.com)

## SIMATIC

### ET 200AL Analog output module AQ 4xU/I 4xM12 (6ES7145-5ND00-0BA0) Equipment Manual

#### Preface

---

#### ET 200AL Documentation Guide

**1**

#### Product overview

**2**

#### Wiring

**3**

#### Parameters/address space

**4**

#### Interrupts/diagnostics alarms

**5**

#### Technical specifications

**6**

#### PROFInergy

**7**

#### Dimension drawing

**A**

#### Representation of analog values

**B**

## Legal information

### Warning notice system

This manual contains notices you have to observe in order to ensure your personal safety, as well as to prevent damage to property. The notices referring to your personal safety are highlighted in the manual by a safety alert symbol, notices referring only to property damage have no safety alert symbol. These notices shown below are graded according to the degree of danger.

|                                                                                                        |
|--------------------------------------------------------------------------------------------------------|
|  <b>DANGER</b>        |
| indicates that death or severe personal injury <b>will</b> result if proper precautions are not taken. |
|  <b>WARNING</b>       |
| indicates that death or severe personal injury <b>may</b> result if proper precautions are not taken.  |
|  <b>CAUTION</b>       |
| indicates that minor personal injury can result if proper precautions are not taken.                   |
| <b>NOTICE</b>                                                                                          |
| indicates that property damage can result if proper precautions are not taken.                         |

If more than one degree of danger is present, the warning notice representing the highest degree of danger will be used. A notice warning of injury to persons with a safety alert symbol may also include a warning relating to property damage.

### Qualified Personnel

The product/system described in this documentation may be operated only by **personnel qualified** for the specific task in accordance with the relevant documentation, in particular its warning notices and safety instructions. Qualified personnel are those who, based on their training and experience, are capable of identifying risks and avoiding potential hazards when working with these products/systems.

### Proper use of Siemens products

Note the following:

|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |
|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|  <b>WARNING</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                   |
| Siemens products may only be used for the applications described in the catalog and in the relevant technical documentation. If products and components from other manufacturers are used, these must be recommended or approved by Siemens. Proper transport, storage, installation, assembly, commissioning, operation and maintenance are required to ensure that the products operate safely and without any problems. The permissible ambient conditions must be complied with. The information in the relevant documentation must be observed. |

### Trademarks

All names identified by ® are registered trademarks of Siemens AG. The remaining trademarks in this publication may be trademarks whose use by third parties for their own purposes could violate the rights of the owner.

### Disclaimer of Liability

We have reviewed the contents of this publication to ensure consistency with the hardware and software described. Since variance cannot be precluded entirely, we cannot guarantee full consistency. However, the information in this publication is reviewed regularly and any necessary corrections are included in subsequent editions.

# Preface

## Preface

### Purpose of the documentation

This manual supplements the ET 200AL distributed I/O system (<http://support.automation.siemens.com/WW/view/en/89254965>) system manual. Functions that are generally applicable to the ET 200AL distributed I/O system are described there.

The information provided in the present manual, the system manual and the function manuals enables you to commission the ET 200AL distributed I/O system.

### Changes compared to the previous version

Compared to the previous version, this manual contains the following adaptations in the section Technical specifications (Page 26).

### Conventions

Please also observe notes marked as follows:

---

#### Note

A note contains important information on the product described in the documentation and on the handling of the product to which particular attention should be paid.

---

### See also

ET 200AL Documentation Guide (Page 6)

## Security information

Siemens provides products and solutions with industrial security functions that support the secure operation of plants, systems, machines and networks.

In order to protect plants, systems, machines and networks against cyber threats, it is necessary to implement – and continuously maintain – a holistic, state-of-the-art industrial security concept. Siemens' products and solutions constitute one element of such a concept.

Customers are responsible for preventing unauthorized access to their plants, systems, machines and networks. Such systems, machines and components should only be connected to an enterprise network or the internet if and to the extent such a connection is necessary and only when appropriate security measures (e.g. firewalls and/or network segmentation) are in place.

For additional information on industrial security measures that may be implemented, please visit (<https://www.siemens.com/industrialsecurity>).

Siemens' products and solutions undergo continuous development to make them more secure. Siemens strongly recommends that product updates are applied as soon as they are available and that the latest product versions are used. Use of product versions that are no longer supported, and failure to apply the latest updates may increase customers' exposure to cyber threats.

To stay informed about product updates, subscribe to the Siemens Industrial Security RSS Feed visit (<https://www.siemens.com/industrialsecurity>).

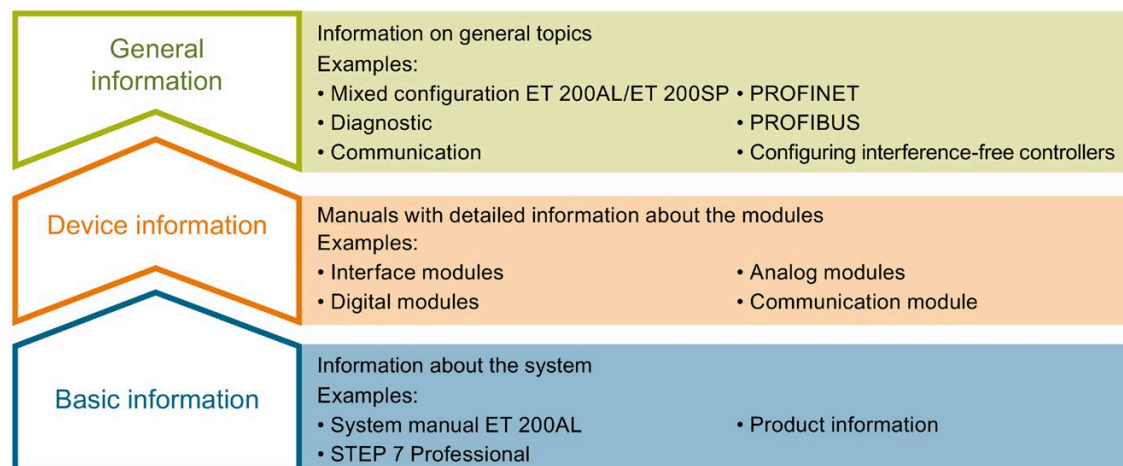
# Table of contents

|          |                                                                    |           |
|----------|--------------------------------------------------------------------|-----------|
|          | <b>Preface .....</b>                                               | <b>3</b>  |
| <b>1</b> | <b>ET 200AL Documentation Guide .....</b>                          | <b>6</b>  |
| <b>2</b> | <b>Product overview .....</b>                                      | <b>10</b> |
| 2.1      | Properties .....                                                   | 10        |
| 2.2      | Operator controls and display elements.....                        | 12        |
| <b>3</b> | <b>Wiring .....</b>                                                | <b>13</b> |
| 3.1      | Terminal and block diagram .....                                   | 13        |
| 3.2      | Pin assignment .....                                               | 14        |
| <b>4</b> | <b>Parameters/address space .....</b>                              | <b>17</b> |
| 4.1      | Output ranges .....                                                | 17        |
| 4.2      | Parameters .....                                                   | 18        |
| 4.3      | Explanation of the parameters .....                                | 20        |
| 4.4      | Address space .....                                                | 22        |
| <b>5</b> | <b>Interrupts/diagnostics alarms .....</b>                         | <b>23</b> |
| 5.1      | Status and error displays .....                                    | 23        |
| 5.2      | Interrupts .....                                                   | 25        |
| 5.3      | Diagnostics alarms.....                                            | 25        |
| <b>6</b> | <b>Technical specifications.....</b>                               | <b>26</b> |
| <b>7</b> | <b>PROFlenergy .....</b>                                           | <b>30</b> |
| 7.1      | Pause function.....                                                | 30        |
| 7.2      | Response of analog output module .....                             | 31        |
| <b>A</b> | <b>Dimension drawing .....</b>                                     | <b>32</b> |
| <b>B</b> | <b>Representation of analog values.....</b>                        | <b>33</b> |
| B.1      | Representation of analog values in the voltage output ranges ..... | 33        |
| B.2      | Representation of analog values in the current output ranges.....  | 35        |

# ET 200AL Documentation Guide

The documentation for the SIMATIC ET 200AL distributed I/O system is arranged into three areas.

This arrangement enables you to access the specific content you require.



## Basic information

The System Manual and Getting Started describe in detail the configuration, installation, wiring and commissioning of the SIMATIC ET 200AL distributed I/O system. The STEP 7 online help supports you in the configuration and programming.

## Device information

Product manuals contain a compact description of the module-specific information, such as properties, wiring diagrams, characteristics and technical specifications.

## General information

The function manuals contain detailed descriptions on general topics regarding the SIMATIC ET 200AL distributed I/O system, e.g. diagnostics, communication, Motion Control, Web server.

You can download the documentation free of charge from the Internet (<https://support.industry.siemens.com/cs/ww/en/view/109742667>).

## Manual Collection ET 200AL

The Manual Collection contains the complete documentation on the SIMATIC ET 200AL distributed I/O system gathered together in one file.

You can find the Manual Collection on the Internet (<https://support.automation.siemens.com/WW/view/en/95242965>).

## **"mySupport"**

With "mySupport", your personal workspace, you make the best out of your Industry Online Support.

In "mySupport", you can save filters, favorites and tags, request CAx data and compile your personal library in the Documentation area. In addition, your data is already filled out in support requests and you can get an overview of your current requests at any time.

You must register once to use the full functionality of "mySupport".

You can find "mySupport" on the Internet (<https://support.industry.siemens.com/My/ww/en>).

## **"mySupport" - Documentation**

With "mySupport", your personal workspace, you make the best out of your Industry Online Support.

In "mySupport", you can save filters, favorites and tags, request CAx data and compile your personal library in the Documentation area. In addition, your data is already filled out in support requests and you can get an overview of your current requests at any time.

You must register once to use the full functionality of "mySupport".

You can find "mySupport" on the Internet  
(<https://support.industry.siemens.com/My/ww/en/documentation>).

## **"mySupport" - CAx data**

In the CAx data area of "mySupport", you can access the latest product data for your CAx or CAe system.

You configure your own download package with a few clicks.

In doing so you can select:

- Product images, 2D dimension drawings, 3D models, internal circuit diagrams, EPLAN macro files
- Manuals, characteristics, operating manuals, certificates
- Product master data

You can find "mySupport" - CAx data on the Internet  
(<https://support.industry.siemens.com/my/ww/en/CAxOnline>).

## **Application examples**

The application examples support you with various tools and examples for solving your automation tasks. Solutions are shown in interplay with multiple components in the system - separated from the focus on individual products.

You will find the application examples on the Internet  
(<https://support.industry.siemens.com/cs/ww/en/ps/ae>).



## TIA Selection Tool

With the TIA Selection Tool, you can select, configure and order devices for Totally Integrated Automation (TIA).

This tool is the successor of the SIMATIC Selection Tool and combines the known configurators for automation technology into one tool.

With the TIA Selection Tool, you can generate a complete order list from your product selection or product configuration.

You can find the TIA Selection Tool on the Internet

(<https://support.industry.siemens.com/cs/ww/en/view/109767888>).

## SIMATIC Automation Tool

You can use the SIMATIC Automation Tool to perform commissioning and maintenance activities simultaneously on various SIMATIC S7 stations as a bulk operation independent of TIA Portal.

The SIMATIC Automation Tool provides a multitude of functions:

- Scanning of a PROFINET/Ethernet system network and identification of all connected CPUs
- Address assignment (IP, subnet, gateway) and station name (PROFINET device) to a CPU
- Transfer of the date and the programming device/PC time converted to UTC time to the module
- Program download to CPU
- RUN/STOP mode switchover
- CPU localization by means of LED flashing
- Reading out of CPU error information
- Reading of the CPU diagnostics buffer
- Reset to factory settings
- Firmware update of the CPU and connected modules

You can find the SIMATIC Automation Tool on the Internet

(<https://support.industry.siemens.com/cs/ww/en/view/98161300>).

## PRONETA

SIEMENS PRONETA (PROFINET network analysis) allows you to analyze the plant network during commissioning. PRONETA features two core functions:

- The topology overview automatically scans the PROFINET and all connected components.
- The IO check is a fast test of the wiring and the module configuration of a plant.

You can find SIEMENS PRONETA on the Internet

(<https://support.industry.siemens.com/cs/ww/en/view/67460624>).

## SINETPLAN

SINETPLAN, the Siemens Network Planner, supports you in planning automation systems and networks based on PROFINET. The tool facilitates professional and predictive dimensioning of your PROFINET installation as early as in the planning stage. In addition, SINETPLAN supports you during network optimization and helps you to exploit network resources optimally and to plan reserves. This helps to prevent problems in commissioning or failures during productive operation even in advance of a planned operation. This increases the availability of the production plant and helps improve operational safety.

The advantages at a glance

- Network optimization thanks to port-specific calculation of the network load
- Increased production availability thanks to online scan and verification of existing systems
- Transparency before commissioning through importing and simulation of existing STEP 7 projects
- Efficiency through securing existing investments in the long term and the optimal use of resources

You can find SINETPLAN on the Internet (<https://www.siemens.com/sinetplan>).

## Product overview

### 2.1 Properties

#### Article number

6ES7145-5ND00-0BA0

#### View of the module

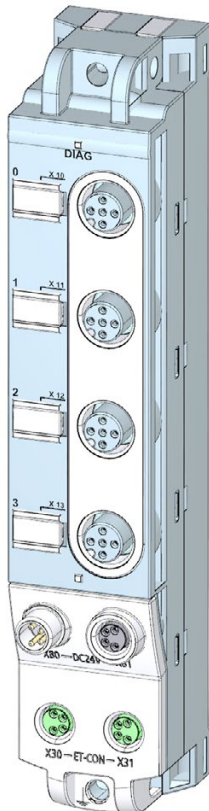


Figure 2-1 View of the analog output module AQ 4xU/I 4xM12

## Properties

The module has the following technical properties:

- 4 analog outputs
- M12 sockets for connection of actuators
- Voltage output can be set for each channel
- Current output can be set for each channel
- Resolution: 16-bit
- Dimensions 30 x 159 mm
- Configurable diagnostics can be set for each channel

The module supports the following functions:

- Firmware update
- Identification and maintenance data I&M0 to I&M3
- Value status (Quality Information)
- PROFIenergy

## Accessories

The following components are included in the module package:

- Identification labels
- Spacers

## Other components

The following component can be ordered as spare part:

- Identification labels

The following components can be ordered as accessories:

- Connectors
- Cables
- Stripping Tool for ET-Connection
- M8 sealing cap
- M12 sealing cap

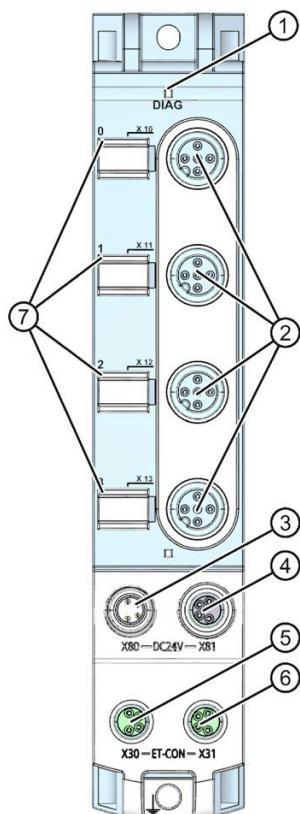
## See also

You can find more information on accessories in the Accessories/spare parts section of the ET 200AL distributed I/O system

(<https://support.industry.siemens.com/cs/us/en/view/89254965>) system manual.

## 2.2 Operator controls and display elements

The figure below shows the operator controls and display elements of the AQ 4xUI/ 4xM12 analog output module.



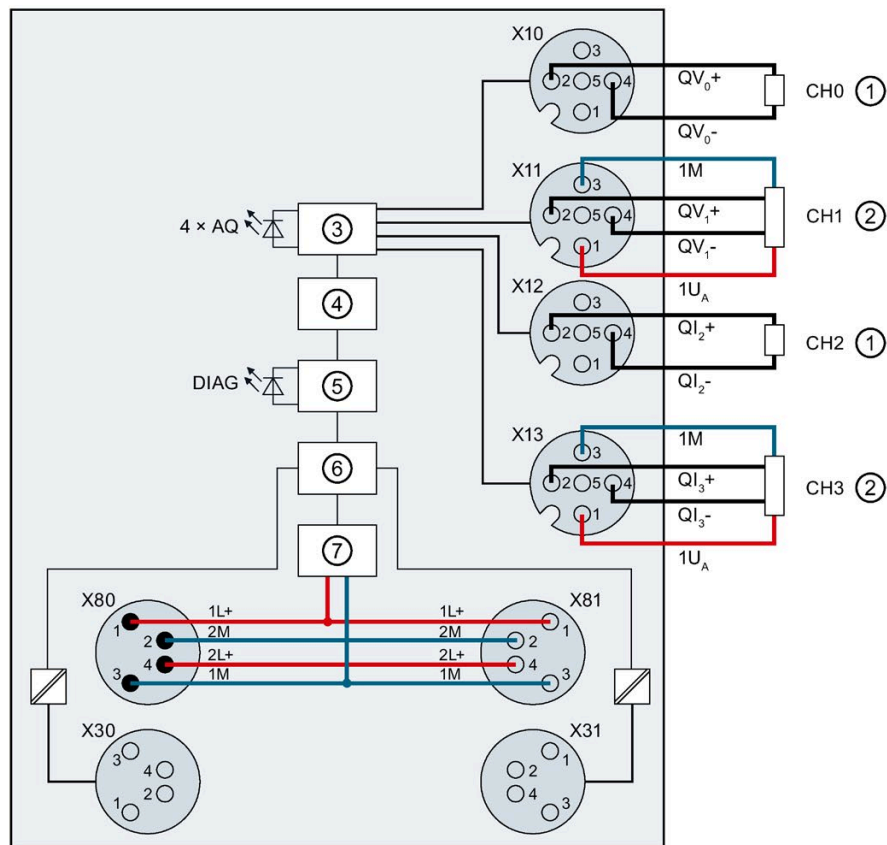
- ① DIAG: LED display for the diagnostic status
- ② X10 to X13: Sockets for the output signal
- ③ X80: Connector for infeed of the supply voltage (POWER input)
- ④ X81: Socket for loop-through of the supply voltage (POWER output)
- ⑤ X30: Socket for ET-Connection IN
- ⑥ X31: Socket for ET-Connection OUT
- ⑦ LED displays 0 to 3 for the channel status

Figure 2-2 Operator controls and display elements

# Wiring

## 3.1 Terminal and block diagram

The example in the following figure shows the pin assignment for voltage and current output of the analog output module AQ 4xU/I 4xM12.



|            |                                             |                                    |                                             |
|------------|---------------------------------------------|------------------------------------|---------------------------------------------|
| ①          | Voltage/current output as 2-wire connection | X31                                | Loop-through of the ET-Connection           |
| ②          | Voltage/current output as 4-wire connection | 1L+                                | Supply voltage 1L+ (non-switched)           |
| ③          | Output driver                               | 1M                                 | Ground 1M (non-switched)                    |
| ④          | Digital-to-analog converter (DAC)           | 2L+                                | Load voltage 2L+ (switched)                 |
| ⑤          | Microcontroller                             | 2M                                 | Ground 2M (switched)                        |
| ⑥          | ET-Connection interface                     | 1U <sub>A</sub>                    | 24 V actuator supply                        |
| ⑦          | Internal supply voltage                     | QV <sub>n</sub> /QI <sub>n</sub> + | Voltage/current output positive, channel n  |
| X10 to X13 | Channels 0 to 3                             | QV <sub>n</sub> /QI <sub>n</sub> - | Voltage/current output negative, channel n  |
| X80        | Infeed of supply voltages                   | AQ                                 | Channel status LEDs (0, 1, 2 and 3) (green) |
| X81        | Loop-through of supply voltages             | DIAG                               | Diagnostic status LED (red/green)           |
| X30        | Infeed of the ET-Connection                 |                                    |                                             |

Figure 3-1 Terminal and block diagram for voltage and current output

## 3.2 Pin assignment

### Note

#### Color coding

The sockets for ET-Connection and the power supply of the modules are color-coded. These colors correspond to the colors of the offered cables.

### Pin assignment of the sockets for analog outputs

The tables below show the pin assignments of the 4 sockets for connection of the analog outputs.

Table 3- 1 Pin assignment of the sockets for analog outputs (voltage output)

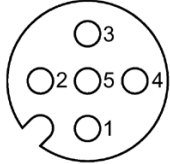
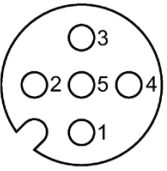
| Pin    | Assignment                                                                                                                                                                                                                                    | Front view of the sockets                                                            |
|--------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------|
|        | X10 to X13 - sockets for analog outputs (voltage output)                                                                                                                                                                                      |                                                                                      |
| 1      | 24 V actuator supply 1U <sub>A</sub><br>(derived from 1L+ Non-Switched)                                                                                                                                                                       |  |
| 2      | Voltage output positive QV <sub>0</sub> +: Connector X10<br>Voltage output positive QV <sub>1</sub> +: Connector X11<br>Voltage output positive QV <sub>2</sub> +: Connector X12<br>Voltage output positive QV <sub>3</sub> +: Connector X13  |                                                                                      |
| 3      | Ground for actuator supply 1M                                                                                                                                                                                                                 |                                                                                      |
| 4      | Voltage output negative QV <sub>0</sub> -: Connector X 10<br>Voltage output negative QV <sub>1</sub> -: Connector X11<br>Voltage output negative QV <sub>2</sub> -: Connector X12<br>Voltage output negative QV <sub>3</sub> -: Connector X13 |                                                                                      |
| 5      | Functional earth FE                                                                                                                                                                                                                           |                                                                                      |
| Shield | Functional earth FE                                                                                                                                                                                                                           |                                                                                      |

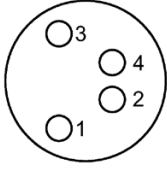
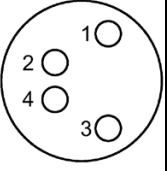
Table 3- 2 Pin assignment of the sockets for analog outputs (current output)

| Pin    | Assignment                                                                                                                                                                                                                                   | Front view of the sockets                                                           |
|--------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------|
|        | X10 to X13 - sockets for analog outputs (current output)                                                                                                                                                                                     |                                                                                     |
| 1      | 24 V actuator supply 1U <sub>A</sub><br>(derived from 1L+ Non-Switched)                                                                                                                                                                      |  |
| 2      | Current output positive Q <sub>10</sub> +: Connector X10<br>Current output positive Q <sub>11</sub> +: Connector X11<br>Current output positive Q <sub>12</sub> +: Connector X12<br>Current output positive Q <sub>13</sub> +: Connector X13 |                                                                                     |
| 3      | Ground for actuator supply 1M                                                                                                                                                                                                                |                                                                                     |
| 4      | Current output negative Q <sub>10</sub> -: Connector X10<br>Current output negative Q <sub>11</sub> -: Connector X11<br>Current output negative Q <sub>12</sub> -: Connector X12<br>Current output negative Q <sub>13</sub> -: Connector X13 |                                                                                     |
| 5      | Functional earth FE                                                                                                                                                                                                                          |                                                                                     |
| Shield | Functional earth FE                                                                                                                                                                                                                          |                                                                                     |

### Pin assignment of the sockets for ET-Connection

The table below shows the pin assignments of the 2 sockets for the connection of ET-Connection.

Table 3- 3 Pin assignment for ET-Connection

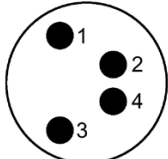
| Pin    | Assignment                    |                                | Assignment of the core color of the bus cable for ET-Connection | Front view of the sockets                                                             |                                                                                       |
|--------|-------------------------------|--------------------------------|-----------------------------------------------------------------|---------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------|
|        | X30 socket (ET-Connection IN) | X31 socket (ET-Connection OUT) |                                                                 | X30                                                                                   | X31                                                                                   |
| 1      | TXP                           | RXP                            | yellow                                                          |  |  |
| 2      | RXP                           | TXP                            | white                                                           |                                                                                       |                                                                                       |
| 3      | RXN                           | TXN                            | blue                                                            |                                                                                       |                                                                                       |
| 4      | TXN                           | RXN                            | orange                                                          |                                                                                       |                                                                                       |
| Shield | Functional earth FE           |                                | -                                                               |                                                                                       |                                                                                       |



### Pin assignment of the connector for infeed of the supply voltage

The table below shows the pin assignment of the connector for infeed of the supply voltage.

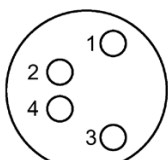
Table 3- 4 Pin assignment of the supply voltage connector

| Pin | Assignment                        | Assignment of the core color of the power cable | Front view of the connector                                                         |
|-----|-----------------------------------|-------------------------------------------------|-------------------------------------------------------------------------------------|
|     | X80 connector (POWER input)       |                                                 |                                                                                     |
| 1   | Supply voltage 1L+ (non-switched) | brown                                           |  |
| 2   | Ground 2M (switched)              | white                                           |                                                                                     |
| 3   | Ground 1M (non-switched)          | blue                                            |                                                                                     |
| 4   | Load voltage 2L+ (switched)       | black                                           |                                                                                     |

### Pin assignment of the socket for loop-through of the supply voltage

The table below shows the pin assignment of the socket for loop-through of the supply voltage.

Table 3- 5 Pin assignment of the supply voltage socket

| Pin | Assignment                        | Assignment of the core color of the power cable | Front view of the socket                                                              |
|-----|-----------------------------------|-------------------------------------------------|---------------------------------------------------------------------------------------|
|     | X81 socket (POWER output)         |                                                 |                                                                                       |
| 1   | Supply voltage 1L+ (non-switched) | brown                                           |  |
| 2   | Ground 2M (switched)              | white                                           |                                                                                       |
| 3   | Ground 1M (non-switched)          | blue                                            |                                                                                       |
| 4   | Load voltage 2L+ (switched)       | black                                           |                                                                                       |

#### NOTICE

##### ET-Connection/supply voltage

Observe the correct wiring of the M8 sockets for ET-Connection and the supply voltage.

Mixing up the connector for ET-Connection and the connector for the supply voltage can destroy the module.

## Parameters/address space

### 4.1 Output ranges

The table below indicates which output types and ranges are configurable.

#### Output type and output ranges

Table 4- 1 Output type and output ranges

| Output type | Output range                                |
|-------------|---------------------------------------------|
| Disabled    | -                                           |
| Voltage     | +/- 10 V<br>0 V to 10 V<br>1 V to 5 V       |
| Current     | +/- 20 mA<br>0 mA to 20 mA<br>4 mA to 20 mA |

The tables of the output ranges, overflow, overrange, etc. are provided in the appendix Representation of analog values (Page 33).

## 4.2 Parameters

### Parameters of the AQ 4xU/I 4xM12 analog output module

The table below lists the parameters that can be set. The effective range of the parameters that can be set depends on the type of configuration. The following configurations are possible:

- Distributed operation on PROFINET IO
- Distributed operation with PROFIBUS DP

The following parameter settings are possible:

Table 4- 2 Configurable parameters and their defaults

| Parameters                                                 | Value range                                                                                                                                                                                                                                                                    | Default                     | GSD file<br>PROFINET IO | GSD file<br>PROFIBUS DP |
|------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------|-------------------------|-------------------------|
| Output type/range                                          | <ul style="list-style-type: none"> <li>• Disabled</li> <li>• Voltage <math>\pm 10</math> V</li> <li>• Voltage 0 V to 10 V</li> <li>• Voltage 1 V to 5 V</li> <li>• Current <math>\pm 20</math> mA</li> <li>• Current 0 mA to 20 mA</li> <li>• Current 4 mA to 20 mA</li> </ul> | Current<br>4 mA to<br>20 mA | Channel                 | Channel                 |
| Diagnostics: Actuator supply short circuit to ground       | <ul style="list-style-type: none"> <li>• Disable</li> <li>• Enable</li> </ul>                                                                                                                                                                                                  | Disable                     | Module                  | Module*                 |
| Diagnostics: Short circuit to ground (output type voltage) | <ul style="list-style-type: none"> <li>• Disable</li> <li>• Enable</li> </ul>                                                                                                                                                                                                  | Disable                     | Channel                 |                         |
| Diagnostics: Wire break (output type current)              | <ul style="list-style-type: none"> <li>• Disable</li> <li>• Enable</li> </ul>                                                                                                                                                                                                  | Disable                     | Channel                 | Module                  |
| Diagnostics: Underflow                                     | <ul style="list-style-type: none"> <li>• Disable</li> <li>• Enable</li> </ul>                                                                                                                                                                                                  | Disable                     | Channel                 | Module                  |
| Diagnostics: Overflow                                      | <ul style="list-style-type: none"> <li>• Disable</li> <li>• Enable</li> </ul>                                                                                                                                                                                                  | Disable                     | Channel                 | Module                  |

| Parameters                  | Value range                                                                                                           | Default   | GSD file<br>PROFINET IO | GSD file<br>PROFIBUS DP |
|-----------------------------|-----------------------------------------------------------------------------------------------------------------------|-----------|-------------------------|-------------------------|
| Reaction to CPU/master STOP | <ul style="list-style-type: none"> <li>Shut down</li> <li>Keep last value</li> <li>Output substitute value</li> </ul> | Shut down | Channel                 | Module                  |
| Substitute value            | See section Explanation of the parameters (Page 20)                                                                   | 0         | Channel                 | Channel                 |

\* = With configuration via PROFIBUS GSD file, the two short-circuit diagnostics ("Diagnostics: Actuator supply short circuit to ground" and "Diagnostics: Short circuit to ground" for voltage outputs) are activated or deactivated using a module-wide parameter "Diagnostics: Short circuit to ground". They cannot be adjusted independently of one another.

### Short-circuit detection

The diagnostics for short circuit to ground can be configured for the voltage output type. Short-circuit detection cannot be guaranteed for small output values (between 0.1 V and +0.1 V).

### Wire break detection

The diagnostics for wire break can be configured for the current output type. Wire break detection cannot be guaranteed for small output values (between -0.2 mA and +0.2 mA).

## 4.3 Explanation of the parameters

### Output type/range channel n

With this parameter, you set the output type or output range for the channel to control the actuator.

---

#### Note

##### Unused channels

"Deactivate" unused channels in the parameter assignment to improve the power consumption of the module.

A deactivated channel always returns the value "no voltage or current".

---

### Diagnostics: Actuator supply short circuit to ground

Enabling of the diagnostics if a short-circuit of the actuator supply to ground occurs.

### Diagnostics: Short circuit to ground

Enabling of the diagnostics if a short-circuit of the output to ground occurs.

### Diagnostics: Wire break

Enabling of the diagnostics if the line to the actuator is broken.

### Diagnostics: Underflow

Enabling of the diagnostics when the output value violates the underrange, falls below the minimum output value or reaches the underflow.

### Diagnostics: Overflow

Enabling of the diagnostics when the output value exceeds the overrange.

### Reaction to CPU/master STOP

Adjusts the reaction of the module after a CPU/master STOP.

- Shut down: The analog output is de-energized.
- Keep last value: The last value of the analog output remains activated.
- Output substitute value: The channel outputs a configured substitute value.

## Substitute value

With this parameter, you set substitute values for the analog outputs.

The table below shows the permitted value ranges for the substitute values:

Table 4- 3 Permissible substitute values for the output ranges

| Output type | Output range  | Valid substitute value |
|-------------|---------------|------------------------|
| Current     | ±10 V         | -32512 to 32511        |
|             | 0 V to 10 V   | 0..32511               |
|             | 1 V to 5 V    | -6912 to 32511         |
| Voltage     | ±20 mA        | -29031..29030          |
|             | 0 mA to 20 mA | 0..29030               |
|             | 4 mA to 20 mA | -692 to 29376          |

## 4.4 Address space

The following figure shows the assignment of the address space for the AQ 4xU/I 4xM12 analog output module with value status (Quality Information (QI)).

The address space for the value status is occupied by the module if the value status is configured using the PROFINET interface module.

Assignment in the process image output (PIQ)

|        |   |   |   |   |   |   |   |   | Connec-<br>tors | Pin assignment |          | Channe |
|--------|---|---|---|---|---|---|---|---|-----------------|----------------|----------|--------|
|        |   |   |   |   |   |   |   |   |                 | U              | I        |        |
|        | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |                 |                |          |        |
| QB x   |   |   |   |   |   |   |   |   | X10             | Pin 2, 4       | Pin 2, 4 | 0      |
| QB x+1 |   |   |   |   |   |   |   |   |                 |                |          |        |
| QB x+2 |   |   |   |   |   |   |   |   | X11             | Pin 2, 4       | Pin 2, 4 | 1      |
| QB x+3 |   |   |   |   |   |   |   |   |                 |                |          |        |
| QB x+4 |   |   |   |   |   |   |   |   | X12             | Pin 2, 4       | Pin 2, 4 | 2      |
| QB x+5 |   |   |   |   |   |   |   |   |                 |                |          |        |
| QB x+6 |   |   |   |   |   |   |   |   |                 |                |          |        |
| QB x+7 |   |   |   |   |   |   |   |   | X13             | Pin 2, 4       | Pin 2, 4 | 3      |

Assignment in the process image input (PII)

|      | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |                                      |  |  |
|------|---|---|---|---|---|---|---|---|--------------------------------------|--|--|
| QB x | 0 | 0 | 0 | 0 |   |   |   |   | Value status (QI) at channels 0 to 3 |  |  |

Figure 4-1 Address space

### Configuration options of the AQ 4xU/I 4xM12 analog output module

You have the following configuration options:

- Configuration 1: without value status
- Configuration 2: with value status

### Evaluating the value status

An additional byte is occupied in the input address space if you enable the value status for the analog output module. Bits 0 to 3 in this byte are assigned to a channel and return information about the validity of the analog values or the channel status.

Bit = 1: No error on channel.

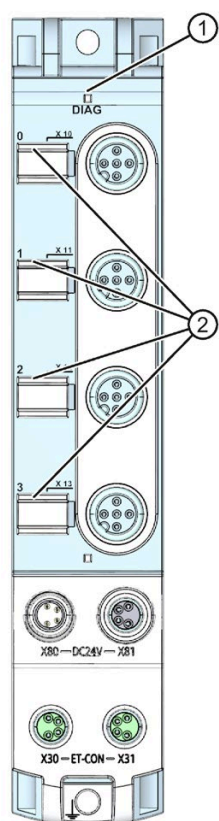
Bit = 0: Error on channel.

# Interrupts/diagnostics alarms

## 5.1 Status and error displays

### LED displays

The figure below shows the LED display (status and error displays) of the AQ 4xU/I 4xM12 analog output module.



- ① Diagnostic status (DIAG) (red/green)
- ② Channel status (0, 1, 2 and 3) (green)

Figure 5-1 LED displays



## Meaning of the LEDs

The following tables set out the meaning of the status and error displays. Corrective measures for diagnostics alarms can be found in the section Diagnostics alarms (Page 25).

### DIAG LED

Table 5- 1 Error display of the DIAG LED

| DIAG LED                                                                                     | Meaning                                                                                                                                                                                                                                                                                                     |
|----------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <br>Off     | No supply voltage 1L+                                                                                                                                                                                                                                                                                       |
| <br>Flashes | <ul style="list-style-type: none"> <li>Module parameters not assigned (after switching on the supply voltage 1L+)</li> <li>Loading firmware (while the firmware update is being performed, all LEDs retain their current status)</li> <li>No connection to the ET-Connection and/or the fieldbus</li> </ul> |
| <br>On      | Module parameters assigned and no diagnostics                                                                                                                                                                                                                                                               |
| <br>Flashes | Module parameters assigned and diagnostics                                                                                                                                                                                                                                                                  |

### LED for the channel status

Table 5- 2 Status display of the LEDs 0, 1, 2 and 3

| LED 0, 1, 2 and 3                                                                          | Meaning                                                                                                                                                                        |
|--------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <br>Off | <ul style="list-style-type: none"> <li>Channel deactivated</li> <li>Channel activated and incorrect parameter assignment</li> <li>Parameter error possible with GSD</li> </ul> |
| <br>On  | <ul style="list-style-type: none"> <li>Channel activated and correct parameter assignment</li> </ul>                                                                           |

## 5.2 Interrupts

The AQ 4xU/I 4xM12 analog output module supports diagnostics interrupts.

### Diagnostic interrupt

The module generates a diagnostic interrupt at the following events:

- Short-circuit of the actuator supply
- Short-circuit (voltage)
- Wire break (current)
- High limit violated
- Low limit violated
- Parameter assignment error

## 5.3 Diagnostics alarms

For each diagnostic event, a diagnostics alarm is issued and the DIAG LED flashes red on the analog output module. You can read out the diagnostics alarms, for example, in the diagnostics buffer of the CPU. You can evaluate the error codes with the user program.

The following tables show the diagnostics alarms for all measuring ranges.

Table 5- 3 Diagnostics alarms

| Diagnostics alarm          | Error code      | Meaning                                                                                                                                     | Solution                                                                                                                                |
|----------------------------|-----------------|---------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------|
| Short circuit to ground    | 1 <sub>H</sub>  | <ul style="list-style-type: none"> <li>• Short-circuit of actuator supply to ground</li> <li>• Short-circuit of output to ground</li> </ul> | Correct the process wiring                                                                                                              |
| Wire break                 | 6 <sub>H</sub>  | Actuator circuit impedance too high                                                                                                         | Use a different actuator type or modify the wiring, e.g. use cables with larger cross-section                                           |
|                            |                 | Wire break between the module and sensor                                                                                                    | Connect the cable                                                                                                                       |
|                            |                 | Channel not connected (open)                                                                                                                | <ul style="list-style-type: none"> <li>• Deactivate diagnostics</li> <li>• Connect the channel</li> <li>• Deactivate channel</li> </ul> |
| High limit violated        | 7 <sub>H</sub>  | The output value set by the user program violates the valid rated range/overrange.                                                          | Correct the output value                                                                                                                |
| Low limit violated         | 8 <sub>H</sub>  | The output value set by the user program violates the valid rated range/underrange.                                                         | Correct the output value                                                                                                                |
| Parameter assignment error | 10 <sub>H</sub> | Module parameter assignment is faulty                                                                                                       | Correct the parameter assignment                                                                                                        |

## Technical specifications

### Technical specifications of the AQ 4xU/I 4xM12 analog output module

The following table shows the technical specifications as of the issue date. You will find a data sheet including daily updated technical specifications on the Internet (<https://support.industry.siemens.com/cs/ww/en/pv/6ES7145-5ND00-0BA0/td?dl=en>).

|                                                                                                          |                                                                                        |
|----------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------|
| <b>Article number</b>                                                                                    | <b>6ES7145-5ND00-0BA0</b>                                                              |
| <b>General information</b>                                                                               |                                                                                        |
| Product type designation                                                                                 | AQ 4xU/I                                                                               |
| HW functional status                                                                                     | from FS04                                                                              |
| Firmware version                                                                                         | V1.0.x                                                                                 |
| <b>Product function</b>                                                                                  |                                                                                        |
| <ul style="list-style-type: none"> <li>I&amp;M data</li> </ul>                                           | Yes; I&M0 to I&M3                                                                      |
| <b>Engineering with</b>                                                                                  |                                                                                        |
| <ul style="list-style-type: none"> <li>STEP 7 TIA Portal configurable/integrated from version</li> </ul> | STEP 7 V14 or higher                                                                   |
| <ul style="list-style-type: none"> <li>STEP 7 configurable/integrated from version</li> </ul>            | V5.5 SP4 Hotfix 7 or higher                                                            |
| <ul style="list-style-type: none"> <li>PROFIBUS from GSD version/GSD revision</li> </ul>                 | GSD as of Revision 5                                                                   |
| <ul style="list-style-type: none"> <li>PROFINET from GSD version/GSD revision</li> </ul>                 | GSDML V2.3.1                                                                           |
| <b>Supply voltage</b>                                                                                    |                                                                                        |
| <b>Load voltage 1L+</b>                                                                                  |                                                                                        |
| <ul style="list-style-type: none"> <li>Rated value (DC)</li> </ul>                                       | 24 V                                                                                   |
| <ul style="list-style-type: none"> <li>permissible range, lower limit (DC)</li> </ul>                    | 20.4 V                                                                                 |
| <ul style="list-style-type: none"> <li>permissible range, upper limit (DC)</li> </ul>                    | 28.8 V                                                                                 |
| <ul style="list-style-type: none"> <li>Reverse polarity protection</li> </ul>                            | Yes; Against destruction; actuator power supply outputs applied with reversed polarity |
| <b>Input current</b>                                                                                     |                                                                                        |
| Current consumption (rated value)                                                                        | 110 mA; without load                                                                   |
| from load voltage 1L+ (unswitched voltage)                                                               | 4 A; Maximum value                                                                     |
| from load voltage 2L+, max.                                                                              | 4 A; Maximum value                                                                     |
| <b>Actuator supply</b>                                                                                   |                                                                                        |
| Number of outputs                                                                                        | 4                                                                                      |
| Short-circuit protection                                                                                 | Yes; per module, electronic                                                            |
| <b>Output current</b>                                                                                    |                                                                                        |
| <ul style="list-style-type: none"> <li>Rated value</li> </ul>                                            | Total current 1 A up to 45 °C; 0.5 A up to 55 °C                                       |
| <b>Power loss</b>                                                                                        |                                                                                        |
| Power loss, typ.                                                                                         | 2.6 W                                                                                  |

|                                                                            |                           |
|----------------------------------------------------------------------------|---------------------------|
| <b>Article number</b>                                                      | <b>6ES7145-5ND00-0BA0</b> |
| <b>Analog outputs</b>                                                      |                           |
| Number of analog outputs                                                   | 4                         |
| Voltage output, short-circuit protection                                   | Yes                       |
| Voltage output, short-circuit current, max.                                | 24 mA                     |
| Current output, no-load voltage, max.                                      | 15 V                      |
| Cycle time (all channels) max.                                             | 1 ms                      |
| <b>Output ranges, voltage</b>                                              |                           |
| • 0 to 10 V                                                                | Yes; 15 bit               |
| • 1 V to 5 V                                                               | Yes; 14 bit               |
| • -10 V to +10 V                                                           | Yes; 16 bit incl. sign    |
| <b>Output ranges, current</b>                                              |                           |
| • 0 to 20 mA                                                               | Yes; 15 bit               |
| • -20 mA to +20 mA                                                         | Yes; 16 bit incl. sign    |
| • 4 mA to 20 mA                                                            | Yes; 14 bit               |
| <b>Connection of actuators</b>                                             |                           |
| • for voltage output two-wire connection                                   | Yes                       |
| • for voltage output four-wire connection                                  | Yes                       |
| • for current output two-wire connection                                   | Yes                       |
| • for current output four-wire connection                                  | Yes                       |
| <b>Load impedance (in rated range of output)</b>                           |                           |
| • with voltage outputs, min.                                               | 1 kΩ                      |
| • with voltage outputs, capacitive load, max.                              | 1 μF                      |
| • with current outputs, max.                                               | 500 Ω                     |
| • with current outputs, inductive load, max.                               | 1 mH                      |
| <b>Destruction limits against externally applied voltages and currents</b> |                           |
| • Voltages at the outputs towards MANA                                     | 16 V                      |
| <b>Cable length</b>                                                        |                           |
| • shielded, max.                                                           | 30 m                      |
| <b>Analog value generation for the outputs</b>                             |                           |
| <b>Integration and conversion time/resolution per channel</b>              |                           |
| • Resolution with overrange (bit including sign), max.                     | 16 bit                    |
| <b>Settling time</b>                                                       |                           |
| • for resistive load                                                       | 1 ms                      |
| • for capacitive load                                                      | 1 ms                      |
| • for inductive load                                                       | 1 ms                      |

|                                                                            |                                                                                     |
|----------------------------------------------------------------------------|-------------------------------------------------------------------------------------|
| <b>Article number</b>                                                      | <b>6ES7145-5ND00-0BA0</b>                                                           |
| <b>Errors/accuracies</b>                                                   |                                                                                     |
| Output ripple (relative to output range, bandwidth 0 to 50 kHz), (+/-)     | 0.02 %                                                                              |
| Linearity error (relative to output range), (+/-)                          | 0.1 %                                                                               |
| Temperature error (relative to output range), (+/-)                        | 0.005 %/K                                                                           |
| Crosstalk between the outputs, max.                                        | -70 dB                                                                              |
| Repeat accuracy in steady state at 25 °C (relative to output range), (+/-) | 0.03 %                                                                              |
| <b>Operational error limit in overall temperature range</b>                |                                                                                     |
| • Voltage, relative to output range, (+/-)                                 | 0.25 % from 55 °C to -25 °C and 0.35 % to -30 °C                                    |
| • Current, relative to output range, (+/-)                                 | 0.25 %                                                                              |
| <b>Basic error limit (operational limit at 25 °C)</b>                      |                                                                                     |
| • Voltage, relative to output range, (+/-)                                 | 0.15 %                                                                              |
| • Current, relative to output range, (+/-)                                 | 0.15 %                                                                              |
| <b>Interrupts/diagnostics/status information</b>                           |                                                                                     |
| Substitute values connectable                                              | Yes; channel by channel, parameterizable                                            |
| <b>Alarms</b>                                                              |                                                                                     |
| • Diagnostic alarm                                                         | Yes; Parameterizable                                                                |
| <b>Diagnoses</b>                                                           |                                                                                     |
| • Wire-break                                                               | Yes; channel-by-channel, only for output type "current"                             |
| • Short-circuit                                                            | Yes; Actuator supply module by module; channel by channel for output type "voltage" |
| <b>Diagnostics indication LED</b>                                          |                                                                                     |
| • Channel status display                                                   | Yes; green LED                                                                      |
| • for module diagnostics                                                   | Yes; green/red LED                                                                  |
| <b>Potential separation</b>                                                |                                                                                     |
| between the load voltages                                                  | Yes                                                                                 |
| <b>Potential separation channels</b>                                       |                                                                                     |
| • between the channels                                                     | No                                                                                  |
| • between the channels and backplane bus                                   | Yes                                                                                 |
| • between the channels and the power supply of the electronics             | No                                                                                  |
| <b>Isolation</b>                                                           |                                                                                     |
| Isolation tested with                                                      | 707 V DC (type test)                                                                |
| <b>Degree and class of protection</b>                                      |                                                                                     |
| IP degree of protection                                                    | IP65/67                                                                             |

|                                                                                        |                           |
|----------------------------------------------------------------------------------------|---------------------------|
| <b>Article number</b>                                                                  | <b>6ES7145-5ND00-0BA0</b> |
| <b>Standards, approvals, certificates</b>                                              |                           |
| Suitable for safety-related tripping of standard modules                               | Yes; from FS04            |
| <b>Highest safety class achievable for safety-related tripping of standard modules</b> |                           |
| • Performance level according to ISO 13849-1                                           | PL d                      |
| • Category according to ISO 13849-1                                                    | Cat. 3                    |
| • SILCL according to IEC 62061                                                         | SILCL 2                   |
| <b>Ambient conditions</b>                                                              |                           |
| <b>Ambient temperature during operation</b>                                            |                           |
| • min.                                                                                 | -30 °C                    |
| • max.                                                                                 | 55 °C                     |
| <b>Connection method</b>                                                               |                           |
| Design of electrical connection for the inputs and outputs                             | M12, 5-pole               |
| Design of electrical connection for supply voltage                                     | M8, 4-pole                |
| <b>ET-Connection</b>                                                                   |                           |
| • ET-Connection                                                                        | M8, 4-pin, shielded       |
| <b>Dimensions</b>                                                                      |                           |
| Width                                                                                  | 30 mm                     |
| Height                                                                                 | 159 mm                    |
| Depth                                                                                  | 40 mm                     |
| <b>Weights</b>                                                                         |                           |
| Weight, approx.                                                                        | 175 g                     |

# PROFlenergy

## 7.1 Pause function

### Introduction

PROFlenergy is a PROFINET-based data interface for switching off consumers centrally and in a coordinated manner during pause times regardless of the manufacturer or device type. This has the aim that the process is only provided with the energy that is absolutely required. In so doing, the majority of the energy savings come from the process itself; the PROFINET device contributes only a few watts to the possible savings. In PROFlenergy, this operating state is referred to as a "pause".

### Start and end of a pause

You enable and disable the pause function of the system at the beginning and end of pauses, respectively; the IO controller then sends the PROFlenergy command "Start\_Pause" or "End\_Pause" to the modules.

Use the "Start\_Pause" command to start a pause.

Use the "End\_Pause" command to end a pause.

The following conditions will also cause a pause to be ended:

- Reconfiguration in RUN
- Controller failure
- Firmware update
- Station stop
- Restart of the interface module through:
  - POWER OFF/POWER ON of an interface module
  - POWER OFF/POWER ON of an I/O module
  - Termination of ET-Connection1 or ET-Connection2

The specific response of the analog output module is explained in the section below.

### Additional information

You can find additional information on working with PROFlenergy in the "PROFlenergy" section of the manual IM 157-1 PN interface module (<https://support.industry.siemens.com/cs/ww/en/view/89254863>) and the "Saving energy with PROFlenergy" section of function manual PROFINET with STEP 7 V14 (<https://support.industry.siemens.com/cs/ww/en/view/49948856>).

Application examples (<https://support.industry.siemens.com/cs/ww/en/view/41986454>) are also available on the Internet.

## 7.2 Response of analog output module

### Display

The channel status LEDs are not affected by PROFlenergy.

### Response to error detection

All channels that are in pause mode on "PE\_MODE\_PROCEED" report their diagnostic status as in productive mode.

The following conditions apply to all channels which switch to the pause mode "PE\_MODE\_SHUTDOWN":

- "Wire break" and "Short circuit" error detection is **not** possible during the pause:
  - Alarms for errors already pending before the "pause" are retained.
  - Incoming and outgoing errors are reported once the "pause" has ended.

The following applies for all channels which switch to a different pause mode:

- "Wire break" and "Short circuit" error recognition is possible during the pause. These errors are reported.
- The selection of an incorrect pause substitute value which does not correspond to the output range may result in the message "High limit violated" or "Low limit violated". The pause substitute output value effective at the channel is limited to the high or low control limit for the output range.

### Mode parameter

The following table shows the "Mode" parameter.

Table 7- 1 Mode parameter

| Element | Code                    | Explanation                                                                                                              |
|---------|-------------------------|--------------------------------------------------------------------------------------------------------------------------|
| Mode    | 0b: PE_MODE_PROCEED     | Proceed at "pause"<br>• Value status "GOOD"                                                                              |
|         | 1b: PE_MODE_SHUTDOWN    | Switch off at "pause"<br>• Actuator supply U <sub>A</sub> switched off<br>• Outputs de-energized<br>• Value status "BAD" |
|         | 3b: PE_MODE_LAST_VALUE  | Last value at "pause"<br>• Pause substitute value: Last output value:<br>• Value status "BAD"                            |
|         | 4b: PE_MODE_SUBST_VALUE | Substitute value at "pause"<br>• Pause substitute value: Configured pause substitute value<br>• Value status "BAD"       |

<sup>1</sup> As there is only one actuator supply U<sub>A</sub> for all channels, the supply can only be switched off during a "pause" if all channel parameters have been set to switch off.



## Dimension drawing

The figure below shows the dimension drawing of the AQ 4xU/I 4xM12 analog output module in front and side view.

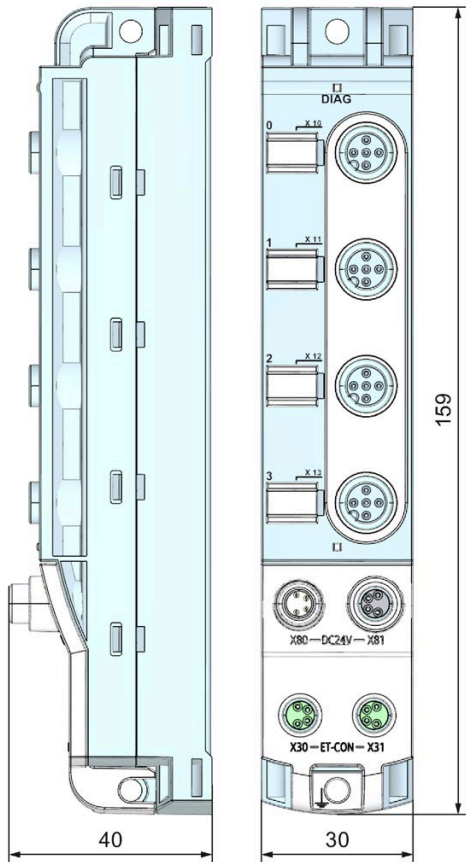


Figure A-1 Dimension drawing

## Representation of analog values

This appendix shows the analog values for all output ranges supported by the AQ 4xU/I 4xM12 analog output module.

### Measured value resolution

The digitized analog value is the same for all output values at the same nominal range. Analog values are output as fixed point numbers in two's complement.

Table B- 1 Resolution of the analog values

| Resolution in bits including sign | Values  |                | Analog value       |               |
|-----------------------------------|---------|----------------|--------------------|---------------|
|                                   | Decimal | Hexadecimal    | High byte          | Low byte      |
| 16                                | 1       | 1 <sub>H</sub> | Sign 0 0 0 0 0 0 0 | 0 0 0 0 0 0 1 |

### B.1 Representation of analog values in the voltage output ranges

The tables below list the decimal and hexadecimal values (codes) of the possible voltage output ranges.

Table B- 2 Voltage output range +/-10 V

| Values    |        |      | Voltage output range | Range                |
|-----------|--------|------|----------------------|----------------------|
|           | Dec.   | Hex. | ±10 V                |                      |
| 118.5149% | 32767  | 7FFF | 11.76 V              | Maximum output value |
|           | 32512  | 7F00 |                      |                      |
| 117.589%  | 32511  | 7EFF | 11.76 V              | Overrange            |
|           | 27649  | 6C01 |                      |                      |
| 100%      | 27648  | 6C00 | 10 V                 | Nominal range        |
| 75%       | 20736  | 5100 | 7.5 V                |                      |
| 0.003617% | 1      | 1    | 361.7 µV             |                      |
| 0%        | 0      | 0    | 0 V                  |                      |
|           | -1     | FFFF | -361.7 µV            |                      |
| -75%      | -20736 | AF00 | -7.5 V               |                      |
| -100%     | -27648 | 9400 | -10 V                |                      |
|           | -27649 | 93FF |                      | Underrange           |
| -117.593% | -32512 | 8100 | -11.76 V             |                      |
|           | -32513 | 80FF | -11.76               | Minimum output value |
| -118.519% | -32768 | 8000 |                      |                      |

## B.1 Representation of analog values in the voltage output ranges

Table B- 3 Voltage output range 0 V to 10 V

| Values    |        |      | Voltage output range | Range                |
|-----------|--------|------|----------------------|----------------------|
|           | Dec.   | Hex. | 0 V to 10 V          |                      |
| 118.519%  | 32767  | 7FFF | 11.76 V              | Maximum output value |
|           | 32512  | 7F00 |                      |                      |
| 117.589%  | 32511  | 7EFF | 11.76 V              | Overrange            |
|           | 27649  | 6C01 |                      |                      |
| 100%      | 27648  | 6C00 | 10 V                 | Nominal range        |
| 75%       | 20736  | 5100 | 7.5 V                |                      |
| 0.003617% | 1      | 1    | 361.7 $\mu$ V        |                      |
| 0%        | 0      | 0    | 0 V                  |                      |
|           | -1     | FFFF | 0 V                  | Minimum output value |
| -118.519% | -32768 | 8000 |                      |                      |

Table B- 4 Voltage output range 1 to 5 V

| Values    |        |      | Voltage output range | Range                |
|-----------|--------|------|----------------------|----------------------|
|           | Dec.   | Hex. | 1 V to 5 V           |                      |
| 118.519%  | 32767  | 7FFF | 5.70 V               | Maximum output value |
|           | 32512  | 7F00 |                      |                      |
| 117.589%  | 32511  | 7EFF | 5.70 V               | Overrange            |
|           | 27649  | 6C01 |                      |                      |
| 100%      | 27648  | 6C00 | 5 V                  | Nominal range        |
| 75%       | 20736  | 5100 | 4 V                  |                      |
| 0.003617% | 1      | 1    | 1 V + 144.7 $\mu$ V  |                      |
| 0%        | 0      | 0    | 1 V                  |                      |
|           | -1     | FFFF | 1 V - 144.7 $\mu$ V  | Underrange           |
| -25%      | -6912  | E500 | 0 V                  |                      |
|           | -6913  | E4FF | 0 V                  | Minimum output value |
| -118.519% | -32768 | 8000 |                      |                      |

## B.2 Representation of analog values in the current output ranges

The tables below list the decimal and hexadecimal values (codes) of the possible current output ranges.

Table B- 5 Current output range +/-20 mA

| Values    |        |      | Current output range | Range                |
|-----------|--------|------|----------------------|----------------------|
|           | Dec.   | Hex. | $\pm 20$ mA          |                      |
| 118.5149% | 32767  | 7FFF | 21 mA                | Maximum output value |
|           | 29031  | 7167 |                      |                      |
| 105%      | 29030  | 7166 | 21 mA                | Overrange            |
|           | 27649  | 6C01 | 20 mA + 723.4 nA     |                      |
| 100%      | 27648  | 6C00 | 20 mA                | Nominal range        |
| 75%       | 20736  | 5100 | 15 mA                |                      |
| 0.003617% | 1      | 1    | 723.4 nA             |                      |
| 0%        | 0      | 0    | 0 mA                 |                      |
|           | -1     | FFFF | -723.4 nA            |                      |
| -75%      | -20736 | AF00 | -15 mA               |                      |
| -100%     | -27648 | 9400 | -20 mA               |                      |
|           | -27649 | 93FF | -20 mA + 723.4 nA    | Underrange           |
| -105%     | -29031 | 8E99 | -21 mA               |                      |
|           | -29032 | 8E98 | -21 mA               | Minimum output value |
| -118.519% | -32768 | 8000 |                      |                      |

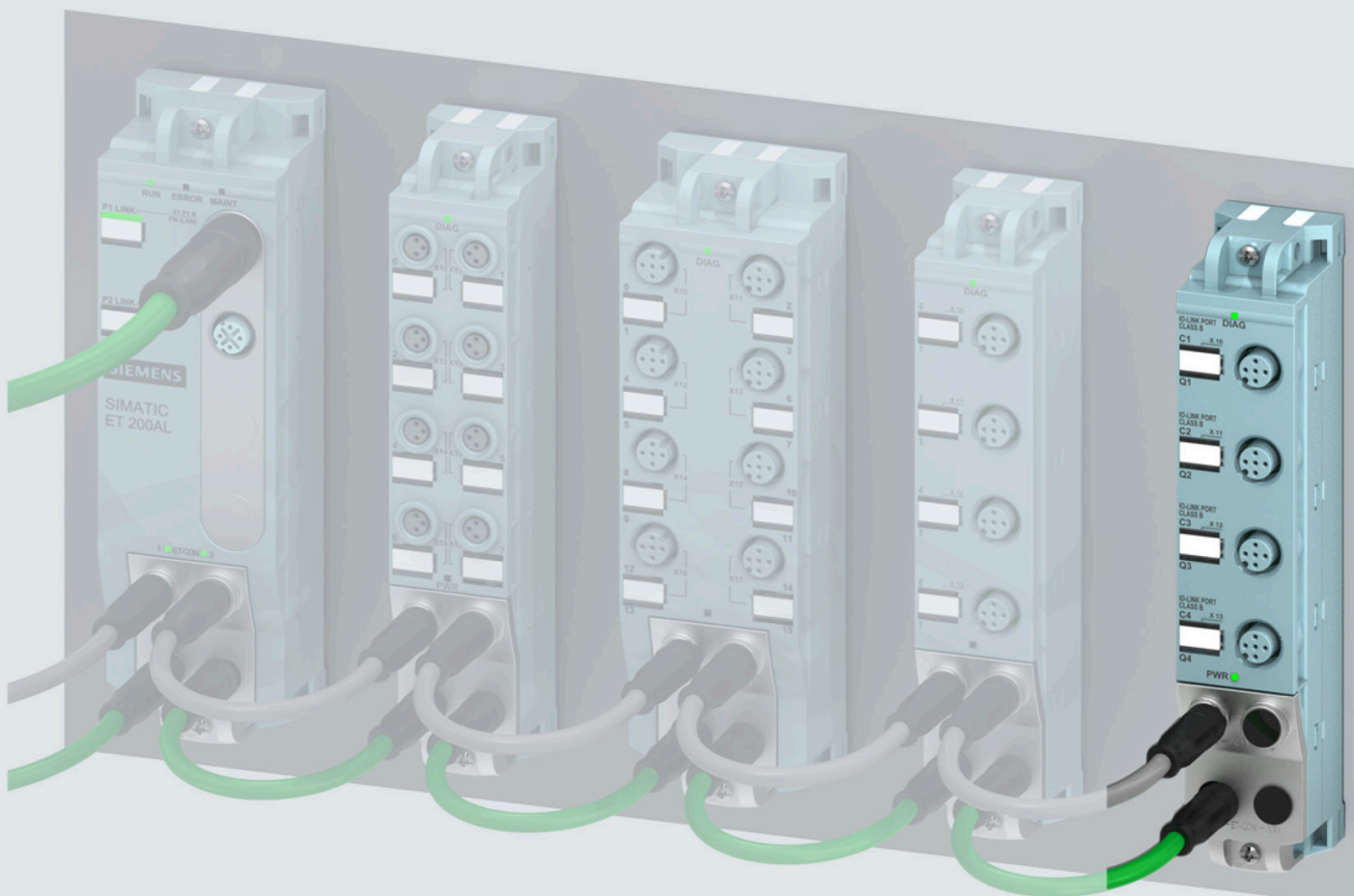
Table B- 6 Current output range 0 mA to 20 mA

| Values    |        |      | Current output range | Range                |
|-----------|--------|------|----------------------|----------------------|
|           | Dec.   | Hex. | 0 mA to 20 mA        |                      |
| 118.5149% | 32767  | 7FFF | 21 mA                | Maximum output value |
|           | 29031  | 7167 |                      |                      |
| 105%      | 29030  | 7166 | 21 mA                | Overrange            |
|           | 27649  | 6C01 | 20 mA + 723.4 nA     |                      |
| 100%      | 27648  | 6C00 | 20 mA                | Nominal range        |
| 75%       | 20736  | 5100 | 15 mA                |                      |
| 0.003617% | 1      | 1    | 723.4 nA             |                      |
| 0%        | 0      | 0    | 0 mA                 |                      |
|           | -1     | FFFF | 0 mA                 |                      |
| -118.519% | -32768 | 8000 |                      | Minimum output value |

Table B- 7 Current output range 4 mA to 20 mA

| Values    |        |      | Current output range | Range                |
|-----------|--------|------|----------------------|----------------------|
|           | Dec.   | Hex. | 4 mA to 20 mA        |                      |
| 118.5149% | 32767  | 7FFF | 21 mA                | Maximum output value |
|           | 29377  | 72C1 |                      |                      |
| 106.25%   | 29376  | 72C0 | 21 mA                | Overrange            |
|           | 27649  | 6C01 | 20 mA + 578.7 nA     |                      |
| 100%      | 27648  | 6C00 | 20 mA                | Nominal range        |
| 75%       | 19008  | 4A40 | 16 mA                |                      |
| 0.003617% | 1      | 1    | 4 mA + 578.7 nA      |                      |
| 0%        | 0      | 0    | 4 mA                 |                      |
|           | -1     | FFFF | 3.9995 mA            | Underrange           |
| -2.5%     | -692   | FD4C | 3.6 mA               |                      |
|           | -693   | FD4B | 3.6 mA               | Minimum output value |
| -118.519% | -32768 | 8000 |                      |                      |

# SIEMENS



Manual

## SIMATIC

### ET 200AL

Communication module CM 4xIO-Link 4xM12  
(6ES7147-5JD00-0BA0)

Edition

04/2021

[support.industry.siemens.com](https://support.industry.siemens.com)

## SIMATIC

### ET 200AL CM 4xIO-Link 4xM12 (6ES7147-5JD00-0BA0)

#### Equipment Manual

#### Preface

#### Documentation guide

1

#### Product overview

2

#### Wiring

3

#### Parameters/address space

4

#### Diagnostics alarms

5

#### Technical specifications

6

#### Replacing modules

7

#### PROFInergy

8

#### Dimension drawing

A

## Legal information

### Warning notice system

This manual contains notices you have to observe in order to ensure your personal safety, as well as to prevent damage to property. The notices referring to your personal safety are highlighted in the manual by a safety alert symbol, notices referring only to property damage have no safety alert symbol. These notices shown below are graded according to the degree of danger.

#### **DANGER**

indicates that death or severe personal injury **will** result if proper precautions are not taken.

#### **WARNING**

indicates that death or severe personal injury **may** result if proper precautions are not taken.

#### **CAUTION**

indicates that minor personal injury can result if proper precautions are not taken.

#### **NOTICE**

indicates that property damage can result if proper precautions are not taken.

If more than one degree of danger is present, the warning notice representing the highest degree of danger will be used. A notice warning of injury to persons with a safety alert symbol may also include a warning relating to property damage.

### Qualified Personnel

The product/system described in this documentation may be operated only by **personnel qualified** for the specific task in accordance with the relevant documentation, in particular its warning notices and safety instructions. Qualified personnel are those who, based on their training and experience, are capable of identifying risks and avoiding potential hazards when working with these products/systems.

### Proper use of Siemens products

Note the following:

#### **WARNING**

Siemens products may only be used for the applications described in the catalog and in the relevant technical documentation. If products and components from other manufacturers are used, these must be recommended or approved by Siemens. Proper transport, storage, installation, assembly, commissioning, operation and maintenance are required to ensure that the products operate safely and without any problems. The permissible ambient conditions must be complied with. The information in the relevant documentation must be observed.

### Trademarks

All names identified by ® are registered trademarks of Siemens AG. The remaining trademarks in this publication may be trademarks whose use by third parties for their own purposes could violate the rights of the owner.

### Disclaimer of Liability

We have reviewed the contents of this publication to ensure consistency with the hardware and software described. Since variance cannot be precluded entirely, we cannot guarantee full consistency. However, the information in this publication is reviewed regularly and any necessary corrections are included in subsequent editions.



# Preface

## Purpose of the documentation

This manual supplements the ET 200AL distributed I/O system (<http://support.automation.siemens.com/WW/view/en/89254965>) system manual. Functions that are generally applicable to the ET 200AL distributed I/O system are described there.

The information provided in the present manual, the system manual and the function manuals enables you to commission the ET 200AL distributed I/O system.

## Conventions

Please also observe notes marked as follows:

---

### Note

Indicates important product information to which particular attention should be paid.

---

## Security information

Siemens provides products and solutions with industrial security functions that support the secure operation of plants, systems, machines and networks.

In order to protect plants, systems, machines and networks against cyber threats, it is necessary to implement – and continuously maintain – a holistic, state-of-the-art industrial security concept. Siemens' products and solutions constitute one element of such a concept.

Customers are responsible for preventing unauthorized access to their plants, systems, machines and networks. Such systems, machines and components should only be connected to an enterprise network or the internet if and to the extent such a connection is necessary and only when appropriate security measures (e.g. firewalls and/or network segmentation) are in place.

For additional information on industrial security measures that may be implemented, please visit (<https://www.siemens.com/industrialsecurity>).

Siemens' products and solutions undergo continuous development to make them more secure. Siemens strongly recommends that product updates are applied as soon as they are available and that the latest product versions are used. Use of product versions that are no longer supported, and failure to apply the latest updates may increase customers' exposure to cyber threats.

To stay informed about product updates, subscribe to the Siemens Industrial Security RSS Feed under (<https://www.siemens.com/industrialsecurity>).

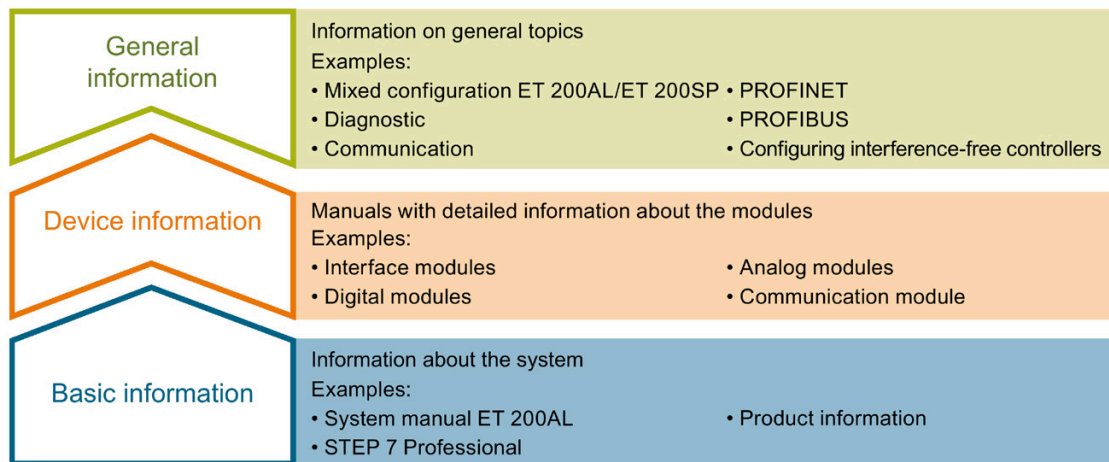
# Table of contents

|          |                                                     |           |
|----------|-----------------------------------------------------|-----------|
|          | <b>Preface .....</b>                                | <b>3</b>  |
| <b>1</b> | <b>Documentation guide .....</b>                    | <b>5</b>  |
| <b>2</b> | <b>Product overview .....</b>                       | <b>9</b>  |
| 2.1      | Properties .....                                    | 9         |
| 2.2      | Operator controls and display elements.....         | 12        |
| 2.3      | Functions .....                                     | 13        |
| 2.4      | Reset communication module to factory settings..... | 13        |
| <b>3</b> | <b>Wiring .....</b>                                 | <b>14</b> |
| 3.1      | Terminal and block diagram .....                    | 14        |
| 3.2      | Pin assignment .....                                | 15        |
| <b>4</b> | <b>Parameters/address space .....</b>               | <b>18</b> |
| 4.1      | Parameters .....                                    | 18        |
| 4.2      | Explanation of the parameters .....                 | 20        |
| <b>5</b> | <b>Diagnostics alarms.....</b>                      | <b>25</b> |
| 5.1      | Status and error displays .....                     | 25        |
| 5.2      | Diagnostics alarms.....                             | 28        |
| <b>6</b> | <b>Technical specifications.....</b>                | <b>33</b> |
| <b>7</b> | <b>Replacing modules .....</b>                      | <b>33</b> |
| <b>8</b> | <b>PROFenergy .....</b>                             | <b>34</b> |
| 8.1      | Pause function.....                                 | 34        |
| 8.2      | DI operating mode.....                              | 35        |
| 8.3      | DQ operating mode .....                             | 37        |
| 8.4      | IO-Link operating mode .....                        | 39        |
| <b>A</b> | <b>Dimension drawing .....</b>                      | <b>41</b> |

# Documentation guide

The documentation for the SIMATIC ET 200AL distributed I/O system is arranged into three areas.

This arrangement enables you to access the specific content you require.



## Basic information

The System Manual and Getting Started describe in detail the configuration, installation, wiring and commissioning of the SIMATIC ET 200AL distributed I/O system. The STEP 7 online help supports you in the configuration and programming.

## Device information

Product manuals contain a compact description of the module-specific information, such as properties, terminal diagrams, characteristics and technical specifications.

## General information

The function manuals contain detailed descriptions on general topics regarding the SIMATIC ET 200AL distributed I/O system, e.g. diagnostics, communication, Motion Control, Web server.

You can download the documentation free of charge from the Internet (<https://support.industry.siemens.com/cs/ww/en/view/109742667>).

## Manual Collection ET 200AL

The Manual Collection contains the complete documentation on the SIMATIC ET 200AL distributed I/O system gathered together in one file.

You can find the Manual Collection on the Internet (<http://support.automation.siemens.com/WW/view/en/95242965>).

## "mySupport"

With "mySupport", your personal workspace, you make the best out of your Industry Online Support.

In "mySupport", you can save filters, favorites and tags, request CAx data and compile your personal library in the Documentation area. In addition, your data is already filled out in support requests and you can get an overview of your current requests at any time.

You must register once to use the full functionality of "mySupport".

You can find "mySupport" on the Internet (<https://support.industry.siemens.com/My/ww/en>).

## "mySupport" - Documentation

In the Documentation area in "mySupport" you can combine entire manuals or only parts of these to your own manual.

You can export the manual as PDF file or in a format that can be edited later.

You can find "mySupport" - Documentation on the Internet (<http://support.industry.siemens.com/My/ww/en/documentation>).

## "mySupport" - CAx data

In the CAx data area in "mySupport", you can access the current product data for your CAx or CAe system.

You configure your own download package with a few clicks.

In doing so you can select:

- Product images, 2D dimension drawings, 3D models, internal circuit diagrams, EPLAN macro files
- Manuals, characteristics, operating manuals, certificates
- Product master data

You can find "mySupport" - CAx data on the Internet (<http://support.industry.siemens.com/my/ww/en/CAxOnline>).

## Application examples

The application examples support you with various tools and examples for solving your automation tasks. Solutions are shown in interplay with multiple components in the system - separated from the focus on individual products.

You will find the application examples on the Internet (<https://support.industry.siemens.com/sc/ww/en/sc/2054>).

## TIA Selection Tool

With the TIA Selection Tool, you can select, configure and order devices for Totally Integrated Automation (TIA).

This tool is the successor of the SIMATIC Selection Tool and combines the known configurators for automation technology into one tool.

With the TIA Selection Tool, you can generate a complete order list from your product selection or product configuration.

You can find the TIA Selection Tool on the Internet

(<http://w3.siemens.com/mcms/topics/en/simatic/tia-selection-tool>).

## SIMATIC Automation Tool

You can use the SIMATIC Automation Tool to perform commissioning and maintenance activities simultaneously on different SIMATIC S7 stations as a bulk operation, independently of the TIA Portal.

General function overview:

- Network browsing and creation of a table showing the accessible devices in the network
- Flashing of device LEDs or HMI display to locate a device
- Downloading of addresses (IP, subnet, gateway) to a device
- Downloading the PROFINET name (station name) to a device
- Placing a CPU in RUN or STOP mode
- Setting the time in a CPU to the current time of your PG/PC
- Downloading a new program to a CPU or an HMI device
- Downloading from CPU, downloading to CPU or deleting recipe data from a CPU
- Downloading from CPU or deleting data log data from a CPU
- Backup/restore of data from/to a backup file for CPUs and HMI devices
- Downloading service data from a CPU
- Reading the diagnostics buffer of a CPU
- Performing a CPU memory reset
- Resetting devices to factory settings
- Downloading a firmware update to a device

You can find the SIMATIC Automation Tool on the Internet

(<https://support.industry.siemens.com/cs/ww/en/view/98161300>).

## PRONETA

With SIEMENS PRONETA (PROFINET network analysis), you analyze the system network during commissioning. PRONETA features two core functions:

- The topology overview independently scans the PROFINET network and all connected components.
- The IO check is a fast test of the wiring and the module configuration of a system.

You can find SIEMENS PRONETA on the Internet

(<https://support.industry.siemens.com/cs/ww/en/view/67460624>).

## SINETPLAN

SINETPLAN, the Siemens Network Planner, supports you in planning automation systems and networks based on PROFINET. The tool facilitates professional and predictive dimensioning of your PROFINET installation as early as in the planning stage. In addition, SINETPLAN supports you during network optimization and helps you to exploit network resources optimally and to plan reserves. This helps to prevent problems in commissioning or failures during productive operation even in advance of a planned operation. This increases the availability of the production plant and helps improve operational safety.

The advantages at a glance

- Network optimization thanks to port-specific calculation of the network load
- Increased production availability thanks to online scan and verification of existing systems
- Transparency before commissioning through importing and simulation of existing STEP 7 projects
- Efficiency through securing existing investments in the long term and optimal exploitation of resources

You can find SINETPLAN on the Internet (<https://www.siemens.com/sinetplan>).

## Product overview

### 2.1 Properties

#### Article number

6ES7147-5JD00-0BA0

#### View of the module

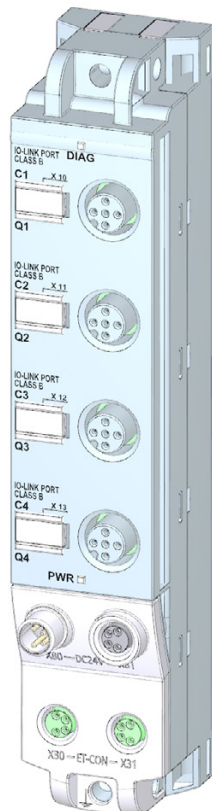


Figure 2-1 View of the CM 4xIO-Link 4xM12 communication module

## Properties

The module has the following technical properties:

- IO-Link Master according to IO-Link specification V1.1
- 4 ports, type class B
- 4 M12 connectors
- SIO mode (standard IO mode)
- Supported data transmission rates:
  - COM1 (4.8 kBd)
  - COM2 (38.4 kBd)
  - COM3 (230.4 kBd)
- Configuration limits:
  - Max. 33 bytes of input data and 32 bytes of output data per port
  - Max. 132 bytes of input data and 128 bytes of output data per module
- Automatic backup of device parameters during replacement of the IO-Link device (only for V1.1 devices)
- Suitable for connection of IO-Link devices with 3-wire and 5-wire connection
- Configurable diagnostics can be set for each channel
- Dimensions 30 x 159 mm

The module supports the following functions:

Table 2- 1 Version dependencies of the module functions

| Function                                            | Firmware version of the module |
|-----------------------------------------------------|--------------------------------|
| Firmware update                                     | V1.0 or higher                 |
| Identification and maintenance data (I&M)           | V1.0 or higher                 |
| PROFenergy                                          | V1.0 or higher                 |
| IO-Link port configuration with S7-PCT (as of V3.2) | V1.0 or higher                 |
| IO-Link port configuration without S7-PCT           | V1.1 or higher                 |
| Master backup with "IO_LINK_MASTER" function block  | V1.1 or higher                 |
| Port Qualifier Information (PQI)                    | V1.1 or higher                 |
| Support of I/O data per module > 32 bytes           | V1.2 or higher                 |

## Accessories

The following components are included in the module package:

- Identification labels
- Spacers



## Other components

The following component can be ordered as spare part:

- Identification labels

The following components can be ordered as accessories:

- Connectors
- Cables
- Stripping Tool for ET-Connection
- M8 sealing cap
- M12 sealing cap

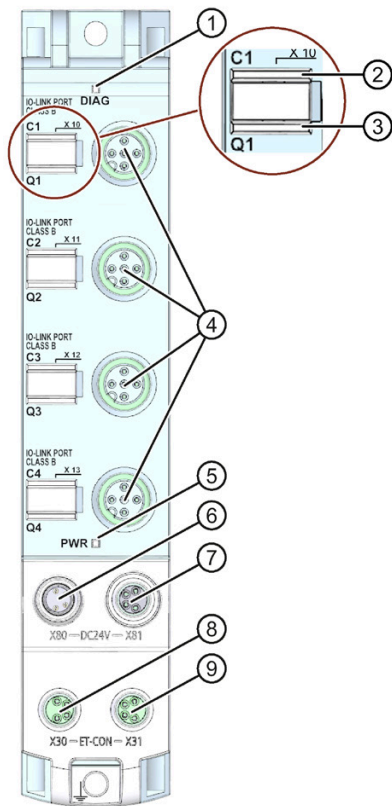
## See also

You can find more information on accessories in the Accessories/spare parts section of the ET 200AL distributed I/O system

(<http://support.automation.siemens.com/WW/view/en/89254965>) system manual.

## 2.2 Operator controls and display elements

The following figure shows the operator controls and display elements of the CM 4xIO-Link 4xM12 communication module.



- ① DIAG: LED display for mode and diagnostic status
- ② C1 to C4: LED displays for port status
- ③ Q1 to Q4: LED displays for channel status in SIO mode
- ④ X10 to X13: Sockets for device connection
- ⑤ PWR: LED display for the load voltage 2L+
- ⑥ X80: Connector for infeed of the supply voltage (POWER input)
- ⑦ X81: Socket for loop-through of the supply voltage (POWER output)
- ⑧ X30: Socket for ET-Connection IN
- ⑨ X31: Socket for ET-Connection OUT

Figure 2-2 Operator controls and display elements

## 2.3 Functions

IO-Link is a point-to-point connection between an IO-Link master and an IO-Link device. On the IO-Link master, you can use IO-Link devices as well as conventional sensors/actuators with unshielded standard cables using proven 3-wire technology. IO-Link is backward compatible to conventional digital sensors or actuators. Switching status channel and data channel are in proven 24 V DC technology.

### Reference

For more information on the IO-Link system, please see the IO-Link system (<http://support.automation.siemens.com/WW/view/en/65949252>) function manual.

## 2.4 Reset communication module to factory settings

### Effects of resetting to the factory settings

Use the "Reset to factory settings" function to restore the parameter assignments of your CM 4xIO-Link 4xM12 communication module made with S7-PCT to the factory state.

After a "Reset to factory settings", the parameters of the CM 4xIO-Link 4xM12 communication module are assigned as follows:

- The ports are in DI mode
- The ports are mapped to the relative addresses 0.0 ... 0.3
- The PortQualifier is disabled
- The I&M data 1 ... 3 are deleted

---

### Note

The device parameters are deleted and the factory state is restored.

You should reset a removed CM 4xIO-Link 4xM12 communication module to the factory settings before you place it in storage.

---

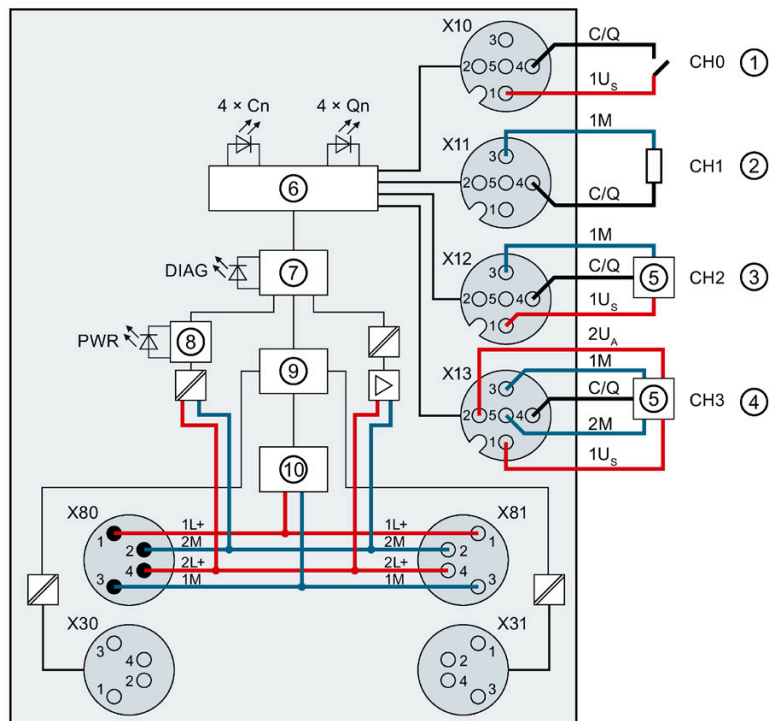
### Procedure

To perform a "Reset to factory settings", proceed as described in the S7-PCT online help.

# Wiring

## 3.1 Terminal and block diagram

The following figure shows an example of the pin assignment for Port Class A (Type A) and Port Class B (Type b).



|            |                                 |      |                                   |
|------------|---------------------------------|------|-----------------------------------|
| ①          | SIO input                       | X31  | Loop-through of the ET-Connection |
| ②          | SIO output                      | 1L+  | Supply voltage 1L+ (non-switched) |
| ③          | Port Class A (Type A)           | 1M   | Ground 1M (non-switched)          |
| ④          | Port Class B (Type B)           | 2L+  | Load voltage 2L+ (switched)       |
| ⑤          | IO-Link device                  | 2M   | Ground 2M (switched)              |
| ⑥          | IO-Link switching               | 1Us  | 24 V encoder supply               |
| ⑦          | Microcontroller                 | 2Us  | 24 V actuator supply              |
| ⑧          | Monitoring                      | 1M   | Ground for encoder supply         |
| ⑨          | ET-Connection interface         | 2M   | Ground for actuator supply        |
| ⑩          | Internal supply voltage         | C/Q  | Port n                            |
| X10 to X13 | Channels 0 to 3                 | Cn   | LEDs channel status (green)       |
| X80        | Infeed of supply voltages       | Qn   | LED status in SIO mode (green)    |
| X81        | Loop-through of supply voltages | DIAG | LED diagnostic status (red/green) |
| X30        | Infeed of the ET-Connection     | PWR  | LED supply voltage 2L+ (green)    |

Figure 3-1 Terminal and block diagram

## 3.2 Pin assignment

### Note

Color coding

The sockets for ET-Connection and the power supply of the modules are color-coded. These colors correspond to the colors of the offered cables.

### Pin assignment of the IO-Link sockets

### Note

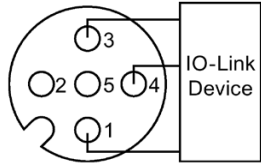
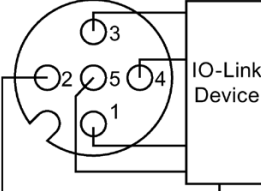
#### Port Class B

The pin assignment of the IO-Link interface corresponds to the IO-Link specification as per Port Class B. Port Class B is specially suited for the connection of actuators with additional supply (e.g. valve terminals).

To connect devices with Port Class A (e.g. sensors) to the communication module CM 4xIO-Link 4xM12, a 3-wire connection cable should be used (Port Class A compatibility).

The table below shows the pin assignments of the 4 sockets for the connection of IO-Link.

Table 3- 1 Pin assignment of the IO-Link

| Pin                                                                                                  | Assignment                                                                                                               | Front view of the sockets                                                                                                                                                                                                              |
|------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|                                                                                                      | X10 to X13 - sockets for IO-Link                                                                                         |                                                                                                                                                                                                                                        |
| 1                                                                                                    | 24 V encoder supply 1Us (from 1L+)                                                                                       | <p>Port Class A (Type A)*</p>  <p>Port Class B (Type B)</p>  |
| 2                                                                                                    | 24 V actuator supply 2U <sub>A</sub> (from 2L+)                                                                          |                                                                                                                                                                                                                                        |
| 3                                                                                                    | Encoder supply ground 1M                                                                                                 |                                                                                                                                                                                                                                        |
| 4                                                                                                    | Port 1 (C/Q): Connector X10<br>Port 2 (C/Q): Connector X11<br>Port 3 (C/Q): Connector X12<br>Port 4 (C/Q): Connector X13 |                                                                                                                                                                                                                                        |
| 5                                                                                                    | Ground for actuator supply 2M                                                                                            |                                                                                                                                                                                                                                        |
| * If you use the sockets for IO-Link as Port Class A, you may not place any signals on pins 2 and 5. |                                                                                                                          |                                                                                                                                                                                                                                        |

The M12 connectors are designed according to IO-Link specification as port type Class B. Pins 2 and 5 contain an additional power supply.

Reaction-free connection of devices with different port types (Class A and Class B) is possible using a 3-wire connecting cable (assignment of pins 1, 3 and 4).

#### NOTICE

#### 24 V encoder supply 1Us

For the supply of devices, only use the 24 V 1Us encoder supply provided by the communication device.

### Pin assignment of the sockets for ET-Connection

The table below shows the pin assignments of the 2 sockets for the connection of ET-Connection.

Table 3- 2 Pin assignment for ET-Connection

| Pin    | Assignment                    |                                | Assignment of the wire color of the bus line cable for ET-Connection | Front view of the sockets |     |
|--------|-------------------------------|--------------------------------|----------------------------------------------------------------------|---------------------------|-----|
|        | X30 socket (ET-Connection IN) | X31 socket (ET-Connection OUT) |                                                                      | X30                       | X31 |
| 1      | TXP                           | RXP                            | Yellow                                                               |                           |     |
| 2      | RXP                           | TXP                            | White                                                                |                           |     |
| 3      | RXN                           | TXN                            | Blue                                                                 |                           |     |
| 4      | TXN                           | RXN                            | Orange                                                               |                           |     |
| Shield | Functional earth FE           |                                | -                                                                    |                           |     |

### Pin assignment of the connector for infeed of the supply voltage

The table below shows the pin assignment of the connector for infeed of the supply voltage.

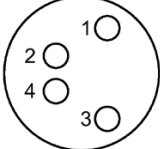
Table 3- 3 Pin assignment of the supply voltage connector

| Pin | Assignment                        | Assignment of the wire color of the power line cable | Front view of the connector |
|-----|-----------------------------------|------------------------------------------------------|-----------------------------|
|     | X80 connector (POWER input)       |                                                      |                             |
| 1   | Supply voltage 1L+ (non-switched) | Brown                                                |                             |
| 2   | Ground 2M (switched)              | White                                                |                             |
| 3   | Ground 1M (non-switched)          | Blue                                                 |                             |
| 4   | Load voltage 2L+ (switched)       | Black                                                |                             |

### Pin assignment of the socket for loop-through of the supply voltage

The table below shows the pin assignment of the socket for loop-through of the supply voltage.

Table 3- 4 Pin assignment of the supply voltage socket

| Pin | Assignment                        | Assignment of the wire color of the power line cable | Front view of the socket                                                            |
|-----|-----------------------------------|------------------------------------------------------|-------------------------------------------------------------------------------------|
|     | X81 socket (POWER output)         |                                                      |                                                                                     |
| 1   | Supply voltage 1L+ (non-switched) | Brown                                                |  |
| 2   | Ground 2M (switched)              | White                                                |                                                                                     |
| 3   | Ground 1M (non-switched)          | Blue                                                 |                                                                                     |
| 4   | Load voltage 2L+ (switched)       | Black                                                |                                                                                     |

#### NOTICE

##### ET-Connection/supply voltage

Observe the correct wiring of the M8 sockets for ET-Connection and the supply voltage.

Mixing up the connector for ET-Connection and the connector for the supply voltage can destroy the module.

## Parameters/address space

### 4.1 Parameters

#### Parameters

The following table shows the general parameters for the communication module CM 4xIO-Link 4xM12.

Table 4- 1 General parameters

| Parameters                         | Range of values                                                               | Default | Scope   |
|------------------------------------|-------------------------------------------------------------------------------|---------|---------|
| <b>Diagnostics</b>                 |                                                                               |         |         |
| Diagnostics: No supply voltage 2L+ | <ul style="list-style-type: none"> <li>• Disable</li> <li>• Enable</li> </ul> | Disable | Module  |
| Diagnostics port 1                 | <ul style="list-style-type: none"> <li>• Disable</li> <li>• Enable</li> </ul> | Disable | Channel |
| Diagnostics port 2                 | <ul style="list-style-type: none"> <li>• Disable</li> <li>• Enable</li> </ul> | Disable | Channel |
| Diagnostics port 3                 | <ul style="list-style-type: none"> <li>• Disable</li> <li>• Enable</li> </ul> | Disable | Channel |
| Diagnostics port 4                 | <ul style="list-style-type: none"> <li>• Disable</li> <li>• Enable</li> </ul> | Disable | Channel |
| <b>Configuration</b>               |                                                                               |         |         |
| Input / output type                | See table in section Explanation of the parameters (Page 23)                  | 32I/32O | Module  |
| Port configuration without S7-PCT  | <ul style="list-style-type: none"> <li>• Disable</li> <li>• Enable</li> </ul> | Disable | Module  |
| Port Qualifier Information (PQI)   | <ul style="list-style-type: none"> <li>• Disable</li> <li>• Enable</li> </ul> | Enable  | Module  |



## 4.1 Parameters

The following table shows the port parameters for the communication module CM 4xIO-Link 4xM12 with firmware version V1.1.

Table 4- 2 Port parameters

| Parameters                         | Range of values                                                                                                                                                                                                                                               | Default                                      |
|------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------|
| <b>Port configuration</b>          |                                                                                                                                                                                                                                                               |                                              |
| Operating mode                     | <ul style="list-style-type: none"> <li>IO-Link autostart</li> <li>IO-Link manual</li> <li>DI</li> <li>DQ</li> <li>Disabled</li> </ul>                                                                                                                         | IO-Link autostart                            |
| Length of input data (without PQI) | Depending on the total length of the module*                                                                                                                                                                                                                  | Depending on the total length of the module* |
| Length of output data              | Depending on the total length of the module*                                                                                                                                                                                                                  | Depending on the total length of the module* |
| Vendor ID**                        | Vendor ID of the connected IO-Link device                                                                                                                                                                                                                     | 0                                            |
| Device ID**                        | Device ID of the connected IO-Link device                                                                                                                                                                                                                     | 0                                            |
| Testing accuracy / data storage**  | <ul style="list-style-type: none"> <li>Same type (V1.0) without Backup&amp;Restore</li> <li>Type compatible (V1.1) without Backup&amp;Restore</li> <li>Type compatible (V1.1) with Backup&amp;Restore</li> <li>Type compatible (V1.1) with Restore</li> </ul> | Type compatible (V1.1) with Backup&Restore   |

\* Make sure that you do not exceed the maximum possible length of the input or output data for all ports that you selected.

Example:

You selected the 64I/64O configuration. You have assigned 16 bytes of input data to the first port. You can still assign a total of 48 bytes of input data for the remaining three ports.

\*\* Only in effect when "IO-Link manual" port mode is used.

## 4.2 Explanation of the parameters

### Diagnostics: No supply voltage 2L+

Enabling of the diagnostics for no or insufficient supply voltage 2L+.

### Diagnostics port

This parameter enables the diagnostics for the selected port.

The diagnostics possible depends on the IO-Link device in use. Additional information about the diagnostic interrupts can be found in the description of the utilized IO-Link device.

### Input / output type

This parameter sets the maximum length of the input and output data of the module.

### Port configuration without S7-PCT

This parameter releases the port configuration without S7-PCT for the module.

### Port Qualifier Information

This parameter releases the Port Qualifier Information (PQI).

The PQI provides information on the device status of the port and IO-Link.

## Operating mode

This parameter determines the mode in which the selected port should be operated. You can select from the following options:

- IO-Link autostart
- IO-Link manual
- DI
- DQ
- Disabled

### IO-Link autostart

The connected IO-Link device starts automatically (Plug&Play functionality). The IO-Link device is immediately ready for operation.

### IO-Link manual

The connected IO-Link device is **not** started automatically.

You must store the Vendor ID and Device ID of the connected IO-Link device in STEP 7. In addition, you can select the inspection severity for data storage:

- Identical type (V1.0) without Backup&Restore
- Type-compatible (V1.1) without Backup&Restore
- Type-compatible (V1.1) with Backup&Restore
- Type-compatible (V1.1) with Restore

You can find the Vendor ID and Device ID on the Internet

(<https://support.industry.siemens.com/cs/ww/en/view/109748852>).

### DI

The port is operating as a standard digital input.

### DQ

The port is operating as a standard digital output.

### Disabled

The port is disabled.

## Configuration options of the communication module CM 4xIO-Link 4xM12

The CM 4xIO-Link 4xM12 communication module supports a variable address space for I/O data.

The following table provides an overview of the configuration options for the supported address spaces for I/O data:

Table 4- 3 Configuration options of the communication module CM 4xIO-Link 4xM12

| Module configuration/<br>supporting address space for I/O<br>data | IO-Link Master<br>with Firmware<br>V1.0 | IO-Link Master<br>with Firmware<br>V1.1 | IO-Link master<br>with firmware<br>V1.2 |
|-------------------------------------------------------------------|-----------------------------------------|-----------------------------------------|-----------------------------------------|
| 1-byte input/1-byte output                                        | X                                       |                                         |                                         |
| 2-byte inputs/2-byte outputs                                      | X                                       |                                         |                                         |
| 4-byte inputs/4-byte outputs                                      | X                                       | X*                                      | X*                                      |
| 8-byte inputs/0-byte outputs                                      |                                         | X                                       | X                                       |
| 8-byte inputs/8-byte outputs                                      | X                                       | X                                       | X                                       |
| 12-byte inputs/8-byte outputs                                     |                                         | X                                       | X                                       |
| 16-byte inputs/16-byte outputs                                    | X                                       | X                                       | X                                       |
| 20-byte inputs/16-byte outputs                                    |                                         | X                                       | X                                       |
| 32-byte inputs/32-byte outputs                                    | X                                       | X                                       | X                                       |
| 36-byte inputs/32-byte outputs                                    |                                         |                                         | X                                       |
| 48-byte inputs/48-byte outputs                                    |                                         |                                         | X                                       |
| 52-byte inputs/48-byte outputs                                    |                                         |                                         | X                                       |
| 64-byte inputs/64-byte outputs                                    |                                         |                                         | X                                       |
| 68-byte inputs/64-byte outputs                                    |                                         |                                         | X                                       |
| 80-byte inputs/80-byte outputs                                    |                                         |                                         | X                                       |
| 84-byte inputs/80-byte outputs                                    |                                         |                                         | X                                       |
| 96-byte inputs/96-byte outputs                                    |                                         |                                         | X                                       |
| 100-byte inputs/96-byte outputs                                   |                                         |                                         | X                                       |
| 112-byte inputs/112-byte outputs                                  |                                         |                                         | X                                       |
| 116-byte inputs/112-byte outputs                                  |                                         |                                         | X                                       |
| 128-byte inputs/128-byte outputs                                  |                                         |                                         | X                                       |
| 132-byte inputs/128-byte outputs                                  |                                         |                                         | X                                       |

\* No PortQualifierInformation is transferred with this configuration.

## Port configuration

You can use a CM 4xIO-Link 4xM12 communication module as of firmware version V1.1 to commission the IO-Link ports of the IO-Link master or the connected IO-Link devices in two different ways:

- Port configuration without S7-PCT
- Port configuration with S7-PCT

## Port configuration without S7-PCT

### Requirement

You have enabled the check box "Port configuration without S7-PCT" for the configuration of the IO-Link master in STEP 7.

### Procedure

You configure the IO-Link master directly in STEP 7:

- Enabling of the diagnostics
- Configuration of the I/O data lengths per port
- Enabling of the Port Qualifier Information (PQI)
- Port mode:
  - Operation in "IO-Link autostart" mode (default)
  - Operation in "IO-Link manual" mode
  - Operated as DI
  - Operated as DQ
  - Disabled

## Port configuration with S7-PCT

### Requirement

You deselected the "Port configuration without S7-PCT" check box in the configuration of the IO-Link master in STEP 7.

### Procedure

You configure the port configuration of the IO-Link master using the port configuration tool S7-PCT as of V3.2.

## Port Qualifier Information (PQI)

You can enable the Port Qualifier Information (PQI) for your IO-Link master as of firmware version V1.1.

---

### Note

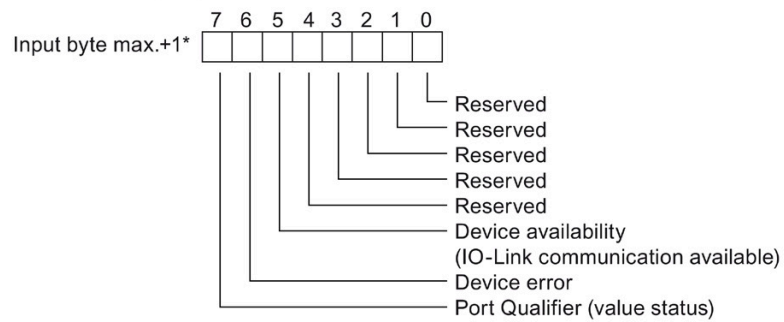
#### Port Qualifier Information (PQI)

If you have enabled the Port Qualifier Information (PQI), this information is always sent with the size of 1 byte together with the input data of the IO-Link device.

---

The following figure show the structure of the PQI byte.  
You enable a parameter by setting the corresponding bit to "1".

## Port Qualifier Information (PQI)



\* The PQI byte is always located after the last input byte of the port.

Figure 4-1 Structure of the PQI byte

## Reference

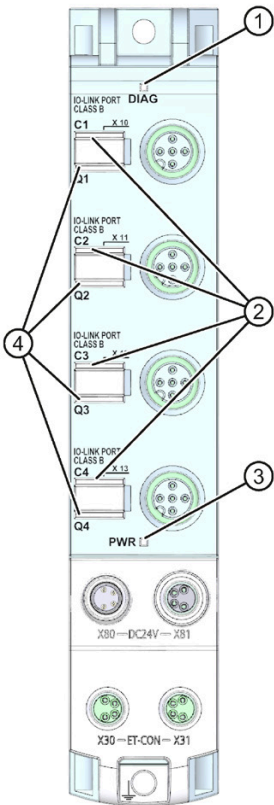
For more information, please refer to the IO-Link system  
(<http://support.automation.siemens.com/WW/view/en/65949252>) function manual.

## Diagnostics alarms

### 5.1 Status and error displays

#### LED displays

The following figure shows the LED display of the CM 4xIO-Link 4xM12 communication module.



- |   |                                   |             |
|---|-----------------------------------|-------------|
| ① | Diagnostics (DIAG)                | (green/red) |
| ② | Port status / IO-Link status (Cn) | (green)     |
| ③ | Load voltage 2L+ (PWR)            | (green)     |
| ④ | Channel status in SIO mode (Qn)   | (green)     |

Figure 5-1 LED displays

#### Meaning of the LEDs

The following tables set out the meaning of the status and error displays. Corrective measures for diagnostics alarms can be found in the section Diagnostics alarms (Page 32).

## DIAG LED

Table 5- 1 Error display of the DIAG LED

| DIAG LED                                                                                     | Meaning                                                                                                                                                                                                                                                                                                     |
|----------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <br>Off     | No supply voltage 1L+                                                                                                                                                                                                                                                                                       |
| <br>Flashes | <ul style="list-style-type: none"> <li>Module parameters not assigned (after switching on the supply voltage 1L+)</li> <li>Loading firmware (while the firmware update is being performed, all LEDs retain their current status)</li> <li>No connection to the ET-Connection and/or the fieldbus</li> </ul> |
| <br>On      | Module parameters assigned and no module diagnostics                                                                                                                                                                                                                                                        |
| <br>Flashes | Module parameters assigned and module diagnostics                                                                                                                                                                                                                                                           |

## LEDs Cn

Valid for IO-Link port in IO-Link mode.

Table 5- 2 Status displays of the C1, C2, C3, and C4 LEDs

| C1, C2, C3, or C4 LED                                                                          | Meaning                                                                                     |
|------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------|
| <br>Off     | Port disabled or in SIO mode                                                                |
| <br>Flashes | Port in IO-Link mode, device not connected or port not connected with the configured device |
| <br>On      | Port in IO-Link mode, device not connected                                                  |

## PWR LED

Table 5- 3 Status display of the PWR LED

| PWR LED                                                                                    | Meaning                                |
|--------------------------------------------------------------------------------------------|----------------------------------------|
| <br>Off | Load voltage 2L+ is missing or too low |
| <br>On  | Load voltage 2L+ present               |



## LEDs Qn

Valid for IO-Link port in SIO mode.

Table 5- 4 Status displays of the Q1, Q2, Q3, and Q4 LEDs

| Q1, Q2, Q3, and Q4 LEDs                                                                  | Meaning                                                        |
|------------------------------------------------------------------------------------------|----------------------------------------------------------------|
| <br>Off | Process signal = 0 in SIO mode, deactivated or in IO-Link mode |
| <br>On  | Process signal = 1 in SIO mode                                 |

## 5.2 Diagnostics alarms

For each diagnostic event, a diagnostics alarm is issued and the DIAG LED flashes red on the communication module. You can read out the diagnostics alarms, for example, in the diagnostics buffer of the CPU. You can evaluate the error codes with the user program.

Table 5- 5 Error types

| Diagnostics alarm          | Error code      | Meaning (IO-Link error code)                                                                                                                                                                                                                                                                                                                                                                                                                                         | IO-Link master | IO-Link device |
|----------------------------|-----------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------|----------------|
| Short-circuit              | 1 <sub>H</sub>  | • Short-circuit at the process cables on the IO-Link device (1804 <sub>H</sub> )                                                                                                                                                                                                                                                                                                                                                                                     | X              |                |
|                            |                 | • Short-circuit on IO device (7710 <sub>H</sub> )                                                                                                                                                                                                                                                                                                                                                                                                                    |                | X              |
| Undervoltage               | 2 <sub>H</sub>  | • Supply voltage too low (5111 <sub>H</sub> , 5112 <sub>H</sub> )                                                                                                                                                                                                                                                                                                                                                                                                    |                | X              |
| Overvoltage                | 3 <sub>H</sub>  | • Supply voltage too high (5110 <sub>H</sub> )                                                                                                                                                                                                                                                                                                                                                                                                                       |                | X              |
| Overtemperature            | 5 <sub>H</sub>  | • Temperature exceeded on master (1805 <sub>H</sub> )                                                                                                                                                                                                                                                                                                                                                                                                                | X              |                |
|                            |                 | • Temperature exceeded on device (4000 <sub>H</sub> , 4210 <sub>H</sub> )                                                                                                                                                                                                                                                                                                                                                                                            |                | X              |
| Wire break                 | 6 <sub>H</sub>  | • No IO-Link device connected<br>• There is a break on the signal line to the IO-Link device<br>• IO-Link device cannot communicate due to a different error (1800 <sub>H</sub> )                                                                                                                                                                                                                                                                                    | X              |                |
| Overflow                   | 7 <sub>H</sub>  | • Process tag range exceeded (8C10 <sub>H</sub> )<br>• Measuring range exceeded (8C20 <sub>H</sub> )                                                                                                                                                                                                                                                                                                                                                                 |                | X              |
| Underflow                  | 8 <sub>H</sub>  | • Process tag range too low (8C30 <sub>H</sub> )                                                                                                                                                                                                                                                                                                                                                                                                                     |                | X              |
| Error                      | 9 <sub>H</sub>  | • All IO-Link error codes which are not listed here are mapped to this PROFIBUS DP error                                                                                                                                                                                                                                                                                                                                                                             |                | X              |
| Parameter assignment error | 10 <sub>H</sub> | • Incorrect device (1802 <sub>H</sub> )<br>• Vendor ID and Device ID not defined (1817 <sub>H</sub> )<br>• Process data length of the IO-Link device exceeded (1818 <sub>H</sub> )<br>• No cycle time configured (1819 <sub>H</sub> )<br>• IO-Link master could not be configured (1882 <sub>H</sub> , 1883 <sub>H</sub> )<br>• Memory error (1886 <sub>H</sub> )<br>• Process data length exceeded (1887 <sub>H</sub> )<br>• PQI not supported (1889 <sub>H</sub> ) | X              |                |
|                            |                 | • Device was not configured correctly (6320 <sub>H</sub> , 6321 <sub>H</sub> , 6350 <sub>H</sub> )                                                                                                                                                                                                                                                                                                                                                                   |                | X              |
| Supply voltage missing     | 11 <sub>H</sub> | • 24 V encoder supply 1Us (of 1L+) for device missing (1806 <sub>H</sub> )<br>• 24 V encoder supply 1Us (of 1L+) for device too low (<20 V) (1807 <sub>H</sub> )<br>• Load voltage 2L+ (switched) missing (1888 <sub>H</sub> )<br>• 24 V actuator supply 2 UA (of 2L+) for device missing (180E <sub>H</sub> )                                                                                                                                                       | X              |                |
| Defective fuse             | 12 <sub>H</sub> | • Fuse on device is defective (5101 <sub>H</sub> )                                                                                                                                                                                                                                                                                                                                                                                                                   |                | X              |

| Diagnostics alarm | Error code      | Meaning (IO-Link error code)                                                                                                                                                                                                                                                                                                                                                                                | IO-Link master | IO-Link device |
|-------------------|-----------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------|----------------|
| Safety shutdown   | 19 <sub>H</sub> | <ul style="list-style-type: none"> <li>Serious error (master has to be replaced) (1880<sub>H</sub>)</li> </ul>                                                                                                                                                                                                                                                                                              | X              |                |
| External fault    | 1A <sub>H</sub> | <ul style="list-style-type: none"> <li>Error during data backup (1809<sub>H</sub>, 180A<sub>H</sub>, 180B<sub>H</sub>, 180C<sub>H</sub>, 180D<sub>H</sub>)</li> <li>More than six errors are pending simultaneously on the IO-Link device (1808<sub>H</sub>)</li> <li>Consistency error in electronic coding element (1885<sub>H</sub>)</li> <li>Process data length exceeded (1887<sub>H</sub>)</li> </ul> | X              |                |

## Technical specifications

### Technical specifications of the CM 4xIO-Link 4xM12 communication module

The following table shows the technical specifications as of 03/2021. You can find a data sheet including daily updated technical specifications on the Internet (<https://support.industry.siemens.com/cs/ww/en/pv/6ES7147-5JD00-0BA0/td?dl=en>).

|                                                          |                                           |
|----------------------------------------------------------|-------------------------------------------|
| <b>Article number</b>                                    | <b>6ES7147-5JD00-0BA0</b>                 |
| <b>General information</b>                               |                                           |
| Product type designation                                 | CM 4x IO-Link                             |
| HW functional status                                     | FS05                                      |
| Firmware version                                         | V1.2.x                                    |
| <b>Product function</b>                                  |                                           |
| • I&M data                                               | Yes; I&M0 to I&M3                         |
| <b>Engineering with</b>                                  |                                           |
| • STEP 7 TIA Portal configurable/integrated from version | STEP 7 V13 SP1 or higher                  |
| • STEP 7 configurable/integrated from version            | From V5.5 SP4 Hotfix 3                    |
| • PROFIBUS from GSD version/GSD revision                 | GSD as of Revision 5                      |
| • PROFINET from GSD version/GSD revision                 | GSDML V2.3.1                              |
| <b>Supply voltage</b>                                    |                                           |
| <b>Load voltage 1L+</b>                                  |                                           |
| • Rated value (DC)                                       | 24 V                                      |
| • permissible range, lower limit (DC)                    | 20.4 V                                    |
| • permissible range, upper limit (DC)                    | 28.8 V                                    |
| • Reverse polarity protection                            | Yes                                       |
| <b>Load voltage 2L+</b>                                  |                                           |
| • Rated value (DC)                                       | 24 V                                      |
| • permissible range, lower limit (DC)                    | 20.4 V                                    |
| • permissible range, upper limit (DC)                    | 28.8 V                                    |
| • Reverse polarity protection                            | Yes; against destruction; load increasing |
| <b>Input current</b>                                     |                                           |
| Current consumption (rated value)                        | 40 mA; without load                       |
| from load voltage 1L+ (unswitched voltage)               | 4 A; Maximum value                        |
| from load voltage 2L+, max.                              | 4 A; Maximum value                        |
| <b>Encoder supply</b>                                    |                                           |
| Number of outputs                                        | 4                                         |

|                                                                                                          |                                                                  |
|----------------------------------------------------------------------------------------------------------|------------------------------------------------------------------|
| <b>Article number</b>                                                                                    | <b>6ES7147-5JD00-0BA0</b>                                        |
| <b>24 V encoder supply</b>                                                                               |                                                                  |
| <ul style="list-style-type: none"> <li>Short-circuit protection</li> <li>Output current, max.</li> </ul> | Yes; per module, electronic<br>1.4 A; Total current of all ports |
| <b>Power loss</b>                                                                                        |                                                                  |
| Power loss, typ.                                                                                         | 2.6 W                                                            |
| <b>IO-Link</b>                                                                                           |                                                                  |
| Number of ports                                                                                          | 4                                                                |
| <ul style="list-style-type: none"> <li>of which simultaneously controllable</li> </ul>                   | 4                                                                |
| IO-Link protocol 1.0                                                                                     | Yes                                                              |
| IO-Link protocol 1.1                                                                                     | Yes                                                              |
| Transmission rate                                                                                        | 4.8 kBaud (COM1); 38.4 kBaud (COM2), 230 kBaud (COM3)            |
| Size of process data, input per port                                                                     | 32 byte                                                          |
| Size of process data, input per module                                                                   | 132 byte                                                         |
| Size of process data, output per port                                                                    | 32 byte                                                          |
| Size of process data, output per module                                                                  | 128 byte                                                         |
| Memory size for device parameter                                                                         | 2 kbyte; for each port                                           |
| Master backup                                                                                            | Possible with function block IO_LINK_MASTER                      |
| Configuration without S7-PCT                                                                             | Possible; autostart/manual function                              |
| Cable length unshielded, max.                                                                            | 20 m                                                             |
| <b>Operating modes</b>                                                                                   |                                                                  |
| <ul style="list-style-type: none"> <li>IO-Link</li> </ul>                                                | Yes                                                              |
| <ul style="list-style-type: none"> <li>DI</li> </ul>                                                     | Yes                                                              |
| <ul style="list-style-type: none"> <li>DQ</li> </ul>                                                     | Yes; max. 100 mA                                                 |
| <b>Connection of IO-Link devices</b>                                                                     |                                                                  |
| <ul style="list-style-type: none"> <li>Port type A</li> </ul>                                            | Yes; via 3-core cable                                            |
| <ul style="list-style-type: none"> <li>Port type B</li> </ul>                                            | Yes; Additional device supply: 1.6 A total current of all ports  |
| <b>Interrupts/diagnostics/status information</b>                                                         |                                                                  |
| <b>Alarms</b>                                                                                            |                                                                  |
| <ul style="list-style-type: none"> <li>Diagnostic alarm</li> </ul>                                       | Yes; Parameterizable                                             |
| <b>Diagnoses</b>                                                                                         |                                                                  |
| <ul style="list-style-type: none"> <li>Monitoring the supply voltage</li> </ul>                          | Yes                                                              |
| <ul style="list-style-type: none"> <li>Wire-break</li> </ul>                                             | Yes                                                              |
| <ul style="list-style-type: none"> <li>Short-circuit</li> </ul>                                          | Yes                                                              |
| <b>Diagnostics indication LED</b>                                                                        |                                                                  |
| <ul style="list-style-type: none"> <li>Channel status display</li> </ul>                                 | Yes; green LED                                                   |
| <ul style="list-style-type: none"> <li>for module diagnostics</li> </ul>                                 | Yes; green/red LED                                               |
| <ul style="list-style-type: none"> <li>For load voltage monitoring</li> </ul>                            | Yes; green LED                                                   |
| <b>Potential separation</b>                                                                              |                                                                  |
| between the load voltages                                                                                | Yes                                                              |
| <b>Potential separation channels</b>                                                                     |                                                                  |

|                                                                                                                |                           |
|----------------------------------------------------------------------------------------------------------------|---------------------------|
| <b>Article number</b>                                                                                          | <b>6ES7147-5JD00-0BA0</b> |
| <ul style="list-style-type: none"> <li>between the channels</li> </ul>                                         | No                        |
| <ul style="list-style-type: none"> <li>between the channels and backplane bus</li> </ul>                       | Yes                       |
| <ul style="list-style-type: none"> <li>between the channels and the power supply of the electronics</li> </ul> | No                        |
| <b>Isolation</b>                                                                                               |                           |
| Isolation tested with                                                                                          | 707 V DC (type test)      |
| <b>Standards, approvals, certificates</b>                                                                      |                           |
| Suitable for safety-related tripping of standard modules                                                       | Yes; From FS01            |
| <b>Highest safety class achievable for safety-related tripping of standard modules</b>                         |                           |
| <ul style="list-style-type: none"> <li>Performance level according to ISO 13849-1</li> </ul>                   | PL d                      |
| <ul style="list-style-type: none"> <li>Category according to ISO 13849-1</li> </ul>                            | Cat. 3                    |
| <ul style="list-style-type: none"> <li>SILCL according to IEC 62061</li> </ul>                                 | SILCL 2                   |
| <b>Ambient conditions</b>                                                                                      |                           |
| <b>Ambient temperature during operation</b>                                                                    |                           |
| <ul style="list-style-type: none"> <li>min.</li> </ul>                                                         | -30 °C                    |
| <ul style="list-style-type: none"> <li>max.</li> </ul>                                                         | 55 °C                     |
| <b>Connection method</b>                                                                                       |                           |
| Design of electrical connection for the inputs and outputs                                                     | M12, 5-pole               |
| Design of electrical connection for supply voltage                                                             | M8, 4-pole                |
| <b>ET-Connection</b>                                                                                           |                           |
| <ul style="list-style-type: none"> <li>ET-Connection</li> </ul>                                                | M8, 4-pin, shielded       |
| <b>Dimensions</b>                                                                                              |                           |
| Width                                                                                                          | 30 mm                     |
| Height                                                                                                         | 159 mm                    |
| Depth                                                                                                          | 40 mm                     |
| <b>Weights</b>                                                                                                 |                           |
| Weight, approx.                                                                                                | 145 g                     |

# Replacing modules

## What do you need to know when replacing modules?

When you replace the communication module CM 4xIO-Link 4xM12, you must transfer the IO-Link parameter settings (master/device) again. You can transfer the IO-Link configuration using S7-PCT or save it with the Master Backup function.

## Master Backup

The "IO\_LINK\_MASTER" function block is used to read all relevant IO-Link device and IO-Link master parameters. These can be stored retentively at a central location, such as in a data block in the IO controller.

The status of the IO-Link devices or IO-Link ports stored in the IO-Link master can be restored with the "IO\_LINK\_MASTER" function block.

As a result, the IO-Link ports and the IO-Link master are configured with the values stored in the master backup.

A typical application is the restoration of parameters after replacement of the IO-Link master.

---

### Note

#### Availability

Note that the Master Backup function is available only for IO-Link devices that are specified for the IO-Link Standard as of V1.1.

---

You will find information on the Master Backup and Master Restore functions in section "Master backup" of chapter "Integration into the automation system" of the IO-Link System (<https://support.industry.siemens.com/cs/ww/en/view/65949252>) function manual.

## Reference

You will find additional information on replacing modules in the system manual ET 200AL distributed I/O system (<http://support.automation.siemens.com/WW/view/en/89254965>) in the "Module" section.

You will find additional information on replacing IO-Link masters in the S7-PCT online help.

# PROFlenergy

## 8.1 Pause function

### Introduction

PROFlenergy is a PROFINET-based data interface for switching off consumers centrally and in a coordinated manner during pause times regardless of the manufacturer or device type. This has the aim that the process is only provided with the energy that is absolutely required. In so doing, the majority of the energy savings come from the process itself; the PROFINET device contributes only a few watts to the possible savings. In PROFlenergy, this operating state is referred to as a "pause".

### Start and end of a pause

You enable and disable the pause function of the system at the beginning and end of pauses, respectively; the IO controller then sends the PROFlenergy command "Start\_Pause" or "End\_Pause" to the modules.

Use the "Start\_Pause" command to start a pause.

Use the "End\_Pause" command to end a pause.

The following conditions will also cause a pause to be ended:

- Reconfiguration in RUN
- Controller failure
- Firmware update
- Station stop
- Restart of the interface module through:
  - POWER OFF/POWER ON of an interface module
  - POWER OFF/POWER ON of an I/O module
  - Termination of ET-Connection1 or ET-Connection2

The specific behavior of the communication module is explained in the following sections.

### Additional information

You can find additional information on working with PROFlenergy in the "PROFlenergy" section of the manual IM 157-1 PN interface module (<http://support.automation.siemens.com/WW/view/en/89254863>) and the "Saving energy with PROFlenergy" section of function manual PROFINET with STEP 7 V13 (<http://support.automation.siemens.com/WW/view/en/49948856>).

Application examples (<http://support.automation.siemens.com/WW/view/en/41986454>) are also available on the Internet.



## 8.2 DI operating mode

### Display

If no external supply voltage is connected, switching off supply voltages 1U<sub>s</sub> and 2U<sub>A</sub> also leads to switching off the associated channel status LED Q<sub>n</sub>.

### Response to error detection

All channels that are in pause mode on "PE\_MODE\_PROCEED" report their diagnostic status as in productive mode.

The following applies for all channels which switch to a different pause mode:

- During the "pause", error detection of "Load voltage 2L+" is not possible:
  - Alarms for errors already pending before the "pause" are retained.
  - After the "pause" is over, the error status is updated and incoming/outgoing errors are reported correspondingly.

### Mode parameter

The following table shows the "Mode" parameter.

Table 8- 1 Mode parameter

| Element | Code                                 | Explanation                                                                                                                                                                                                                              |
|---------|--------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Mode    | 0 <sub>D</sub> : PE_MODE_PROCEED     | Proceed at "pause" <ul style="list-style-type: none"> <li>• Value status "GOOD"</li> </ul>                                                                                                                                               |
|         | 1 <sub>D</sub> : PE_MODE_SHUTDOWN    | Switch off at "pause" <ul style="list-style-type: none"> <li>• Supply voltages 1U<sub>s</sub> and 2U<sub>A</sub> off</li> <li>• Pause substitute value: 0<sub>B</sub></li> <li>• Value status "BAD"</li> </ul>                           |
|         | 3 <sub>D</sub> : PE_MODE_LAST_VALUE  | Last value at "pause" <ul style="list-style-type: none"> <li>• Supply voltages 1U<sub>s</sub> and 2U<sub>A</sub> off</li> <li>• Pause substitute value: Last input value</li> <li>• Value status "BAD"</li> </ul>                        |
|         | 4 <sub>D</sub> : PE_MODE_SUBST_VALUE | Substitute value at "pause" <ul style="list-style-type: none"> <li>• Supply voltages 1U<sub>s</sub> and 2U<sub>A</sub> off</li> <li>• Pause substitute value: Configured pause substitute value</li> <li>• Value status "BAD"</li> </ul> |

---

**Note****Supply voltages 1U<sub>s</sub> and 2U<sub>A</sub>**

Supply voltages 1U<sub>s</sub> and 2U<sub>A</sub> can only be switched off separately for each module.

If all channels require switching off during the pause, all supply voltages are switched off if no channel is assigned in PE\_MODE\_PROCEED.

---

## 8.3 DQ operating mode

### Display

The channel status LEDs Qn show the output value.

### Response to error detection

All channels that are in pause mode on "PE\_MODE\_PROCEED" report their diagnostic status as in productive mode.

The following applies for all channels which switch to a different pause mode:

- During the "pause", error detection of "Load voltage 2L+ missing" is not possible:
  - Alarms for errors already pending before the "pause" are retained.
  - After the "pause" is over, the error status is updated and incoming/outgoing errors are reported correspondingly.

### Mode parameter

The following table shows the "Mode" parameter.

Table 8- 2 Mode parameter

| Element | Code                    | Explanation                                                                                                                                                                                                    |
|---------|-------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Mode    | 0D: PE_MODE_PROCEED     | Proceed at "pause" <ul style="list-style-type: none"> <li>• Value status "GOOD"</li> </ul>                                                                                                                     |
|         | 1D: PE_MODE_SHUTDOWN    | Switch off at "pause" <ul style="list-style-type: none"> <li>• Supply voltages 1U<sub>s</sub> and 2U<sub>A</sub> off</li> <li>• Pause substitute value: 0<sub>B</sub></li> <li>• Value status "BAD"</li> </ul> |
|         | 3D: PE_MODE_LAST_VALUE  | Last value at "pause" <ul style="list-style-type: none"> <li>• Pause substitute value: Last output value is maintained</li> <li>• Value status "BAD"</li> </ul>                                                |
|         | 4D: PE_MODE_SUBST_VALUE | Substitute value at "pause" <ul style="list-style-type: none"> <li>• Pause substitute value: Configured pause substitute value is output</li> <li>• Value status "BAD"</li> </ul>                              |

---

**Note****Supply voltages 1U<sub>S</sub> and 2U<sub>A</sub>**

Supply voltages 1U<sub>S</sub> and 2U<sub>A</sub> can only be switched off separately for each module.

If all channels require switching off in the pause, the supply voltages are switched off.

---

## 8.4 IO-Link operating mode

### Display

Switching off the supply voltage 1Us also switches off the associated port status LED Cn.

### Response to error detection

All channels which are set to "PE\_MODE\_PROCEED" and "PE\_MODE\_LAST\_VALUE" in pause mode report errors as in productive operation.

The following conditions apply to all channels (ports) which switch to a different pause mode ("PE\_MODE\_SHUTDOWN" and "PE\_MODE\_SUBST\_VALUE"):

- Switching off the supply voltage  $U_{Sn}$  (port) upon starting the "pause" does not lead to generation of the alarms "Wire break" and "Short circuit".
- Error detection is not possible during the "pause" (no IO-Link device communication):
  - Alarms for errors already pending before the "pause" are retained.
  - After the "pause" is over, the error status is updated and incoming/outgoing errors are reported correspondingly.

### Mode parameter

The following table shows the "Mode" parameter.

Table 8-3 Mode parameter

| Element | Code                    | Explanation                                                                                                                                                                                             |
|---------|-------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Mode    | 0D: PE_MODE_PROCEED     | Proceed at "pause" <ul style="list-style-type: none"> <li>• Value status "GOOD"</li> </ul>                                                                                                              |
|         | 1D: PE_MODE_SHUTDOWN    | Switch off at "pause" <ul style="list-style-type: none"> <li>• Supply voltages 1Us and 2UA off<sup>1</sup></li> <li>• Pause substitute value (input): 0B</li> <li>• Value status "BAD"</li> </ul>       |
|         | 3D: PE_MODE_LAST_VALUE  | Last value at "pause" <ul style="list-style-type: none"> <li>• Pause substitute value: Last input value</li> <li>• Value status "BAD"</li> </ul>                                                        |
|         | 4D: PE_MODE_SUBST_VALUE | Substitute value at "pause" <ul style="list-style-type: none"> <li>• Supply voltages 1Us and 2UA off<sup>1</sup></li> <li>• Pause substitute value (input): 0B</li> <li>• Value status "BAD"</li> </ul> |

<sup>1</sup> Supply voltage 1Us of the assigned port is switched off. Result: The IO-Link device is no longer supplied with voltage.

---

**Note****Supply voltages 1U<sub>S</sub> and 2U<sub>A</sub>**

Supply voltages 1U<sub>S</sub> and 2U<sub>A</sub> can only be switched off separately for each module.

If all channels require switching off in the pause, the supply voltages are switched off.

---

## Dimension drawing

The following figure shows the dimension drawing of the CM 4xIO-Link 4xM12 communication module in front and side view.

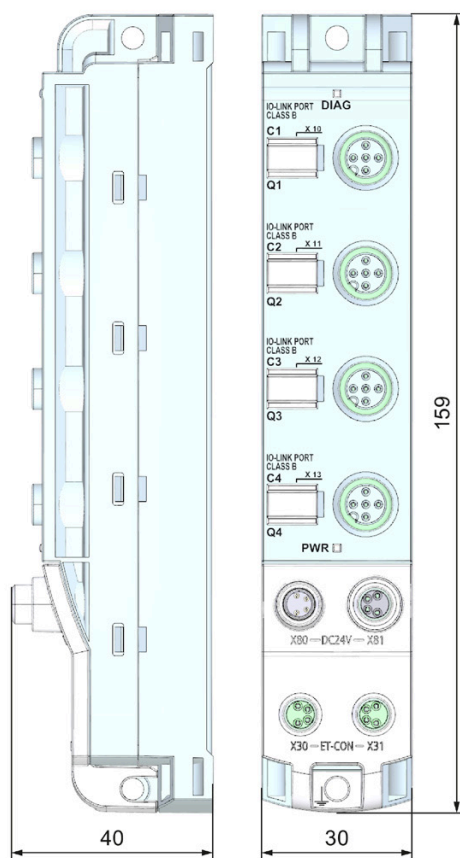
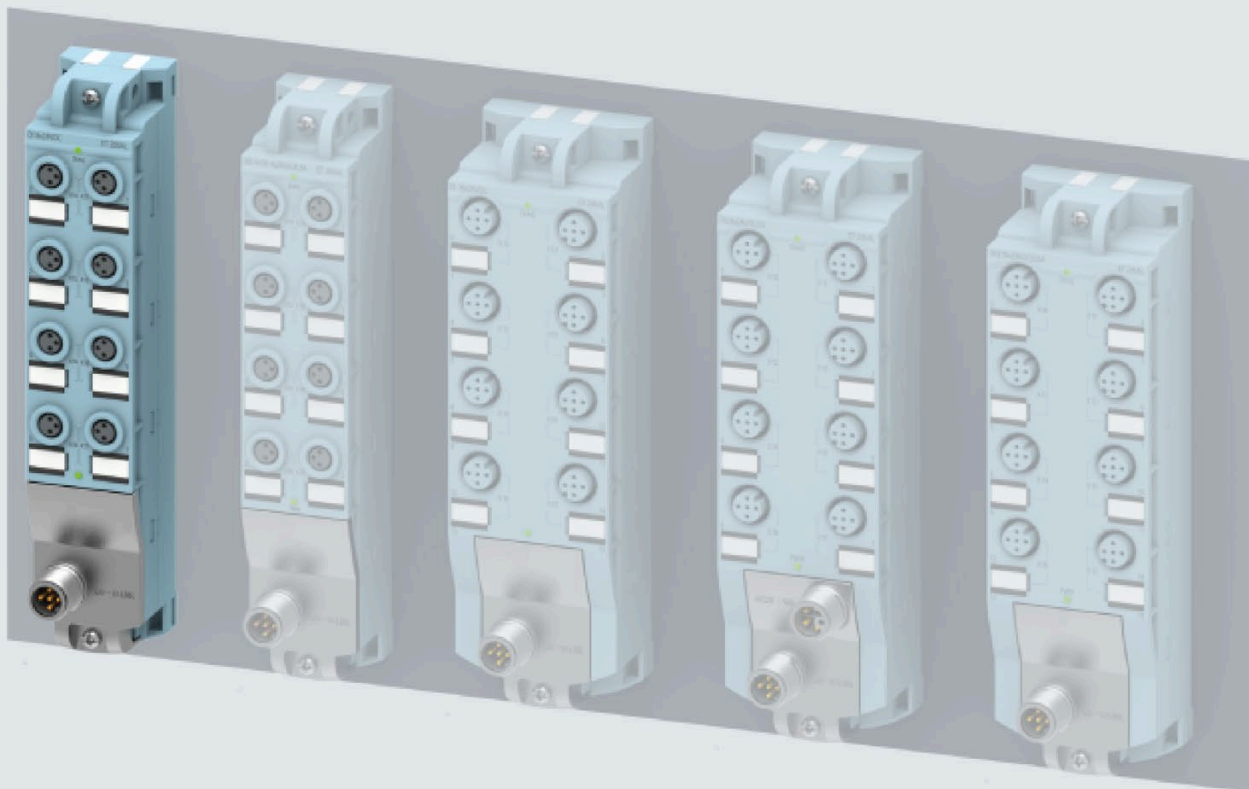


Figure A-1 Dimension drawing

# SIEMENS



Manual

## SIMATIC

### ET 200AL

IO-Link Digital input module DI 8x24VDC 8xM8  
(6ES7141-5BF00-0BL0)

Edition

08/2021

[support.industry.siemens.com](https://support.industry.siemens.com)



## SIMATIC

### ET 200AL IO-Link digital input module DI 8x24VDC 8xM8 (6ES7141-5BF00-0BL0)

Equipment Manual

#### Preface

ET 200AL IO-Link I/O  
modules Documentation  
Guide

**1**

Product overview

**2**

Wiring

**3**

Parameters/address space

**4**

Interrupts/diagnostics  
alarms

**5**

Technical specifications

**6**

Dimension drawing

**A**

## Legal information

### Warning notice system

This manual contains notices you have to observe in order to ensure your personal safety, as well as to prevent damage to property. The notices referring to your personal safety are highlighted in the manual by a safety alert symbol, notices referring only to property damage have no safety alert symbol. These notices shown below are graded according to the degree of danger.

#### **DANGER**

indicates that death or severe personal injury **will** result if proper precautions are not taken.

#### **WARNING**

indicates that death or severe personal injury **may** result if proper precautions are not taken.

#### **CAUTION**

indicates that minor personal injury can result if proper precautions are not taken.

#### **NOTICE**

indicates that property damage can result if proper precautions are not taken.

If more than one degree of danger is present, the warning notice representing the highest degree of danger will be used. A notice warning of injury to persons with a safety alert symbol may also include a warning relating to property damage.

### Qualified Personnel

The product/system described in this documentation may be operated only by **personnel qualified** for the specific task in accordance with the relevant documentation, in particular its warning notices and safety instructions. Qualified personnel are those who, based on their training and experience, are capable of identifying risks and avoiding potential hazards when working with these products/systems.

### Proper use of Siemens products

Note the following:

#### **WARNING**

Siemens products may only be used for the applications described in the catalog and in the relevant technical documentation. If products and components from other manufacturers are used, these must be recommended or approved by Siemens. Proper transport, storage, installation, assembly, commissioning, operation and maintenance are required to ensure that the products operate safely and without any problems. The permissible ambient conditions must be complied with. The information in the relevant documentation must be observed.

### Trademarks

All names identified by ® are registered trademarks of Siemens AG. The remaining trademarks in this publication may be trademarks whose use by third parties for their own purposes could violate the rights of the owner.

### Disclaimer of Liability

We have reviewed the contents of this publication to ensure consistency with the hardware and software described. Since variance cannot be precluded entirely, we cannot guarantee full consistency. However, the information in this publication is reviewed regularly and any necessary corrections are included in subsequent editions.

# Preface

## Preface IO-Link module AL

### Purpose of the documentation

This manual supplements the system manual ET 200AL IO-Link (<https://support.automation.siemens.com/WW/view/en/109773203>). Functions that generally relate to the distributed I/O system ET 200AL IO-Link I/O modules are described there.

The information provided in this manual and in the system manual and function manuals supports you in commissioning the ET 200AL IO-Link I/O modules.

### Changes compared to the previous version

This manual contains the following changes compared to the previous version:

- Supplements in the section Parameters (Page 14).

### Conventions

Also observe notes labeled as follows:

---

#### Note

Indicates important product information to which particular attention should be paid.

---

### Security information

Siemens provides products and solutions with industrial security functions that support the secure operation of plants, systems, machines and networks.

In order to protect plants, systems, machines and networks against cyber threats, it is necessary to implement – and continuously maintain – a holistic, state-of-the-art industrial security concept. Siemens' products and solutions constitute one element of such a concept.

Customers are responsible for preventing unauthorized access to their plants, systems, machines and networks. Such systems, machines and components should only be connected to an enterprise network or the internet if and to the extent such a connection is necessary and only when appropriate security measures (e.g. firewalls and/or network segmentation) are in place.

For additional information on industrial security measures that may be implemented, please visit (<https://www.siemens.com/industrialsecurity>).

Siemens' products and solutions undergo continuous development to make them more secure. Siemens strongly recommends that product updates are applied as soon as they are available and that the latest product versions are used. Use of product versions that are no longer supported, and failure to apply the latest updates may increase customers' exposure to cyber threats.

To stay informed about product updates, subscribe to the Siemens Industrial Security RSS Feed visit (<https://www.siemens.com/industrialsecurity>).

# Table of contents

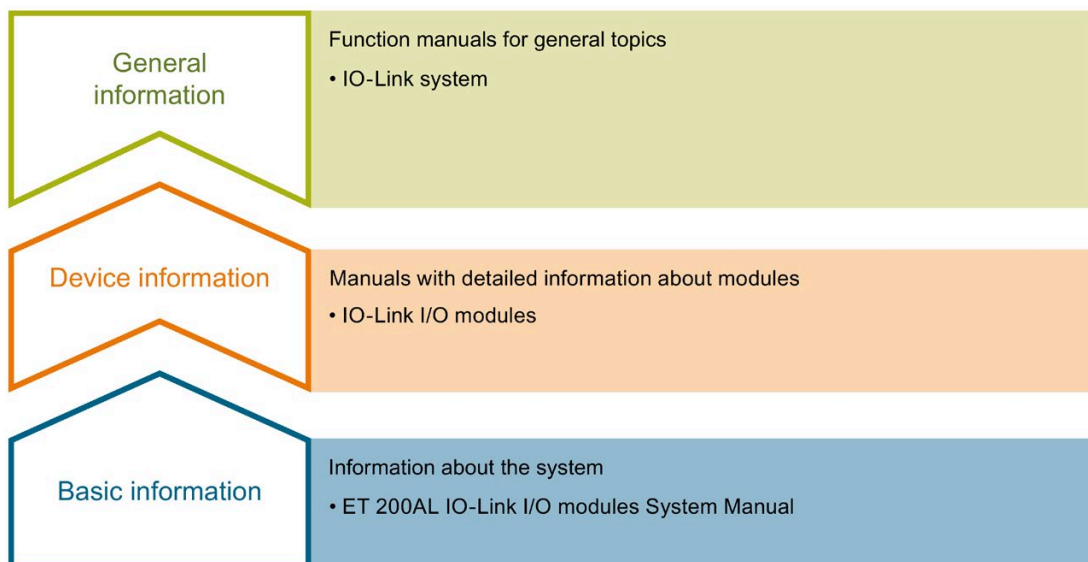
|   |                                                        |    |
|---|--------------------------------------------------------|----|
|   | Preface .....                                          | 3  |
| 1 | ET 200AL IO-Link I/O modules Documentation Guide ..... | 5  |
| 2 | Product overview .....                                 | 8  |
|   | 2.1 Properties .....                                   | 8  |
|   | 2.2 Operator controls and display elements .....       | 10 |
| 3 | Wiring .....                                           | 11 |
|   | 3.1 Terminal and block diagram .....                   | 11 |
|   | 3.2 Pin assignment .....                               | 12 |
| 4 | Parameters/address space .....                         | 14 |
|   | 4.1 Parameters .....                                   | 14 |
|   | 4.2 Explanation of the parameters .....                | 14 |
|   | 4.3 Address space .....                                | 14 |
|   | 4.4 IODD parameters .....                              | 15 |
| 5 | Interrupts/diagnostics alarms .....                    | 16 |
|   | 5.1 Status and error displays .....                    | 16 |
|   | 5.2 Interrupts .....                                   | 17 |
|   | 5.3 Diagnostics alarms .....                           | 18 |
| 6 | Technical specifications .....                         | 19 |
| A | Dimension drawing .....                                | 22 |

# ET 200AL IO-Link I/O modules Documentation Guide

# 1

The documentation for the SIMATIC ET 200AL IO-Link I/O modules is arranged into three areas.

This arrangement enables you to access the specific content you require.



## Basic information

The system manual describes in detail the configuration, installation, wiring and commissioning of the distributed I/O system SIMATIC ET 200AL IO-Link I/O modules.

## Device information

Equipment manuals contain a compact description of the module-specific information, such as properties, wiring diagrams, characteristics and technical specifications.

## General information

The function manuals contain detailed descriptions on general topics regarding the SIMATIC IO-Link system.

You can download the documentation free of charge from the Internet (<https://support.industry.siemens.com/cs/ww/en/view/109742667>).

## ET 200AL Manual Collection

The Manual Collection contains the complete documentation on the SIMATIC ET 200AL distributed I/O system gathered together in one file.

You can find the Manual Collection on the Internet (<https://support.automation.siemens.com/WW/view/en/95242965>).

## "mySupport"

With "mySupport", your personal workspace, you make the best out of your Industry Online Support.

In "mySupport", you can save filters, favorites and tags, request CAx data and compile your personal library in the Documentation area. In addition, your data is already filled out in support requests and you can get an overview of your current requests at any time.

You must register once to use the full functionality of "mySupport".

You can find "mySupport" on the Internet (<https://support.industry.siemens.com/My/ww/en>).

## "mySupport" - Documentation

With "mySupport", your personal workspace, you make the best out of your Industry Online Support.

In "mySupport", you can save filters, favorites and tags, request CAx data and compile your personal library in the Documentation area. In addition, your data is already filled out in support requests and you can get an overview of your current requests at any time.

You must register once to use the full functionality of "mySupport".

You can find "mySupport" on the Internet (<https://support.industry.siemens.com/My/ww/en/documentation>).

## "mySupport" - CAx data

In the CAx data area of "mySupport", you can access the latest product data for your CAx or CAe system.

You configure your own download package with a few clicks.

You can select:

- Product images, 2D dimension drawings, 3D models, internal circuit diagrams, EPLAN macro files
- Manuals, characteristics, operating manuals, certificates
- Product master data

You can find "mySupport" CAx data on the Internet (<https://support.industry.siemens.com/my/ww/en/CAxOnline>).

## Application examples

The application examples support you with various tools and examples for solving your automation tasks. Solutions are shown in interplay with multiple components in the system - separated from the focus on individual products.

You will find the application examples on the Internet (<https://support.industry.siemens.com/cs/ww/en/ps/ae>).

## TIA Selection Tool

With the TIA Selection Tool, you can select, configure and order devices for Totally Integrated Automation (TIA).

This tool is the successor of the SIMATIC Selection Tool and combines the known configurators for automation technology into one tool.

With the TIA Selection Tool, you can generate a complete order list from your product selection or product configuration.

You can find the TIA Selection Tool on the Internet

(<https://support.industry.siemens.com/cs/ww/en/view/109767888>).

## PRONETA

SIEMENS PRONETA (PROFINET network analysis) allows you to analyze the plant network during commissioning. PRONETA has two core functions:

- The topology overview automatically scans the PROFINET and all connected components.
- The IO check is a fast test of the wiring and the module configuration of a plant.

You can find SIEMENS PRONETA on the Internet

(<https://support.industry.siemens.com/cs/ww/en/view/67460624>).

## SIMATIC S7-PCT

The Port Configuration Tool ("PCT") is PC-based software for the parameter assignment of Siemens IO-Link master-modules and IO-Link devices from any manufacturer.

The IO-Link devices are integrated using the standardized device description "IODD" that is available from the respective device manufacturer. S7-PCT supports the version 1.0 as well as V1.1 of the IODD.

S7-PCT is called via the hardware configuration of the IO-Link masters from STEP 7; however, it can also be started as "standalone" if the IO-Link master is not operated on a SIMATIC controller or when STEP 7 is not used.

You can find additional information on IO-Link on the Internet

(<https://new.siemens.com/global/en/products/automation/industrial-communication/io-link.html>).

## Product overview

### 2.1 Properties

#### Article number

6ES7141-5BF00-0BL0

#### View of the module

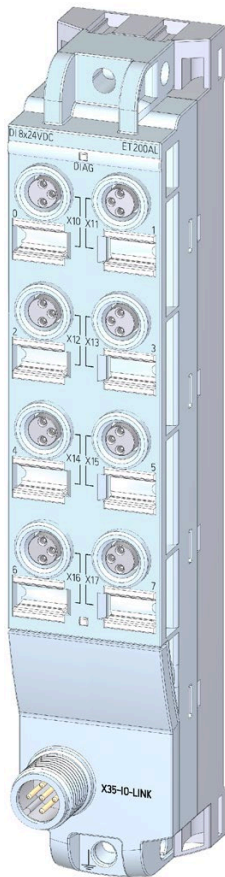


Figure 2-1 View of the DI 8x24VDC 8xM8 IO-Link digital input module



## Properties

The module has the following technical properties:

- 8 digital inputs
- M8 sockets for connection of sensors
- 24 V DC supply voltage
- Configurable diagnostics can be set for each module
- Typical input delay of 3 ms
- Suitable for switches and proximity switches
- Dimensions 30 x 159 mm

Interface for IO-Link and power supply:

- M12 connector A-coded
- IO-Link Port Class A (Type A)
- Supply of module electronics and sensor supply

The module supports the following functions:

- Firmware update
- IO-Link profile: General profile

## Accessories

The following components are included in the module package:

- Identification labels
- Spacers

## Other components

The following component can be ordered as spare part:

- Identification labels

The following components can be ordered as accessories:

- Connectors
- Cables
- M8 sealing cap

## See also

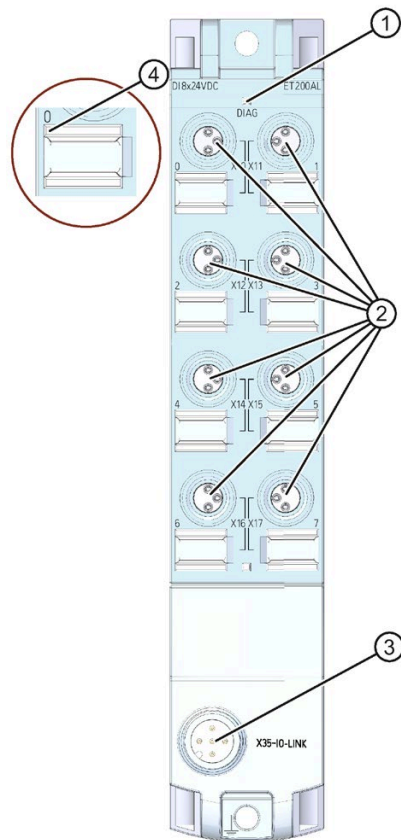
You can find more information on accessories in the system manual IO-Link IO modules Hotspot text ET 200AL distributed I/O system in the section Accessories/spare parts.

## See also

ET 200AL system manual (<https://support.automation.siemens.com/WW/view/en/109773203>)

## 2.2 Operator controls and display elements

The figure below shows the operator controls and display elements of the DI 8x24VDC 8xM8 IO-Link digital input module.

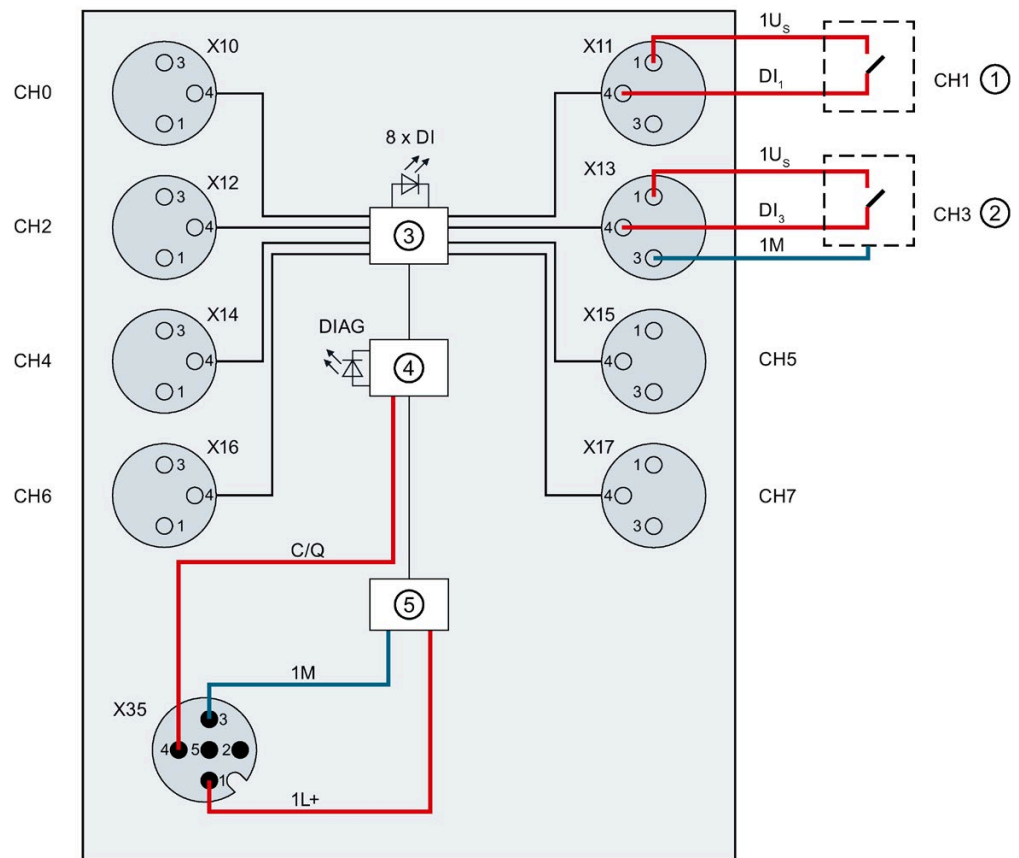


- ① DIAG: LED display for the diagnostic status
- ② X10 to X17: Sockets for the input signal
- ③ X35: IO-Link interface
- ④ LED displays 0 to 7 for the channel status

Figure 2-2 Operator controls and display elements

## 3.1 Terminal and block diagram

The following figure shows an example of the pin assignment of signal outputs with 2- and 3-wire connection.



|            |                         |      |                                      |
|------------|-------------------------|------|--------------------------------------|
| ①          | 2-wire connection       | 1L+  | Supply voltage 1L+ (non-switched)    |
| ②          | 3-wire connection       | 1M   | Ground 1M (non-switched)             |
| ③          | DI circuit              | 1Us  | 24 V encoder supply                  |
| ④          | Microcontroller         | DIn  | Input signal                         |
| ⑤          | Internal supply voltage | DI   | Channel status LEDs (0 to 7) (green) |
| X10 to X17 | Channels 0 to 7         | DIAG | LED diagnostic status (red/green)    |
| X35        | IO-Link interface       |      |                                      |

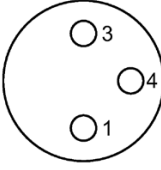
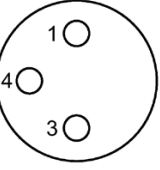
Figure 3-1 Terminal and block diagram

## 3.2 Pin assignment

### Pin assignment of the sockets for digital inputs

The table below shows the pin assignment of the 8 sockets for the connection of digital inputs.

Table 3- 1 Pin assignment for digital inputs

| Pin | Assignment                                                                                                                                                                                           | Front view of the sockets                                                           |                                                                                     |
|-----|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------|
|     | X10 to X17 sockets for digital inputs                                                                                                                                                                | X10, X12, X14, X16                                                                  | X11, X13, X15, X17                                                                  |
| 1   | 24 V encoder supply 1Us<br>(derived from 1L+ non-switched)                                                                                                                                           |  |  |
| 3   | Encoder supply ground 1M                                                                                                                                                                             |                                                                                     |                                                                                     |
| 4   | Input signal DI0: X10<br>Input signal DI1: X11<br>Input signal DI2: X12<br>Input signal DI3: X13<br>Input signal DI4: X14<br>Input signal DI5: X15<br>Input signal DI6: X16<br>Input signal DI7: X17 |                                                                                     |                                                                                     |

#### NOTICE

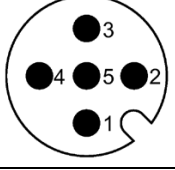
##### 24 V encoder supply 1Us

Use only the 24 V encoder supply 1Us provided by the digital input module to supply power to the encoder.

### Pin assignment of the IO-Link connector

The following table shows the pin assignment of the connector for the IO-Link connection. The IO-Link interface corresponds to the specification according to port Class A.

Table 3- 2 Pin assignment of the IO-Link interface

| Pin | Assignment                              | Front view of the connector (Port Class A)                                            |
|-----|-----------------------------------------|---------------------------------------------------------------------------------------|
|     | X35                                     |                                                                                       |
| 1   | 1L+                                     |  |
| 2   | Unassigned                              |                                                                                       |
| 3   | Ground 1M                               |                                                                                       |
| 4   | Switching and communication cable (C/Q) |                                                                                       |
| 5   | Unassigned                              |                                                                                       |

---

**Note**

Note that the module can only be supplied with a protective low voltage according to the standard SELV/PELV.

---

## Parameters/address space

### 4.1 Parameters

The following table shows the parameters for the DI 8x24VDC 8xM8 IO-Link digital input module.

Table 4- 1 Parameters

| Parameters                           | Value range |          |          | Default | Scope  | ISDU index (decimal) | ISDU subindex (decimal) |
|--------------------------------------|-------------|----------|----------|---------|--------|----------------------|-------------------------|
|                                      | Value       | Dec<br>· | Hex<br>· |         |        |                      |                         |
| Diagnostics: Short-circuit to ground | Disable     | 0        | 0        | Disable | Module | 131                  | 1                       |
|                                      | Enable      | 255      | FF       |         |        |                      |                         |

### 4.2 Explanation of the parameters

#### Diagnostics: Short-circuit to ground

Enabling of the diagnostics if a short-circuit of the encoder supply to ground occurs.

### 4.3 Address space

The figure below shows the assignment of the address space for the DI 8x24VDC 8xM8 IO-Link digital input module.

Assignment in the process image input (PII)

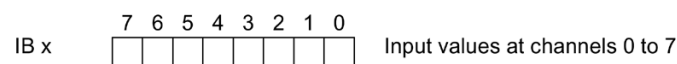


Figure 4-1 Address space IO-Link DI 8x24VDC 8xM8

## 4.4 IODD parameters

### Device description IODD

An electronic device description is available for the DI 8x24VDC 8xM8 IO-Link digital input module, the IODD file (IO Device Description). The IODD provides a wealth of information for system integration:

- Communication properties
- Device parameters with value range and default value
- Identification, process and diagnostic data
- Device data
- Text description
- Image of the device
- Manufacturer logo

The structure of the IODD is identical for all devices from all manufacturers. The structure of the IODD is always represented in the identical manner by the IO-Link Configuration Tool of the master manufacturer (for Siemens, S7-PCT). This ensures that the handling is the same for all IO-Link devices regardless of the manufacturer.

### IODDfinder

The IODDfinder is a cross-vendor, central IO-Link database.

This database provides you with the latest IODDs of the device manufacturers and offers an information and download platform.

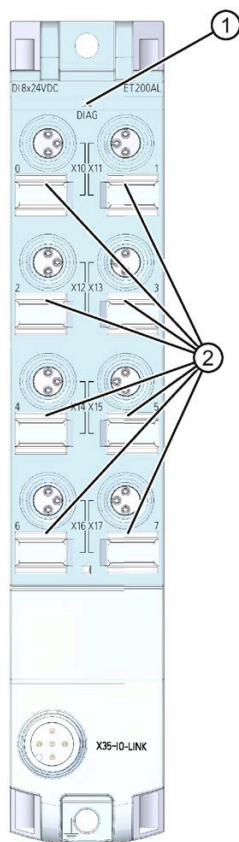
The IODDfinder is available on the Internet (<https://ioddfinder.io-link.com>).

# Interrupts/diagnostics alarms

## 5.1 Status and error displays

### LED displays

The figure below shows the LED displays (status and error displays) of the DI 8x24VDC 8xM8 IO-Link digital input module.



- ① Diagnostic status (DIAG) (red/green)
- ② Channel status (0 to 7) (green)

Figure 5-1 LED displays



## Meaning of the LEDs

The following tables set out the meaning of the status and error displays. Corrective measures for diagnostics alarms can be found in the section Diagnostics alarms (Page 18).

### DIAG LED

Table 5- 1 Error display of the DIAG LED

| DIAG LED                                                                                     | Meaning                                                                                                                                                 |
|----------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------|
| <br>Off     | No supply voltage 1L+                                                                                                                                   |
| <br>Flashes | <ul style="list-style-type: none"> <li>No data exchange with the IO-Link Master, for example, due to wire break</li> <li>Firmware is loading</li> </ul> |
| <br>On      | Module is currently exchanging data with the IO-Link master and no module diagnostics                                                                   |
| <br>Flashes | Module is currently exchanging data with the IO-Link master and module diagnostics                                                                      |

### LED channel status

Table 5- 2 LED channel status display

| LED channel status                                                                         | Meaning            |
|--------------------------------------------------------------------------------------------|--------------------|
| <br>Off | Process signal = 0 |
| <br>On  | Process signal = 1 |

## 5.2 Interrupts

The DI 8x24VDC 8xM8 IO-Link digital input module supports diagnostic interrupts.

### Diagnostic interrupt

The IO-Link digital input module generates a diagnostic interrupt at the following events:

- Short-circuit of encoder supply to ground

## 5.3 Diagnostics alarms

For each diagnostic event, a diagnostics alarm is issued and the DIAG LED flashes red on the digital input module. You can read out the diagnostics alarms, for example, in the diagnostics buffer of the CPU. You can evaluate the error codes with the user program.

Table 5- 3      Diagnostics alarms, their meanings and corrective measures

| Diagnostics alarm | Error code | Meaning                                      | Remedy                                                                      |
|-------------------|------------|----------------------------------------------|-----------------------------------------------------------------------------|
| Short-circuit     | 0x7710     | Short-circuit of an encoder supply to ground | <ul style="list-style-type: none"><li>Eliminate the short-circuit</li></ul> |

---

### Note

#### Short-circuit at the sensor supply

A short-circuit at the sensor supply can cause wire break diagnostics of the IO-Link Master. The behavior depends on the technical specifications of the IO-Link Master used.

---

## Technical specifications

### Technical specifications of the DI 8x24VDC 8xM8 IO-Link digital input module

The following table shows the technical specifications as of the issue date. You can find a data sheet including daily updated technical specifications on the Internet (<https://support.industry.siemens.com/cs/de/en/pv/6ES7141-5BF00-0BLO/td?dl=de>).

|                                                                            |                                                                                       |
|----------------------------------------------------------------------------|---------------------------------------------------------------------------------------|
| <b>Article number</b>                                                      | <b>6ES7141-5BF00-0BLO</b>                                                             |
| <b>General information</b>                                                 |                                                                                       |
| Product type designation                                                   | DI 8x24VDC                                                                            |
| HW functional status                                                       | FS01                                                                                  |
| Firmware version                                                           | V1.0.x                                                                                |
| Vendor identification (VendorID)                                           | 42                                                                                    |
| Device identifier (DeviceID)                                               | 229379                                                                                |
| <b>Engineering with</b>                                                    |                                                                                       |
| • IODD file                                                                | Yes                                                                                   |
| <b>Supply voltage</b>                                                      |                                                                                       |
| <b>Load voltage 1L+</b>                                                    |                                                                                       |
| • Rated value (DC)                                                         | 24 V; Supply from 1Us+ of the IO-Link master                                          |
| • permissible range, lower limit (DC)                                      | 18 V                                                                                  |
| • permissible range, upper limit (DC)                                      | 30 V                                                                                  |
| • Reverse polarity protection                                              | Yes; Against destruction; encoder power supply outputs applied with reversed polarity |
| <b>Input current</b>                                                       |                                                                                       |
| Current consumption (rated value)                                          | 15 mA; without load                                                                   |
| <b>Encoder supply</b>                                                      |                                                                                       |
| Number of outputs                                                          | 8; Supply from 1Us+ of the IO-Link master                                             |
| <b>24 V encoder supply</b>                                                 |                                                                                       |
| • Short-circuit protection                                                 | Yes; per module, electronic                                                           |
| • Output current, max.                                                     | 0.7 A; Total current of all encoders (depending on IO-Link master supply via 1Us+)    |
| <b>Power loss</b>                                                          |                                                                                       |
| Power loss, typ.                                                           | 1.5 W                                                                                 |
| <b>Digital inputs</b>                                                      |                                                                                       |
| Number of digital inputs                                                   | 8                                                                                     |
| Input characteristic curve in accordance with IEC 61131, type 3            | Yes                                                                                   |
| <b>Number of simultaneously controllable inputs all mounting positions</b> |                                                                                       |
| – up to 55 °C, max.                                                        | 8                                                                                     |

|                                                                                                                                                                                                                                        |                                           |
|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------|
| <b>Article number</b>                                                                                                                                                                                                                  | <b>6ES7141-5BF00-0BL0</b>                 |
| <b>Input voltage</b> <ul style="list-style-type: none"> <li>Rated value (DC)</li> <li>for signal "0"</li> <li>for signal "1"</li> </ul>                                                                                                | 24 V<br>-30 to +5 V<br>+11 to +30V        |
| <b>Input current</b> <ul style="list-style-type: none"> <li>for signal "1", typ.</li> </ul>                                                                                                                                            | 3 mA                                      |
| <b>Input delay (for rated value of input voltage) for standard inputs</b> <ul style="list-style-type: none"> <li>at "0" to "1", min.</li> <li>at "0" to "1", max.</li> <li>at "1" to "0", min.</li> <li>at "1" to "0", max.</li> </ul> | 1.2 ms<br>4.8 ms<br>1.2 ms<br>4.8 ms      |
| <b>Cable length</b> <ul style="list-style-type: none"> <li>unshielded, max.</li> </ul>                                                                                                                                                 | 30 m                                      |
| <b>Encoder</b>                                                                                                                                                                                                                         |                                           |
| <b>Connectable encoders</b> <ul style="list-style-type: none"> <li>2-wire sensor</li> <li>permissible quiescent current (2-wire sensor), max.</li> </ul>                                                                               | Yes<br>1.5 mA                             |
| <b>IO-Link</b>                                                                                                                                                                                                                         |                                           |
| IO-Link protocol 1.1                                                                                                                                                                                                                   | Yes                                       |
| Transmission rate                                                                                                                                                                                                                      | 38.4 kBd (COM2)                           |
| Cycle time, min.                                                                                                                                                                                                                       | 2.1 ms                                    |
| Size of process data, input per module                                                                                                                                                                                                 | 1 byte                                    |
| Size of process data, output per module                                                                                                                                                                                                | 0 byte                                    |
| Supported IO-Link profiles                                                                                                                                                                                                             | common profile                            |
| Cable length unshielded, max.                                                                                                                                                                                                          | 20 m                                      |
| <b>Connection of IO-Link devices</b> <ul style="list-style-type: none"> <li>Port type A</li> </ul>                                                                                                                                     | Yes                                       |
| <b>Interrupts/diagnostics/status information</b>                                                                                                                                                                                       |                                           |
| <b>Alarms</b> <ul style="list-style-type: none"> <li>Diagnostic alarm</li> </ul>                                                                                                                                                       | Yes; Parameterizable                      |
| <b>Diagnoses</b> <ul style="list-style-type: none"> <li>Short-circuit</li> </ul>                                                                                                                                                       | Yes; Sensor supply to M; module by module |
| <b>Diagnostics indication LED</b> <ul style="list-style-type: none"> <li>Channel status display</li> <li>for module diagnostics</li> </ul>                                                                                             | Yes; green LED<br>Yes; green/red LED      |

|                                                                |                           |
|----------------------------------------------------------------|---------------------------|
| <b>Article number</b>                                          | <b>6ES7141-5BF00-0BLO</b> |
| <b>Potential separation</b>                                    |                           |
| <b>Potential separation channels</b>                           |                           |
| • between the channels                                         | No                        |
| • between the channels and the power supply of the electronics | No                        |
| <b>Isolation</b>                                               |                           |
| Isolation tested with                                          | 707 V DC (type test)      |
| <b>Degree and class of protection</b>                          |                           |
| IP degree of protection                                        | IP65/67                   |
| <b>Ambient conditions</b>                                      |                           |
| <b>Ambient temperature during operation</b>                    |                           |
| • min.                                                         | -30 °C                    |
| • max.                                                         | 55 °C                     |
| <b>Dimensions</b>                                              |                           |
| Width                                                          | 30 mm                     |
| Height                                                         | 159 mm                    |
| Depth                                                          | 40 mm                     |
| <b>Weights</b>                                                 |                           |
| Weight, approx.                                                | 124 g                     |

## Dimension drawing

The figure below shows the dimension drawing of the DI 8x24VDC 8xM8 IO-Link digital input module in front and side view.

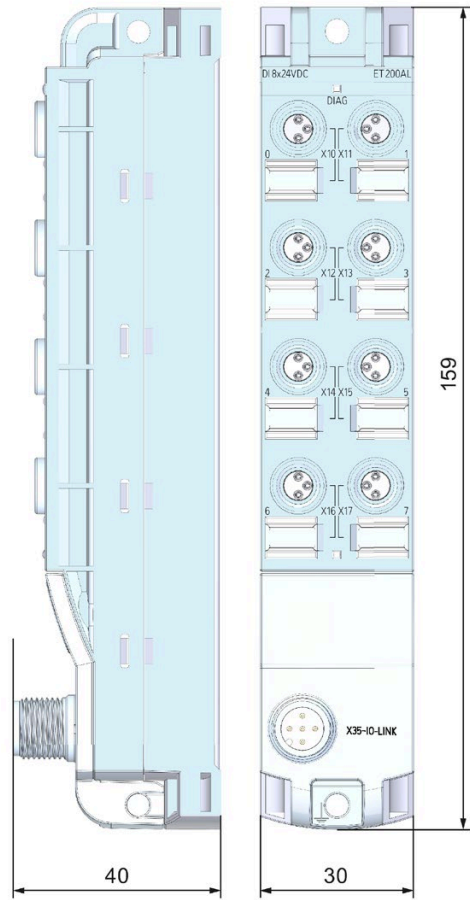
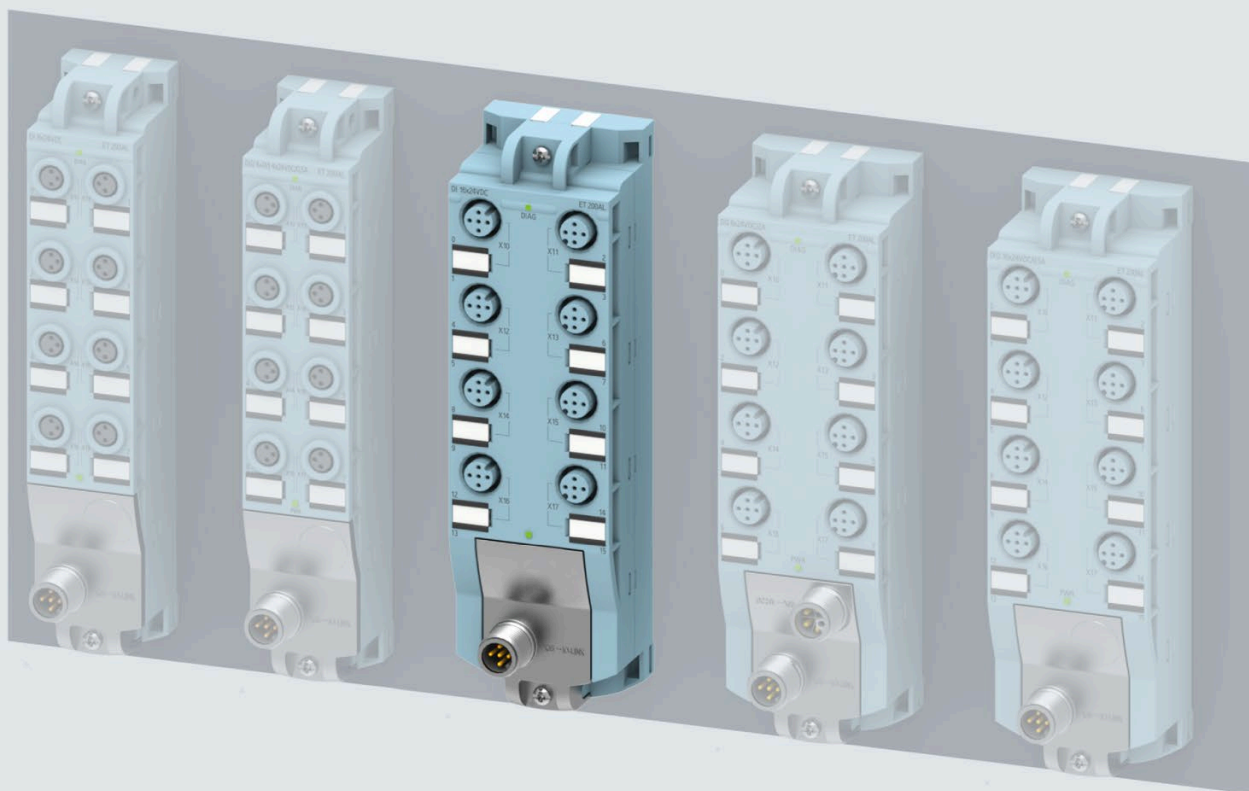


Figure A-1 Dimension drawing

# SIEMENS



Manual

## SIMATIC

### ET 200AL

IO-Link Digital Input module DI 16x24VDC 8xM12  
(6ES7141-5AH00-0BL0)

Edition

08/2021

[support.industry.siemens.com](https://support.industry.siemens.com)

## SIMATIC

### ET 200AL IO-Link digital input module DI 16x24VDC 8xM12 (6ES7141-5AH00-0BL0)

Equipment Manual

#### Preface

ET 200AL IO-Link I/O  
modules Documentation  
Guide

**1**

Product overview

**2**

Wiring

**3**

Parameters/address space

**4**

Interrupts/diagnostic  
alarms

**5**

Technical specifications

**6**

Dimension drawing

**A**



## Legal information

### Warning notice system

This manual contains notices you have to observe in order to ensure your personal safety, as well as to prevent damage to property. The notices referring to your personal safety are highlighted in the manual by a safety alert symbol, notices referring only to property damage have no safety alert symbol. These notices shown below are graded according to the degree of danger.

#### **DANGER**

indicates that death or severe personal injury **will** result if proper precautions are not taken.

#### **WARNING**

indicates that death or severe personal injury **may** result if proper precautions are not taken.

#### **CAUTION**

indicates that minor personal injury can result if proper precautions are not taken.

#### **NOTICE**

indicates that property damage can result if proper precautions are not taken.

If more than one degree of danger is present, the warning notice representing the highest degree of danger will be used. A notice warning of injury to persons with a safety alert symbol may also include a warning relating to property damage.

### Qualified Personnel

The product/system described in this documentation may be operated only by **personnel qualified** for the specific task in accordance with the relevant documentation, in particular its warning notices and safety instructions. Qualified personnel are those who, based on their training and experience, are capable of identifying risks and avoiding potential hazards when working with these products/systems.

### Proper use of Siemens products

Note the following:

#### **WARNING**

Siemens products may only be used for the applications described in the catalog and in the relevant technical documentation. If products and components from other manufacturers are used, these must be recommended or approved by Siemens. Proper transport, storage, installation, assembly, commissioning, operation and maintenance are required to ensure that the products operate safely and without any problems. The permissible ambient conditions must be complied with. The information in the relevant documentation must be observed.

### Trademarks

All names identified by ® are registered trademarks of Siemens AG. The remaining trademarks in this publication may be trademarks whose use by third parties for their own purposes could violate the rights of the owner.

### Disclaimer of Liability

We have reviewed the contents of this publication to ensure consistency with the hardware and software described. Since variance cannot be precluded entirely, we cannot guarantee full consistency. However, the information in this publication is reviewed regularly and any necessary corrections are included in subsequent editions.

# Preface

## Preface IO-Link module AL

### Purpose of the documentation

This manual supplements the system manual ET 200AL IO-Link (<https://support.automation.siemens.com/WW/view/en/109773203>). Functions that generally relate to the distributed I/O system ET 200AL IO-Link I/O modules are described in this manual.

The information provided in this manual and in the system manual and function manuals supports you in commissioning the ET 200AL IO-Link I/O modules.

### Changes compared to the previous version

This manual contains the following changes compared to the previous version:

- Supplements in the section Parameters (Page 15)

### Conventions

Also observe notes labeled as follows:

---

#### Note

Indicates important product information to which particular attention should be paid.

---

## Security information

Siemens provides products and solutions with industrial security functions that support the secure operation of plants, systems, machines and networks.

In order to protect plants, systems, machines and networks against cyber threats, it is necessary to implement – and continuously maintain – a holistic, state-of-the-art industrial security concept. Siemens' products and solutions constitute one element of such a concept.

Customers are responsible for preventing unauthorized access to their plants, systems, machines and networks. Such systems, machines and components should only be connected to an enterprise network or the internet if and to the extent such a connection is necessary and only when appropriate security measures (e.g. firewalls and/or network segmentation) are in place.

For additional information on industrial security measures that may be implemented, please visit (<https://www.siemens.com/industrialsecurity>).

Siemens' products and solutions undergo continuous development to make them more secure. Siemens strongly recommends that product updates are applied as soon as they are available and that the latest product versions are used. Use of product versions that are no longer supported, and failure to apply the latest updates may increase customers' exposure to cyber threats.

To stay informed about product updates, subscribe to the Siemens Industrial Security RSS Feed visit (<https://www.siemens.com/industrialsecurity>).

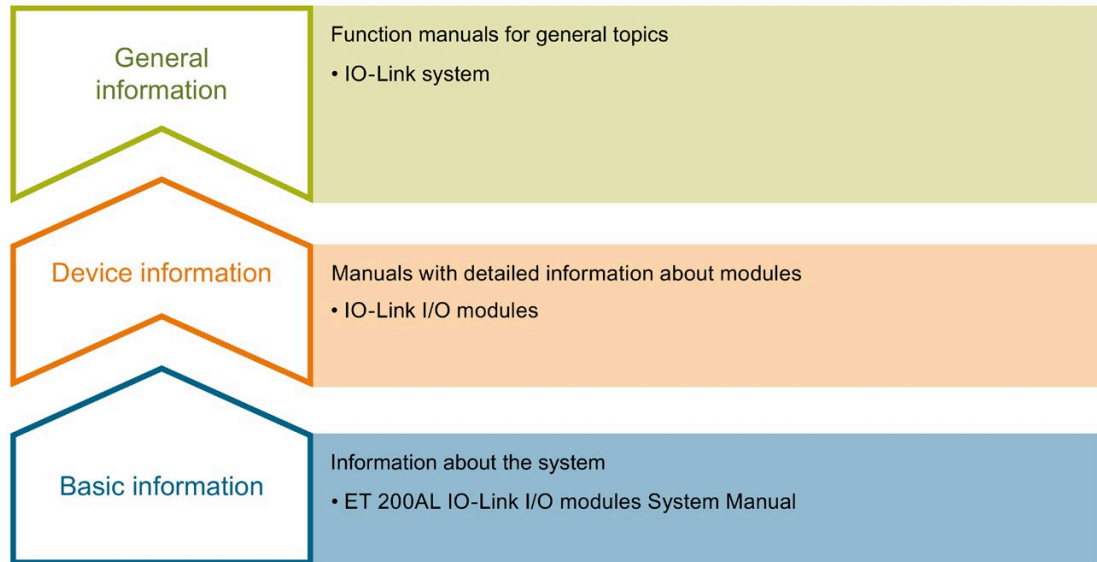
# Table of contents

|          |                                                               |           |
|----------|---------------------------------------------------------------|-----------|
|          | <b>Preface .....</b>                                          | <b>3</b>  |
| <b>1</b> | <b>ET 200AL IO-Link I/O modules Documentation Guide .....</b> | <b>6</b>  |
| <b>2</b> | <b>Product overview .....</b>                                 | <b>9</b>  |
|          | 2.1 Properties .....                                          | 9         |
|          | 2.2 Operator controls and display elements.....               | 11        |
| <b>3</b> | <b>Wiring .....</b>                                           | <b>12</b> |
|          | 3.1 Terminal and block diagram .....                          | 12        |
|          | 3.2 Pin assignment .....                                      | 13        |
| <b>4</b> | <b>Parameters/address space .....</b>                         | <b>15</b> |
|          | 4.1 Parameters .....                                          | 15        |
|          | 4.2 Explanation of the parameters .....                       | 15        |
|          | 4.3 Address space .....                                       | 15        |
|          | 4.4 IODD parameters .....                                     | 16        |
| <b>5</b> | <b>Interrupts/diagnostic alarms .....</b>                     | <b>17</b> |
|          | 5.1 Status and error displays .....                           | 17        |
|          | 5.2 Interrupts .....                                          | 18        |
|          | 5.3 Diagnostics alarms.....                                   | 19        |
| <b>6</b> | <b>Technical specifications.....</b>                          | <b>20</b> |
| <b>A</b> | <b>Dimension drawing .....</b>                                | <b>23</b> |

# ET 200AL IO-Link I/O modules Documentation Guide

# 1

The documentation for the SIMATIC ET 200AL IO-Link I/O modules is arranged into three areas.  
This arrangement enables you to access the specific content you require.



## Basic information

The system manual describes in detail the configuration, installation, wiring and commissioning of the distributed I/O system SIMATIC ET 200AL IO-Link I/O modules.

## Device information

Equipment manuals contain a compact description of the module-specific information, such as properties, wiring diagrams, characteristics and technical specifications.

## General information

The function manuals contain detailed descriptions on general topics regarding the SIMATIC IO-Link system.

You can download the documentation free of charge from the Internet (<https://support.industry.siemens.com/cs/ww/en/view/109742667>).

## ET 200AL Manual Collection

The Manual Collection contains the complete documentation on the SIMATIC ET 200AL distributed I/O system gathered together in one file.

You can find the Manual Collection on the Internet (<https://support.automation.siemens.com/WW/view/en/95242965>).

## "mySupport"

With "mySupport", your personal workspace, you make the best out of your Industry Online Support.

In "mySupport", you can save filters, favorites and tags, request CAx data and compile your personal library in the Documentation area. In addition, your data is already filled out in support requests and you can get an overview of your current requests at any time.

You must register once to use the full functionality of "mySupport".

You can find "mySupport" on the Internet (<https://support.industry.siemens.com/My/ww/en>).

## "mySupport" - Documentation

With "mySupport", your personal workspace, you make the best out of your Industry Online Support.

In "mySupport", you can save filters, favorites and tags, request CAx data and compile your personal library in the Documentation area. In addition, your data is already filled out in support requests and you can get an overview of your current requests at any time.

You must register once to use the full functionality of "mySupport".

You can find "mySupport" on the Internet (<https://support.industry.siemens.com/My/ww/en/documentation>).

## "mySupport" - CAx data

In the CAx data area of "mySupport", you can access the latest product data for your CAx or CAe system.

You configure your own download package with a few clicks.

You can select:

- Product images, 2D dimension drawings, 3D models, internal circuit diagrams, EPLAN macro files
- Manuals, characteristics, operating manuals, certificates
- Product master data

You can find "mySupport" CAx data on the Internet (<https://support.industry.siemens.com/my/ww/en/CAxOnline>).

## Application examples

The application examples support you with various tools and examples for solving your automation tasks. Solutions are shown in interplay with multiple components in the system - separated from the focus on individual products.

You will find the application examples on the Internet (<https://support.industry.siemens.com/cs/ww/en/ps/ae>).

## TIA Selection Tool

With the TIA Selection Tool, you can select, configure and order devices for Totally Integrated Automation (TIA).

This tool is the successor of the SIMATIC Selection Tool and combines the known configurators for automation technology into one tool.

With the TIA Selection Tool, you can generate a complete order list from your product selection or product configuration.

You can find the TIA Selection Tool on the Internet

(<https://support.industry.siemens.com/cs/ww/en/view/109767888>).

## PRONETA

SIEMENS PRONETA (PROFINET network analysis) allows you to analyze the plant network during commissioning. PRONETA has two core functions:

- The topology overview automatically scans the PROFINET and all connected components.
- The IO check is a fast test of the wiring and the module configuration of a plant.

You can find SIEMENS PRONETA on the Internet

(<https://support.industry.siemens.com/cs/ww/en/view/67460624>).

## SIMATIC S7-PCT

The Port Configuration Tool ("PCT") is PC-based software for the parameter assignment of Siemens IO-Link master-modules and IO-Link devices from any manufacturer.

The IO-Link devices are integrated using the standardized device description "IODD" that is available from the respective device manufacturer. S7-PCT supports the version 1.0 as well as V1.1 of the IODD.

S7-PCT is called via the hardware configuration of the IO-Link masters from STEP 7; however, it can also be started as "standalone" if the IO-Link master is not operated on a SIMATIC controller or when STEP 7 is not used.

You can find additional information on IO-Link on the Internet

(<https://new.siemens.com/global/en/products/automation/industrial-communication/io-link.html>).

## Product overview

### 2.1 Properties

#### Article number

6ES7141-5AH00-0BLO

#### View of the module

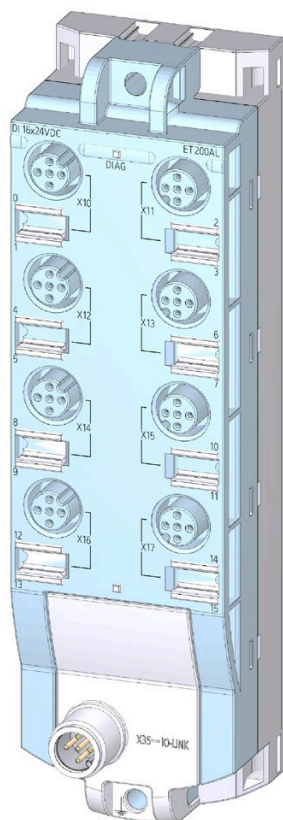


Figure 2-1 View of the DI 16x24VDC 8xM12 IO-Link digital input module



## 2.1 Properties

### Properties

The module has the following technical properties:

- 16 digital inputs
- M12 sockets for connection of sensors
- 24 V DC supply voltage
- Configurable diagnostics can be set for each module
- Typical input delay of 3 ms
- Suitable for switches and proximity switches
- Dimensions 45 x 159 mm

Interface for IO-Link and power supply:

- M12 connector A-coded
- IO-Link Port Class A
- Supply of the module electronics
- Encoder supply

The module supports the following functions:

- Firmware update
- IO-Link profile: General profile

### Accessories

The following components are included in the module package:

- Identification labels

### Other components

The following component can be ordered as spare part:

- Identification labels

The following components can be ordered as accessories:

- Connectors
- Cables
- M12 sealing cap

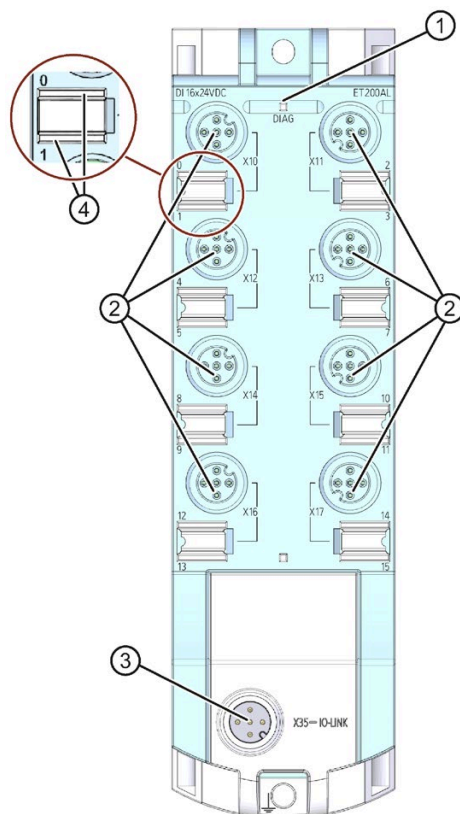
### See also

You can find more information on accessories in the Accessories/spare parts section of the ET 200AL distributed I/O system

(<https://support.automation.siemens.com/WW/view/en/109773203>) IO-Link I/O modules system manual.

## 2.2 Operator controls and display elements

The figure below shows the operator controls and display elements of the DI 16x24VDC 8xM12 IO-Link digital input module.

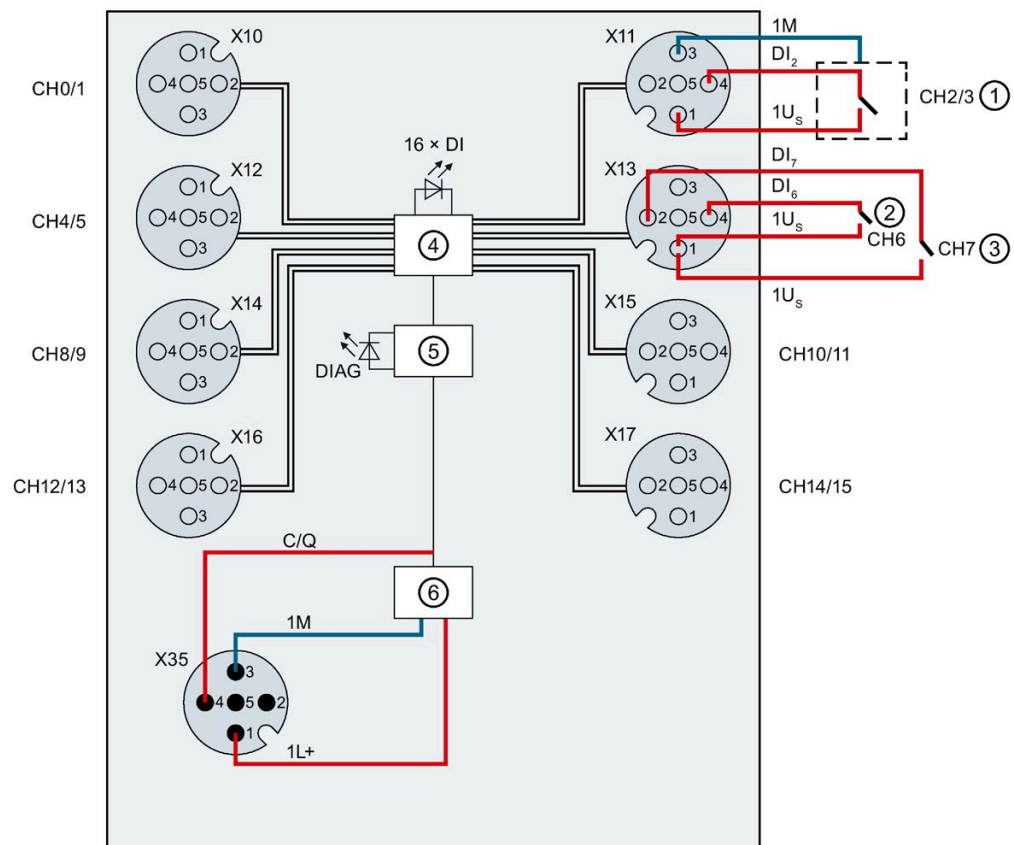


- ① DIAG: LED display for the diagnostic status
- ② X10 to X17: Sockets for the input signal
- ③ X35: IO-Link interface
- ④ LED displays 0 to 15 for the channel status

Figure 2-2 Operator controls and display elements

## 3.1 Terminal and block diagram

The figure below shows an example of the pin assignment of signal inputs with 2-wire and 3-wire connection.



|            |                         |                 |                                       |
|------------|-------------------------|-----------------|---------------------------------------|
| ①          | 3-wire connection       | 1L+             | Supply voltage 1L+ (non-switched)     |
| ②          | 2-wire connection       | 1M              | Ground 1M (non-switched)              |
| ③          | 2-wire connection       | 1Us             | 24 V encoder supply                   |
| ④          | DI circuit              | DI <sub>n</sub> | Input signal                          |
| ⑤          | Microcontroller         | DI              | Channel status LEDs (0 to 15) (green) |
| ⑥          | Internal supply voltage | DIAG            | Diagnostic status LED (red/green)     |
| X10 to X17 | Channels 0 to 7         |                 |                                       |
| X35        | IO-Link interface       |                 |                                       |

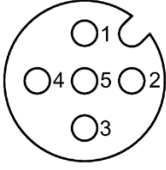
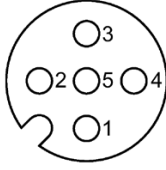
Figure 3-1 Terminal and block diagram

## 3.2 Pin assignment

### Pin assignment of the sockets for digital inputs

The table below shows the pin assignment of the 8 sockets for the connection of digital inputs.

Table 3- 1 Pin assignment for digital inputs

| Pin | Assignment                                                                                                                                                                                                                                                                              | Front view of the sockets                                                           |                                                                                     |
|-----|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------|
|     | X10 to X17 sockets for digital inputs                                                                                                                                                                                                                                                   | X10, X12, X14, X16                                                                  | X11, X13, X15, X17                                                                  |
| 1   | 24 V encoder supply 1Us<br>(derived from 1L+ non-switched)                                                                                                                                                                                                                              |  |  |
| 2   | Input signal DI1: Connector X10<br>Input signal DI3: Connector X11<br>Input signal DI5: Connector X12<br>Input signal DI7: Connector X13<br>Input signal DI9: Connector X14<br>Input signal DI11: Connector X15<br>Input signal DI13: Connector X16<br>Input signal DI15: Connector X17 |                                                                                     |                                                                                     |
| 3   | Encoder supply ground 1M                                                                                                                                                                                                                                                                |                                                                                     |                                                                                     |
| 4   | Input signal DI0: Connector X10<br>Input signal DI2: Connector X11<br>Input signal DI4: Connector X12<br>Input signal DI6: Connector X13<br>Input signal DI8: Connector X14<br>Input signal DI10: Connector X15<br>Input signal DI12: Connector X16<br>Input signal DI14: Connector X17 |                                                                                     |                                                                                     |
| 5   | Functional earth FE                                                                                                                                                                                                                                                                     |                                                                                     |                                                                                     |

#### NOTICE

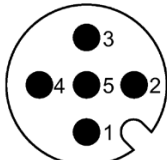
##### 24 V encoder supply 1Us

Use only the 24 V encoder supply 1Us provided by the digital input module to supply power to the encoder.

### Pin assignment of the IO-Link connector

The following table shows the pin assignment of the connector for the IO-Link connection. The IO-Link interface corresponds to the specification according to Port Class A.

Table 3- 2 Pin assignment of the IO-Link interface

| Pin | Assignment                              | Front view of the connector (Port Class A)                                          |
|-----|-----------------------------------------|-------------------------------------------------------------------------------------|
|     | X35                                     |                                                                                     |
| 1   | 1L+                                     |  |
| 2   | Unassigned                              |                                                                                     |
| 3   | Ground 1M                               |                                                                                     |
| 4   | Switching and communication cable (C/Q) |                                                                                     |
| 5   | Unassigned                              |                                                                                     |

#### Note

Note that the module can only be supplied with a protective low voltage according to the standard SELV/PELV.

## Parameters/address space

### 4.1 Parameters

The following table shows the parameters for the DI 16x24VDC 8xM12 IO-Link digital input module.

Table 4- 1 Parameters

| Parameters                           | Value range |     |     | Default | Scope  | ISDU index<br>(hexadecimal) | ISDU subindex<br>(hexadecimal) |
|--------------------------------------|-------------|-----|-----|---------|--------|-----------------------------|--------------------------------|
|                                      | Value       | Dec | Hex |         |        |                             |                                |
| Diagnostics: Short-circuit to ground | Disable     | 0   | 0   | Disable | Module | 131                         | 1                              |
|                                      | Enable      | 255 | FF  |         |        |                             |                                |

### 4.2 Explanation of the parameters

#### Diagnostics: Short-circuit to ground

Enabling of the diagnostics if a short-circuit of the encoder supply to ground occurs.

### 4.3 Address space

The figure below shows the assignment of the address space for the DI 16x24VDC 8xM12 IO-Link digital input module.

Assignment in the process image input (PII)

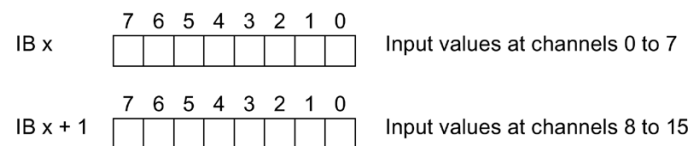


Figure 4-1 Address space IO-Link DI 16x24VDC 8xM12

## 4.4 IODD parameters

### Device description IODD

An electronic device description is available for the DI 16x24VDC 8xM12 IO-Link digital input module, the IODD file (IO Device Description). The IODD provides a wealth of information for system integration:

- Communication properties
- Device parameters with value range and default value
- Identification, process and diagnostic data
- Device data
- Text description
- Image of the device
- Manufacturer logo

The structure of the IODD is identical for all devices from all manufacturers. The structure of the IODD is always represented in the same manner by the IO-Link Configuration Tool of the master manufacturer (for Siemens, S7-PCT). This ensures that the handling is the same for all IO-Link devices regardless of the manufacturer.

### IODDfinder

The IODDfinder is a cross-vendor, central IO-Link database.

This database provides you with the latest IODDs of the device manufacturers and offers an information and download platform.

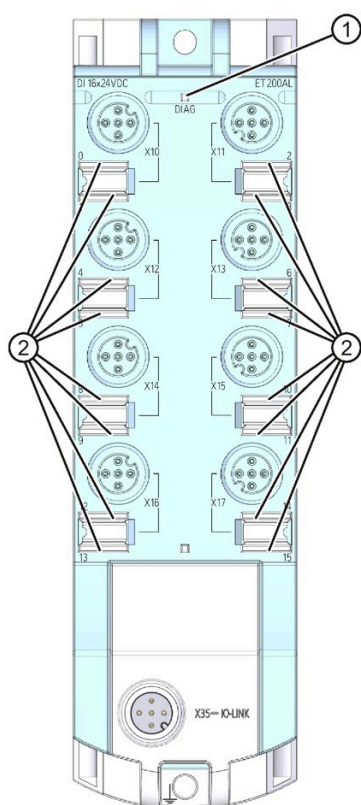
The IODDfinder is available on the Internet (<https://ioddfinder.io-link.com>).

# Interrupts/diagnostic alarms

## 5.1 Status and error displays

### LED displays

The figure below shows the LED displays (status and error displays) of the DI 16x24VDC 8xM12 IO-Link digital input module.



- ① Diagnostic status (DIAG) (red/green)
- ② Channel status (0 to 15) (green)

Figure 5-1 LED displays



## Meaning of the LEDs

The following tables set out the meaning of the status and error displays. Corrective measures for diagnostics alarms can be found in section Diagnostics alarms (Page 19).

### DIAG LED

Table 5- 1 Error display of the DIAG LED

| DIAG LED                                                                                     | Meaning                                                                                                                                   |
|----------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------|
| <br>Off     | No supply voltage 1L+                                                                                                                     |
| <br>Flashes | <ul style="list-style-type: none"> <li>No data exchange with the IO-Link master (e.g. wire break)</li> <li>Firmware is loading</li> </ul> |
| <br>On      | Module is currently exchanging data with the IO-Link master and no module diagnostics                                                     |
| <br>Flashes | Module is currently exchanging data with the IO-Link master and module diagnostics                                                        |

### LED channel status

Table 5- 2 LED channel status display

| LED channel status                                                                         | Meaning            |
|--------------------------------------------------------------------------------------------|--------------------|
| <br>Off | Process signal = 0 |
| <br>On  | Process signal = 1 |

## 5.2 Interrupts

The DI 16x24VDC 8xM12 IO-Link digital input module supports diagnostic interrupts.

### Diagnostic interrupt

The digital input module generates a diagnostic interrupt at the following events:

- Short-circuit of encoder supply to ground

## 5.3 Diagnostics alarms

For each diagnostic event, a diagnostics alarm is issued and the LED DIAG flashes red on the digital input module. You can read out the diagnostics alarms, for example, from the status of the IO-Link master. You can evaluate the error codes with the user program.

Table 5- 3 Diagnostics alarms, their meanings and corrective measures

| Diagnostics alarm | Error code | Meaning                                      | Remedy                      |
|-------------------|------------|----------------------------------------------|-----------------------------|
| Short-circuit     | 0x7710     | Short-circuit of an encoder supply to ground | Eliminate the short-circuit |

---

### Note

#### Short-circuit at the sensor supply

A short-circuit at the sensor supply can cause wire break diagnostics of the IO-Link Master. The behavior depends on the technical specifications of the IO-Link Master used.

---

## Technical specifications

### Technical specifications of the DI 16x24VDC 8xM12 IO-Link digital input module

The following table shows the technical specifications as of the issue date. You can find a data sheet including daily updated technical specifications on the Internet (<https://support.industry.siemens.com/cs/de/en/pv/6ES7141-5AH00-0BL0/td?dl=en>).

|                                                                            |                                                                                       |
|----------------------------------------------------------------------------|---------------------------------------------------------------------------------------|
| <b>Article number</b>                                                      | <b>6ES7141-5AH00-0BL0</b>                                                             |
| <b>General information</b>                                                 |                                                                                       |
| Product type designation                                                   | DI 16x24VDC                                                                           |
| HW functional status                                                       | FS01                                                                                  |
| Firmware version                                                           | V1.0.x                                                                                |
| Vendor identification (VendorID)                                           | 42                                                                                    |
| Device identifier (DeviceID)                                               | 229380                                                                                |
| <b>Engineering with</b>                                                    |                                                                                       |
| • IODD file                                                                | Yes                                                                                   |
| <b>Supply voltage</b>                                                      |                                                                                       |
| <b>Load voltage 1L+</b>                                                    |                                                                                       |
| • Rated value (DC)                                                         | 24 V; Supply from 1Us+ of the IO-Link master                                          |
| • permissible range, lower limit (DC)                                      | 18 V                                                                                  |
| • permissible range, upper limit (DC)                                      | 30 V                                                                                  |
| • Reverse polarity protection                                              | Yes; Against destruction; encoder power supply outputs applied with reversed polarity |
| <b>Input current</b>                                                       |                                                                                       |
| Current consumption (rated value)                                          | 20 mA; without load                                                                   |
| <b>Encoder supply</b>                                                      |                                                                                       |
| Number of outputs                                                          | 8; Supply from 1Us+ of the IO-Link master                                             |
| <b>24 V encoder supply</b>                                                 |                                                                                       |
| • Short-circuit protection                                                 | Yes; per module, electronic                                                           |
| • Output current, max.                                                     | 0.7 A; Total current of all encoders (depending on IO-Link master supply via 1Us+)    |
| <b>Power loss</b>                                                          |                                                                                       |
| Power loss, typ.                                                           | 2.4 W                                                                                 |
| <b>Digital inputs</b>                                                      |                                                                                       |
| Number of digital inputs                                                   | 16                                                                                    |
| Input characteristic curve in accordance with IEC 61131, type 3            | Yes                                                                                   |
| <b>Number of simultaneously controllable inputs all mounting positions</b> |                                                                                       |
| – up to 55 °C, max.                                                        | 16                                                                                    |

|                                                                                                                                                                                                                                        |                                                                                |
|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------|
| <b>Article number</b>                                                                                                                                                                                                                  | <b>6ES7141-5AH00-0BL0</b>                                                      |
| <b>Input voltage</b> <ul style="list-style-type: none"> <li>Rated value (DC)</li> <li>for signal "0"</li> <li>for signal "1"</li> </ul>                                                                                                | 24 V<br>-30 to +5 V<br>+11 to +30V                                             |
| <b>Input current</b> <ul style="list-style-type: none"> <li>for signal "1", typ.</li> </ul>                                                                                                                                            | 3 mA                                                                           |
| <b>Input delay (for rated value of input voltage) for standard inputs</b> <ul style="list-style-type: none"> <li>at "0" to "1", min.</li> <li>at "0" to "1", max.</li> <li>at "1" to "0", min.</li> <li>at "1" to "0", max.</li> </ul> | 1.2 ms<br>4.8 ms<br>1.2 ms<br>4.8 ms                                           |
| <b>Cable length</b> <ul style="list-style-type: none"> <li>unshielded, max.</li> </ul>                                                                                                                                                 | 30 m                                                                           |
| <b>Encoder</b>                                                                                                                                                                                                                         |                                                                                |
| <b>Connectable encoders</b> <ul style="list-style-type: none"> <li>2-wire sensor</li> <li>permissible quiescent current (2-wire sensor), max.</li> </ul>                                                                               | Yes<br>1.5 mA                                                                  |
| <b>IO-Link</b>                                                                                                                                                                                                                         |                                                                                |
| IO-Link protocol 1.1<br>Transmission rate<br>Cycle time, min.<br>Size of process data, input per module<br>Size of process data, output per module<br>Supported IO-Link profiles<br>Cable length unshielded, max.                      | Yes<br>38.4 kBd (COM2)<br>2.5 ms<br>2 byte<br>0 byte<br>common profile<br>20 m |
| <b>Connection of IO-Link devices</b> <ul style="list-style-type: none"> <li>Port type A</li> </ul>                                                                                                                                     | Yes                                                                            |
| <b>Interrupts/diagnostics/status information</b>                                                                                                                                                                                       |                                                                                |
| <b>Alarms</b> <ul style="list-style-type: none"> <li>Diagnostic alarm</li> </ul>                                                                                                                                                       | Yes; Parameterizable                                                           |
| <b>Diagnoses</b> <ul style="list-style-type: none"> <li>Short-circuit</li> </ul>                                                                                                                                                       | Yes; Sensor supply to M; module by module                                      |
| <b>Diagnostics indication LED</b> <ul style="list-style-type: none"> <li>Channel status display</li> <li>for module diagnostics</li> </ul>                                                                                             | Yes; green LED<br>Yes; green/red LED                                           |

|                                                                |                           |
|----------------------------------------------------------------|---------------------------|
| <b>Article number</b>                                          | <b>6ES7141-5AH00-0BL0</b> |
| <b>Potential separation</b>                                    |                           |
| <b>Potential separation channels</b>                           |                           |
| • between the channels                                         | No                        |
| • between the channels and the power supply of the electronics | No                        |
| <b>Isolation</b>                                               |                           |
| Isolation tested with                                          | 707 V DC (type test)      |
| <b>Degree and class of protection</b>                          |                           |
| IP degree of protection                                        | IP65/67                   |
| <b>Ambient conditions</b>                                      |                           |
| <b>Ambient temperature during operation</b>                    |                           |
| • min.                                                         | -30 °C                    |
| • max.                                                         | 55 °C                     |
| <b>Dimensions</b>                                              |                           |
| Width                                                          | 45 mm                     |
| Height                                                         | 159 mm                    |
| Depth                                                          | 40 mm                     |
| <b>Weights</b>                                                 |                           |
| Weight, approx.                                                | 155 g                     |

## Dimension drawing

The figure below shows the dimension drawing of the DI 16x24VDC 8xM12 IO-Link digital input module in front and side view.

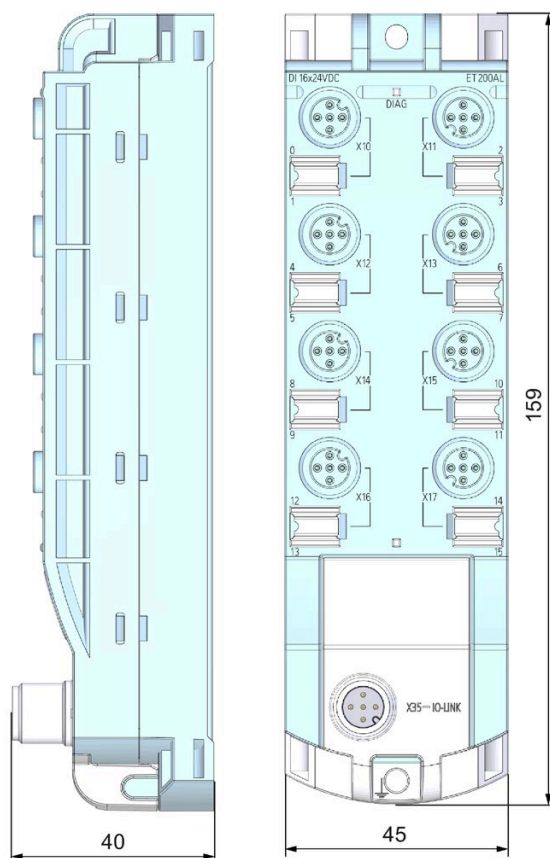
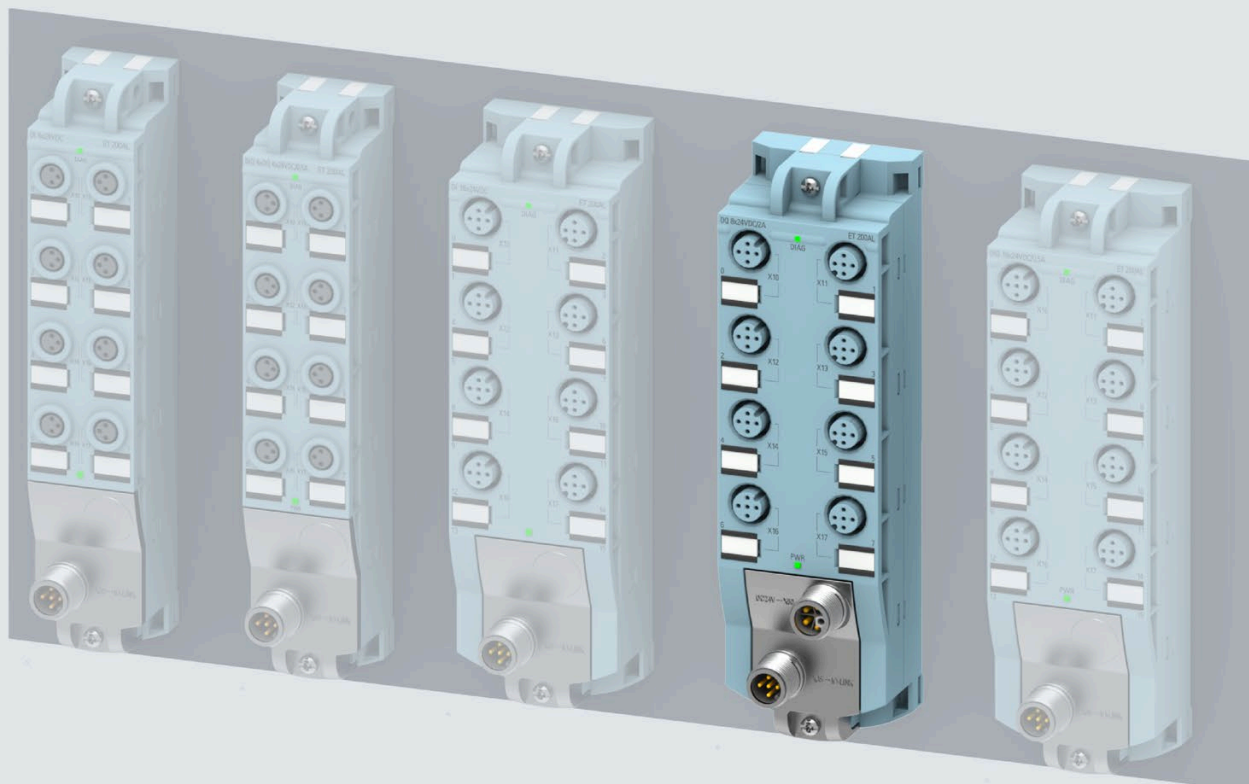


Figure A-1 Dimension drawing

# SIEMENS



Manual

## SIMATIC

### ET 200AL

IO-Link Digital output module DQ 8x24VDC/2A 8xM12  
(6ES7142-5AF00-0BL0)

Edition

08/2021

[support.industry.siemens.com](https://support.industry.siemens.com)

## SIMATIC

### ET 200AL IO-Link digital output module DQ 8x24VDC/2A 8xM12 (6ES7142-5AF00-0BL0)

Equipment Manual

#### Preface

ET 200AL IO-Link I/O  
modules Documentation  
Guide

1

Product overview

2

Wiring

3

Parameters/address space

4

Interrupts/diagnostic  
alarms

5

Technical specifications

6

Dimension drawing

A



## Legal information

### Warning notice system

This manual contains notices you have to observe in order to ensure your personal safety, as well as to prevent damage to property. The notices referring to your personal safety are highlighted in the manual by a safety alert symbol, notices referring only to property damage have no safety alert symbol. These notices shown below are graded according to the degree of danger.

|                                                                                                        |
|--------------------------------------------------------------------------------------------------------|
|  <b>DANGER</b>        |
| indicates that death or severe personal injury <b>will</b> result if proper precautions are not taken. |
|  <b>WARNING</b>       |
| indicates that death or severe personal injury <b>may</b> result if proper precautions are not taken.  |
|  <b>CAUTION</b>       |
| indicates that minor personal injury can result if proper precautions are not taken.                   |
| <b>NOTICE</b>                                                                                          |
| indicates that property damage can result if proper precautions are not taken.                         |

If more than one degree of danger is present, the warning notice representing the highest degree of danger will be used. A notice warning of injury to persons with a safety alert symbol may also include a warning relating to property damage.

### Qualified Personnel

The product/system described in this documentation may be operated only by **personnel qualified** for the specific task in accordance with the relevant documentation, in particular its warning notices and safety instructions. Qualified personnel are those who, based on their training and experience, are capable of identifying risks and avoiding potential hazards when working with these products/systems.

### Proper use of Siemens products

Note the following:

|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |
|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|  <b>WARNING</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                   |
| Siemens products may only be used for the applications described in the catalog and in the relevant technical documentation. If products and components from other manufacturers are used, these must be recommended or approved by Siemens. Proper transport, storage, installation, assembly, commissioning, operation and maintenance are required to ensure that the products operate safely and without any problems. The permissible ambient conditions must be complied with. The information in the relevant documentation must be observed. |

### Trademarks

All names identified by ® are registered trademarks of Siemens AG. The remaining trademarks in this publication may be trademarks whose use by third parties for their own purposes could violate the rights of the owner.

### Disclaimer of Liability

We have reviewed the contents of this publication to ensure consistency with the hardware and software described. Since variance cannot be precluded entirely, we cannot guarantee full consistency. However, the information in this publication is reviewed regularly and any necessary corrections are included in subsequent editions.

# Preface

## Preface IO-Link module AL

### Purpose of the documentation

This manual supplements the system manual ET 200AL IO-Link (<https://support.automation.siemens.com/WW/view/en/109773203>). Functions that generally relate to the distributed I/O system ET 200AL IO-Link I/O modules are described there.

The information provided in this manual and in the system manual and function manuals supports you in commissioning the ET 200AL IO-Link I/O modules.

### Changes compared to the previous version

This manual contains the following changes compared to the previous version:

- Supplements in the section Parameters (Page 15).
- Update of the section Technical specifications (Page 20)

### Conventions

Also observe notes labeled as follows:

---

**Note**

Indicates important product information to which particular attention should be paid.

---

## Security information

Siemens provides products and solutions with industrial security functions that support the secure operation of plants, systems, machines and networks.

In order to protect plants, systems, machines and networks against cyber threats, it is necessary to implement – and continuously maintain – a holistic, state-of-the-art industrial security concept. Siemens' products and solutions constitute one element of such a concept.

Customers are responsible for preventing unauthorized access to their plants, systems, machines and networks. Such systems, machines and components should only be connected to an enterprise network or the internet if and to the extent such a connection is necessary and only when appropriate security measures (e.g. firewalls and/or network segmentation) are in place.

For additional information on industrial security measures that may be implemented, please visit (<https://www.siemens.com/industrialsecurity>).

Siemens' products and solutions undergo continuous development to make them more secure. Siemens strongly recommends that product updates are applied as soon as they are available and that the latest product versions are used. Use of product versions that are no longer supported, and failure to apply the latest updates may increase customers' exposure to cyber threats.

To stay informed about product updates, subscribe to the Siemens Industrial Security RSS Feed visit (<https://www.siemens.com/industrialsecurity>).

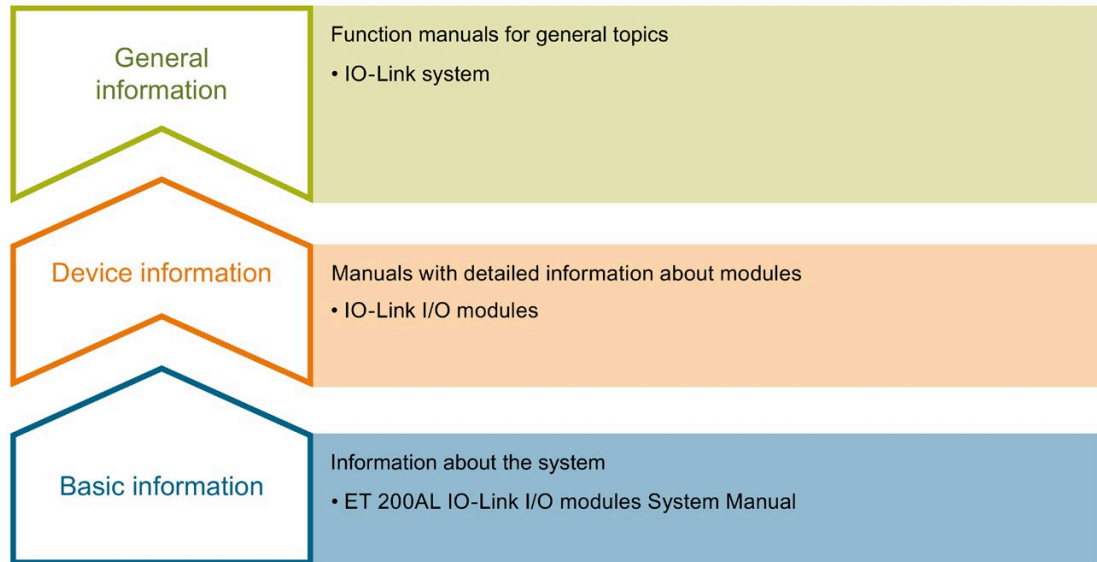
# Table of contents

|          |                                                               |           |
|----------|---------------------------------------------------------------|-----------|
|          | <b>Preface .....</b>                                          | <b>3</b>  |
| <b>1</b> | <b>ET 200AL IO-Link I/O modules Documentation Guide .....</b> | <b>6</b>  |
| <b>2</b> | <b>Product overview .....</b>                                 | <b>9</b>  |
|          | 2.1 Properties .....                                          | 9         |
|          | 2.2 Operator controls and display elements.....               | 11        |
| <b>3</b> | <b>Wiring .....</b>                                           | <b>12</b> |
|          | 3.1 Terminal and block diagram .....                          | 12        |
|          | 3.2 Pin assignment .....                                      | 13        |
| <b>4</b> | <b>Parameters/address space .....</b>                         | <b>15</b> |
|          | 4.1 Parameters .....                                          | 15        |
|          | 4.2 Explanation of the parameters .....                       | 15        |
|          | 4.3 Address space .....                                       | 16        |
|          | 4.4 IODD parameters .....                                     | 16        |
| <b>5</b> | <b>Interrupts/diagnostic alarms .....</b>                     | <b>17</b> |
|          | 5.1 Status and error displays .....                           | 17        |
|          | 5.2 Interrupts .....                                          | 19        |
|          | 5.3 Diagnostics alarms.....                                   | 19        |
| <b>6</b> | <b>Technical specifications.....</b>                          | <b>20</b> |
| <b>A</b> | <b>Dimension drawing .....</b>                                | <b>24</b> |

# ET 200AL IO-Link I/O modules Documentation Guide

# 1

The documentation for the SIMATIC ET 200AL IO-Link I/O modules is arranged into three areas.  
This arrangement enables you to access the specific content you require.



## Basic information

The system manual describes in detail the configuration, installation, wiring and commissioning of the distributed I/O system SIMATIC ET 200AL IO-Link I/O modules.

## Device information

Equipment manuals contain a compact description of the module-specific information, such as properties, wiring diagrams, characteristics and technical specifications.

## General information

The function manuals contain detailed descriptions on general topics regarding the SIMATIC IO-Link system.

You can download the documentation free of charge from the Internet (<https://support.industry.siemens.com/cs/ww/en/view/109742667>).

## ET 200AL Manual Collection

The Manual Collection contains the complete documentation on the SIMATIC ET 200AL distributed I/O system gathered together in one file.

You can find the Manual Collection on the Internet (<https://support.automation.siemens.com/WW/view/en/95242965>).

## "mySupport"

With "mySupport", your personal workspace, you make the best out of your Industry Online Support.

In "mySupport", you can save filters, favorites and tags, request CAx data and compile your personal library in the Documentation area. In addition, your data is already filled out in support requests and you can get an overview of your current requests at any time.

You must register once to use the full functionality of "mySupport".

You can find "mySupport" on the Internet (<https://support.industry.siemens.com/My/ww/en>).

## "mySupport" - Documentation

With "mySupport", your personal workspace, you make the best out of your Industry Online Support.

In "mySupport", you can save filters, favorites and tags, request CAx data and compile your personal library in the Documentation area. In addition, your data is already filled out in support requests and you can get an overview of your current requests at any time.

You must register once to use the full functionality of "mySupport".

You can find "mySupport" on the Internet  
(<https://support.industry.siemens.com/My/ww/en/documentation>).

## "mySupport" - CAx data

In the CAx data area of "mySupport", you can access the latest product data for your CAx or CAe system.

You configure your own download package with a few clicks.

You can select:

- Product images, 2D dimension drawings, 3D models, internal circuit diagrams, EPLAN macro files
- Manuals, characteristics, operating manuals, certificates
- Product master data

You can find "mySupport" CAx data on the Internet  
(<https://support.industry.siemens.com/my/ww/en/CAxOnline>).

## Application examples

The application examples support you with various tools and examples for solving your automation tasks. Solutions are shown in interplay with multiple components in the system - separated from the focus on individual products.

You will find the application examples on the Internet  
(<https://support.industry.siemens.com/cs/ww/en/ps/ae>).

## TIA Selection Tool

With the TIA Selection Tool, you can select, configure and order devices for Totally Integrated Automation (TIA).

This tool is the successor of the SIMATIC Selection Tool and combines the known configurators for automation technology into one tool.

With the TIA Selection Tool, you can generate a complete order list from your product selection or product configuration.

You can find the TIA Selection Tool on the Internet

(<https://support.industry.siemens.com/cs/ww/en/view/109767888>).

## PRONETA

SIEMENS PRONETA (PROFINET network analysis) allows you to analyze the plant network during commissioning. PRONETA has two core functions:

- The topology overview automatically scans the PROFINET and all connected components.
- The IO check is a fast test of the wiring and the module configuration of a plant.

You can find SIEMENS PRONETA on the Internet

(<https://support.industry.siemens.com/cs/ww/en/view/67460624>).

## SIMATIC S7-PCT

The Port Configuration Tool ("PCT") is PC-based software for the parameter assignment of Siemens IO-Link master-modules and IO-Link devices from any manufacturer.

The IO-Link devices are integrated using the standardized device description "IODD" that is available from the respective device manufacturer. S7-PCT supports the version 1.0 as well as V1.1 of the IODD.

S7-PCT is called via the hardware configuration of the IO-Link masters from STEP 7; however, it can also be started as "standalone" if the IO-Link master is not operated on a SIMATIC controller or when STEP 7 is not used.

You can find additional information on IO-Link on the Internet

(<https://new.siemens.com/global/en/products/automation/industrial-communication/io-link.html>).

## Product overview

### 2.1 Properties

#### Article number

6ES7142-5AF00-0BL0

#### View of the module

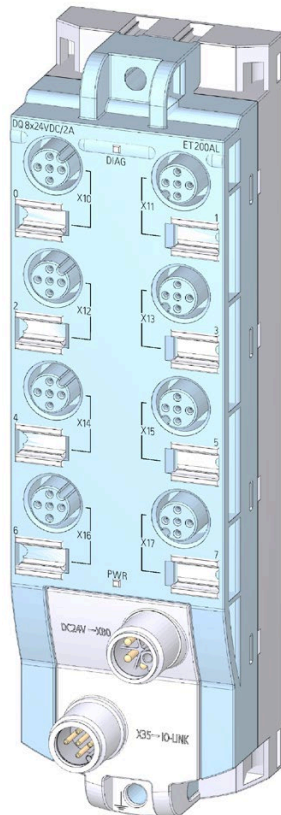


Figure 2-1 View of the DQ 8x24VDC/2A 8xM12 IO-Link digital output module



## 2.1 Properties

### Properties

The module has the following technical properties:

- 8 digital outputs
  - Channels 0 to 7 connected to 2L+ (switched)
- M12 sockets for connection of actuators
- Rated load voltage 24 V DC
- Suitable for solenoid valves, DC contactors, and indicator lights
- Output current per output 2 A
- Configurable diagnostics can be set for each module
- Dimensions 45 x 159 mm
- Interface for supply 2L+

Interface for IO-Link and power supply:

- M12 connector A-coded
- IO-Link Port Class A
- Supply of module electronics

Load voltage supply of output

- M12 connector L-coded

The module supports the following functions:

- Firmware update
- IO-Link profile: General profile

### Accessories

The following components are included in the module package:

- Identification labels

### Other components

The following component can be ordered as spare part:

- Identification labels

The following components can be ordered as accessories:

- Connectors
- Cables
- M12 sealing cap

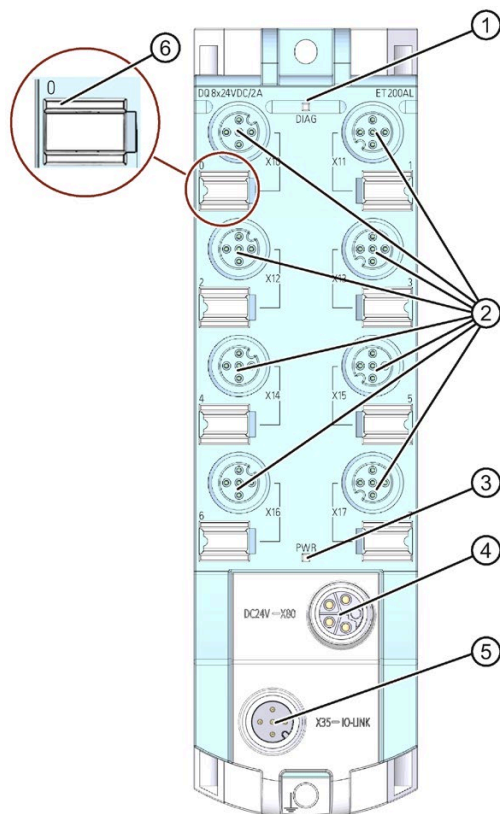
### See also

You can find more information on accessories in the Accessories/spare parts section of the ET 200AL distributed I/O system

(<https://support.automation.siemens.com/WW/view/en/109773203>) IO-Link I/O modules system manual.

## 2.2 Operator controls and display elements

The figure below shows the operator controls and display elements of the IO-Link DQ 8x24VDC/2A 8xM12 digital output module.



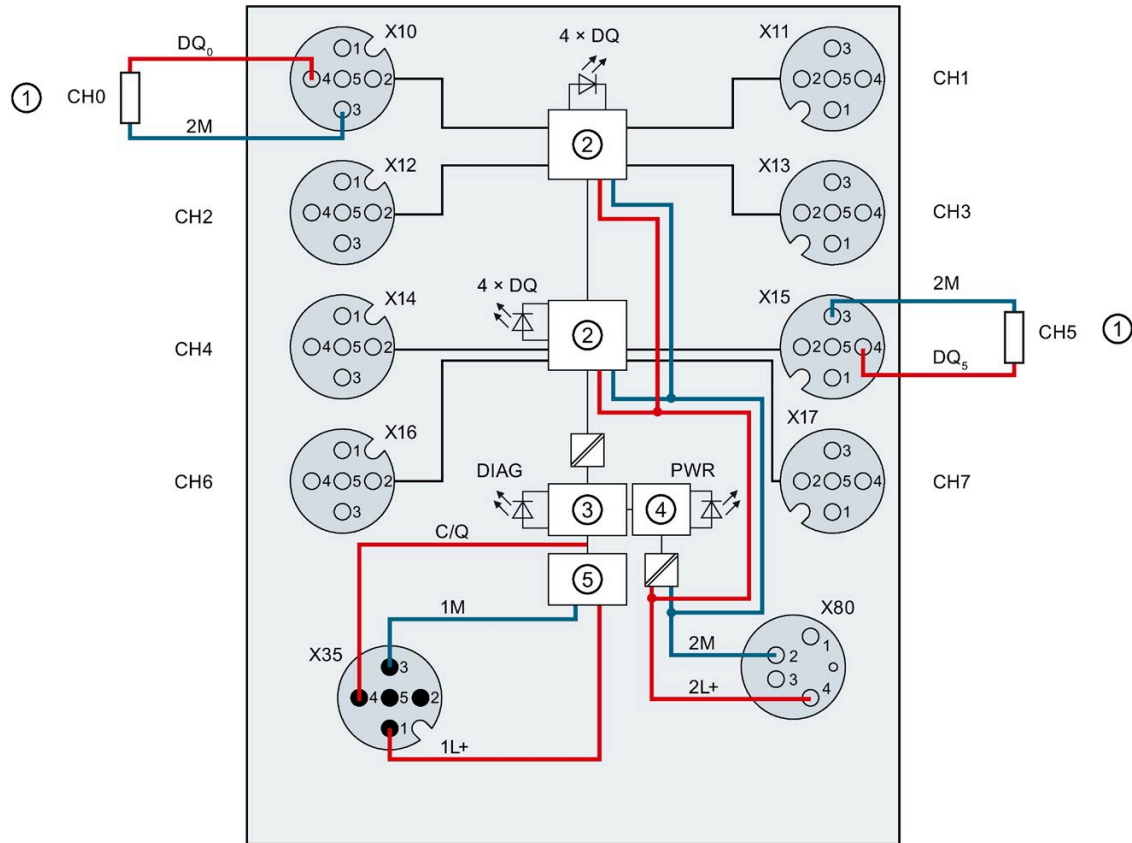
- ① DIAG: LED display for the diagnostic status
- ② X10 to X17: Sockets for the output signal
- ③ PWR: LED display for load voltage 2L+
- ④ X80: Connector for infeed of the supply voltage (POWER input)
- ⑤ X35: IO-Link interface
- ⑥ LED displays 0 to 7 for the channel status

Figure 2-2 Operator controls and display elements

## Wiring

### 3.1 Terminal and block diagram

The example in the figure below shows the pin assignment of signal outputs.



|            |                                            |                 |                                      |
|------------|--------------------------------------------|-----------------|--------------------------------------|
| ①          | Output to 2L+                              | 1L+             | Supply voltage 1L+ (non-switched)    |
| ②          | DQ circuit                                 | 1M              | Ground 1M (non-switched)             |
| ③          | Microcontroller                            | 2L+             | Load voltage 2L+ (switched)          |
| ④          | Monitoring                                 | 2M              | Ground 2M (switched)                 |
| ⑤          | Internal supply voltage                    | DQ <sub>n</sub> | Output signal                        |
| X10 to X17 | Channels 0 to 7                            | DQ              | Channel status LEDs (0 to 7) (green) |
| X35        | IO-Link interface                          | DIAG            | Diagnostic status LED (red/green)    |
| X80        | Connector for infeed of supply voltage 2L+ | PWR             | Supply voltage LED 2L+ (green)       |

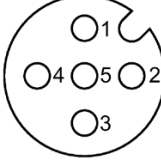
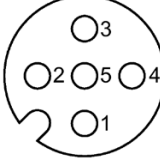
Figure 3-1 Terminal and block diagram

## 3.2 Pin assignment

### Pin assignment of the sockets for digital outputs

The table below shows the pin assignment of the 8 sockets for the connection of the digital outputs.

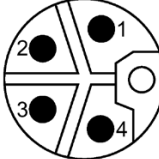
Table 3- 1 Pin assignment for digital outputs

| Pin | Assignment                                                                                                                                                                                                                                                                                   | Front view of the sockets                                                           |                                                                                     |
|-----|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------|
|     | X10 to X17 sockets for digital outputs                                                                                                                                                                                                                                                       | X10, X12, X14, X16                                                                  | X11, X13, X15, X17                                                                  |
| 1   | Unassigned                                                                                                                                                                                                                                                                                   |                                                                                     |                                                                                     |
| 2   | Unassigned                                                                                                                                                                                                                                                                                   |                                                                                     |                                                                                     |
| 3   | Ground 2M                                                                                                                                                                                                                                                                                    |                                                                                     |                                                                                     |
| 4   | Output signal DQ0: Connector X10<br>Output signal DQ1: Connector X11<br>Output signal DQ2: Connector X12<br>Output signal DQ3: Connector X13<br>Output signal DQ4: Connector X14<br>Output signal DQ5: Connector X15<br>Output signal DQ6: Connector X16<br>Output signal DQ7: Connector X17 |  |  |
| 5   | Functional earth FE                                                                                                                                                                                                                                                                          |                                                                                     |                                                                                     |

### Pin assignment of the connector for infeed of the supply voltage 2L+

The table below shows the pin assignment of the connector for infeed of the supply voltage 2L+.

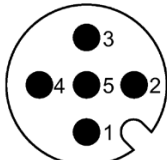
Table 3- 2 Pin assignment of the supply voltage connector

| Pin | Assignment | Front view of the connector                                                           |
|-----|------------|---------------------------------------------------------------------------------------|
|     | X80        |                                                                                       |
| 1   | Unassigned |  |
| 2   | Ground 2M  |                                                                                       |
| 3   | Unassigned |                                                                                       |
| 4   | 2L+        |                                                                                       |

### Pin assignment of the connector for IO-Link

The following table shows the pin assignment of the connector for IO-Link. The IO-Link interface corresponds to the specification according to port Class A.

Table 3- 3 Pin assignment of the IO-Link interface

| Pin | Assignment                              | Front view of the connector (Port Class A)                                          |
|-----|-----------------------------------------|-------------------------------------------------------------------------------------|
|     | X35                                     |                                                                                     |
| 1   | 1L+                                     |  |
| 2   | Unassigned                              |                                                                                     |
| 3   | Ground 1M                               |                                                                                     |
| 4   | Switching and communication cable (C/Q) |                                                                                     |
| 5   | Unassigned                              |                                                                                     |

#### Note

Note that the module can only be supplied with a protective low voltage according to the standard SELV/PELV.

## Parameters/address space

### 4.1 Parameters

The following table shows the parameters for the DQ 8x24VDC/2A 8xM12 IO-Link digital output module.

Table 4- 1 Parameters

| Parameters                            | Value range             |     |     | Default  | Scope                                         | ISDU index (decimal) | ISDU subindex (decimal) |
|---------------------------------------|-------------------------|-----|-----|----------|-----------------------------------------------|----------------------|-------------------------|
|                                       | Value                   | Dec | Hex |          |                                               |                      |                         |
| Diagnostics: Missing load voltage 2L+ | Disable                 | 0   | 0   | Disable  | Module                                        | 131                  | 1                       |
|                                       | Enable                  | 255 | FF  |          |                                               |                      |                         |
| Diagnostics: Short-circuit to ground  | Disable                 | 0   | 0   | Disable  | Module (Short-circuit of an output to ground) | 131                  | 2                       |
|                                       | Enable                  | 255 | FF  |          |                                               |                      |                         |
| Reaction to CPU/master STOP           | Shutdown                | 0   | 0   | Shutdown | Module                                        | 131                  | 3                       |
|                                       | Keep last value         | 2   | 2   |          |                                               |                      |                         |
|                                       | Output substitute value | 3   | 3   |          |                                               |                      |                         |
| Substitute value channel              | 0                       | 0   | 0   | 0        | Channel                                       | 131                  | 4 ... 11                |
|                                       | 1                       | 255 | FF  |          |                                               |                      |                         |

### 4.2 Explanation of the parameters

#### Diagnostics: Missing load voltage 2L+

Enabling of the diagnostics for missing or insufficient load voltage 2L+.

#### Diagnostics: Short-circuit to ground

Enabling of the diagnostics for short-circuit of the output to ground.

#### Reaction to CPU/master STOP

With this parameter, you set the reaction of the digital outputs of the module after a CPU/master STOP:

- Shut down: The digital output is de-energized.
- Keep last value: The last value of the digital output remains activated.
- Output substitute value: The module outputs a configured substitute value.

#### Substitute value channel

With this parameter, you set substitute values for the digital outputs.

## 4.3 Address space

The figure below shows the assignment of the address space for the DQ 8x24VDC/2A 8xM12 IO-Link digital output module.

Assignment in the process image output (PIQ)



Figure 4-1 Address space IO-Link DQ 8x24VDC/2A 8xM12

## 4.4 IODD parameters

### Device description IODD

An electronic device description is available for the DQ 8x24VDC/2A 8xM12 IO-Link digital output module, the IODD file (IO Device Description). The IODD provides a wealth of information for system integration:

- Communication properties
- Device parameters with value range and default value
- Identification, process and diagnostic data
- Device data
- Text description
- Image of the device
- Manufacturer logo

The structure of the IODD is identical for all devices from all manufacturers. The structure of the IODD is always represented in the same manner by the IO-Link Configuration Tool of the master manufacturer (for Siemens, S7-PCT). This ensures that the handling is the same for all IO-Link devices regardless of the manufacturer.

### IODDfinder

The IODDfinder is a cross-vendor, central IO-Link database.

This database provides you with the latest IODDs of the device manufacturers and offers an information and download platform.

The IODDfinder is available on the Internet (<https://ioddfinder.io-link.com>).

# Interrupts/diagnostic alarms

## 5.1 Status and error displays

### LED displays

The figure below shows the LED displays (status and error displays) of the DQ 8x24VDC/2A 8xM12 IO-Link digital output module.

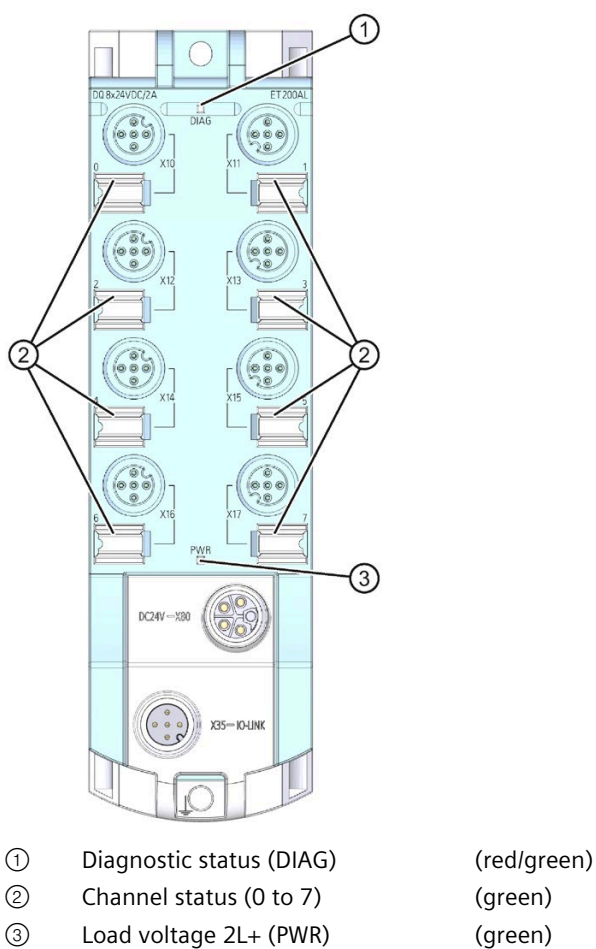


Figure 5-1 LED displays



## Meaning of the LEDs

The following tables set out the meaning of the status and error displays. Remedial measures for diagnostic alarms can be found in the section Diagnostics alarms (Page 19).

### DIAG LED

Table 5- 1 Error display of the DIAG LED

| DIAG LED                                                                                     | Meaning                                                                                                                                   |
|----------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------|
| <br>Off     | No supply voltage 1L+                                                                                                                     |
| <br>Flashes | <ul style="list-style-type: none"> <li>No data exchange with the IO-Link Master (e.g. wire break)</li> <li>Firmware is loading</li> </ul> |
| <br>On      | Module is currently exchanging data with the IO-Link master and no module diagnostics                                                     |
| <br>Flashes | Module is currently exchanging data with the IO-Link master and module diagnostics                                                        |

### LED channel status

Table 5- 2 LED channel status display

| LED channel status                                                                         | Meaning            |
|--------------------------------------------------------------------------------------------|--------------------|
| <br>Off | Process signal = 0 |
| <br>On  | Process signal = 1 |

### PWR LED

Table 5- 3 Status display of the PWR LED

| PWR LED                                                                                    | Meaning                                |
|--------------------------------------------------------------------------------------------|----------------------------------------|
| <br>Off | Load voltage 2L+ is missing or too low |
| <br>On  | Load voltage 2L+ present               |

## 5.2 Interrupts

The DQ 8x24VDC/2A 8xM12 IO-Link digital output module supports diagnostic interrupts.

### Diagnostic interrupt

The digital output module generates a diagnostic interrupt at the following events:

- Short-circuit of outputs to ground
- Load voltage 2L+ missing or too low

## 5.3 Diagnostics alarms

For each diagnostic event, a diagnostics alarm is issued and the LED DIAG flashes red on the digital output module. You can read out the diagnostics alarms, for example, from the status of the IO-Link master. You can evaluate the error codes with the user program.

Table 5- 4 Diagnostics alarms, their meanings and corrective measures

| Diagnostics alarm        | Error code | Meaning                              | Remedy                                                                                                |
|--------------------------|------------|--------------------------------------|-------------------------------------------------------------------------------------------------------|
| Short-circuit            | 0x7711     | Short-circuit of an output to ground | Eliminate the short-circuit                                                                           |
| Load voltage 2L+ missing | 0x5112     | Load voltage 2L+ missing or too low  | <ul style="list-style-type: none"><li>• Check the supply voltage</li><li>• Check the module</li></ul> |

## Technical specifications

### Technical specifications of the DQ 8x24VDC/2A 8xM12 IO-Link digital output module

The following table shows the technical specifications as of the issue date. You can find a data sheet including daily updated technical specifications on the Internet

(<https://support.industry.siemens.com/cs/de/en/pv/6ES7142-5AF00-0BL0/td?dl=en>).

|                                          |                                              |
|------------------------------------------|----------------------------------------------|
| <b>Article number</b>                    | <b>6ES7142-5AF00-0BL0</b>                    |
| <b>General information</b>               |                                              |
| Product type designation                 | IO-Link DQ 8x24VDC/2A                        |
| HW functional status                     | FS01                                         |
| Firmware version                         | V1.0.x                                       |
| <b>Engineering with</b>                  |                                              |
| • IODD file                              | Yes                                          |
| <b>Supply voltage</b>                    |                                              |
| <b>Load voltage 1L+</b>                  |                                              |
| • Rated value (DC)                       | 24 V; Supply from 1Us+ of the IO-Link master |
| • permissible range, lower limit (DC)    | 18 V                                         |
| • permissible range, upper limit (DC)    | 30 V                                         |
| • Reverse polarity protection            | Yes; against destruction                     |
| <b>Load voltage 2L+</b>                  |                                              |
| • Rated value (DC)                       | 24 V; Supply via M12 connector L-coded       |
| • permissible range, lower limit (DC)    | 20.4 V                                       |
| • permissible range, upper limit (DC)    | 28.8 V                                       |
| • Reverse polarity protection            | Yes; against destruction; load increasing    |
| <b>Input current</b>                     |                                              |
| Current consumption (rated value)        | 12 mA; without load                          |
| from load voltage 2L+, max.              | 8 A; Maximum value                           |
| <b>Power loss</b>                        |                                              |
| Power loss, typ.                         | 3.6 W                                        |
| <b>Digital outputs</b>                   |                                              |
| Number of digital outputs                | 8                                            |
| Short-circuit protection                 | Yes; per channel, electronic                 |
| • Response threshold, typ.               | 2.8 A                                        |
| <b>Switching capacity of the outputs</b> |                                              |
| • on lamp load, max.                     | 10 W                                         |

|                                                  |                                                          |
|--------------------------------------------------|----------------------------------------------------------|
| <b>Article number</b>                            | <b>6ES7142-5AF00-0BL0</b>                                |
| <b>Load resistance range</b>                     |                                                          |
| • lower limit                                    | 12 Ω                                                     |
| • upper limit                                    | 4 kΩ                                                     |
| <b>Output voltage</b>                            |                                                          |
| • for signal "1", min.                           | L+ (-0.8 V)                                              |
| <b>Output current</b>                            |                                                          |
| • for signal "1" rated value                     | 2 A (45 °C); 1 A (55 °C)                                 |
| • for signal "1" permissible range, max.         | 2 A; with inductive load to IEC 60947-5-1, DC-13 / AC-15 |
| • for signal "0" residual current, max.          | 0.5 mA                                                   |
| <b>Switching frequency</b>                       |                                                          |
| • with resistive load, max.                      | 100 Hz                                                   |
| • with inductive load, max.                      | 0.1 Hz; 0.25 Hz at 25 °C                                 |
| • on lamp load, max.                             | 1 Hz                                                     |
| <b>Total current of the outputs</b>              |                                                          |
| • Current per module, max.                       | 8 A                                                      |
| <b>Cable length</b>                              |                                                          |
| • unshielded, max.                               | 30 m                                                     |
| <b>IO-Link</b>                                   |                                                          |
| IO-Link protocol 1.1                             | Yes                                                      |
| Transmission rate                                | 38.4 kBd (COM2)                                          |
| Cycle time, min.                                 | 2.1 ms                                                   |
| Size of process data, input per module           | 0 byte                                                   |
| Size of process data, output per module          | 1 byte                                                   |
| Supported IO-Link profiles                       | common profile                                           |
| Cable length unshielded, max.                    | 20 m                                                     |
| <b>Connection of IO-Link devices</b>             |                                                          |
| • Port type A                                    | Yes                                                      |
| <b>Interrupts/diagnostics/status information</b> |                                                          |
| Substitute values connectable                    | Yes; channel by channel, parameterizable                 |
| <b>Alarms</b>                                    |                                                          |
| • Diagnostic alarm                               | Yes; Parameterizable                                     |
| <b>Diagnoses</b>                                 |                                                          |
| • Short-circuit                                  | Yes; Outputs to ground; module by module                 |
| <b>Diagnostics indication LED</b>                |                                                          |
| • Channel status display                         | Yes; green LED                                           |
| • for module diagnostics                         | Yes; green/red LED                                       |
| • For load voltage monitoring                    | Yes; green LED                                           |

|                                                                                        |                           |
|----------------------------------------------------------------------------------------|---------------------------|
| <b>Article number</b>                                                                  | <b>6ES7142-5AF00-0BL0</b> |
| <b>Potential separation</b>                                                            |                           |
| between the load voltages                                                              | Yes                       |
| <b>Potential separation channels</b>                                                   |                           |
| • between the channels                                                                 | No                        |
| • between the channels and the power supply of the electronics                         | Yes                       |
| <b>Isolation</b>                                                                       |                           |
| Isolation tested with                                                                  | 707 V DC (type test)      |
| <b>Standards, approvals, certificates</b>                                              |                           |
| Suitable for safety-related tripping of standard modules                               | Yes; From FS01            |
| <b>Highest safety class achievable for safety-related tripping of standard modules</b> |                           |
| • Performance level according to ISO 13849-1                                           | PL d                      |
| • Category according to ISO 13849-1                                                    | Cat. 3                    |
| • SILCL according to IEC 62061                                                         | SILCL 2                   |
| <b>Ambient conditions</b>                                                              |                           |
| <b>Ambient temperature during operation</b>                                            |                           |
| • min.                                                                                 | -30 °C                    |
| • max.                                                                                 | 55 °C                     |
| <b>Connection method</b>                                                               |                           |
| Design of electrical connection for the inputs and outputs                             | M12, 5-pin, A-coded       |
| Type of electrical connection for IO-Link                                              | M12, 5-pin, A-coded       |
| Design of electrical connection for supply voltage                                     | M12, 4-pin, L-coded       |
| <b>Dimensions</b>                                                                      |                           |
| Width                                                                                  | 45 mm                     |
| Height                                                                                 | 159 mm                    |
| Depth                                                                                  | 45 mm                     |
| <b>Weights</b>                                                                         |                           |
| Weight, approx.                                                                        | 168 g                     |

## Derating curve

The following figure show the load current derating with mounting clearance observed, depending on the ambient temperature.

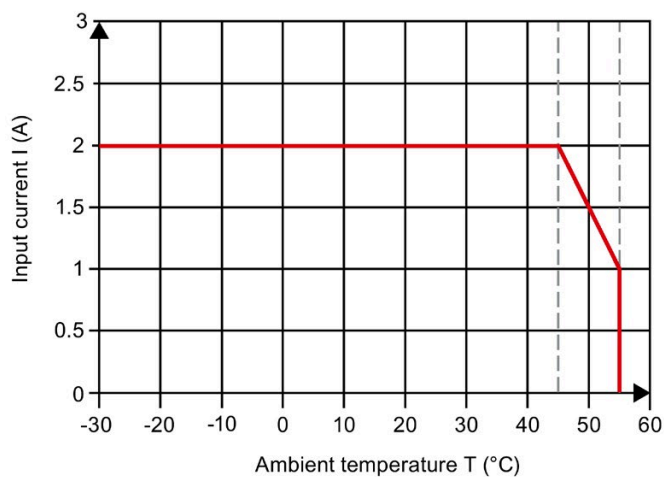


Figure 6-1 Derating curve IO-Link digital output module DQ 8x24VDC/2A 8xM12

## Dimension drawing

The figure below shows the dimension drawing of the DQ 8x24VDC/2A 8xM12 IO-Link digital output module in front and side views.

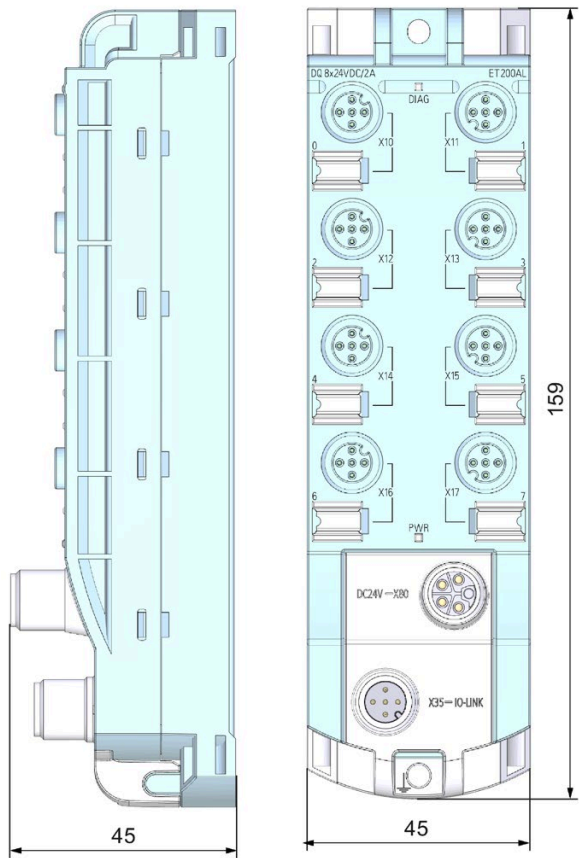
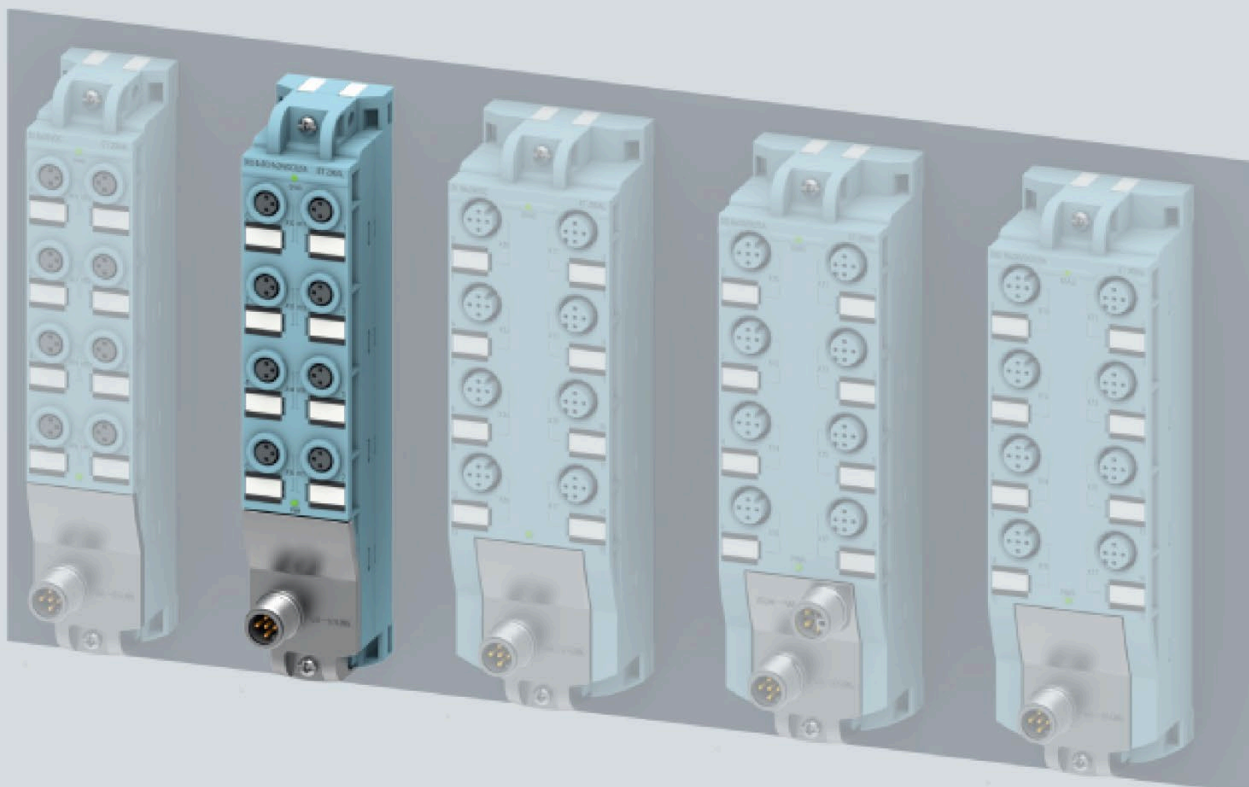


Figure A-1 Dimension drawing

# SIEMENS



Manual

## SIMATIC

### ET 200AL

IO-Link Digital input / output module  
DIQ 4+DQ 4x24VDC/0,5A 8xM8  
(6ES7143-5BF00-0BL0)

Edition

08/2021

[support.industry.siemens.com](https://support.industry.siemens.com)



## SIMATIC

### ET 200AL IO-Link digital input/digital output module DIQ 4+DQ 4x24VDC/0,5A 8xM8 (6ES7143-5BF00-0BL0)

#### Equipment Manual

#### Preface

ET 200AL IO-Link I/O  
modules Documentation  
Guide

**1**

Product overview

**2**

Wiring

**3**

Parameters/address space

**4**

Interrupts/diagnostics  
alarms

**5**

Technical specifications

**6**

Dimension drawing

**A**

## Legal information

### Warning notice system

This manual contains notices you have to observe in order to ensure your personal safety, as well as to prevent damage to property. The notices referring to your personal safety are highlighted in the manual by a safety alert symbol, notices referring only to property damage have no safety alert symbol. These notices shown below are graded according to the degree of danger.

#### **DANGER**

indicates that death or severe personal injury **will** result if proper precautions are not taken.

#### **WARNING**

indicates that death or severe personal injury **may** result if proper precautions are not taken.

#### **CAUTION**

indicates that minor personal injury can result if proper precautions are not taken.

#### **NOTICE**

indicates that property damage can result if proper precautions are not taken.

If more than one degree of danger is present, the warning notice representing the highest degree of danger will be used. A notice warning of injury to persons with a safety alert symbol may also include a warning relating to property damage.

### Qualified Personnel

The product/system described in this documentation may be operated only by **personnel qualified** for the specific task in accordance with the relevant documentation, in particular its warning notices and safety instructions. Qualified personnel are those who, based on their training and experience, are capable of identifying risks and avoiding potential hazards when working with these products/systems.

### Proper use of Siemens products

Note the following:

#### **WARNING**

Siemens products may only be used for the applications described in the catalog and in the relevant technical documentation. If products and components from other manufacturers are used, these must be recommended or approved by Siemens. Proper transport, storage, installation, assembly, commissioning, operation and maintenance are required to ensure that the products operate safely and without any problems. The permissible ambient conditions must be complied with. The information in the relevant documentation must be observed.

### Trademarks

All names identified by ® are registered trademarks of Siemens AG. The remaining trademarks in this publication may be trademarks whose use by third parties for their own purposes could violate the rights of the owner.

### Disclaimer of Liability

We have reviewed the contents of this publication to ensure consistency with the hardware and software described. Since variance cannot be precluded entirely, we cannot guarantee full consistency. However, the information in this publication is reviewed regularly and any necessary corrections are included in subsequent editions.

# Preface

## Purpose of the documentation

This manual supplements the system manual ET 200AL IO-Link (<https://support.automation.siemens.com/WW/view/en/109773203>). Functions that generally relate to the distributed I/O system ET 200AL IO-Link I/O modules are described there.

The information provided in this manual and in the system manual and function manuals supports you in commissioning the ET 200AL IO-Link I/O modules.

## Changes compared to the previous version

This manual contains the following changes compared to the previous version:

- Supplements in the section Parameters (Page 15).
- Update of the section Technical specifications (Page 22)

## Conventions

Also observe notes labeled as follows:

---

### Note

Indicates important product information to which particular attention should be paid.

---

## Security information

Siemens provides products and solutions with industrial security functions that support the secure operation of plants, systems, machines and networks.

In order to protect plants, systems, machines and networks against cyber threats, it is necessary to implement – and continuously maintain – a holistic, state-of-the-art industrial security concept. Siemens' products and solutions constitute one element of such a concept.

Customers are responsible for preventing unauthorized access to their plants, systems, machines and networks. Such systems, machines and components should only be connected to an enterprise network or the internet if and to the extent such a connection is necessary and only when appropriate security measures (e.g. firewalls and/or network segmentation) are in place.

For additional information on industrial security measures that may be implemented, please visit (<https://www.siemens.com/industrialsecurity>).

Siemens' products and solutions undergo continuous development to make them more secure. Siemens strongly recommends that product updates are applied as soon as they are available and that the latest product versions are used. Use of product versions that are no longer supported, and failure to apply the latest updates may increase customers' exposure to cyber threats.

To stay informed about product updates, subscribe to the Siemens Industrial Security RSS Feed visit (<https://www.siemens.com/industrialsecurity>).

# Table of contents

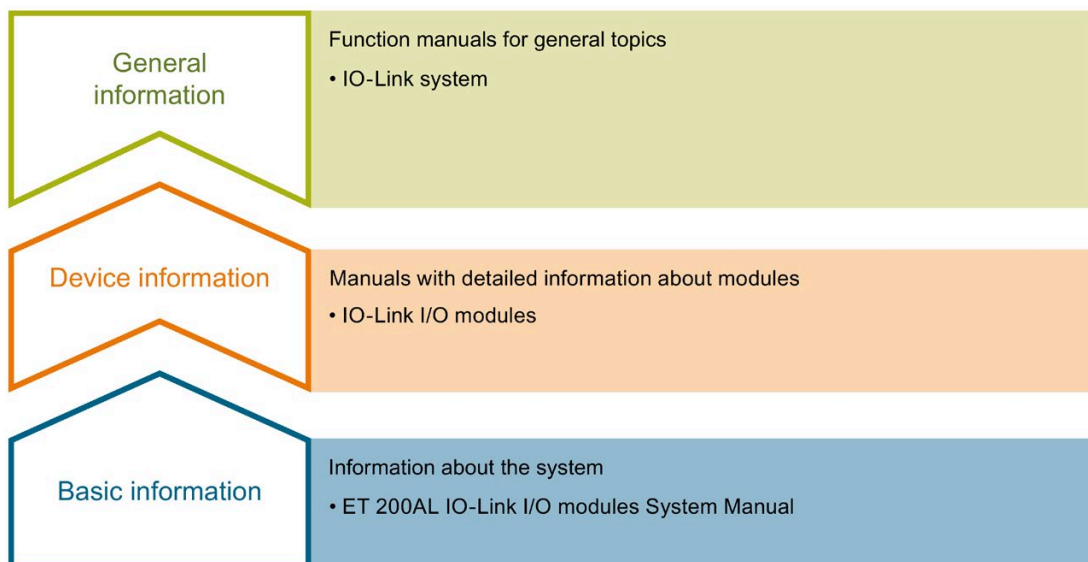
|   |                                                        |    |
|---|--------------------------------------------------------|----|
|   | Preface .....                                          | 3  |
| 1 | ET 200AL IO-Link I/O modules Documentation Guide ..... | 5  |
| 2 | Product overview .....                                 | 8  |
|   | 2.1 Properties .....                                   | 8  |
|   | 2.2 Operator controls and display elements .....       | 11 |
| 3 | Wiring .....                                           | 12 |
|   | 3.1 Terminal and block diagram .....                   | 12 |
|   | 3.2 Pin assignment .....                               | 13 |
| 4 | Parameters/address space .....                         | 15 |
|   | 4.1 Parameters .....                                   | 15 |
|   | 4.2 Explanation of the parameters .....                | 16 |
|   | 4.3 Address space .....                                | 17 |
|   | 4.4 IODD parameters .....                              | 18 |
| 5 | Interrupts/diagnostics alarms .....                    | 19 |
|   | 5.1 Status and error displays .....                    | 19 |
|   | 5.2 Interrupts .....                                   | 21 |
|   | 5.3 Diagnostics alarms .....                           | 21 |
| 6 | Technical specifications .....                         | 22 |
| A | Dimension drawing .....                                | 26 |

# ET 200AL IO-Link I/O modules Documentation Guide

# 1

The documentation for the SIMATIC ET 200AL IO-Link I/O modules is arranged into three areas.

This arrangement enables you to access the specific content you require.



## Basic information

The system manual describes in detail the configuration, installation, wiring and commissioning of the distributed I/O system SIMATIC ET 200AL IO-Link I/O modules.

## Device information

Equipment manuals contain a compact description of the module-specific information, such as properties, wiring diagrams, characteristics and technical specifications.

## General information

The function manuals contain detailed descriptions on general topics regarding the SIMATIC IO-Link system.

You can download the documentation free of charge from the Internet (<https://support.industry.siemens.com/cs/ww/en/view/109742667>).

## ET 200AL Manual Collection

The Manual Collection contains the complete documentation on the SIMATIC ET 200AL distributed I/O system gathered together in one file.

You can find the Manual Collection on the Internet (<https://support.automation.siemens.com/WW/view/en/95242965>).

## "mySupport"

With "mySupport", your personal workspace, you make the best out of your Industry Online Support.

In "mySupport", you can save filters, favorites and tags, request CAx data and compile your personal library in the Documentation area. In addition, your data is already filled out in support requests and you can get an overview of your current requests at any time.

You must register once to use the full functionality of "mySupport".

You can find "mySupport" on the Internet (<https://support.industry.siemens.com/My/ww/en>).

## "mySupport" - Documentation

With "mySupport", your personal workspace, you make the best out of your Industry Online Support.

In "mySupport", you can save filters, favorites and tags, request CAx data and compile your personal library in the Documentation area. In addition, your data is already filled out in support requests and you can get an overview of your current requests at any time.

You must register once to use the full functionality of "mySupport".

You can find "mySupport" on the Internet (<https://support.industry.siemens.com/My/ww/en/documentation>).

## "mySupport" - CAx data

In the CAx data area of "mySupport", you can access the latest product data for your CAx or CAe system.

You configure your own download package with a few clicks.

You can select:

- Product images, 2D dimension drawings, 3D models, internal circuit diagrams, EPLAN macro files
- Manuals, characteristics, operating manuals, certificates
- Product master data

You can find "mySupport" CAx data on the Internet (<https://support.industry.siemens.com/my/ww/en/CAxOnline>).

## Application examples

The application examples support you with various tools and examples for solving your automation tasks. Solutions are shown in interplay with multiple components in the system - separated from the focus on individual products.

You will find the application examples on the Internet (<https://support.industry.siemens.com/cs/ww/en/ps/ae>).

## TIA Selection Tool

With the TIA Selection Tool, you can select, configure and order devices for Totally Integrated Automation (TIA).

This tool is the successor of the SIMATIC Selection Tool and combines the known configurators for automation technology into one tool.

With the TIA Selection Tool, you can generate a complete order list from your product selection or product configuration.

You can find the TIA Selection Tool on the Internet

(<https://support.industry.siemens.com/cs/ww/en/view/109767888>).

## PRONETA

SIEMENS PRONETA (PROFINET network analysis) allows you to analyze the plant network during commissioning. PRONETA has two core functions:

- The topology overview automatically scans the PROFINET and all connected components.
- The IO check is a fast test of the wiring and the module configuration of a plant.

You can find SIEMENS PRONETA on the Internet

(<https://support.industry.siemens.com/cs/ww/en/view/67460624>).

## SIMATIC S7-PCT

The Port Configuration Tool ("PCT") is PC-based software for the parameter assignment of Siemens IO-Link master-modules and IO-Link devices from any manufacturer.

The IO-Link devices are integrated using the standardized device description "IODD" that is available from the respective device manufacturer. S7-PCT supports the version 1.0 as well as V1.1 of the IODD.

S7-PCT is called via the hardware configuration of the IO-Link masters from STEP 7; however, it can also be started as "standalone" if the IO-Link master is not operated on a SIMATIC controller or when STEP 7 is not used.

You can find additional information on IO-Link on the Internet

(<https://new.siemens.com/global/en/products/automation/industrial-communication/io-link.html>).

## Product overview

### 2.1 Properties

#### Article number

6ES7143-5BF00-0BL0

#### View of the module

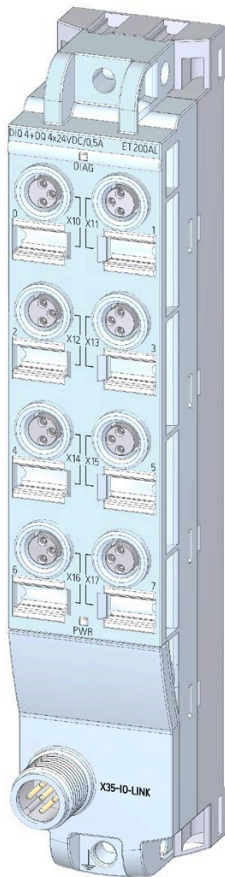


Figure 2-1 View of the DIQ 4+DQ 4x24VDC/0,5A 8xM8 IO-Link digital input/digital output module



## Properties

The module has the following technical properties:

- 4 digital inputs or digital outputs and 4 digital outputs, depending on parameter assignment
  - DIQ signals connected to 2L+ (switched)
  - DQ signals connected to 2L+ (switched)
- M8 sockets for connection of sensors and actuators
- Digital inputs:
  - 24 V DC supply voltage
  - Configurable diagnostics can be set for each module
  - Typical input delay of 3 ms
  - Suitable for switches and proximity switches
- Digital outputs:
  - Rated load voltage 24 V DC
  - Suitable for solenoid valves, DC contactors, and indicator lights
  - Output current 0.5 A per output
  - Configurable diagnostics can be set for each module
- Dimensions 30 x 159 mm
- Interface for IO-Link and power supply:
  - M12 connector A-coded
  - IO-Link Port Class B
  - Supply of the module electronics
  - Encoder supply and load voltage supply of output

The module supports the following functions:

- Firmware update
- IO-Link profile: General profile

## Accessories

The following components are included in the module package:

- Identification labels
- Spacers

## Other components

The following component can be ordered as spare part:

- Identification labels

The following components can be ordered as accessories:

- Connectors
- Cables
- M8 sealing cap

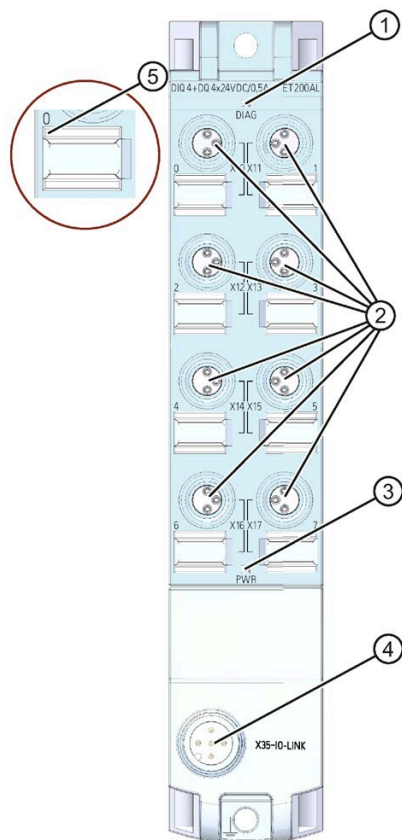
## See also

You can find more information on accessories in the Accessories/spare parts section of the ET 200AL distributed I/O system

(<https://support.automation.siemens.com/WW/view/en/109773203>) IO-Link I/O modules system manual.

## 2.2 Operator controls and display elements

The figure below shows the operator controls and display elements of the DIQ 4+DQ 4x24VDC/0,5A 8xM8 IO-Link digital input/digital output module.



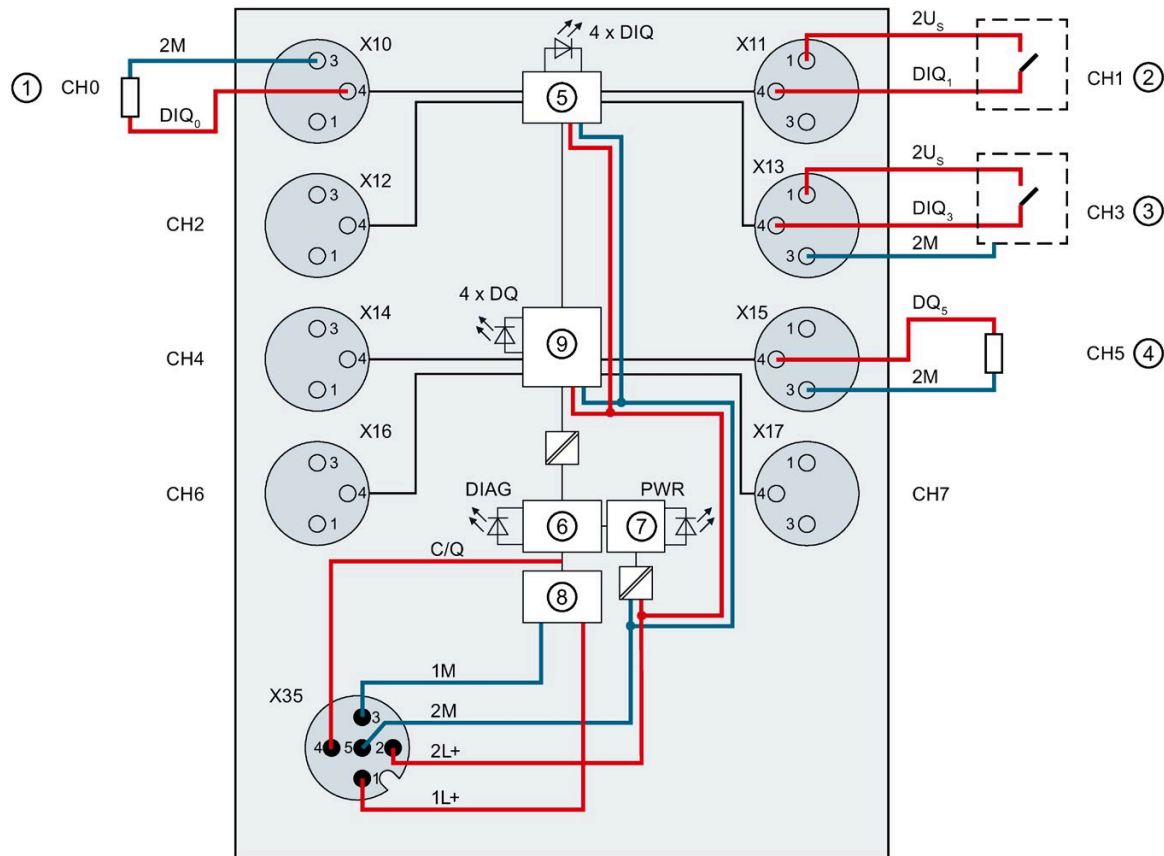
- ① DIAG: LED display for the diagnostic status
- ② X10 to X17: Sockets for the input/output signal
- ③ PWR: LED display for load voltage 2L+
- ④ X35: IO-Link interface
- ⑤ LED displays 0 to 7 for the channel status

Figure 2-2 Operator controls and display elements

## Wiring

### 3.1 Terminal and block diagram

The following figure shows an example of the pin assignment of signal inputs with 2- and 3-wire connection as well as signal outputs.



|            |                                        |                  |                                             |
|------------|----------------------------------------|------------------|---------------------------------------------|
| ①          | Configured as output                   | 1L+              | Supply voltage 1L+ (non-switched)           |
| ②          | Configured as input: 2-wire connection | 1M               | Ground 1M (non-switched)                    |
| ③          | Configured as input: 3-wire connection | 2L+              | Load voltage 2L+ (switched)                 |
| ④          | Output                                 | 2M               | Ground 2M (switched)                        |
| ⑤          | DI/DQ circuit (2L+ switched)           | 2Us              | 24 V encoder supply                         |
| ⑥          | Microcontroller                        | DIQ <sub>n</sub> | Input/output signal                         |
| ⑦          | Monitoring                             | DQ <sub>n</sub>  | Output signal                               |
| ⑧          | Internal supply voltage                | DIQ              | LEDs channel status (0, 1, 2 and 3) (green) |
| ⑨          | DQ circuit (2L+ switched)              | DQ               | LEDs channel status (4, 5, 6 and 7) (green) |
| X10 to X17 | Channels 0 to 7                        | DIAG             | LED diagnostic status (red/green)           |
| X35        | IO-Link interface                      | PWR              | LED supply voltage 2L+ (green)              |

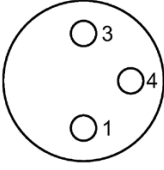
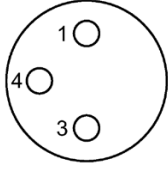
Figure 3-1 Terminal and block diagram

## 3.2 Pin assignment

### Pin assignment of the sockets for digital inputs/digital outputs

The tables below show the pin assignments of the 8 sockets for connection of the digital inputs/digital outputs.

Table 3- 1 Pin assignment for digital inputs/digital outputs

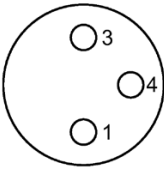
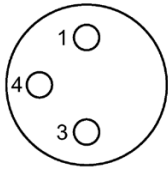
| Pin | Assignment                                                                                                                       | Front view of the sockets                                                           |                                                                                     |
|-----|----------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------|
|     | X10 to X13 - sockets for digital inputs / outputs                                                                                | X10, X12                                                                            | X11, X13                                                                            |
| 1   | 24 V encoder supply 2Us<br>(derived from 2L+ switched)                                                                           |  |  |
| 3   | Ground 2M                                                                                                                        |                                                                                     |                                                                                     |
| 4   | Input/output signal DIQ0: X10<br>Input/output signal DIQ1: X11<br>Input/output signal DIQ2: X12<br>Input/output signal DIQ3: X13 |                                                                                     |                                                                                     |

#### NOTICE

#### 24 V encoder supply 2Us

Use only the 24 V encoder supply 2Us provided by the digital input/digital output module to supply power to the encoder.

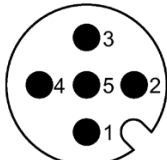
Table 3- 2 Pin assignment for digital outputs

| Pin | Assignment                                                                                           | Front view of the sockets                                                             |                                                                                       |
|-----|------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------|
|     | X14 to X17- sockets for digital inputs / outputs                                                     | X14, X16                                                                              | X15, X17                                                                              |
| 1   | n.c.                                                                                                 |  |  |
| 3   | Ground 2M                                                                                            |                                                                                       |                                                                                       |
| 4   | Output signal DQ4: X14<br>Output signal DQ5: X15<br>Output signal DQ6: X16<br>Output signal DQ7: X17 |                                                                                       |                                                                                       |

### Pin assignment of the IO-Link connector

The following table shows the pin assignment of the connector for the IO-Link connection. The IO-Link interface corresponds to the specification according to Port Class B.

Table 3- 3 Pin assignment of the IO-Link interface

| Pin | Assignment                              | Front view of the connector (Port Class B)                                          |
|-----|-----------------------------------------|-------------------------------------------------------------------------------------|
|     | X35                                     |                                                                                     |
| 1   | 1L+                                     |  |
| 2   | 2L+                                     |                                                                                     |
| 3   | Ground 1M                               |                                                                                     |
| 4   | Switching and communication cable (C/Q) |                                                                                     |
| 5   | Ground 2M                               |                                                                                     |

#### Note

Note that the module can only be supplied with a protective low voltage according to the standard SELV/PELV.

## Parameters/address space

### 4.1 Parameters

The following table shows the parameters for the DIQ 4+DQ 4x24VDC/0,5A 8xM8 IO-Link digital input / digital output module.

Table 4- 1 Parameters

| Parameters                            | Value range             |          |          | Default  | Scope                                                                  | ISDU index (decimal) | ISDU sub-index (decimal) |
|---------------------------------------|-------------------------|----------|----------|----------|------------------------------------------------------------------------|----------------------|--------------------------|
|                                       | Value                   | Dec<br>. | Hex<br>. |          |                                                                        |                      |                          |
| Diagnostics: Missing load voltage 2L+ | Disable                 | 0        | 0        | Disable  | Module                                                                 | 131                  | 1                        |
|                                       | Enable                  | 255      | FF       |          |                                                                        |                      |                          |
| Diagnostics: Short-circuit to ground  | Disable                 | 0        | 0        | Disable  | Module<br>(Short-circuit of encoder supply or of the output to ground) | 131                  | 2                        |
|                                       | Enable                  | 255      | FF       |          |                                                                        |                      |                          |
| Freely assignable channel 0 ... 3     | DI                      | 0        | 0        | DI       | Channel                                                                | 131                  | 3 ... 6                  |
|                                       | DQ                      | 255      | FF       |          |                                                                        |                      |                          |
| Reaction to CPU/master STOP           | Shutdown                | 0        | 0        | Shutdown | Module<br>(digital outputs)                                            | 131                  | 7                        |
|                                       | Keep last value         | 2        | 2        |          |                                                                        |                      |                          |
|                                       | Output substitute value | 3        | 3        |          |                                                                        |                      |                          |
| Substitute value channel              | 0                       | 0        | 0        | 0        | Channel<br>(digital outputs)                                           | 131                  | 8 ... 15                 |
|                                       | 1                       | 255      | FF       |          |                                                                        |                      |                          |

## 4.2 Explanation of the parameters

### **Diagnostics: Missing load voltage 2L+**

Enabling of the diagnostics for missing or insufficient load voltage 2L+.

### **Diagnostics: Short-circuit to ground**

Enabling of the diagnostics for short-circuit of the encoder supply or output to ground.

### **Freely assignable channel n**

With this parameter, you set whether the channel is to be operated as an input or output.

### **Reaction to CPU/master STOP**

With this parameter, you set the reaction of the digital outputs of the digital input/digital output module after a CPU/master STOP:

- Shut down: The digital output is de-energized.
- Keep last value: The last value of the digital output remains activated.
- Output substitute value: The module outputs a configured substitute value.

### **Substitute value channel**

With this parameter, you set substitute values for the digital outputs.



## 4.3 Address space

The figure below shows the assignment of the address space for the IO-Link DIQ 4+DQ 4x24VDC/0,5A 8xM8.

Assignment in the process image input (PII)

|      |   |   |   |   |   |   |   |   |                                 |
|------|---|---|---|---|---|---|---|---|---------------------------------|
|      | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |                                 |
| IB x | 0 | 0 | 0 | 0 |   |   |   |   | Input values at channels 0 to 3 |

Assignment in the process image output (PIQ)

|      |   |   |   |   |   |   |   |   |                                  |
|------|---|---|---|---|---|---|---|---|----------------------------------|
|      | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |                                  |
| QB x |   |   |   |   |   |   |   |   | Output values at channels 0 to 7 |

Figure 4-1 Address space IO-Link DIQ 4+DQ 4x24VDC/0,5A 8xM8

---

### Note

#### Parameter assignment of the channels

Parameters for the first four channels can be freely assigned.

For the channels 0 ... 3 that are configured as input, the corresponding values in the output data do not trigger any reaction.

For the channels 0 ... 3 that are configured as output, the input value in the process image is 0.

---

## 4.4 IODD parameters

### Device description IODD

An electronic device description is available for the DIQ 4+DQ 4x24VDC/0.5A 8xM8 IO-Link digital input / digital output module, the IODD file (IO Device Description). The IODD provides a wealth of information for system integration:

- Communication properties
- Device parameters with value range and default value
- Identification, process and diagnostic data
- Device data
- Text description
- Image of the device
- Manufacturer logo

The structure of the IODD is identical for all devices from all manufacturers. The structure of the IODD is always represented in the same manner by the IO-Link Configuration Tool of the master manufacturer (for Siemens, S7-PCT). This ensures that the handling is the same for all IO-Link devices regardless of the manufacturer.

### IODDfinder

The IODDfinder is a cross-vendor, central IO-Link database.

This database provides you with the latest IODDs of the device manufacturers and offers an information and download platform.

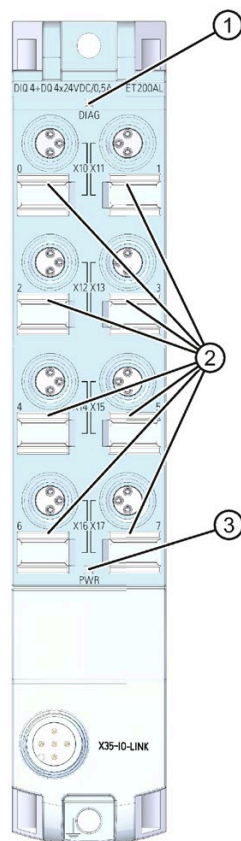
The IODDfinder is available on the Internet (<https://ioddfinder.io-link.com>).

# Interrupts/diagnostics alarms

## 5.1 Status and error displays

### LED displays

The figure below shows the LED displays (status and error displays) of the DIQ 4+DQ 4x24VDC/0,5A 8xM8 IO-Link digital input / digital output module.



- |   |                          |             |
|---|--------------------------|-------------|
| ① | Diagnostic status (DIAG) | (red/green) |
| ② | Channel status (0 to 7)  | (green)     |
| ③ | Load voltage 2L+ (PWR)   | (green)     |

Figure 5-1 LED displays

## Meaning of the LEDs

The following tables set out the meaning of the status and error displays. Corrective measures for diagnostics alarms can be found in the section Diagnostics alarms (Page 21).

### DIAG LED

Table 5- 1 Error display of the DIAG LED

| DIAG LED                                                                                     | Meaning                                                                                                                                                 |
|----------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------|
| <br>Off     | No supply voltage 1L+                                                                                                                                   |
| <br>Flashes | <ul style="list-style-type: none"> <li>No data exchange with the IO-Link Master, for example, due to wire break</li> <li>Firmware is loading</li> </ul> |
| <br>On      | Module is currently exchanging data with the IO-Link master and no module diagnostics                                                                   |
| <br>Flashes | Module is currently exchanging data with the IO-Link master and module diagnostics                                                                      |

### LED channel status

Table 5- 2 LED channel status display

| LED channel status                                                                         | Meaning                           |
|--------------------------------------------------------------------------------------------|-----------------------------------|
| <br>Off | Process signal = 0 or deactivated |
| <br>On  | Process signal = 1                |

### PWR LED

Table 5- 3 Status display of the PWR LED

| PWR LED                                                                                    | Meaning                                |
|--------------------------------------------------------------------------------------------|----------------------------------------|
| <br>Off | Load voltage 2L+ is missing or too low |
| <br>On  | Load voltage 2L+ present               |

## 5.2 Interrupts

The DIQ 4+DQ 4x24VDC/0,5A 8xM8 IO-Link digital input / digital output module supports diagnostic interrupts.

### Diagnostic interrupt

The digital input/digital output module generates a diagnostic interrupt at the following events:

- Short-circuit of encoder supply to ground
- Short-circuit of outputs to ground
- Load voltage 2L+ missing or too low

## 5.3 Diagnostics alarms

For each diagnostic event, a diagnostics alarm is issued and the DIAG LED flashes red on the digital input/output module.

You can read out the diagnostics alarms, for example, from the port status of the IO-Link master. You can evaluate the error codes with the user program.

Table 5- 4 Diagnostics alarms, their meanings and corrective measures

| Diagnostics alarm                                                                                                                                                                                          | Error code | Meaning                                      | Remedy                                                                                                   |
|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------|----------------------------------------------|----------------------------------------------------------------------------------------------------------|
| Short-circuit <sup>1</sup>                                                                                                                                                                                 | 0x7710     | Short-circuit of an encoder supply to ground | <ul style="list-style-type: none"> <li>• Eliminate the short-circuit</li> </ul>                          |
|                                                                                                                                                                                                            | 0x7711     | Short-circuit of an output to ground         |                                                                                                          |
| Load voltage 2L+ missing                                                                                                                                                                                   | 0x5112     | Load voltage 2L+ missing or too low          | <ul style="list-style-type: none"> <li>• Check the supply voltage</li> <li>• Check the module</li> </ul> |
| <sup>1</sup> = If a short-circuit of the encoder supply to ground is detected, the diagnostic alarm "Short-circuit" is always output. This alarm is output even if all channels are configured as outputs. |            |                                              |                                                                                                          |

## Technical specifications

### Technical specifications of the DIQ 4+DQ 4x24VDC/0,5A 8xM8 IO-Link digital input / digital output module

The following table shows the technical specifications as of the issue date. You can find a data sheet including daily updated technical specifications on the Internet (<https://support.industry.siemens.com/cs/de/en/pv/6ES7143-5BF00-0BL0/td?dl=de>).

|                                       |                                                                                                      |
|---------------------------------------|------------------------------------------------------------------------------------------------------|
| <b>Article number</b>                 | <b>6ES7143-5BF00-0BL0</b>                                                                            |
| <b>General information</b>            |                                                                                                      |
| Product type designation              | DIQ 4+DQ 4X24VDC/0.5A, 8xM8                                                                          |
| HW functional status                  | FS01                                                                                                 |
| Firmware version                      | V1.0.x                                                                                               |
| <b>Engineering with</b>               |                                                                                                      |
| • IODD file                           | Yes                                                                                                  |
| <b>Supply voltage</b>                 |                                                                                                      |
| <b>Load voltage 1L+</b>               |                                                                                                      |
| • Rated value (DC)                    | 24 V; Supply from 1Us+ of the IO-Link master                                                         |
| • permissible range, lower limit (DC) | 18 V                                                                                                 |
| • permissible range, upper limit (DC) | 30 V                                                                                                 |
| • Reverse polarity protection         | Yes; against destruction                                                                             |
| <b>Load voltage 2L+</b>               |                                                                                                      |
| • Rated value (DC)                    | 24 V; Supply from 2UA+ of the IO-Link master                                                         |
| • permissible range, lower limit (DC) | 20.4 V                                                                                               |
| • permissible range, upper limit (DC) | 28.8 V                                                                                               |
| • Reverse polarity protection         | Yes; Against destruction; encoder power supply outputs applied with reversed polarity, loads pick up |
| <b>Input current</b>                  |                                                                                                      |
| Current consumption (rated value)     | 15 mA; without load                                                                                  |
| from load voltage 2L+, max.           | 4 A; Maximum value                                                                                   |
| <b>Encoder supply</b>                 |                                                                                                      |
| Number of outputs                     | 8; Supply from 2UA+ of the IO-Link master                                                            |
| <b>24 V encoder supply</b>            |                                                                                                      |
| • Short-circuit protection            | Yes; per module, electronic                                                                          |
| • Output current, max.                | 0.7 A; Total current of all encoders (depending on IO-Link master supply via 2UA+)                   |
| <b>Power loss</b>                     |                                                                                                      |
| Power loss, typ.                      | 2.3 W                                                                                                |

|                                                                            |                                      |
|----------------------------------------------------------------------------|--------------------------------------|
| <b>Article number</b>                                                      | <b>6ES7143-5BF00-0BL0</b>            |
| <b>Digital inputs</b>                                                      |                                      |
| Number of digital inputs                                                   | 4; Parameterizable as DIQ            |
| Input characteristic curve in accordance with IEC 61131, type 3            | Yes                                  |
| <b>Number of simultaneously controllable inputs all mounting positions</b> |                                      |
| – up to 55 °C, max.                                                        | 4                                    |
| <b>Input voltage</b>                                                       |                                      |
| • Rated value (DC)                                                         | 24 V                                 |
| • for signal "0"                                                           | -3 to +5V                            |
| • for signal "1"                                                           | +11 to +30V                          |
| <b>Input current</b>                                                       |                                      |
| • for signal "1", typ.                                                     | 3 mA                                 |
| <b>Input delay (for rated value of input voltage) for standard inputs</b>  |                                      |
| – at "0" to "1", min.                                                      | 1.2 ms                               |
| – at "0" to "1", max.                                                      | 4.8 ms                               |
| – at "1" to "0", min.                                                      | 1.2 ms                               |
| – at "1" to "0", max.                                                      | 4.8 ms                               |
| <b>Cable length</b>                                                        |                                      |
| • unshielded, max.                                                         | 30 m                                 |
| <b>Digital outputs</b>                                                     |                                      |
| Number of digital outputs                                                  | 8; 4 DQ fixed, 4 DIQ parameterizable |
| Short-circuit protection                                                   | Yes; per channel, electronic         |
| • Response threshold, typ.                                                 | 0.7 A                                |
| Limitation of inductive shutdown voltage to                                | 2L+ (-50 V)                          |
| <b>Switching capacity of the outputs</b>                                   |                                      |
| • on lamp load, max.                                                       | 5 W                                  |
| <b>Load resistance range</b>                                               |                                      |
| • lower limit                                                              | 48 Ω                                 |
| • upper limit                                                              | 4 kΩ                                 |
| <b>Output voltage</b>                                                      |                                      |
| • for signal "1", min.                                                     | L+ (-0.8 V)                          |
| <b>Output current</b>                                                      |                                      |
| • for signal "1" rated value                                               | 0.5 A                                |
| • for signal "0" residual current, max.                                    | 0.5 mA                               |
| <b>Switching frequency</b>                                                 |                                      |
| • with resistive load, max.                                                | 100 Hz                               |
| • with inductive load, max.                                                | 0.5 Hz                               |
| • on lamp load, max.                                                       | 1 Hz                                 |

|                                                                |                                                                    |
|----------------------------------------------------------------|--------------------------------------------------------------------|
| <b>Article number</b>                                          | <b>6ES7143-5BF00-0BL0</b>                                          |
| <b>Total current of the outputs</b>                            |                                                                    |
| • Current per module, max.                                     | 4 A                                                                |
| <b>Cable length</b>                                            |                                                                    |
| • unshielded, max.                                             | 30 m                                                               |
| <b>Encoder</b>                                                 |                                                                    |
| <b>Connectable encoders</b>                                    |                                                                    |
| • 2-wire sensor                                                | Yes                                                                |
| – permissible quiescent current (2-wire sensor), max.          | 1.5 mA                                                             |
| <b>IO-Link</b>                                                 |                                                                    |
| IO-Link protocol 1.1                                           | Yes                                                                |
| Transmission rate                                              | 38.4 kBd (COM2)                                                    |
| Cycle time, min.                                               | 2.4 ms                                                             |
| Size of process data, input per module                         | 1 byte                                                             |
| Size of process data, output per module                        | 1 byte                                                             |
| Supported IO-Link profiles                                     | common profile                                                     |
| Cable length unshielded, max.                                  | 20 m                                                               |
| <b>Connection of IO-Link devices</b>                           |                                                                    |
| • Port type B                                                  | Yes                                                                |
| <b>Interrupts/diagnostics/status information</b>               |                                                                    |
| Substitute values connectable                                  | Yes; channel by channel, parameterizable                           |
| <b>Alarms</b>                                                  |                                                                    |
| • Diagnostic alarm                                             | Yes; Parameterizable                                               |
| <b>Diagnoses</b>                                               |                                                                    |
| • Short-circuit                                                | Yes; outputs to ground; encoder supply to ground; module by module |
| <b>Diagnostics indication LED</b>                              |                                                                    |
| • Channel status display                                       | Yes; green LED                                                     |
| • for module diagnostics                                       | Yes; green/red LED                                                 |
| • For load voltage monitoring                                  | Yes; green LED                                                     |
| <b>Potential separation</b>                                    |                                                                    |
| between the load voltages                                      | Yes                                                                |
| <b>Potential separation channels</b>                           |                                                                    |
| • between the channels                                         | No                                                                 |
| • between the channels and the power supply of the electronics | Yes                                                                |
| <b>Isolation</b>                                               |                                                                    |
| Isolation tested with                                          | 707 V DC (type test)                                               |
| <b>Standards, approvals, certificates</b>                      |                                                                    |
| Suitable for safety-related tripping of standard modules       | Yes; From FS01                                                     |



|                                                                                                                                                                                                                                                                            |                           |
|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------|
| <b>Article number</b>                                                                                                                                                                                                                                                      | <b>6ES7143-5BF00-0BL0</b> |
| <b>Highest safety class achievable for safety-related tripping of standard modules</b> <ul style="list-style-type: none"> <li>• Performance level according to ISO 13849-1</li> <li>• Category according to ISO 13849-1</li> <li>• SILCL according to IEC 62061</li> </ul> | PL d<br>Cat. 3<br>SILCL 2 |
| <b>Ambient conditions</b>                                                                                                                                                                                                                                                  |                           |
| <b>Ambient temperature during operation</b> <ul style="list-style-type: none"> <li>• min.</li> <li>• max.</li> </ul>                                                                                                                                                       | -30 °C<br>55 °C           |
| <b>Connection method</b>                                                                                                                                                                                                                                                   |                           |
| Design of electrical connection for the inputs and outputs                                                                                                                                                                                                                 | M8, 3-pole                |
| Type of electrical connection for IO-Link                                                                                                                                                                                                                                  | M12, 5-pin, A-coded       |
| <b>Dimensions</b>                                                                                                                                                                                                                                                          |                           |
| Width                                                                                                                                                                                                                                                                      | 30 mm                     |
| Height                                                                                                                                                                                                                                                                     | 159 mm                    |
| Depth                                                                                                                                                                                                                                                                      | 40 mm                     |
| <b>Weights</b>                                                                                                                                                                                                                                                             |                           |
| Weight, approx.                                                                                                                                                                                                                                                            | 125 g                     |

## Dimension drawing

The figure below shows the dimension drawing of the DIQ 4+DQ 4x24VDC/0,5A 8xM8 IO-Link digital input / digital output module in front and side view.

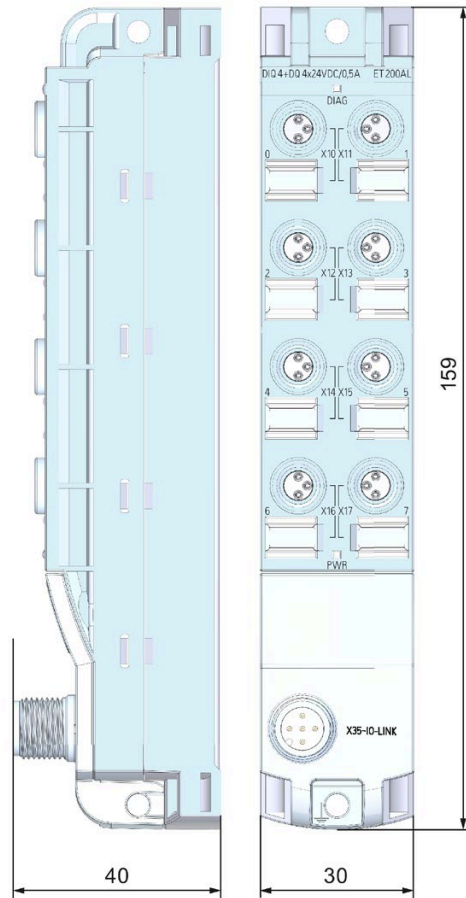
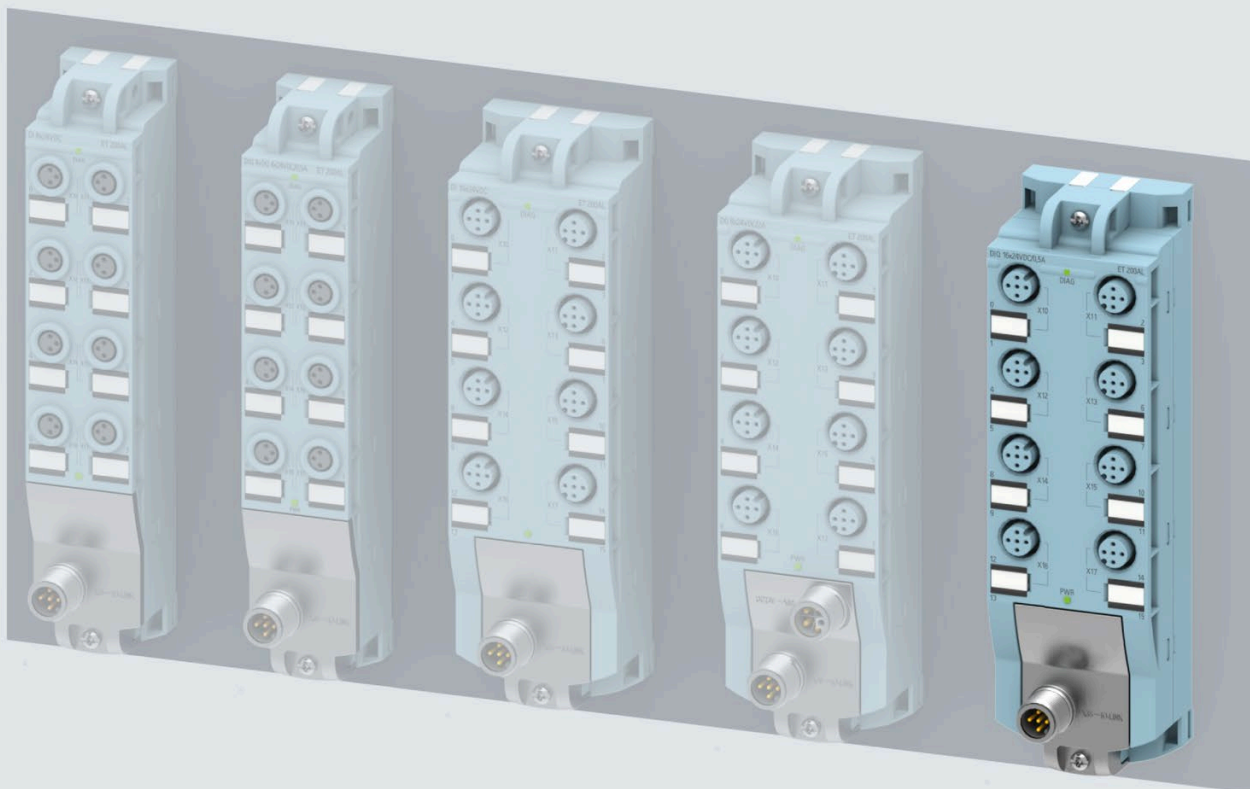


Figure A-1 Dimension drawing

# SIEMENS



Manual

## SIMATIC

### ET 200AL

IO-Link Digital input / output module  
DIQ 16x24VDC/0,5A 8xM12  
(6ES7143-5AH00-0BL0)

Edition

08/2021

[support.industry.siemens.com](https://support.industry.siemens.com)

## SIMATIC

### ET 200AL IO-Link digital input/digital output module DIQ 16x24VDC/0,5A 8xM12 (6ES7143-5AH00-0BL0)

#### Equipment Manual

#### Preface

ET 200AL IO-Link I/O  
modules Documentation  
Guide

**1**

Product overview

**2**

Wiring

**3**

Parameters/address space

**4**

Interrupts/diagnostic  
alarms

**5**

Technical specifications

**6**

Dimension drawing

**A**

## Legal information

### Warning notice system

This manual contains notices you have to observe in order to ensure your personal safety, as well as to prevent damage to property. The notices referring to your personal safety are highlighted in the manual by a safety alert symbol, notices referring only to property damage have no safety alert symbol. These notices shown below are graded according to the degree of danger.

#### **DANGER**

indicates that death or severe personal injury **will** result if proper precautions are not taken.

#### **WARNING**

indicates that death or severe personal injury **may** result if proper precautions are not taken.

#### **CAUTION**

indicates that minor personal injury can result if proper precautions are not taken.

#### **NOTICE**

indicates that property damage can result if proper precautions are not taken.

If more than one degree of danger is present, the warning notice representing the highest degree of danger will be used. A notice warning of injury to persons with a safety alert symbol may also include a warning relating to property damage.

### Qualified Personnel

The product/system described in this documentation may be operated only by **personnel qualified** for the specific task in accordance with the relevant documentation, in particular its warning notices and safety instructions. Qualified personnel are those who, based on their training and experience, are capable of identifying risks and avoiding potential hazards when working with these products/systems.

### Proper use of Siemens products

Note the following:

#### **WARNING**

Siemens products may only be used for the applications described in the catalog and in the relevant technical documentation. If products and components from other manufacturers are used, these must be recommended or approved by Siemens. Proper transport, storage, installation, assembly, commissioning, operation and maintenance are required to ensure that the products operate safely and without any problems. The permissible ambient conditions must be complied with. The information in the relevant documentation must be observed.

### Trademarks

All names identified by ® are registered trademarks of Siemens AG. The remaining trademarks in this publication may be trademarks whose use by third parties for their own purposes could violate the rights of the owner.

### Disclaimer of Liability

We have reviewed the contents of this publication to ensure consistency with the hardware and software described. Since variance cannot be precluded entirely, we cannot guarantee full consistency. However, the information in this publication is reviewed regularly and any necessary corrections are included in subsequent editions.

# Preface

## Preface IO-Link module AL

### Purpose of the documentation

This manual supplements the system manual ET 200AL IO-Link (<https://support.automation.siemens.com/WW/view/en/109773203>). Functions that generally relate to the distributed I/O system ET 200AL IO-Link I/O modules are described there.

The information provided in this manual and in the system manual and function manuals supports you in commissioning the ET 200AL IO-Link I/O modules.

### Changes compared to the previous version

This manual contains the following changes compared to the previous version:

- Supplements in the section Parameters (Page 15).
- Update of the section Technical specifications (Page 21)

### Conventions

Also observe notes labeled as follows:

---

**Note**

Indicates important product information to which particular attention should be paid.

---

## Security information

Siemens provides products and solutions with industrial security functions that support the secure operation of plants, systems, machines and networks.

In order to protect plants, systems, machines and networks against cyber threats, it is necessary to implement – and continuously maintain – a holistic, state-of-the-art industrial security concept. Siemens' products and solutions constitute one element of such a concept.

Customers are responsible for preventing unauthorized access to their plants, systems, machines and networks. Such systems, machines and components should only be connected to an enterprise network or the internet if and to the extent such a connection is necessary and only when appropriate security measures (e.g. firewalls and/or network segmentation) are in place.

For additional information on industrial security measures that may be implemented, please visit (<https://www.siemens.com/industrialsecurity>).

Siemens' products and solutions undergo continuous development to make them more secure. Siemens strongly recommends that product updates are applied as soon as they are available and that the latest product versions are used. Use of product versions that are no longer supported, and failure to apply the latest updates may increase customers' exposure to cyber threats.

To stay informed about product updates, subscribe to the Siemens Industrial Security RSS Feed visit (<https://www.siemens.com/industrialsecurity>).

# Table of contents

|          |                                                               |           |
|----------|---------------------------------------------------------------|-----------|
|          | <b>Preface .....</b>                                          | <b>3</b>  |
| <b>1</b> | <b>ET 200AL IO-Link I/O modules Documentation Guide .....</b> | <b>6</b>  |
| <b>2</b> | <b>Product overview .....</b>                                 | <b>9</b>  |
|          | 2.1 Properties .....                                          | 9         |
|          | 2.2 Operator controls and display elements.....               | 12        |
| <b>3</b> | <b>Wiring .....</b>                                           | <b>13</b> |
|          | 3.1 Terminal and block diagram .....                          | 13        |
|          | 3.2 Pin assignment .....                                      | 14        |
| <b>4</b> | <b>Parameters/address space .....</b>                         | <b>15</b> |
|          | 4.1 Parameters .....                                          | 15        |
|          | 4.2 Explanation of the parameters .....                       | 16        |
|          | 4.3 Address space .....                                       | 17        |
|          | 4.4 IODD parameters .....                                     | 17        |
| <b>5</b> | <b>Interrupts/diagnostic alarms .....</b>                     | <b>18</b> |
|          | 5.1 Status and error displays .....                           | 18        |
|          | 5.2 Interrupts .....                                          | 20        |
|          | 5.3 Diagnostics alarms.....                                   | 20        |
| <b>6</b> | <b>Technical specifications.....</b>                          | <b>21</b> |
| <b>A</b> | <b>Dimension drawing .....</b>                                | <b>25</b> |

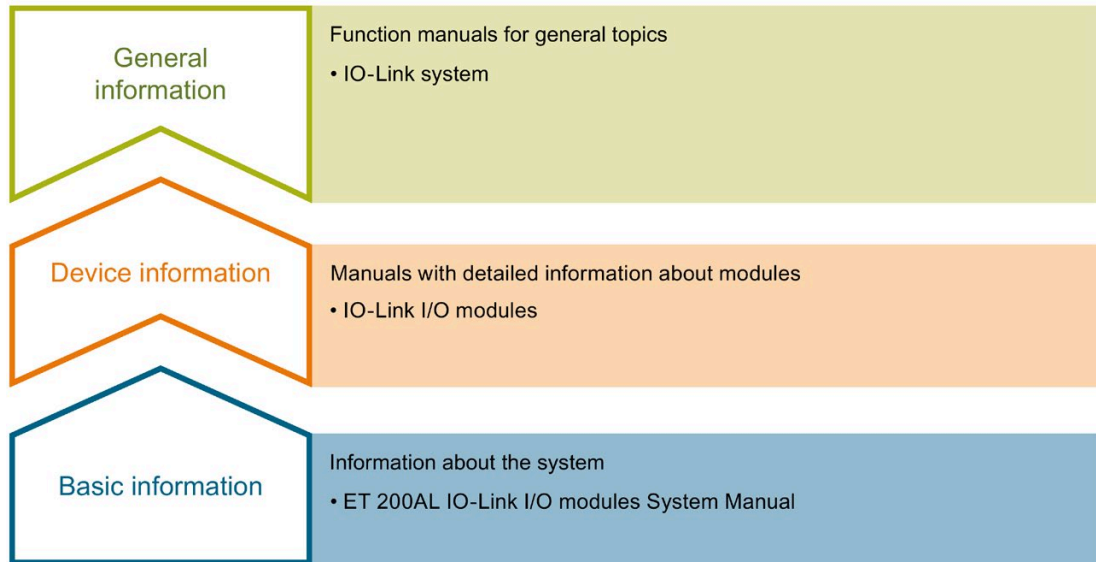


# ET 200AL IO-Link I/O modules Documentation Guide

# 1

The documentation for the SIMATIC ET 200AL IO-Link I/O modules is arranged into three areas.

This arrangement enables you to access the specific content you require.



## Basic information

The system manual describes in detail the configuration, installation, wiring and commissioning of the distributed I/O system SIMATIC ET 200AL IO-Link I/O modules.

## Device information

Equipment manuals contain a compact description of the module-specific information, such as properties, wiring diagrams, characteristics and technical specifications.

## General information

The function manuals contain detailed descriptions on general topics regarding the SIMATIC IO-Link system.

You can download the documentation free of charge from the Internet (<https://support.industry.siemens.com/cs/ww/en/view/109742667>).

## ET 200AL Manual Collection

The Manual Collection contains the complete documentation on the SIMATIC ET 200AL distributed I/O system gathered together in one file.

You can find the Manual Collection on the Internet (<https://support.automation.siemens.com/WW/view/en/95242965>).

## "mySupport"

With "mySupport", your personal workspace, you make the best out of your Industry Online Support.

In "mySupport", you can save filters, favorites and tags, request CAx data and compile your personal library in the Documentation area. In addition, your data is already filled out in support requests and you can get an overview of your current requests at any time.

You must register once to use the full functionality of "mySupport".

You can find "mySupport" on the Internet (<https://support.industry.siemens.com/My/ww/en>).

## "mySupport" - Documentation

With "mySupport", your personal workspace, you make the best out of your Industry Online Support.

In "mySupport", you can save filters, favorites and tags, request CAx data and compile your personal library in the Documentation area. In addition, your data is already filled out in support requests and you can get an overview of your current requests at any time.

You must register once to use the full functionality of "mySupport".

You can find "mySupport" on the Internet  
(<https://support.industry.siemens.com/My/ww/en/documentation>).

## "mySupport" - CAx data

In the CAx data area of "mySupport", you can access the latest product data for your CAx or CAe system.

You configure your own download package with a few clicks.

You can select:

- Product images, 2D dimension drawings, 3D models, internal circuit diagrams, EPLAN macro files
- Manuals, characteristics, operating manuals, certificates
- Product master data

You can find "mySupport" CAx data on the Internet  
(<https://support.industry.siemens.com/my/ww/en/CAxOnline>).

## Application examples

The application examples support you with various tools and examples for solving your automation tasks. Solutions are shown in interplay with multiple components in the system - separated from the focus on individual products.

You will find the application examples on the Internet  
(<https://support.industry.siemens.com/cs/ww/en/ps/ae>).

## TIA Selection Tool

With the TIA Selection Tool, you can select, configure and order devices for Totally Integrated Automation (TIA).

This tool is the successor of the SIMATIC Selection Tool and combines the known configurators for automation technology into one tool.

With the TIA Selection Tool, you can generate a complete order list from your product selection or product configuration.

You can find the TIA Selection Tool on the Internet

(<https://support.industry.siemens.com/cs/ww/en/view/109767888>).

## PRONETA

SIEMENS PRONETA (PROFINET network analysis) allows you to analyze the plant network during commissioning. PRONETA has two core functions:

- The topology overview automatically scans the PROFINET and all connected components.
- The IO check is a fast test of the wiring and the module configuration of a plant.

You can find SIEMENS PRONETA on the Internet

(<https://support.industry.siemens.com/cs/ww/en/view/67460624>).

## SIMATIC S7-PCT

The Port Configuration Tool ("PCT") is PC-based software for the parameter assignment of Siemens IO-Link master-modules and IO-Link devices from any manufacturer.

The IO-Link devices are integrated using the standardized device description "IODD" that is available from the respective device manufacturer. S7-PCT supports the version 1.0 as well as V1.1 of the IODD.

S7-PCT is called via the hardware configuration of the IO-Link masters from STEP 7; however, it can also be started as "standalone" if the IO-Link master is not operated on a SIMATIC controller or when STEP 7 is not used.

You can find additional information on IO-Link on the Internet

(<https://new.siemens.com/global/en/products/automation/industrial-communication/io-link.html>).

## Product overview

### 2.1 Properties

#### Article number

6ES7143-5AH00-0BL0

#### View of the module

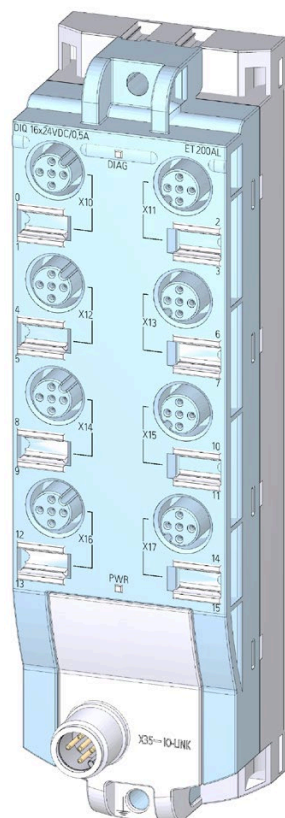


Figure 2-1 View of the DIQ 16x24VDC/0,5A 8xM12 IO-Link digital input/digital output module

## Properties

The module has the following technical properties:

- 16 digital inputs or digital outputs, depending on configuration and parameter assignment
  - 16 DIQ signals connected to 2L+ (switched)
- M12 sockets for connection of sensors and actuators
- Digital inputs:
  - 24 V DC supply voltage
  - Suitable for switches and proximity switches
  - Typical input delay of 3 ms
  - Configurable diagnostics can be set for each module
- Digital outputs:
  - Rated load voltage 24 V DC
  - Suitable for solenoid valves, DC contactors, and indicator lights
  - Output current per output 0.5 A
  - Configurable diagnostics can be set for each module
- Dimensions 45 x 159 mm
- Interface for IO-Link and power supply:
  - M12 connector A-coded
  - Supply of the module electronics
  - IO-Link Port Class B
  - Encoder supply and load voltage supply of output

The module supports the following functions:

- Firmware update
- IO-Link profile: General profile

## Accessories

The following components are included in the module package:

- Identification labels

## Other components

The following component can be ordered as spare part:

- Identification labels

The following components can be ordered as accessories:

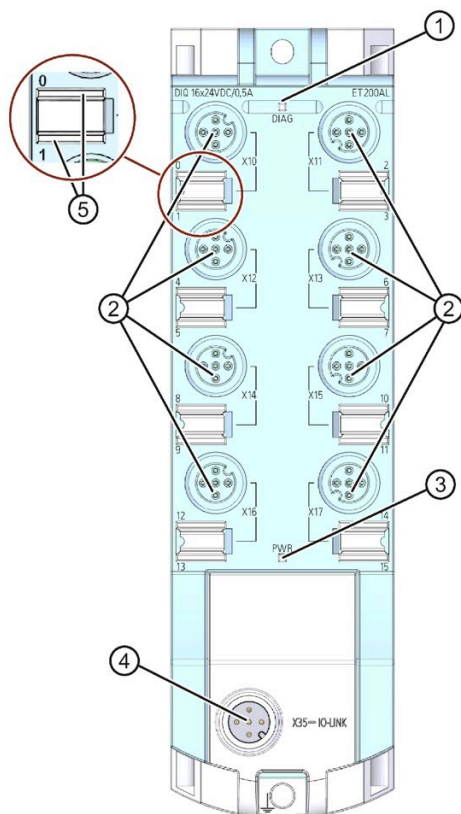
- Connectors
- Cables
- M12 sealing cap

## See also

You can find more information on accessories in the Accessories/spare parts section of the ET 200AL distributed I/O system (<https://support.industry.siemens.com/cs/us/en/view/89254965>) IO-Link I/O modules system manual.

## 2.2 Operator controls and display elements

The figure below shows the operator controls and display elements of the DIQ 16x24VDC/0,5A 8xM12 IO-Link digital input/digital output module.



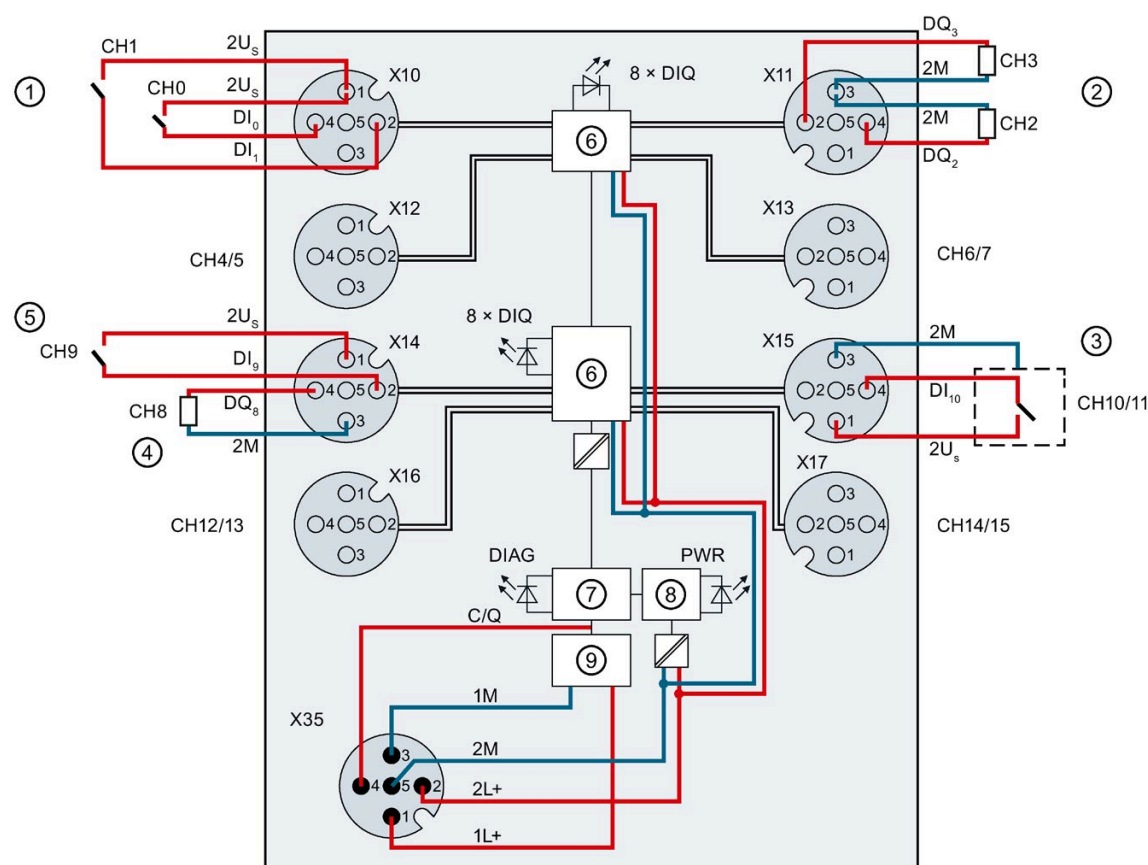
- ① DIAG: LED display for the diagnostic status
- ② X10 to X17: Sockets for the input/output signal
- ③ PWR: LED display for load voltage 2L+
- ④ X35: IO-Link interface
- ⑤ LED displays 0 to 15 for the channel status

Figure 2-2 Operator controls and display elements

# Wiring

## 3.1 Terminal and block diagram

The figure below shows an example of the pin assignment of signal inputs with 2-wire and 3-wire connection and of signal outputs in the configuration modes for digital inputs and outputs.



|            |                                         |                  |                                     |
|------------|-----------------------------------------|------------------|-------------------------------------|
| ①          | Configured as inputs: 2-wire connection | 1L+              | Supply voltage 1L+ (non-switched)   |
| ②          | Configured as outputs                   | 1M               | Ground 1M (non-switched)            |
| ③          | Configured as input: 3-wire connection  | 2L+              | Load voltage 2L+ (switched)         |
| ④          | Configured as output                    | 2M               | Ground 2M (switched)                |
| ⑤          | Configured as input: 2-wire connection  | 2Us              | 24 V encoder supply                 |
| ⑥          | DI/DQ circuit (2L+ switched)            | DIQ <sub>n</sub> | Input/output signal                 |
| ⑦          | Microcontroller                         | DIQ              | LEDs channel status (0..15) (green) |
| ⑧          | Monitoring                              | DIAG             | Diagnostic status LED (red/green)   |
| ⑨          | Internal supply voltage                 | PWR              | LED supply voltage 2L+ (green)      |
| X10 to X17 | Channels 0 to 15                        |                  |                                     |
| X35        | IO-Link interface                       |                  |                                     |

Figure 3-1 Wiring and block diagram of configuration modes for digital inputs and outputs

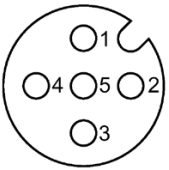
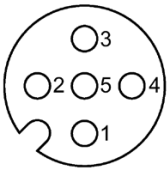


## 3.2 Pin assignment

### Pin assignment of the sockets for digital inputs/digital outputs

The table below shows the pin assignments of the 8 sockets for the connection of the digital inputs/digital outputs.

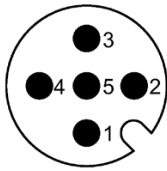
Table 3- 1 Pin assignment for digital inputs/digital outputs

| Pin | Assignment                                                                                                                                                                                                                                                                                                                                                                                                                                                      | Front view of the sockets                                                           |                                                                                     |
|-----|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------|
|     | X10 to X17 - sockets for digital inputs/outputs                                                                                                                                                                                                                                                                                                                                                                                                                 | X10, X12, X14, X16                                                                  | X11, X13, X15, X17                                                                  |
| 1   | 24 V encoder supply 2Us<br>(derived from 2L+ switched)                                                                                                                                                                                                                                                                                                                                                                                                          |  |  |
| 2   | Input/output signal DIQ <sub>1</sub> : Connector X10<br>Input/output signal DIQ <sub>3</sub> : Connector X11<br>Input/output signal DIQ <sub>5</sub> : Connector X12<br>Input/output signal DIQ <sub>7</sub> : Connector X13<br>Input/output signal DIQ <sub>9</sub> : Connector X14<br>Input/output signal DIQ <sub>11</sub> : Connector X15<br>Input/output signal DIQ <sub>13</sub> : Connector X16<br>Input/output signal DIQ <sub>15</sub> : Connector X17 |                                                                                     |                                                                                     |
| 3   | Ground 2M                                                                                                                                                                                                                                                                                                                                                                                                                                                       |                                                                                     |                                                                                     |
| 4   | Input/output signal DIQ <sub>0</sub> : Connector X10<br>Input/output signal DIQ <sub>2</sub> : Connector X11<br>Input/output signal DIQ <sub>4</sub> : Connector X12<br>Input/output signal DIQ <sub>6</sub> : Connector X13<br>Input/output signal DIQ <sub>8</sub> : Connector X14<br>Input/output signal DIQ <sub>10</sub> : Connector X15<br>Input/output signal DIQ <sub>12</sub> : Connector X16<br>Input/output signal DIQ <sub>14</sub> : Connector X17 |                                                                                     |                                                                                     |
| 5   | Functional earth FE                                                                                                                                                                                                                                                                                                                                                                                                                                             |                                                                                     |                                                                                     |

### Pin assignment of the connector for IO-Link

The following table shows the pin assignment of the connector for the IO-Link.

Table 3- 2 Pin assignment of the IO-Link interface

| Pin | Assignment                              | Front view of the connector (Port Class B)                                            |
|-----|-----------------------------------------|---------------------------------------------------------------------------------------|
|     | X35                                     |                                                                                       |
| 1   | 1L+                                     |  |
| 2   | 2L+                                     |                                                                                       |
| 3   | Ground 1M                               |                                                                                       |
| 4   | Switching and communication cable (C/Q) |                                                                                       |
| 5   | Ground 2M                               |                                                                                       |

#### Note

Note that the module can only be supplied with a protective low voltage according to the standard SELV/PELV.

## Parameters/address space

### 4.1 Parameters

The table below shows the parameters for the IO-Link digital input/digital output module DIQ 16x24VDC/0,5A 8xM12.

Table 4- 1 Parameters

| Parameters                            | Value range             |          |          | Default   | Scope                                                                  | ISDU index (decimal) | ISDU sub-index (decimal) |
|---------------------------------------|-------------------------|----------|----------|-----------|------------------------------------------------------------------------|----------------------|--------------------------|
|                                       | Value                   | Dec<br>. | Hex<br>. |           |                                                                        |                      |                          |
| Diagnostics: Missing load voltage 2L+ | Disable                 | 0        | 0        | Disable   | Module                                                                 | 131                  | 1                        |
|                                       | Enable                  | 255      | FF       |           |                                                                        |                      |                          |
| Diagnostics: Short-circuit to ground  | Disable                 | 0        | 0        | Disable   | Module<br>(Short-circuit of encoder supply or of the output to ground) | 131                  | 2                        |
|                                       | Enable                  | 255      | FF       |           |                                                                        |                      |                          |
| Freely assignable channel 0 ... 7     | DI                      | 0        | 0        | DI        | Channel                                                                | 131                  | 3 ... 10                 |
|                                       | DQ                      | 255      | FF       |           |                                                                        |                      |                          |
| Freely assignable channel 8 ... 15    | DI                      | 0        | 0        | DQ        | Channel                                                                | 131                  | 11 ... 18                |
|                                       | DQ                      | 255      | FF       |           |                                                                        |                      |                          |
| Reaction to CPU/master STOP           | Shutdown                | 0        | 0        | Shut-down | Module<br>(digital outputs)                                            | 131                  | 19                       |
|                                       | Keep last value         | 2        | 2        |           |                                                                        |                      |                          |
|                                       | Output substitute value | 3        | 3        |           |                                                                        |                      |                          |
| Substitute value channel              | 0                       | 0        | 0        | 0         | Channel<br>(digital outputs)                                           | 131                  | 20 ... 35                |
|                                       | 1                       | 255      | FF       |           |                                                                        |                      |                          |

## 4.2 Explanation of the parameters

### **Diagnostics: Missing load voltage 2L+**

Enabling of the diagnostics for missing or insufficient load voltage 2L+.

### **Diagnostics: Short-circuit to ground**

Enabling of the diagnostics, at short-circuit of an encoder supply or of an output to ground.

### **Freely assignable channel**

With this parameter, you set whether the channel is to be operated as an input or output.

### **Reaction to CPU/master STOP**

With this parameter, you set the reaction of the channels configured as output of the digital input/output module after a CPU/master STOP:

- Deactivate: The digital output is de-energized.
- Keep last value: The last value of the digital output remains activated.
- Output substitute value: The module outputs a configured substitute value.

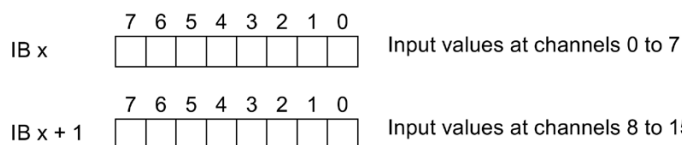
### **Substitute value channel**

With this parameter, you set substitute values for the digital outputs.

## 4.3 Address space

The figure below shows the assignment of the address space for the DIQ 16x24VDC/0,5A 8xM12 IO-Link digital input/digital output module.

Assignment in the process image input (PII)



Assignment in the process image output (PIQ)

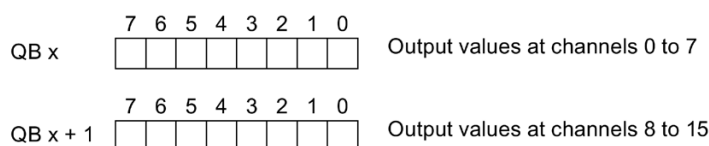


Figure 4-1 Address space IO-Link DIQ 16x24VDC/0,5A 8xM12

## 4.4 IODD parameters

### Device description IODD

An electronic device description is available for the DIQ 16x24VDC/0,5A 8xM12 IO-Link digital input/digital output module, the IODD file (IO Device Description). The IODD provides a wealth of information for system integration:

- Communication properties
- Device parameters with value range and default value
- Identification, process and diagnostic data
- Device data
- Text description
- Image of the device
- Manufacturer logo

The structure of the IODD is identical for all devices from all manufacturers. The structure of the IODD is always represented in the same manner by the IO-Link Configuration Tool of the master manufacturer (for Siemens, S7-PCT). This ensures that the handling is the same for all IO-Link devices regardless of the manufacturer.

### IODDfinder

The IODDfinder is a cross-vendor, central IO-Link database.

This database provides you with the latest IODDs of the device manufacturers and offers an information and download platform.

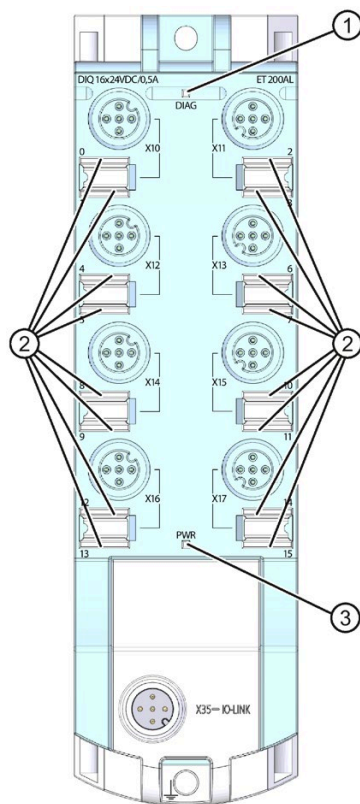
The IODDfinder is available on the Internet (<https://ioddfinder.io-link.com>).

## Interrupts/diagnostic alarms

### 5.1 Status and error displays

#### LED displays

The figure below shows the LED displays (status and error displays) of the DIQ 16x24VDC/0,5A 8xM12 IO-Link digital input/digital output module.



- |   |                          |             |
|---|--------------------------|-------------|
| ① | Diagnostic status (DIAG) | (red/green) |
| ② | Channel status (0 to 15) | (green)     |
| ③ | Load voltage 2L+ (PWR)   | (green)     |

Figure 5-1 LED displays

## Meaning of the LEDs

The following tables set out the meaning of the status and error displays. Remedial measures for diagnostic reports can be found in chapter Diagnostics alarms (Page 20).

### DIAG LED

Table 5- 1 Error display of the DIAG LED

| DIAG LED                                                                                     | Meaning                                                                                                                                   |
|----------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------|
| <br>Off     | No supply voltage 1L+                                                                                                                     |
| <br>Flashes | <ul style="list-style-type: none"> <li>No data exchange with the IO-Link Master (e.g. wire break)</li> <li>Firmware is loading</li> </ul> |
| <br>On      | Module is currently exchanging data with the IO-Link master and no module diagnostics                                                     |
| <br>Flashes | Module is currently exchanging data with the IO-Link master and module diagnostics                                                        |

### LED channel status

Table 5- 2 LED channel status display

| LED channel status                                                                         | Meaning            |
|--------------------------------------------------------------------------------------------|--------------------|
| <br>Off | Process signal = 0 |
| <br>On  | Process signal = 1 |

### PWR LED

Table 5- 3 Status display of the PWR LED

| PWR LED                                                                                    | Meaning                                |
|--------------------------------------------------------------------------------------------|----------------------------------------|
| <br>Off | Load voltage 2L+ is missing or too low |
| <br>On  | Load voltage 2L+ present               |

## 5.2 Interrupts

Diagnostic interrupts of the DIQ 16x24VDC/0,5A 8xM12 IO-Link digital input/digital output module.

### Diagnostic interrupt

The digital input/digital output module generates a diagnostic interrupt at the following events:

- Short-circuit of an encoder supply to ground, or
- Short-circuit of an output to ground
- Load voltage 2L+ missing or too low

## 5.3 Diagnostics alarms

For each diagnostic event, a diagnostics alarm is issued and the LED DIAG flashes red on the digital input/digital output module.

You can read out the diagnostics alarms, for example, from the status of the IO-Link master. You can evaluate the error codes with the user program.

Table 5- 4 Diagnostics alarms, their meanings and corrective measures

| Diagnostics alarm                                                                                                                                                                                                                                                                                                                                                               | Error code | Meaning                                      | Solution                                                                                                 |
|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------|----------------------------------------------|----------------------------------------------------------------------------------------------------------|
| Short circuit <sup>1</sup>                                                                                                                                                                                                                                                                                                                                                      | 0x7710     | Short-circuit of an encoder supply to ground | <ul style="list-style-type: none"> <li>• Eliminate the short-circuit</li> </ul>                          |
|                                                                                                                                                                                                                                                                                                                                                                                 | 0x7711     | Short-circuit of an output to ground         |                                                                                                          |
| Load voltage 2L+ missing <sup>2</sup>                                                                                                                                                                                                                                                                                                                                           | 0x5112     | Load voltage 2L+ missing or too low          | <ul style="list-style-type: none"> <li>• Check the supply voltage</li> <li>• Check the module</li> </ul> |
| <sup>1</sup> = If a short-circuit of an encoder supply to ground is detected, the diagnostic alarm "Short-circuit" is always output. This alarm is output even if all channels are configured as outputs.<br><sup>2</sup> = If you are using ET 200AL modules in connection with the ET 200SP distributed I/O system, the diagnostic alarm "Load voltage missing" is displayed. |            |                                              |                                                                                                          |

## Technical specifications

### Technical specifications of the DIQ 16x24VDC/0,5A 8xM12 IO-Link digital input/digital output module

The following table shows the technical specifications as of the issue date. You can find a data sheet including daily updated technical specifications on the Internet (<https://support.industry.siemens.com/cs/de/en/pv/6ES7143-5AH00-0BL0/td?dl=en>).

|                                       |                                                                                                      |
|---------------------------------------|------------------------------------------------------------------------------------------------------|
| <b>Article number</b>                 | <b>6ES7143-5AH00-0BL0</b>                                                                            |
| <b>General information</b>            |                                                                                                      |
| Product type designation              | DIQ 16X24VDC/0.5A, 8XM12                                                                             |
| HW functional status                  | FS01                                                                                                 |
| Firmware version                      | V1.0.x                                                                                               |
| <b>Engineering with</b>               |                                                                                                      |
| • IODD file                           | Yes                                                                                                  |
| <b>Supply voltage</b>                 |                                                                                                      |
| <b>Load voltage 1L+</b>               |                                                                                                      |
| • Rated value (DC)                    | 24 V; Supply from 1Us+ of the IO-Link master                                                         |
| • permissible range, lower limit (DC) | 18 V                                                                                                 |
| • permissible range, upper limit (DC) | 30 V                                                                                                 |
| • Reverse polarity protection         | Yes; against destruction                                                                             |
| <b>Load voltage 2L+</b>               |                                                                                                      |
| • Rated value (DC)                    | 24 V; Supply from 2UA+ of the IO-Link master                                                         |
| • permissible range, lower limit (DC) | 20.4 V                                                                                               |
| • permissible range, upper limit (DC) | 28.8 V                                                                                               |
| • Reverse polarity protection         | Yes; Against destruction; encoder power supply outputs applied with reversed polarity, loads pick up |
| <b>Input current</b>                  |                                                                                                      |
| Current consumption (rated value)     | 20 mA; without load                                                                                  |
| from load voltage 2L+, max.           | 4 A; Maximum value                                                                                   |
| <b>Encoder supply</b>                 |                                                                                                      |
| Number of outputs                     | 8; Supply from 2UA+ of the IO-Link master                                                            |
| <b>24 V encoder supply</b>            |                                                                                                      |
| • Short-circuit protection            | Yes; per module, electronic                                                                          |
| • Output current, max.                | 0.7 A; Total current of all encoders (depending on IO-Link master supply via 2UA+)                   |
| <b>Power loss</b>                     |                                                                                                      |
| Power loss, typ.                      | 4 W                                                                                                  |



|                                                                            |                              |
|----------------------------------------------------------------------------|------------------------------|
| <b>Article number</b>                                                      | <b>6ES7143-5AH00-0BLO</b>    |
| <b>Digital inputs</b>                                                      |                              |
| Number of digital inputs                                                   | 16; Parameterizable as DIQ   |
| Input characteristic curve in accordance with IEC 61131, type 3            | Yes                          |
| <b>Number of simultaneously controllable inputs all mounting positions</b> |                              |
| – up to 55 °C, max.                                                        | 16                           |
| <b>Input voltage</b>                                                       |                              |
| • Rated value (DC)                                                         | 24 V                         |
| • for signal "0"                                                           | -3 to +5V                    |
| • for signal "1"                                                           | +11 to +30V                  |
| <b>Input current</b>                                                       |                              |
| • for signal "1", typ.                                                     | 3 mA                         |
| <b>Input delay (for rated value of input voltage) for standard inputs</b>  |                              |
| – at "0" to "1", min.                                                      | 1.2 ms                       |
| – at "0" to "1", max.                                                      | 4.8 ms                       |
| – at "1" to "0", min.                                                      | 1.2 ms                       |
| – at "1" to "0", max.                                                      | 4.8 ms                       |
| <b>Cable length</b>                                                        |                              |
| • unshielded, max.                                                         | 30 m                         |
| <b>Digital outputs</b>                                                     |                              |
| Number of digital outputs                                                  | 16; Parameterizable as DIQ   |
| Short-circuit protection                                                   | Yes; per channel, electronic |
| • Response threshold, typ.                                                 | 0.7 A                        |
| Limitation of inductive shutdown voltage to                                | 2L+ (-50 V)                  |
| <b>Switching capacity of the outputs</b>                                   |                              |
| • on lamp load, max.                                                       | 5 W                          |
| <b>Load resistance range</b>                                               |                              |
| • lower limit                                                              | 48 Ω                         |
| • upper limit                                                              | 4 kΩ                         |
| <b>Output voltage</b>                                                      |                              |
| • for signal "1", min.                                                     | L+ (-0.8 V)                  |
| <b>Output current</b>                                                      |                              |
| • for signal "1" rated value                                               | 0.5 A                        |
| • for signal "0" residual current, max.                                    | 0.5 mA                       |

|                                                                |                                                                    |
|----------------------------------------------------------------|--------------------------------------------------------------------|
| <b>Article number</b>                                          | <b>6ES7143-5AH00-0BL0</b>                                          |
| <b>Switching frequency</b>                                     |                                                                    |
| • with resistive load, max.                                    | 100 Hz                                                             |
| • with inductive load, max.                                    | 0.5 Hz                                                             |
| • on lamp load, max.                                           | 1 Hz                                                               |
| <b>Total current of the outputs</b>                            |                                                                    |
| • Current per module, max.                                     | 4 A                                                                |
| <b>Cable length</b>                                            |                                                                    |
| • unshielded, max.                                             | 30 m                                                               |
| <b>Encoder</b>                                                 |                                                                    |
| <b>Connectable encoders</b>                                    |                                                                    |
| • 2-wire sensor                                                | Yes                                                                |
| – permissible quiescent current (2-wire sensor), max.          | 1.5 mA                                                             |
| <b>IO-Link</b>                                                 |                                                                    |
| IO-Link protocol 1.1                                           | Yes                                                                |
| Transmission rate                                              | 38.4 k Bd (COM2)                                                   |
| Cycle time, min.                                               | 3 ms                                                               |
| Size of process data, input per module                         | 2 byte                                                             |
| Size of process data, output per module                        | 2 byte                                                             |
| Supported IO-Link profiles                                     | common profile                                                     |
| Cable length unshielded, max.                                  | 20 m                                                               |
| <b>Connection of IO-Link devices</b>                           |                                                                    |
| • Port type B                                                  | Yes                                                                |
| <b>Interrupts/diagnostics/status information</b>               |                                                                    |
| Substitute values connectable                                  | Yes; channel by channel, parameterizable                           |
| <b>Alarms</b>                                                  |                                                                    |
| • Diagnostic alarm                                             | Yes; Parameterizable                                               |
| <b>Diagnoses</b>                                               |                                                                    |
| • Short-circuit                                                | Yes; outputs to ground; encoder supply to ground; module by module |
| <b>Diagnostics indication LED</b>                              |                                                                    |
| • Channel status display                                       | Yes; green LED                                                     |
| • for module diagnostics                                       | Yes; green/red LED                                                 |
| • For load voltage monitoring                                  | Yes; green LED                                                     |
| <b>Potential separation</b>                                    |                                                                    |
| between the load voltages                                      | Yes                                                                |
| <b>Potential separation channels</b>                           |                                                                    |
| • between the channels                                         | No                                                                 |
| • between the channels and the power supply of the electronics | Yes                                                                |

|                                                                                        |                           |
|----------------------------------------------------------------------------------------|---------------------------|
| <b>Article number</b>                                                                  | <b>6ES7143-5AH00-0BLO</b> |
| <b>Isolation</b>                                                                       |                           |
| Isolation tested with                                                                  | 707 V DC (type test)      |
| <b>Standards, approvals, certificates</b>                                              |                           |
| Suitable for safety-related tripping of standard modules                               | Yes; From FS01            |
| <b>Highest safety class achievable for safety-related tripping of standard modules</b> |                           |
| • Performance level according to ISO 13849-1                                           | PL d                      |
| • Category according to ISO 13849-1                                                    | Cat. 3                    |
| • SILCL according to IEC 62061                                                         | SILCL 2                   |
| <b>Ambient conditions</b>                                                              |                           |
| <b>Ambient temperature during operation</b>                                            |                           |
| • min.                                                                                 | -30 °C                    |
| • max.                                                                                 | 55 °C                     |
| <b>Connection method</b>                                                               |                           |
| Design of electrical connection for the inputs and outputs                             | M12, 5-pin, A-coded       |
| Type of electrical connection for IO-Link                                              | M12, 5-pin, A-coded       |
| <b>Dimensions</b>                                                                      |                           |
| Width                                                                                  | 45 mm                     |
| Height                                                                                 | 159 mm                    |
| Depth                                                                                  | 40 mm                     |
| <b>Weights</b>                                                                         |                           |
| Weight, approx.                                                                        | 157 g                     |

## Dimension drawing

The figure below shows the dimension drawing of the DIQ 16x24VDC/0,5A 8xM12 IO-Link digital input/digital output module in front and side view.

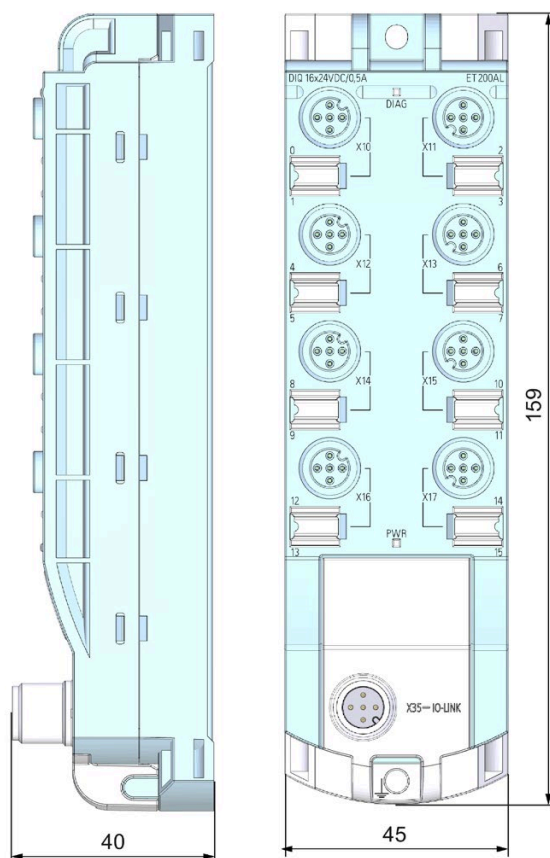


Figure A-1 Dimension drawing

SIEMENS



# SIMATIC

## ET 200AL

Digital I/O module F-DI 4+F-DQ 2x24VDC/2A, 4xM12

(6ES7146-5FF00-0BA0)

Manual

Edition

05/2021

Answers for industry.

## SIMATIC

ET 200AL  
Digital I/O module  
F-DI 4+F-DQ 2x24VDC/2A,  
4xM12 (6ES7146-5FF00-0BA0)  
Equipment Manual

### Preface

#### Documentation guide

1

#### Product overview

2

#### Wiring

3

#### Parameters/address space

4

#### Applications of the F-I/O module

5

#### Interrupts/diagnostic messages/diagnostics

6

#### Technical specifications

7

#### Dimension drawing

A

#### Response times

B

#### Switching of loads

C

## Legal information

### Warning notice system

This manual contains notices you have to observe in order to ensure your personal safety, as well as to prevent damage to property. The notices referring to your personal safety are highlighted in the manual by a safety alert symbol, notices referring only to property damage have no safety alert symbol. These notices shown below are graded according to the degree of danger.

#### **DANGER**

indicates that death or severe personal injury **will** result if proper precautions are not taken.

#### **WARNING**

indicates that death or severe personal injury **may** result if proper precautions are not taken.

#### **CAUTION**

indicates that minor personal injury can result if proper precautions are not taken.

#### **NOTICE**

indicates that property damage can result if proper precautions are not taken.

If more than one degree of danger is present, the warning notice representing the highest degree of danger will be used. A notice warning of injury to persons with a safety alert symbol may also include a warning relating to property damage.

### Qualified Personnel

The product/system described in this documentation may be operated only by **personnel qualified** for the specific task in accordance with the relevant documentation, in particular its warning notices and safety instructions. Qualified personnel are those who, based on their training and experience, are capable of identifying risks and avoiding potential hazards when working with these products/systems.

### Proper use of Siemens products

Note the following:

#### **WARNING**

Siemens products may only be used for the applications described in the catalog and in the relevant technical documentation. If products and components from other manufacturers are used, these must be recommended or approved by Siemens. Proper transport, storage, installation, assembly, commissioning, operation and maintenance are required to ensure that the products operate safely and without any problems. The permissible ambient conditions must be complied with. The information in the relevant documentation must be observed.

### Trademarks

All names identified by ® are registered trademarks of Siemens AG. The remaining trademarks in this publication may be trademarks whose use by third parties for their own purposes could violate the rights of the owner.

### Disclaimer of Liability

We have reviewed the contents of this publication to ensure consistency with the hardware and software described. Since variance cannot be precluded entirely, we cannot guarantee full consistency. However, the information in this publication is reviewed regularly and any necessary corrections are included in subsequent editions.

# Preface

## Purpose of the documentation

This manual supplements the *ET 200AL distributed I/O system system manual* (<https://support.industry.siemens.com/cs/ww/en/view/89254965>). Functions that are generally applicable to the ET 200AL distributed I/O system are described there.

The information provided in the present manual, the system manual and the function manuals enables you to commission the ET 200AL distributed I/O system.



### WARNING

**The *SIMATIC Safety - Configuring and Programming, Programming and Operating Manual* in the current version is the authoritative source for functional safety-related information concerning configuring and programming.**

Siemens identifies the *SIMATIC Safety - Configuring and Programming, Programming and Operating Manual* as the authoritative and/or original source in the case of discrepancies between the manuals.

All warnings in the *SIMATIC Safety - Configuring and Programming, Programming and Operating Manual* have to be observed. You can find the current version of the manual on the Internet (<https://support.industry.siemens.com/cs/ww/en/view/54110126>).

## Conventions

Please observe notes marked as follows:

---

### Note

Indicates important product information to which particular attention should be paid.

---

## Security information

Siemens provides products and solutions with industrial security functions that support the secure operation of plants, systems, machines and networks.

In order to protect plants, systems, machines and networks against cyber threats, it is necessary to implement – and continuously maintain – a holistic, state-of-the-art industrial security concept. Siemens' products and solutions constitute one element of such a concept.

Customers are responsible for preventing unauthorized access to their plants, systems, machines and networks. Such systems, machines and components should only be connected to an enterprise network or the internet if and to the extent such a connection is necessary and only when appropriate security measures (e.g. firewalls and/or network segmentation) are in place.



For additional information on industrial security measures that may be implemented, please visit (<https://www.siemens.com/industrialsecurity>).

Siemens' products and solutions undergo continuous development to make them more secure. Siemens strongly recommends that product updates are applied as soon as they are available and that the latest product versions are used. Use of product versions that are no longer supported, and failure to apply the latest updates may increase customers' exposure to cyber threats.

To stay informed about product updates, subscribe to the Siemens Industrial Security RSS Feed visit (<https://www.siemens.com/industrialsecurity>).

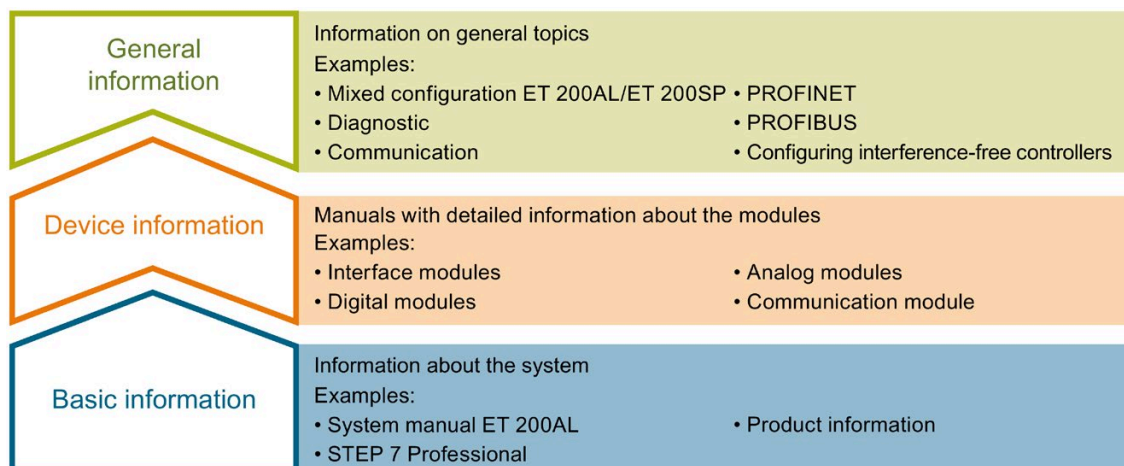
# Table of contents

|          |                                                                                                |           |
|----------|------------------------------------------------------------------------------------------------|-----------|
|          | <b>Preface .....</b>                                                                           | <b>3</b>  |
| <b>1</b> | <b>Documentation guide .....</b>                                                               | <b>7</b>  |
| <b>2</b> | <b>Product overview .....</b>                                                                  | <b>10</b> |
| 2.1      | Properties .....                                                                               | 10        |
| 2.2      | Operator controls and display elements.....                                                    | 13        |
| 2.3      | Fail-safe digital inputs .....                                                                 | 14        |
| 2.4      | Fail-safe digital outputs.....                                                                 | 15        |
| <b>3</b> | <b>Wiring .....</b>                                                                            | <b>17</b> |
| 3.1      | Terminal and block diagram .....                                                               | 18        |
| 3.2      | Pin assignment .....                                                                           | 19        |
| 3.3      | Connecting the M12 eCoding plug .....                                                          | 21        |
| <b>4</b> | <b>Parameters/address space .....</b>                                                          | <b>23</b> |
| 4.1      | Configuring module I/O properties .....                                                        | 23        |
| 4.2      | Parameters .....                                                                               | 24        |
| 4.3      | Explanation of parameters .....                                                                | 26        |
| 4.3.1    | F-parameters .....                                                                             | 26        |
| 4.3.2    | DI parameters .....                                                                            | 27        |
| 4.3.3    | DQ parameters .....                                                                            | 32        |
| 4.4      | Address space .....                                                                            | 36        |
| <b>5</b> | <b>Applications of the F-I/O module .....</b>                                                  | <b>38</b> |
| 5.1      | Digital input applications .....                                                               | 39        |
| 5.1.1    | Applications 1 and 2: 1oo1 evaluation of single-channel sensors .....                          | 41        |
| 5.1.2    | Applications 3 and 4: 1oo2 evaluation of equivalent sensors .....                              | 44        |
| 5.1.3    | Applications 5 and 6: 1oo2 evaluation of a 3-wire, nonequivalent sensor circuit .....          | 46        |
| 5.1.4    | Applications 7 and 8: 1oo2 evaluation of a 4-wire, nonequivalent sensor circuit .....          | 49        |
| 5.2      | Digital output applications .....                                                              | 51        |
| 5.2.1    | Application 1: Wiring a directly-connected SIL-rated actuator.....                             | 53        |
| 5.2.2    | Application 2: Wiring external contactors: Separate P and M controlled contactors.....         | 53        |
| 5.2.3    | Application 3: Wiring external contactors: Parallel-connected contactors between P and M ..... | 54        |
| 5.2.4    | Application 4: Wiring external contactors: Separate output channels for each contactor.....    | 55        |
| 5.3      | Examples of application modes for the F-DI 4/F-DQ 2 Fail-Safe module .....                     | 55        |
| <b>6</b> | <b>Interrupts/diagnostic messages/diagnostics .....</b>                                        | <b>61</b> |
| 6.1      | Reactions to faults .....                                                                      | 61        |
| 6.2      | Fault diagnostics overview .....                                                               | 65        |

|          |                                                                     |           |
|----------|---------------------------------------------------------------------|-----------|
| 6.3      | Diagnostics performed at startup .....                              | 65        |
| 6.4      | Diagnostics by LED display .....                                    | 67        |
| 6.4.1    | Status and error displays .....                                     | 67        |
| 6.5      | Fault types, causes, and corrective measures.....                   | 70        |
| <b>7</b> | <b>Technical specifications.....</b>                                | <b>78</b> |
| 7.1      | Specifications .....                                                | 78        |
| <b>A</b> | <b>Dimension drawing .....</b>                                      | <b>82</b> |
| A.1      | Dimension drawing.....                                              | 82        |
| <b>B</b> | <b>Response times.....</b>                                          | <b>83</b> |
| B.1      | Maximum response time.....                                          | 83        |
| B.2      | Response time parameters for the F-DI 4/F-DQ 2 digital inputs.....  | 83        |
| B.3      | Response time parameters for the F-DI 4/F-DQ 2 digital outputs..... | 85        |
| <b>C</b> | <b>Switching of loads .....</b>                                     | <b>86</b> |
| C.1      | Connecting capacitive loads.....                                    | 86        |
| C.2      | Switching of inductive loads .....                                  | 87        |

# Documentation guide

The documentation for the SIMATIC ET 200AL distributed I/O system is arranged into three areas.



## Basic information

The *System Manual* and *Getting Started* describe in detail the configuration, installation, wiring and commissioning of the SIMATIC ET 200AL distributed I/O system. The STEP 7 online help supports you in the configuration and programming.

## Device information

Product manuals contain a compact description of the module-specific information, such as properties, terminal diagrams, characteristics and technical specifications.

## General information

The function manuals contain detailed descriptions on general topics regarding the SIMATIC ET 200AL distributed I/O system, e.g. diagnostics, communication, Motion Control, Web server.

You can download the documentation free of charge from the Internet (<https://support.industry.siemens.com/cs/ww/en/view/109742667>).

## Manual Collection ET 200AL

The Manual Collection contains the complete documentation on the SIMATIC ET 200AL distributed I/O system gathered together in one file.

You can find the Manual Collection on the Internet  
(<https://support.industry.siemens.com/cs/ww/en/view/95242965>).

## "mySupport"

With "mySupport", your personal workspace, you make the best out of your Industry Online Support.

In "mySupport", you can save filters, favorites and tags, request CAX data and compile your personal library in the Documentation area. In addition, your data is already filled out in support requests and you can get an overview of your current requests at any time.

You must register once to use the full functionality of "mySupport".

You can find "mySupport" on the Internet  
(<https://support.industry.siemens.com/cs/ww/en/my>).

## Application examples

The application examples support you with various tools and examples for solving your automation tasks. Solutions are shown in interplay with multiple components in the system - separated from the focus on individual products.

You will find the application examples on the Internet  
(<https://support.industry.siemens.com/sc/ww/en/sc/2054>).

## TIA Selection Tool

With the TIA Selection Tool, you can select, configure and order devices for Totally Integrated Automation (TIA).

This tool is the successor of the SIMATIC Selection Tool and combines the known configurators for automation technology into one tool.

With the TIA Selection Tool, you can generate a complete order list from your product selection or product configuration.

You can find the TIA Selection Tool on the Internet  
(<https://support.industry.siemens.com/cs/us/en/view/109767888>).

## Safety technology support

Siemens provides the following online comprehensive support for your use of safety technology:

- Safety Evaluation Tool - assists you in determining required safety levels
- Functional Examples - guides you in your safety applications
- Siemens training (SITRAIN) classes - offers training in safety standards and products
- SIMATIC STEP 7 Safety Advance F-Execution Times, F-Runtimes, F-Monitoring and Reaction Times Excel file (RT\_calculator) - assists you in calculating your maximum system response time

You can find the Safety Evaluation Tool on the Internet (<http://www.siemens.com/safety-evaluation-tool>).

You can find Functional Examples on the Internet (<http://www.siemens.com/safety-functional-examples>).

You can find SITRAIN classes on the Internet (<http://www.siemens.com/sitrain-safetyintegrated>).

You can find the RT\_calculator on the Internet (<http://support.automation.siemens.com/WW/view/en/49368678/133100>).

## Product overview

### 2.1 Properties

#### Article Number

6ES7146-5FF00-0BA0

#### View of the Module



Figure 2-1 View of the F-DI 4+F-DQ 2x24VDC/2A, 4xM12 Fail-Safe I/O module

## Properties

The module has the following technical properties:

- Four fail-safe digital inputs and two fail-safe digital outputs (M12 sockets for connection of sensors and actuators)
- One eCoding connection (M12 socket for eCoding plug)
- Two power ports, infeed and loop-through, which contain both logic and input power (1L+) and output power (2L+) (M8 module supply voltage ports)
- Two ET-Connection communication ports (M8 sockets)
- Fail-safe digital inputs:
  - 24 V DC rated
  - Two short-circuit proof sensor supplies
  - External sensor supply possible
  - Configurable diagnostics can be set for each channel
  - Configurable input delay
  - Suitable for switches and 3/4-wire proximity switches
- Fail-safe digital outputs:
  - Rated load voltage 24 V DC
  - Suitable for solenoid valves, DC contactors, and indicator lights
  - Output current per output 2.0 A
  - Configurable diagnostics can be set for each channel
- Dimensions 45 x 159 mm

The module supports the following functions:

- Firmware update
- Identification and maintenance data I&M0 to I&M3
- Value status (Quality Information)

The module has the following maximum achievable safety class in safety mode:

| Maximum achievable safety class in safety mode | 1-channel input | 2-channel input | Output channel |
|------------------------------------------------|-----------------|-----------------|----------------|
| Performance level according to EN ISO 13849-1  | Cat. 3, PL d    | Cat. 4, PL e    | Cat. 4, PL e   |
| SIL according to IEC 61508                     | SIL 2           | SIL 3           | SIL 3          |

## Accessories

The following components are included in the module package:

- Identification labels (Yellow)
- eCoding plug (Used to store the application's PROFI-safe addresses)



## Other components

The following components can be ordered as a spare part:

- Identification labels (Yellow)
- eCoding plug

The following components can be ordered as accessories:

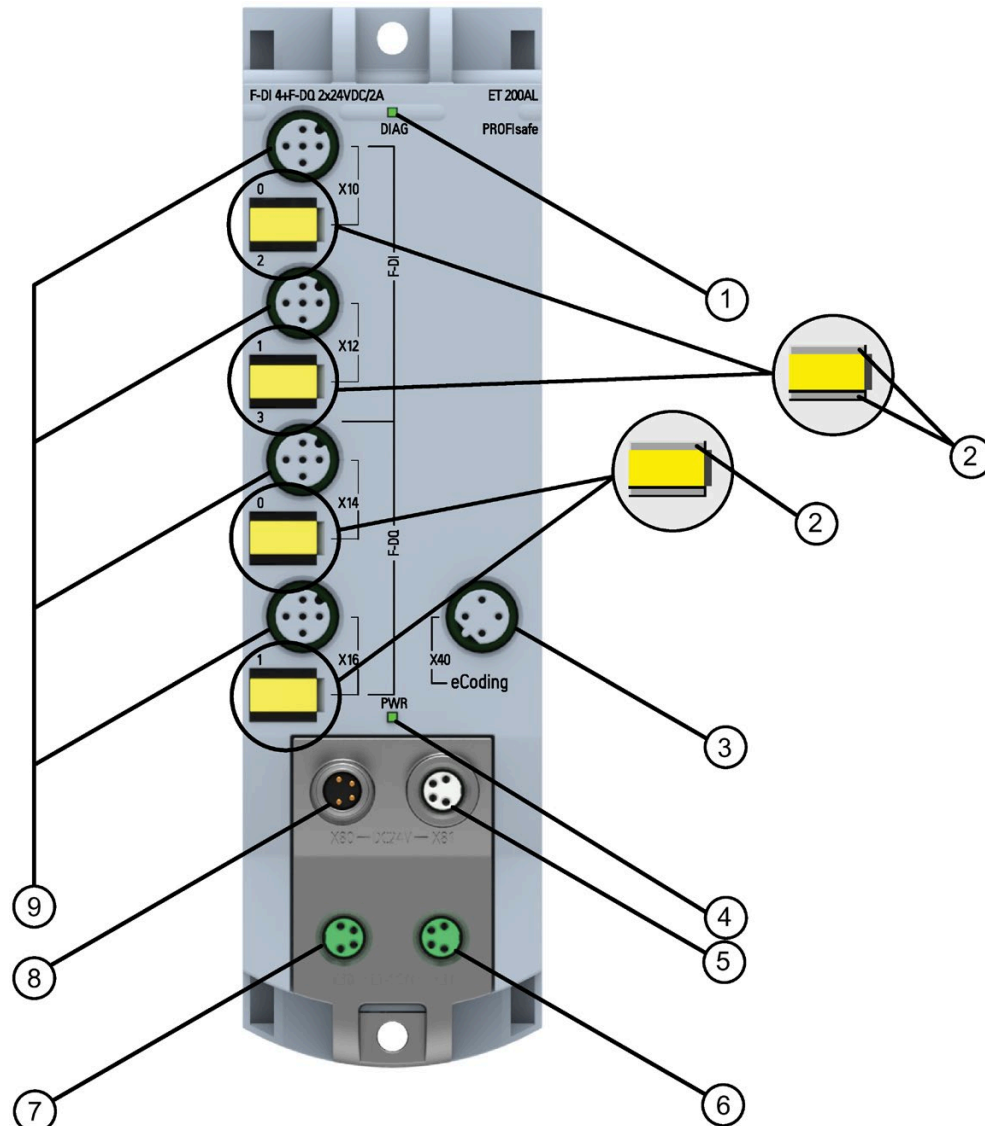
- Connectors
- Cables
- Stripping Tool for ET-Connection
- M8 sealing cap
- M12 sealing cap

## See also

You can find more information on accessories in "Accessories/spare parts" in the *ET 200AL distributed I/O system* system manual (<https://support.industry.siemens.com/cs/ww/en/view/89254965>).

## 2.2 Operator controls and display elements

The figure below shows the operator controls and display elements of the F-DI 4/F-DQ 2 Fail-Safe module:



- ① DIAG: LED display for the diagnostic status
- ② LED displays for the channel status
- ③ X40: eCoding plug connection
- ④ PWR: LED display for load voltage 2L+
- ⑤ X81: Socket for loop-through of the supply voltage (POWER output)
- ⑥ X31: Socket for ET-Connection OUT
- ⑦ X30: Socket for ET-Connection IN
- ⑧ X80: Connector for infeed of the supply voltage (POWER input)
- ⑨ X10 to X16: Sockets for the input/output signals

Figure 2-2 Operator controls and display elements

## 2.3 Fail-safe digital inputs

The digital inputs of the F-DI 4/F-DQ 2 Fail-Safe module are rated for connection to 24 V DC sensors/switches and 3/4-wire proximity switches (for example, BEROs: Siemens line of no-touch sensors) and have an EN 61131-2 type 1 input rating.

The fail-safe module has two 0.5 A sensor supply outputs that can power external sensors (inputs). All 1oo1 and 1oo2 application modes, except the "1oo2, 2 channel 3-wire nonequivalent" application mode, use the  $V_{S1}$  sensor supply to provide power for channels 0 and 1, and the  $V_{S2}$  sensor supply to provide power for channels 2 and 3. The "1oo2, 2 channel 3-wire nonequivalent" application mode uses the  $V_{S1}$  sensor supply to provide power for all four inputs and does not use the  $V_{S2}$  sensor supply.

### Inputs and test circuit

The fail-safe digital inputs consist of four input channels (F-DI x.0 to x.3). You can configure these channels as four one-out-of-one (1oo1) inputs (SIL 2/Cat. 3/PL d), two one-out-of-two (1oo2) inputs (SIL 3/Cat. 3 or Cat. 4/PL e), or combinations of 1oo1 and 1oo2 inputs.

| Connections | Input channel pairs |
|-------------|---------------------|
| X10         | 0 and 2             |
| X12         | 1 and 3             |

The fail-safe digital inputs use two microcontrollers to implement the safety function. One microcontroller monitors inputs 0 and 1, and the other microcontroller monitors inputs 2 and 3. The corresponding channels (0, 2) and (1, 3) form a 1oo2 channel group. The lower numbered channel of the group is called the primary input and the other channel is called the secondary input. The first of the two inputs in the channel group conveys the signal in a 1oo2 configuration. For example, if you wire F-DI 0.0 and F-DI 0.2 in a 1oo2 configuration and configure STEP 7 to use 1oo2 sensor evaluation, the signal state is reported at only the F-DI 0.0 input when you close or open the circuit for both.

When you configure a channel group as 1oo2, the two microcontrollers must sense the same input change within a configured time. Otherwise, the two microcontrollers detect a discrepancy error.

You can enable short-circuit testing if you use a sensor supply output to provide power to a sensor. The short-circuit test checks for shorts to 24 V DC by periodically pulsing the sensor output off and verifying that the associated input is off.

This short-circuit test also checks for shorts to the other circuit in "1oo2, 2 channel equivalent" and "1oo2, 2 channel 4-wire nonequivalent" application modes because the test pulses the two sensor outputs off at different times.

The microcontrollers provide internal test pulses to each other's process input circuits to verify that sensing electronics are responsive to both "1" and "0" inputs.

**See also**

Accessories for the ET200AL distributed I/O system  
<https://support.industry.siemens.com/cs/us/en/view/89254965>

**2.4 Fail-safe digital outputs**

The digital outputs of the F-DI 4/F-DQ 2 Fail-Safe module are for use in fail-safe applications and are suitable for various actuators such as the following:

- Solenoid valves
- DC contactors
- Indicator lights

The two digital outputs each have P- and M-switches that are rated to connect 24 V DC actuators with up to a 2.0 A rating. The two digital outputs use the load voltage 2L+ with a maximum current of 4.0 A. This means that the total current usage by the two digital outputs cannot exceed 3.96 A because the 2L+ supply uses about 40 mA.

**Outputs**

The fail-safe digital outputs consist of two output channels (F-DQ x.0 to x.1). You can use each output for SIL 3 applications.

| Connections | Output channel |
|-------------|----------------|
| X14         | 0              |
| X16         | 1              |

Each output consists of two switches:

- A P-switch connects 24 V DC positive (L+) to the load.
- An M-switch connects the load to M or 24 V DC return.

Both switches must be ON for current to flow to the load.

The fail-safe digital outputs use two microcontrollers to implement the safety function. One microcontroller controls the P-switch while the other microcontroller controls the M-switch. Status of the P-switch is fed back to the other microcontroller (the one that controls the M-switch). Likewise, status of the M-switch is fed back to the other microcontroller (the one that controls the P-switch). The microcontrollers use the feedback to verify that the output switches are operating properly and in the commanded state.

You must configure a "Maximum readback time" that specifies the allowed delay for the output voltage to respond to the switch change.

The fail-safe digital outputs regularly test each P- and M-switch to verify that each switch is still functional and under independent control. Your configured "Maximum readback time" also sets the duration of the "OFF" test pulse. You must configure a "Maximum readback time switch on test" which sets the duration of the "ON" test pulse. Choose these durations short enough to not affect your load.

## 2.4 Fail-safe digital outputs

The module can detect a broken wire or missing load when the output PV is OFF. If the broken wire diagnostic is enabled, then the load must be wired in the PM configuration or a broken wire diagnostic will occur (see applications 1, 3 or 4 in section 5.2 Digital output applications (Page 51)).

## Wiring

** WARNING**

**You can come into contact with live electrical wires connected to the main power supply.**

Death or serious personal injury and damage to machines and equipment may result if proper precautions are not taken.

Shut off the supply and load voltage before you wire the fail-safe module.

### 3.1 Terminal and block diagram

The following figure shows an example of the pin assignment of signal inputs with 4-wire connection as well as signal outputs:

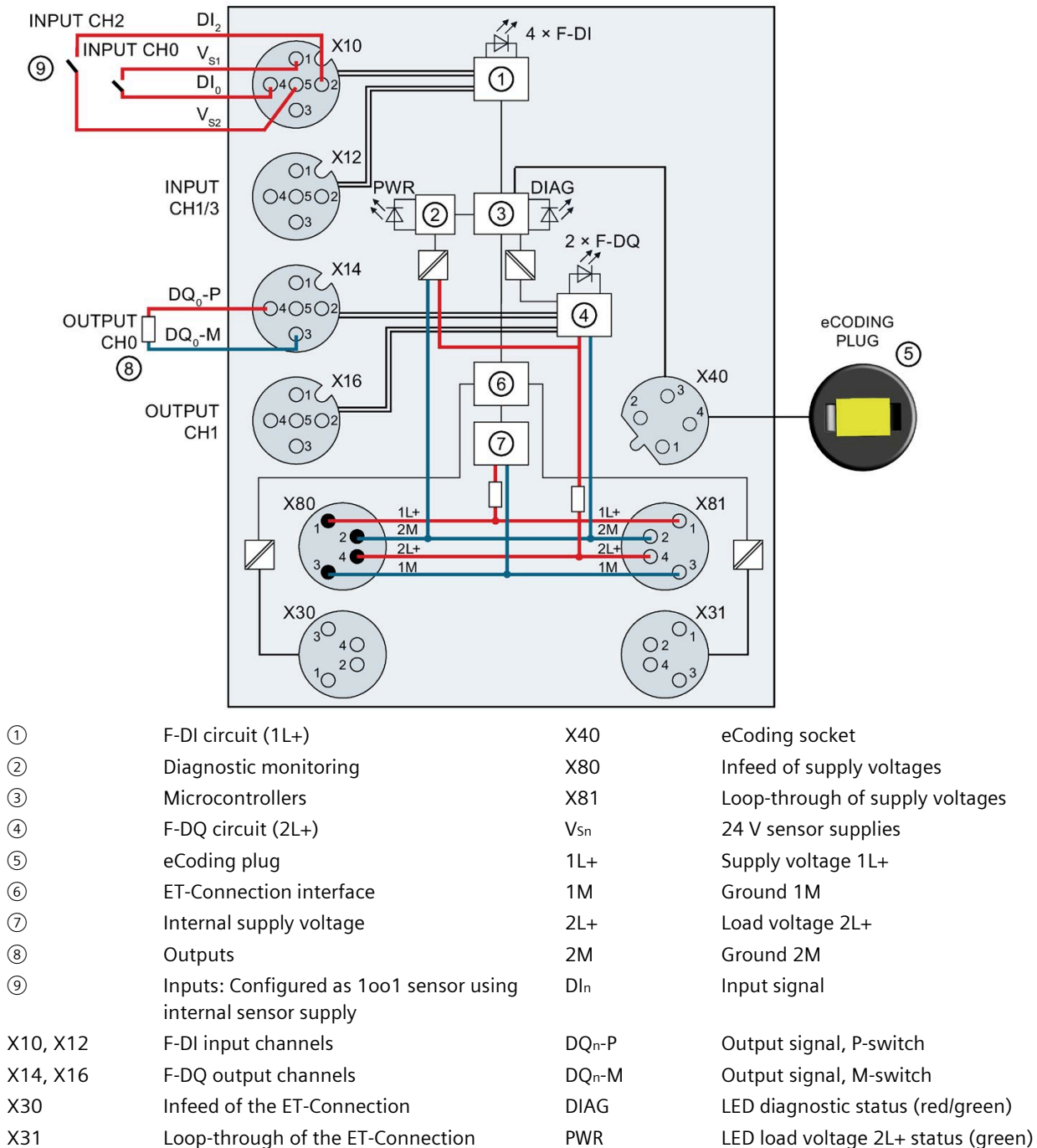


Figure 3-1 Terminal and block diagram

## 3.2 Pin assignment

### Note

Color coding

The sockets for ET-Connection and the power supply of the modules are color-coded. These colors correspond to the colors of the offered cables.

### Pin assignment of the sockets for fail-safe digital inputs/outputs

The tables below show the pin assignments of the four sockets for connection of the fail-safe digital inputs/outputs:

Table 3- 1 Pin assignment for fail-safe digital input sockets

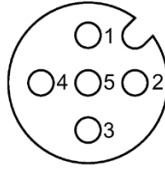
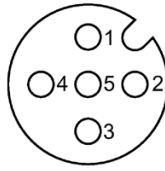
| Pin | Assignment                                                         | Front view of the sockets                                                            |
|-----|--------------------------------------------------------------------|--------------------------------------------------------------------------------------|
|     | X10 and X12 - sockets for fail-safe digital inputs                 | X10, X12                                                                             |
| 1   | 24 V DC sensor supply Vs1                                          |  |
| 2   | Input signal DI2: Connector X10<br>Input signal DI3: Connector X12 |                                                                                      |
| 3   | Sensor supply ground 1M                                            |                                                                                      |
| 4   | Input signal DI0: Connector X10<br>Input signal DI1: Connector X12 |                                                                                      |
| 5   | 24 V DC sensor supply Vs2                                          |                                                                                      |

Table 3- 2 Pin assignment for fail-safe digital output sockets

| Pin | Assignment                                                               | Front view of the sockets                                                             |
|-----|--------------------------------------------------------------------------|---------------------------------------------------------------------------------------|
|     | X14 and X16 - sockets for fail-safe digital outputs                      | X14, X16                                                                              |
| 1   | Unassigned                                                               |  |
| 2   | Unassigned                                                               |                                                                                       |
| 3   | Output signal DQ0-M: Connector X14<br>Output signal DQ1-M: Connector X16 |                                                                                       |
| 4   | Output signal DQ0-P: Connector X14<br>Output signal DQ1-P: Connector X16 |                                                                                       |
| 5   | Functional earth FE                                                      |                                                                                       |

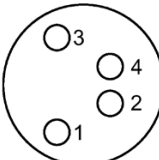
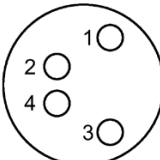


## 3.2 Pin assignment

## Pin assignment of the sockets for ET-Connection

The table below shows the pin assignments of the two sockets for the connection of ET-Connection:

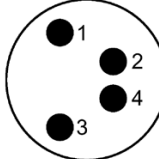
Table 3- 3 Pin assignment for ET-Connection

| Pin       | Assignment                    |                                | Assignment of the wire color of the bus cable for ET-Connection | Front view of the sockets                                                           |                                                                                     |
|-----------|-------------------------------|--------------------------------|-----------------------------------------------------------------|-------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------|
|           | X30 socket (ET-Connection IN) | X31 socket (ET-Connection OUT) |                                                                 | X30                                                                                 | X31                                                                                 |
| 1         | TXP                           | RXP                            | Yellow                                                          |  |  |
| 2         | RXP                           | TXP                            | White                                                           |                                                                                     |                                                                                     |
| 3         | RXN                           | TXN                            | Blue                                                            |                                                                                     |                                                                                     |
| 4         | TXN                           | RXN                            | Orange                                                          |                                                                                     |                                                                                     |
| Shielding | Functional earth FE           |                                | -                                                               |                                                                                     |                                                                                     |

## Pin assignment of the connector for infeed of the supply voltage

The table below shows the pin assignment of the connector for infeed of the supply voltage:

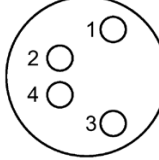
Table 3- 4 Pin assignment of the supply voltage connector

| Pin | Assignment                  | Assignment of the wire color of the power line cable | Front view of the connector                                                           |
|-----|-----------------------------|------------------------------------------------------|---------------------------------------------------------------------------------------|
|     | X80 connector (POWER input) |                                                      |                                                                                       |
| 1   | Supply voltage 1L+          | Brown                                                |  |
| 2   | Ground 2M                   | White                                                |                                                                                       |
| 3   | Ground 1M                   | Blue                                                 |                                                                                       |
| 4   | Load voltage 2L+            | Black                                                |                                                                                       |

## Pin assignment of the socket for loop-through of the supply voltage

The table below shows the pin assignment of the socket for loop-through of the supply voltage:

Table 3- 5 Pin assignment of the supply voltage socket

| Pin | Assignment                | Assignment of the wire color of the power line cable | Front view of the socket                                                              |
|-----|---------------------------|------------------------------------------------------|---------------------------------------------------------------------------------------|
|     | X81 socket (POWER output) |                                                      |                                                                                       |
| 1   | Supply voltage 1L+        | Brown                                                |  |
| 2   | Ground 2M                 | White                                                |                                                                                       |
| 3   | Ground 1M                 | Blue                                                 |                                                                                       |
| 4   | Load voltage 2L+          | Black                                                |                                                                                       |

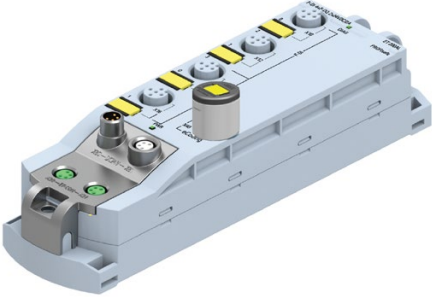
**Note****ET-Connection/supply voltage**

Installing a supply voltage cable in an ET-connection socket or an ET-connection cable in the supply voltage loop-through socket can destroy the module.

Observe the correct wiring of the M8 sockets for ET-Connection and the supply voltage.

### 3.3 Connecting the M12 eCoding plug

The eCoding plug (6ES7194-6KB01-0AA0) stores the PROFIsafe addresses that you assign to the F-DI 4/F-DQ 2 Fail-Safe module:

| eCoding Plug<br>(side view)                                                        | F-DI 4/F-DQ 2 with eCoding Plug Attached<br>(front view)                           | F-DI 4/F-DQ 2 with eCoding Plug Attached<br>(side view)                             |
|------------------------------------------------------------------------------------|------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------|
|  |  |  |

The eCoding plug stores the following information:

- PROFIsafe source address
- PROFIsafe destination address
- Address validity information

The eCoding plug occupies the X40 M12 socket, utilizing a B-coded plug. You use the eCoding plug to facilitate module replacement.

The eCoding plug stores assigned PROFIsafe source and destination addresses. The "Assign PROFIsafe address option" is selected in STEP 7 during the F-DI 4/F-DQ 2 Fail-Safe module set-up. The module checks the PROFIsafe addresses stored in the eCoding plug against the PROFIsafe reference addresses provided to the module during start-up parameterization.

Protection mechanisms prevent you from damaging the eCoding plug or an I/O channel due to attempted plugging of the eCoding plug into an I/O M12 socket or plugging of an I/O M12 cable into the X40 socket.

### 3.3 Connecting the M12 eCoding plug

Install the eCoding plug into the M12 socket at X40 with a torque of 1 Nm. Do not overtighten the eCoding plug as it could damage the threading.



#### **WARNING**

**If you remove/insert the eCoding plug with the power connected, this can lead to undefined states in your system.**

Death or serious personal injury and damage to the fail-safe module and associated machines/equipment may result if proper precautions are not taken.

Only remove or replace the eCoding plug when the power is disconnected. Always comply with the required standards and safety guidelines when configuring a system.

---

#### **Note**

When replacing the F-DI 4/F-DQ 2 Fail-Safe module, transfer the eCoding plug of the failed module to the replacement module to retain the PROFIsafe addresses stored in the eCoding plug. Otherwise, use STEP 7 to configure the PROFIsafe address in the replacement module. Ensure that the eCoding plug is not accidentally inserted in a module other than the intended F-DI 4/F-DQ 2 Fail-Safe module.

---

## Parameters/address space

All connected fail-safe I/O must have their operating properties configured by the STEP 7 Safety configuration software. You have the responsibility to ensure that no unconfigured modules are connected in a fail-safe automation system.

### F-Parameters

You must assign the PROFIsafe addresses (F-destination address together with F-source address) to the F-module before you put it into operation as follows:

- You define the F-source address using the "Central F-source addresses" parameter in the F-CPU.
- An F-destination address unique throughout the project's hardware configuration is automatically assigned for each F-module. You can manually change the F-destination addresses assigned in the hardware configuration.

You can find further information on F-parameters such as the F-monitoring time, the PROFIsafe address assignment (F-source address, F-destination address), F-parameter signature (with or without addresses) and the F-I/O DB in the *SIMATIC, Industrial Software, SIMATIC Safety - Configuring and Programming, Programming and Operating Manual* on the Internet (<https://support.industry.siemens.com/cs/ww/en/view/54110126>).

## 4.1 Configuring module I/O properties

To configure fail-safe module I/O properties, follow these steps:

1. Select the image of a fail-safe I/O device (on the Device view or Device overview) and view the module's "Properties" tab.
2. On the "Properties" view, select the "General" tab.
3. Select a property category in the left-side property tree and then set values in the right-side property fields.
4. A successful compile and download of your hardware configuration to one of the following CPUs automatically puts your new configuration settings in the I/O modules:
  - ET 200pro F
  - ET 200SP F
  - S7-1200 F
  - S7-1500 F
  - Prior generation S7-300 F and S7-400 F

## 4.2 Parameters

The following table shows the parameters for the F-DI 4/F-DQ 2 Fail-Safe module:

| Channel                                   | Value range                                                                                                                                                                               | Default                                | Parameter re-assignment in RUN | Scope   |
|-------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------|--------------------------------|---------|
| <b>F-parameters</b>                       |                                                                                                                                                                                           |                                        |                                |         |
| Manual assignment of F-monitoring time    | <ul style="list-style-type: none"> <li>disable</li> <li>enable</li> </ul>                                                                                                                 | disable                                | no                             | Module  |
| F-monitoring time                         | 1 to 65535 ms                                                                                                                                                                             | 150 ms                                 | no                             | Module  |
| F-source address                          | 1 to 65534                                                                                                                                                                                | 1 (always disabled)                    | no                             | Module  |
| F-destination address                     | 1 to 65534                                                                                                                                                                                | 65534 (always enabled)                 | no                             | Module  |
| F-parameter signature (with addresses)    | 0 to 65535                                                                                                                                                                                | always disabled                        | no                             | Module  |
| F-parameter signature (without addresses) | 0 to 65535                                                                                                                                                                                | always disabled                        | no                             | Module  |
| Behavior after channel fault              | <ul style="list-style-type: none"> <li>Passivate channel</li> <li>Passivate entire module</li> </ul>                                                                                      | Passivate channel (always enabled)     | no                             | Module  |
| Reintegration after channel fault         | <ul style="list-style-type: none"> <li>Adjustable</li> <li>All channels automatically</li> <li>All channels manually</li> </ul>                                                           | All channels manually (always enabled) | no                             | Module  |
| F-I/O DB manual number assignment         | <ul style="list-style-type: none"> <li>disable</li> <li>enable</li> </ul>                                                                                                                 | disable                                | no                             | Module  |
| F-I/O DB number                           | <ul style="list-style-type: none"> <li>Fixed value, if DB manual number assignment is disabled</li> <li>Value can be edited by user, if DB manual number assignment is enabled</li> </ul> | Fixed value                            | no                             | Module  |
| F-I/O DB name                             | -                                                                                                                                                                                         | always disabled                        | no                             | Module  |
| <b>DI parameters</b>                      |                                                                                                                                                                                           |                                        |                                |         |
| <b>Sensor supply</b>                      |                                                                                                                                                                                           |                                        |                                |         |
| Short-circuit test                        | <ul style="list-style-type: none"> <li>disable</li> <li>enable</li> </ul>                                                                                                                 | enable                                 | no                             | Channel |

| Channel                               | Value range                                                                                                                                                                                                                                               | Default                               | Parameter re-assignment in RUN | Scope   |
|---------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------|--------------------------------|---------|
| Interval for short-circuit test       | <ul style="list-style-type: none"> <li>12.8 ms</li> <li>25.6 ms</li> <li>51.2 ms</li> <li>102.4 ms</li> <li>204.8 ms</li> <li>409.6 ms</li> <li>819.2 ms</li> </ul>                                                                                       | 25.6 ms                               | no                             | Channel |
| Duration of short-circuit test        | <ul style="list-style-type: none"> <li>1.6 ms</li> <li>3.2 ms</li> <li>6.4 ms</li> <li>12.8 ms</li> </ul>                                                                                                                                                 | 1.6 ms                                | no                             | Channel |
| <b>Channel n, n+2</b>                 |                                                                                                                                                                                                                                                           |                                       |                                |         |
| Sensor evaluation                     | <ul style="list-style-type: none"> <li>1oo1 evaluation</li> <li>1oo2 evaluation: <ul style="list-style-type: none"> <li>2 channel equivalent</li> <li>2 channel - 3 wire non-equivalent</li> <li>2 channel - 4 wire non-equivalent</li> </ul> </li> </ul> | 1oo2 evaluation, 2 channel equivalent | no                             | Channel |
| Discrepancy behavior                  | <ul style="list-style-type: none"> <li>Supply value 0</li> <li>Supply last valid value</li> </ul>                                                                                                                                                         | Supply value 0                        | no                             | Channel |
| Discrepancy time                      | 5 ms to 30 s                                                                                                                                                                                                                                              | 5 ms                                  | no                             | Channel |
| Reintegration after discrepancy error | <ul style="list-style-type: none"> <li>Test 0-Signal not necessary</li> <li>Test 0-Signal necessary</li> </ul>                                                                                                                                            | Test 0-Signal not necessary           | no                             | Channel |
| <b>Channel n</b>                      |                                                                                                                                                                                                                                                           |                                       |                                |         |
| Activated                             | <ul style="list-style-type: none"> <li>disable</li> <li>enable</li> </ul>                                                                                                                                                                                 | enable                                | no                             | Channel |
| Input filters                         | <ul style="list-style-type: none"> <li>0.8 ms</li> <li>1.6 ms</li> <li>3.2 ms</li> <li>6.4 ms</li> <li>12.8 ms</li> </ul>                                                                                                                                 | 6.4 ms                                | no                             | Channel |

## 4.3 Explanation of parameters

| Channel                                      | Value range                                                                                           | Default              | Parameter re-assignment in RUN | Scope   |
|----------------------------------------------|-------------------------------------------------------------------------------------------------------|----------------------|--------------------------------|---------|
| Channel failure acknowledge                  | <ul style="list-style-type: none"> <li>Automatic</li> <li>Manual</li> </ul>                           | Manual               | no                             | Channel |
| Sensor supply                                | <ul style="list-style-type: none"> <li>Internal</li> <li>External</li> </ul>                          | Internal             | no                             | Channel |
| <b>DQ parameters</b>                         |                                                                                                       |                      |                                |         |
| Maximum test period                          | <ul style="list-style-type: none"> <li>100 s</li> <li>1000 s</li> </ul>                               | 1000 s               | no                             | Channel |
| <b>Channel n</b>                             |                                                                                                       |                      |                                |         |
| Wire break                                   | <ul style="list-style-type: none"> <li>disable</li> <li>enable</li> </ul>                             | disable              | no                             | Channel |
| Activated                                    | <ul style="list-style-type: none"> <li>disable</li> <li>enable</li> </ul>                             | enable               | no                             | Channel |
| Channel failure acknowledge                  | <ul style="list-style-type: none"> <li>Automatic</li> <li>Manual</li> </ul>                           | Manual               | no                             | Channel |
| Maximum readback time                        | 1.0 ms to 400.0 ms                                                                                    | 2.0 ms               | no                             | Channel |
| Maximum readback time switch on test         | 0.5 ms to 5.0 ms                                                                                      | 1.0 ms               | no                             | Channel |
| Disable dark test (max. SIL 2, Cat. 3, PL d) | <ul style="list-style-type: none"> <li>dark test is disabled</li> <li>dark test is enabled</li> </ul> | dark test is enabled | no                             | Channel |

## 4.3 Explanation of parameters

### 4.3.1 F-parameters

Information on F-parameters is available in the *SIMATIC Safety – Configuring and Programming* manual (<https://support.industry.siemens.com/cs/us/en/view/54110126>).

#### Behavior after channel fault

Use this parameter to specify whether the entire F-module is passivated or just the faulty channel(s) in the event of channel faults:

- "Passivate the entire module"
- "Passivate channel"

## Reintegration after channel fault

Use this parameter to select how the channels of the fail-safe module are reintegrated after a fault.

### Use in S7-300/400 F-CPUs

This parameter is always set to "Adjustable" when you use the fail-safe module in S7- 300/400 F-CPUs. You make the required setting in the F-I/O DB of the fail-safe module.

### Use in ET 200pro, ET 200SP and S7-1200/1500 F-CPUs

When using the fail-safe module in ET 200pro, ET 200SP and S7-1200/1500 F-CPUs, you set this parameter in the STEP 7 dialog of the fail-safe module:

- "Adjustable"
- "All channels automatically"
- "All channels manually"

If you have set the "Behavior after channel fault" parameter to "Passivate channel", you enable individual setting of the reintegration type per channel with the parameter assignment "Adjustable". The reintegration type of the respective channel is specified with the "Channel failure acknowledge" channel parameter.

If you have set the "Behavior after channel fault" parameter to "Passivate the entire module", you can only select the same reintegration type for all channels.

## 4.3.2 DI parameters

### Short-circuit test

You can enable the short-circuit detection for the channels of the F-module for which "Internal sensor supply" is set.

The short-circuit test is only useful if you are using simple switches that do not have their own power supply. For switches with a power supply, for example, 3/4-wire proximity switches, a short-circuit test is not possible.

The short-circuit test switches off the sensor supply briefly. The length of the deactivation period is equivalent to the configured "Duration of short-circuit test".

If a short-circuit is detected, the fault is reported to the F-CPU and the input is passivated.

The following short-circuits are detected:

- Short-circuit of input to L+
- Short-circuit of the input to another channel when it has a 1 signal
- Short-circuit between the input and sensor supply of another channel
- Short-circuit between the sensor supply and the sensor supply of another channel

If the short-circuit test is disabled, you must make your wiring short-circuit and cross-circuit proof or select a connection type (discrepancy, nonequivalent) which also detects the cross circuits using discrepancy.



### 4.3 Explanation of parameters

During the execution time (duration of short-circuit test + startup time of sensor after the short-circuit test) of the short-circuit test, the last valid value of the input before the start of the short circuit test is passed to the F-CPU. The activation of the short-circuit test thus affects the response time of the respective channel or channel pair.

#### Discrepancy time variation with short-circuit test

If your process input changes near when a short-circuit test is in progress, a discrepancy is detected in less time than your configured discrepancy time.

Elements of discrepancy time variations are defined as follows:

- **Tdisc** = configured discrepancy time
- **Tsct** = configured short circuit test duration
- **Tfilter** = configured input filter time
- **Tda** = actual discrepancy time, time between process signal changes that can be detected as a fault

The range of detected discrepancy time is as follows:

- If **Tfilter** < **Tsct**:  $\{Tdisc - (Tfilter + Tsct)\} \leq Tda \leq Tdisc$
- If **Tfilter** ≥ **Tsct**:  $\{Tdisc - (2 \times Tsct)\} \leq Tda \leq Tdisc$

Your configured discrepancy time should account for this variation to avoid unexpected passivations.

#### Interval for short-circuit test

You can specify how often the short-circuit test is executed (Interval) when the "Short-circuit test" check box is selected. The interval defines the period of time between two consecutive sensor supply OFF test pulses.

This value is the time between the OFF pulses of the sensor supply.

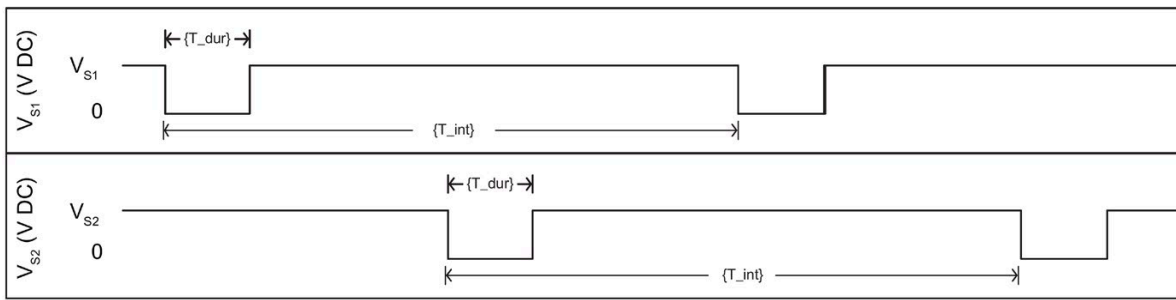
---

#### Note

The interval between pulses must be a minimum of eight times the duration of a pulse.

---

Short-circuit testing is performed on  $V_{s1}$  and  $V_{s2}$  independently, allowing module circuitry to detect shorts between the two sensor supplies as follows:



$V_{Sn}$   $V_{S1}$  or  $V_{S2}$  sensor supplies (V DC)

$T_{int}$  Short-circuit test interval (time period) between the OFF pulses of the sensor supply (ms)

$T_{dur}$  Short-circuit test OFF pulse time duration (ms)

### Duration of short-circuit test

You can specify the duration of the test pulse applied to the sensor supply when the "Short-circuit test" check box is selected.

This value is the time that the power supply remains off during the test. The short-circuit test OFF pulse must be long enough for the external sensors and wiring to respond and present a "0" to the inputs.

### Sensor evaluation

You can assign whether "channel n" input operates individually (1oo1) or is paired with its companion channel "n+2" input (1oo2).

Defines signal evaluation and wiring definitions. These selections correspond with the various application mode wiring examples.

**1oo1 evaluation:** One sensor is connected to the module on a single channel.

**1oo2 evaluation:** Two input channels are occupied by either:

- **2 channel equivalent** (with equivalent signals): One two-channel equivalent sensor or two single-channel equivalent sensors are connected to the two channels, in a channel pair.
- **2 channel - 3 wire nonequivalent:** One two-channel nonequivalent sensor is connected to the two channels, in a channel pair.
- **2 channel - 4 wire nonequivalent** One two-channel nonequivalent sensor or two single-channel nonequivalent sensors are connected to the two channels, in a channel pair.

If 1oo2 is selected, you must assign the discrepancy properties.

Refer to "Digital input applications (Page 39)" for illustrations of connection modes.

### 4.3 Explanation of parameters

When you select the channel group as 1oo2, STEP 7 (TIA Portal) enables the parameters in the first channel of the group and completely disables the parameters in the second channel of the group. The second channel derives its parameter values from the first channel's parameter values. When you select the channel group as 1oo1, STEP 7 (TIA Portal) enables all of the parameters in both channels.

---

**Note****Safety program access to 1oo2 input data**

For 1oo2 evaluation, two paired input channels (for example, F-DI 0 and F-DI 2) are connected to one or two sensors. The F-DI performs the discrepancy analysis and sends the result to the safety program, at the input address of the low-numbered channel of the pair (F-DI 0, in the example).

---

### Discrepancy behavior

A 1oo2 input configuration allows a logical difference between the two signals, without error, for the configured discrepancy time. You assign the value that is supplied to the safety program in the F-CPU during a discrepancy between two relevant input channels, which means while discrepancy time is running. You assign the discrepancy behavior as follows:

- "Supply last valid value"
- "Supply value 0"

---

**Note****Sensor-actuator response time is increased when you add more input discrepancy time**

The discrepancy time adds directly to the maximum response time of a 1oo2 evaluation if the two signals do not agree in logical state. If you select the "Supply value 0" option, then the F-DI does not delay a transition from "1" to "0" but can delay the transition from "0" to "1". If you select the "Supply last valid value" option, then the F-DI can delay both transitions from "1" to "0" and "0" to "1". The discrepancy time is influenced by sensor specifications, installation tolerances, and wiring. For best response time, select the smallest discrepancy time that provides reliable normal operation. Refer to "Response times (Page 83)" for further information.

---

### Discrepancy time

The two signals in a 1oo2 input configuration will not change exactly at the same time, due to differences in sensors, contacts, and wiring. You can configure a maximum expected duration for a mismatch between signals during transition.

### Reintegration after discrepancy error

You can assign whether a zero state must be detected on both 1oo2 inputs before a previously declared discrepancy can be cleared.

#### **"Test 0-signal necessary"**

If you have assigned "Test 0-signal necessary", a discrepancy error is not regarded as corrected until a 0-signal is present at both of the relevant input channels for a duration of at least 100 ms.

If you are using nonequivalent sensors, which means you have set "Sensor evaluation" to "1oo2 evaluation, nonequivalent", a 0-signal must be present again at the low order channel of the channel pair.

#### **"Test 0-signal not necessary"**

If you have assigned "Test 0-Signal not necessary", a discrepancy error is regarded as corrected when a discrepancy no longer exists between the two relevant input channels.

### **Activated**

You can enable the corresponding channel for signal processing in the safety program.

If you disable a channel, channel diagnostics are no longer reported to the F-CPU for the deactivated channel. Whenever you disable all output channels, you do not have to power 2L+ and 2L+ undervoltage reporting is suspended.

### **Input filters**

The module filters the digital inputs to remove contact bounce and short duration noise. This parameter assigns the duration of the filter time.

### **Channel failure acknowledge**

Controls whether the channel is automatically reintegrated after a fault clears or requires an acknowledgement (manual) in the user program. Refer to "Reactions to faults (Page 61)" for the reintegration procedure.

---

#### **Note**

The configuration of the "F-Parameters": "Reintegration after channel fault" parameter can determine your ability to modify the "Channel failure acknowledge" parameter's selection.

---

### **Sensor supply**

You can assign whether to supply 24 V DC power to sensors from the module's integrated sensor supply (internal) or from an external power supply (external).

Short-circuit tests are not performed for any channel where external power is selected.

### 4.3.3 DQ parameters

#### Maximum test period

You can assign the time interval between bit pattern tests for F-DQ DC output faults to a value of either 100 seconds or 1000 seconds.

Functional bit pattern tests are applied to the output switches. These tests detect faulted P- or M- output switches and wiring faults. Short circuits to other signals or power rails can be detected. Open circuits between the wiring terminals and the load are not detected.

If an error is detected on a channel, the test interval is shortened to 60 seconds. If an error is no longer detected on any output channel, the configured test interval is used again.

A persistent fault is reported to the fail-safe CPU and the affected channels are passivated.

#### Wire break

You can enable or disable wire break testing. Wire break is only detected when the channel is in the OFF state (process value is "0").

#### Activated

You can enable the corresponding channel for signal processing in the safety program.

If you disable a channel, channel diagnostics are no longer reported to the F-CPU for the deactivated channel.

---

#### Note

Whenever you disable all output channels, you do not have to power 2L+ and 2L+ undervoltage reporting is suspended.

---

#### Channel failure acknowledge

Controls whether the channel is automatically reintegrated after a fault clears or requires an acknowledgement (manual) in the user program. Refer to "Reactions to faults (Page 61)" for the reintegration procedure.

---

#### Note

The configuration of the "F-Parameters": "Reintegration after channel fault" parameter can determine your ability to modify the "Channel failure acknowledge" parameter's selection.

---

## Maximum readback time

The maximum readback time is a user-configured parameter that assigns the maximum time allowed for an output to reach the new state (ON or OFF) due to a process value change without generating an error. Also, this is the maximum width of a diagnostic test pulse applied during the bit pattern test to verify that an output can be turned OFF while it is in the ON state. The time of the OFF pulse should be as long as possible, but short enough so that the actuator cannot react.

The "Maximum readback time" parameter allows you to set the maximum time for verification that the channel's output switch states are as expected after a process value change.

If the expected output switch states (as reported by P-readback and M-readback signals) are not reached upon expiration of the "Maximum readback time", the output channel is passivated.

No new process values are switched to the output channels while a test pattern is applied to the outputs. This means that a higher "Maximum readback time" increases the response time of the F-module.



### WARNING

#### Short-circuit (cross-circuit) detection may not be possible for high frequency signals

Through the configured "Maximum readback time", short-circuits (cross-circuits) to a signal with a frequency greater than  $1/(2 \times \text{configured "Maximum readback time"})$  Hz cannot be detected (50:50 sampling ratio).

You must take this into consideration for your application and respective requirements of your product standards.

Short-circuits (cross-circuits) to an output of the same module are recognized regardless of the frequency of the output channel.

You can adjust the maximum readback time to change the frequency of the signal that can be detected.

The parameter also effects the short-circuit detection (cross-circuit) with a "1" signal when the output signal is changed from "1" to "0" with the safety program.

### Setting the parameter "Maximum readback time"

Because the fault response time is extended by the configured maximum readback time, we recommend that you set the "Maximum readback time" as low as possible, but high enough that the output channel is not passivated.

You determine the readback time required for your actuator with the diagram in "Connecting capacitive loads (Page 86)".

If the capacitance of the actuator is not known, it may be necessary for you to determine the value for the "Maximum readback time" by trial and error. This may also be necessary due to the part variances in the actuator or external influences.

Proceed as follows:

- Set the "Maximum readback time" so that the output channel can be read back correctly but your actuator does not respond yet.
- For verification, use the process value "0" with a minimum duration that corresponds to the "maximum test period" parameter. Execute a process value change from "1" to "0".
- If the output channel is passivated, the "Maximum readback time" is too small for the connected capacitive load. The discharge cannot take place within the configured "Maximum readback time". Increase the "Maximum readback time".

If you have set the "Maximum readback time" to the maximum value of 400 ms and there is still a passivation of the output channel, there is either an external fault or the connected capacitance is outside the permitted range.

### Dark test

Dark tests are switch-off tests which occur during an output bit-pattern test sequence.

When dark test is disabled on an output channel, the parameter "Maximum readback time" is only relevant for the process value change.

For a dark test, one of the output channel's switches is briefly turned OFF while the output channel is active (output signal "1"). As a result, current flow through the output is interrupted for a short time. A sufficiently slow actuator does not respond to this and remains switched on.

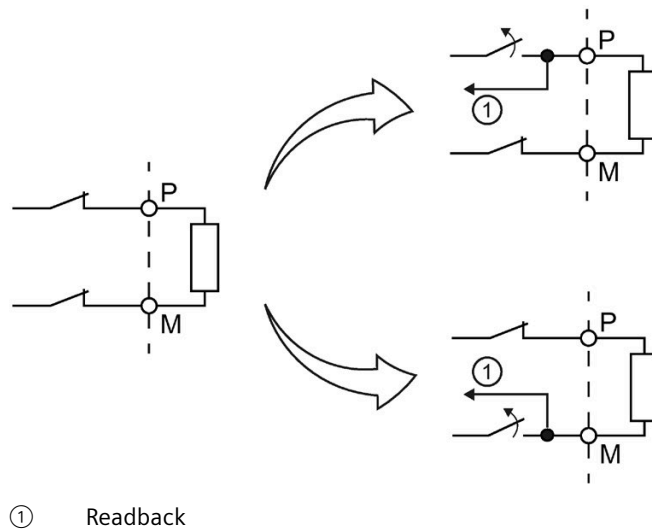


Figure 4-1 Functional principle of the dark test (PM switching)

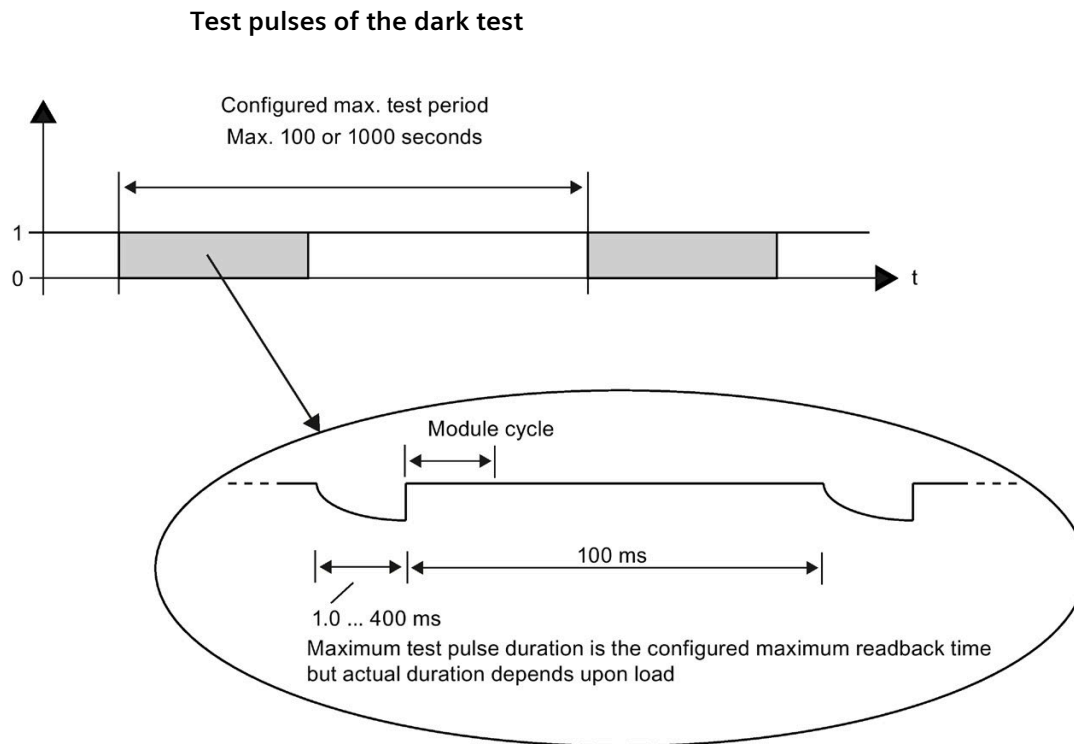


Figure 4-2 Test pulses of the dark test

You configure the time between output bit pattern test sequences to either 100 or 1000 seconds. Each output bit pattern test sequence includes multiple test pulses. The interval between two test pulses is at least 100 ms.

### Maximum readback time switch on test

You can configure the maximum readback time switch on test parameter to assign the maximum time for which the P-switch or the M-switch of a channel that is currently in OFF state can be switched ON during a bit pattern test step. This action tests the P- and M-switches on a channel such that only one switch is turned on at a time. Unless there is a fault in the system (for example, actuator shorted to ground), the actuator is not energized during either the P- or M-switch on tests. Under single fault conditions (either internal or external to the module), test pulses applied to either the P- or the M-switch of channels in the OFF state can repeatedly energize the actuator. You must select the parameter so that the duration of such pulses is too short to cause the actuator to react and, therefore, cannot have a hazardous effect on the equipment under control.

### Disable dark test (max. SIL 2, Cat. 3, PL d)

You can select the check box to disable channel dark testing.

To prevent an unwanted reaction of the actuator to a dark test, you can disable the dark test at the F-module output. An unwanted reaction can be for example, the brief de-energizing of a magnetic drive.



#### 4.4 Address space

A capacitive load that does not meet the load curve (see "Switching of loads (Page 86)") can result in a passivation of the output in case of a process value change or switch-on test, even if the dark test is disabled.

You can only reach up to SIL 2/Cat. 3/PL d with the dark test disabled.



#### WARNING

##### Loss of SIL 2/Cat. 3/PL d rating, loss of output control due to potential undetected faults

With the dark test disabled, an output that is turned on for more than 1 year may not be able to be turned off.

SIL 2/Cat. 3/PL d requires that there is a signal change from "1" to "0" at the corresponding output at least once a year.

Ensure the "0" signal has a duration of at least 2 seconds. It is not enough to simply turn off the supply or load voltage of the F-module and turn it on again.



#### WARNING

##### Loss of cross-circuit detection between channels

When you use the function "Disable dark test", cross-circuits between channels with "1" signal are not detected.

You must take this into consideration for your application and respective requirements of your product standards.

You must also take into consideration the respective requirements of your product standards regarding error detection time.

## 4.4 Address space

### Note

The F-DI 4/F-DQ 2 Fail-Safe module uses more I and Q memory than required for the physical number of inputs and outputs on the module. The extra bytes carry the PROFIsafe safety status and data integrity information. The number of input (I) bytes and output (Q) bytes that the F-DI 4/F-DQ 2 Fail-Safe module requires depends upon which PROFIsafe profile your fail-safe CPU uses.

| Module                        | PROFIsafe profile                                | Input (I) bytes required | Output (Q) bytes required |
|-------------------------------|--------------------------------------------------|--------------------------|---------------------------|
| F-DI 4+F-DQ 2x24VDC/2A, 4xM12 | V2.4 (with S7-300/S7-400)                        | 7                        | 5                         |
|                               | V2.6 (with ET 200pro, ET 200SP and S7-1200/1500) | 8                        | 6                         |

The figure below shows the assignment of the address space for the F-DI 4/F-DQ 2 Fail-Safe module with value status (Quality Information (QI)).

Assignment in the process image input (PII)

|      | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
|------|---|---|---|---|---|---|---|---|
| IB x | 0 | 0 | 0 | 0 |   |   |   |   |
|      | 0 | 0 | 0 | 0 | 0 | 0 |   |   |

Input values at channels 0 to 3 (all channels 1oo1)

Input values at channels 0 and 1 (all channels 1oo2)

|          | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
|----------|---|---|---|---|---|---|---|---|
| IB x + 1 | 0 | 0 | 0 | 0 |   |   |   |   |
|          | 0 | 0 | 0 | 0 | 0 | 0 |   |   |

Value status (QI) for inputs at channels 0 to 3 (all channels 1oo1)

Value status (QI) for inputs at channels 0 and 1 (all channels 1oo2)

|          | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
|----------|---|---|---|---|---|---|---|---|
| IB x + 2 | 0 | 0 | 0 | 0 | 0 | 0 |   |   |

Value status (QI) for outputs at channels 0 and 1

Assignment in the process image output (PIQ)

|      | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
|------|---|---|---|---|---|---|---|---|
| QB x | 0 | 0 | 0 | 0 | 0 | 0 |   |   |

Output values at channels 0 and 1

Figure 4-3 Address space

## Evaluating the value status

The value status bits provide information regarding the validity of the digital values or channel status:

- Bit = 1: Corresponding process value is valid
- Bit = 0: Channel is passivated

## Applications of the F-I/O module

The PLC system has an extremely low failure rate and therefore contributes only a small part of the total probability of dangerous failure of an automated system. The probability of dangerous failures of the sensors and actuators is typically far larger than the probability of dangerous failure per hour (PFH)/probability of dangerous failure on demand (PFD) of the PLC system. Estimates for quantitative safety properties like PFD and PFH are calculated using the following methods:

- standard data tables
- calculation methods according to international standards which include the following standards:
  - IEC 61508
  - ISO 13849
  - IEC 61131-6

The values are based on the following assumptions:

- continuous full nominal load
- nominal voltage
- equipment ambient temperature of 55 °C

Faults in the wiring system can also be a substantial contributor to failures.

To achieve a targeted level of safety performance for each safety function, perform these actions:

- Choose an appropriate architecture.
- Choose sensors and actuators that are appropriately rated.
- Provide a safety program that meets the requirements of the safety function.
- Provide diagnostics and proof-tests to maintain the ratings of the sensors and actuators.
- Use wiring installation practices, diagnostics, and proof-tests to assure wiring integrity.
- Generate and control operating and maintenance procedures for the lifetime of the installation.

The ET 200AL, ET 200pro, ET 200SP, and S7-1200/1500 Fail-Safe systems provide a high level of internal diagnostic coverage. Diagnostic coverage of your external circuits, sensors, and actuators depends on your design choices using features of the PLC system and other measures.

The PFH/PFD of each fail-safe PLC component is stated assuming there is no field proof-test within the lifetime of the product. Sensors and actuators typically require regular proof-tests to maintain an expected level of safety performance.

The reaction time of each safety function depends on the reaction time of each component, including the sensor, the PLC system, and the actuator. "Maximum response time (Page 83)" gives further information on delay times through the PLC components. You must choose PLC

parameters and external component reaction times to achieve a total safety reaction time goal.

In addition to the total delay from the safety demand input to the safe actuator response, you must consider these additional time-related factors. Refer to "Maximum response time (Page 83)" for exact information:

- To be assured of a safety response, a safety demand signal from the input sensor lasts long enough to be seen by the safety program. Your configured filter time, discrepancy resolution time, and short-circuit test duration all contribute to determining the required signal duration.
- The F-DI 4/F-DQ 2 Fail-Safe module digital outputs regularly test each P- and M-switch to verify that each switch is still functional and under independent control. The OFF test pulse duration can be as long as your configured "Maximum readback time". The ON test pulse duration can be as long as your configured "Maximum readback time switch on test". For a given output, the ON test pulse is only provided to one of the P- or M-switches at a time, but in the presence of single fault this could apply energy to your load. Your actuator should not respond to an OFF signal up to the "Maximum readback time" duration, or to an ON signal up to the "Maximum readback time switch on test" duration.
- The F-DI 4/F-DQ 2 Fail-Safe module digital outputs expect to complete and confirm any commanded transition from the ON to OFF output state. After your program changes the process output value from "1" to "0", do not change the "0" back to a "1" until the output's configured "Maximum readback time" has elapsed. The affected output passivates on commanded "0" states that are too short to confirm.

#### WARNING

**The safety performance of your installation depends on your design and continued maintenance of each complete safety function.**

The ET 200pro, ET 200SP and S7-1200/1500 Fail-Safe CPUs and F-DI 4/F-DQ 2 Fail-Safe module provide components for logic processing with a certified level of safety integrity when used in accordance with ratings, specifications, and instructions.

Failure to comply with these guidelines could cause damage or unpredictable operation which could result in death or severe personal injury and/or property damage.

You must choose all components of your installation and complete your design and maintenance according to accepted safety standards and practices to achieve your required level of safety.

## 5.1 Digital input applications

You should consider the application modes presented here along with the features of the F-DI 4/F-DQ 2 Fail-Safe module as described in the overview. Refer to "Fail-safe digital inputs (Page 14)".

## 5.1 Digital input applications

The main features of the F-DI 4/F-DQ 2 Fail-Safe module digital inputs include the following items:

- Inputs are 24 V DC rated inputs that meet the requirements of IEC 61131-2 as Type 1 inputs.
- Configure each channel as 1oo1 or part of a 1oo2 channel group. The corresponding channels (x.0, x.2) and (x.1, x.3) form a 1oo2 channel group. The lower numbered channel of the group is called the primary input and the other channel is called the secondary input. Within this restriction, you can assign 1oo1 and 1oo2 in any order.
- Short-circuit testing requires use of the internal sensor supply. For all evaluation and sensor interconnections except for 1oo2, 2 channel - 3 wire nonequivalent, use  $V_{S1}$  with inputs x.0 to x.1 and  $V_{S2}$  with inputs x.2 to x.3. For evaluation and sensor interconnection for 1oo2, 2 channel - 3 wire nonequivalent, use  $V_{S1}$  with inputs x.0 to x.3, and do not use  $V_{S2}$ .
- If you enable the short-circuit test, you configure both  $V_{S1}$  and  $V_{S2}$  with the same parameters. All channels that you configure for internal sensor supply are subject to the same short-circuit test. You configure a test duration (length of dark time) and test interval (time between the start of the dark tests).
- The module performs these short-circuit functions for F-DI channels:
  - Monitors the sensor supply to detect short-circuit or overload.
  - Cycles the sensor supply once on each power up to assure control and readback are working. This ensures operational integrity of the sensor supply at power up even when disabled.
  - Monitors the readback during input short-circuit tests.
- Configure a discrepancy time to identify unacceptable differences between 1oo2 inputs.
- Configure a filter time for each channel or each 1oo2 pair.

You can achieve Cat. 3 in 1oo1 configurations if you diagnose external wiring faults or exclude them according to standards by proper routing, protection, and proof-testing of conductors:

- Each F-DI input includes sufficient diagnostics and redundant components such that no single internal fault can cause a dangerous failure.
- An appropriately-rated, single sensor can reach Cat. 3 by internal fault tolerance.
- The external wiring of a single sensor to a single input is vulnerable to single fault dangerous failures unless you apply additional measures.

You can achieve Cat. 4 in 1oo2 configurations if you diagnose external wiring faults or exclude them according to standards by proper routing, protection, and proof-testing of conductors:

- With 1oo2 evaluation, a pair of F-DI inputs is not subject to dangerous internal failure within a reasonable number of accumulated internal faults.
- Appropriately-rated, external-paired sensors or equivalent redundancy can achieve Cat. 4.
- The duplicated external wiring of two sensors to two input points is vulnerable to accumulated fault dangerous failure unless you apply additional measures.

The fail-safe digital inputs are certified for SIL 3/PL e only when you select 1oo2 evaluation.

## Input architectures for achieving Safety Integrity Level (SIL)/Category/Performance Level (PL)

The following are the minimum conditions which must be met for achieving the corresponding safety requirements:

Table 5- 1 Safety Integrity Level (SIL)/Category/Performance Level (PL) requirements

| Application | Sensor supply <sup>1</sup> | Sensor evaluation | Channel connection | Type of sensor connection        | Achievable SIL/Category/PL      |                              |
|-------------|----------------------------|-------------------|--------------------|----------------------------------|---------------------------------|------------------------------|
|             |                            |                   |                    |                                  | Without short-circuit detection | With short-circuit detection |
| 1           | Internal                   | 1oo1 evaluation   | Single input       | 1 channel                        | 2/3/d                           |                              |
| 2           | External                   |                   |                    |                                  |                                 |                              |
| 3           | Internal                   | 1oo2 evaluation   | Two inputs         | 2 channel equivalent             | 3/3/e                           | 3/4/e                        |
| 4           | External                   |                   |                    |                                  | 3/3/e                           |                              |
| 5           | Internal                   |                   |                    | 2 channel - 3 wire nonequivalent | 3/3/e                           | 3/4/e                        |
| 6           | External                   |                   |                    |                                  | 3/3/e                           |                              |
| 7           | Internal                   |                   |                    | 2 channel - 4 wire nonequivalent | 3/3/e                           | 3/4/e                        |
| 8           | External                   |                   |                    |                                  | 3/3/e                           |                              |

<sup>1</sup> The F-DI 4/F-DQ 2 Fail-Safe module uses M12 I/O connections and is intended for use outside a cabinet in IP67 applications (everything sealed). If you require the use of an external supply, cut the M12 cable and make the connection inside a sealed cabinet or inside a sealed sensor. For external supplies, do not connect the pin 1 wire (V<sub>S1</sub>) or the pin 5 wire (V<sub>S2</sub>) in the M12 cable. This action prevents the sensor supply (which may be ON due to a different channel being configured as internal) from being shorted to the external 24 V DC. In addition, make the external 24 V DC connection inside a sealed cabinet or inside a sealed sensor.

Refer to "Pin assignment" (Page 19) for further information on connector pin assignments.

### 5.1.1 Applications 1 and 2: 1oo1 evaluation of single-channel sensors

#### F-DI application mode 1

This application mode uses single-channel sensors with a 1oo1 evaluation as shown in the following illustrations. When you use an internal sensor supply, you can successfully perform short-circuit detection.

#### Note

To incorporate F-DI application mode 1 into a SIL 2-rated application, ensure the sensors are appropriately qualified devices.



Figure 5-1 F-DI application mode 1: Internal sensor supply (1oo1 evaluation of a single-channel sensor shown)

Use Y cable (6ES7194-6KB00-0XA0) for F-DI application mode 1 to connect two single-channel sensors in 1oo1 evaluation as follows:

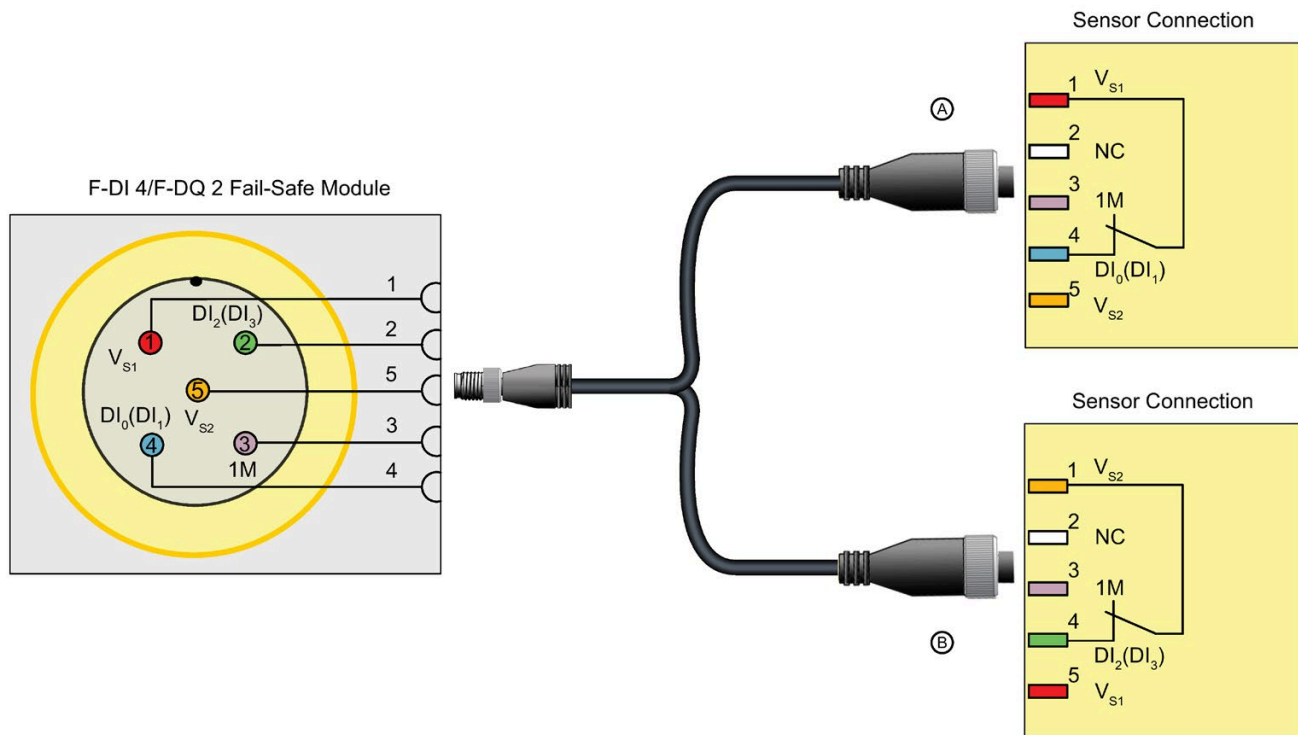


Figure 5-2 F-DI application mode 1: Internal sensor supply (1oo1 evaluation of two single-channel sensors shown)

## Parameter assignment

| Parameter name     | Parameter value |
|--------------------|-----------------|
| Sensor evaluation  | 1oo1 evaluation |
| Sensor supply      | Internal        |
| Short-circuit test | Enable          |

## F-DI application mode 2

This application mode uses single-channel sensors with a 1oo1 evaluation. When you use an external sensor supply, the module does not evaluate that channel for short-circuit testing.

### Note

To incorporate F-DI application mode 2 into a SIL 2-rated application, ensure the sensors are appropriately qualified devices.

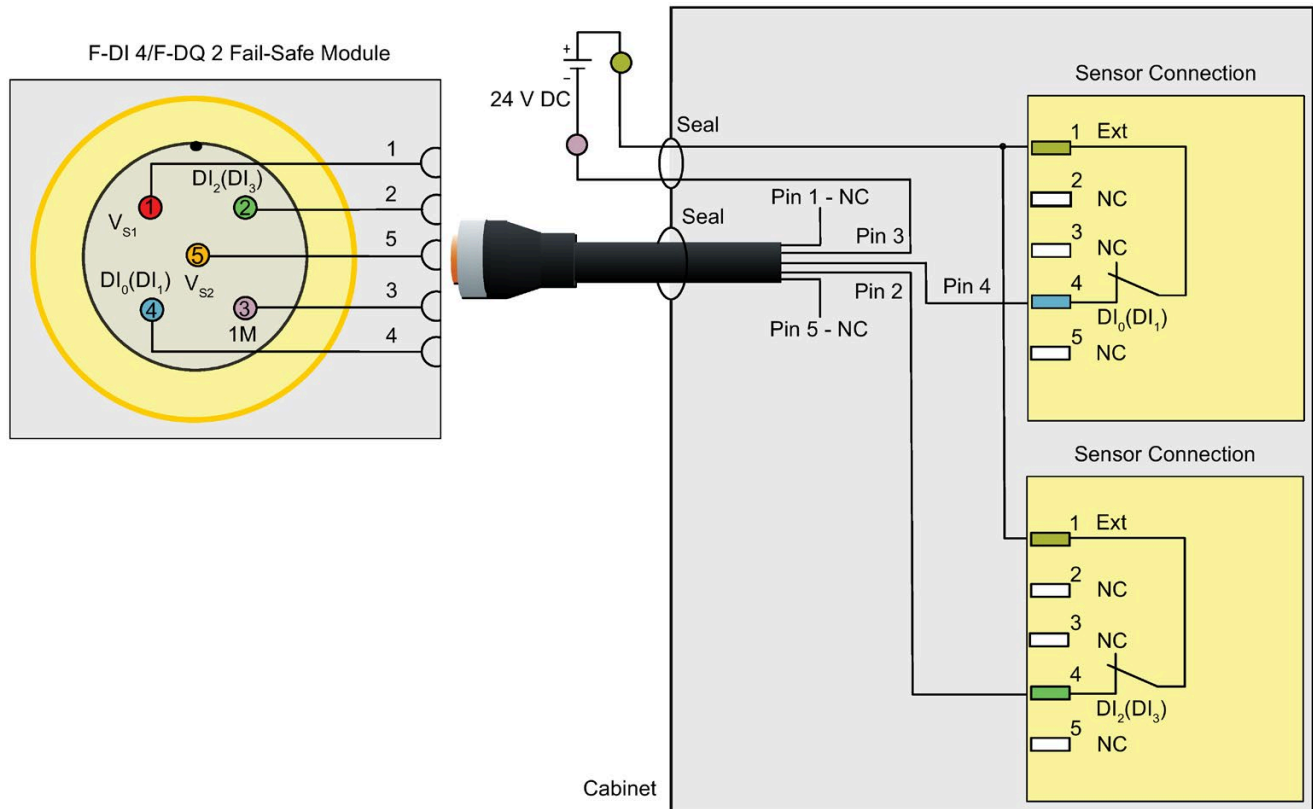


Figure 5-3 F-DI application mode 2: External sensor supply (1oo1 evaluation of two single-channel sensors shown)

## Parameter assignment

| Parameter name    | Parameter value |
|-------------------|-----------------|
| Sensor evaluation | 1oo1 evaluation |
| Sensor supply     | External        |



## 5.1.2 Applications 3 and 4: 1oo2 evaluation of equivalent sensors

### F-DI application mode 3

This application mode uses a two-channel sensor or two single-channel sensors in a 1oo2 voting with discrepancy evaluation. When you use an internal sensor supply, you can successfully perform short-circuit detection.

#### Note

To incorporate F-DI application mode 3 into a SIL 3-rated application, ensure the sensors are appropriately qualified devices.



Figure 5-4 F-DI application mode 3: Internal sensor supply (1oo2 evaluation of two-channel sensor shown)

Use Y cable (6ES7194-6KB00-0XA0) for F-DI application mode 3 as follows:

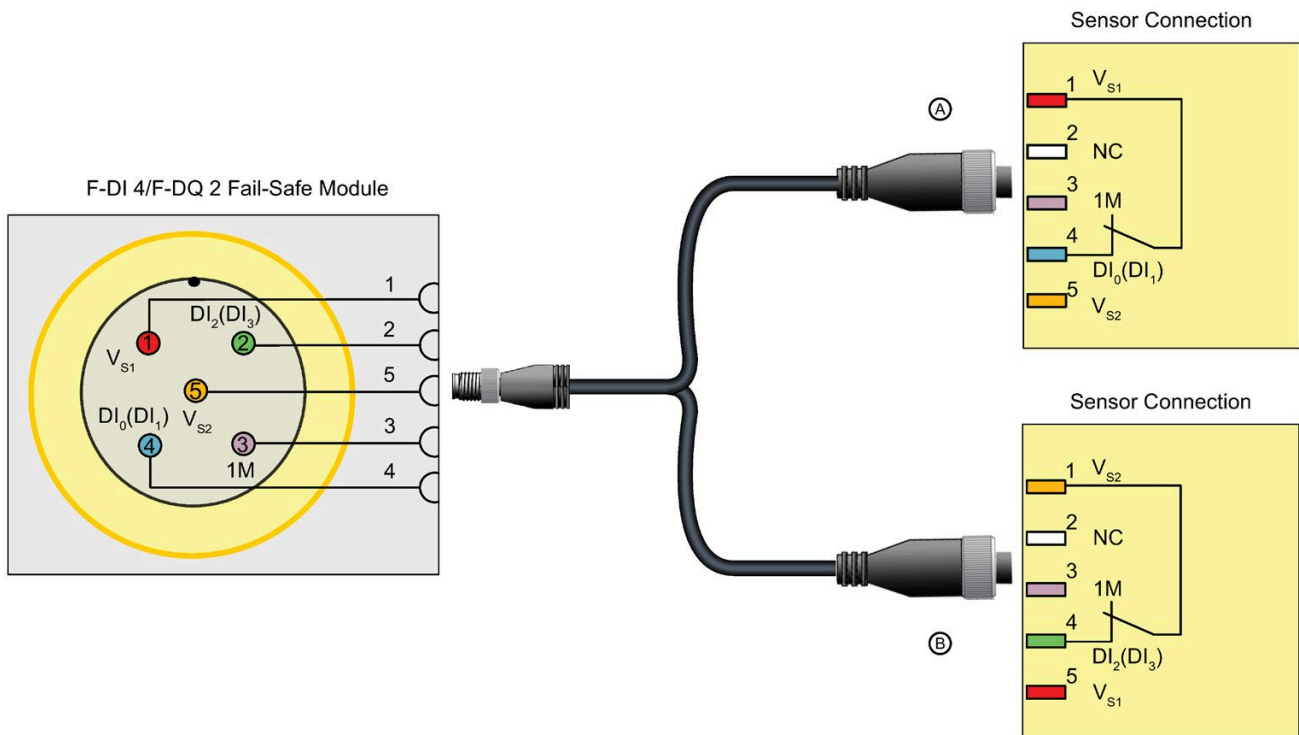


Figure 5-5 F-DI application mode 3: Internal sensor supply (1oo2 evaluation of two single-channel sensors shown)

### Parameter assignment

| Parameter name     | Parameter value                       |
|--------------------|---------------------------------------|
| Sensor evaluation  | 1oo2 evaluation, 2 channel equivalent |
| Sensor supply      | Internal                              |
| Short-circuit test | Enable                                |

### F-DI application mode 4

This application mode uses a two-channel sensor or two single-channel sensors in a 1oo2 voting with discrepancy evaluation. When you use an external sensor supply, the module does not evaluate that channel for short-circuit testing.

#### Note

To incorporate F-DI application mode 4 into a SIL 3-rated application, ensure the sensors are appropriately qualified devices.

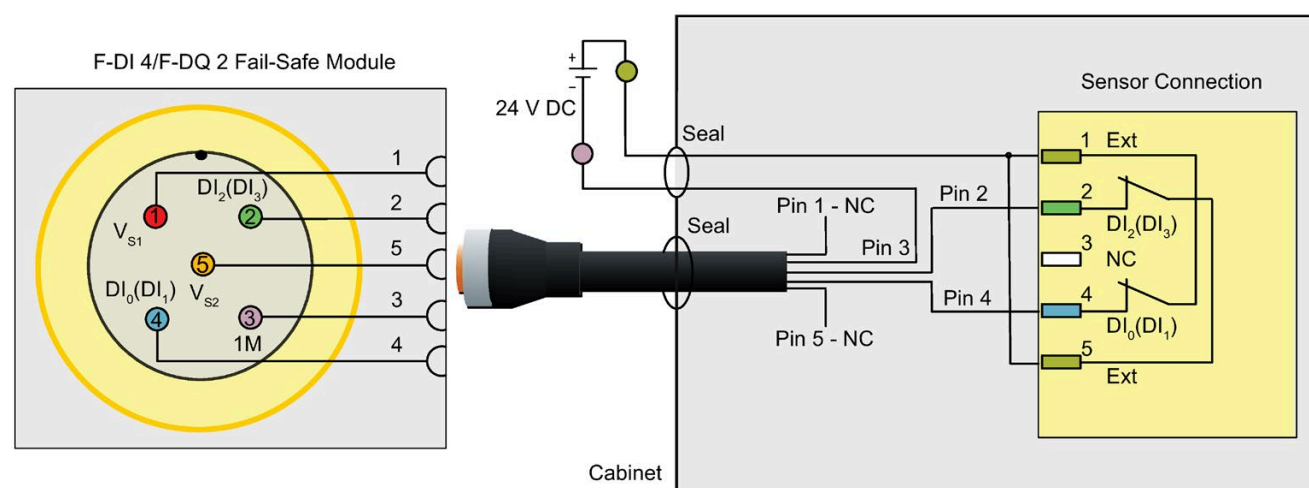


Figure 5-6 F-DI application mode 4: External sensor supply (1oo2 evaluation of two-channel sensor shown)

### Parameter assignment

| Parameter name    | Parameter value                       |
|-------------------|---------------------------------------|
| Sensor evaluation | 1oo2 evaluation, 2 channel equivalent |
| Sensor supply     | External                              |

### 5.1.3 Applications 5 and 6: 1oo2 evaluation of a 3-wire, nonequivalent sensor circuit

#### F-DI application mode 5

This application mode uses a two-channel sensor or two single-channel sensors with two nonequivalent outputs in a 1oo2 voting with discrepancy evaluation. When you use an internal sensor supply, you can successfully perform short-circuit detection. The application mode uses the following pins:

- Pin 2 (channels 2 and 3) is the inverted input of the nonequivalent configuration
- Pin 4 (channels 0 and 1) is the non-inverted input of the nonequivalent configuration

#### Note

To incorporate F-DI application mode 5 into a SIL 3-rated application, ensure the sensors are appropriately qualified devices.



Figure 5-7 F-DI application mode 5: Internal sensor supply (1oo2 evaluation of two-channel sensor with nonequivalent outputs shown)

Use Y cable (6ES7194-6KA00-0XA0) for application mode 5 as follows:

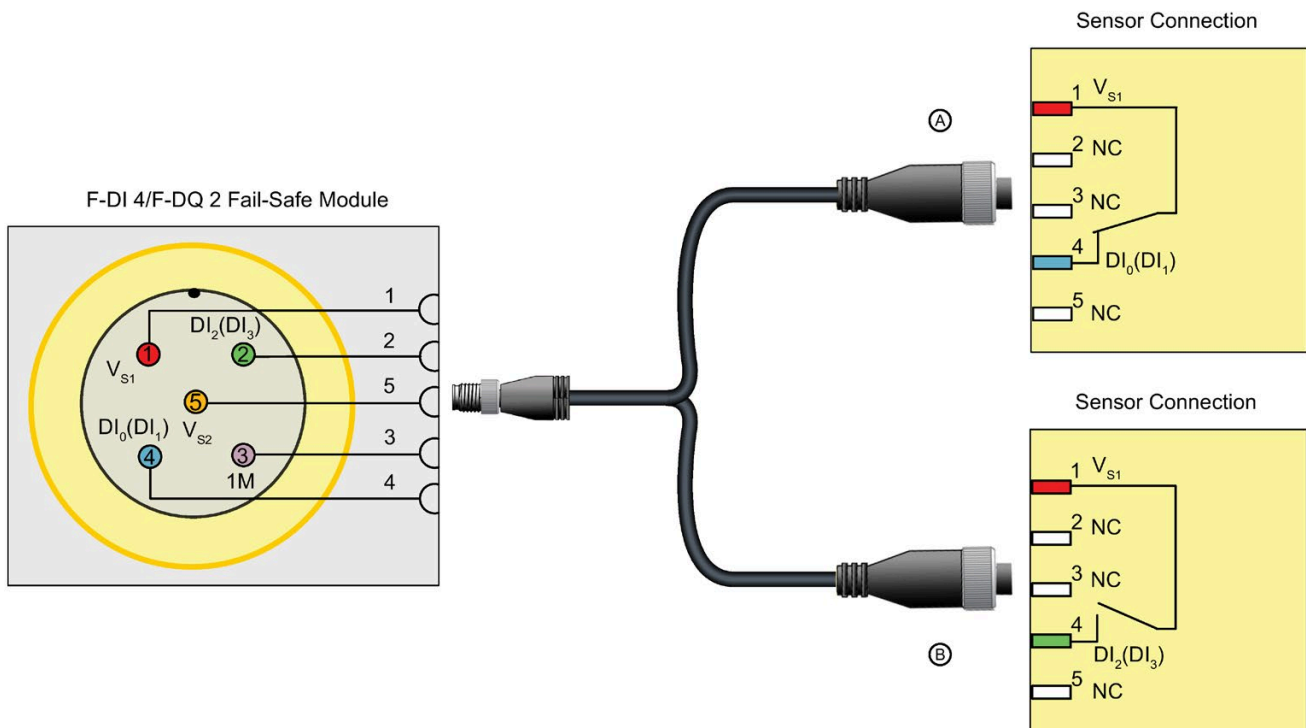


Figure 5-8 F-DI application mode 5: Internal sensor supply (1oo2 evaluation of two single-channel sensors with nonequivalent outputs shown)

## Parameter assignment

| Parameter name     | Parameter value                                   |
|--------------------|---------------------------------------------------|
| Sensor evaluation  | 1oo2 evaluation, 2 channel - 3 wire nonequivalent |
| Sensor supply      | Internal                                          |
| Short-circuit test | Enable                                            |

## F-DI application mode 6

This application mode uses a two-channel sensor or two single-channel sensors with two nonequivalent outputs in a 1oo2 voting with discrepancy evaluation. When you use an external sensor supply, the module does not evaluate that channel for short-circuit testing. The application mode uses the following pins:

- Pin 2 (channels 2 and 3) is the inverted input of the nonequivalent configuration
- Pin 4 (channels 0 and 1) is the non-inverted input of the nonequivalent configuration

### Note

To incorporate F-DI application mode 6 into a SIL 3-rated application, ensure the sensors are appropriately qualified devices.

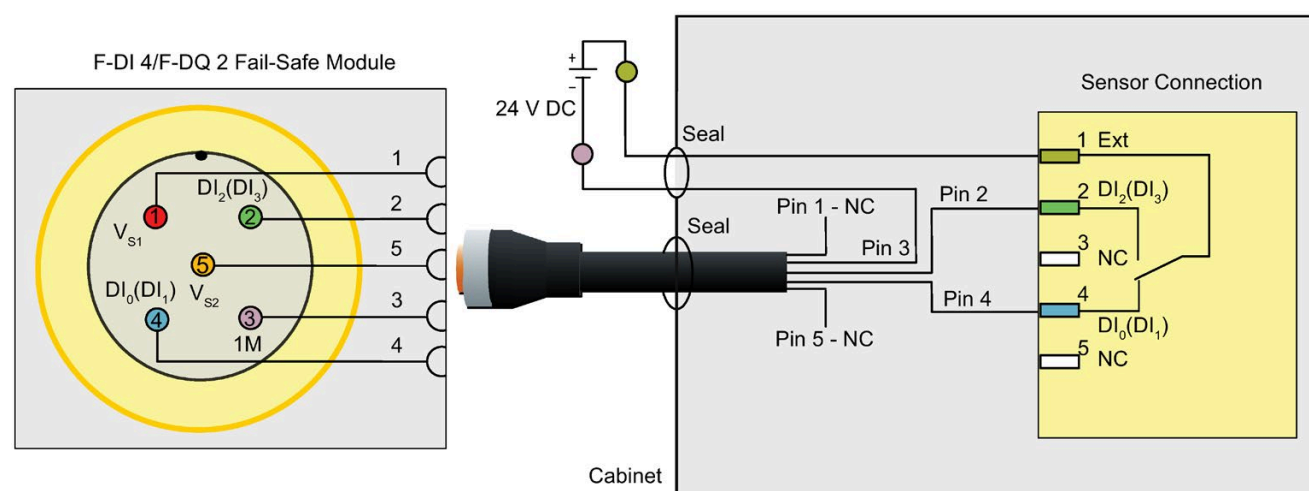


Figure 5-9 F-DI application mode 6: External sensor supply (1oo2 evaluation of two-channel sensor with nonequivalent outputs shown)

## Parameter assignment

| Parameter name    | Parameter value                                   |
|-------------------|---------------------------------------------------|
| Sensor evaluation | 1oo2 evaluation, 2 channel - 3 wire nonequivalent |
| Sensor supply     | External                                          |

### 5.1.4 Applications 7 and 8: 1oo2 evaluation of a 4-wire, nonequivalent sensor circuit

#### F-DI application mode 7

This application mode uses a two-channel sensor or two single-channel sensors in nonequivalent configuration (4-wire connection) in a 1oo2 voting with discrepancy evaluation. When you use an internal sensor supply, you can successfully perform short-circuit detection. The application mode uses the following pins:

- Pin 2 (channels 2 and 3) is the inverted input of the nonequivalent configuration
- Pin 4 (channels 0 and 1) is the non-inverted input of the nonequivalent configuration

#### Note

To incorporate F-DI application mode 7 into a SIL 3-rated application, ensure the sensors are appropriately qualified devices.



Figure 5-10 F-DI application mode 7: Internal sensor supply (1oo2 evaluation of two-channel sensor with nonequivalent outputs shown)

Use Y cable (6ES7194-6KB00-0XA0) for application mode 7 as follows:

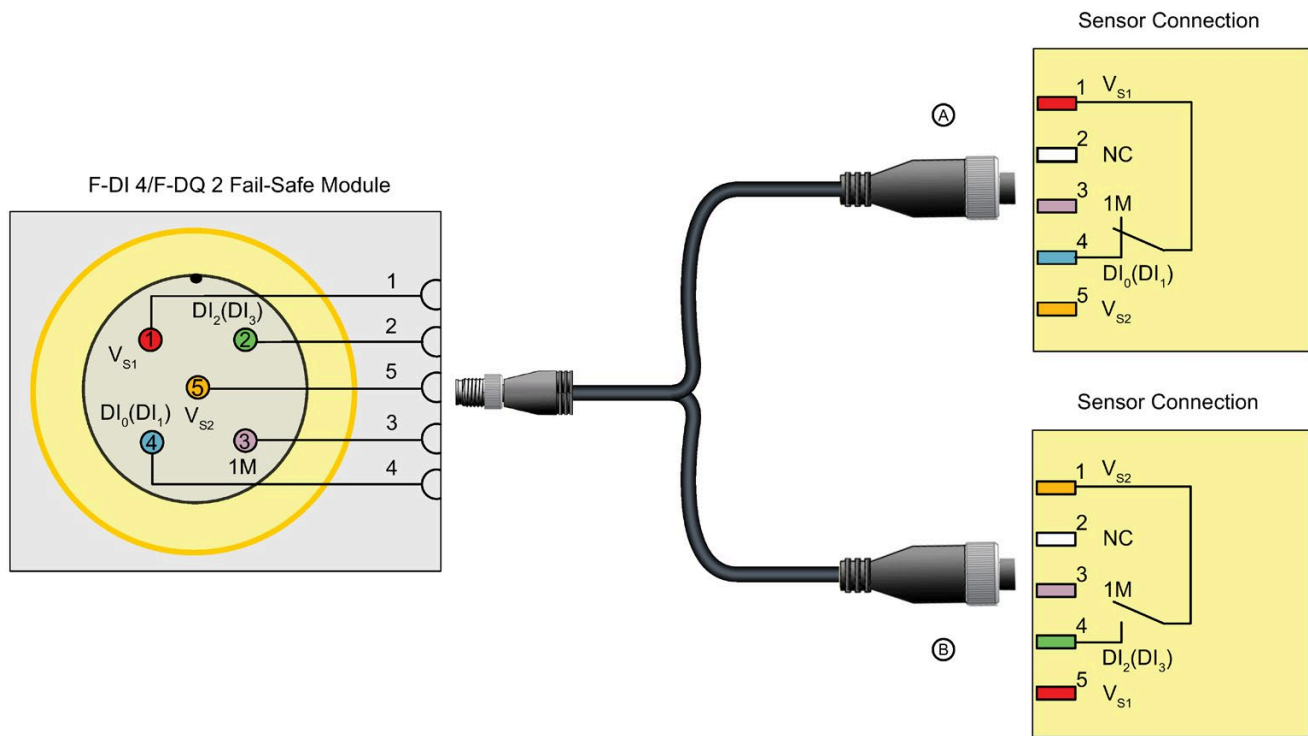


Figure 5-11 F-DI application mode 7: Internal sensor supply (1oo2 evaluation of two single-channel sensors with nonequivalent outputs shown)

### Parameter assignment

| Parameter name     | Parameter value                                   |
|--------------------|---------------------------------------------------|
| Sensor evaluation  | 1oo2 evaluation, 2 channel - 4 wire nonequivalent |
| Sensor supply      | Internal                                          |
| Short-circuit test | Enable                                            |

### F-DI application mode 8

This application mode uses two single-channel sensors or a two-channel sensor with two nonequivalent outputs in a 1oo2 voting with discrepancy evaluation. When you use an external sensor supply, the module does not evaluate that channel for short-circuit testing. The application mode uses the following pins:

- Pin 2 (channels 2 and 3) is the inverted input of the nonequivalent configuration
- Pin 4 (channels 0 and 1) is the non-inverted input of the nonequivalent configuration

#### Note

To incorporate F-DI application mode 8 into a SIL 3-rated application, ensure the sensors are appropriately qualified devices.

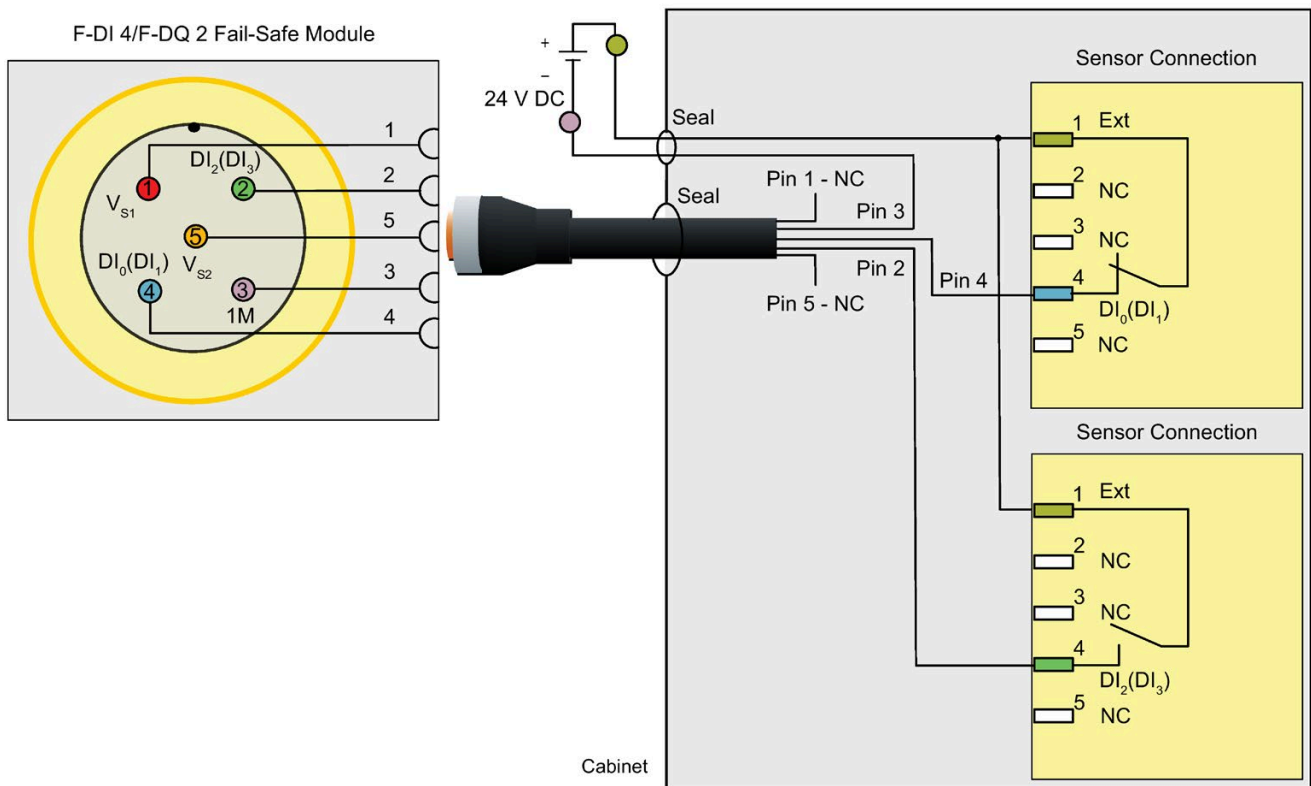


Figure 5-12 F-DI application mode 8: External sensor supply (1oo2 evaluation of two single channel sensors with nonequivalent outputs shown)

### Parameter assignment

| Parameter name    | Parameter value                                   |
|-------------------|---------------------------------------------------|
| Sensor evaluation | 1oo2 evaluation, 2 channel - 4 wire nonequivalent |
| Sensor supply     | External                                          |

## 5.2 Digital output applications

You should consider the application modes presented here along with the features of the F-DI 4/F-DQ 2 Fail-Safe module as described in the overview. Refer to "Fail-safe digital outputs (Page 15)".

The main features of the F-DI 4/F-DQ 2 Fail-Safe module digital outputs include the following items, which apply to each output channel:

- The fail-safe module separately controls current flow in the P output and M output.
- The voltage at the P and M outputs is read back to confirm proper state.
- The P and M outputs are regularly tested with short ON and OFF pulses to confirm control.



Ensure that the following steps are accomplished:

- Configure readback times that are sufficiently long to allow the channel's external voltages to respond to process value changes and applied test patterns from the bit pattern test. However, configuring readback times that are too long can cause your load to physically respond to applied test patterns during dark tests.
- Verify that internal current limiting as described in the data sheet is sufficient in combination with your 24 V DC supply. Consider whether additional current limits or fuses are necessary. Refer to "Specifications" and "Connecting" in the *ET 200AL distributed I/O system* manual (<https://support.industry.siemens.com/cs/ww/en/view/89254965>).

The module controls all output channels as 1oo2 with cross-diagnostics.

All applications shown are capable of reaching SIL 3/Cat. 4/PL e unless you have dark testing disabled.

To reach Cat. 4, ensure that the following conditions are met:

- The dark testing is enabled.
- The external contactors are SIL-rated with sense contacts.
- The diagnostics are within limits when you read the sense contacts back and confirm the external contactor response in your program. Siemens recommends using an F-DI input for sense contact and other safety diagnostic inputs.

## Output architectures for achieving Safety Integrity Level (SIL)/Category/Performance Level (PL)

The following are the minimum conditions which must be met for achieving the corresponding safety requirements:

Table 5- 2 Safety Integrity Level (SIL)/Category/Performance Level (PL) requirements

| Application | Type of actuator connection                                        | Achievable<br>SIL/Category/PL |                   |
|-------------|--------------------------------------------------------------------|-------------------------------|-------------------|
|             |                                                                    | Dark test disabled            | Dark test enabled |
| 1           | Directly-connected SIL-rated actuator                              | 2/3/d                         | 3/4/e             |
| 2           | External contactors: Separate P and M controlled contactors        | 2/3/d                         | 3/4/e             |
| 3           | External contactors: Parallel-connected contactors between P and M | 2/3/d                         | 3/4/e             |
| 4           | External contactors: Separate output channels for each contactor   | 2/3/d                         | 3/4/e             |

Refer to "Pin assignment (Page 19)" for further information on connector pin assignments.

Refer to "Disable Dark Test (max. SIL 2, Cat. 3, PL d)" in "DQ parameters (Page 32)" for additional information on enabling and disabling dark testing.

### 5.2.1 Application 1: Wiring a directly-connected SIL-rated actuator

The module supports application mode 1, where there is a direct connection of a load between the P and M outputs of one channel. Both switches are opened when de-energizing the load.

#### Note

This configuration achieves SIL 3/Cat. 4/PL e if neither channel is configured to disable the dark test.

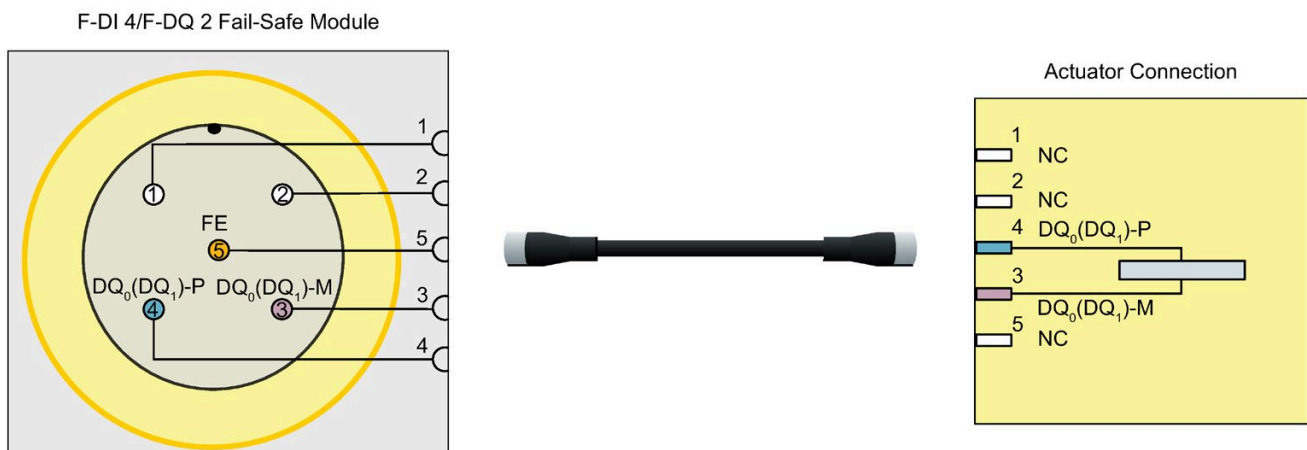


Figure 5-13 F-DQ application mode 1

### 5.2.2 Application 2: Wiring external contactors: Separate P and M controlled contactors

The module supports application mode 2, where the module controls the load using series-connected, normally-open contacts of two relays. The coil of one relay connects the P-output of a channel and M. The coil of the other relay connects the M-output of the same channel and L+.

#### Note

This configuration achieves SIL 3/Cat. 4/PL e if you fulfill the following conditions:

- The CPU checks the relay status (feedback) using a separate digital input.
- You adequately protect the wiring against shorts from the P output to L+ and shorts from the M output to M. The CPU cannot switch off the actuator if both faults occur.
- You do not disable dark test for either output.

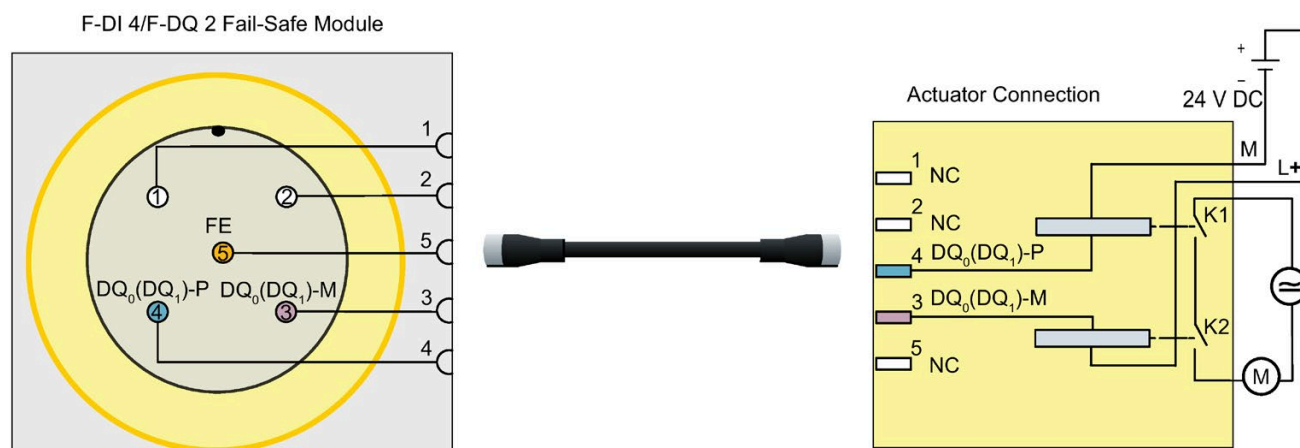


Figure 5-14 F-DQ application mode 2

### 5.2.3 Application 3: Wiring external contactors: Parallel-connected contactors between P and M

The module supports application mode 3, where the module controls the load using the series-connected, normally-open contacts of two relays. You connect the coils of both relays, in parallel, across the outputs of one channel.

#### Note

This configuration achieves SIL 3/Cat. 4/PL e if the CPU checks the relay status (feedback) using a separate digital input and if neither channel is configured to disable the dark test.

Application mode 3 is the preferred way of controlling an actuator using relays in a safety-related application. Application mode 3 avoids the problems mentioned for Application mode 2, regarding short-circuits of the P and M outputs.

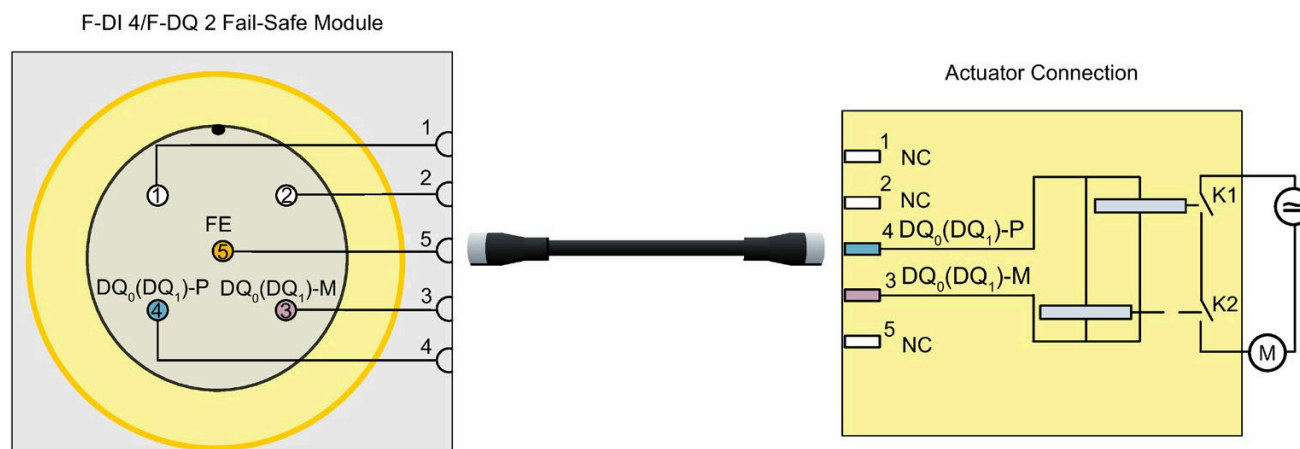


Figure 5-15 F-DQ application mode 3

### 5.2.4 Application 4: Wiring external contactors: Separate output channels for each contactor

The module supports application mode 4, where the module controls the load using the series-connected, normally-open contacts of two relays. Connect the coils of both relays across the outputs of two channels. In the safety program, write the same process value (ON or OFF) to both output channels.

#### Note

This configuration achieves SIL 3/Cat. 4/PL e if the CPU checks the relay status (feedback) using a separate digital input and neither channel is configured to disable the dark test.

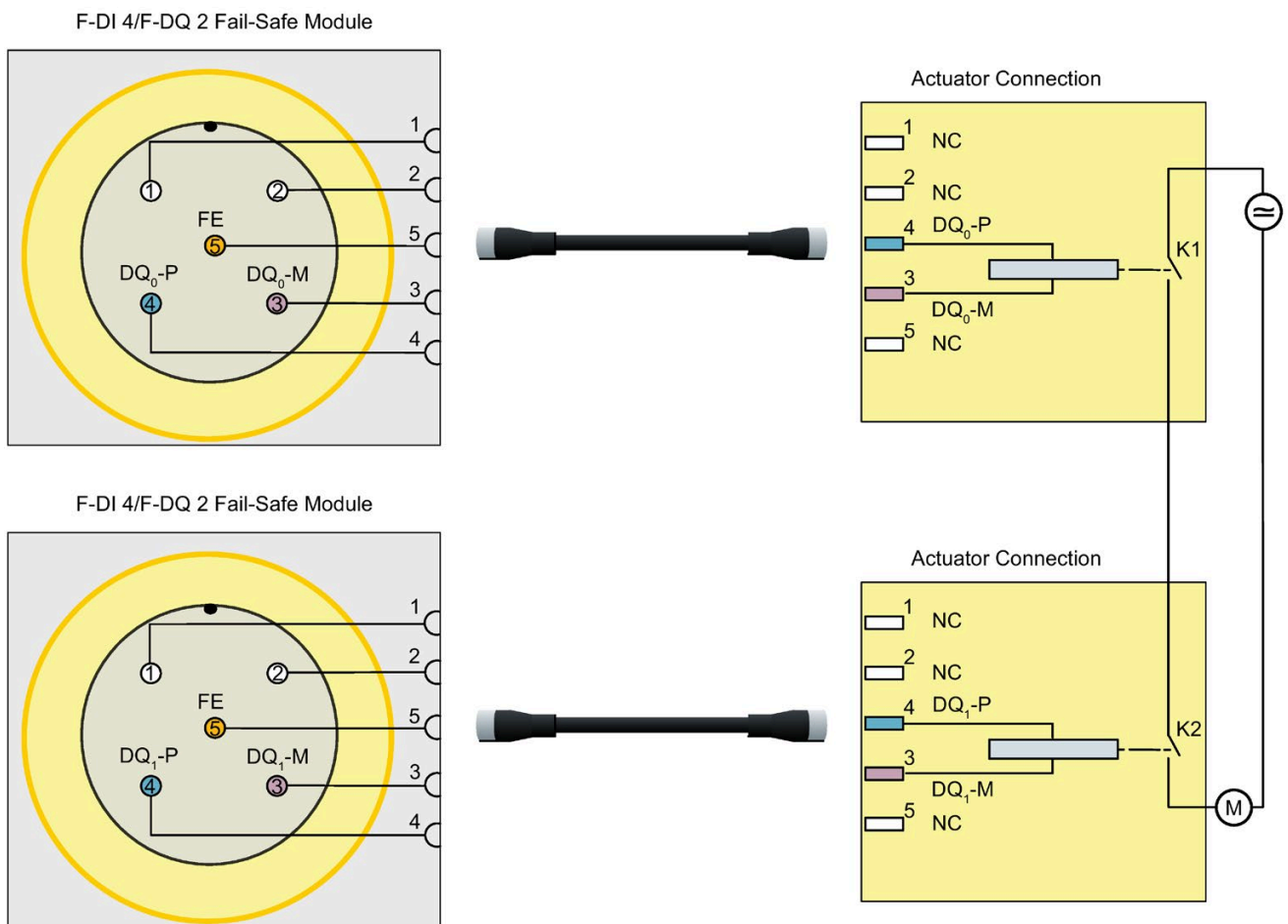


Figure 5-16 F-DQ application mode 4

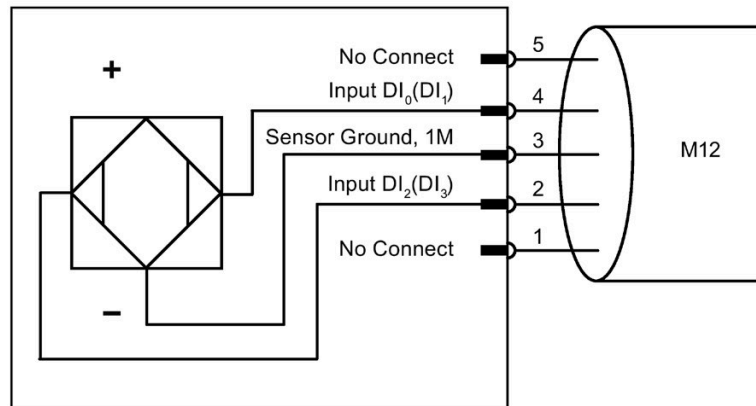
## 5.3 Examples of application modes for the F-DI 4/F-DQ 2 Fail-Safe module

You can connect field devices to the F-DI 4/F-DQ 2 Fail-Safe module as shown below.

**Laser scanner (1oo2 evaluation)**

For the output signal switching device (OSSD) sensors of a Laser Scanner, use F-DI application mode 4 to connect the Laser Scanner output signal switching device with 1oo2 evaluation to the F-DI 4/F-DQ 2 Fail-Safe module:

Laser Scanner (1oo2)

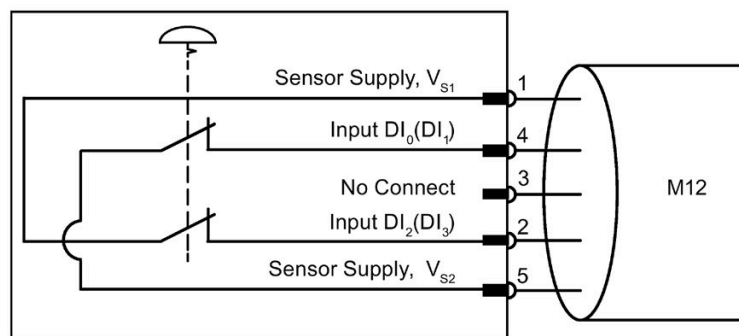


Alternatively, use F-DI application mode 3 and disable the parameter "Short-circuit test" for both sensor supplies.

**ESTOP (Emergency Stop) (1oo2 evaluation)**

For the ESTOP, use F-DI application mode 3 to connect an ESTOP device with 1oo2 evaluation to the F-DI 4/F-DQ 2 Fail-Safe module:

ESTOP (1oo2)

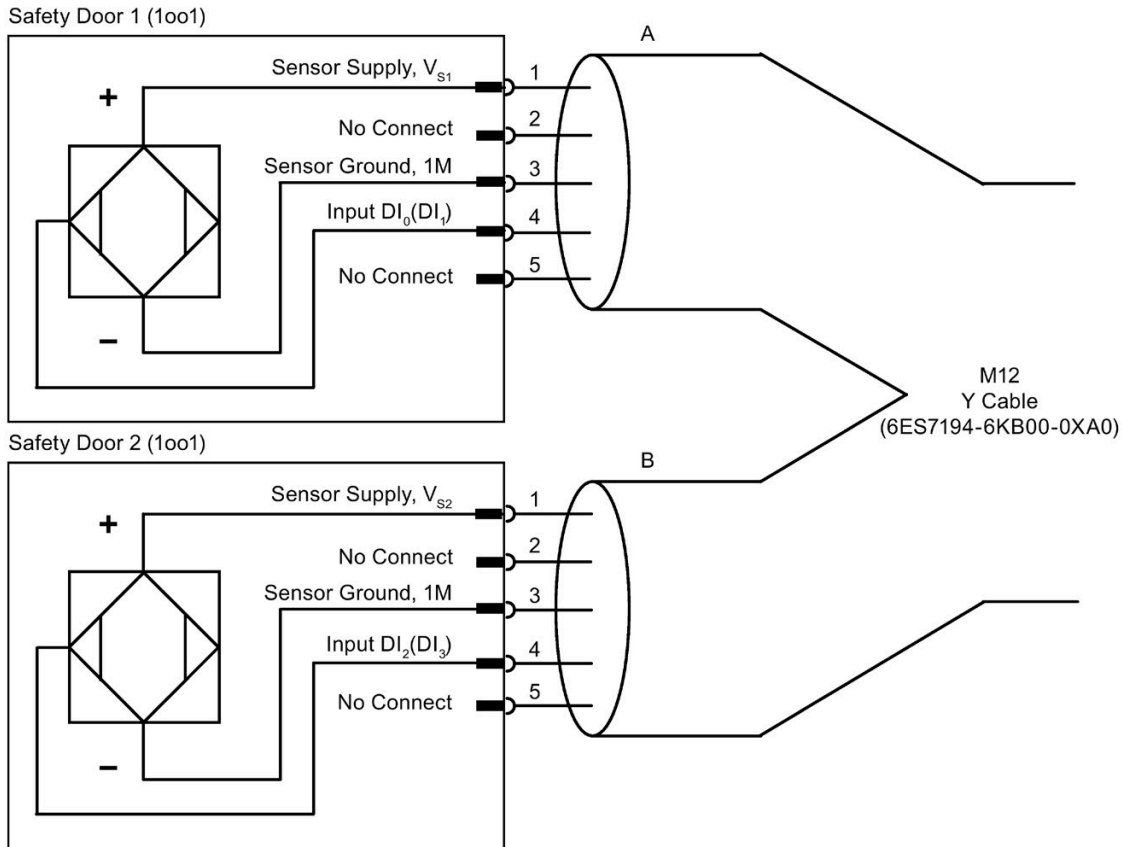


Alternatively, use F-DI application modes 5 or 7 if nonequivalent evaluation is required for your ESTOP device.

### Safety doors (1oo1 or 1oo2 evaluation)

For the Safety Doors, you can do one of the following:

- Use F-DI application mode 1 with the fail-safe Y cable (6ES7194-6KB00-0XA0) to connect two single-channel sensors with 1oo1 evaluation to one input connection of the F-DI 4/F-DQ 2 Fail-Safe module.
- Use F-DI application mode 3 (1oo2 evaluation), using two single-channel sensors on the same safety door.



Alternatively, use F-DI application mode 5 with the fail-safe Y cable (6ES7194-6KA00-0XA0) to connect two nonequivalent single-channel sensors with 1oo2 evaluation on the same safety door.

### Safety position switch with interlock (1oo2 evaluation)

Use F-DI application mode 3 and F-DQ application mode 1 to connect the safety position switch with interlock to the F-DI 4/F-DQ 2 Fail-Safe module.

## 5.3 Examples of application modes for the F-DI 4/F-DQ 2 Fail-Safe module

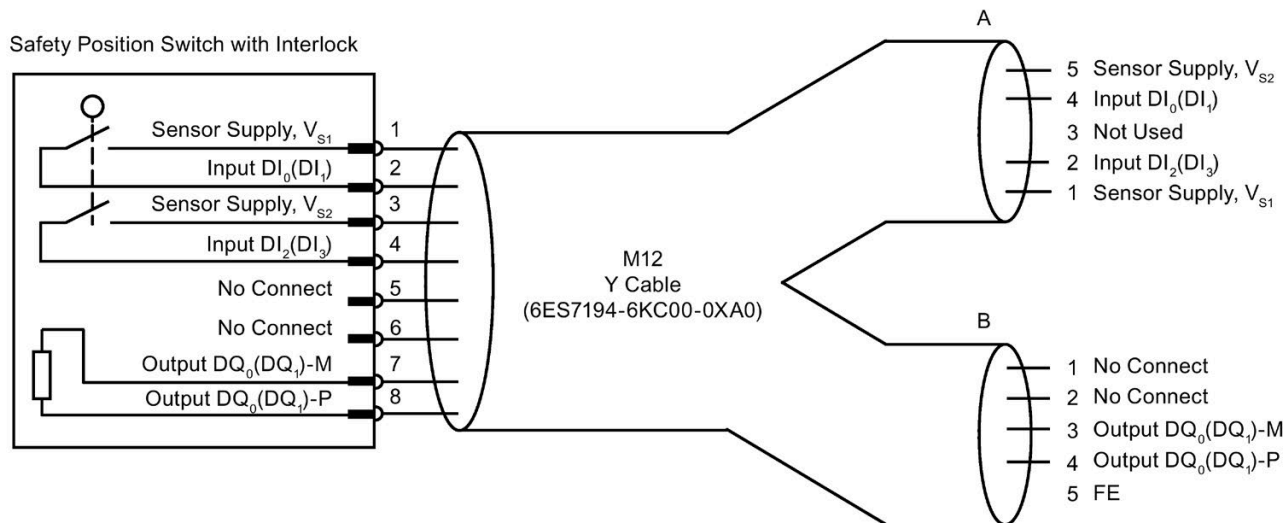
Use inverted Y cable (6ES7194-6KC00-0XA0) for a safety position switch with interlock. The inverted Y cable is designed to properly connect the fail-safe module F-inputs and F-output to the safety position switch.

**Note**

This configuration achieves SIL 3/Cat. 4/PL e if neither output channel is configured to disable the dark test.

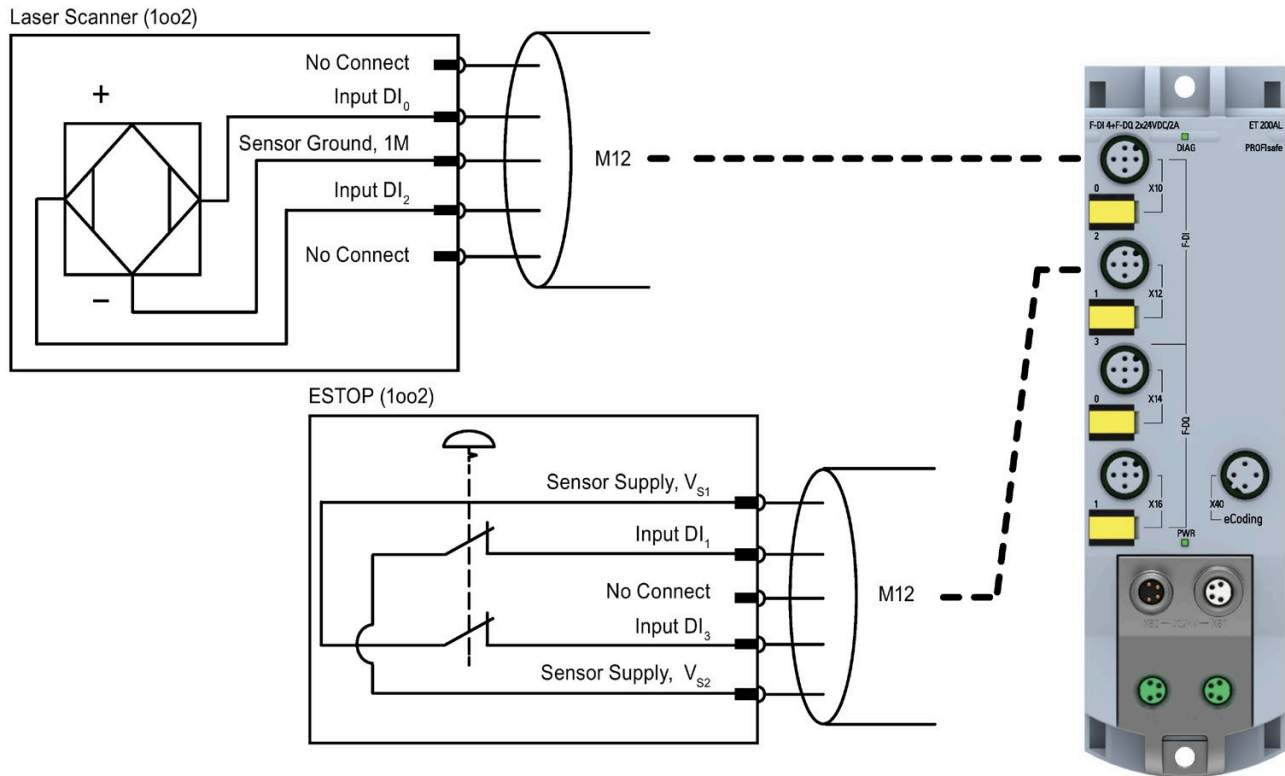
**Note**

To incorporate this application into a SIL 3-rated application, ensure the sensors are appropriately qualified devices: either SIL 3 or SIL 2 with the Systematic Capability rules defined in the SIRIUS documentation. For further information, refer to the *Industrial Controls, Detecting devices SIRIUS 3SE5/3SF1/3SE66/3SE67 position switches configuration manual* on the Internet (<https://support.industry.siemens.com/cs/us/en/view/43920150>).



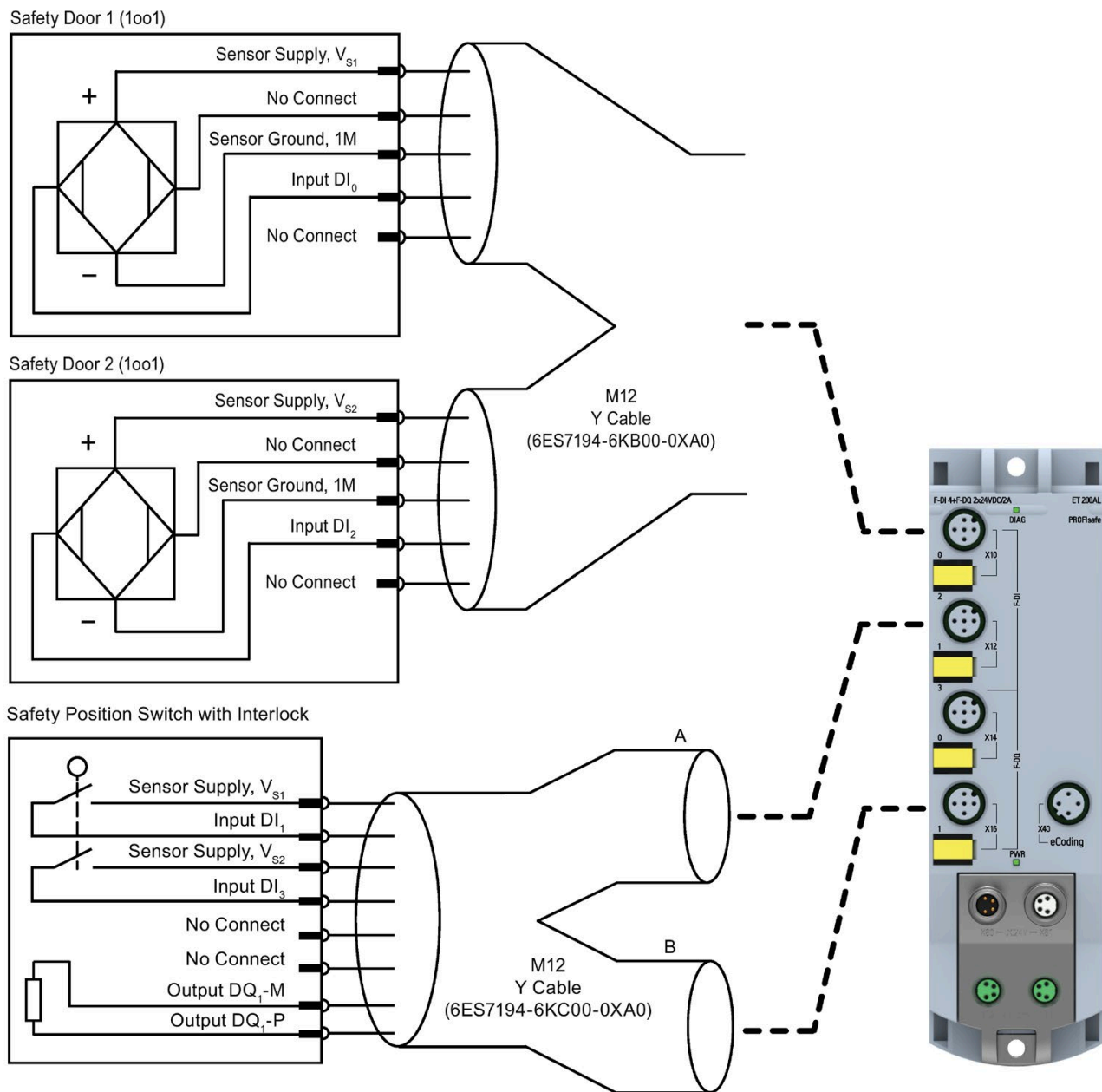
### Connect devices to F-DI 4/F-DQ 2 Fail-Safe module

The figures below are examples of field devices connected to the input and output sockets of the F-DI 4/F-DQ 2 Fail-Safe module:





### 5.3 Examples of application modes for the F-DI 4/F-DQ 2 Fail-Safe module



## Interrupts/diagnostic messages/diagnostics

### 6.1 Reactions to faults

#### Reactions to startup of the fail-safe system and to faults

The fail-safe concept depends on the identification of a safe state for all process variables. The value "0" (de-energized) represents this safe state for digital fail-safe modules. This applies to both sensors and actuators.

The safety function requires that safe state values be applied to the fail-safe channel(s) instead of process values (passivation of the fail-safe module or channel(s)) in the following situations:

- When the fail-safe system is started up
- If module faults are detected, such as RAM or processor failures
- If errors are detected during safety-related communication between the fail-safe CPU and the fail-safe module through the PROFIsafe safety protocol (communication error)
- If module channel faults occur (for example, short-circuit and discrepancy errors)

The fail-safe CPU enters information about detected system faults into the diagnostic buffer.

Automatic safety measures and the PROFIsafe protocol ensure that the safe state is set if the system detects a fault.

Fail-safe modules do not remember errors upon power cycle. When the system is powered down and then restarted, the modules detect any faults still existing again. The exception to this is a permanent deactivation fault such as "sustained overvoltage".

#### Fail-Safe value for fail-safe modules

If digital input channels are passivated, the fail-safe system always provides safe state values ("0") for the safety program instead of the process values applied to the fail-safe inputs.

If digital output channels are passivated in the fail-safe module digital outputs, the fail-safe system always transfers safe state values "0" to the fail-safe outputs instead of the output values provided by the safety program. The output channels are de-energized.

The passivation safe state value and the output state value in CPU STOP mode are always "0", de-energized. You cannot select or program a default "ON" state for passivation or STOP mode.

## 6.1 Reactions to faults

Passivation is applied to individual channels when a channel-specific diagnostic failure is detected. Failures that can affect the entire module result in passivation of all channels.

**Note**

In the **F-DI 4/F-DQ 2 Properties > F-parameters > "Behavior after channel fault"** field, if you select "Passivate the entire module", a single channel fault will result in passivation of all channels.

Timeout of the PROFIsafe message (F-monitoring time exceeded) passivates all module channels.

Table 6- 1 Module signal type and passivation result

| Module signal type        | Passivation result                                                                                                                                                                                                                                                                                                                                                                                       |
|---------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Fail-safe digital inputs  | <ul style="list-style-type: none"> <li>Tests are evaluated per channel, in order to allow channel-granular passivation of defective inputs.</li> <li>If a channel fault occurs for a 1oo1 configuration, depending on your configuration, only the affected channel or all channels may be passivated. For a 1oo2, both inputs of the channel group in the 1oo2 configuration are passivated.</li> </ul> |
| Fail-safe digital outputs | <ul style="list-style-type: none"> <li>Tests are evaluated per channel, in order to allow channel-granular passivation of defective outputs.</li> <li>Diagnostic evaluations are performed separately for each of the two switches of a channel. Depending on your configuration, failure detection for one switch may lead to passivation of only the affected channel or all channels.</li> </ul>      |

**Response to faults in the fail-safe system**

You should prepare maintenance procedures for your system to assure that return to operation after a detected fault is controlled and documented.

Perform the following steps:

1. Diagnosis and repair of the fault
2. Revalidation of the safety function
3. Recording in the service report

**Reintegration of a fail-safe module**

A channel or module can be reintegrated after diagnostics determine that a fault has cleared successfully.

You can configure reintegration as automatic or manual. You can make this selection on a per channel basis in the Device Configuration. Module wide errors such as PROFIsafe

communication errors or supply voltage errors are always manually reintegrated. Fatal diagnostic errors require a power cycle with successful diagnostics to reintegrate.

#### Automatic

Channels that you select to be automatically reintegrated are immediately reintegrated when the fault has cleared.

#### Manual

Channels that you select to be manually reintegrated are acknowledged in your program after the fault has cleared.

The "ACK\_REQ" bit for that module goes true to indicate that reintegration is possible. After the "ACK\_REQ" bit is true, your program can set the "ACK\_REI" bit to allow the reintegration of all channels in that module that are ready to be reintegrated.

You can also acknowledge all faults in an F-runtime group using the "ACK\_REI\_GLOB" input of the "ACK\_GL" instruction.

### Reintegration after high stress events

High temperature, high voltage, or excessive current stress can damage electronics, reducing the reliability while components continue to work apparently as expected. Passivation does not remove the potentially damaging effects of high ambient temperature or high applied voltage. Solid state switch outputs can be damaged by high currents prior to protective device activations. The PFD and PFH reliability calculations assume the fail-safe module is operated within its specified operating parameters. When a module has passivated due to a high stress event, even though it apparently works correctly and passes all diagnostics, the probability of a future dangerous failure may be increased.

#### WARNING

**It is possible to reintegrate a channel or module while some fault is still present that is not readily detected by the module diagnostics.**

Reintegration of a faulty system can result in unexpected machine or process operation, which may cause death or serious injury to personnel, and/or damage to equipment.

After any reported fault, the steps outlined in this chapter and in safety standards applicable to your system should be followed to assure that the fault is completely understood and corrected before reintegration.

For an exact list of faults for the module, refer to "Fault types, causes, and corrective measures (Page 70)".

At reintegration, the following occurs:

- For a fail-safe module digital input, the process values pending at the fail-safe inputs are again provided for the safety program.
- For a fail-safe module digital output, the output values provided in the safety program are again transferred to the fail-safe outputs.

## Safety repair time

The repair time used for PFH and PFD calculations is 100 hours.

Passivation is designed to provide the safe state of the safety function in the event of a single fault. While a channel is passivated and energy is still available to the channel, there is a possibility that additional faults can cause a dangerous failure of the safety function. You should respond to passivations by repairing the fault or taking the passivated channel out of service in less than 100 hours to preserve the safety integrity level of your system.

Deactivated fail-safe I/O are not being diagnosed and are subject to dangerous failure without warning.

If any error persists for 100 hours, the entire module is passivated and can only be recovered by power cycling.

If a repair within 100 hours is not possible, passivated fail-safe outputs should be taken out of service by physically disconnecting or opening circuits so that faults in the fail-safe module cannot apply energy to the load. To remove input channels from service in an operating PLC system, references to any passivated fail-safe inputs are removed from any operating F-CPU Safety program logic that can result in activation of a safety function output.

Do not depend on channel or module passivation to maintain safe state for more than 100 hours.

Do not depend on deactivation or lack of configuration to maintain safe state in any circumstances.



### WARNING

#### Unintentional activation of F-I/O module with fail-safe output

If a fail-safe output is passivated for a period longer than the safety repair time (> 100 hours) and the fault remains uncorrected, you need to be aware that an F-output could be activated unintentionally due to a second fault. This would place the F-system in a dangerous state.

Even though it is highly unlikely that such hardware faults occur, you must prevent the unintentional activation of a fail-safe output by using measures for the physical circuits or other organizational measures. One possibility is the shutdown of the power supply to the affected F-module. Required measures are often standardized for operations with defined design and risk reduction principles. For all other situations, necessary measures must be defined and approved.

## Additional information on passivation and reintegration

For further information about fail-safe module access, refer to the *SIMATIC Safety - Configuring and Programming, Programming and Operating Manual* on the Internet (<https://support.industry.siemens.com/cs/ww/en/view/54110126>).

## 6.2 Fault diagnostics overview

Diagnostics detect faults that can affect the integrity of safety-related I/O. The faults can be in the fail-safe module, communication with the CPU, or external circuits. Diagnostic information is assigned either to a single channel or to the entire fail-safe module.

Most diagnostics operate without user selection. You can configure the following diagnostic options:

- Short-circuit testing using the digital input sensor supply can be enabled. The interval and duration of short-circuit tests is configurable.
- The readback times for 24 V DC digital outputs are configurable.
- The timeout intervals for failures in the safety communication or failure of a safety program to run is configurable.
- Dark testing of the digital outputs can be disabled (max. SIL 2, Cat. 3, PL d).

Refer to "Parameters/address space (Page 23)" for a complete description of these options.

The safety-critical and validated action of the diagnostics is to passivate I/O when faults are detected. The reporting of status and diagnostic results through the LED displays and diagnostic messages is subject to single point failures in electronics or software. These reports are offered as maintenance and debugging aids. Observe and interpret the reports with caution.

In the presence of single faults, any or all LED indications can be wrong. You should not rely solely on the presence or absence of red or green LED indicators to make safety decisions.

In the presence of single faults, diagnostic messages may fail to be delivered, or the numerical event ID or text message can be wrong. You should not rely solely on the presence, absence, or content of diagnostic reports to make safety decisions.

### WARNING

**Diagnostic and status reports through LEDs and text messages are subject to single point failure errors.**

Reliance on such reported information to determine that a system or I/O point is in a safely-controlled state can result in death, severe personal injury, or property damage.

If the integrity of your fail-safe system is in doubt, you should use additional measures such as restricted access or power removal to control hazards during maintenance and debug activities.

## 6.3 Diagnostics performed at startup

Each fail-safe module executes self-diagnostics at power-up to assure that the electronics and software meet testable expectations before allowing the module to participate in process control. If tests are not successful, the module passivates either individual or all channels.

In addition to internal tests, some tests create signal changes at the terminals.

### *6.3 Diagnostics performed at startup*

The F-DI 4/F-DQ 2 Fail-Safe module executes tests for its digital outputs of the P- and M-switches as defined by your configured parameters for "Maximum readback time" and "Maximum readback time switch on test" after receiving configuration parameters from the fail-safe CPU at power-up. P- and M-switch ON tests are sequenced so that normally or in the presence of a single detected fault, there is no complete PM circuit to energize the load.

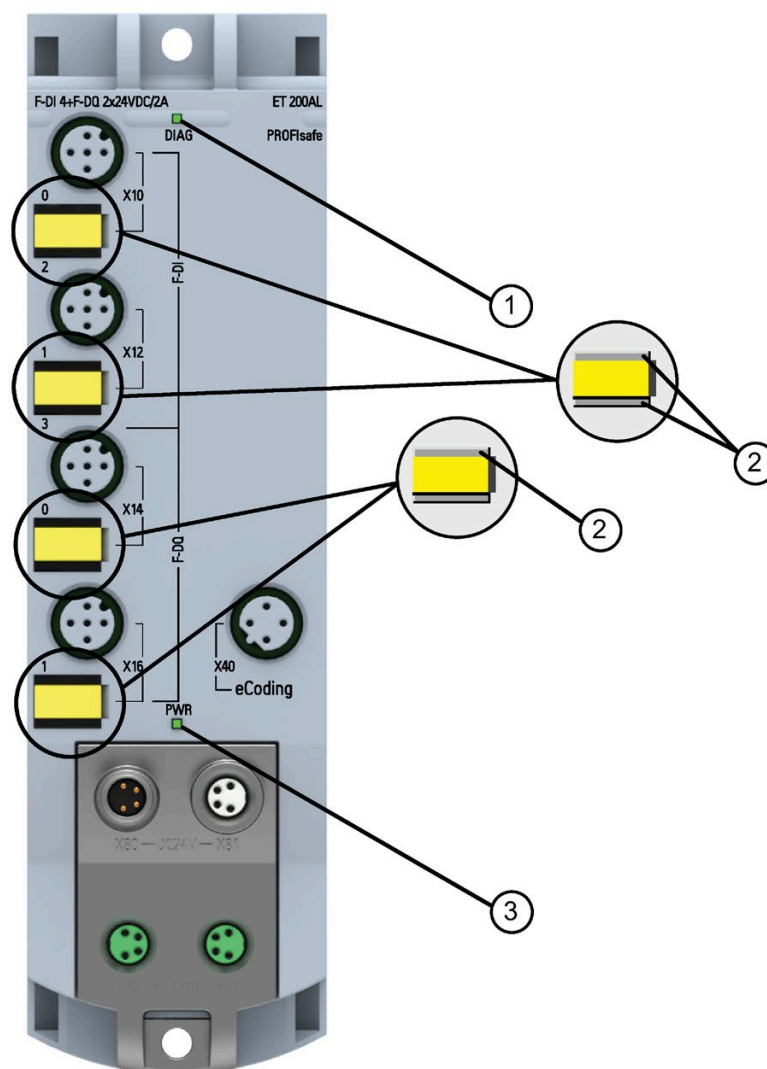
The F-DI 4/F-DQ 2 Fail-Safe module executes tests for its digital inputs of the sensor supply at power-up, including ON and OFF pulses, whether or not you have enabled the sensor supply or short-circuit testing in your configuration. If your configuration includes short-circuit testing, the module also executes a short-circuit test according to your configured parameters after receiving the parameters from the fail-safe CPU at power-up.

## 6.4 Diagnostics by LED display

### 6.4.1 Status and error displays

#### LED displays

The figure below shows the LED displays (status and error displays) of the F-DI 4/F-DQ 2 Fail-Safe module:



- ① Diagnostic status (DIAG (red/green))
- ② Channel status and channel error (red/green) for each channel (F-DI 0 - 3, F-DQ 0 and 1)
- ③ Load voltage 2L+ status (PWR (green))

Figure 6-1 LED displays



## 6.4 Diagnostics by LED display

## Meaning of the LEDs

The following tables set out the meaning of the status and error displays. Remedial measures for diagnostic alarms can be found in section Fault types, causes, and corrective measures (Page 70).

## PWR LED

Table 6- 2 Meaning of the PWR LED

| PWR                                                                                           | Meaning                                                                  |
|-----------------------------------------------------------------------------------------------|--------------------------------------------------------------------------|
| <br>Off      | Load voltage 2L+ missing or supply voltage 1L+ is too low or not present |
| <br>On green | Load voltage 2L+ available                                               |

## DIAG LED

Table 6- 3 Meaning of the DIAG LED

| DIAG LED                                                                                                             | Meaning                                                                                                                                                                                                                                                        |
|----------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <br>Off                           | No supply voltage 1L+                                                                                                                                                                                                                                          |
| <br>Flashes green                 | Configuration/parameterization has not been received and no module diagnostics                                                                                                                                                                                 |
| <br>Alternately Flashes red/green | Module-wide reintegratable faults such as the following are resolved and are awaiting reintegration: <ul style="list-style-type: none"> <li>• Overvoltage</li> <li>• Undervoltage</li> <li>• PROFIsafe CRC error</li> <li>• PROFIsafe timeout error</li> </ul> |
| <br>On green                      | Module parameters assigned and no module or channel diagnostics                                                                                                                                                                                                |
| <br>Flashes red                   | <ul style="list-style-type: none"> <li>• Module diagnostic and/or one or more channel diagnostics</li> <li>• Module has inconsistent hardware and/or firmware versions</li> </ul>                                                                              |

## Channel LED for 1oo1 input channels

Table 6- 4 Meaning of the channel LED for 1oo1 input channels

| DIAGInput LEDs                                                                                  | Meaning            |
|-------------------------------------------------------------------------------------------------|--------------------|
| <br>Off      | Process signal = 0 |
| <br>On green | Process signal = 1 |

| DIAGInput LEDs                                                                                                        | Meaning                                             |
|-----------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------|
| <br>On red                           | Channel fault or module fault affecting the channel |
| <br>Alternately Flashes<br>red/green | Fault resolved, awaiting reintegration              |

## Channel LEDs for 1oo2 input channels

Table 6- 5 Meaning of the channel LEDs for 1oo2 input channels

| Primary input LED                                                                                                       | Secondary input LED                                                                                                     | Meaning                                             |
|-------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------|
| <br>Off                                | <br>Off                                | Process signal = 0 (equivalent)                     |
| <br>On green                           | <br>On green                           | Process signal = 1 (equivalent)                     |
| <br>Off                                | <br>On green                           | Process signal = 0 (nonequivalent)                  |
| <br>On green                           | <br>Off                                | Process signal = 1 (nonequivalent)                  |
| <br>On red                           | <br>On red                           | Channel fault or module fault affecting the channel |
| <br>Alternately Flashes<br>red/green | <br>Alternately Flashes<br>red/green | Fault resolved, awaiting reintegration              |

## Channel LED for output channels

Table 6- 6 Meaning of the channel LED for output channels

| Output LED                                                                                                              | Meaning                                             |
|-------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------|
| <br>Off                              | Process signal = 0 or channel deactivated           |
| <br>On green                         | Process signal = 1                                  |
| <br>On red                           | Channel fault or module fault affecting the channel |
| <br>Alternately Flashes<br>red/green | Fault resolved, awaiting reintegration              |

## 6.5 Fault types, causes, and corrective measures

The "Fault types, causes, and corrective measures" table below lists the messages of the F-DI 4/F-DQ 2 Fail-Safe module. These messages are displayed in the TIA Portal under "Online & diagnostics" > "Diagnostics" > "Diagnostic buffer". When you highlight an individual text line in the diagnostic buffer, the Event ID for that text item is displayed, along with module identity and location that generated the message. You may need to expand the window to see all information.

Table 6- 7 Fault types, causes, and corrective measures

| Event ID | Diagnostic message | F-DI 4/F-DQ 2 Fail-Safe module | Description                                                                                                                                                                                                                                              | Possible causes                                                                                                                                                                                                                                                                                                            | Corrective measures <sup>1</sup>                                                                                                                                                                                            |
|----------|--------------------|--------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 16x0001  | Short-circuit      | F-DI 4/F-DQ 2 digital outputs  | A channel problem has been detected where either the P terminal or M terminal is at an unexpected potential                                                                                                                                              | <ul style="list-style-type: none"> <li>Short-circuit of the output</li> <li>Short-circuit between channels with different signals</li> <li>Output overload</li> <li>"Maximum readback time switch on test" value is configured too small</li> <li>Short-circuit of output to M</li> <li>Defective output driver</li> </ul> | <ul style="list-style-type: none"> <li>Eliminate the short-circuit</li> <li>Eliminate the overload</li> <li>Increase "Maximum readback time switch on test" if permissible</li> <li>Replace the fail-safe module</li> </ul> |
| 16x0005  | Overtemperature    | Module                         | <ul style="list-style-type: none"> <li>Overtemperature at microcontroller</li> <li>Overtemperature at I/O</li> </ul>                                                                                                                                     | Shutdown due to violation of high temperature limit value in the module case                                                                                                                                                                                                                                               | Check the ambient temperature. Once the fault has been eliminated, switch the power off and on                                                                                                                              |
| 16x0006  | Wire break         | Module                         | <p>Wire break failure. The module can detect a wire break when all of the following are true:</p> <ul style="list-style-type: none"> <li>The channel is wired using a PM load</li> <li>The PV=0</li> <li>The wire break diagnostic is enabled</li> </ul> | <p>Output is activated:</p> <ul style="list-style-type: none"> <li>No load is connected to the PM output</li> <li>Output is wired in output application mode 2</li> <li>Too small of a load is detected</li> </ul>                                                                                                         | <ul style="list-style-type: none"> <li>Change the output load characteristics</li> <li>Deactivate unused channels</li> <li>Disable wire break diagnostic for the offending channels</li> </ul>                              |

| Event ID | Diagnostic message                                    | F-DI 4/F-DQ 2 Fail-Safe module | Description                                                                                                                                                                                                                                                                                                                                                       | Possible causes                                                                                                                                                                                                                                                                                                  | Corrective measures <sup>1</sup>                                                                                                                                                    |
|----------|-------------------------------------------------------|--------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 16x0009  | Hardware revision mismatch                            | Module                         | <ul style="list-style-type: none"> <li>The module detects hardware mismatch</li> <li>DIAG LED is flashes red</li> </ul>                                                                                                                                                                                                                                           |                                                                                                                                                                                                                                                                                                                  | Replace module                                                                                                                                                                      |
| 16x0010  | Parameterization failure (invalid parameters)         | Module                         | When the module receives new parameters, the module checks for parameter failures. On detection of invalid parameters, the module stays in the configured state and signals the rejection of the faulty parameter to the fail-safe CPU. The module LEDs give an immediate indication of this fault.                                                               | <ul style="list-style-type: none"> <li>i-Parameter CRC error</li> <li>Invalid i-parameters (for example, invalid selection, parameter out-of-range, unsupported feature selected, and wrong value of reserved field)</li> <li>Any PROFIsafe parameterization problem detected by the PROFIsafe driver</li> </ul> | Correct the parameter assignment                                                                                                                                                    |
|          | Parameterization failure (address assignment failure) | Module                         | <ul style="list-style-type: none"> <li>On detection of an address assignment failure that indicates a hardware fault, the module enters the fatal error state.</li> <li>The module performs this fault reaction if the address verification information provided by the F parameters is different than what has been previously assigned to the module</li> </ul> | <ul style="list-style-type: none"> <li>Indicates assignment of an incorrect F address to one or more module(s)</li> <li>Missing eCoding plug</li> </ul>                                                                                                                                                          | <ul style="list-style-type: none"> <li>Reinsert the eCoding plug</li> <li>Reassign the PROFIsafe F addresses using STEP 7 (TIA Portal)</li> <li>Replace the eCoding plug</li> </ul> |

## 6.5 Fault types, causes, and corrective measures

| Event ID | Diagnostic message                                  | F-DI 4/F-DQ 2 Fail-Safe module | Description                                                                                                                      | Possible causes                                                                                                                                                                                                                | Corrective measures <sup>1</sup>                                                                                                                                                                                                                                                        |
|----------|-----------------------------------------------------|--------------------------------|----------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 16x0040  | Mismatch of safety destination address (F_Dest_Add) | Module                         | The PROFIsafe driver has detected a destination address mismatch. Checked after new parameters received.                         | <ul style="list-style-type: none"> <li>eCoding plug has been replaced with a different plug</li> <li>eCoding plug is defective</li> <li>Incorrect F-source address was downloaded as part of hardware configuration</li> </ul> | <ul style="list-style-type: none"> <li>Reassign the PROFIsafe F addresses using STEP 7 (TIA Portal)</li> <li>Replace the eCoding plug</li> <li>Correct the F-destination address in hardware configuration and re-download</li> </ul>                                                   |
| 16x0041  | Safety destination address not valid (F_Dest_Add)   | Module                         | The PROFIsafe driver has detected an invalid destination address. Checked after new parameters received.                         | <ul style="list-style-type: none"> <li>eCoding plug has been replaced with a different plug</li> <li>eCoding plug is defective</li> </ul>                                                                                      | <ul style="list-style-type: none"> <li>Reassign the PROFIsafe F addresses using STEP 7 (TIA Portal)</li> <li>Replace the eCoding plug</li> </ul>                                                                                                                                        |
| 16x0042  | Safety source address not valid (F_Source_Add)      | Module                         | The PROFIsafe driver has detected a source address mismatch or an invalid source address. Checked after new parameters received. | <ul style="list-style-type: none"> <li>eCoding plug has been replaced with a different plug</li> <li>eCoding plug is defective</li> <li>Incorrect F-source address was downloaded as part of hardware configuration</li> </ul> | <ul style="list-style-type: none"> <li>Reassign the PROFIsafe F addresses using STEP 7 (TIA Portal)</li> <li>Replace the eCoding plug</li> <li>Correct the F-source address in hardware configuration and re-download</li> </ul>                                                        |
| 16x004B  | Inconsistent iParameters (iParCRC error)            | Module                         | The firmware of the F-module has detected a CRC error.                                                                           | <ul style="list-style-type: none"> <li>Communication between the F-CPU and F-module is disturbed</li> <li>Impermissibly high electromagnetic interference is present</li> </ul>                                                | <ul style="list-style-type: none"> <li>Check PROFINET communications between the F-module and F-CPU</li> <li>Eliminate the electromagnetic interference</li> <li>Power switched OFF and ON for station</li> <li>Reassign the PROFIsafe F addresses using STEP 7 (TIA Portal)</li> </ul> |

| Event ID | Diagnostic message                        | F-DI 4/F-DQ 2 Fail-Safe module | Description                                                                                                                                    | Possible causes                                                                                                                                                                                                                               | Corrective measures <sup>1</sup>                                                                                                                                                                                                                                                                                                                 |
|----------|-------------------------------------------|--------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 16x004D  | PROFIsafe communication error (CRC)       | Module                         | Transmission error in data message frame: Data inconsistent (CRC (cyclic redundancy check) error). Checked after new output telegram received. | Communication interference between the fail-safe CPU and the fail-safe module (for example, due to electromagnetic interference in excess of limits or sign-of-life monitoring error)                                                         | <ul style="list-style-type: none"> <li>• Check the communications connection</li> <li>• Eliminate the interference</li> </ul>                                                                                                                                                                                                                    |
| 16x004E  | PROFIsafe communication failure (timeout) | Module                         | Monitoring time exceeded for data message frame (timeout). Checked after new output telegram received.                                         | F-monitoring time exceeded. Transmission error: timeout (watchdog time 1 or 2 elapsed)                                                                                                                                                        | <ul style="list-style-type: none"> <li>• Adjust F-monitoring time</li> <li>• Check Safety program and all other CPU activities for excessive execution or demands: <ul style="list-style-type: none"> <li>– Interrupts</li> <li>– Ethernet communication</li> <li>– OB scheduling conflicts</li> <li>– Long program paths</li> </ul> </li> </ul> |
| 16x004F  | Channel failure acknowledgment            | Module                         | Channel configured for manual acknowledgment is ready to reintegrate                                                                           | Manual acknowledgment required                                                                                                                                                                                                                | Manually acknowledge correction of channel fault so that reintegration can occur                                                                                                                                                                                                                                                                 |
| 16x0100  | Module is defective                       | Module                         | Fatal internal error                                                                                                                           | Fail-safe module is defective                                                                                                                                                                                                                 | Replace the fail-safe module                                                                                                                                                                                                                                                                                                                     |
| 16x0103  | Watchdog tripped                          | Module                         | The watchdog timer in the module communications processor timed out                                                                            | Fail-safe module is defective                                                                                                                                                                                                                 | Replace the fail-safe module                                                                                                                                                                                                                                                                                                                     |
| 16x0105  | Short-circuit to L+                       | F-DI 4/F-DQ 2 digital outputs  | Output shorted to P. The fail-safe module detects a channel problem where the P-terminal is unexpectedly at L+ potential.                      | <ul style="list-style-type: none"> <li>• Short-circuit to L+</li> <li>• Short-circuit between channels with different signals</li> <li>• Defective output driver</li> <li>• "Maximum read-back time" value is configured too small</li> </ul> | <ul style="list-style-type: none"> <li>• Eliminate the short-circuit</li> <li>• Increase readback time</li> <li>• Replace the fail-safe module</li> </ul>                                                                                                                                                                                        |

## 6.5 Fault types, causes, and corrective measures

| Event ID | Diagnostic message                     | F-DI 4/F-DQ 2 Fail-Safe module | Description                                                                                                                                                         | Possible causes                                                                                                                                                                                                                            | Corrective measures <sup>1</sup>                                                                                                                                                                                                                                   |
|----------|----------------------------------------|--------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 16x0106  | Short-circuit to ground                | F-DI 4/F-DQ 2 digital outputs  | The fail-safe module detects a channel problem where the M-switch output terminal is unexpectedly at M potential                                                    | <ul style="list-style-type: none"> <li>Short-circuit of output to M, ground, or another channel</li> <li>Defective output driver</li> <li>"Maximum read-back time" value is configured too small</li> </ul>                                | <ul style="list-style-type: none"> <li>Eliminate the short-circuit</li> <li>Increase readback time</li> <li>Replace the fail-safe module</li> </ul>                                                                                                                |
| 16x011B  | Invalid/inconsistent firmware present  | Module                         | Inconsistency between bus ASIC firmware and fail-safe controller firmware.                                                                                          | A firmware update operation was performed using an update file not suitable for the module (incorrect article number or hardware revision)                                                                                                 | <ul style="list-style-type: none"> <li>The firmware update operation should be repeated with a suitable update file</li> <li>Replace the fail-safe module</li> </ul>                                                                                               |
| 16x013E  | Diagnostic event queue overflow        | Module                         | Overflow of the diagnostic events queue has occurred. A newly-occurred diagnostic event could not be queued for transmission to the CPU because the buffer is full. | This can happen if channel errors come and go very quickly (for example, discrepancy errors)                                                                                                                                               | Examine the Diagnostics buffer to see what errors are occurring, then address that issue                                                                                                                                                                           |
| 16x0300  | Discrepancy failure, channel state 0/0 | F-DI 4/F-DQ 2 digital inputs   | External discrepancy failure: Channel state 0/0 with 1oo2 nonequivalent configuration                                                                               | <ul style="list-style-type: none"> <li>Process signal faulty, sensor may be defective</li> <li>Configured discrepancy time too short</li> <li>Short-circuit</li> <li>Sensor mechanical activation or alignment out of tolerance</li> </ul> | <ul style="list-style-type: none"> <li>Check the process signal, replace sensor if necessary</li> <li>Check the configured discrepancy time</li> <li>Check the wiring</li> <li>Check that both sensors are mounted and aligned to be activated together</li> </ul> |
| 16x0301  | Discrepancy failure, channel state 0/1 | F-DI 4/F-DQ 2 digital inputs   | External discrepancy failure: Channel state 0/1 with 1oo2 equivalent configuration                                                                                  |                                                                                                                                                                                                                                            |                                                                                                                                                                                                                                                                    |
| 16x0302  | Discrepancy failure, channel state 1/0 | F-DI 4/F-DQ 2 digital inputs   | External discrepancy failure: Channel state 1/0 with 1oo2 equivalent configuration                                                                                  |                                                                                                                                                                                                                                            |                                                                                                                                                                                                                                                                    |
| 16x0303  | Discrepancy failure, channel state 1/1 | F-DI 4/F-DQ 2 digital inputs   | External discrepancy failure: Channel state 1/1 with 1oo2 nonequivalent configuration                                                                               |                                                                                                                                                                                                                                            |                                                                                                                                                                                                                                                                    |

| Event ID | Diagnostic message                                         | F-DI 4/F-DQ 2 Fail-Safe module | Description                                                                                                                   | Possible causes                                                                                                                                                            | Corrective measures <sup>1</sup>                                                                                                                                        |
|----------|------------------------------------------------------------|--------------------------------|-------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 16x0306  | Internal sensor supply short-circuit to P                  | F-DI 4/F-DQ 2 digital inputs   | Module-provided sensor supply voltage shorted to P                                                                            | <ul style="list-style-type: none"> <li>• Sensor supply shorted to P</li> <li>• Short-circuit test duration configured too short</li> <li>• Failed sensor supply</li> </ul> | <ul style="list-style-type: none"> <li>• Eliminate the short-circuit</li> <li>• Increase short-circuit test duration</li> <li>• Replace the fail-safe module</li> </ul> |
| 16x0307  | Overload or internal sensor supply short-circuit to ground | F-DI 4/F-DQ 2 digital inputs   | Internal sensor supply voltage shorted to M, ground, or excessive load on sensor supply                                       | <ul style="list-style-type: none"> <li>• Short-circuit</li> <li>• Excessive load on sensor supply</li> <li>• Failed sensor supply</li> </ul>                               | <ul style="list-style-type: none"> <li>• Eliminate the short-circuit</li> <li>• Reduce load on sensor supply</li> <li>• Replace the fail-safe module</li> </ul>         |
| 16x030D  | F-address memory not accessible                            | Module                         | The memory where the F-address is stored is not accessible                                                                    | <ul style="list-style-type: none"> <li>• eCoding plug is missing</li> <li>• eCoding plug is defective</li> </ul>                                                           | <ul style="list-style-type: none"> <li>• Install an eCoding plug into X40 of the module</li> <li>• Replace the defective eCoding plug</li> </ul>                        |
| 16x030E  | No valid F-address available                               | Module                         | Fail-safe address is not valid (F-address and CRC inconsistent)                                                               | <ul style="list-style-type: none"> <li>• eCoding plug has never been assigned a PROFIsafe address</li> <li>• eCoding plug is defective</li> </ul>                          | <ul style="list-style-type: none"> <li>• Assign the PROFIsafe Address</li> <li>• Replace the eCoding plug</li> </ul>                                                    |
| 16x0311  | Frequency too high                                         | F-DI 4/F-DQ 2 digital outputs  | Switching frequency exceeded; readback not in time                                                                            | Process value from safety program changing too rapidly for module to follow                                                                                                | Change Safety program logic to guarantee more time between output changes                                                                                               |
| 16x0312  | Undertemperature                                           | Module                         | <ul style="list-style-type: none"> <li>• Under-temperature at microcontrollers</li> <li>• Under-temperature at I/O</li> </ul> | Shutdown due to violation of low temperature limit value in the module case                                                                                                | <ul style="list-style-type: none"> <li>• Check the ambient temperature</li> <li>• Once the fault has been eliminated, switch the power off and on</li> </ul>            |



## 6.5 Fault types, causes, and corrective measures

| Event ID | Diagnostic message              | F-DI 4/F-DQ 2 Fail-Safe module | Description                                                                                      | Possible causes                                                                                                                                                                                                                                    | Corrective measures <sup>1</sup>                                                                                                                                                                                                           |
|----------|---------------------------------|--------------------------------|--------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 16x0313  | Failure in the input circuit    | F-DI 4/F-DQ 2 digital inputs   | Internal fault at the read circuit/test circuit                                                  | <ul style="list-style-type: none"> <li>The module digital inputs detect a failure during bit pattern testing of inputs</li> <li>EMI or module hardware fault</li> </ul>                                                                            | <ul style="list-style-type: none"> <li>If intermittent, it is probably due to interference; eliminate the interference</li> <li>If persistent, or repeats after efforts to eliminate interference, replace the fail-safe module</li> </ul> |
| 16x031C  | Input shorted to P              | F-DI 4/F-DQ 2 digital inputs   | Input shorted to P failure                                                                       | <ul style="list-style-type: none"> <li>External wiring or sensor shorts input signal to L+</li> <li>Input configured for internal sensor supply with short-circuit detection enabled, but wired to external L+</li> <li>Input defective</li> </ul> | <ul style="list-style-type: none"> <li>Check/correct external short-circuit</li> <li>Make wiring and configuration agree</li> <li>Replace the fail-safe module</li> </ul>                                                                  |
| 16x031E  | Read back failure               | F-DI 4/F-DQ 2 digital outputs  | The module has detected a channel problem where the expected terminal voltage(s) are not reached | <ul style="list-style-type: none"> <li>"Maximum readback time" or "Maximum readback time switch on test" configured value is too small</li> <li>Output switch failure</li> </ul>                                                                   | <ul style="list-style-type: none"> <li>Increase readback time</li> <li>Replace the fail-safe module if output does not respond</li> </ul>                                                                                                  |
| 16x0320  | Overload                        | F-DI 4/F-DQ 2 digital outputs  | Overload condition at the output driver that leads to passivation of the channel                 | Overload at output                                                                                                                                                                                                                                 | Eliminate overload                                                                                                                                                                                                                         |
| 16x0321  | Supply or load voltage too high | Module                         | Supply voltage (1L+) or load voltage (2L+) maximum exceeded                                      | Supply or load voltage is set too high                                                                                                                                                                                                             | Adjust supply or load voltage                                                                                                                                                                                                              |
| 16x0322  | Supply or load voltage too low  | Module                         | Supply voltage (1L+) or load voltage (2L+) minimum exceeded                                      | Supply or load voltage is set too low                                                                                                                                                                                                              | Adjust supply or load voltage                                                                                                                                                                                                              |

<sup>1</sup> Once the fault is eliminated, reintegrate the fail-safe module (return to normal state) from passivation into the safety program.

## **Electromagnetic interference and diagnostic reports**

Electromagnetic interference can cause communication errors, disturb external and internal signal measurements, and cause processing errors. When error reports do not apparently relate to an identifiable device failure, wiring problem, programming, or configuration error, consider sources of electromagnetic interference and installation and wiring problems that might introduce electromagnetic interference in your installation. Typical problem sources include poor suppression of inductive loads and voltage dips due to excessive load inrush currents.

## Technical specifications

### 7.1 Specifications

| 6ES7146-5FF00-0BA0                                      |                                                                                                                            |
|---------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------|
| <b>General information</b>                              |                                                                                                                            |
| Product type designation                                | F-DI 4+F-DQ 2x24VDC/2A, 4xM12                                                                                              |
| HW functional status                                    | FS01                                                                                                                       |
| Firmware version                                        | V1.0.x                                                                                                                     |
| <b>Product function</b>                                 |                                                                                                                            |
| I&M data                                                | Yes; I&M0 to I&M3                                                                                                          |
| <b>Engineering with</b>                                 |                                                                                                                            |
| STEP 7 TIA Portal configurable/integrated as of version | Step 7 V17 or higher                                                                                                       |
| <b>Operating mode</b>                                   |                                                                                                                            |
| DI                                                      | Yes                                                                                                                        |
| DQ                                                      | Yes                                                                                                                        |
| <b>Supply voltage</b>                                   |                                                                                                                            |
| <b>Load voltage 1L+</b>                                 |                                                                                                                            |
| Rated value (DC)                                        | 24 V                                                                                                                       |
| permissible range, lower limit (DC)                     | 20,4 V                                                                                                                     |
| permissible range, upper limit (DC)                     | 28,8 V                                                                                                                     |
| Reverse polarity protection                             | Yes; against destruction                                                                                                   |
| <b>Load voltage2 L+</b>                                 |                                                                                                                            |
| Rated value (DC)                                        | 24 V                                                                                                                       |
| permissible range, lower limit (DC)                     | 20,4 V                                                                                                                     |
| permissible range, upper limit (DC)                     | 28,8 V                                                                                                                     |
| Reverse polarity protection                             | Yes; against destruction; outputs applied with reversed polarity for loads connected between M-switch and 2L+ will conduct |
| <b>Input current</b>                                    |                                                                                                                            |
| Current consumption (rated value)                       | 55 mA (1L+) / 40 mA (2L+); without load                                                                                    |
| from load voltage 1L+ (unswitched voltage)              | 4 A; Maximum value                                                                                                         |
| from load voltage 2L+, max.                             | 4 A; Maximum value                                                                                                         |
| <b>Encoder supply</b>                                   |                                                                                                                            |
| Number of outputs                                       | 2                                                                                                                          |
| <b>24 V encoder supply</b>                              |                                                                                                                            |
| Short-circuit protection                                | Yes; per load voltage, electronic (response threshold 0.7 A to 1.7 A)                                                      |
| Output current, max.                                    | 1 A; total current of all encoders, max. 0.5 A per load voltage; maximum of 2.0 V drop                                     |
| <b>Power loss</b>                                       |                                                                                                                            |
| Power loss, typ.                                        | 4,7 W                                                                                                                      |

| 6ES7146-5FF00-0BA0                                    |                                                                          |
|-------------------------------------------------------|--------------------------------------------------------------------------|
| <b>Digital inputs</b>                                 |                                                                          |
| Number of digital inputs                              | 4                                                                        |
| Input characteristic according to IEC 61131           | Type 1                                                                   |
| <b>Number of simultaneously controllable inputs</b>   |                                                                          |
| <b>all mounting positions</b>                         |                                                                          |
| up to 55 °C, max.                                     | 4                                                                        |
| <b>Input voltage</b>                                  |                                                                          |
| Rated value (DC)                                      | 24 V                                                                     |
| for signal "0"                                        | -30 to +5 V                                                              |
| for signal "1"                                        | +15 to +30 V                                                             |
| <b>Input current</b>                                  |                                                                          |
| for signal "1", typ.                                  | 4,85 mA                                                                  |
| <b>Input delay (for rated value of input voltage)</b> |                                                                          |
| <b>for standard inputs</b>                            |                                                                          |
| parameterizable                                       | Yes                                                                      |
| at "0" to "1", min.                                   | 0,8 ms                                                                   |
| at "0" to "1", max.                                   | 12,8 ms                                                                  |
| at "1" to "0", min.                                   | 0,8 ms                                                                   |
| at "1" to "0", max.                                   | 12,8 ms                                                                  |
| <b>Cable length</b>                                   |                                                                          |
| unshielded, max.                                      | 30 m                                                                     |
| <b>Digital outputs</b>                                |                                                                          |
| Number of digital outputs                             | 2                                                                        |
| in groups of                                          | 2                                                                        |
| Short-circuit protection                              | Yes; per channel, electronic                                             |
| Response threshold, typ.                              | 10 A; measured at M-switch, threshold for P-switch is higher             |
| Open-circuit detection                                | Yes; per channel, only detects when output is off                        |
| Overload protection                                   | Yes                                                                      |
| Response threshold, typ.                              | 3,4 A; measured at P-switch                                              |
| Limitation of inductive shutdown voltage to           | P-switch: -26 V DC referenced to 2M, M-switch: +48 V DC referenced to 2M |
| <b>Switching capacity of the outputs</b>              |                                                                          |
| on lamp load, max.                                    | 10 W                                                                     |
| <b>Load resistance range</b>                          |                                                                          |
| lower limit                                           | 12 Ω                                                                     |
| upper limit                                           | 2 kΩ                                                                     |
| <b>Output current</b>                                 |                                                                          |
| for signal "1" rated value                            | 2 A                                                                      |
| for signal "0" residual current, max.                 | 0,5 mA                                                                   |
| <b>Switching frequency</b>                            |                                                                          |
| with resistive load, max.                             | 30 Hz                                                                    |
| with inductive load, max.                             | 0,1 Hz                                                                   |
| on lamp load, max.                                    | 10 Hz                                                                    |

| 6ES7146-5FF00-0BA0                                                                        |                                                                                                           |
|-------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------|
| <b>Total current of the outputs</b>                                                       |                                                                                                           |
| Current per group, max.                                                                   | 4 A                                                                                                       |
| <b>Cable length</b>                                                                       |                                                                                                           |
| unshielded, max.                                                                          | 30 m                                                                                                      |
| <b>Encoder</b>                                                                            |                                                                                                           |
| <b>Connectable encoders</b>                                                               |                                                                                                           |
| 2-wire sensor                                                                             | No                                                                                                        |
| permissible quiescent current (2-wire sensor), max.                                       | 0.5 mA                                                                                                    |
| <b>Interrupts/diagnostics/status information</b>                                          |                                                                                                           |
| Substitute values connectable                                                             | No                                                                                                        |
| <b>Alarms</b>                                                                             |                                                                                                           |
| Diagnostic alarm                                                                          | Yes; Parameterizable                                                                                      |
| <b>Diagnoses</b>                                                                          |                                                                                                           |
| Monitoring the supply voltage                                                             | Yes                                                                                                       |
| Wire-break                                                                                | Yes; outputs when off                                                                                     |
| Short-circuit                                                                             | Yes; inputs, outputs, encoder supply                                                                      |
| <b>Diagnostics indication LED</b>                                                         |                                                                                                           |
| Channel status display                                                                    | Yes; green LED                                                                                            |
| for channel diagnostics                                                                   | Yes; red LED                                                                                              |
| for module diagnostics                                                                    | Yes; green/red LED                                                                                        |
| For load voltage monitoring                                                               | Yes; green LED                                                                                            |
| <b>Potential separation</b>                                                               |                                                                                                           |
| between the load voltages                                                                 | Yes                                                                                                       |
| <b>Potential separation channels</b>                                                      |                                                                                                           |
| between the channels. in groups of                                                        | 4 DI channels are isolated from 2 DQ channels                                                             |
| between the channels and backplane bus                                                    | Yes                                                                                                       |
| between the channels and the power supply of the electronics                              | DI channels are not isolated from supply voltage 1L+ and DQ channels are isolated from supply voltage 1L+ |
| <b>Isolation</b>                                                                          |                                                                                                           |
| Isolation tested with                                                                     | 707 V DC (type test)                                                                                      |
| <b>Degree and class of protection</b>                                                     |                                                                                                           |
| IP degree of protection                                                                   | IP65/67                                                                                                   |
| <b>Standards, approvals, certificates</b>                                                 |                                                                                                           |
| <b>Highest safety class achievable in safety mode</b>                                     |                                                                                                           |
| Performance level according to ISO 13849-1                                                | PLd (DI single-channel), PLe (DI two-channel, DQ)                                                         |
| Category according to ISO 13849-1                                                         | Cat. 3 (DI single-channel), Cat. 4 (DI two-channel, DQ)                                                   |
| SIL acc. to IEC 61508                                                                     | SIL 2 (DI single-channel), SIL 3 (DI two-channel, DQ)                                                     |
| <b>Probability of failure (for service life of 20 years and repair time of 100 hours)</b> |                                                                                                           |
| Low demand mode: PFDavg in accordance with SIL2                                           | < 1.0E-03 DI single-channel; < 1.0E-03 DQ with dark test disabled                                         |

| <b>6ES7146-5FF00-0BA0</b>                                  |                                                                           |
|------------------------------------------------------------|---------------------------------------------------------------------------|
| Low demand mode: PFDavg in accordance with SIL3            | < 1.0E-05 DI two-channel; < 2.0E-05 DQ with dark test enabled             |
| High demand/continuous mode: PFH in accordance with SIL2   | < 1.0E-08 1/h DI single-channel; < 1.0E-07 1/h DQ with dark test disabled |
| High demand/continuous mode: PFH in accordance with SIL3   | < 1.0E-09 1/h DI two-channel; < 1.0E-08 1/h DQ with dark test enabled     |
| <b>Ambient conditions</b>                                  |                                                                           |
| <b>Ambient temperature during operation</b>                |                                                                           |
| min.                                                       | -30 °C                                                                    |
| max.                                                       | 55 °C                                                                     |
| <b>Connection method</b>                                   |                                                                           |
| Design of electrical connection for the inputs and outputs | M12, 5-pin                                                                |
| Design of electrical connection for supply voltage         | M8, 4-pin                                                                 |
| <b>ET-Connection</b>                                       |                                                                           |
| ET-Connection                                              | M8, 4-pin, shielded                                                       |
| <b>Dimensions</b>                                          |                                                                           |
| Width                                                      | 45 mm                                                                     |
| Height                                                     | 159 mm                                                                    |
| Depth                                                      | 40 mm                                                                     |
| <b>Weights</b>                                             |                                                                           |
| Weight, approx.                                            | 220 g                                                                     |

## Dimension drawing

### A.1 Dimension drawing

The figure below shows the dimension drawing of the F-DI 4/F-DQ 2 Fail-Safe module in front and side views. The dimensions are in mm.

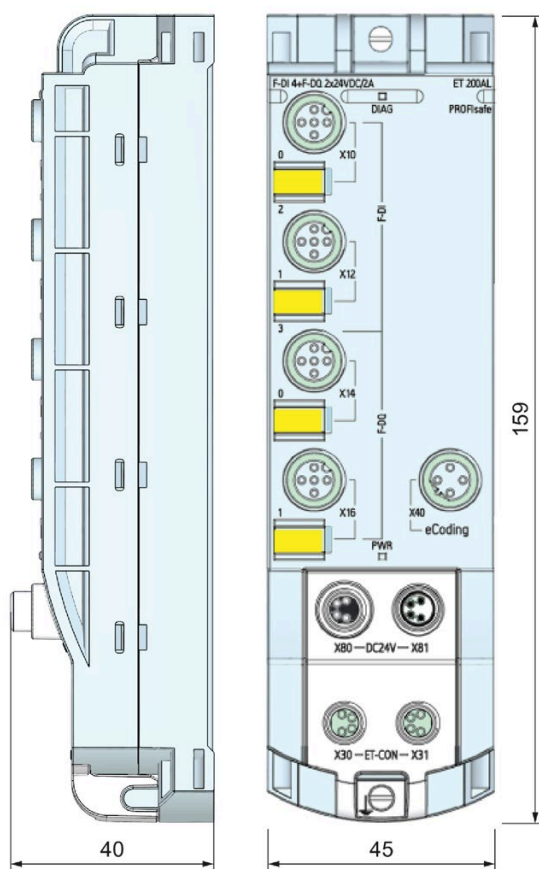


Figure A-1 Dimension drawing

## Response times

### B.1 Maximum response time

This section shows the response times of the F-DI 4/F-DQ 2 Fail-Safe module. The response times are included in the calculation of the F-system response time.

#### Definition of response time for fail-safe digital outputs

The response time represents the interval between an incoming safety message frame from the ET-Connection and the signal change at the digital output.

#### Times required for the calculation

Maximum cycle time:  $T_{\text{cycle}} = 23 \text{ ms}$

Maximum acknowledge time (Device Acknowledge Time):  $T_{\text{dat}} = 18 \text{ ms}$

You assign the "Maximum readback time" and "Maximum readback time switch on test" settings in STEP 7.

#### Calculating the maximum response time of the system

You can calculate your maximum system response time using the "SIMATIC STEP 7 Safety Advanced: F-Execution Times, F-Runtimes, F-Monitoring and Reaction Times (<http://support.automation.siemens.com/WW/view/en/49368678/133100>)" Excel file (RT\_calculator). Use your configured individual fail-safe module timing parameters and the module characteristic parameters found in this appendix to determine the maximum response time of your system.

#### Data transport delays included

The  $T_{\text{cycle}}$  parameter values given above include an allowance for the fail-safe module to acquire and deliver PROFIsafe messages in transactions with the PLC I/O bus. The execution time of the Safety FB in the fail-safe CPU includes the physical transport delay time for PROFIsafe messages moving between the fail-safe module location and the fail-safe CPU. There are no separate transport delay parameters that you can include in your calculations.

### B.2 Response time parameters for the F-DI 4/F-DQ 2 digital inputs

#### Maximum Device Acknowledge Response Time of the F-DI 4/F-DQ 2 Fail-Safe module digital inputs

1oo1 evaluation:



## B.2 Response time parameters for the F-DI 4/F-DQ 2 digital inputs

$$T_{WCDT\_i} = T_{filter} + T_{sct} + 2 \times T_{cycle}$$

$$T_{OFDT\_i} = T_{WCDT\_i} + T_{scf}$$

1oo2 evaluation:

$$T_{WCDT\_i} = T_{filter} + T_{sct} + 2 \times T_{cycle}$$

$$T_{OFDT\_i} = T_{WCDT\_i} + \text{MAX}(T_{scf}, T_{dis})$$

Where:

|               |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |
|---------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| $T_{cycle}$   | Internal cycle time of the fail-safe module                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |
| $T_{dis}$     | <p>Discrepancy time:</p> <ul style="list-style-type: none"> <li>Configured "Discrepancy time" for 1oo2 channels changing from "0" to "1"</li> <li>Configured "Discrepancy time" for 1oo2 channels changing from "1" to "0" and "Supply last valid value" option configured for discrepancy behavior</li> <li>"0" for 1oo2 channels changing from "1" to "0" and "Supply value 0" option configured for discrepancy behavior</li> </ul> <p>You should include the expected discrepancy time between your sensor inputs in your external sensor delay. Your configured <math>T_{dis}</math> contributes to <math>T_{OFDT\_i}</math> as the time delay for the fail-safe module's digital inputs to passivate the channel due to fault case extension of the discrepancy time.</p> <p>This parameter can be listed separately in the RT_calculator. Do not include <math>T_{dis}</math> in the value of <math>T_{OFDT\_i}</math> that you enter into the RT_calculator if you enter <math>T_{dis}</math> as a separate item.</p> |
| $T_{filter}$  | Configured "Input filters" time for the channel                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |
| $T_{OFDT\_i}$ | One Fault Delay Time: Maximum response time for the fail-safe module's digital input to report a channel as passivated                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |
| $T_{scf}$     | <p>Time delay for short-circuit fault duration:</p> <ul style="list-style-type: none"> <li>Configured "Interval for short-circuit test", when operating in high demand or continuous mode and depending on the short-circuit test to achieve your required level of safety integrity</li> <li>"0" when not depending on the short-circuit test to achieve your required level of safety integrity</li> </ul>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |
| $T_{sct}$     | <p>Time delay for short-circuit test duration:</p> <ul style="list-style-type: none"> <li>"0" if no short-circuit test configured</li> <li>"0" for 1oo2 channels changing from "1" to "0" and "Supply value 0" option configured for discrepancy behavior</li> <li>"Duration of short-circuit test" + "Input filters" time if short-circuit test is configured</li> </ul> <p>(Confirmation: "Input filters" can occur twice in equation for <math>T_{WCDT\_i}</math> if short-circuit test is configured.)</p>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |
| $T_{WCDT\_i}$ | Worst Case Delay Time: Maximum response time from a signal transition at the digital input to the reliable availability of the safety message frame available for the fail-safe CPU request                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |

The term " $2 \times T_{cycle}$ " for "maximum response time of the fail-safe module" allows for other input delays to complete just after the beginning of a cycle. The fail-safe module's digital inputs process and report the changed input data on the next cycle.

## B.3 Response time parameters for the F-DI 4/F-DQ 2 digital outputs

### Maximum response time of the F-DI 4/F-DQ 2 Fail-Safe module digital outputs

$$T_{WCDT\_q} = T_{rb} + \text{MAX}(T_{rb}, T_{rb\_swon}) + 2 \times T_{cycle}$$

$$T_{OFDT\_q} = T_{WCDT\_q}$$

When dark testing is disabled, a channel fault might not be detected until a process value change "1" to "0" takes place on the corresponding output. When dark testing is disabled and the process value is "1" for a given channel, the respective output switches are not manipulated by the various safety measures.

Where:

|                |                                                                                                                                                                                                                                 |
|----------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| $T_{cycle}$    | Internal cycle time of the fail-safe module                                                                                                                                                                                     |
| $T_{OFDT\_q}$  | One Fault Delay Time: Maximum response time for the module's digital outputs to turn an output OFF upon detection of a channel or module fault                                                                                  |
| $T_{rb}$       | Configured "Maximum readback time" for the channel                                                                                                                                                                              |
| $T_{rb\_swon}$ | Configured "Maximum readback time switch on test" for the channel                                                                                                                                                               |
| $T_{WCDT\_q}$  | Worst Case Delay Time: Maximum response time of the fail-safe module's digital output DC from the receipt of a safety message frame from the safety program in the fail-safe CPU to the signal transition at the digital output |

The term " $2 \times T_{cycle}$ " allows for a new process value to be delivered from the fail-safe CPU just after the beginning of a cycle. The fail-safe module's digital outputs process the changed output request and apply new data to the output switches on the next cycle.

After the fail-safe module's digital outputs command the output switch to change, the actual voltage on the load might not be realized until the configured readback time completes. If a bit pattern test is in progress, the new process value cannot be applied to the switches until the applicable readback time completes.

### Minimum permissible OFF time for F-DI 4/F-DQ 2 Fail-Safe module digital outputs

The fail-safe module's digital outputs expect to complete and confirm each ON to OFF transition before receiving a new command to go from OFF to ON. A process value of "0" presented for less than  $T_{WCDT\_q}$  can cause the channel to passivate.

## Switching of loads

### C.1 Connecting capacitive loads

If an F-DI 4/F-DQ 2 Fail-Safe module is interconnected with loads that require little current and have capacitance, this can lead to detection of a short circuit or overload. Reason: The capacitance cannot be sufficiently discharged or charged during the configured readback time of the bit pattern test.

Load capacitance can delay the voltage response as seen at the P- and M-switches of the F-DI 4/F-DQ 2 Fail-Safe module digital outputs. For a capacitive load with capacitance  $C$  across P and M, and a parallel load resistance  $R$ , the "Maximum readback time" needs to be in the range of 2.0 to 2.5 time constant ( $R * C$ ) of the load. This allows enough time for an appreciable voltage change to be seen when you briefly de-energize an energized load during bit pattern testing. If the resulting "Maximum readback time" is too long for your application, you can reduce this time constant by adding parallel resistance across the load to reduce the realized  $R * C$  time constant.

Alternatively, you can add a diode between the P-output and the load (capacitor and resistors) so that when you turn off the output, the voltage on the capacitor is not present at the P-output. Typically, power supplies with input capacitors that have reverse voltage protection have this diode built into the power supply. Using the added diode, you can greatly reduce the "Maximum readback time" to some portion of the hold-up time of the power supply/capacitor. This reduced "Maximum readback time" allows the load to operate normally (load stays ON) during the bit pattern tests.

Stray capacitance between the load circuit and ground, M, and P increases the time required for the "Maximum readback time switch on test". When module diagnostics switch "ON" a P- or M-switch to a de-energized load during bit pattern testing, both sides of the load are driven towards L+ or M, limited by stray capacitance. This effect is typically small.

Your "Maximum readback time switch on test" setting should be long enough for the load circuit voltage to react, but short enough that if one side of the load faults to P or M, testing of the opposite switch should not cause the load to mechanically react.

Capacitive loads (including power supplies with input capacitors) with low series resistance can have a large inrush current. If you have a large capacitive load, you should add series resistance to reduce the inrush current to reduce the risk of opened fuses or overcurrent fault detection on normal load switch ON events.

## C.2 Switching of inductive loads

The diagram below shows the maximum permitted inductive load and switching frequency allowed using only the internal suppression circuits of the F-DI 4/F-DQ 2 Fail-Safe module digital outputs. You should equip larger or more frequently switched inductive loads with external suppression circuits to avoid early failure of the F-DI 4/F-DQ 2 Fail-Safe module digital output switch. External suppression conducts the load current at a voltage less than the internal suppression threshold to avoid overloading the internal suppression.

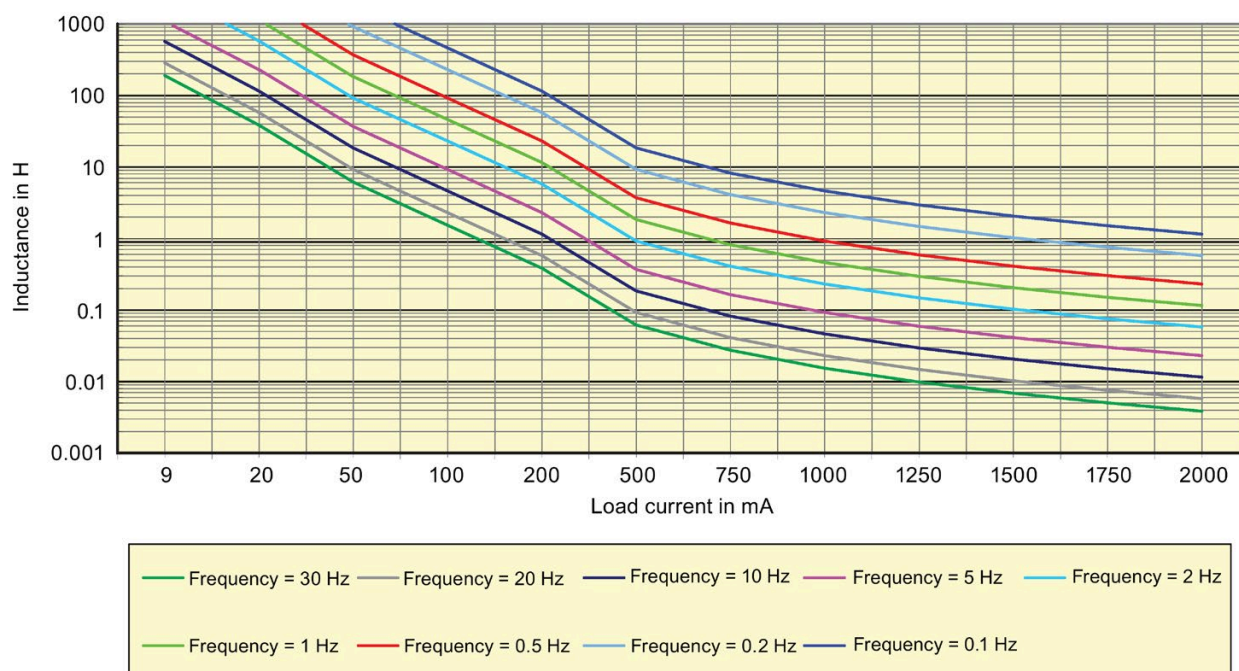


Figure C-1 Switching of inductive loads for the F-DI 4/F-DQ 2 Fail-Safe module depending on the load current and switching frequency

### **! WARNING**

#### **Unsuppressed inductive loads can lead to failures.**

The following failures can result:

- Unsuppressed inductive loads can lead to early "stuck-on" failures of the fail-safe module digital outputs.
- Unsuppressed inductive load switching generates an EMI hazard to the PLC system and correct processing of the safety function.

Death or serious personal injury and damage to machines and equipment may result if proper precautions are not taken.

You should use suppressor circuits with inductive loads to limit the voltage rise when a control output turns off and to limit the electrical noise generated when switching inductive loads.

# SIEMENS

## SIMATIC

### ET200

## Product Information for F-DI 4 + F-DQ 2x24 VDC/2A, 4xM12

### Product Information

## Introduction

### Introduction

#### Scope of the product information

This product information includes amendments and corrections to the documentation of the *ET 200AL System Manual*. The statements provided herein should be considered to be more up-to-date than other documentation if uncertainties arise.

## Security information

Siemens provides products and solutions with industrial security functions that support the secure operation of plants, systems, machines and networks.

In order to protect plants, systems, machines and networks against cyber threats, it is necessary to implement – and continuously maintain – a holistic, state-of-the-art industrial security concept. Siemens' products and solutions constitute one element of such a concept.

Customers are responsible for preventing unauthorized access to their plants, systems, machines and networks. Such systems, machines and components should only be connected to an enterprise network or the internet if and to the extent such a connection is necessary and only when appropriate security measures (e.g. firewalls and/or network segmentation) are in place.

For additional information on industrial security measures that may be implemented, please visit (<https://www.siemens.com/industrialsecurity>).

Siemens' products and solutions undergo continuous development to make them more secure. Siemens strongly recommends that product updates are applied as soon as they are available and that the latest product versions are used. Use of product versions that are no longer supported, and failure to apply the latest updates may increase customers' exposure to cyber threats.

To stay informed about product updates, subscribe to the Siemens Industrial Security RSS Feed visit (<https://www.siemens.com/industrialsecurity>).

# Power cycling the module used with S7-300 F-CPUs

## Statement of the problem

When the ET 200AL F-DI 4 + F-DQ 2 module is used with S7-300 F CPUs (PROFIsafe V2.4), there are certain power cycling situations which can lead to the module powering up in an error state. If the system is operating in RUN state and either of the following conditions occur, then the problem can occur:

- The module is power cycled independently
- The module and interface module (IM) are power cycled simultaneously

## If the problem occurs

Perform one of the following actions to restore the module to normal operation:

- Power cycle the IM independently
- Power cycle the CPU independently
- Download the hardware configuration to the F-CPU using STEP7 (TIA Portal) or Step 7 Classic

## Steps to avoid the problem

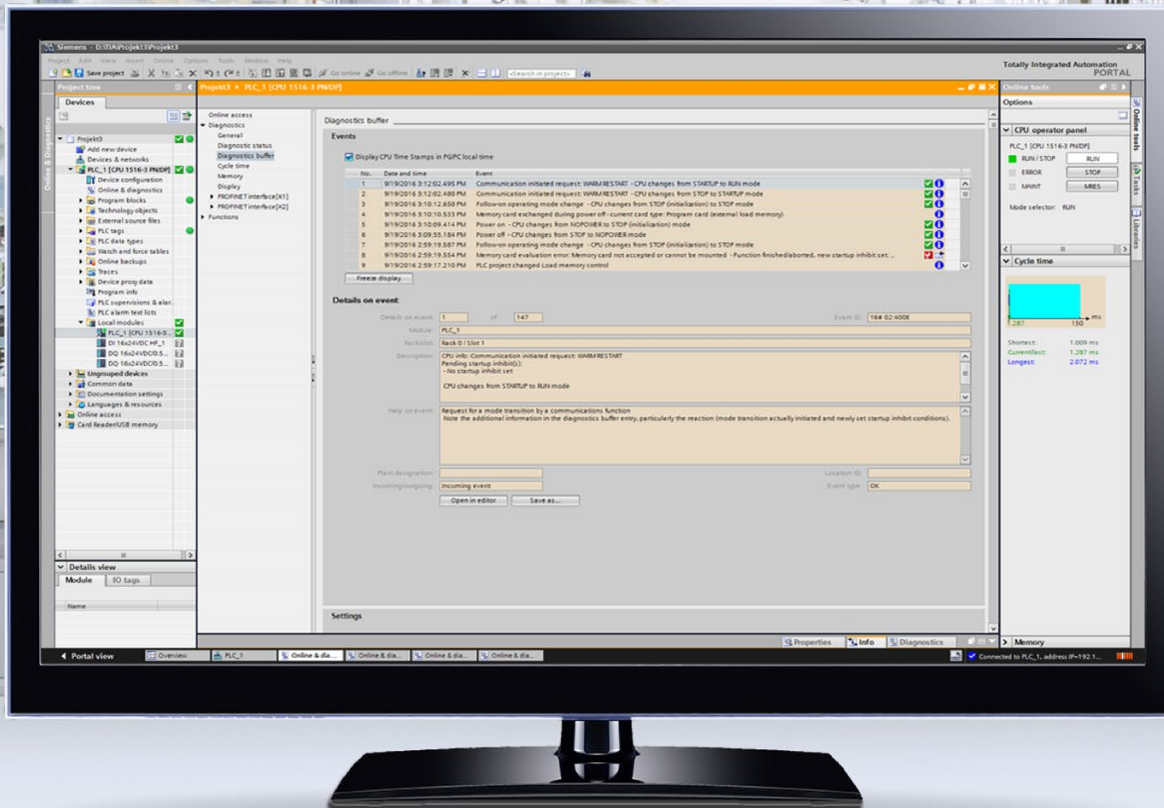
The problem can be avoided by ensuring that for any situation in which the module is power cycled with the system in RUN state:

- The CPU and the IM are also power cycled simultaneously with the module, or
- The CPU and/or the IM are power cycled independently after the module has completed its power cycle

Siemens AG  
Digital Industries  
Postfach 48 48  
90026 NÜRNBERG  
GERMANY

Product Information for F-DI 4 + F-DQ 2x24 VDC/2A, 4xM12  
A5E51082356-AA, V1.0 05/2021

SIEMENS



Function manual

# SIMATIC

S7-1500, ET 200MP, ET 200SP,  
ET 200AL, ET 200pro

Diagnostics

Edition

11/2019

[support.industry.siemens.com](https://support.industry.siemens.com)

## SIMATIC

### S7-1500, ET 200MP, ET 200SP, ET 200AL, ET 200pro Diagnostics

Function Manual

#### Preface

---

|                                                    |   |
|----------------------------------------------------|---|
| Function manuals<br>Documentation Guide            | 1 |
| Overview of system<br>diagnostics                  | 2 |
| Quick start                                        | 3 |
| Setting and determining<br>system diagnostics      | 4 |
| System diagnostics by<br>means of the user program | 5 |
| Alarms                                             | 6 |
| Diagnostics of the S7-<br>1500R/H redundant system | 7 |



## Legal information

### Warning notice system

This manual contains notices you have to observe in order to ensure your personal safety, as well as to prevent damage to property. The notices referring to your personal safety are highlighted in the manual by a safety alert symbol, notices referring only to property damage have no safety alert symbol. These notices shown below are graded according to the degree of danger.

#### **DANGER**

indicates that death or severe personal injury **will** result if proper precautions are not taken.

#### **WARNING**

indicates that death or severe personal injury **may** result if proper precautions are not taken.

#### **CAUTION**

indicates that minor personal injury can result if proper precautions are not taken.

#### **NOTICE**

indicates that property damage can result if proper precautions are not taken.

If more than one degree of danger is present, the warning notice representing the highest degree of danger will be used. A notice warning of injury to persons with a safety alert symbol may also include a warning relating to property damage.

### Qualified Personnel

The product/system described in this documentation may be operated only by **personnel qualified** for the specific task in accordance with the relevant documentation, in particular its warning notices and safety instructions. Qualified personnel are those who, based on their training and experience, are capable of identifying risks and avoiding potential hazards when working with these products/systems.

### Proper use of Siemens products

Note the following:

#### **WARNING**

Siemens products may only be used for the applications described in the catalog and in the relevant technical documentation. If products and components from other manufacturers are used, these must be recommended or approved by Siemens. Proper transport, storage, installation, assembly, commissioning, operation and maintenance are required to ensure that the products operate safely and without any problems. The permissible ambient conditions must be complied with. The information in the relevant documentation must be observed.

### Trademarks

All names identified by ® are registered trademarks of Siemens AG. The remaining trademarks in this publication may be trademarks whose use by third parties for their own purposes could violate the rights of the owner.

### Disclaimer of Liability

We have reviewed the contents of this publication to ensure consistency with the hardware and software described. Since variance cannot be precluded entirely, we cannot guarantee full consistency. However, the information in this publication is reviewed regularly and any necessary corrections are included in subsequent editions.

# Preface

## Purpose of the documentation

This function manual provides an overview of the diagnostics options for the automation system SIMATIC S7-1500, for the CPUs 1513pro-2 PN and 1516pro-2 PN based on SIMATIC S7-1500, and for the distributed I/O systems SIMATIC ET 200MP, ET 200SP and ET 200AL.

The documentation covers the following:

- Illustration of the uniformity and consistency of system diagnostics
- Overview of the options for establishing system diagnostics information

## Basic knowledge required

The following knowledge is required in order to understand the function manual:

- General knowledge in the field of automation technology
- Knowledge of the industrial automation system SIMATIC
- Knowledge of working with STEP 7 and WinCC
- Knowledge about the use of Microsoft Windows operating systems

## Scope of the documentation

This documentation is the basic documentation for all products of the S7-1500, ET 200MP, ET 200SP and ET 200AL systems, as well as for the CPUs 1513pro-2 PN und 1516pro-2 PN. The product documentation is based on this documentation.

## What's new in the Diagnostics function manual, Edition 11/2019 compared to Edition 10/2018

| What's new?      |                                                          | What are the customer benefits?                                                                                                       | Where can I find the information?                                |
|------------------|----------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------|
| Changed contents | Updated restrictions for the S7-1500R/H redundant system | Functions with which you are familiar from the SIMATIC S7-1500 automation system are implemented for the S7-1500R/H redundant system. | Section Diagnostics of the S7-1500R/H redundant system (Page 97) |

## What's new in the Diagnostics function manual, Edition 10/2018 compared to Edition 09/2016

| What's new?      |                                                                                  | What are the customer benefits?                                                                                                       | Where can I find the information?                                                                                                                                                     |
|------------------|----------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| New contents     | Description of the diagnostics of the S7-1500R/H redundant system                | You obtain information in compact form on the special features of the diagnostics in the S7-1500R/H redundant systems.                | Section Diagnostics of the S7-1500R/H redundant system (Page 97)                                                                                                                      |
| Changed contents | Scope of the function manual expanded to include the S7-1500R/H redundant system | Functions with which you are familiar from the SIMATIC S7-1500 automation system are implemented for the S7-1500R/H redundant system. | Redundant System S7-1500R/H System Manual ( <a href="https://support.industry.siemens.com/cs/ww/en/view/109754833">https://support.industry.siemens.com/cs/ww/en/view/109754833</a> ) |

## What's new in the Diagnostics function manual, Edition 09/2016 compared to Edition 06/2014

| What's new?      |                                                                   | What are the customer benefits?                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             | Where can I find the information?                                                                                                                                                                                                                                                                                                                                                                                                               |
|------------------|-------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| New contents     | Extended functionality of the Web server                          | <ul style="list-style-type: none"> <li>You obtain information about:               <ul style="list-style-type: none"> <li>Know-how protection or copy protection of the PLC program</li> <li>Program/communication load and cycle time</li> <li>F-collective signatures, cycle times and runtimes of the F-runtime group(s) (with an F-CPU)</li> </ul> </li> <li>You can monitor statuses, errors, technology alarms and the current values of technology objects (TOs) with the Web server.</li> <li>You can read, view and save trace recordings via the Web server and thus obtain plant and project information for diagnostics and maintenance without STEP 7.</li> <li>You can set four additional languages for the Web server interface.</li> </ul> | Section Diagnostics information using the web server (Page 48),<br>Web server<br><a href="http://support.automation.siemens.com/WW/view/en/59193560">http://support.automation.siemens.com/WW/view/en/59193560</a> ) function manual,<br>Using the trace and logic analyzer function<br><a href="https://support.industry.siemens.com/cs/ww/en/view/64897128">https://support.industry.siemens.com/cs/ww/en/view/64897128</a> ) function manual |
|                  | Assignment of different project languages extended                | You can assign up to three different project languages for comments and alarm texts to the user interface languages of display devices.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     | Section Editing alarms in the alarm editor (Page 78)                                                                                                                                                                                                                                                                                                                                                                                            |
| Changed contents | Scope of the function manual expanded to include CPU 1516pro-2 PN | Functions that you will be familiar with from the SIMATIC S7-1500 CPUs are implemented in the CPU 1516pro-2 PN (degree of protection IP65, IP66 and IP67).                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  | Operating instructions CPU 1516pro-2 PN<br><a href="https://support.industry.siemens.com/cs/ww/en/view/109482416">https://support.industry.siemens.com/cs/ww/en/view/109482416</a> )                                                                                                                                                                                                                                                            |
|                  | Security events added                                             | You know which types of events are registered as security events in the diagnostics buffer and can configure group alarms for them.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         | Section CPU diagnostics buffer (Page 42)                                                                                                                                                                                                                                                                                                                                                                                                        |
|                  | Influence of the value status explained                           | You know which factors influence the bit in the value status and can take this into account during configuration.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           | Section System diagnostics using process image inputs (Page 73)                                                                                                                                                                                                                                                                                                                                                                                 |
|                  | Note added on the maximum configuration limits of program alarms. |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             | Section Creating alarms with the "Program_Alarm" instruction (Page 77).                                                                                                                                                                                                                                                                                                                                                                         |

## Conventions

**STEP 7:** We refer to "STEP 7" in this documentation as a synonym for the configuration and programming software "STEP 7 as of V12 (TIA Portal)" and subsequent versions.

This document contains illustrations of the described devices. The illustrations may differ slightly from the device supplied.

You should also pay particular attention to notes such as the one shown below:

---

### Note

A note contains important information on the product, on the handling of the product or on the section of the documentation to which particular attention should be paid.

---

## Security information

Siemens provides products and solutions with industrial security functions that support the secure operation of plants, systems, machines and networks.

In order to protect plants, systems, machines and networks against cyber threats, it is necessary to implement – and continuously maintain – a holistic, state-of-the-art industrial security concept. Siemens' products and solutions constitute one element of such a concept.

Customers are responsible for preventing unauthorized access to their plants, systems, machines and networks. Such systems, machines and components should only be connected to an enterprise network or the internet if and to the extent such a connection is necessary and only when appropriate security measures (e.g. firewalls and/or network segmentation) are in place.

For additional information on industrial security measures that may be implemented, please visit (<https://www.siemens.com/industrialsecurity>).

Siemens' products and solutions undergo continuous development to make them more secure. Siemens strongly recommends that product updates are applied as soon as they are available and that the latest product versions are used. Use of product versions that are no longer supported, and failure to apply the latest updates may increase customers' exposure to cyber threats.

To stay informed about product updates, subscribe to the Siemens Industrial Security RSS Feed visit (<https://www.siemens.com/industrialsecurity>).

## Siemens Industry Online Support

You can find current information on the following topics quickly and easily here:

- **Product support**

All the information and extensive know-how on your product, technical specifications, FAQs, certificates, downloads, and manuals.

- **Application examples**

Tools and examples to solve your automation tasks – as well as function blocks, performance information and videos.

- **Services**

Information about Industry Services, Field Services, Technical Support, spare parts and training offers.

- **Forums**

For answers and solutions concerning automation technology.

- **mySupport**

Your personal working area in Industry Online Support for messages, support queries, and configurable documents.

This information is provided by the Siemens Industry Online Support in the Internet (<https://support.industry.siemens.com>).

## Industry Mall

The Industry Mall is the catalog and order system of Siemens AG for automation and drive solutions on the basis of Totally Integrated Automation (TIA) and Totally Integrated Power (TIP).

Catalogs for all the products in automation and drives are available on the Internet (<https://mall.industry.siemens.com>).

# Table of contents

|          |                                                              |           |
|----------|--------------------------------------------------------------|-----------|
|          | <b>Preface .....</b>                                         | <b>3</b>  |
| <b>1</b> | <b>Function manuals Documentation Guide .....</b>            | <b>10</b> |
| <b>2</b> | <b>Overview of system diagnostics .....</b>                  | <b>12</b> |
| 2.1      | Properties of system diagnostics .....                       | 12        |
| 2.2      | Benefits of innovative system diagnostics .....              | 14        |
| <b>3</b> | <b>Quick start .....</b>                                     | <b>15</b> |
| 3.1      | Using the display of the CPU .....                           | 16        |
| 3.2      | Using STEP 7 .....                                           | 18        |
| <b>4</b> | <b>Setting and determining system diagnostics .....</b>      | <b>23</b> |
| 4.1      | Configuring alarms for system diagnostics .....              | 23        |
| 4.2      | Options for displaying system diagnostics .....              | 25        |
| 4.2.1    | Diagnostics information at the devices .....                 | 26        |
| 4.2.1.1  | LEDs .....                                                   | 26        |
| 4.2.1.2  | Display of the CPU .....                                     | 27        |
| 4.2.2    | Diagnostics information in STEP 7 .....                      | 29        |
| 4.2.2.1  | Explanation of diagnostics symbols .....                     | 29        |
| 4.2.2.2  | Accessible devices (without project) .....                   | 31        |
| 4.2.2.3  | Devices & networks .....                                     | 33        |
| 4.2.2.4  | Online & diagnostics .....                                   | 36        |
| 4.2.2.5  | "Diagnostics" tab in the Inspector window .....              | 39        |
| 4.2.2.6  | CPU diagnostics buffer .....                                 | 42        |
| 4.2.2.7  | "Online tools" task card .....                               | 45        |
| 4.2.2.8  | Configuring the settings for I/O modules in STEP 7 .....     | 47        |
| 4.2.3    | Diagnostics information using the web server .....           | 48        |
| 4.2.4    | Diagnostics information using the HMI diagnostics view ..... | 59        |
| 4.2.4.1  | Configuring system diagnostics .....                         | 60        |
| 4.2.4.2  | Different views of the HMI diagnostics view .....            | 63        |
| 4.2.4.3  | Inserting system diagnostics indicator .....                 | 66        |
| 4.2.4.4  | Configuring button as system diagnostics indicator .....     | 68        |
| <b>5</b> | <b>System diagnostics by means of the user program .....</b> | <b>71</b> |
| 5.1      | Options of system diagnostics in the user program .....      | 71        |
| 5.2      | System diagnostics using process image inputs .....          | 73        |

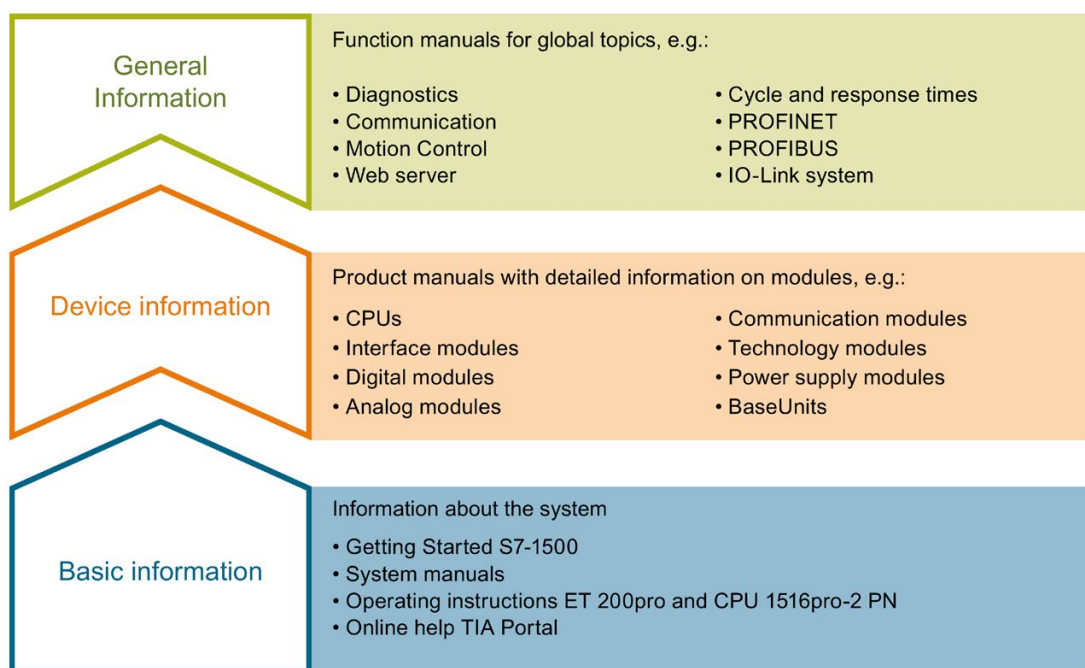
|          |                                                                                    |            |
|----------|------------------------------------------------------------------------------------|------------|
| <b>6</b> | <b>Alarms .....</b>                                                                | <b>76</b>  |
| 6.1      | Creating alarms with the "Program_Alarm" instruction .....                         | 77         |
| 6.2      | Editing alarms in the alarm editor .....                                           | 78         |
| 6.3      | Display of program alarms .....                                                    | 81         |
| 6.4      | Output of the alarm state with the "Get_AlarmState" instruction .....              | 82         |
| 6.5      | Example program for program alarms .....                                           | 83         |
| 6.5.1    | Task .....                                                                         | 83         |
| 6.5.2    | Example 1: Program alarm without associated values .....                           | 84         |
| 6.5.3    | Example 2: Program alarm with associated value .....                               | 89         |
| 6.5.4    | Displaying the alarm .....                                                         | 96         |
| <b>7</b> | <b>Diagnostics of the S7-1500R/H redundant system .....</b>                        | <b>97</b>  |
| 7.1      | Online and Diagnostics view .....                                                  | 100        |
| 7.2      | "Online Tools" task card .....                                                     | 103        |
| 7.3      | Diagnostics view in the project tree and in the device view and network view ..... | 106        |
| 7.4      | Diagnostics in the RUN-Redundant system state .....                                | 111        |
| 7.5      | Restrictions in the RUN-Solo system state .....                                    | 117        |
| 7.6      | System diagnostics by means of the user program .....                              | 118        |
|          | <b>Glossary .....</b>                                                              | <b>119</b> |
|          | <b>Index .....</b>                                                                 | <b>123</b> |



# Function manuals Documentation Guide

The documentation for the SIMATIC S7-1500 automation system, for CPU 1516pro-2 PN based on SIMATIC S7-1500, and for the distributed I/O systems SIMATIC ET 200MP, ET 200SP and ET 200AL is divided into three areas.

This division allows you easier access to the specific information you require.



## Basic information

System manuals and Getting Started manuals describe in detail the configuration, installation, wiring and commissioning of the SIMATIC S7-1500, ET 200MP, ET 200SP and ET 200AL systems; use the corresponding operating instructions for CPU 1516pro-2 PN. The STEP 7 online help supports you in configuration and programming.

## Device information

Product manuals contain a compact description of the module-specific information, such as properties, terminal diagrams, characteristics and technical specifications.

### General information

The function manuals contain detailed descriptions on general topics such as diagnostics, communication, Motion Control, Web server, OPC UA.

You can download the documentation free of charge from the Internet (<https://support.industry.siemens.com/cs/ww/en/view/109742705>).

Changes and additions to the manuals are documented in product information sheets.

You will find the product information on the Internet:

- S7-1500/ET 200MP (<https://support.industry.siemens.com/cs/us/en/view/68052815>)
- ET 200SP (<https://support.industry.siemens.com/cs/us/en/view/73021864>)
- ET 200AL (<https://support.industry.siemens.com/cs/us/en/view/99494757>)

### Manual Collections

The Manual Collections contain the complete documentation of the systems put together in one file.

You will find the Manual Collections on the Internet:

- S7-1500/ET 200MP (<https://support.industry.siemens.com/cs/ww/en/view/86140384>)
- ET 200SP (<https://support.industry.siemens.com/cs/ww/en/view/84133942>)
- ET 200AL (<https://support.industry.siemens.com/cs/ww/en/view/95242965>)

### "mySupport"

With "mySupport", your personal workspace, you make the best out of your Industry Online Support.

In "mySupport", you can save filters, favorites and tags, request CAx data and compile your personal library in the Documentation area. In addition, your data is already filled out in support requests and you can get an overview of your current requests at any time.

You must register once to use the full functionality of "mySupport".

You can find "mySupport" on the Internet (<https://support.industry.siemens.com/My/ww/en>).

### Application examples

The application examples support you with various tools and examples for solving your automation tasks. Solutions are shown in interplay with multiple components in the system - separated from the focus on individual products.

You will find the application examples on the Internet (<https://support.industry.siemens.com/sc/ww/en/sc/2054>).

# Overview of system diagnostics

## 2.1 Properties of system diagnostics

### Introduction

In the SIMATIC environment, the term "system diagnostics" refers to diagnostics of devices and modules.

All SIMATIC products have integrated diagnostic functions that you can use to detect and remedy faults. The components automatically flag a potential fault in the operation and provide detailed information. You can minimize unscheduled standstill times with plant-wide diagnostics.

The SIMATIC automation system monitors the following states in the running plant:

- Device failure/recovery
- Insert/remove event
- Module fault
- I/O access error
- Channel fault
- Parameter assignment error
- Failure of the external auxiliary voltage

### Properties of SIMATIC system diagnostics

- Integrated as standard in the hardware
- System-wide across bus limits
- Automatic localization of the error source
- Automatic output of the cause of the error in plain text
- Plant-wide diagnostics of all components
- Archiving and logging of alarms
- Configurability of alarms

## Consistent diagnostics from the field level all the way to the management level

The various diagnostics media give you a uniform view of maintenance-related information of every automation component in the plant: System status (module and network status, alarms for system errors) are available plant-wide in a uniform display.

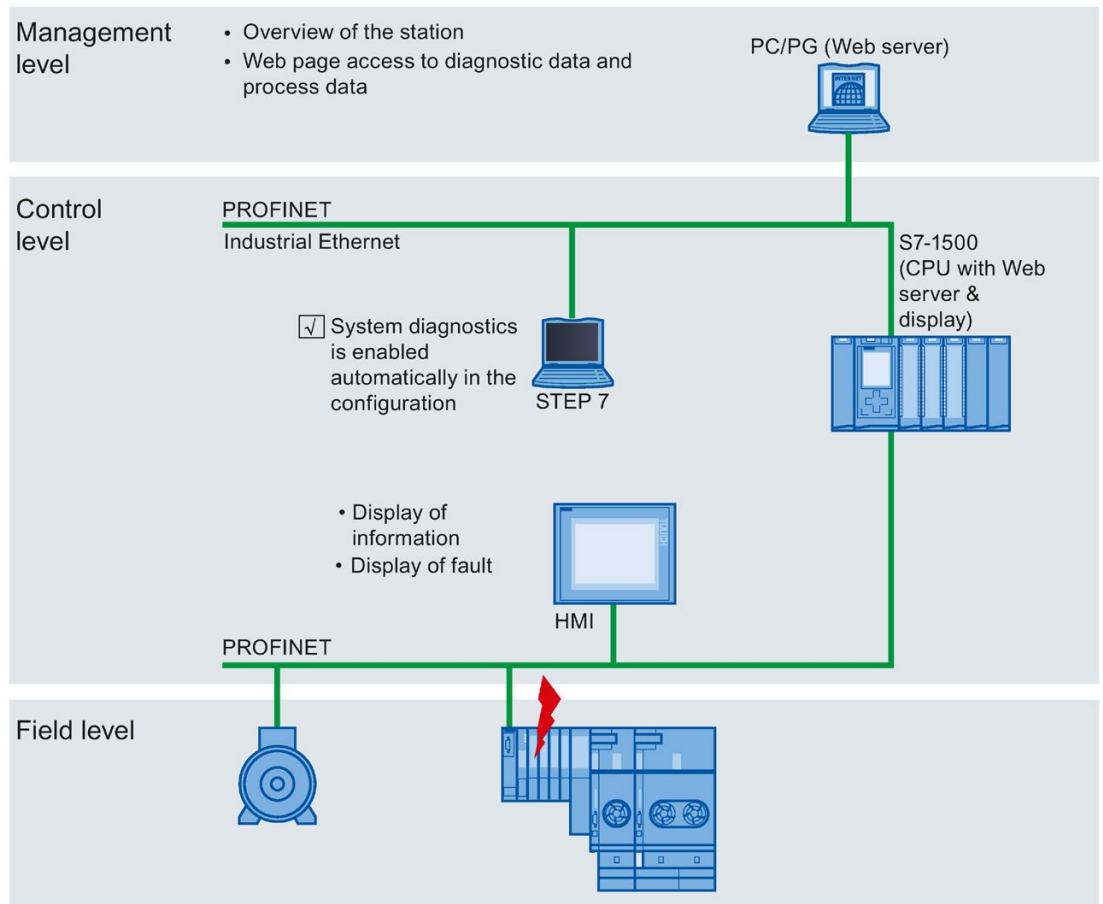


Figure 2-1 Overview of system diagnostics in a plant

## 2.2 Benefits of innovative system diagnostics

### System diagnostics is also possible in STOP

The system diagnostics is integrated in the firmware of the CPU and works independently of the cyclic user program. This means it is also available in the STOP CPU operating mode. Faults are detected immediately and signaled to the higher-level HMI devices, the Web server and the display of the SIMATIC S7-1500 CPU, even in STOP mode. This makes system diagnostics consistent with the actual plant state at all times.

### Uniform display concept

All clients of a system are provided with diagnostics information by a uniform mechanism. The same system diagnostics information is used regardless of the display medium.

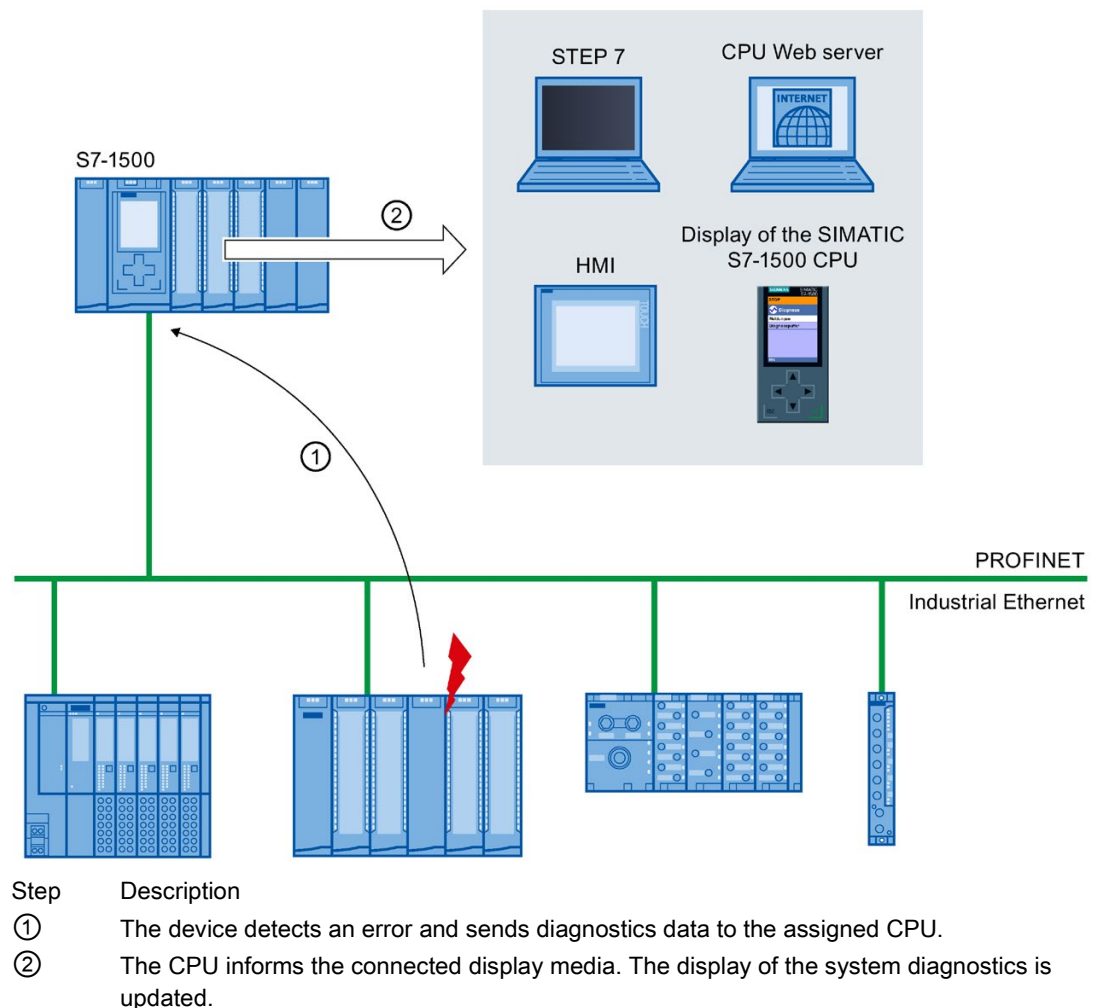


Figure 2-2 Sequence of the system diagnostics

## Quick start

### Introduction

The following chapters of this documentation describe the different options for establishing system diagnostics. All described options can be used independently of one another.

This chapter gives you an overview of the basic procedure to get initial diagnostics information fast.

---

**Note**

System diagnostics is generally available for the devices of the SIMATIC series.

---

## 3.1 Using the display of the CPU

The display of the SIMATIC S7-1500 CPU offers a fast and direct option to get diagnostics information. You can call up status information in different menus on the display.

### Requirements

- A project has been created.
- The project has been downloaded to the CPU.

### Determining diagnostics information using the display of the SIMATIC S7-1500 CPU

To determine diagnostics information using the display, follow these steps:

1. Select the "Diagnostics" menu on the display.
2. Select the "Diagnostics buffer" command from the "Diagnostics" menu.



Figure 3-1 Display of SIMATIC S7-1500 CPU

## Result

The diagnostics events are displayed in the diagnostics buffer in the sequence in which they occur.

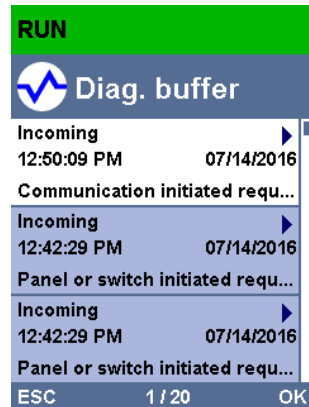


Figure 3-2 Display of the diagnostics buffer in the display of the SIMATIC S7-1500 CPU

---

### Note

#### Automatic updating of diagnostics information

You set automatic updating of the diagnostics information under: "Display" > "DiagnosticRefresh".

---

## Additional information

You can find information about the configuration of alarms in the section Configuring alarms for system diagnostics (Page 23).



## 3.2 Using STEP 7

Getting started with STEP 7 gives you fast access to detailed diagnostics information.

### Requirements

- A project has been created.
- The project has been downloaded to the CPU.
- An error has occurred.
- The programming device must be able to establish a connection to the CPU via an interface.

### Determining diagnostics information using STEP 7

To determine diagnostics information using STEP 7, follow these steps:

1. Open the respective project in STEP 7.
2. Open the portal view of STEP 7.
3. Select the "Online & Diagnostics" portal.
4. Select the "Online status" action.

The "Select device" dialog opens. The dialog is an image of the configured devices in the project.

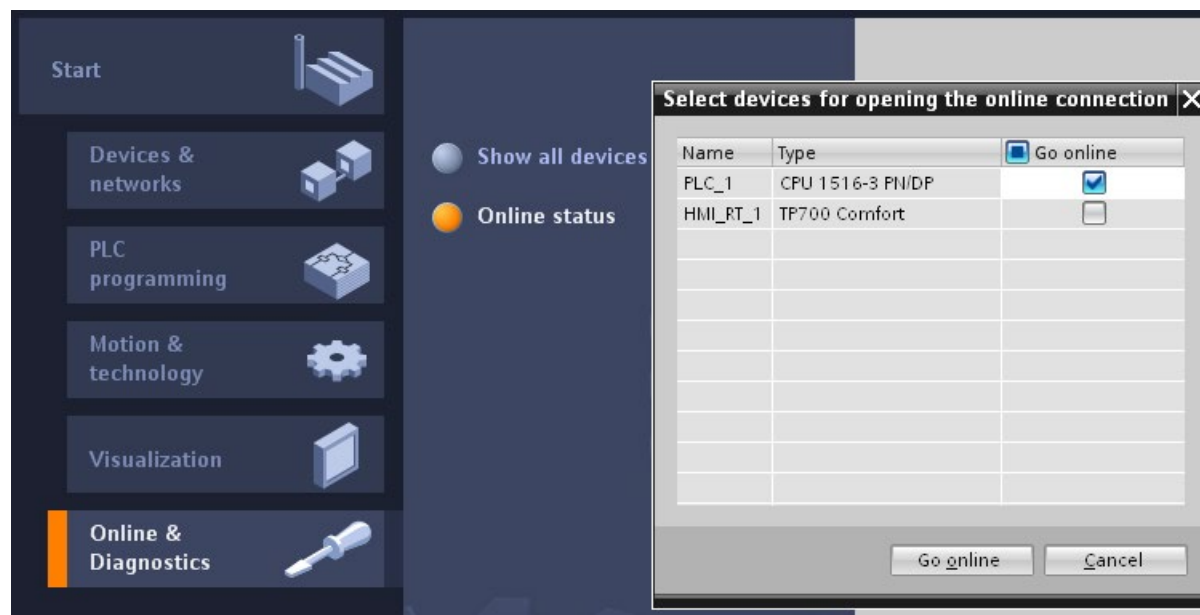


Figure 3-3 Device selection for online connection in the portal view

5. Activate the "Go online" option button for the device that you want to use to establish an online connection.
6. Click on the "Go online" button.

7. The "Go online" dialog opens.

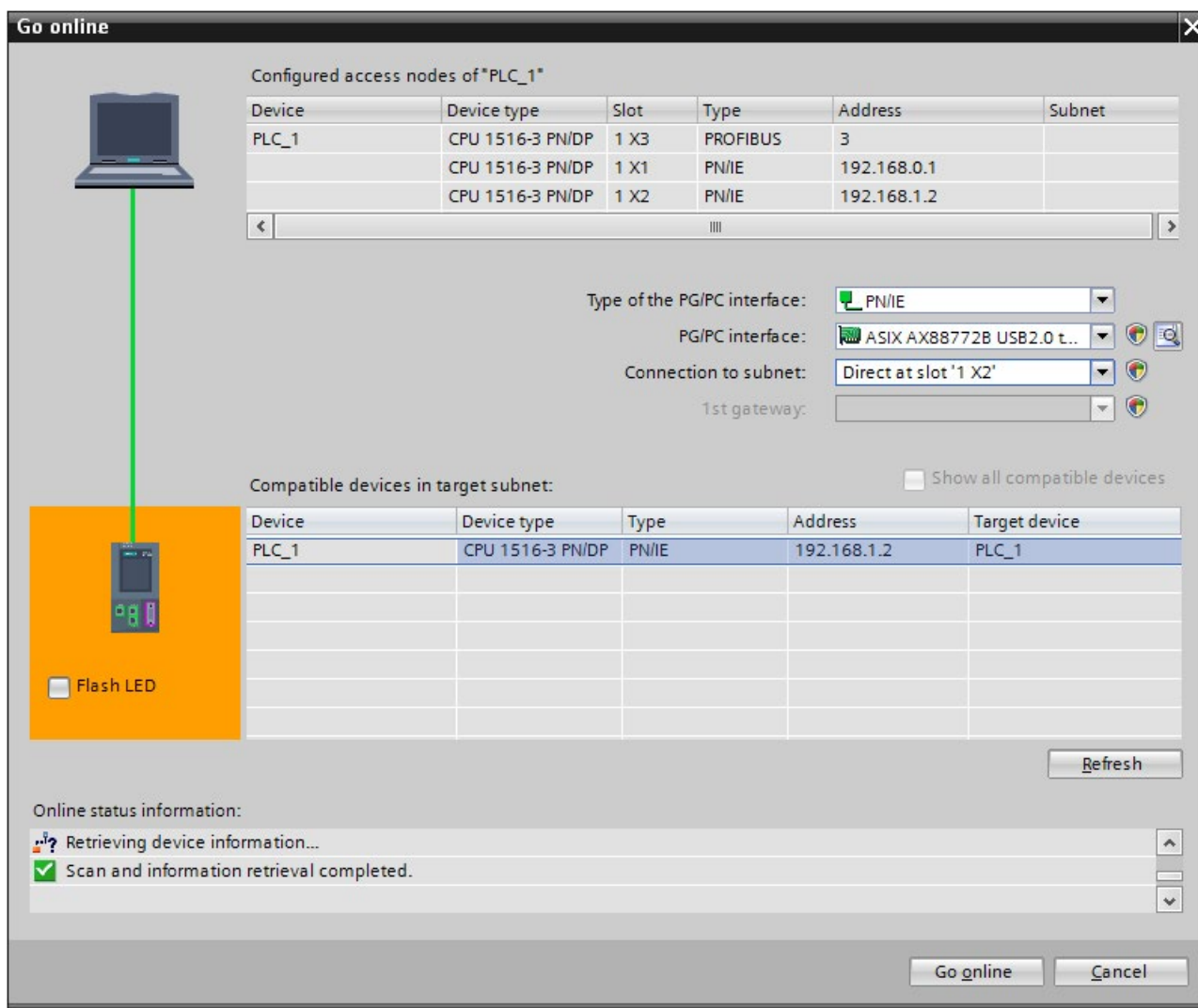


Figure 3-4 Establishing an online connection

8. Make the settings for the interface.

9. Click on the "Go online" button.

The project view of STEP 7 opens. The network view is opened in the work area.

The symbols in the project tree provide initial information about the faulty modules.

The screenshot displays the Siemens STEP 7 software interface. On the left is the 'Project tree' showing the hierarchy of the 'Diagnostics\_Project'. The 'Devices & networks' folder is expanded, showing 'PLC\_3 [CPU 1516-3 PN/DP]' selected. Below it, 'Local modules' are listed, including 'PLC\_3 [CPU 1516-3 PN/D...', 'DI 16x24VDC HF\_1', 'DQ 16x24VDC/0.5A ST\_1', and 'DQ 16x24VDC/0.5A ST\_2'. The 'PLC\_3' module has a red error icon. The 'Diagnostics' tab is active in the bottom right pane.

The main work area shows the 'Network view' of the 'Diagnostics\_Project'. It displays a network diagram with two devices: 'PLC\_3 CPU 1516-3 PN/...' and 'HMI\_1 TP1900 Comfort'. They are connected via a 'PN/IE\_2' network. The 'PLC\_3' device has a red error icon. The 'HMI\_1' device has a green status icon.

Below the network diagram, the 'Diagnostics' pane shows a table with the following data:

| 1 Device with problems |          |               |               |                           |                                        |  |
|------------------------|----------|---------------|---------------|---------------------------|----------------------------------------|--|
| Online...              | Opera... | Device/module | Connection... | Message                   | Details                                |  |
| Error, ...             | RUN      | PLC_3         | Direkt        | Error, Difference in I... | <a href="#">For more detailed i...</a> |  |

Figure 3-5 Display of the fault in the network view

10. Double-click the device which displays an alarm message to access the faulty module directly. This is the CPU in the example.

The device view of the CPU is opened in the work area. In this view you can see directly in which module the error has occurred.

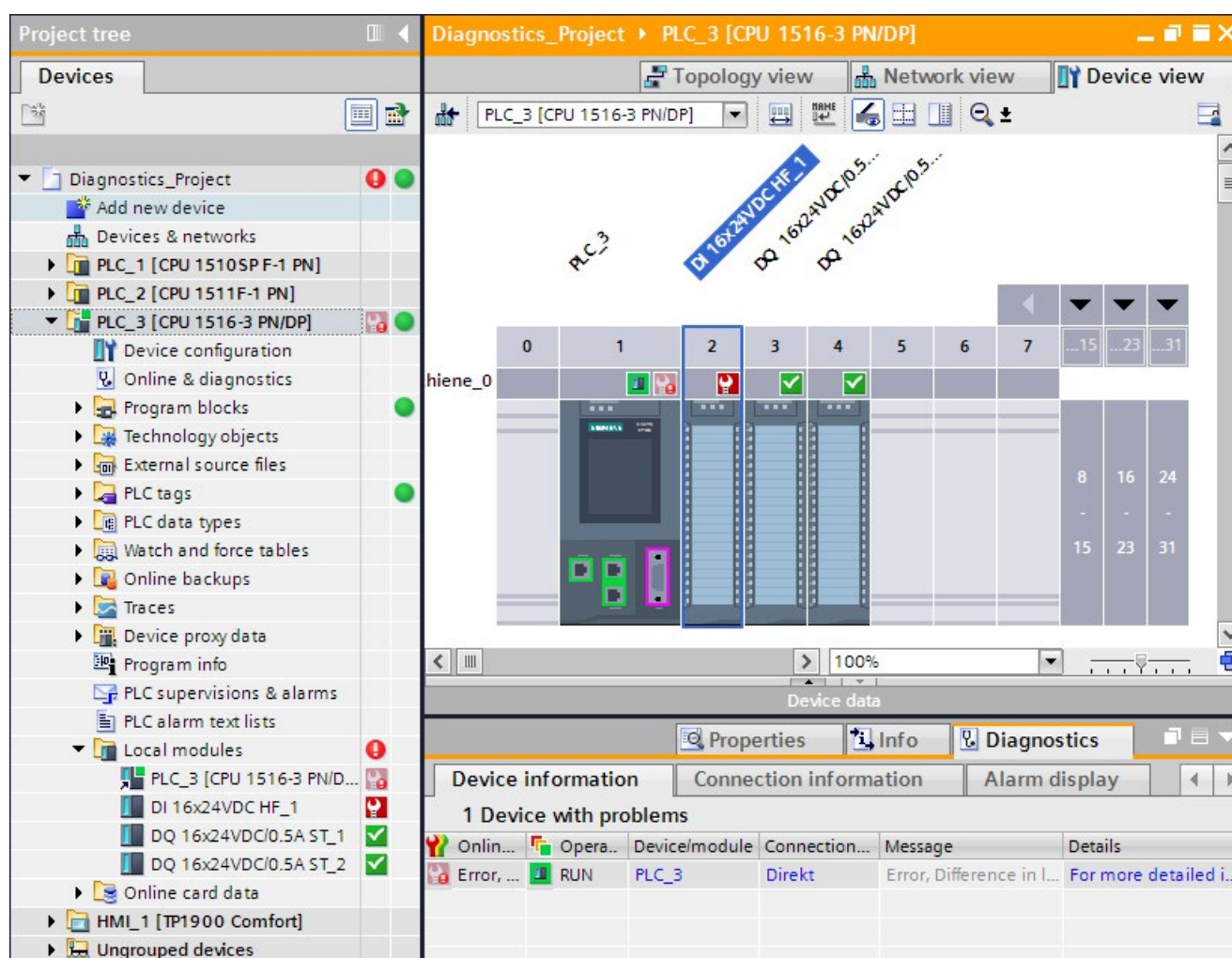


Figure 3-6 Display of the faulty module in the device view

11. Open the "Diagnostics" tab and the subordinate "Device information" tab in the Inspector window for a more detailed error description.

## Result

The link in the "Details" table column takes you to the online and diagnostics view of the device and to the diagnostics buffer there, for example. This includes more information on all diagnostics events in the order in which they occurred.

The screenshot displays the 'Diagnostics buffer' window in STEP 7. The window title is 'Diagnostics\_Project > PLC\_3 [CPU 1516-3 PN/DP]'. The left sidebar shows a tree view with 'Diagnostics' expanded, and 'Diagnostics buffer' selected. The main area shows a table of events with columns 'No.', 'Date and time', and 'Event'. Below the table is a checkbox 'Display CPU Time Stamps in PG/PC local time' which is checked. At the bottom, there are tabs for 'Properties', 'Info', and 'Diagnostics', and a section titled '1 Device with problems' with a table showing device status and error details.

| No. | Date and time            | Event                                                       |
|-----|--------------------------|-------------------------------------------------------------|
| 641 | 2/25/2016 6:21:41.707 PM | Power off - CPU changes from STOP to NOPOWER mode           |
| 642 | 2/25/2016 6:18:03.230 PM | Follow-on operating mode change - CPU changes from ST...    |
| 643 | 2/25/2016 6:18:02.981 PM | Memory card evaluation error: Memory card not accepted ...  |
| 644 | 2/25/2016 6:18:00.675 PM | Memory card exchanged during power off - current card ty... |
| 645 | 2/25/2016 6:18:00.066 PM | Power on - CPU changes from NOPOWER to STOP (initializa...  |
| 646 | 2/25/2016 6:17:48.930 PM | Power off - CPU changes from STOP to NOPOWER mode           |
| 647 | 2/25/2016 6:16:37.409 PM | Follow-on operating mode change - CPU changes from ST...    |
| 648 | 2/25/2016 6:16:37.210 PM | Memory card evaluation error: Memory card not accepted ...  |
| 649 | 2/25/2016 6:16:34.221 PM | Power on - CPU changes from NOPOWER to STOP (initializa...  |

| Online...  | Opera... | Device/module | Connection... | Message                   | Details                                           | Help |
|------------|----------|---------------|---------------|---------------------------|---------------------------------------------------|------|
| Error, ... | RUN      | PLC_3         | Direkt        | Error, Difference in l... | For more detailed information, refer to devi... ? |      |

Figure 3-7 Diagnostics buffer with detailed error description

### Note

#### Symbols and their meaning

You can find a legend with the meaning of each symbol in Explanation of diagnostics symbols (Page 29) and in the online help for STEP 7.

# Setting and determining system diagnostics

## Introduction

System diagnostics is generally available for the devices of the SIMATIC series.

In the properties of each individual CPU, you can specify if you want to receive alarms for system diagnostics on your display device. Alarms are provided on the display of the SIMATIC S7-1500 CPU, the CPU Web server and the HMI device. Alarms are enabled by default. If you do not want to receive alarms for system diagnostics on your display devices, you can disable the sending of alarms.

## 4.1 Configuring alarms for system diagnostics

Predefined alarm texts are available for establishing the system diagnostics.

### Requirements

- STEP 7 is open.
- A project is open.



## Procedure

To make alarm settings for system diagnostics of the project in STEP 7, follow these steps:

1. Open the "Common data" folder in the project tree.
2. Double-click the "System diagnostics settings" entry.

You now have access to the alarm settings. System diagnostics is enabled by default. System diagnostics cannot be disabled for the use of a CPU from the SIMATIC S7-1500 product series.

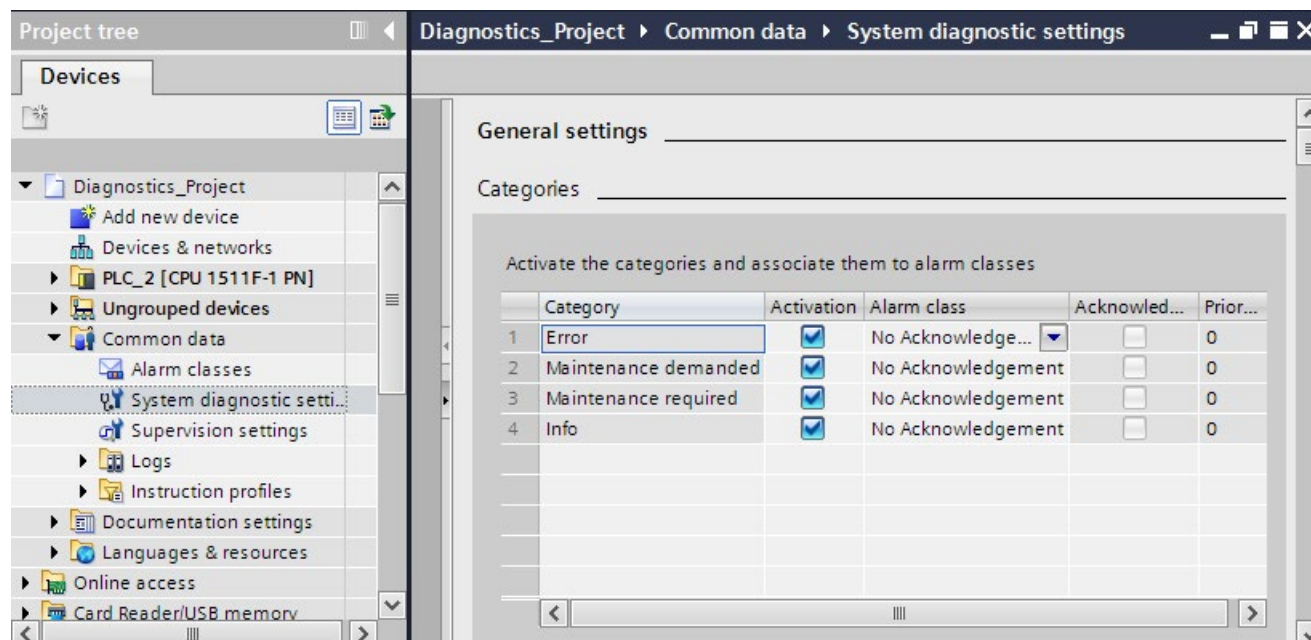


Figure 4-1 Properties of system diagnostics and alarm settings

3. In the settings, specify the alarm category that is to be displayed and if it needs to be acknowledged.

The check boxes in the "Activation" column are enabled by default. When you disable all check boxes, the status of the HMI system diagnostics view is still updated with the "Info Report" functionality.

## Result

You have configured the alarms for system diagnostics of the project in STEP 7.

The settings are saved with the project and become effective after the compiling and downloading of the hardware configuration to the involved components.

Maintenance events (maintenance demanded, maintenance required) are entered in the alarm buffer of the CPU just like any other event.

## 4.2 Options for displaying system diagnostics

### Example

This section includes a diagnostics example to show how system diagnostics is established with the help of different display options. The example includes a CPU from the SIMATIC S7-1500 product series that is connected to an ET 200S distributed I/O system and an HMI Comfort Panel via PROFINET.

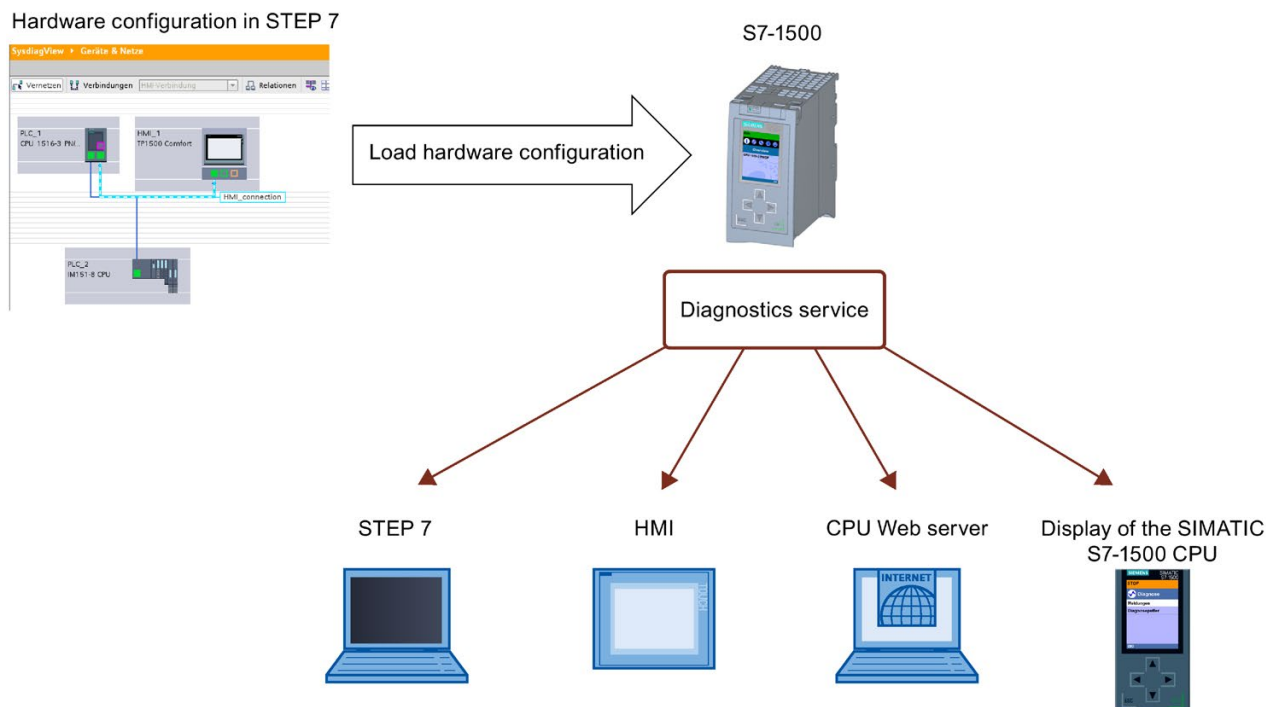


Figure 4-2 System diagnostics display options

The following sections include figures that illustrate how diagnostics information is displayed with the help of different display options.

- Using the LEDs on the hardware (Page 26)
- Local error analysis via the display of the CPU (Page 27)
- Using STEP 7 as of V12 (Page 29)
- Remote diagnostics using the Web server (Page 48)
- Stationary system diagnostics using the HMI diagnostics view (Page 59)



## 4.2.1 Diagnostics information at the devices

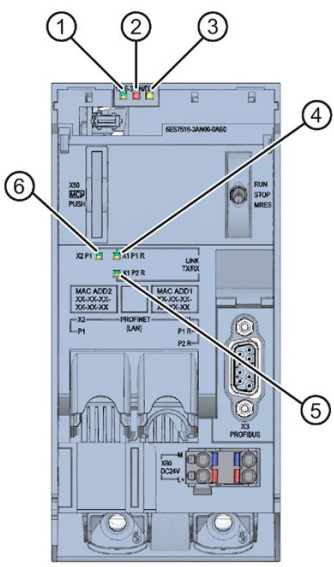
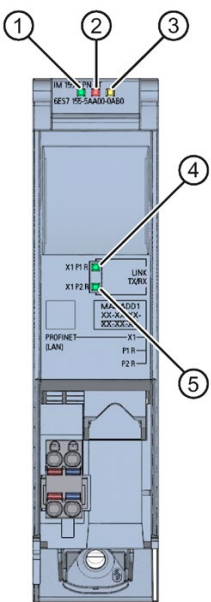
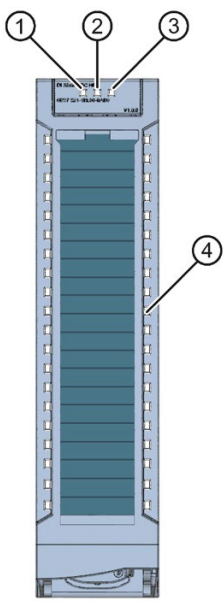
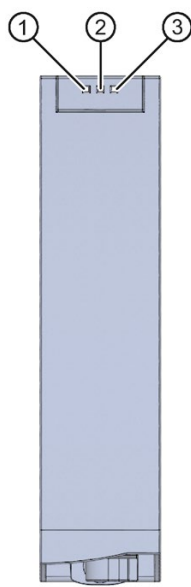
### 4.2.1.1 LEDs

#### Overview

All hardware components, such as CPUs, interface modules and modules, provide information about their operating mode as well as internal and external errors through their LEDs. Diagnostics by means of LEDs is an initial tool for error localization.

The graphics below include examples for the arrangement of LEDs on some modules.

Table 4- 1 LED displays on the modules

|   | CPU 1516-3 PN/DP                                                                   | IM 155-5 PN ST                                                                     | DI 32x24VDC HF                                                                      | PS 25W 24VDC                                                                         |
|---|------------------------------------------------------------------------------------|------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------|
|   |  |  |  |  |
| ① | RUN/STOP LED<br>(two-colored LED: green/yellow)                                    | RUN LED<br>(two-colored LED:<br>green/yellow)                                      | RUN LED<br>(single-colored LED:<br>green)                                           | RUN LED<br>(single-colored LED:<br>green)                                            |
| ② | ERROR LED<br>(single-colored LED: red)                                             | ERROR LED<br>(single-colored LED: red)                                             | ERROR LED<br>(single-colored LED: red)                                              | ERROR LED<br>(single-colored LED: red)                                               |
| ③ | MAINT LED<br>(single-colored LED: yellow)                                          | MAINT LED<br>(single-colored LED:<br>yellow)                                       | without function                                                                    | MAINT LED<br>(single-colored LED:<br>yellow)                                         |
| ④ | X1 P1<br>(two-colored LED:<br>green/yellow)                                        | X1 P1<br>(single-colored LED:<br>green)                                            | LED CHx<br>(two-colored LED:<br>green/red)                                          |                                                                                      |

|   | CPU 1516-3 PN/DP                            | IM 155-5 PN ST                          | DI 32x24VDC HF | PS 25W 24VDC |
|---|---------------------------------------------|-----------------------------------------|----------------|--------------|
| ⑤ | X1 P2<br>(two-colored LED:<br>green/yellow) | X1 P2<br>(single-colored LED:<br>green) |                |              |
| ⑥ | X2 P1<br>(two-colored LED:<br>green/yellow) |                                         |                |              |

### Additional information

The meaning of the individual LED displays, their different combinations and the remedial measures resulting from them in case of errors are device-specific. The explanation can be found in the manuals of the modules.

#### 4.2.1.2 Display of the CPU

##### Introduction

Each CPU in the S7-1500 automation system has a front cover with a display and operating keys. You can display status information in various menus on the display of the CPU. You use the operating keys to navigate through the menus.



Figure 4-3 Display - diagnostics screen

## Display options

The display of the SIMATIC S7-1500 CPU shows the following diagnostics information:

- CPU operating state

"Diagnostics" menu

- Error and alarm texts (system diagnostics alarms)
- Information entered in the diagnostics buffer
- Watch tables
- Information on the cycle times of the user program
- Utilization of the CPU memory

"Modules" menu

- Information on modules and the network
- Detailed device view with diagnostics symbols
- Order number, CPU version and central I/O modules
- Module status for central and distributed modules
- Information about the currently installed firmware

## Additional information

For additional information on the topic "Functions and operation of the display of the SIMATIC S7-1500 CPU", see the documentation for the S7-1500 automation system (<http://support.automation.siemens.com/WW/view/en/59191792>).

You can find detailed information on the individual options, a training course and a simulation of the available menu commands of the display for the CPU in the SIMATIC S7-1500 Display Simulator ([http://www.automation.siemens.com/salesmaterial-as/interactive-manuals/getting-started\\_simatic-s7-1500/disp\\_tool/start\\_en.html](http://www.automation.siemens.com/salesmaterial-as/interactive-manuals/getting-started_simatic-s7-1500/disp_tool/start_en.html)).

## 4.2.2 Diagnostics information in STEP 7

### 4.2.2.1 Explanation of diagnostics symbols

#### Diagnostics symbols for modules and devices

When the online connection to a device is established in STEP 7, the diagnostics status of the device and its lower-level components and, if applicable, the device operating mode are also determined. The following table shows the possible symbols and their meaning.

Table 4- 2 Diagnostics symbols for modules and devices

| Symbol                                                                              | Meaning                                                                                                                                                                       |
|-------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|    | The connection with a CPU is being established.                                                                                                                               |
|    | The CPU is not reachable at the set address.                                                                                                                                  |
|    | The configured CPU and the CPU actually present are of incompatible types.<br>Example: An existing CPU 315-2 DP is incompatible with a configured CPU 1516-3 PN/DP.           |
|   | On establishment of the online connection to a protected CPU, the password dialog was terminated without specification of the correct password.                               |
|  | No fault                                                                                                                                                                      |
|  | Maintenance required                                                                                                                                                          |
|  | Maintenance demanded                                                                                                                                                          |
|  | Error                                                                                                                                                                         |
|  | The module or device is deactivated.                                                                                                                                          |
|  | The module or the device cannot be reached from the CPU (valid for modules and devices below a CPU).                                                                          |
|  | Diagnostics data is not available because the current online configuration data differ from the offline configuration data.                                                   |
|  | The configured module or device and the module or device actually present are incompatible (valid for modules or devices under a CPU).                                        |
|  | The configured module does not support display of the diagnostics status (valid for modules under a CPU).                                                                     |
|  | The connection is established, but the module status has not yet been determined or is unknown.                                                                               |
|  | Hardware error in lower-level component: A hardware fault has occurred in at least one lower-level hardware component (occurs as a separate symbol only in the project tree). |

## Symbols for the comparison status

The diagnostics symbols can be combined at the bottom right with additional smaller symbols that indicate the result of the online/offline comparison. The following table shows the possible comparison symbols and their meaning.

Table 4- 3 Symbols for the comparison status

| Symbol                                                                            | Meaning                                                                                                                                                    |
|-----------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------|
|  | Hardware error in lower-level component: The online and offline versions differ (only in the project tree) in at least one lower-level hardware component. |
|  | Software error in lower-level component: The online and offline versions differ (only in the project tree) in at least one lower-level software component. |
|  | Online and offline versions of the object are different                                                                                                    |
|  | Object only exists online                                                                                                                                  |
|  | Object only exists offline                                                                                                                                 |
|  | Online and offline versions of the object are the same                                                                                                     |

## Operating mode symbols for CPUs and CPs

The following table shows the possible symbols and their respective operating states.

Table 4- 4 Operating mode symbols for CPUs and CPs

| Symbol                                                                              | Operating mode                                                        |
|-------------------------------------------------------------------------------------|-----------------------------------------------------------------------|
|  | RUN                                                                   |
|  | STOP                                                                  |
|  | STARTUP                                                               |
|  | DEFECTIVE                                                             |
|  | Unknown operating mode                                                |
|  | The configured module does not support display of the operating mode. |

## Event table

The following information is displayed in the table for each diagnostics event:

- Sequential number of the entry  
The first entry contains the latest event.
- Date and time of the diagnostics event  
If no date and time are shown, the module has no integrated clock.
- Short designation of the event and, if applicable, the reaction of the CPU
- Symbol for information on incoming/outgoing status

The following table shows the possible symbols and their meaning.

Table 4- 5 Symbols in the event table

| Symbol                                                                             | Meaning                                                         |
|------------------------------------------------------------------------------------|-----------------------------------------------------------------|
|   | Incoming event                                                  |
|   | Outgoing event                                                  |
|   | Incoming event for which there is no independent outgoing event |
|  | User-defined diagnostics event                                  |

## Additional information

For additional information on the individual symbols, please refer to the online help for STEP 7.

### 4.2.2.2 Accessible devices (without project)

#### Accessible devices

Accessible devices are all devices that are connected to a PG/PC either directly by an interface or by means of a subnet and that are switched on. These devices can display diagnostic information even without an offline project.

## Requirements

- STEP 7 is open.
- The portal view or project view is open.

## Procedure

To display diagnostic information for specific devices even without an offline project, follow these steps:

1. Establish a connection to the respective CPU.
2. Select the command "Accessible devices" from the "Online" menu.

The "Accessible devices" dialog opens.

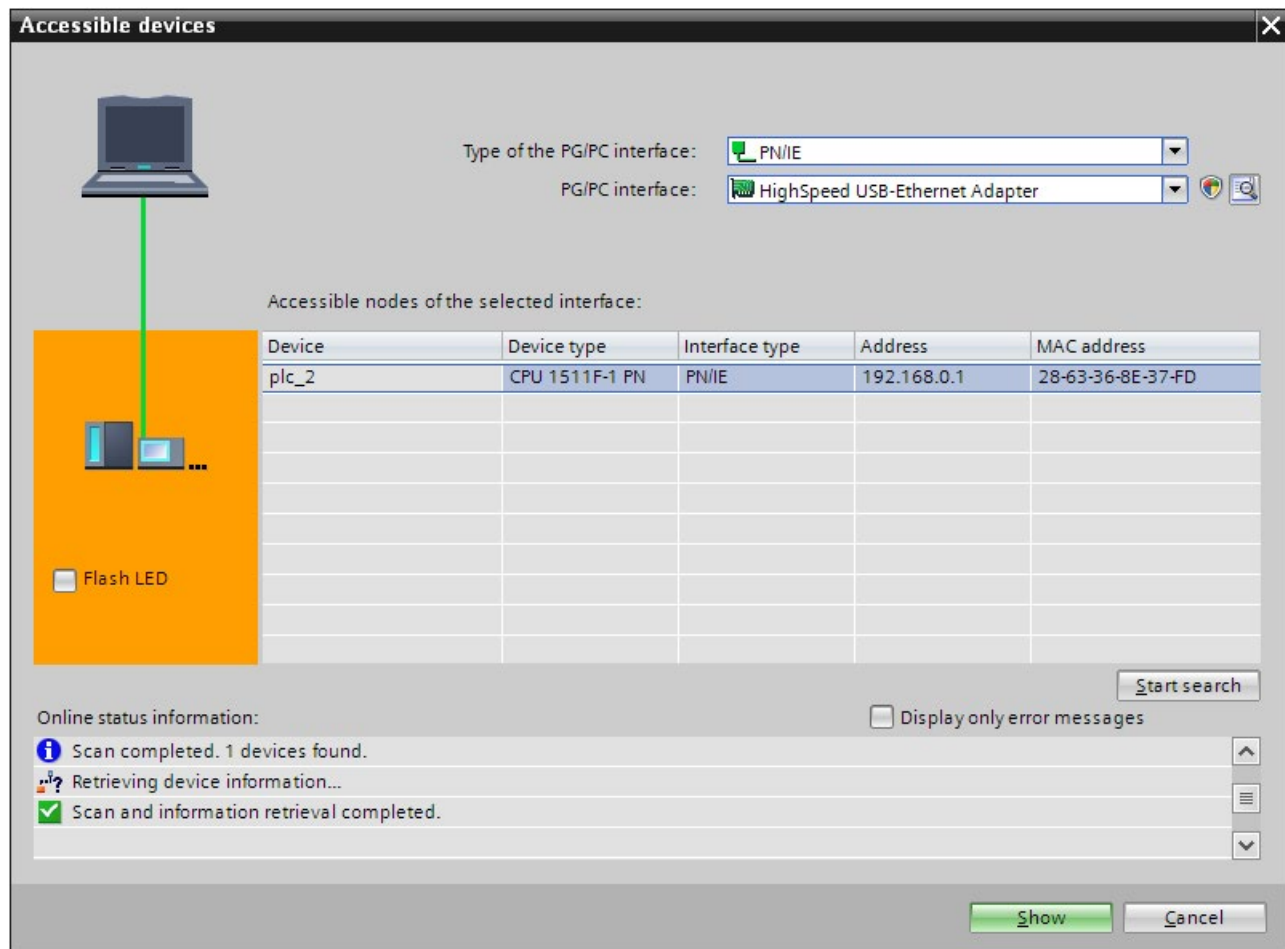


Figure 4-4 "Accessible devices" dialog

3. Make the settings for the interface.
4. Select the respective device under "Accessible nodes of the selected interface".
5. Confirm the dialog with the "Display" button.

## Result

The device is displayed in the project tree. You open the diagnostic information in the work area with a double-click on "Online & Diagnostics".

Information is available on the diagnostic status, cycle times, memory usage and the diagnostics buffer.

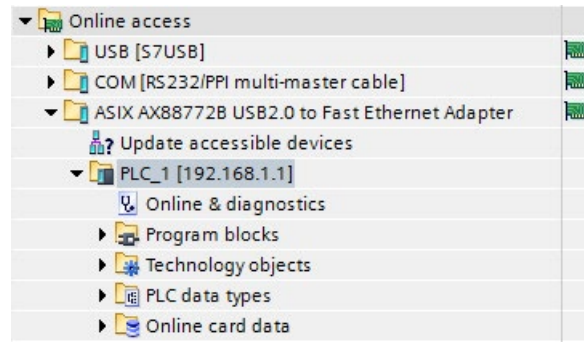


Figure 4-5 Device in the project tree

### 4.2.2.3 Devices & networks

#### Devices & networks - Go online

You can get an overview of the current state of your automation system in the device view or network view.

You implement the following tasks in the device view:

- Device configuration and parameter assignment
- Module configuration and parameter assignment

You implement the following tasks in the network view:

- Device configuration and parameter assignment
- Networking devices

## Requirements

- STEP 7 is open.
- A project is open.
- The project view is open.



## Procedure

To get an overview of the current state of your automation system, follow these steps:

1. Open the "Network view" in the working area.
2. Select the CPU.
3. Click the "Go online"  **Go online** button in the toolbar.

The "Go online" dialog opens.

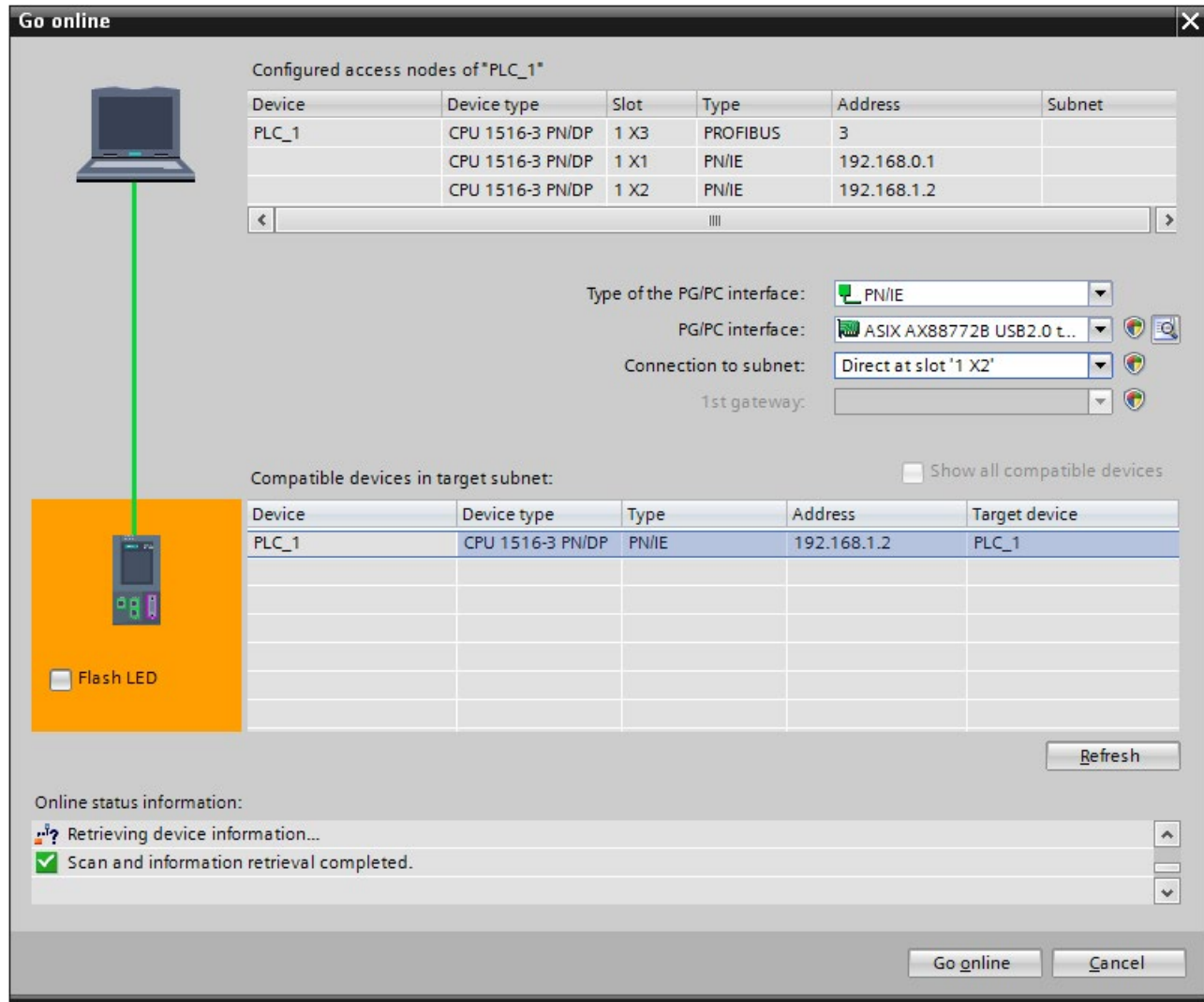


Figure 4-6 Go online

4. Make the settings for the interface.
5. Select the respective device under "Compatible devices in the target subnet".
6. Confirm the dialog with the "Connect" button.

The online mode is started.

## Result

The connected devices are now displayed with diagnostic information in the network view in the working area. Here you get an overview of the current state of your automation device.

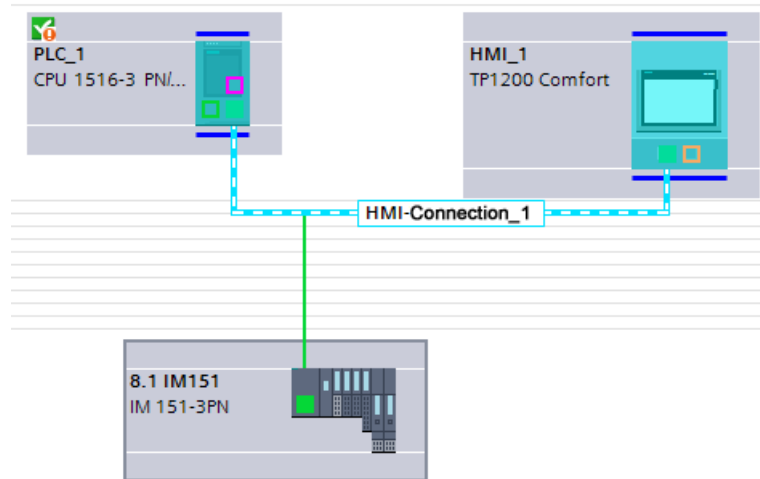


Figure 4-7 CPU with diagnostic information

You get to the "Device view" with a double-click on the device. The diagnostic information for the individual modules is displayed in this view.

---

### Note

#### Symbols and their meaning

You will find a legend with the meaning of each symbol in Explanation of diagnostics symbols (Page 29) and in the online help for STEP 7.

---

#### **4.2.2.4 Online & diagnostics**

##### **Online mode**

In online mode there is an online connection between your PG/PC and one or several devices. Depending on the properties of a device, you are offered specific diagnostics options and certain functions in online mode.

- Diagnostics
  - General module information
  - Diagnostics status
  - Cycle time
  - Memory
  - Diagnostics buffer
  - Display
  - Interface information (e.g. IP parameter, port information)
- Functions
  - Assign IP address
  - Set time and date of the CPU
  - Firmware update (e.g. for PLC, display)
  - Assign device name
  - Reset to factory settings
  - Format memory card
  - Save service data

To establish an online connection at least one PG/PC interface must be installed that is physically connected with a device, for example, with an Ethernet cable. The current online status of a device is indicated by a symbol to the right of the device in the project tree.

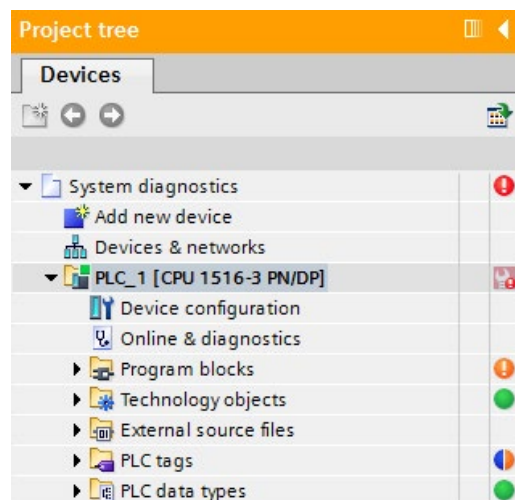


Figure 4-8 Partial view of network view

## Requirements

- STEP 7 is open.
- A project is open.
- The project view is open.

## Procedure

To display an overview of the faulty devices, follow these steps:

1. Select the affected device folder in the project tree.
2. Select the shortcut menu command "Online & Diagnostics".

The online and diagnostics view of the module to be diagnosed is started.

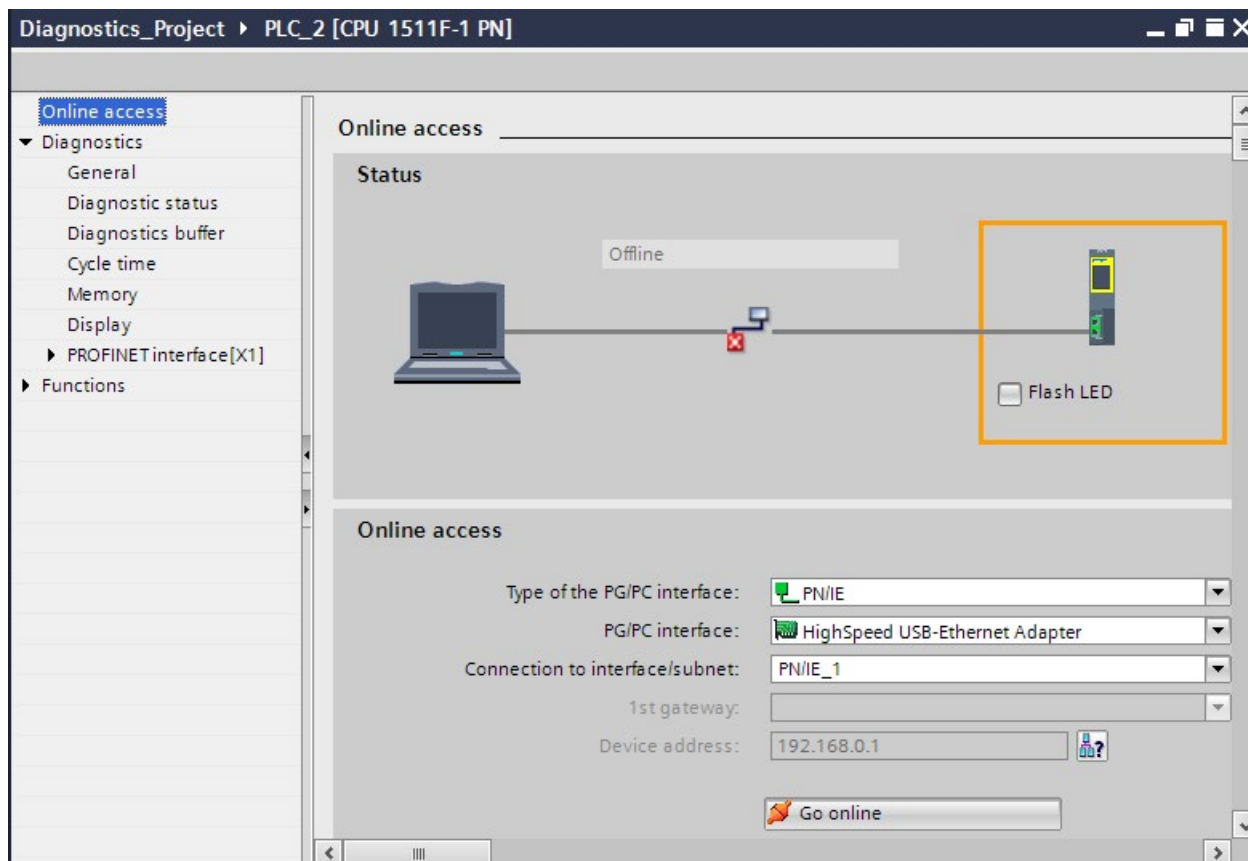


Figure 4-9 Setting online access

3. Make the settings for the interface.

Here you can change an interface access that has already been set for an online connection that was successfully established previously.

4. Click on the "Go online" button.

The online connection is established.

## Result

You can find detailed diagnostics information on each device in the Inspector window, in the "Diagnostics" section of the area navigation on the "Properties" tab.

#### 4.2.2.5 "Diagnostics" tab in the Inspector window

##### "Diagnostics" tab in the Inspector window

The "Diagnostics" tab of the Inspector window includes information on diagnostics events and configured alarm events.

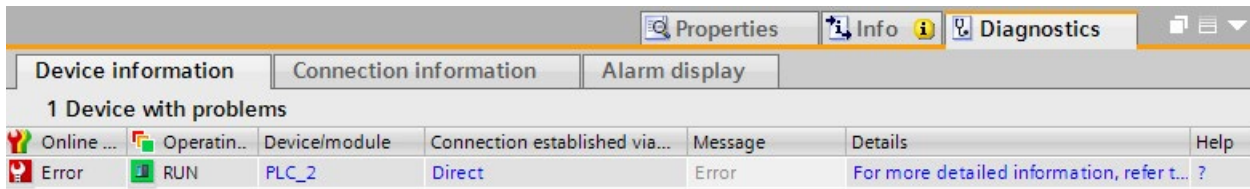


Figure 4-10 Diagnostics in the Inspector window, "Device information" tab

---

##### Note

##### Symbols and their meaning

You can find a legend with the meaning of each symbol in Explanation of diagnostics symbols (Page 29) and in the online help for STEP 7.

---

##### Subordinate "Device information" tab

This tab gives you an overview of faulty devices to which an online connection exists or has existed. The table provides the following diagnostics information on the faulty devices:

- Online status: Includes the online status as diagnostics symbol and in words
- Operating mode: Includes the operating mode as symbol and in words
- Device/module: Name of the affected device or the affected module
- Connection established via ...: Specifies the path used to establish the connection to the failed device.
- Alarm: This explains the entry in the previous columns and displays an alarm, if necessary
- Details: The link opens the online and diagnostics view associated with the device or puts it in the foreground.  
If the device cannot be reached, the link opens the "Go online" dialog.
- Help: The link provides additional information on the fault.

---

##### Note

##### Communication and access errors

Errors that occur in the user program (e.g., communication errors, access errors) are not reported in the "Diagnostics" tab of the device information. You must read out the diagnostics buffer of the CPU in the online and diagnostics view to get this information. The link in the "Details" column opens the diagnostics buffer.

---

### Subordinate "Connection information" tab

The "Connection information" tab displays detailed diagnostics information for connections.

There will only be information on the "Connection information" tab if there is an active online connection to at least one end point of the relevant connection.

If a connection has been selected (connection table), the tab contains the following groups:

- Connection details
- Address details of the connection

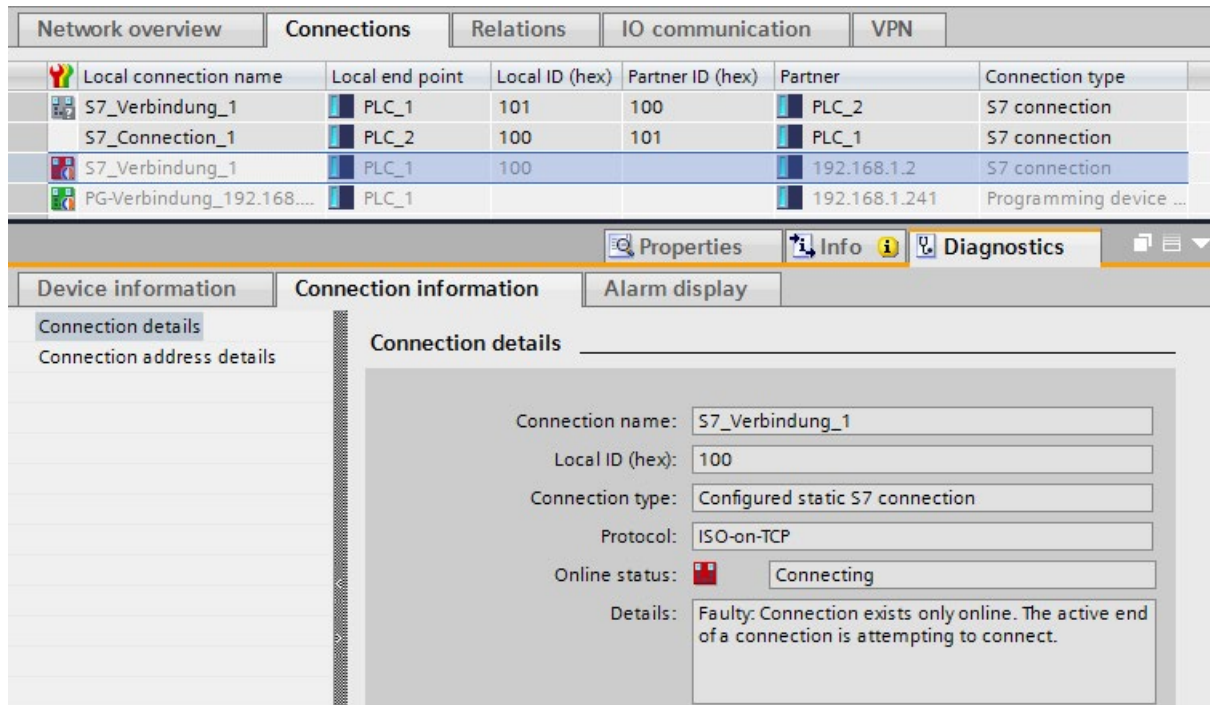


Figure 4-11 "Connection information" tab and open connection overview

If a module has been selected (network view), the tab contains the following group:

- Connection resources

## Subordinate "Alarm display" tab

System diagnostics alarms are output in the "Alarm display" tab.

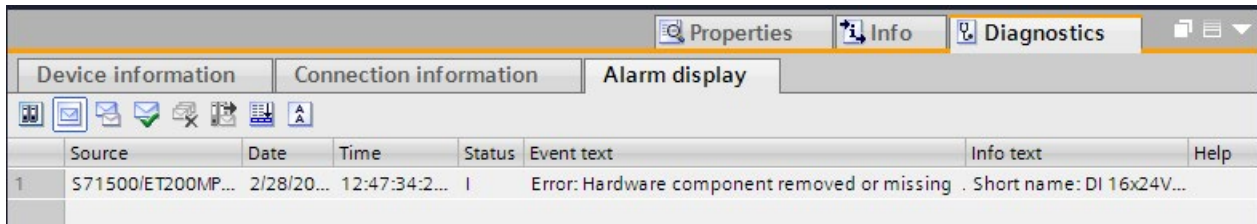


Figure 4-12 "Alarm display" tab

To receive alarms in STEP 7, follow these steps:

1. Open the project view.
2. Select the required CPU in the project tree.
3. To connect online with the respective CPU, select the shortcut menu command "Go online".
4. Select the required CPU once again in the project tree and select the shortcut menu command "Receive alarms".

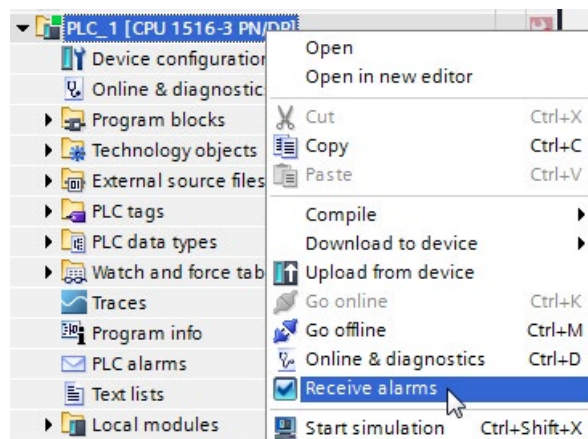


Figure 4-13 Receive alarms

5. Alarms are now displayed in the alarm display. "Archive view" is enabled by default.
6. To display the latest alarms, click the "Active alarms" icon



#### **4.2.2.6 CPU diagnostics buffer**

##### **Definition**

Each CPU and some other modules have their own diagnostics buffer, in which detailed information on all diagnostic events is entered in the order in which they occurred.

The CPU diagnostics buffer can be displayed on all display media (STEP 7, SIMATIC HMI devices, SIMATIC S7-1500 Web server and display of the CPU).

##### **Diagnostic events**

The entries available in the diagnostics buffer include:

- Internal and external errors on a module
- System errors in the CPU
- Operating mode transitions (e.g., from RUN to STOP)
- Errors in the user program
- Removal/insertion of modules
- Security events

The contents of the diagnostics buffer are stored in the retentive memory in case of a memory reset of the CPU. Errors or events can be evaluated even after a longer period of time thanks to the diagnostics buffer to determine the cause of a STOP or to trace the occurrence of a single diagnostic event and to be able to assign it.

## Procedure

To display the diagnostics buffer of a CPU in STEP 7, follow these steps:

1. Select the respective CPU.
2. Select the shortcut menu command "Online & Diagnostics".

The "Online access" view is opened in the work area.

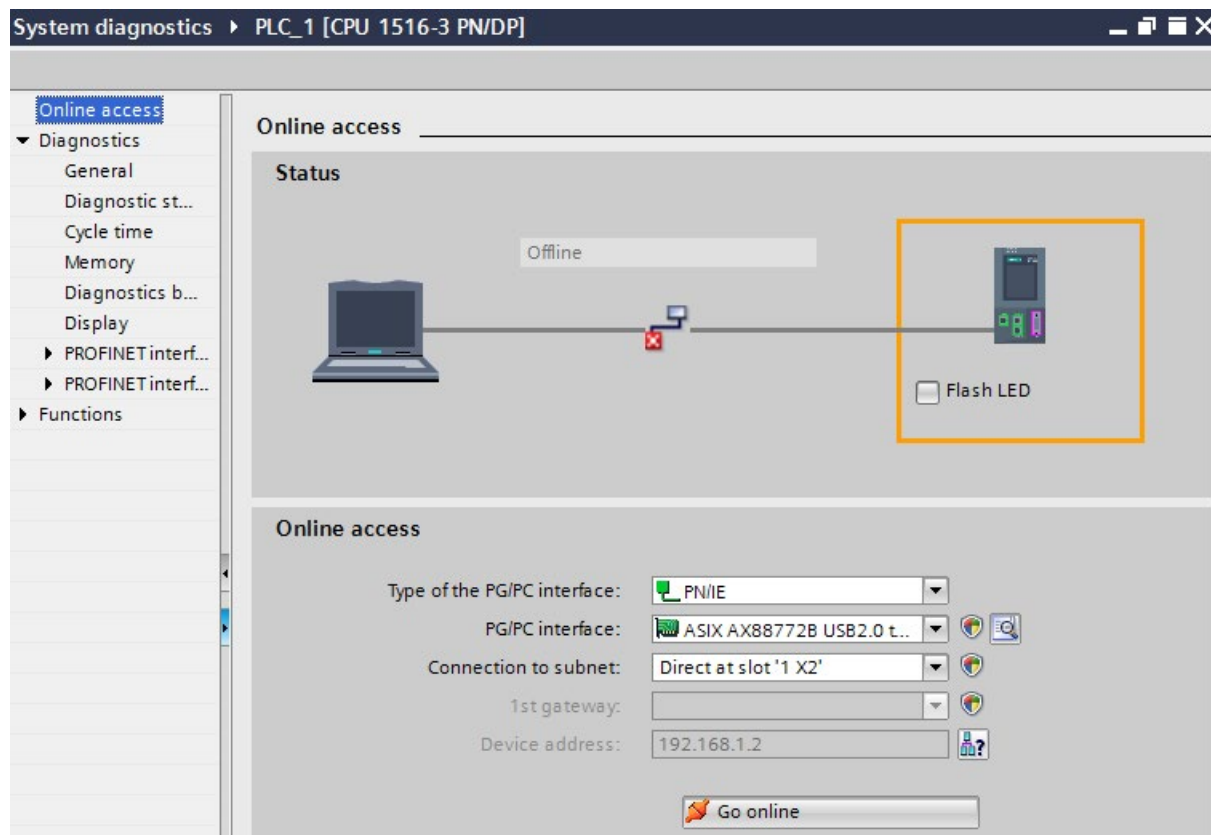


Figure 4-14 Setting up online access

3. Set the interface.

4. Click  Go online.
5. Select the area "Diagnostics buffer".

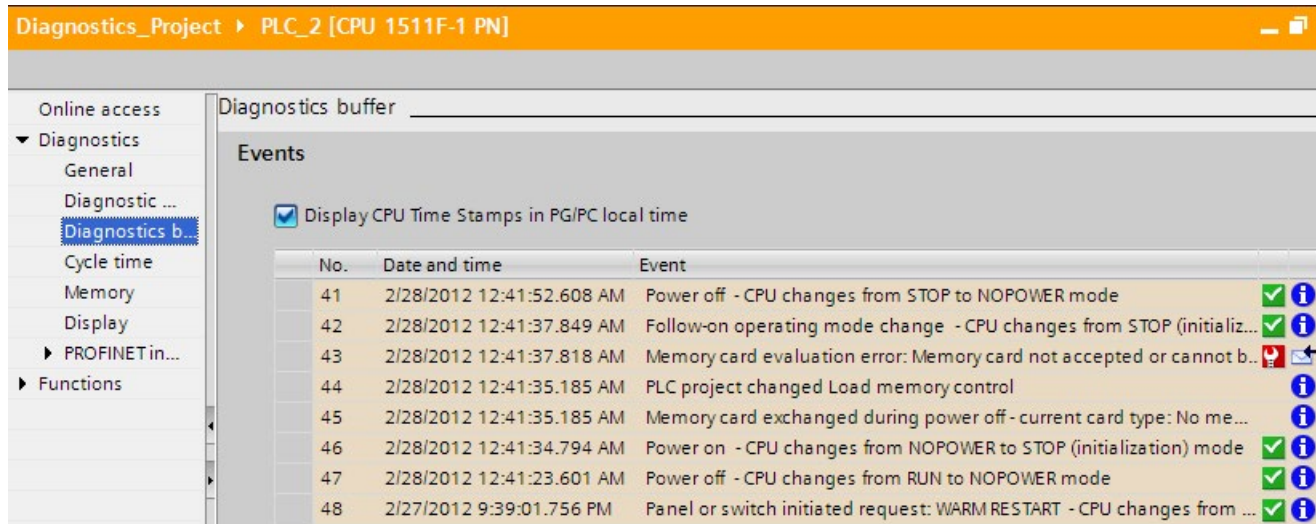


Figure 4-15 Diagnostics buffer in STEP 7

## Note

### Filtering events

You can filter the entries in the diagnostics buffer in the settings of the "Diagnostics buffer" area to only display specific types of events. This means that specific events, such as "CPU and configuration-internal events" or "Connection diagnostics events", can be displayed separately.

## Security events

The following security events (event types) result in an entry in the diagnostics buffer.

- Going online with the correct or incorrect password
- Manipulated communications data detected
- Manipulated data detected on memory card
- Manipulated firmware update file detected
- Changed protection level (access protection) downloaded to the CPU
- Password legitimization restricted or enabled (by instruction or CPU display)
- Online access denied due to the possible number of simultaneous access attempts being exceeded
- Timeout when an existing online connection is inactive
- Logging on to the Web server with the correct or incorrect password
- Creating a backup of the CPU
- Restoring the CPU configuration (Restore)

To prevent the diagnostics buffer being "swamped" by large numbers of identical security events, you can set parameters so that these events are entered in the diagnostics buffer as a group alarm. For every interval (monitoring time), the CPU then only generates one group alarm per event type.

### Configuring a group alarm for security events

To configure group alarms for security events, follow these steps:

1. Click on the CPU icon in the network view.  
The properties of the CPU are displayed in the Inspector window.
2. Navigate to the "Protection" > "Security event" area.
3. Click "Security event".
4. Select the option "Summarize security events in case of high message volume" to enable group alarms for security events.
5. Set the duration of an interval (monitoring period); the default is 20 seconds.

### 4.2.2.7 "Online tools" task card

#### Online view in the "Online tools" task card

The following requirements must be met to display the online view of the "Online tools" task card in STEP 7:

- An online connection to the CPU is available.
- You have selected the CPU in the topology view, network view or device view.

The "Online tools" task card provides an overview of the CPU state, the cycle time and the memory usage.

- The "CPU operator panel" pane displays the current state of some LEDs and the mode selector of a CPU.
- The "Cycle time" pane displays the cycle time diagram and below it the measured cycle times as absolute values.
- The "Memory" pane contains the current memory usage of the associated CPU. The free memory is shown both as a bar graph and as a numerical value (percentage). The display for "Load memory" contains, in addition to the online project data (program code, data blocks, hardware configuration etc.), all other data that may be on the SIMATIC memory card, such as recipes, data logs, HMI backups or non-SIMATIC files that have been copied to the memory card via the Web server of the CPU or offline in Explorer (for example, PDF files).

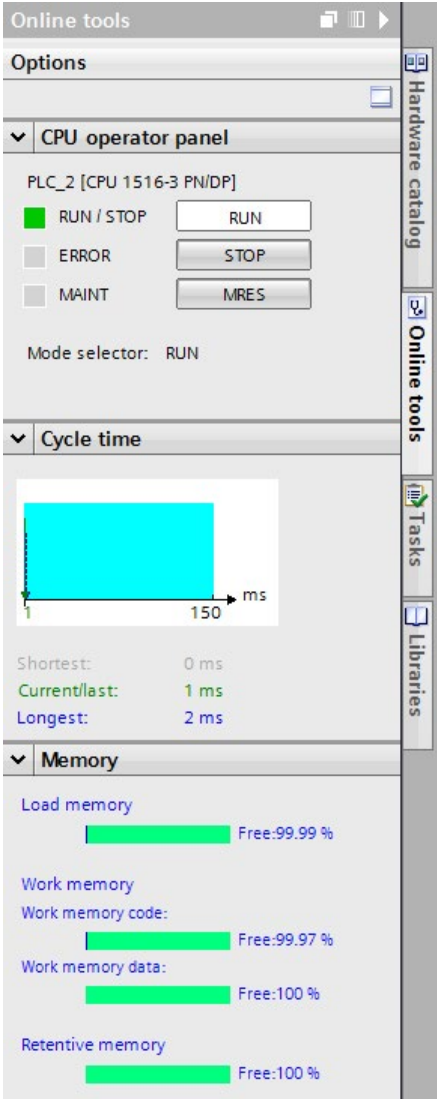


Figure 4-16 "Online tools" task card

#### 4.2.2.8 Configuring the settings for I/O modules in STEP 7

You can also make settings for system diagnostics in STEP 7 for I/O modules. The parameters you have to configure depend on the I/O module.

The settings are optional.

##### Requirements

- STEP 7 is open.
- A project is open.
- The project view is open.
- A design with I/O modules has been configured.

##### Procedure

To make settings for system diagnostics of I/O modules in STEP 7, follow these steps:

1. Select the respective I/O module in the device view.
2. Open the "Properties" tab in the Inspector window.
3. Select the area "Inputs", for example.

You have access to the settings for system diagnostics of the I/O module. If you select "Wire break", for example, a possible wire break for the channel is signaled during operation.

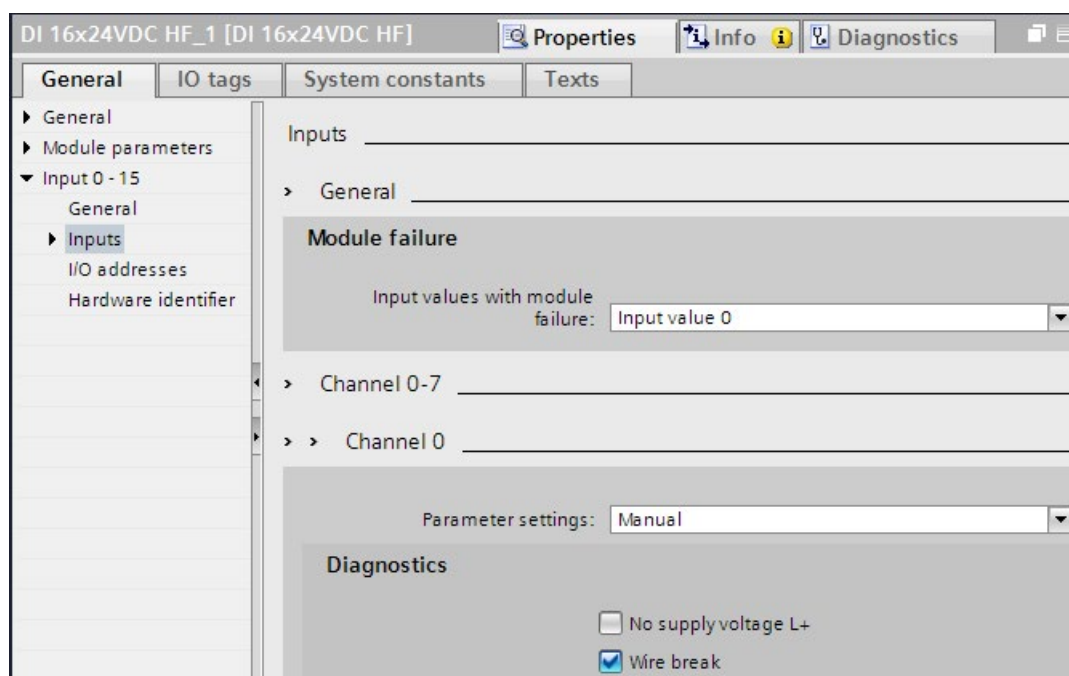


Figure 4-17 I/O setting with a digital input module

4. Save the hardware configuration.
5. Download the new hardware configuration to the CPU.

## Additional information

The documentation for the respective module includes additional information on parameter assignment of I/O modules.

### 4.2.3 Diagnostics information using the web server

#### System diagnostics using the CPU Web server

The CPUs of the SIMATIC series have an integrated Web server and let you display the system diagnostics information by means of PROFINET. Any terminal devices, such as PCs or smartphones, can thus access module data, user program data and diagnostics data of a CPU by using an Internet browser. This means access to CPUs is possible without installed STEP 7.

In addition to normal websites, the Web server provides so-called basic websites with reduced content that are adapted to the requirements of small screens with low resolution.

Using CPU 1516-3 PN/DP as an example, the following figure shows the start page of the Web server:



Figure 4-18 Web server, Start page

The following diagnostics options are available with the integrated Web server:

- Start page with general CPU information
- Information on diagnostics
- Contents of the diagnostics buffer
- Module information
- Alarms
- Information about communication
- PROFINET topology
- Motion Control diagnostics
- Trace

## Configuring the Web server in STEP 7

Proceed as follows to activate the Web server:

### Requirements

- You have opened STEP 7.
- You have added a CPU to the project.
- You have opened the project view.

### Procedure

1. Open the network view.
2. Select the CPU.
3. Open the "Properties" tab in the Inspector window.
4. Select the entry "Web server" in the "General" area navigation.

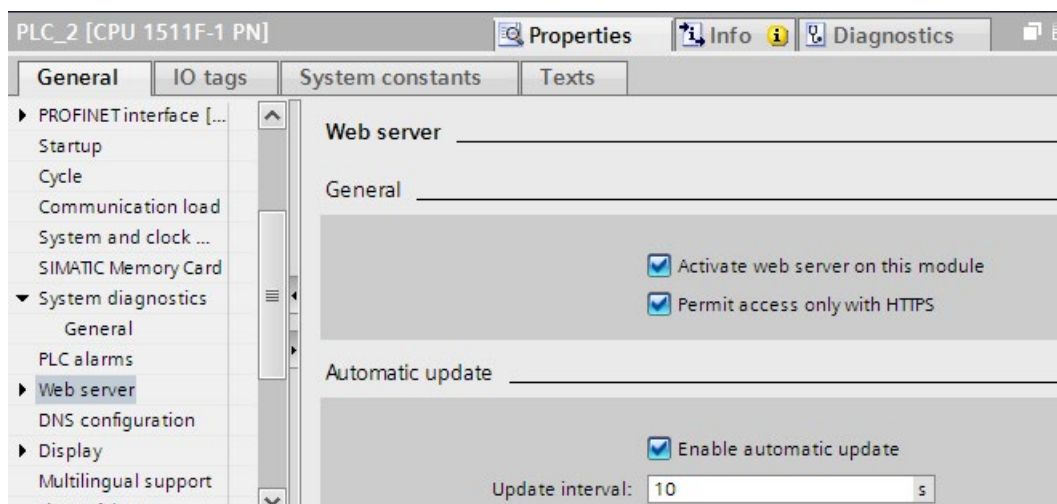


Figure 4-19 Activate the Web server



5. Select the "Activate web server on this module" check box.
6. "Permit access only with HTTPS": The activation of the Web server using the secure transmission protocol "HTTPS" requires a valid Web server certificate in the CPU.

**NOTICE**

**Utilizing the full functionality of the Web server**

A valid CA-signed Web server certificate in the CPU is a requirement for:

- User management with password-protected users
- Saving and downloading diagnostic information in csv files
- Using the following safety-related functions:
  - Backing up and restoring the CPU configuration

To use the full functionality of the Web server, we recommend that you create a CA-signed server certificate and assign it to the CPU.

To create a CA-signed Web server certificate, you must enable the Certificate Manager in the global security settings of STEP 7 and assign a CA-signed server certificate to the Web server in the properties of the CPU.

You can find additional information on handling Web server certificates in the "Configuring the Web server" section of the Web server function manual (<http://support.automation.siemens.com/WW/view/en/59193560>).

Detailed information on Certification Authority (CA) certificates, device certificates (End Entity certificate), "Public Key Infrastructure" (PKI) and certificate management can be found in the Communication function manual (<https://support.industry.siemens.com/cs/ww/en/view/59192925>) and in the online help for STEP 7, keyword "Secure communication".

7. Automatic updating is activated in the default setting of a configured CPU.
8. Activate the Web server also for each interface via which you want to access the Web server.  
To do this, open the "Properties" tab in the Inspector window and select the "Web server" entry in the "General" area navigation. In the "Overview of interfaces" area, select the "Enabled web server access" check box for the corresponding interface.
9. Compile and load the configuration into the CPU.

## Accessing the Web server

To access the Web server, proceed as follows:

1. Connect the display device (PG/PC, HMI, mobile terminal device) with the CPU or a communication module using a PROFINET interface.  
If you are working with WLAN, activate the WLAN on the display device and establish a connection to the access point (e.g. SCALANCE W788-1RR or SCALANCE W784-1), which is in turn connected to the CPU.
2. Open the web browser on the display device.
3. Enter the IP address of the interface of the CPU which is connected to the client in the "Address" field of the web browser in the following format: http://a.b.c.d or https://a.b.c.d (example input: https://192.168.3.141).  
The intro page of the CPU opens.
4. You need to perform the installation of the CA certificate again for each display device you want to use. A valid CA certificate is available for download from the "Intro" web page under "Download certificate". You can find instructions for installing the certificate in the help system of your Web browser and in the FAQ with the entry ID 103528224 at the Service&Support (<https://support.industry.siemens.com/cs/ww/en/view/103528224>) website.
5. Click the NEXT link to go to the Web server pages.

---

### Note

#### Managing access rights

In STEP 7, you can create users, define access rights and assign passwords under "Web server > User management". Users only have access to the options that are permanently linked to the access rights.

You can find additional information on managing access rights in the "Configuring the Web server" section of the Web server function manual (<http://support.automation.siemens.com/WW/view/en/59193560>).

---

## "Diagnostics" option

The "Diagnostics" web page provides more information about the tabs:

- Identification

This tab contains the characteristics of the CPU (serial number, article number, hardware and firmware version, etc.).

- Program protection

This tab provides information on whether the PLC program contains know-how protection or copy protection.

- Memory

This tab contains current values on the memory currently in use.

- Runtime information

Current information on program/communication load and cycle time can be found in this tab.

- Fail-safe (only with an F CPU)

The safety program of an F-CPU consists of one or two F-runtime groups. You can find their cycle time (F-monitoring time) and runtime in this tab.

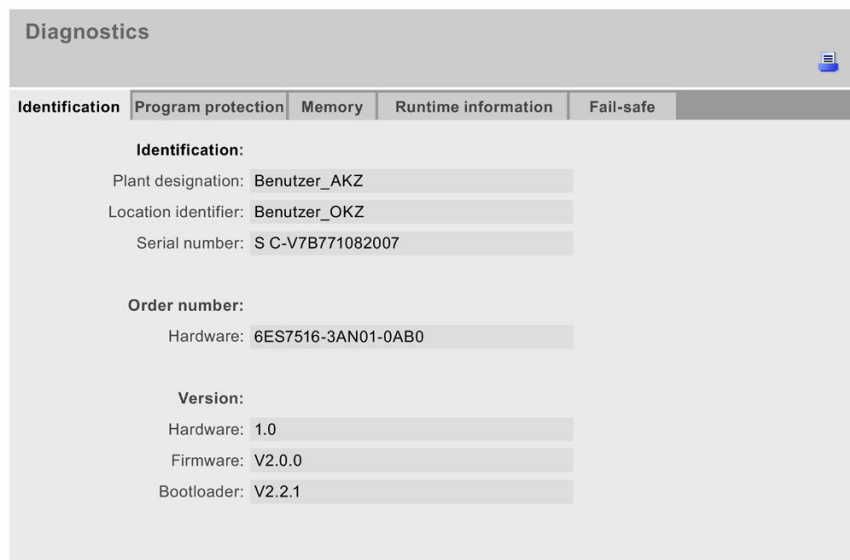


Figure 4-20 Web server, "Diagnostics" Web page

## Diagnostics option "Diagnostics buffer"

The browser displays the content of the diagnostics buffer on the "Diagnostics buffer" Web page.

Diagnostic Buffer

Diagnostic buffer entries 1-50

| Number | Time         | Date       | Status         | Event                                                      |
|--------|--------------|------------|----------------|------------------------------------------------------------|
| 1      | 10:45:20:907 | 13.11.2014 | incoming event | Mode transition from STARTUP to RUN                        |
| 2      | 10:45:20:905 | 13.11.2014 | incoming event | Request for Automatic warm restart                         |
| 3      | 10:45:20:873 | 13.11.2014 | incoming event | Parameter assignment error                                 |
| 4      | 10:45:20:856 | 13.11.2014 | incoming event | Parameter assignment error                                 |
| 5      | 10:45:20:834 | 13.11.2014 | incoming event | Mode transition from STOP to STARTUP                       |
| 6      | 10:45:16:805 | 13.11.2014 | incoming event | Distributed I/Os: end of the synchronization with a DP ... |
| 7      | 10:44:57:159 | 13.11.2014 | incoming event | All modules are ready for operation                        |
| 8      | 10:42:36:635 | 13.11.2014 | incoming event | Module monitoring time started                             |
| 9      | 10:42:36:467 | 13.11.2014 | incoming event | Power on backed up                                         |
| 10     | 10:42:36:321 | 13.11.2014 | incoming event | Power failure                                              |

Details: 1

Event ID: 16# 4302

Mode transition from STARTUP to RUN

Startup information:

- Startup with modified system configuration
- Difference between setpoint and actual configuration
- Time for time stamp at the last backed up power on
- Single processor operation

Current/last startup type:

- Automatic warm restart after backed up power on

Permissibility of certain startup types:

- Manual warm restart permitted
- Automatic warm restart permitted

Last valid operation or setting of automatic startup type at power on:

- Automatic warm restart after backed up power on

Previous operating mode: STARTUP (warm restart)

Requested operating mode: RUN

Incoming event

Figure 4-21 Web server, "Diagnostics buffer" Web page

## Diagnostics option "Module information"

The status of a device is indicated by the Web browser with symbols and comments on the "Module information" Web page.

Modules are displayed on the "Module information" Web page in the "Name" column with a link. You can thus get to the faulty module in hierarchical order.

| Module information                                           |        |                     |                    |           |           |                  |
|--------------------------------------------------------------|--------|---------------------|--------------------|-----------|-----------|------------------|
| CPU1516 - Ethernet(1): PROFINET-IOSystem (100) - IM155-5PNST |        |                     |                    |           |           | Off              |
| Slot                                                         | Status | Name                | Order number       | I address | Q address | Comment          |
| 0                                                            | ✓      | IM155-5PNST         | 6ES7155-6AA00-0BN0 |           |           |                  |
| 1                                                            | ✓      | PS 1505 25Wx24 VDC  | 6ES7505-5KA00-0AB0 |           |           | ...Module PS (3) |
| 2                                                            | ✓      | DI 16x24VDC HF      | 6ES7521-1BH00-0AB0 | 2         |           | ...Module DI (3) |
| 3                                                            | ✗      | DQ 16x24VDC/0.5A ST | 6ES7522-1BH00-0AB0 |           | 5         | ...Module DQ (3) |
| Status Identification                                        |        |                     |                    |           |           |                  |
| PN device 3 on PN system 100 Slot 3: Module removed          |        |                     |                    |           |           |                  |
| Name: IM155-5PNST Module: DQ 16x24VDC/0.5 ST                 |        |                     |                    |           |           |                  |
| I/O address: Q1                                              |        |                     |                    |           |           |                  |

Figure 4-22 Web server, "Module information" Web page

## Diagnostics option "Messages"

The Web browser displays the content of the message buffer on the "Messages" Web page. The messages can be acknowledged via the Web server if you have the appropriate user rights.

| Alarms                                                                                                                                                                                           |            |                 |                                                                                                     |          |                   |
|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------|-----------------|-----------------------------------------------------------------------------------------------------|----------|-------------------|
| Entries 1-50                                                                                                                                                                                     |            |                 |                                                                                                     |          | Off               |
| AlarmNr.                                                                                                                                                                                         | Date       | Time            | Alarm text                                                                                          | State    | Acknowledgement   |
| 31                                                                                                                                                                                               | 07/14/2018 | 11:12:18.614 am | Error: Hardware component not available due to type mismatch<br>PLC_1 / DI 16/DQ 16x24VDC/0.5A BA_1 | incoming | Acknowledge alarm |
| 35                                                                                                                                                                                               | 07/14/2018 | 11:13:25.550 am | CPU status message: CPU not in RUN Current CPU operating mode: RUN<br>PLC_1 / PLC_1                 | outgoing | Acknowledge alarm |
| <div> <div>&lt;</div> <div>Details on alarm number: 31</div> <div>&gt;</div> </div> <div>Short name: DI 16/DQ 16x24VDC/0.5A BA Order number: 6ES7 523-1BL00-0AA0</div> <div>incoming event</div> |            |                 |                                                                                                     |          |                   |

Figure 4-23 Web server, "Messages" Web page

## Diagnostics option "Communication"

The "Communication" web page provides detailed information about the following tabs:

- Parameter

A summary of the information on the PROFINET and Ethernet interfaces of the selected CPU is available in this tab.

- Statistics

You will find information on data transmission in this tab.

- Resources

Information about the resource consumption of the connections is available in this tab.

- Connections

Information about the status of the communication connections is available in this tab.

**Communication**

Parameter Statistics Resources Connections

PROFINET Interface [X1]:

Network connection:

MAC address: 00-0E-8C-84-DE-F0

Name: PNIO

IP parameter:

IP Address: 192.168.2.80

Subnet mask: 255.255.255.0

Default router: ---

IP settings: IP address set in project

Physical properties:

| Port number | Link status | Settings  | Mode                   | Connection medium |
|-------------|-------------|-----------|------------------------|-------------------|
| X1 P1       | OK          | automatic | 100 MBit/s full-duplex | Copper cable      |
| X1 P2       | OK          | automatic | 100 MBit/s full-duplex | Copper cable      |

Figure 4-24 Web server, "Communication" Web page

**"Topology" diagnostics option**

The "Topology" Web page provides information on the topological configuration and status of the PROFINET devices in your PROFINET IO system.

Topology

PLC 1 X1

Off

Graphic view

Table view

Status overview

| Port                    |                                   |                   | Partner port |                   |          |
|-------------------------|-----------------------------------|-------------------|--------------|-------------------|----------|
| Status                  | Name                              | Module type       | Port         | Name              | Port     |
| <div></div> <div></div> | <a href="#">CPU 1516-3PN/DP</a>   | CPU 1516-3PN/DP   | port-001     | SCALANCE-X-204IRT | port-001 |
| <div></div> <div></div> | <a href="#">IM155-6PN-2</a>       | IM 155-6PN ST     |              |                   |          |
| <div></div> <div></div> | <a href="#">IM155-5PN</a>         | IM 155-5PN ST     | port-001     | SCALANCE-X-204IRT | port-004 |
| <div></div> <div></div> | <a href="#">SCALANCE-X-204IRT</a> | SCALANCE-X-204IRT | port-002     | cpux6-7-1xet200mp | port-002 |
|                         |                                   |                   | port-001     | CPU1516-3PN/DP    | port-001 |
|                         |                                   |                   | port-002     |                   |          |
|                         |                                   |                   | port-003     |                   |          |
|                         |                                   |                   | port-004     | IM155-5PN         | port-001 |
| <div></div> <div></div> | <a href="#">SCALANCE-X-208</a>    | SCALANCE-X-208    |              |                   |          |
| <div></div> <div></div> | cpux6-7-1xet200mp                 |                   | port-002     | IM155-5PN         | port-002 |

Figure 4-25 Web server, "Topology" Web page

## "Motion Control Diagnostics" diagnostic option

The Web server displays statuses, errors, technology alarms and the current values of the configured technology objects (TOs).

The "Motion Control Diagnostics" web page provides detailed information on the configured technology objects in the following views:

- **Diagnostics**

This view provides an overview list of configured technology objects, the status and error messages of a selected technology object, as well as values and limits of the movement status for a selected axis.

- **Service overview**

This view contains diagnostic information for multiple technology objects and a filter option for selecting the displayed technology objects.

**Motion control diagnostics** On

**Diagnostics** | **Service overview**

| State | Enabled                  | Homed                    | TO Name           | TO Type         |
|-------|--------------------------|--------------------------|-------------------|-----------------|
|       | <input type="checkbox"/> | <input type="checkbox"/> | PositioningAxis_1 | PositioningAxis |
|       | <input type="checkbox"/> | <input type="checkbox"/> | SynchronousAxis_1 | SynchronousAxis |
|       | <input type="checkbox"/> | <input type="checkbox"/> | ExternalEncoder_1 | ExternalEncoder |
|       | <input type="checkbox"/> | <input type="checkbox"/> | OutputCam_1       | OutputCam       |
|       | <input type="checkbox"/> | <input type="checkbox"/> | CamTrack_1        | CamTrack        |
|       | <input type="checkbox"/> | <input type="checkbox"/> | MeasuringInput_1  | MeasuringInput  |
|       | <input type="checkbox"/> | <input type="checkbox"/> | SpeedAxis_1       | SpeedAxis       |

**Status and error bits** | **Motion status**

**Axis status**

- ☒ Simulation active
- ☐ Enabled
- ☐ Error
- ☐ Restart active
- ☐ Axis control panel active
- ☐ Drive ready
- ☐ Restart required

**Motion status**

- ☒ Done (no motion command)
- ☐ Jog
- ☐ Speed setpoint
- ☒ Constant speed
- ☐ Accelerating
- ☐ Decelerating
- ☐ Torque limiting command

**Warnings**

- ☐ Configuration
- ☐ The task was rejected
- ☐ Dynamic limitation

**Error**

- ☐ System
- ☐ Configuration
- ☐ User program
- ☐ Drive
- ☐ Data exchange
- ☐ I/O
- ☐ The task was rejected
- ☐ Dynamic limitation

Figure 4-26 Web server, "Motion Control diagnostics" webpage



## "Trace" diagnostic options

You can read, view and save the trace recordings via the Web server and thus obtain plant and project information for diagnostics and maintenance.

The web page of the trace and logic analyzer function consists of several areas. The example in the figure below shows how the Web server user interface is divided when the "Trace" web page is first called.

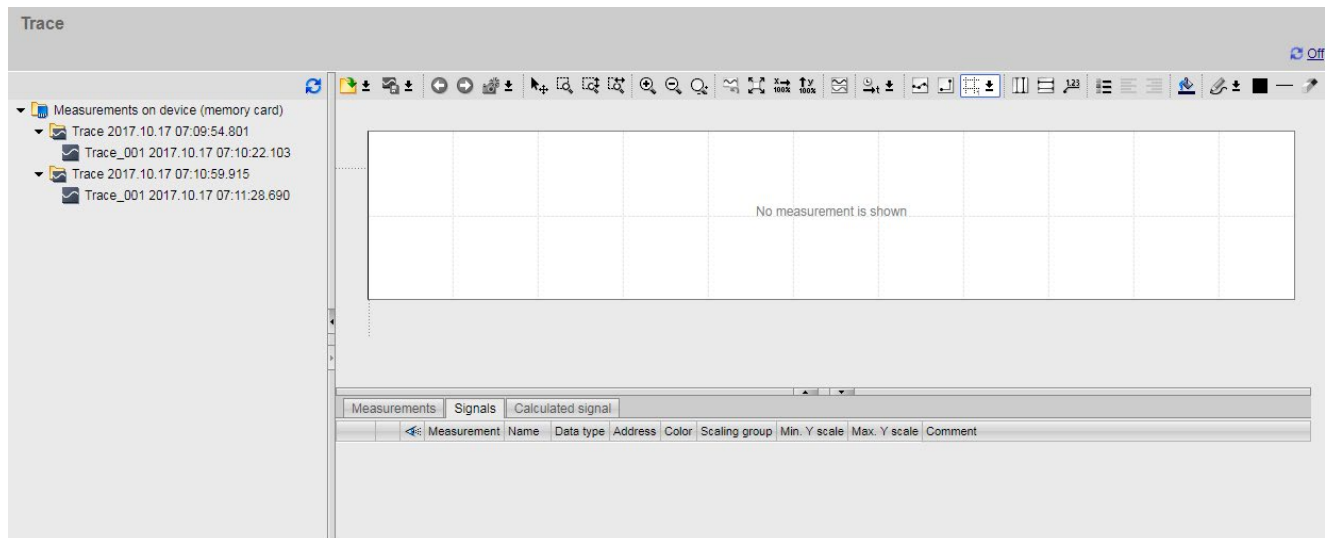


Figure 4-27 Web server, "Trace" home page (without measurement)

## Additional information

Additional information on the topic is available in the Web server function manual (<http://support.automation.siemens.com/WW/view/en/59193560>).

You can find additional information on the trace function in the Using the trace and logic analyzer function (<https://support.industry.siemens.com/cs/ww/en/view/64897128>) function manual.

## **4.2.4       Diagnostics information using the HMI diagnostics view**

### **Objects for system diagnostics**

The full functionality of the HIM diagnostics view is only available with Comfort Panels and WinCC RT Advanced . Basic Panels do not support the complete range of system diagnostics functions.

Two objects are available for system diagnostics on an HMI device.

### **System diagnostics view**

The system diagnostics view reflects the current status of all accessible devices in your plant. You navigate directly to the cause of the error and the associated device. You have access to all diagnostics-capable devices that you have configured in the STEP 7 hardware and network editor.

### **System diagnostics window**

The system diagnostics window is an operating element and display object.

The functions of the system diagnostics window are the same as for the system diagnostics view. Because the system diagnostics window is configured in the "Global screen", you can also specify, for example, if the object can be closed in WinCC Runtime.

---

#### **Note**

##### **Compatibility with Basic Panels**

Only the "System diagnostics view" object is available with Basic Panels.

Basic Panels do not support the "System diagnostics window" object or the graphic symbol "System diagnostics indicator".

---

#### **4.2.4.1 Configuring system diagnostics**

##### **Introduction**

You add a system diagnostics view or a system diagnostics window to your project to get an overview of all devices available in your plant.

The system diagnostics window behaves like the system diagnostics view but is only available in the global screen.

##### **Requirements**

- At least one CPU has been set up in the project.
- An HMI device (e.g., Comfort Panel) has been set up in the project.
- CPU and the HMI device are connected with each other by an HMI connection.
- You have created a screen (for the system diagnostics view).
- The global screen is open (for the system diagnostics window).
- The Inspector window is open.

## Procedure

Proceed as follows to configure the system diagnostics:

1. Double-click the "System diagnostics view" object in the "Tools" task card. The object is added to the screen.

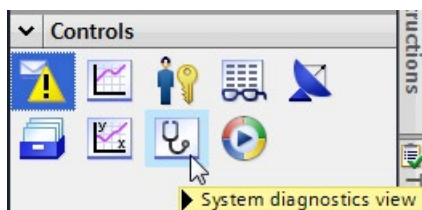


Figure 4-28 Adding a system diagnostics view

2. Select the "Properties" tab in the Inspector window.
3. Select the area "Columns".
4. Enable the columns that you require in the device view for WinCC Runtime, for example:
  - Status
  - Name
  - Operating mode
  - Slot
  - Address
5. Enable the columns that you require in the detail view for WinCC Runtime, for example:
  - Status
  - Name
  - Operating mode
  - Plant designation
  - Address
6. You can change the column headers in the "Columns" area, if necessary.
7. Select the "Display" area.
8. Enable "Column settings > Columns moveable" to move the columns in WinCC Runtime.
9. To close the system diagnostics window in WinCC Runtime, select "Properties > Window > Closable" in the "Properties" tab of the Inspector window.

## Result

The system diagnostics view has been added to the screen. The diagnostics status of the entire plant is displayed in the system diagnostics view in WinCC Runtime.

| Diagnostic overview                                                 |          |            |      |      |              |         |
|---------------------------------------------------------------------|----------|------------|------|------|--------------|---------|
| Status                                                              | Name     | Operati... | Slot | Type | Order num... | Address |
| ✓                                                                   | Rack_1   |            |      |      |              |         |
| ✓                                                                   | PLC_1    | ✓          |      |      | 36979        |         |
| ✓                                                                   | CP 443-1 | ✓          |      |      | 53939        |         |
| ✗                                                                   | DI_1     |            |      |      | 5363         |         |
| ✓                                                                   | DI_2     |            |      |      | 22323        |         |
| ✓                                                                   | PS_1     |            |      |      | 39283        |         |
| <div> <div>◀</div> <div></div> <div>▶</div> </div>                  |          |            |      |      |              |         |
| <div> <div>🏠</div> <div>⬅️</div> <div>➡️</div> <div>✉️</div> </div> |          |            |      |      |              |         |

Figure 4-29 System diagnostics view in the screen

The system diagnostics window has been added to the global screen. If there is an error message in the plant, the system diagnostics window responds and displays the affected device.

#### 4.2.4.2 Different views of the HMI diagnostics view

##### Introduction

There are three different views available in the system diagnostics view and the system diagnostics window.

- Device view
- Details view
- Distributed I/O view (only for PROFIBUS and PROFINET systems)

##### Device view

The device view shows all the available devices of a layer in a table. Double-clicking on a device opens either the lower-level devices or the detail view. Symbols in the first column provide information about the current state of the device.

S7-1500 station\_1

| Status | Name              | Operati... | Slot | Type      | Order num...  | Address |
|--------|-------------------|------------|------|-----------|---------------|---------|
|        | S7-1500 statio... |            |      | S7-150... |               | 32*     |
|        | CPU proxy_1       |            | 1    | CPU 15... | 6ES7 516-3... | 49*     |
|        | DQ32              |            | 2    | DQ32      | 6ES7 522-1... | 258*    |
|        | DI32              |            | 3    | DI32      | 6ES7 521-1... | 259*    |
|        |                   |            |      |           |               |         |
|        |                   |            |      |           |               |         |

Navigation icons: Home, Previous, Next, Mail/Report

Figure 4-30 Device view

## Details view

The detail view gives detailed information about the selected device and any pending errors. Check whether the data is correct in the detail view.

S7-1500 station\_1 \ DI32

|                         |                                                                                   |
|-------------------------|-----------------------------------------------------------------------------------|
| > Status                |  |
| > Name                  | DI32                                                                              |
| > Operating state       |                                                                                   |
| > Rack                  | 0                                                                                 |
| > Slot                  | 3                                                                                 |
| > Type                  | DI32                                                                              |
| > Order number          | 6ES7 521-1BL00-0AB0                                                               |
| > Address               | 259*                                                                              |
| > Plant designation     |                                                                                   |
| > Location identifier   |                                                                                   |
| > Manufacturer ID       | SIEMENS AG                                                                        |
| > Hardware version      | 97                                                                                |
| > Profile ID            |                                                                                   |
| > Specific profile data | 0003                                                                              |
| > I&M data version      | 1.1                                                                               |
| > Error text            | Wire break                                                                        |
|                         | Help: Check the status of the connecting cables.                                  |

Figure 4-31 Details view

## Distributed I/O view

The distributed I/O view is only available for distributed I/O systems. The distributed I/O view shows the status of the devices of the PROFIBUS/PROFINET subnet.

Each element in the view shows the device name, the device type and the IP address or the PROFIBUS address.

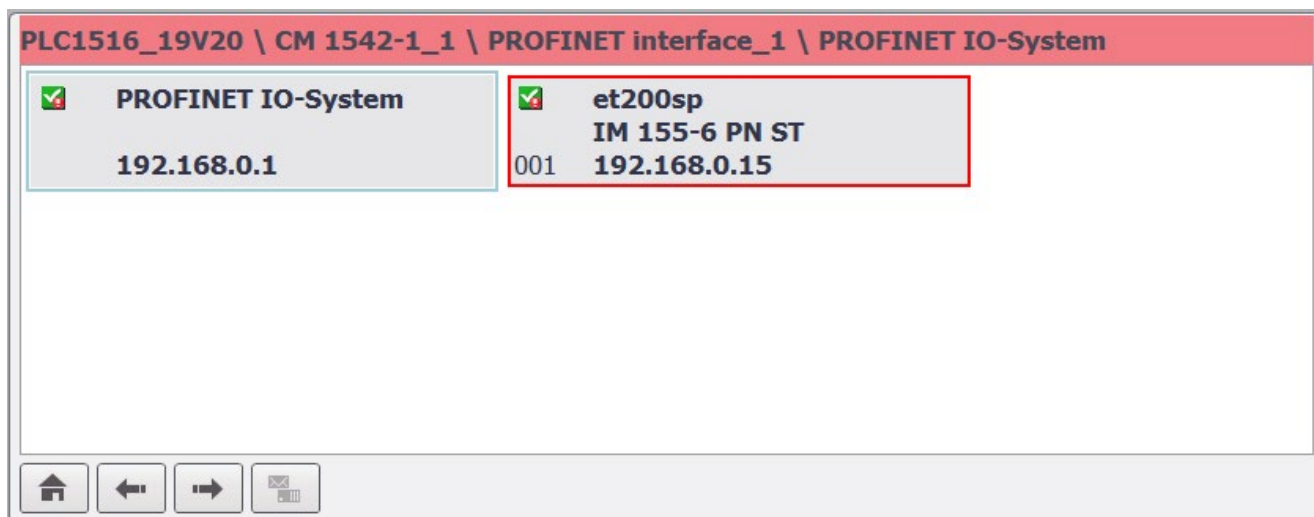


Figure 4-32 Distributed I/O view

## Navigation buttons

| Button                                                                              | Function                                                                              |
|-------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------|
|  | Opens the lower-level devices or the detail view if there are no lower-level devices. |
|  | Opens the higher-level device or the device view if there is no higher-level device.  |
|  | Opens the device view.                                                                |



#### **4.2.4.3 Inserting system diagnostics indicator**

##### **Introduction**

The system diagnostics indicator is a predefined graphic symbol of the library which alerts you to errors in your plant.

The library object shows two different states:

- No error
- Error

##### **Requirements**

- An HMI device (e.g., Comfort Panel) has been set up in the project.
- The "Libraries" task card is opened.
- The global library "Buttons and Switches > DiagnosticsButtons" is open.
- A screen is open.
- The system diagnostics window has been set up in the global screen.

## Procedure

1. Select the "DiagnosticsIndicator" object in the library.
2. Drag-and-drop the library object to the position in the work area where you want to insert the object.

The library object is added.

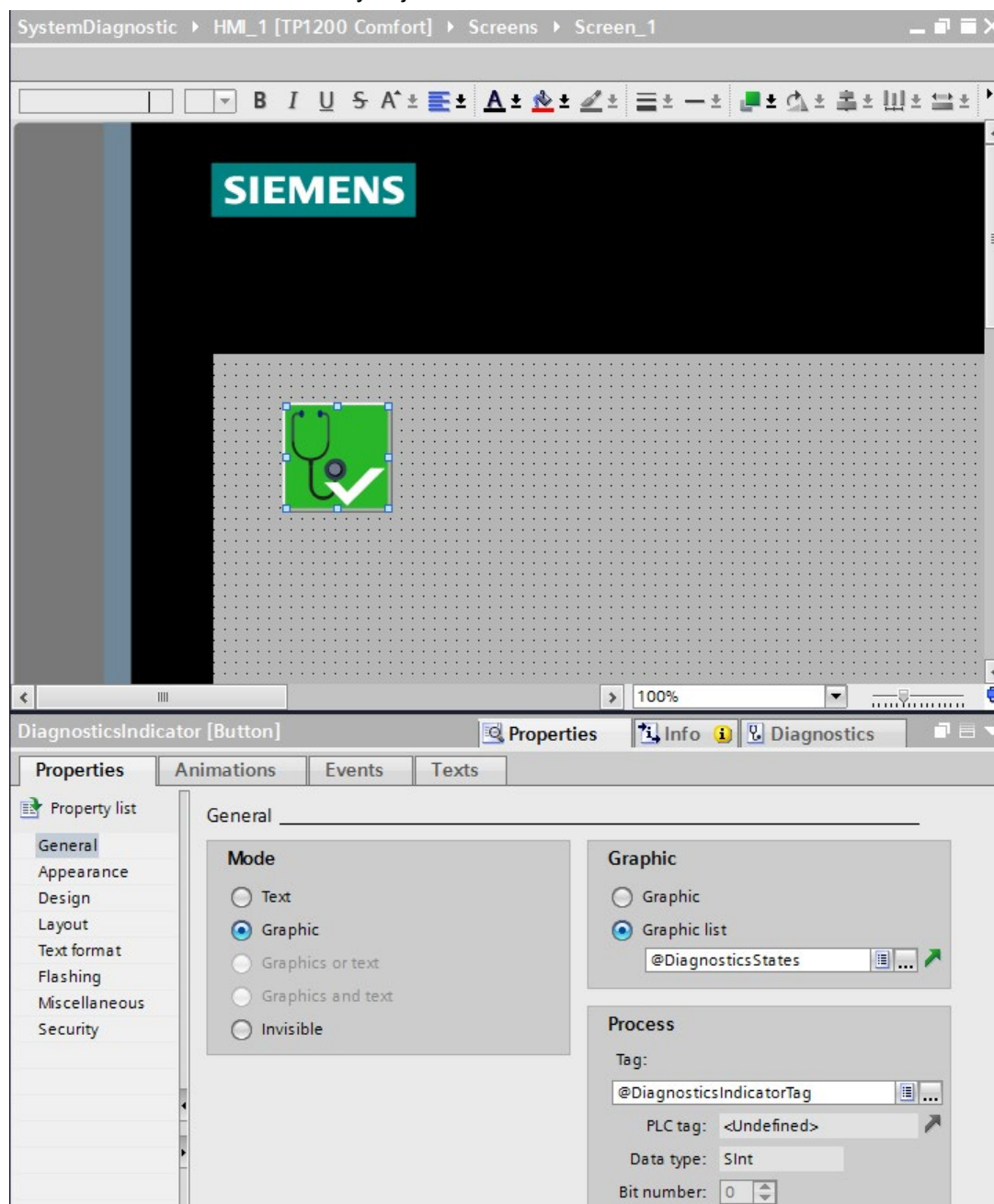


Figure 4-33 Inserting library object in the work area

3. Select the library object.
4. Open the "Events" tab in the Inspector window.  
The "ShowSystemDiagnosticsWindow" is preset for the event "Click".

## Result

The system diagnostics indicator has been added to the project and connected with the system diagnostics window.

The system diagnostics indicator changes its appearance if an error message is output in WinCC Runtime. The system diagnostics window opens when you click on the system diagnostics indicator. The system diagnostics window shows the detail view of the affected device.

## Configuring access protection for the system diagnostics window

Configure access protection for the system diagnostics indicator to prevent unauthorized access to the system diagnostics windows.

1. Select the "DiagnosticsIndicator" object in the screen.
2. Open the "Properties" tab in the Inspector window.
3. Select an authorization in the "Security in Runtime" area.

A logon dialog opens when you click on the system diagnostics indicator in WinCC Runtime. The system diagnostics window does not open unless you have the required authorization.

### 4.2.4.4 Configuring button as system diagnostics indicator

## Introduction

Instead of using the object "DiagnosticsIndicator" from the library, you can, for example, configure a button in "Graphic" mode to indicate errors in your plant.

## Requirements

- At least one CPU has been created.
- An HMI device (e.g., Comfort Panel) has been set up in the project.
- The "Tools" task card is open.
- A bit graphics list has been created with two different graphics for the states.
- A screen is open.
- You have created a system diagnostics view.

## Procedure

Follow these steps to configure a button as system diagnostics indicator:

1. Double-click the "Button" object in the "Tools" task card. A button is added to the screen.
2. Enable the "Properties" tab in the Inspector window and the "Graphic" mode in the "General" area.
3. Select the bit graphics list as graphics list.
4. Select the "Properties" tab in the Inspector window and select the tag @DiagnosticsIndicatorTag under "Tag" in the "General" area.
5. To assign a function to the button, select the "Events" tab in the Inspector window.
6. Select the "Click" event.
7. Click on "Add function" in the table.
8. Select "EnableSystemDiagnosticsView".
9. Select the system diagnostics view.

## Result

You have configured an interface that reacts to error events from the CPU. The button changes when an error event occurs in Runtime.

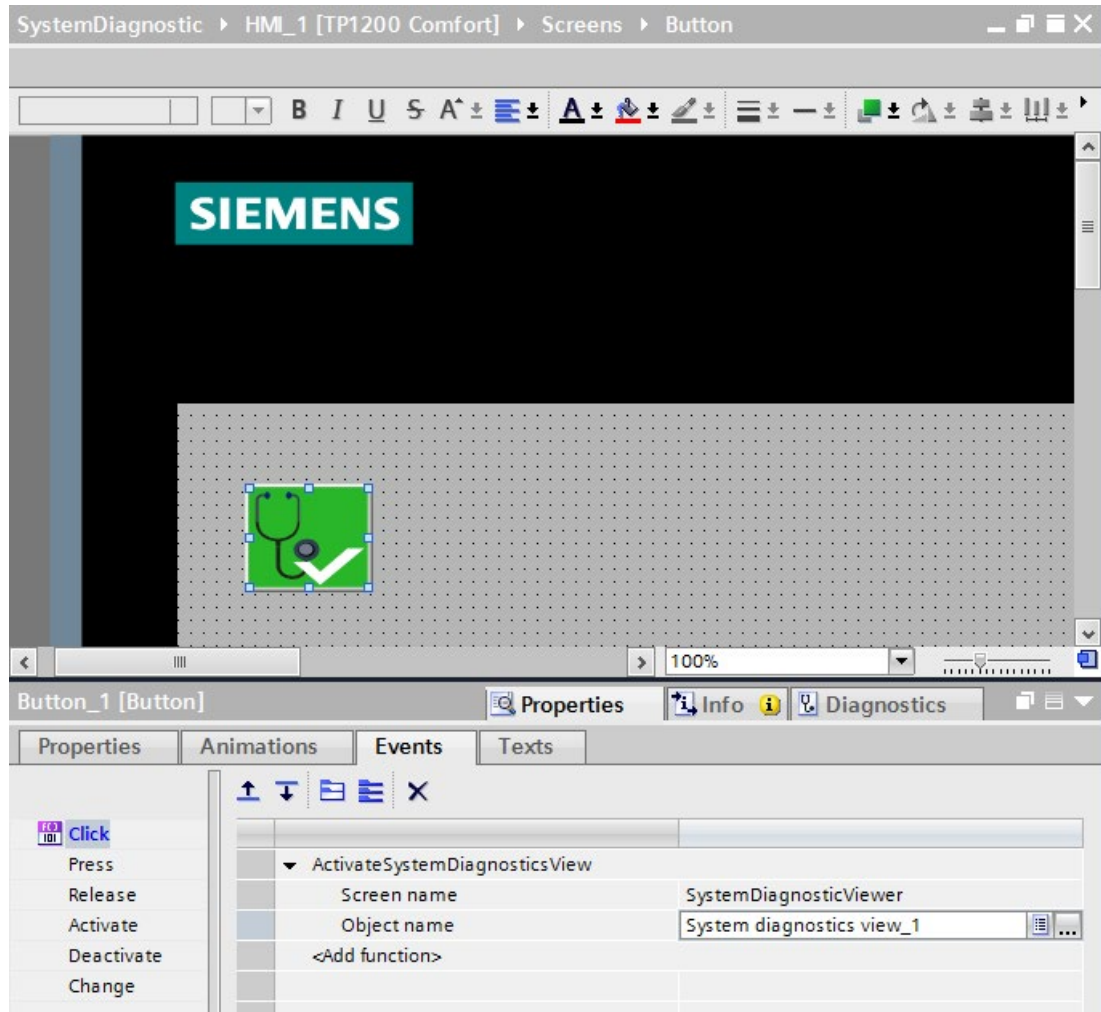


Figure 4-34 Configured button

The button has two states.

- Error  
The system diagnostics view opens when you click on the button. The system diagnostics view shows the detail view of the affected device.
- No error  
The system diagnostics view opens when you click on the button. The system diagnostics view shows the device view.

# System diagnostics by means of the user program

## 5.1 Options of system diagnostics in the user program

### Introduction

You can configure responses to diagnostics alarms in the user program. You can, for example, specify that your plant is stopped in case of specific diagnostics alarms.

### Instructions

A vendor-independent structure of data records with diagnostics information applies. The following instructions are available for determining the system diagnostics of a device:

Table 5- 1 Instructions for determining the system diagnostics

| Instruction  | Description                                                                                                                                                                                                                                                 |
|--------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| RDREC        | <ul style="list-style-type: none"> <li>Reads data records of a component (module or submodule) of a DP slave/IO device that may contain error information</li> <li>Works asynchronously, which means processing takes place across several calls</li> </ul> |
| RALRM        | <ul style="list-style-type: none"> <li>Reads the start information of the OB when calling the diagnostics interrupt OB (OB 82)</li> <li>Provides information on cause and location of error</li> </ul>                                                      |
| DPNRM_DG     | <ul style="list-style-type: none"> <li>Reads the current diagnostics data of a DP slave (DP standard diagnostics)</li> </ul>                                                                                                                                |
| GEN_DIAG     | <ul style="list-style-type: none"> <li>Generates diagnostics information</li> <li>To generate diagnostics information, the module or submodule is identified with its logical address</li> </ul>                                                            |
| Gen_UsrMsg   | <ul style="list-style-type: none"> <li>Generates an alarm that is entered in the diagnostics buffer</li> </ul>                                                                                                                                              |
| GET_DIAG     | <ul style="list-style-type: none"> <li>Provides diagnostics information</li> <li>To provide diagnostics information, the module or submodule is selected</li> </ul>                                                                                         |
| GET_Name     | <ul style="list-style-type: none"> <li>Reads the name of an IO device</li> </ul>                                                                                                                                                                            |
| T_DIAG       | <ul style="list-style-type: none"> <li>Provides diagnostics and status information on a connection</li> <li>Works asynchronously, which means processing takes place across several calls</li> </ul>                                                        |
| RD_SINFO     | <ul style="list-style-type: none"> <li>Reads the start information of the OB called last that has not been processed completely and the startup OB started last</li> <li>Provides general error information</li> </ul>                                      |
| LED          | <ul style="list-style-type: none"> <li>Reads the status of the module LED</li> </ul>                                                                                                                                                                        |
| Get_IM_Data  | <ul style="list-style-type: none"> <li>Reads the Information&amp;Maintenance data of the CPU</li> <li>Works asynchronously, which means processing takes place across several calls</li> </ul>                                                              |
| DeviceStates | <ul style="list-style-type: none"> <li>Outputs the state of all devices of an IO system</li> </ul>                                                                                                                                                          |
| ModuleStates | <ul style="list-style-type: none"> <li>Outputs the state of all modules of a device</li> </ul>                                                                                                                                                              |

## Additional information

### Online help

In the online help for STEP 7, you can find:

- Additional information on instructions for system diagnostics
- Information about further options for evaluating diagnostic information in the user program (e.g. with the "RDREC", "RALRM", "GET\_DIAG" instructions)
- Information on SIMATIC ProDiag. This functionality enables targeted and fast machine and plant diagnostics for SIMATIC S7-1500 and SIMATIC HMI:
  - Standardized diagnostics concept for different SIMATIC components
  - No additional configuration work for diagnostics functionality
  - Reduces the load on PLC memory and program run time

You can find details in the online help under "Supervising machinery and plants with ProDiag".

### Manuals

You can find additional information about evaluating diagnostic information in the user program in the following manuals:

- PROFINET function manual  
(<http://support.automation.siemens.com/WW/view/en/49948856>)
- From PROFIBUS DP to PROFINET IO  
(<https://support.industry.siemens.com/cs/ww/en/view/19289930>) programming manual
- Manual for the respective module

### Application examples

You can find detailed application examples with further documentation and example projects on the Service&Support Website:

- Diagnostic overview for SIMATIC S7-1200 and S7-1500  
(<https://support.industry.siemens.com/cs/ww/en/view/109752283>)

### FAQ

For more information about how to realize channel diagnostics in the user program of the SIMATIC S7-1500, refer to the FAQ with entry ID 109480387 on the Service&Support Website (<https://support.industry.siemens.com/cs/ww/en/view/109480387>).

## 5.2 System diagnostics using process image inputs

### Introduction

In addition to event-driven system diagnostics, the input and output modules of the SIMATIC series provide diagnostics information using the process image input.

The system diagnostics described in the preceding sections is made available asynchronously to the program processing. To ensure the correct processing of the input and output data in the case of faults while reading the input and output data, some modules offer the so-called value status (QI = Quality Information) for evaluation.

### Requirement for evaluation of the value status

The diagnostics information about the process image input is transmitted synchronized with the user data. Select the "Value status" check box in the properties of the I/O module in STEP 7 if you want to evaluate the value status of the channel.

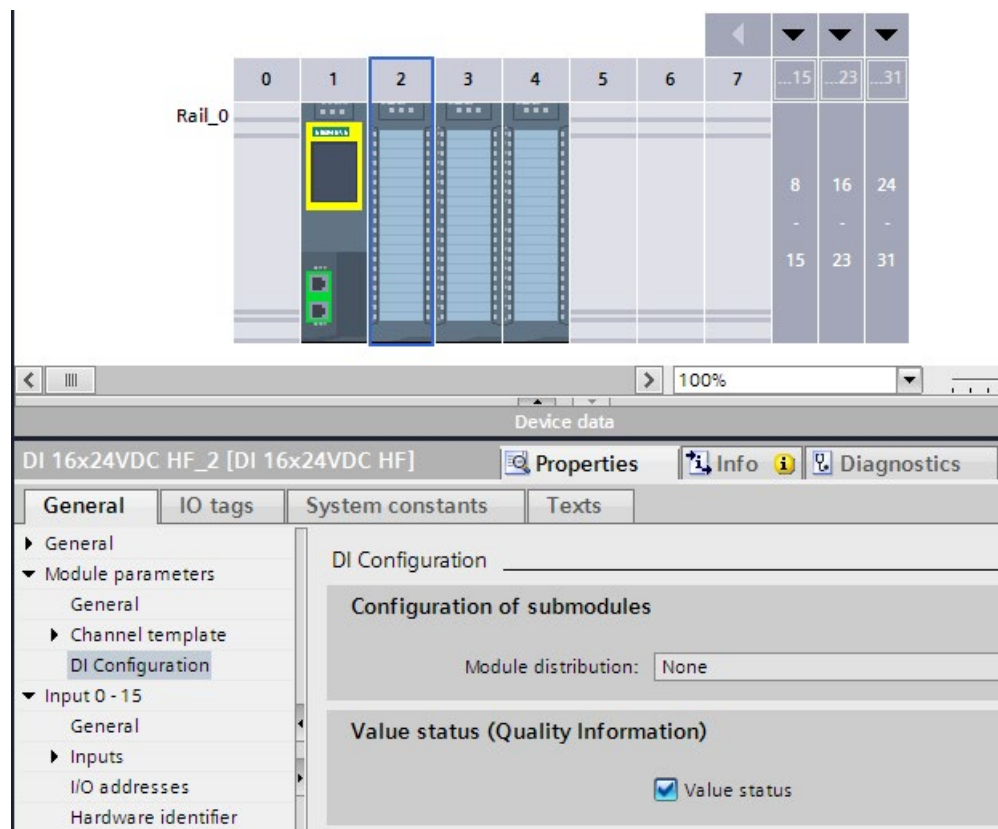


Figure 5-1 Enable value status



### Evaluation of the value status

If you have enabled the value status for an I/O module, this module provides additional information on the value status in addition to the user data. This information is directly available in the process image input and can be called with simple binary operations.

Each channel is uniquely assigned one bit in the value status. The bit in the value status indicates the validity of the read-in value in the user data.

Table 5- 2 Example for evaluation of the user datum in case of a wire break for a digital input module

|                    | Bit in user datum        | Bit in value status | Value in user datum |
|--------------------|--------------------------|---------------------|---------------------|
| Faulty channel     | Logical 0                | 0                   | Invalid             |
| Fault-free channel | Logical 0 (actual value) | 1                   | Valid               |

### Influence of the value status

The value status of an active channel is "Invalid" when any **one** of the following factors is given:

- Channel diagnostics pending (regardless of whether diagnostics, for example wire break, is configured for this channel)
- For output channels: "Reaction to CPU STOP" feature is active (due to CPU STOP, interrupted connection)
- For output channels of the digital on-board I/O of compact CPUs: If a channel is used for technology functions, it returns the value status 0 ("Invalid"). It does not matter in this context whether the output value is incorrect or not.
- PROFIenergy is active, i.e. hibernation is enabled (except in "Continue working mode")

When working with non-fail-safe modules, note that an invalid active channel also sets the value status of all other active channels to "Invalid". We therefore recommend that you disable all unconnected or unused channels.

### Example - Evaluation of the value status for the input channel of an analog input module

The example below shows the basic evaluation of the value status for the input channel of an analog input module in the user program. The diameter of a cylinder is measured by means of a channel and its circumference is calculated.

- If the value status indicates the channel is error-free, the circumference is to be calculated.
- If the value status indicates the channel is defective, the value "0" is to be output as substitute value for the circumference.

The figure below shows the evaluation of the value status in the user program.

| Perimeter |                      |           |               |                                    |  |
|-----------|----------------------|-----------|---------------|------------------------------------|--|
|           | Name                 | Data type | Default value | Comment                            |  |
| 1         | ▼ Input              |           |               |                                    |  |
| 2         | ■ Diameter           | Real      | 0.0           | Tag for analog input channel       |  |
| 3         | ■ QualityInformation | Bool      | false         | Tag for QI of analog input channel |  |
| 4         | ▼ Output             |           |               |                                    |  |
| 5         | ■ Perimeter          | Real      | 0.0           | Tag for result of calculation      |  |
| 6         | ► InOut              |           |               |                                    |  |
| 7         | ► Static             |           |               |                                    |  |
| 8         | ► Temp               |           |               |                                    |  |
| 9         | ▼ Constant           |           |               |                                    |  |
| 10        | ■ PI                 | Real      | 3.14          | Constant for pi                    |  |
| 11        | ■ SubstituteValue    | Real      | 0.0           | Constant for substitute value      |  |

| IF...                                                                                                                                                                                                                                                                                                                                                                                                                                 | CASE...<br>OF... | FOR...<br>TO DO... | WHILE...<br>DO... | (*...*) |
|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------|--------------------|-------------------|---------|
| <pre> 1 IF #QualityInformation = true           //Validity check of diameter 2 3     THEN                               //Program run, if quality information is positive 4         #Perimeter := #Diameter * #PI;  //Calculation of perimeter 5 6     ELSE                               //Program run, if quality information is negative 7         #Perimeter := #SubstituteValue; //Substitute value assigned to perimeter </pre> |                  |                    |                   |         |

Figure 5-2 Example - Evaluation of the value status in the user program

### Additional information

Depending on the I/O module, the value status reserves different addresses in the process image input. The manual for the module used includes specific information on the assignment and arrangement.

# Alarms

## Introduction

Alarms allow you to display events from processing in the automation system and to quickly detect errors, to precisely localize them and to remove them. Downtimes are significantly reduced in a plant.

Before alarms can be output, they need to be configured.

You can create, edit and compile event-dependent alarms along with their alarm texts and alarm attributes and display them on display devices.

In STEP 7, you create program alarms in the user program with the "Program\_Alarm" instruction. You edit the attributes and alarm texts in the alarm editor in STEP 7.

You can output the alarm status with the "Get\_AlarmState" instruction.

## Advantages of program alarms

Compared to other alarm methods, such as HMI discrete alarms, program alarms offer the following advantages:

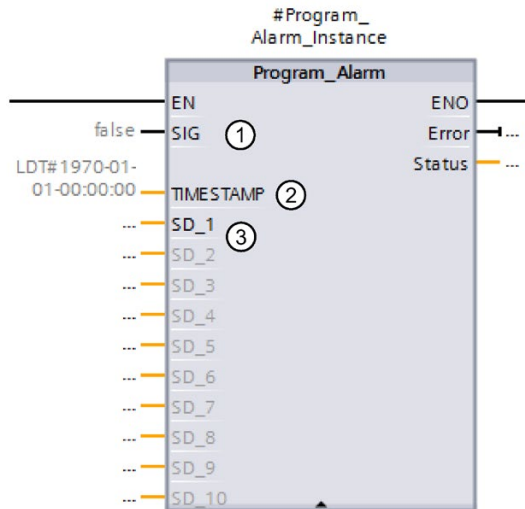
- Central engineering in STEP 7: You only configure a program alarm once for the CPU. The program alarm is automatically transferred from the CPU to all registered HMI devices.
- System-supported acknowledgment: The acknowledgment of a program alarm on an HMI device is automatically updated on other HMI devices by the CPU.
- Time stamping close to the event in the CPU
- Identical time stamps of the alarms on multiple HMI devices without time synchronization

## 6.1 Creating alarms with the "Program\_Alarm" instruction

### "Program\_Alarm" instruction

You create a program alarm in STEP 7 with the "Program\_Alarm" instruction.

The figure below shows the "Program\_Alarm" instruction with the most important input tags.



- ① The "Program\_Alarm" instruction monitors the signal at the SIG block input and generates a program alarm in case of a signal change at the SIG parameter. The instruction generates an incoming alarm when the signal changes from 0 to 1 and an outgoing program alarm if the signal changes from 1 to 0. The program alarm is triggered synchronously to program execution.
- ② The time stamp is automatically created when the alarm event occurs in the automation system and is passed along with the alarm.
- ③ You can append up to ten associated values to the program alarm at the parameters SD\_i ( $1 \leq i \leq 10$ ). The associated values are acquired at the time of the signal change at the SIG parameter and assigned to the program alarm. Associated values are used to display dynamic contents in alarms.  
Example: The temperature in the tank <associated value 1> is <associated value 2> °C.  
You can find more information on associated values in the STEP 7 online help.

Figure 6-1 "Program\_Alarm" instruction

---

**Note**

The "Program\_Alarm" instruction can only be called in a function block.

A program alarm can be up to 256 bytes long in total (with associated values and texts from the text list).

The associated values can be a maximum of 512 bytes in length. Text lists are not affected by this.

The CPUs of the SIMATIC S7-1500 product series have the following memory for text lists:

- CPU 1510-x to CPU 1513-x: 2.25 MB
- CPU 1515-x to CPU 1516-x: 4.5 MB
- CPU 1517-x to CPU 1518-x: 6.75 MB

The number of configurable program alarms depends on the CPU used. With a CPU 1515-2 PN, for example, a maximum of 10,000 program alarms are possible. You can find this information in the device manual for the respective CPU under "Number of configurable alarms".

The number of simultaneously active "Program\_Alarms" depends on the CPU used. With a 1515-2 PN CPU, for example, a maximum of 600 program alarms are possible. You can find this information in the device manual for the respective CPU under "Number of reserved user interrupts".

Sometimes, it is not possible for all program alarms that are active at the same time to be output within one cycle. Query the status of each "Program\_Alarm" and activate the instruction again, if necessary. The cycle time is increased for a short time by simultaneously activating/sending multiple "Program\_Alarms".

A maximum of 40,000 program alarms should be configured in a STEP 7 project on a 64-bit operating system.

---

**Additional information**

You can find more information on creating program alarms in the STEP 7 online help under "Creating and editing alarms".

## 6.2 Editing alarms in the alarm editor

**Introduction**

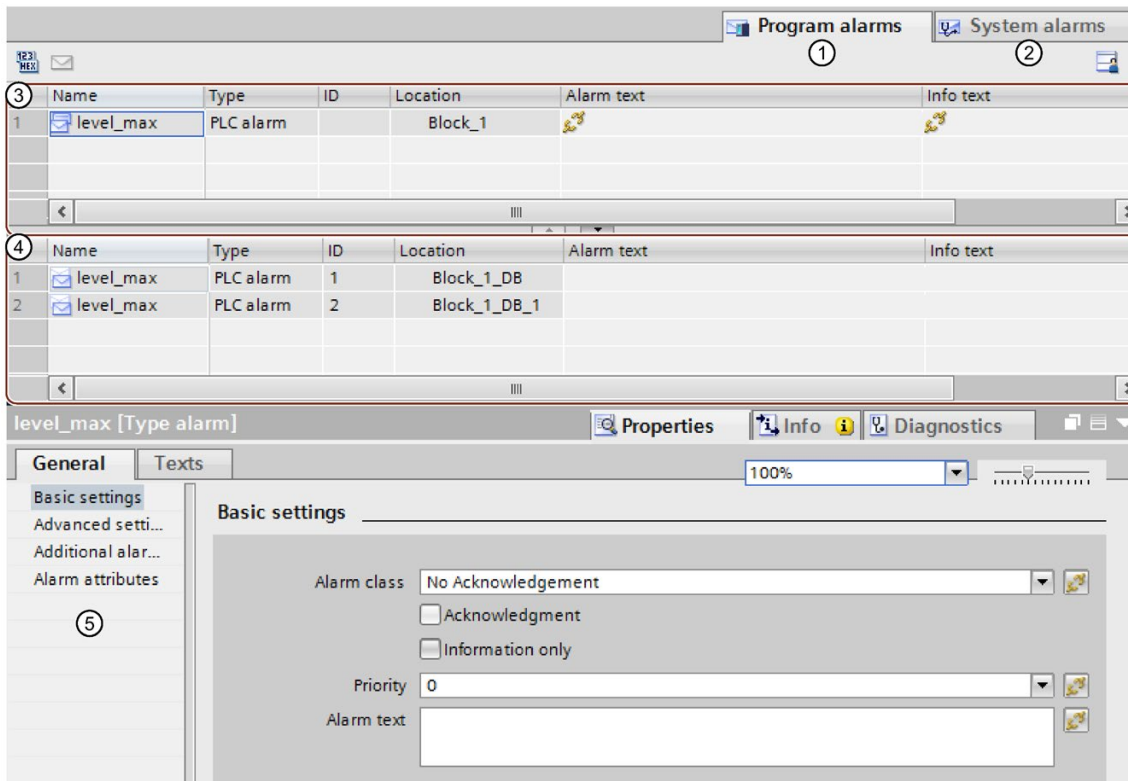
You can edit the created alarms in STEP 7 either in the program editor or in the alarm editor. You can find additional information on editing alarms in the program editor in the STEP 7 online help under "Creating and editing alarms".

## Editing alarms in the alarm editor

You can edit alarm texts in the alarm editor and specify attributes such as alarm class or priority for the alarms.

1. Double-click "PLC supervisions & alarms" in the project tree. Select the "Alarms" tab. The alarm editor opens.
2. Enter the required texts and attributes in the appropriate columns.

The figure below shows the layout of the alarm editor.



- ① "Program alarms" tab: You can edit program alarms here.
- ② "System alarms" tab: System alarms can only be viewed but not edited. To edit these alarms, you must navigate to the device view ("Go to device" menu command), where you can modify the system diagnostics alarms in the Inspector window.
- ③ "Type alarms" area:  
This is where the type alarms created in a function block with the "Program\_Alarm" instruction are displayed. Type alarms serves as templates for instance alarms (④).  
All the inputs you make for the type alarm are automatically included in the instance alarms derived from it.  
You can find more information on type alarms in the STEP 7 online help under "Alarm types and alarms".
- ④ "Instance alarms" area:  
When you assign an instance DB to the message block (for example, call in an OB, FB, FC), instance alarms are automatically generated based on the template of the type alarm and alarm numbers are assigned.  
You can modify the instance alarms for specific instances.  
You can find more information on instance alarms in the STEP 7 online help under "Alarm types and alarms".
- ⑤ Properties of the selected type and instance alarm in the Inspector window

Figure 6-2 Layout of the alarm editor

You can enter or modify the necessary parameters, texts and attributes in the table or in the Inspector window.

## Multilingual alarms

You can have program alarms displayed in multiple languages by assigning different project languages to the interface languages of the display devices.

---

### Note

The project languages you want to assign must be activated and the corresponding texts (translations) must be available in the project. The project language selection can be found in the project tree under "Languages & Resources".

---

To create the texts of the program alarm as multilingual, follow these steps:

1. In the Inspector window of the alarm editor, open the "Properties" tab and the lower-level "Texts" tab.
2. Enter the text in the desired project language.
3. Open the "Properties" tab in the Inspector window of the CPU and select the "Display" command in the "General" area navigation. Under "Multilingual", assign one of the activated project languages to each interface language of the display devices. Overall, you can assign up to three different project languages to the user interface languages. All assigned project languages are loaded into the CPU.

## Additional information

You can find additional information on texts and attributes in the STEP 7 online help under "Texts and attributes".

You can find more information on text lists in the STEP 7 online help under "Text lists for alarms".

## 6.3 Display of program alarms

Program alarms you create with the "Program\_Alarm" instruction are automatically made available to the display devices.

You have the following options to display the alarms:

- STEP 7
- HMI
- Web server of the CPU
- Display of the CPU

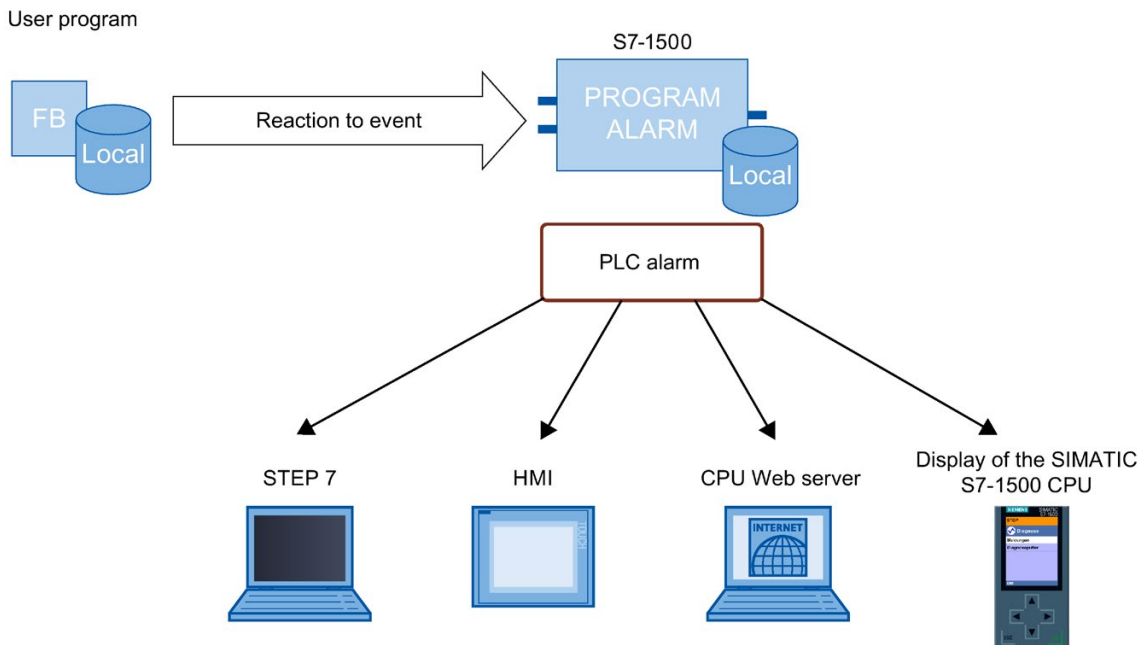


Figure 6-3 Display of program alarms

### Multilingual alarms

You can have program alarms displayed in multiple languages by assigning different project languages to the interface languages. See section Editing alarms in the alarm editor (Page 78).



## 6.4 Output of the alarm state with the "Get\_AlarmState" instruction

### "Get\_AlarmState" instruction

The "Get\_AlarmState" instruction outputs the alarm state of a program alarm. The output of the alarm state always refers to a program alarm that was created using the "Program\_Alarm" instruction.

The program alarm is selected with the "Alarm" input parameter. Specify the instance DB of the "Program\_Alarm" instruction at the "Alarm" parameter.

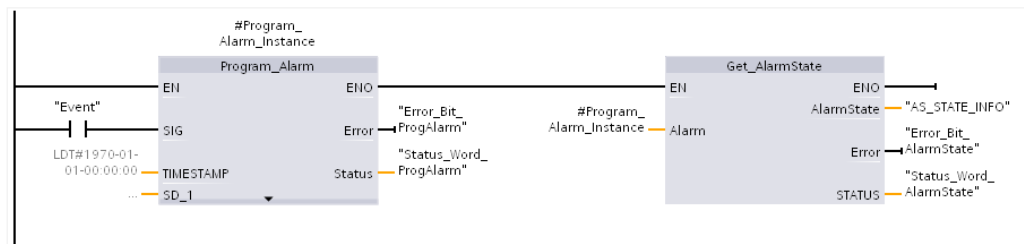


Figure 6-4 Call - Get\_AlarmState

### Additional information

You can find additional information on evaluation of the "Get\_AlarmState" instruction in the STEP 7 online help.

## 6.5 Example program for program alarms

### 6.5.1 Task

#### Introduction

This section describes the basic configuration of program alarms with the "Program\_Alarm" instruction based on two examples. The two examples solve the same problem but use a different approach. Example 1 does not use associated values. In example 2, an associated value is assigned to the program alarm to reference a text list.

#### Example - Minimum/maximum fill level of a tank

A tank is filled with a liquid. The fill level is monitored by two sensors.

If the liquid in the tank drops below a minimum fill level, an alarm is output for low fill level.

If the liquid in the tank exceeds a maximum fill level, an alarm is output for high fill level.

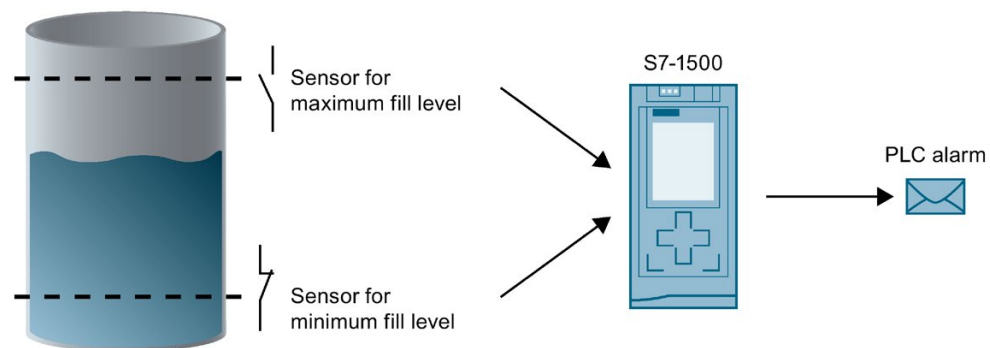


Figure 6-5 Example for fill level alarms

## 6.5.2 Example 1: Program alarm without associated values

### Introduction

In this example, you create a program alarm for the maximum and the minimum fill level.

### How the example works

When the maximum fill level is exceeded in the tank, a program alarm with the alarm text for the excessive fill level is output.

When the minimum fill level is undershot in the tank, a program alarm with the alarm text indicating that the fill level is too low is output.

### Steps

The following steps are necessary for this example:

1. Define tags for signal acquisition
2. Create function block
3. Create program alarms
4. Call function block
5. Edit alarm text

### Define tags for signal acquisition

The following table shows the tags that are used in this example. Define these tags in the standard tag table. The standard tag table is available in the project tree under "PLC tags".

Table 6- 1 Tags for fill level alarms

| Name | Data type | Description                                                                      |
|------|-----------|----------------------------------------------------------------------------------|
| max  | BOOL      | Tag for maximum fill level<br>If "max" = 1, the maximum fill level is exceeded.  |
| min  | BOOL      | Tag for minimum fill level<br>If "min" = 1, the minimum fill level is undershot. |

The figure below shows the standard tag table with the defined tags "max" and "min".

|   | Name                                                                                    | Data type | Address                                                                                   | Retain                   | Visible i...                        | Accessible ..                       |
|---|-----------------------------------------------------------------------------------------|-----------|-------------------------------------------------------------------------------------------|--------------------------|-------------------------------------|-------------------------------------|
| 1 |  max | Bool      | %I0.0                                                                                     | <input type="checkbox"/> | <input checked="" type="checkbox"/> | <input checked="" type="checkbox"/> |
| 2 |  min | Bool      |  %I0.1 | <input type="checkbox"/> | <input checked="" type="checkbox"/> | <input checked="" type="checkbox"/> |
| 3 | <Add new>                                                                               |           |                                                                                           | <input type="checkbox"/> | <input checked="" type="checkbox"/> | <input checked="" type="checkbox"/> |

Figure 6-6 Define tags

## Create function block

To create a function block, follow these steps:

1. Open the "Program blocks" folder in the project tree.
2. Double-click "Add new block".  
The "Add new block" dialog opens.
3. Select the button "Function block".

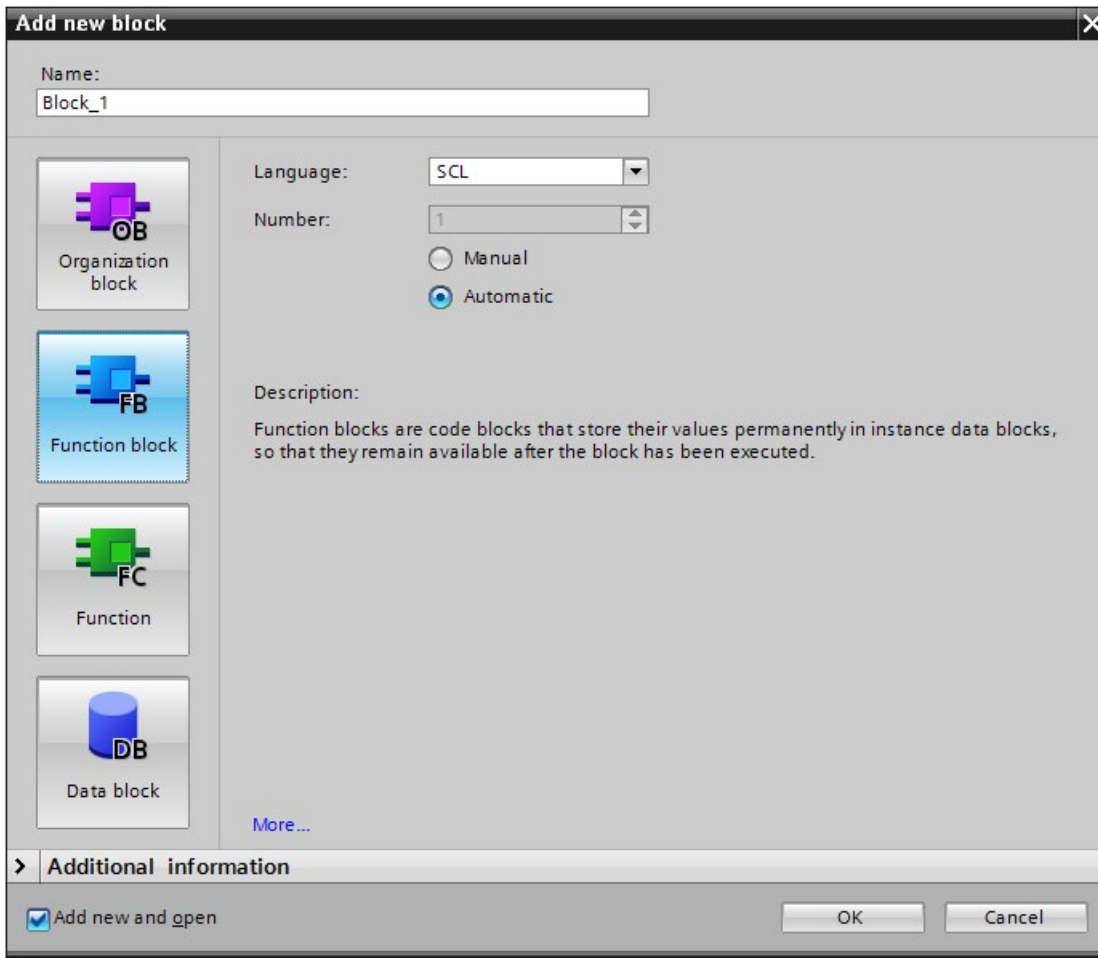


Figure 6-7 Create FB

4. Enter a name for the new block.
  5. Select the language SCL.
  6. Click on "OK" to confirm your input.
- Result: You have created a function block.

## Create program alarms

To create the program alarm for the example program, follow these steps:

1. Select the created function block (FB) in the "Program blocks" folder in the project tree and double-click the function block to open it.
2. Insert the call of the "Program\_Alarm" instruction in the instruction part of the function block. The "Program\_Alarm" instruction is available in the "Instructions" task card under "Extended instructions" > "Alarms".

The "Call options" window opens.

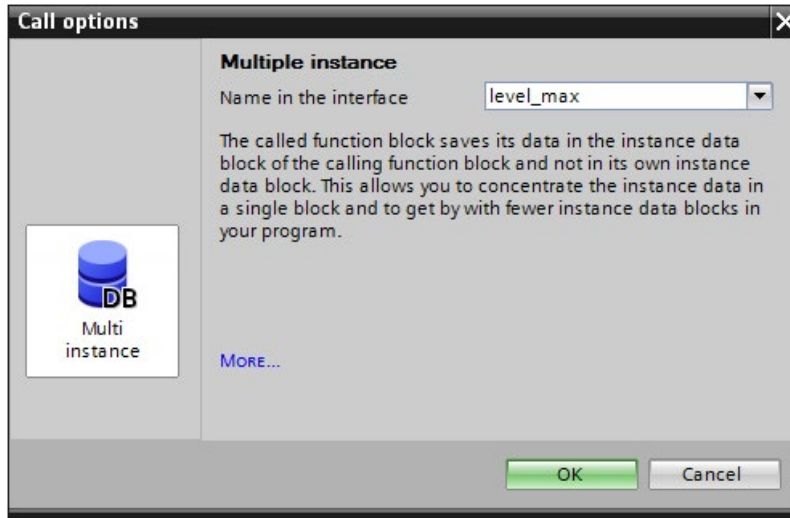


Figure 6-8 Call Program\_Alarm

3. Enter "level\_max" as the name and confirm the call options by clicking "OK".

Result: The input tags of the "Program\_Alarm" instruction are displayed in the instruction part.

4. Supply the SIG input tag of the "Program\_Alarm" instruction with the tags for the maximum fill level.

```
#level_max(SIG:="max");
```

SIG: If a signal change occurs at the SIG input tag, the "Program\_Alarm" instruction generates a program alarm.

5. Insert another call of the "Program\_Alarm" instruction.  
The "Call options" window opens.

6. Enter "level\_min" as the name and confirm the call options by clicking "OK".

Result: The input tags of the "Program\_Alarm" instruction are displayed in the instruction part.

7. Supply the SIG input tag of the "Program\_Alarm" instruction with the tags for the minimum fill level.

```
#level_min(SIG:="min");
```

Result: You have created two type alarms.

## Call function block

To call the function block in the user program, follow these steps:

1. In the "Program blocks" folder, select the cycle OB (e.g., OB1) in which you want to call the function block and open the cycle OB with a double-click.
2. Select the function block you want to call in the "Program blocks" folder.
3. Drag the function block into the instruction part of the cycle OB.  
The "Call options" window opens.

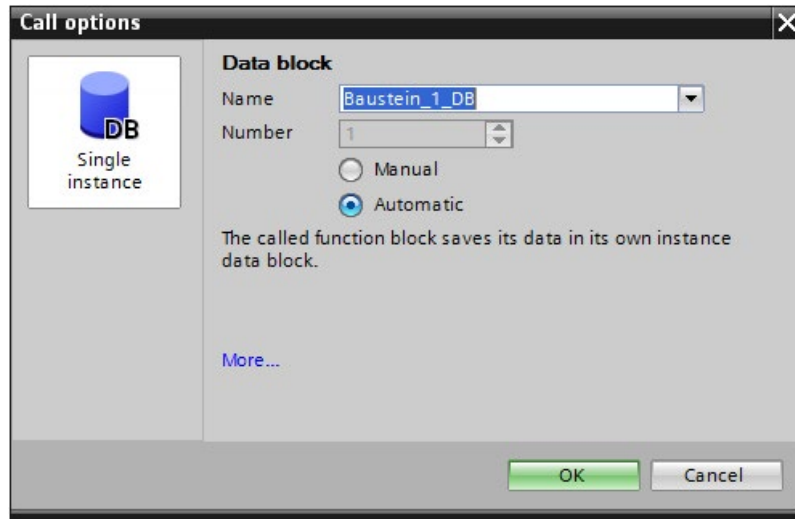


Figure 6-9 Call function block

4. Confirm the call options by clicking "OK".

Result: You have called the alarm block in the user program and created an instance alarm.

## Edit alarm text

To edit the alarm text, follow these steps:

1. Double-click "PLC supervisions & alarms" in the project tree. Select the "Alarms" tab. The alarm editor opens.
2. Select the type alarm for the maximum fill level.
3. Enter the alarm text for the maximum fill level in the "Alarm text" column.
4. Select the type alarm for the minimum fill level.
5. Enter the alarm text for the minimum fill level in the "Alarm text" column.

| Program alarms |           |           |    |               |                |           | System alarms |
|----------------|-----------|-----------|----|---------------|----------------|-----------|---------------|
|                | Name      | Type      | ID | Location      | Alarm text     | Info text |               |
| 1              | level_max | PLC alarm |    | Baustein_1    | level too high |           |               |
| 2              | level_min | PLC alarm |    | Baustein_1    | level too low  |           |               |
|                |           |           |    |               |                |           |               |
|                |           |           |    |               |                |           |               |
|                | Name      | Type      | ID | Location      | Alarm text     | Info text |               |
| 1              | level_min | PLC alarm | 2  | Baustein_1... | level too low  |           |               |

Figure 6-10 Edit alarm text

Result: You have created the alarm texts for both type alarms.

## Additional information

You can learn how to create multilingual texts under "Multilingual alarms" in the section Editing alarms in the alarm editor (Page 78).

### 6.5.3 Example 2: Program alarm with associated value

#### Introduction

In this example, you create a shared program alarm for the maximum and the minimum fill level. The program alarm is given an associated value. The program alarm uses the associated value to access a text list entry and outputs a separate alarm text for the minimum and the maximum fill level.

#### How the example works

The program alarm is output if either the minimum fill level is undershot or the maximum fill level is exceeded.

The associated value 1 of the "Program\_Alarm" instruction is assigned the tag for the maximum fill level. The associated value references a text list with the entries "0" and "1".

The following scenarios are possible for output of the alarm text:

- Associated value is "0": The entry "0" of the text list with the alarm text for the undershot fill level is output.
- Associated value is "1": The entry "1" of the text list with the alarm text for the excessive fill level is output.

#### Steps

The following steps are necessary for this example:

1. Define tags for signal acquisition
2. Create function block
3. Create program alarm
4. Call function block
5. Create a text list
6. Edit alarm text



## Define tags for signal acquisition

The following table shows the tags that are used in this example. Define these tags in the standard tag table. The standard tag table is available in the project tree under "PLC tags".

Table 6- 2 Tags for fill level alarms

| Name | Data type | Description                                                                      |
|------|-----------|----------------------------------------------------------------------------------|
| max  | BOOL      | Tag for maximum fill level<br>If "max" = 1, the maximum fill level is exceeded.  |
| min  | BOOL      | Tag for minimum fill level<br>If "min" = 1, the minimum fill level is undershot. |

The figure below shows the standard tag table with the defined tags "max" and "min".

|   | Name                                                                                  | Data type | Address                                                                                 | Retain                   | Visible i...                        | Accessible ..                       |
|---|---------------------------------------------------------------------------------------|-----------|-----------------------------------------------------------------------------------------|--------------------------|-------------------------------------|-------------------------------------|
| 1 |  max | Bool      | %I0.0                                                                                   | <input type="checkbox"/> | <input checked="" type="checkbox"/> | <input checked="" type="checkbox"/> |
| 2 |  min | Bool      |  %I0.1 | <input type="checkbox"/> | <input checked="" type="checkbox"/> | <input checked="" type="checkbox"/> |
| 3 | <Add new>                                                                             |           |                                                                                         | <input type="checkbox"/> | <input checked="" type="checkbox"/> | <input checked="" type="checkbox"/> |

Figure 6-11 Define tags

## Create function block

To create a function block, follow these steps:

1. Open the "Program blocks" folder in the project tree.
2. Double-click "Add new block".  
The "Add new block" dialog opens.
3. Select the button "Function block".

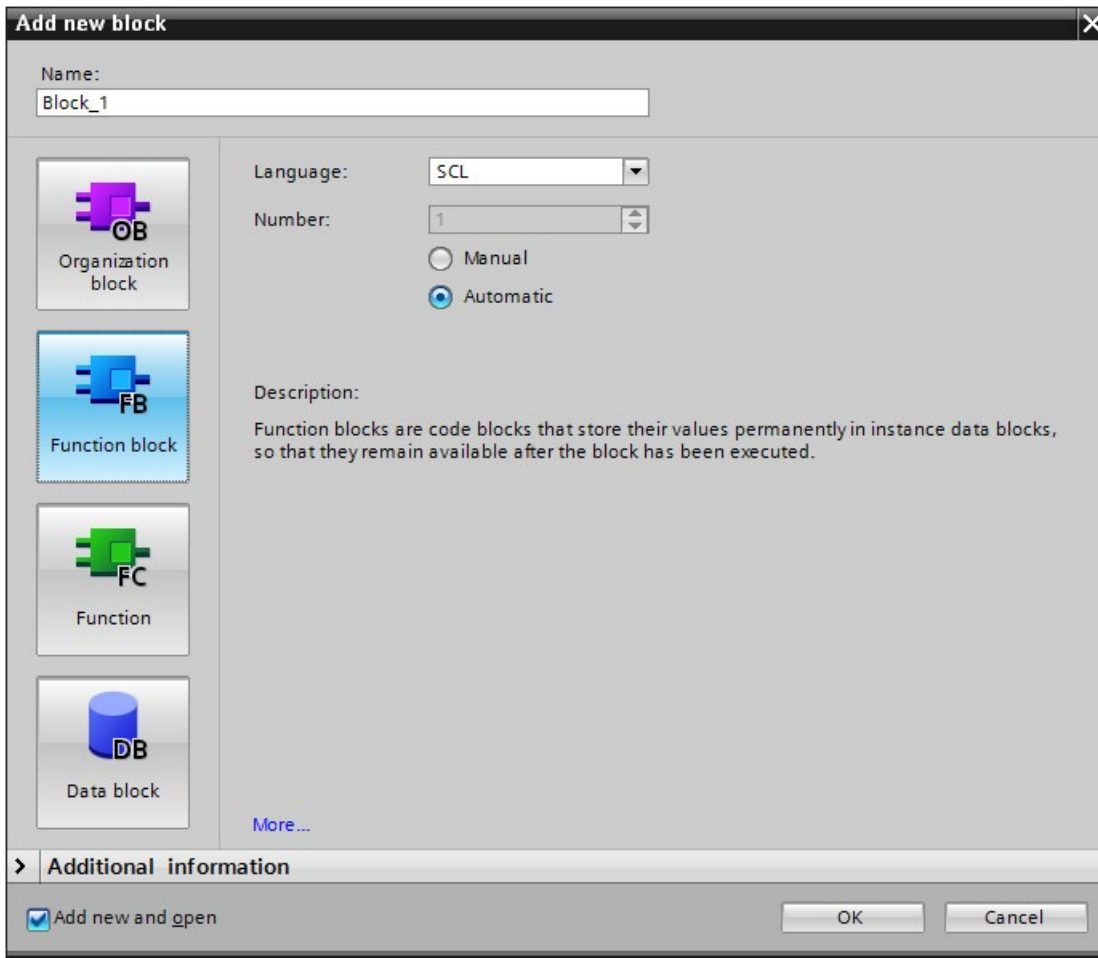


Figure 6-12 Create FB

4. Enter a name for the new block.
  5. Select the language SCL.
  6. Click on "OK" to confirm your input.
- Result: You have created a function block.

## Create program alarm

To create the program alarm for the example program, follow these steps:

1. Select the created function block (FB) in the "Program blocks" folder in the project tree.
2. Insert the call of the "Program\_Alarm" instruction in the instruction part of the function block. The "Program\_Alarm" instruction is available in the "Instructions" task card under "Extended instructions" > "Alarms".

The "Call options" window opens.

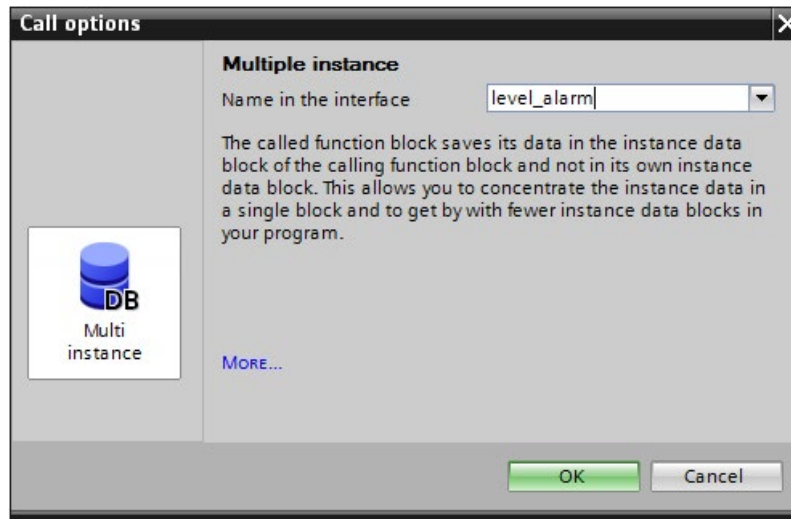


Figure 6-13 Call Program\_Alarm

3. Enter "level\_alarm" as the name and confirm the call options by clicking "OK".

Result: The input tags of the "Program\_Alarm" instruction are displayed in the instruction part.

4. Supply the SIG input tag of the "Program\_Alarm" instruction with the XOR logic operation of the tags for minimum and maximum fill level and the input tag SD\_1 with the tag for the maximum fill level.

```
#level_alarm(SIG:="min"XOR"max",SD_1:="max");
```

SIG: If a signal change occurs at the SIG input tag, the "Program\_Alarm" instruction generates a program alarm.

SD\_1: The associated value is acquired at the time of the signal change at the input tag and assigned to the program alarm.

Result: You have created a type alarm.

## Call function block

To call the function block in the user program, follow these steps:

1. In the "Program blocks" folder, select the cycle OB (e.g., OB1) in which you want to call the function block and open the cycle OB with a double-click.
2. Select the function block you want to call in the "Program blocks" folder.
3. Drag the function block into the instruction part of the cycle OB.  
The "Call options" window opens.

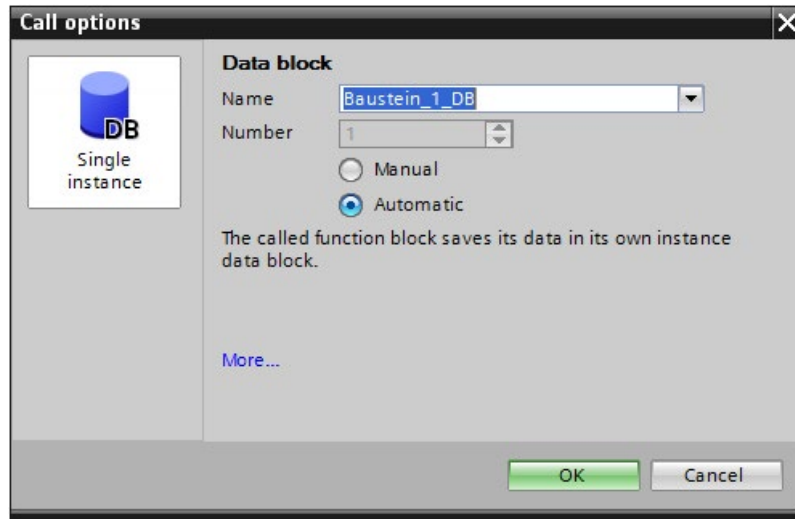


Figure 6-14 Call function block

4. Confirm the call options by clicking "OK".

Result: You have called the alarm block in the user program and created an instance alarm.

## Creating a text list

To create the text list for the example program, follow these steps:

1. Double-click on the "Text lists" command in the program tree.  
The text list editor opens.
2. Double-click "<Add>" in the Text lists area.  
A new text list is added.
3. Name the text list "level\_textlist".
4. Double-click "<Add>" in the Text list entries area of level\_textlist.  
A new text list entry is added in the level\_textlist text list.
5. Enter the alarm text for the maximum fill level in the "Entry" column.
6. Add another entry in the text list.
7. Enter the alarm text for the minimum fill level in the "Entry" column.

| Text lists     |           |         |  |
|----------------|-----------|---------|--|
| Name           | Selection | Comment |  |
| level_textlist | Decimal   |         |  |
| <Add new>      |           |         |  |

| Text list entries of level_textlist |          |                |  |
|-------------------------------------|----------|----------------|--|
| Range from                          | Range to | Entry          |  |
| 0                                   | 0        | level too low  |  |
| 1                                   | 1        | level too high |  |
| <Add new>                           |          |                |  |

Figure 6-15 Creating a text list

Result: You have created the text list for the alarm text.

## Edit alarm text

To edit the alarm text for the example program, follow these steps:

1. Double-click "PLC supervisions & alarms" in the project tree. Select the "Alarms" tab. The alarm editor opens.
2. Select the type alarm created for the example.
3. Click in the "Alarm text" column.
4. Open the shortcut menu and select the command "Insert a dynamic parameter (text list)".

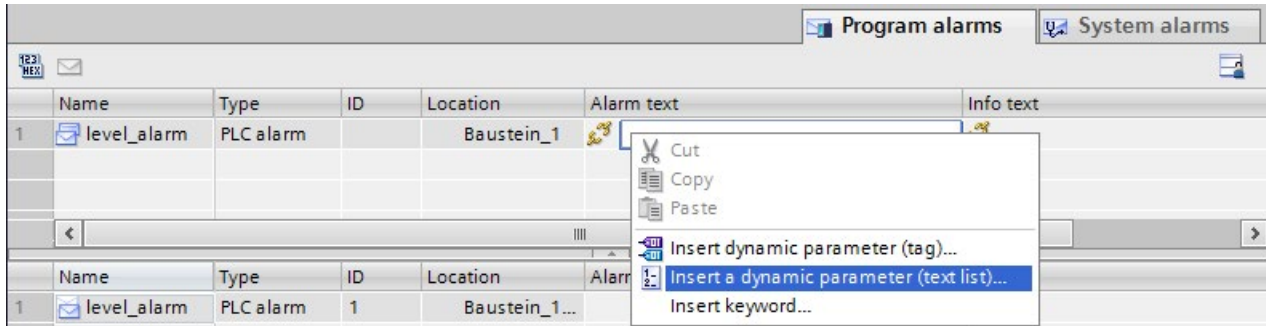


Figure 6-16 Edit alarm text

The window below opens.

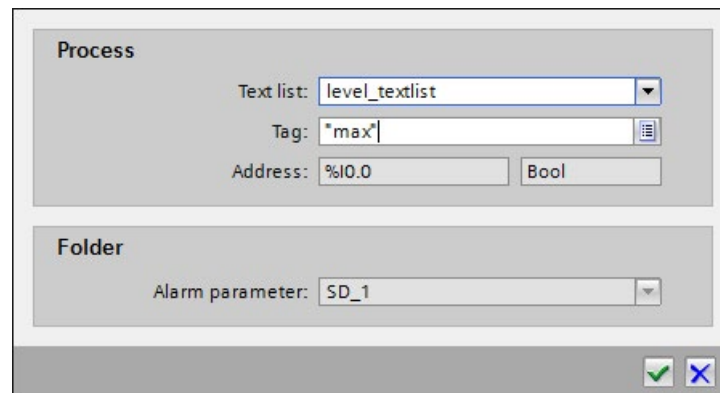


Figure 6-17 Insert a dynamic parameter (text list)

5. Select the text list "level\_textlist" and the tag "max". Confirm your selection by clicking "OK".

Result: You have created the alarm text for the type alarms.

If the tag "max" (associated value 1) is 0, the alarm text "level too low" is output.

If the tag "max" (associated value 1) is 1, the alarm text "level too high" is output.

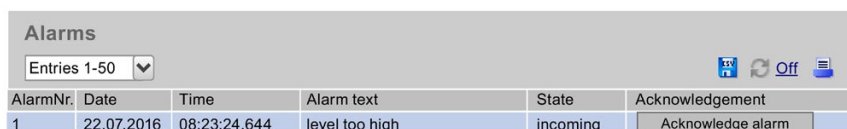
## Additional information

You can learn how to create multilingual texts under "Multilingual alarms" in the section Editing alarms in the alarm editor (Page 78).

## 6.5.4 Displaying the alarm

### Displaying the alarm in the Web server

The figure below shows the display of the alarm in the Web server for both examples.



| Alarms       |            |              |                |          |                   |
|--------------|------------|--------------|----------------|----------|-------------------|
| Entries 1-50 |            |              |                |          |                   |
| AlarmNr.     | Date       | Time         | Alarm text     | State    | Acknowledgement   |
| 1            | 22.07.2016 | 08:23:24.644 | level too high | incoming | Acknowledge alarm |

Figure 6-18 Displaying the alarm in the Web server

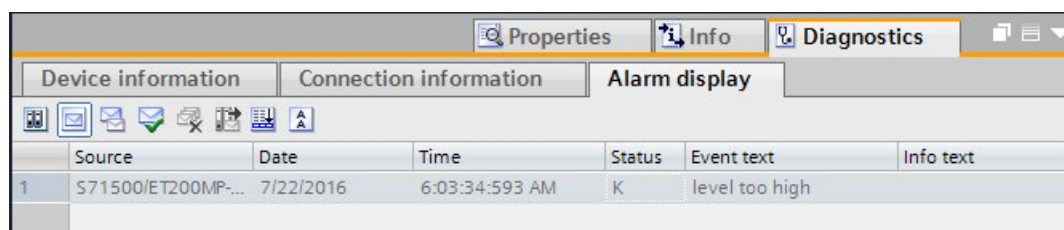
### Displaying the alarm in STEP 7

#### Note

#### Displaying alarms in STEP 7

To display alarms in STEP 7, enable the option "Receive alarms" in the shortcut menu of the CPU.

The figure below shows the display of the alarm in STEP 7 for both examples.



| Diagnostics        |                    |                        |                |               |                |           |
|--------------------|--------------------|------------------------|----------------|---------------|----------------|-----------|
| Device information |                    | Connection information |                | Alarm display |                |           |
|                    | Source             | Date                   | Time           | Status        | Event text     | Info text |
| 1                  | S71500/ET200MP-... | 7/22/2016              | 6:03:34:593 AM | K             | level too high |           |

Figure 6-19 Display in STEP 7

# Diagnostics of the S7-1500R/H redundant system

## S7-1500R/H diagnostics

Diagnostics for a S7-1500R/H redundant system is basically the same as a standard S7-1500. You have the following display options:

- Via STEP 7
- Via HMI devices
- Via the display of the CPUs

The CPUs provide information about their operating states as well as internal and external errors through their LEDs.

The special features of the diagnostics of S7-1500R/H redundant systems are described below. In addition, the information of the current function manual and the STEP 7 online help also apply to S7-1500R/H redundant systems.

## Diagnostics information in STEP 7

Hardware diagnostics can be performed as follows:

- Via the Online and Diagnostics view
- Via the "Online Tools" task card
- Via the "Diagnostics > Device Information" area of the Inspector window
- Via diagnostics icons, for example, in the device view and in the project tree



## Diagnostics view in STEP 7 in dependence on the online connection and system states

The diagnostics view for S7-1500R/H redundant systems is partly dependent on:

- Which of the two CPUs the programming device / PC currently has a connection to
- The current system state in the redundant system

The table below provides an overview. The following sections illustrate the diagnostics view for S7-1500R/H using examples.

Table 7- 1 Diagnostics view in dependence on the online connection and system states

| Diagnostics view in STEP 7                                                                              | An online connection is available to the | System state     | Examples in section                                                                                |
|---------------------------------------------------------------------------------------------------------|------------------------------------------|------------------|----------------------------------------------------------------------------------------------------|
| Online data and diagnostics of the redundant system                                                     | Primary CPU or backup CPU                | RUN-Redundant    | Online and Diagnostics view (Page 100)                                                             |
| Online data and diagnostics of the primary CPU<br>The following are not displayed:                      | Primary CPU                              | RUN-Solo or STOP | Online and Diagnostics view (Page 100) and<br>Restrictions in the RUN-Solo system state (Page 117) |
| • Online data and diagnostics from the backup CPU                                                       |                                          |                  |                                                                                                    |
| Online data and diagnostics of the backup CPU<br>The following are not displayed:                       | Backup CPU                               | RUN-Solo or STOP |                                                                                                    |
| • Online data and diagnostics from the primary CPU                                                      |                                          |                  |                                                                                                    |
| • Online data and diagnostics of the distributed I/O                                                    |                                          |                  |                                                                                                    |
| Display of the 3 operator panels in the "Online Tools" task card                                        | Primary CPU or backup CPU                | Not relevant     | "Online Tools" task card (Page 103)                                                                |
| Cycle time of the primary CPU (of the system) and memory of the primary CPU in "Online Tools" task card | Primary CPU or backup CPU                | RUN-Redundant    |                                                                                                    |
| Cycle time and memory of the primary CPU in the "Online Tools" task card                                | Primary CPU                              | RUN-Solo or STOP |                                                                                                    |
| Cycle time and memory of the backup CPU in the "Online Tools" task card                                 | Backup CPU                               | RUN-Solo or STOP |                                                                                                    |
| Memory reset of the primary CPU via "Online Tools" task card                                            | Primary CPU                              | STOP             |                                                                                                    |
| Memory reset of the backup CPU via "Online Tools" task card                                             | Backup CPU                               | RUN-Solo or STOP |                                                                                                    |
| "Alarm display" tab: Alarms from the primary CPU                                                        | Primary CPU                              | Not relevant     | Diagnostics view in the project tree and in the device view and network view (Page 106)            |
| "Alarm display" tab: Alarms from the backup CPU                                                         | Backup CPU                               | Not relevant     |                                                                                                    |
| Diagnostics of the distributed I/O                                                                      | Primary CPU or backup CPU                | RUN-Redundant    | Diagnostics in the RUN-Redundant system state (Page 111)                                           |
| Diagnostics of the distributed I/O                                                                      | Primary CPU                              | RUN-Solo         | Restrictions in the RUN-Solo system state (Page 117)                                               |

## **Accessible devices**

As for standard S7-1500 systems, the following can be displayed in STEP 7:

- All devices accessible from programming device/PC
- The diagnostics information of devices of a redundant system, for example, from the R/H CPUs

The procedure is described in the section Accessible devices (without project) (Page 31).

## 7.1 Online and Diagnostics view

### Introduction

You open the Online and Diagnostics view for the redundant system or for each CPU of the redundant system.

### Online & diagnostics for the redundant system

#### "Online access":

For the S7-1500R/H redundant system, it is displayed whether an online connection exists between the programming device/PC and a CPU. The additional note "Online (via Primary CPU)" or "Online (via Backup CPU)" indicates which role the "Online" connected CPU has.

If you enable "Receive alarms", you receive asynchronous alarms of diagnostics events from the CPU with online connection. The display corresponds to the representation for standard CPUs.

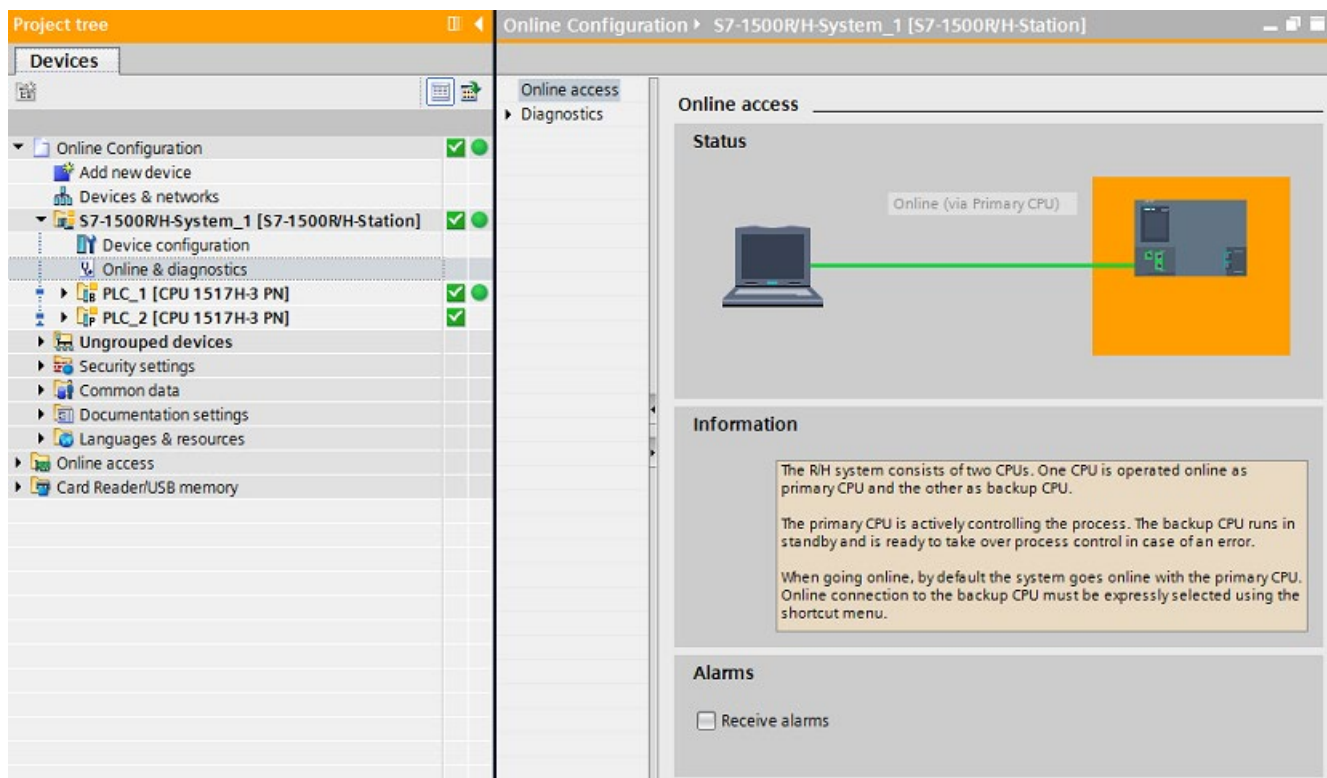


Figure 7-1 Online and Diagnostics view: Redundant system S7-1500R/H

**"Diagnostics":**

"Diagnostics" provides an overview for the redundant system about the:

- System state
- Pairing state
- Operating states of the CPU
- Status of which CPU is the primary CPU and which CPU is the backup CPU

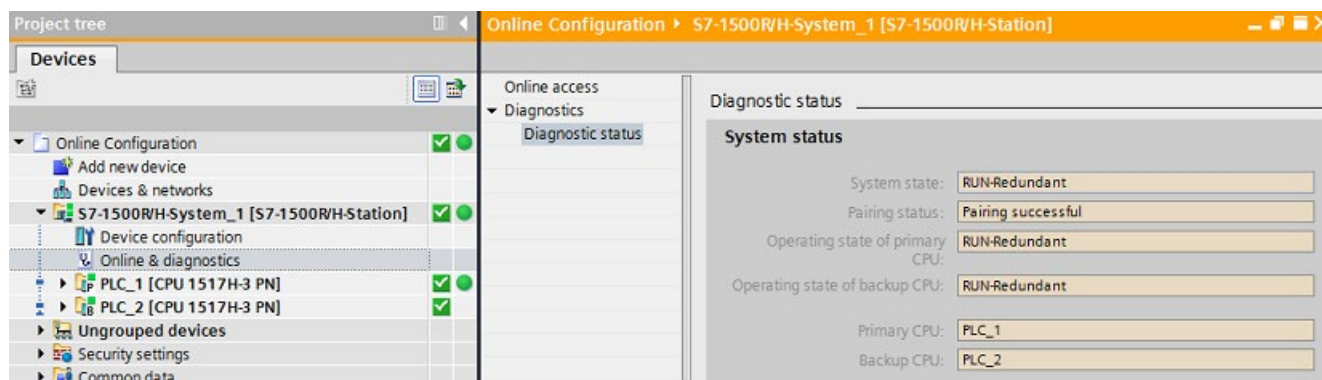


Figure 7-2 Online and Diagnostics view: Diagnostics status of the S7-1500R/H system

## Online & diagnostics for the primary CPU or backup CPU

The Online and Diagnostics view for the CPUs of the redundant system match the display for standard CPUs.

In the RUN-Redundant system state, the primary and backup CPU display the online data of the redundant system irrespective of which of the two CPUs the online connection has been made.

In non-redundant mode, the programming device/PC displays the data of the CPU for which there is an online connection, i.e. either the primary CPU or of the backup CPU.

You select the CPU for display of the online data in the project tree.

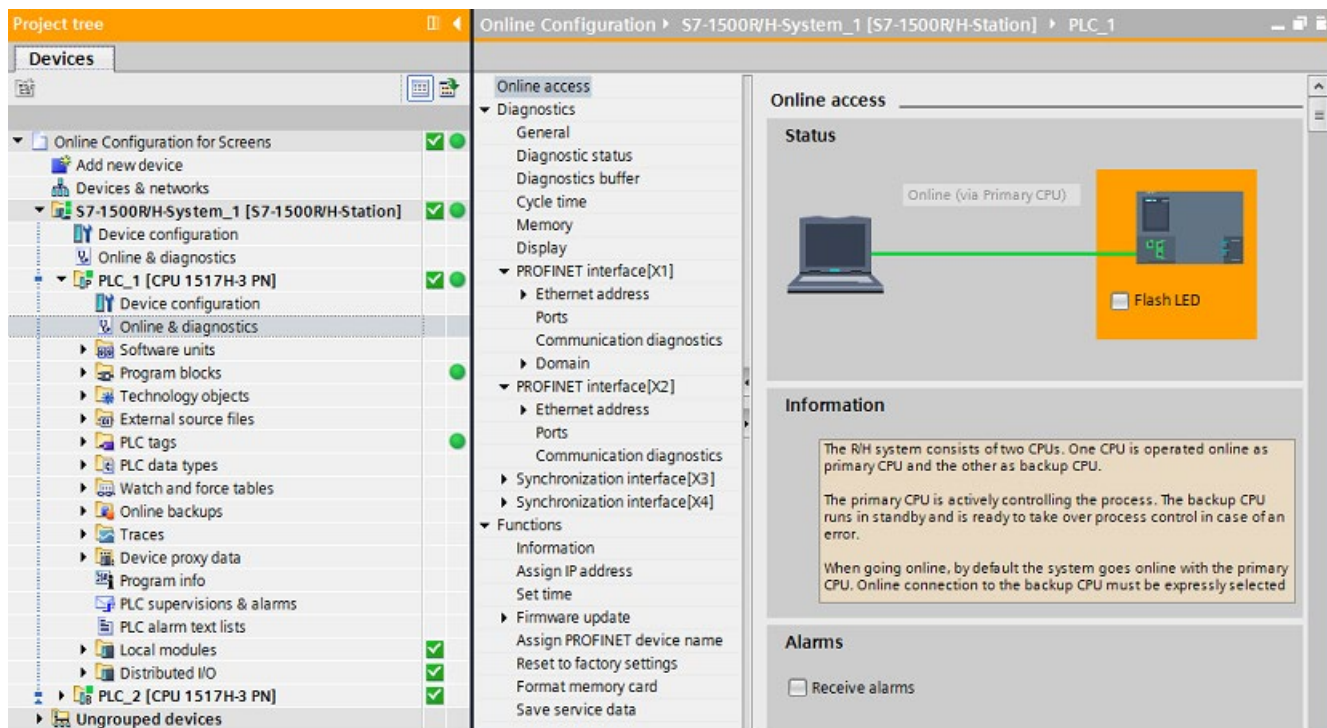


Figure 7-3 Online and Diagnostics view: CPU (RUN-Redundant system state)

## Reference

You can find information on the operating and system states in the Redundant System S7-1500R/H System Manual (<https://support.industry.siemens.com/cs/ww/en/view/109754833>).

## 7.2 "Online Tools" task card

### Introduction

If an online connection exists to a CPU of the redundant system, the "Online Tools" task card displays online information for the redundant system.

For a S7-1500R/H redundant system, "Online Tools" displays:

- 3 panes operator panel
- Cycle time
- Memory

### R/H system operator panel

For the redundant system, the "R/H system operator panel" pane shows the:

- Current states of the LEDs of the primary CPU
- System state
- Status of which CPU is the primary CPU and which CPU is the backup CPU with their current operating states

The "STOP R/H-System" button can be used to switch the S7-1500R/H system to the system state STOP.

---

#### Note

##### Reaching RUN-Redundant system state

Note that you cannot switch the S7-1500R/H to RUN-Redundant system state using the R/H-System operator panel. You reach the RUN-Redundant system state by switching the operating state for each CPU to RUN in the operator panel of the respective CPU.

---

### CPU operator panel

The two "CPU operator panel" panes show for the respective CPU of the redundant system:

- The role of the CPU, primary CPU or backup CPU
- The current states of the LEDs
- The operating state of the CPU

Use the "RUN / STOP" button to change the operating state for the respective CPU.

Use the "MRES" button to perform a memory reset for the CPU, under the following conditions:

- Online connection to this CPU is available
- The CPU is in STOP operating state.

The switch position at the real CPU is displayed under "Mode selector".

## Example

The following figure shows an example of the "Online Tools" task card for the RUN-Solo system state. The primary CPU is in RUN operating state, the backup CPU in STOP operating state.

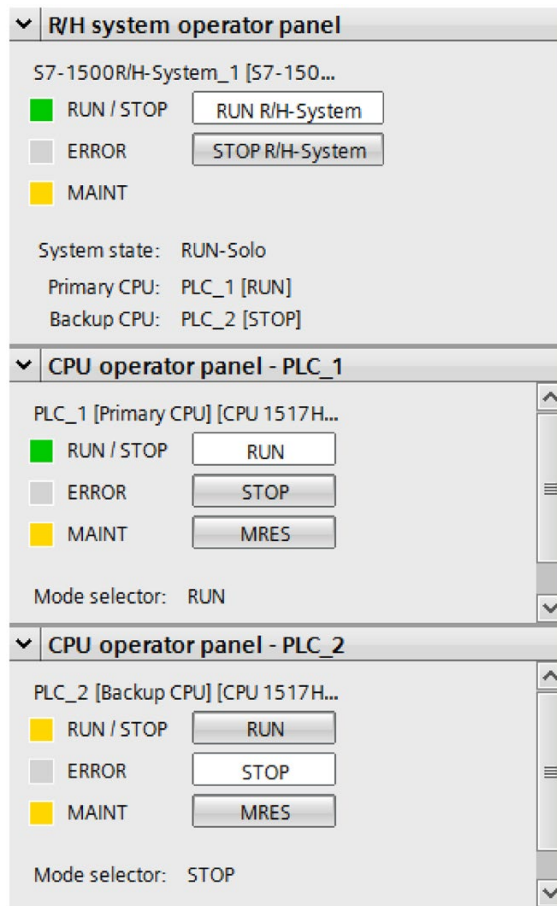


Figure 7-4 "Online Tools" task card: Operator panel (RUN-Solo system state)

## Cycle time and memory

In the RUN-Redundant system state, the "Cycle time" and "Memory" panes show the current values of the primary CPU. In redundant mode, the cycle time of the primary CPU matches the cycle time of the system.

In the RUN-Solo system state, the panes show the current values for the CPU for which there is an online connection.

The display corresponds to the representation for standard CPUs.

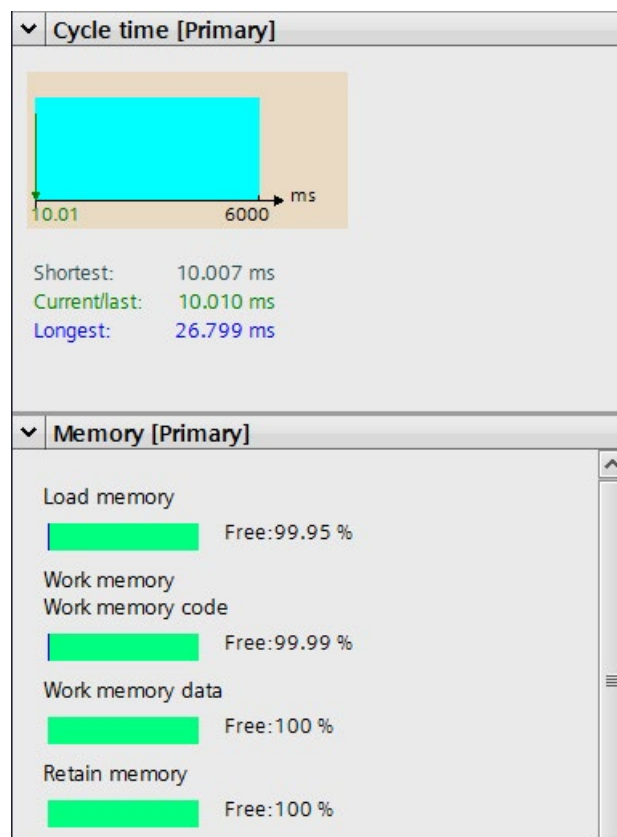


Figure 7-5 "Online Tools" task card: Cycle time and memory of the primary CPU

## Reference

You can find information on the operating and system states in the Redundant System S7-1500R/H System Manual (<https://support.industry.siemens.com/cs/ww/en/view/109754833>).



## 7.3 Diagnostics view in the project tree and in the device view and network view

### Additional icons for redundant systems in the project tree

Table 7- 2 Icons for redundant systems in the project tree of STEP 7

| Icon in the project tree                                                            | Meaning                                                                                                                                                                       |
|-------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|    | Identifier of the folder S7-1500R/H-System:<br>RUN-Redundant system state                                                                                                     |
|    | Identifier of the folder S7-1500R/H-System:<br>RUN-Solo system state                                                                                                          |
|    | Identifier of the folder S7-1500R/H-System:<br>STARTUP system state                                                                                                           |
|    | Identifier of the folder S7-1500R/H-System:<br>STOP system state                                                                                                              |
|    | Identifier of the folder for the primary CPU:<br>RUN operating state                                                                                                          |
|   | Identifier of the folder for the backup CPU:<br>RUN operating state                                                                                                           |
|  | Identifier of the folder for the primary CPU:<br>STARTUP operating state                                                                                                      |
|  | Identifier of the folder for the backup CPU:<br>STARTUP operating state                                                                                                       |
|  | Identifier of the folder for the primary CPU:<br>STOP operating state                                                                                                         |
|  | Identifier of the folder for the backup CPU:<br>STOP operating state                                                                                                          |
|  | Identifier of the folder of a CPU of the redundant system:<br>"Online via partner": The other CPU of the redundant system is connected online to the programming device / PC. |

### Example: Diagnostics view in the project tree and in the device view and network view

An example of the diagnostics view for a S7-1500R/H system is shown below.

The sample configuration consists of two CPUs S7-1517H-3 PN and one interface module IM 155-6 PN HF as PROFINET IO device. PLC\_1 is the primary CPU (in RUN operating state). PLC\_2 is the backup CPU (in STOP operating state). The hardware configuration and the user program were loaded in the primary CPU.

The system is connected online via PLC\_1 (primary CPU) and is in RUN-Solo system state.

## View of the system in the project tree

The system is in RUN-Solo system state . PLC\_1 is in RUN operating state , PLC\_2 is in STOP operating state .

Because the system is in RUN-Solo system state, the following is displayed:

- For the system, maintenance demanded with problem in lower-level component 
- For PLC\_1, maintenance demanded 

For PLC\_2, online connection via partner  is displayed, as the programming device/PC is connected online to PLC\_1.

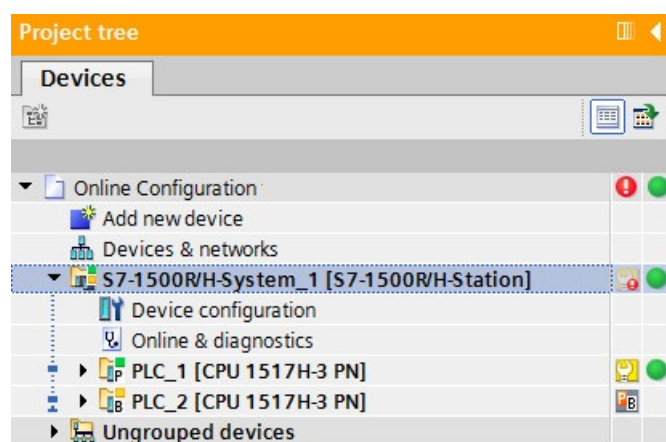


Figure 7-6 Diagnostics example: Redundant system project tree (RUN-Solo)

## Network view of the system

The network view shows no faults for the H-CPU or the IO device.

Maintenance demanded in lower-level component indicated for the system, since the system is not in the RUN-Redundant system state.

No operating states and system states of the redundant system are displayed in the network view.

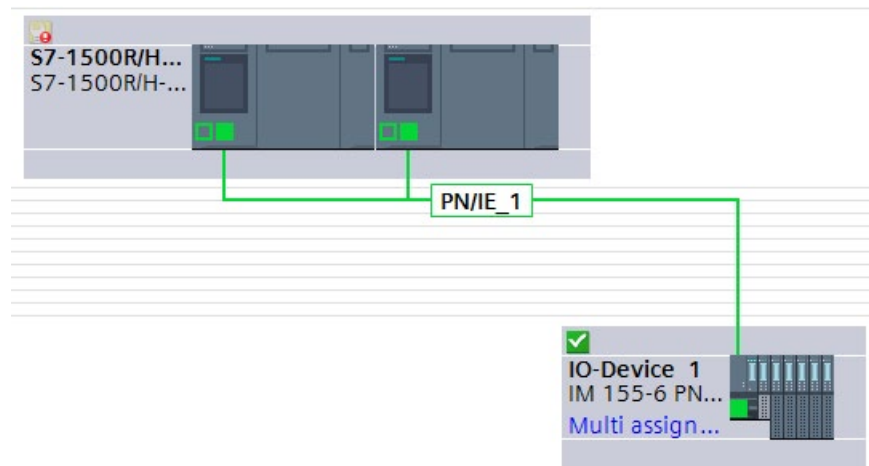


Figure 7-7 Diagnostics example: Network view of redundant system (RUN-Solo)

Doubling-clicking on the system gives you access to the device view of both CPUs.

## Device view of the system

In the device view, you see the operating states of the CPUs based on the icons above PLC\_1:

- Green icon: PLC\_1 is in the RUN operating state.
- Yellow icon (wrench) for maintenance demanded: PLC\_2 is in the STOP operating state.

PLC\_2 indicates that the online connection is available through the partner (PLC\_1).

You can find more detailed information on the system faults in the "Diagnostics" tab, in "Device information". The device information indicates maintenance demanded and RUN operating state for PLC\_1.

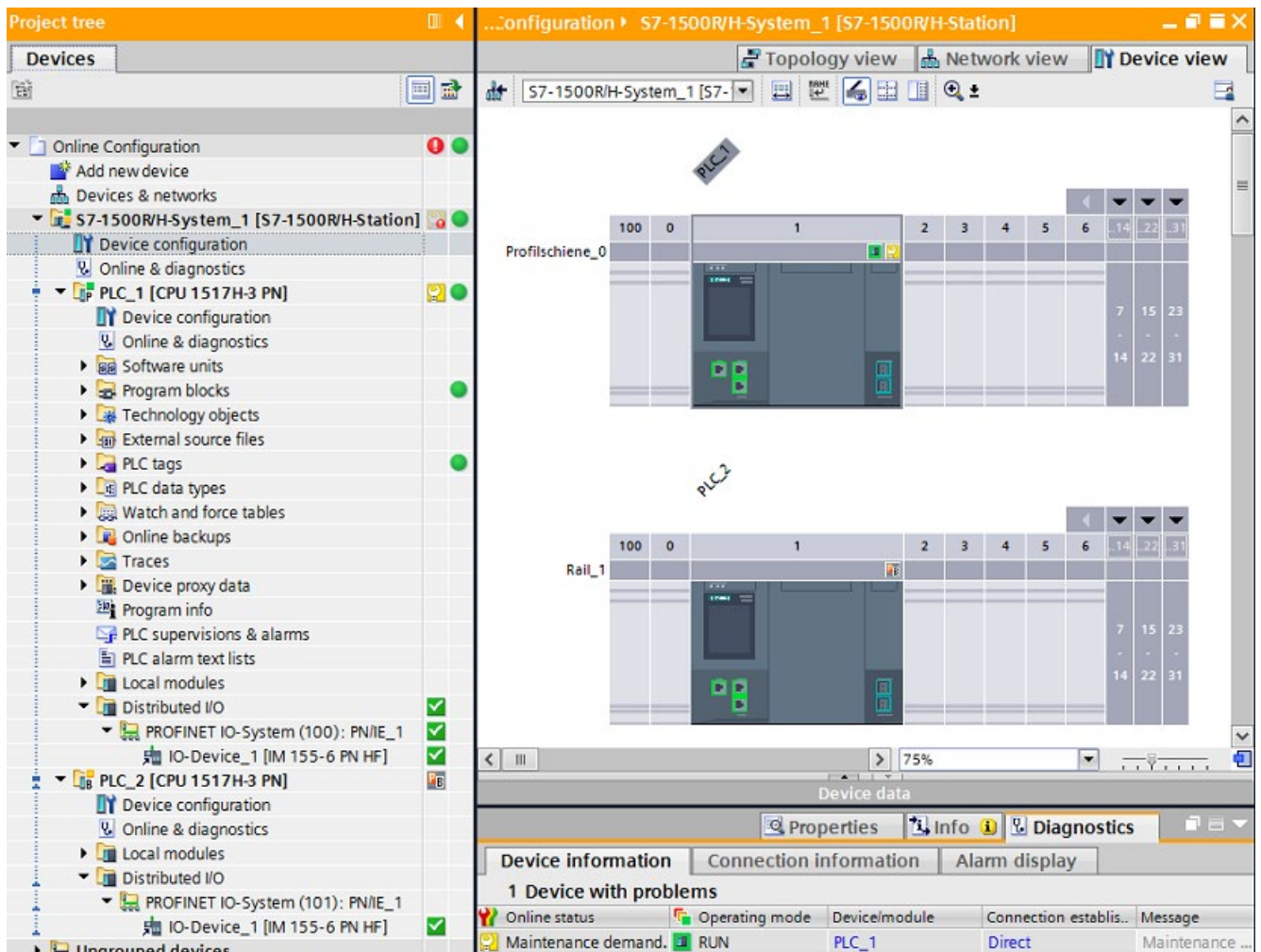


Figure 7-8 Diagnostics example: Device view of redundant system (RUN-Solo)

## Alarm display of the system

As in the RUN-Solo system state, the alarms of the CPU for which there is an online connection are displayed via the "Alarm display" tab (in the example from PLC\_1).

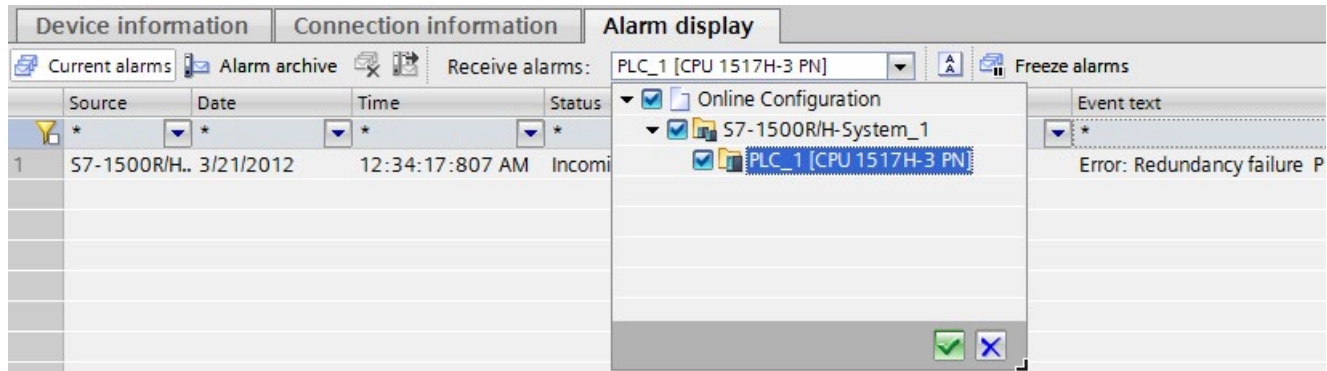


Figure 7-9 Diagnostics example: Alarm display of redundant system (RUN-Solo)

## Device view of the IO device

The IO device is an interface module IM 155-6 PN HF with two I/O modules and one server module. The device view shows that there is no faults in the modules.

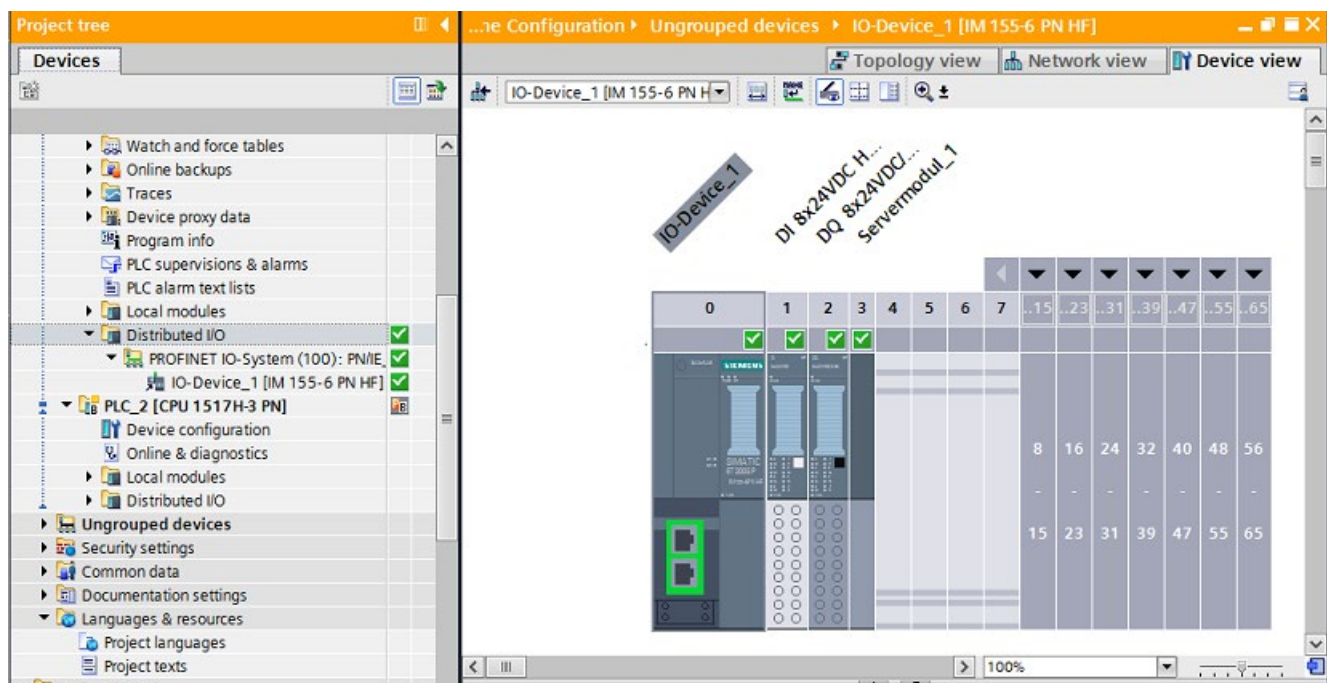


Figure 7-10 Diagnostics example: Device view of IO device



## 7.4 Diagnostics in the RUN-Redundant system state

### Diagnostics view in redundant mode

Primary CPU and backup CPU are each in the RUN-Redundant operating state.

In the RUN-Redundant system state, the primary and backup CPU display the online data of the redundant system irrespective of which of the two CPUs the online connection has been made.

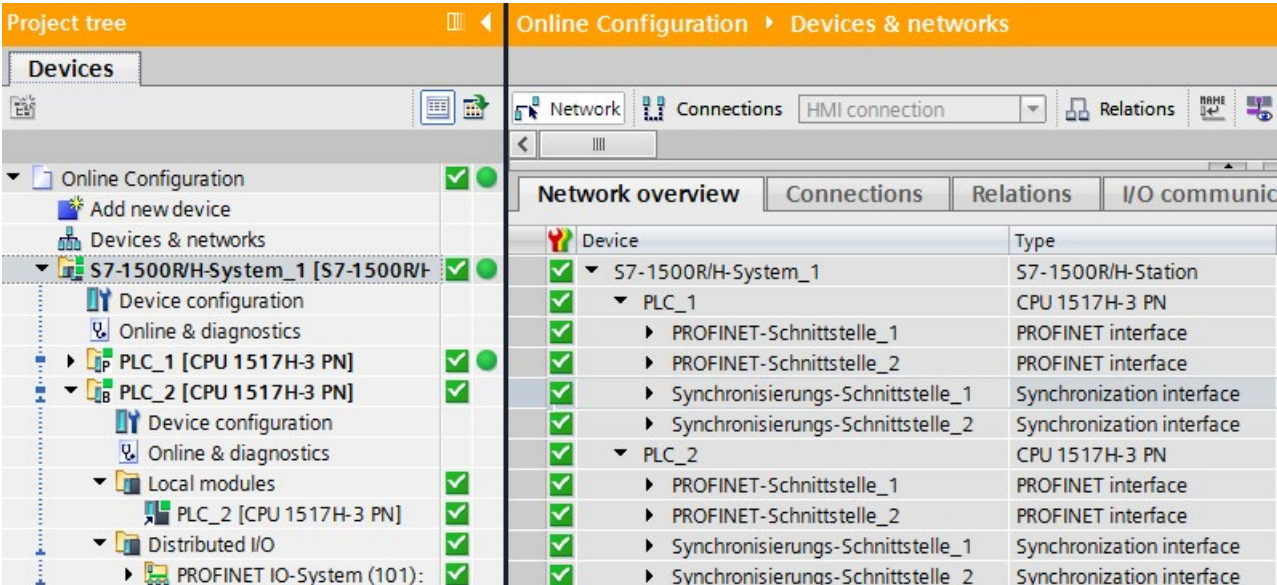
The diagnostics between the two CPUs is synchronized (diagnostics entries, diagnostics events).

The "Alarm display" tab shows the alarms of the redundant system.

You can find more information in the Diagnostics view in the project tree and in the device view and network view (Page 106).

### No error in RUN-Redundant system state

If no error is detected in the RUN-Redundant system state, all diagnostics icons in the project tree and in the network view show "No fault" .



| Project tree                     |   | Online Configuration ▶ Devices & networks |                                         |
|----------------------------------|---|-------------------------------------------|-----------------------------------------|
| Devices                          |   | Network                                   | Connections HMI connection              |
| Online Configuration             | ✓ | Network overview                          | Connections Relations I/O communication |
| Add new device                   |   | Device                                    | Type                                    |
| Devices & networks               |   | ✓ S7-1500R/H-System_1                     | S7-1500R/H-Station                      |
| S7-1500R/H-System_1 [S7-1500R/H] | ✓ | ✓ PLC_1                                   | CPU 1517H-3 PN                          |
| Device configuration             |   | ✓ PROFINET-Schnittstelle_1                | PROFINET interface                      |
| Online & diagnostics             |   | ✓ PROFINET-Schnittstelle_2                | PROFINET interface                      |
| PLC_1 [CPU 1517H-3 PN]           | ✓ | ✓ Synchronisierungs-Schnittstelle_1       | Synchronization interface               |
| PLC_2 [CPU 1517H-3 PN]           | ✓ | ✓ Synchronisierungs-Schnittstelle_2       | Synchronization interface               |
| Device configuration             |   | ✓ PLC_2                                   | CPU 1517H-3 PN                          |
| Online & diagnostics             |   | ✓ PROFINET-Schnittstelle_1                | PROFINET interface                      |
| Local modules                    | ✓ | ✓ PROFINET-Schnittstelle_2                | PROFINET interface                      |
| PLC_2 [CPU 1517H-3 PN]           | ✓ | ✓ Synchronisierungs-Schnittstelle_1       | Synchronization interface               |
| Distributed I/O                  | ✓ | ✓ Synchronisierungs-Schnittstelle_2       | Synchronization interface               |
| PROFINET IO-System (101):        | ✓ |                                           |                                         |

Figure 7-11 Diagnostics example: No fault in the RUN-Redundant project tree

## **Error in the RUN-Redundant system state**

Most errors in the redundant system do not result in a loss of redundancy. The RUN-Redundant system state is retained, for example, if a module in an IO device fails. The diagnostics view is similar to the standard S7-1500 systems.

In the RUN-Redundant system state the redundancy of the system can be restricted, e.g. during the interruption of one of the two redundancy connections in S7-1500H. You can find information on the redundancy scenarios in the Redundant System S7-1500R/H System Manual (<https://support.industry.siemens.com/cs/ww/en/view/109754833>).

Special examples of a redundant system S7-1500H are shown below:

### **S7-1500H Example 1:**

The PROFINET ring between the CPU of the redundant S7-1500H system and an IO device was interrupted.

### **Evaluate diagnostics via LINK TX/RX LEDs on the CPU**

TX/RX X1 P1 LED is not illuminated. This means:

- No Ethernet connection between the P1 port of the respective PROFINET interface and the communication partner

### Diagnostics in STEP 7

The diagnostics buffer of the CPU displays that the PROFINET ring is open.

The diagnostics in the project tree shows:

- Maintenance demanded in lower-level component in the S7-1500H system
- Maintenance demanded in lower-level components of PLC\_1 and PLC\_2
- Maintenance demanded in lower-level components of local modules of PLC\_2

The diagnostics in the network view indicates errors at the affected port of the PROFINET interfaces of PLC\_2.

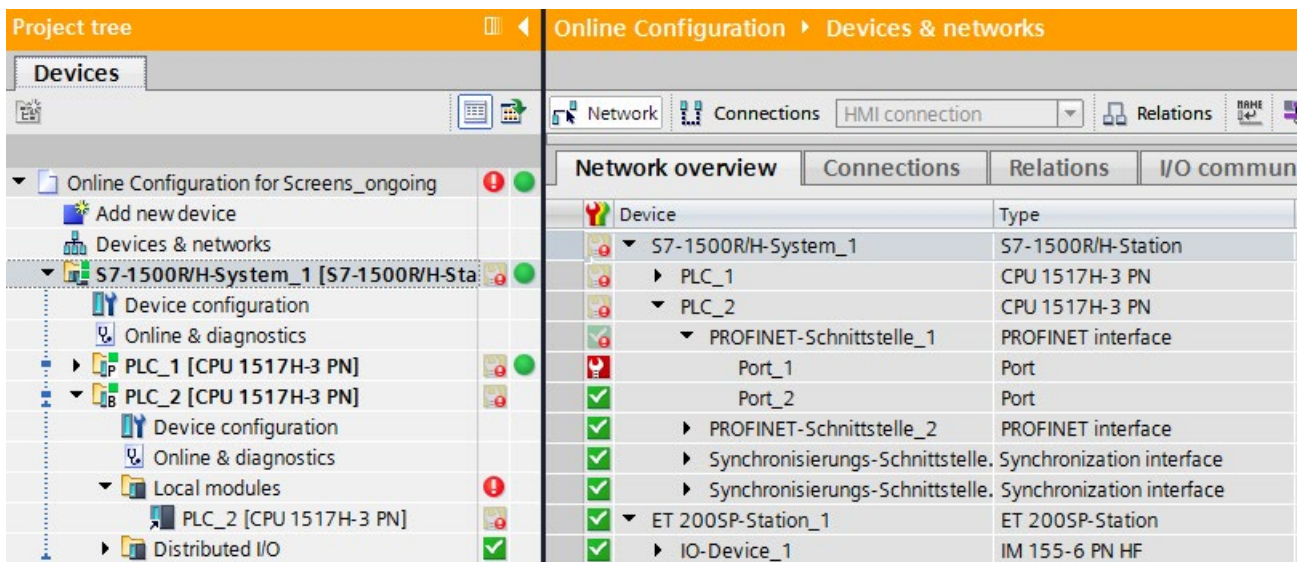


Figure 7-12 Diagnostics example: RUN-Redundant system state, open PROFINET ring

You can evaluate the diagnostics using the displays of the CPUs via the "Diagnostics" menu as with standard CPUs. You can find additional information in the section Display of the CPU (Page 27).

### S7-1500H Example 2:

A synchronization module has been removed from a CPU of the redundant S7-1500H system.

### Evaluating diagnostics via X3 and X4 LEDs on the CPU

The X3 LED on PLC\_2 CPU is not illuminated. This means:

- The redundancy connection on the synchronization module was interrupted at the H-Sync interface X3.
- or
- There is no synchronization module at the H-Sync interface X3.



**Diagnostics in STEP 7**

The diagnostics buffer of the CPU displays:

- that there is only one redundancy connection
- which synchronization module has failed on which CPU

The diagnostics in the project tree shows:

- Maintenance demanded in lower-level component in the S7-1500H system
- Maintenance demanded in lower-level components of PLC\_1 and PLC\_2
- Maintenance demanded in lower-level components of local modules of PLC\_1 and PLC\_2

The diagnostics in the network view displays:

- Errors for the Synchronisationsmodul\_1 of the Synchronisationsschnittstelle\_2 of PLC\_1
- Synchronisationsmodul\_1 of Synchronisationsschnittstelle\_1 of PLC\_2 not reachable

The screenshot displays the STEP 7 software interface. On the left, the 'Project tree' shows the project structure for 'Projekt DLiRR\_Diag'. It includes a 'Devices & networks' section with 'S7-1500R/H-System\_1' and two PLCs, 'PLC\_1 [CPU 1517H-3 PN]' and 'PLC\_2 [CPU 1517H-3 PN]'. The 'PLC\_1' and 'PLC\_2' entries show red error icons. On the right, the 'Network overview' tab is active, showing a table of network components. The table has columns for 'Device' and 'Type'. The components listed include 'S7-1500R/H-Station', 'CPU 1517H-3 PN', 'PROFINET-Schnittstelle', 'Synchronisationsmodul', and 'ET 200SP-Station'. Red icons in the 'Device' column indicate errors for 'Synchronisationsmodul\_1' of 'Synchronisationsschnittstelle\_2' of 'PLC\_1' and 'Synchronisationsmodul\_1' of 'Synchronisationsschnittstelle\_1' of 'PLC\_2'.

| Device                          | Type                          |
|---------------------------------|-------------------------------|
| S7-1500R/H-System_1             | S7-1500R/H-Station            |
| PLC_1                           | CPU 1517H-3 PN                |
| PROFINET-Schnittstelle_1        | PROFINET-Schnittstelle        |
| PROFINET-Schnittstelle_2        | PROFINET-Schnittstelle        |
| Synchronisationsschnittstelle_1 | Synchronisationsschnittstelle |
| Synchronisationsschnittstelle_2 | Synchronisationsschnittstelle |
| Synchronisationsmodul_1         | Synchronisationsmodul         |
| PLC_2                           | CPU 1517H-3 PN                |
| PROFINET-Schnittstelle_1        | PROFINET-Schnittstelle        |
| Port_1                          | Port                          |
| Port_2                          | Port                          |
| PROFINET-Schnittstelle_2        | PROFINET-Schnittstelle        |
| Synchronisationsschnittstelle_1 | Synchronisationsschnittstelle |
| Synchronisationsmodul_1         | Synchronisationsmodul         |
| Synchronisationsschnittstelle_2 | Synchronisationsschnittstelle |
| ET 200SP-Station_1              | ET 200SP-Station              |
| IO-Device_1                     | IM 155-6 PN HF                |

Figure 7-13 Diagnostics example: RUN-Redundant system state, a synchronization module fails

### Evaluate diagnostics on the display

For example 2, display of the PLC\_2 CPU shows:



- In the "Overview" menu command: A message is available in the next lower level page.
- In the "Diagnostics" menu command: A message is available in the next lower level page.
- In the Module menu command: An error has occurred.

To evaluate the display, proceed as follows:

1. Navigate to "Pairing state" via the menu commands "Overview" > "Redundancy".
2. This is displayed as the pairing state: Single paired (X4).

This means that the redundancy connection is available at the H-Sync interface X4, but not at the X3.

3. Navigate to "Alarms" via the "Diagnostics" menu command.
4. View the details of the alarm (evaluate diagnostics buffer).

### S7-1500H Example 3:

A redundancy connection in S7-1500H is interrupted.

#### Evaluating diagnostics via X3 and X4 LEDs on the CPU

The LED X4 on CPU PLC\_1 does not light up. This means:

- The redundancy connection on the synchronization module was interrupted at the H-Sync interface X4.
- or
- There is no synchronization module at the H-Sync interface X4.

**Diagnostics in STEP 7**

The diagnostics buffer of the CPU displays:

- that there is only one redundancy connection
- Fiber-optic error with specification of the CPU and the synchronization module

The diagnostics in the project tree shows:

- Maintenance demanded in lower-level component in the S7-1500H system
- Maintenance demanded in lower-level components of PLC\_1 and PLC\_2
- Maintenance demanded in lower-level components of local modules of PLC\_1 and PLC\_2

The diagnostics in the network view displays:

- Errors for the Synchronisationsmodul\_1 of the Synchronisationsschnittstelle\_2 of PLC\_1
- Errors for the Synchronisationsmodul\_1 of the Synchronisationsschnittstelle\_1 of PLC\_2

The screenshot displays the STEP 7 software interface. On the left, the 'Project tree' shows the project structure for 'Projekt DLiRR\_Diag'. It includes a 'Devices' section with 'S7-1500R/H-System\_1' and its components 'PLC\_1' and 'PLC\_2'. The 'PLC\_1' component is expanded, showing its 'Local modules' and 'Distributed I/O'. On the right, the 'Network overview' tab is active, showing a table of devices and their connections. The table lists devices such as 'S7-1500R/H-System\_1', 'PLC\_1', 'PLC\_2', 'ET 200SP-Station\_1', and 'IO-Device\_1'. A red error icon is visible next to 'Synchronisationsmodul\_1' under 'Synchronisationsschnittstelle\_1' of 'PLC\_2'.

| Device                          | Type                          |
|---------------------------------|-------------------------------|
| S7-1500R/H-System_1             | S7-1500R/H-Station            |
| PLC_1                           | CPU 1517H-3 PN                |
| PROFINET-Schnittstelle_1        | PROFINET-Schnittstelle        |
| PROFINET-Schnittstelle_2        | PROFINET-Schnittstelle        |
| Synchronisationsschnittstelle_1 | Synchronisationsschnittstelle |
| Synchronisationsschnittstelle_2 | Synchronisationsschnittstelle |
| Synchronisationsmodul_1         | Synchronisationsmodul         |
| PLC_2                           | CPU 1517H-3 PN                |
| PROFINET-Schnittstelle_1        | PROFINET-Schnittstelle        |
| Port_1                          | Port                          |
| Port_2                          | Port                          |
| PROFINET-Schnittstelle_2        | PROFINET-Schnittstelle        |
| Synchronisationsschnittstelle_1 | Synchronisationsschnittstelle |
| Synchronisationsmodul_1         | Synchronisationsmodul         |
| Synchronisationsschnittstelle_2 | Synchronisationsschnittstelle |
| ET 200SP-Station_1              | ET 200SP-Station              |
| IO-Device_1                     | IM 155-6 PN HF                |

Figure 7-14 Diagnostics example: RUN-Redundant system state, a redundancy connection has failed

**Evaluate diagnostics on the display**

Perform the analysis of the display of PLC\_2 CPU exactly as for example 2.

## 7.5 Restrictions in the RUN-Solo system state

The primary CPU is in RUN operating state. The Backup CPU is in STOP operating state, is switched off, defective, or not available.

### Restrictions in the RUN-Solo system state

The primary CPU records the diagnostics states of the distributed I/O.

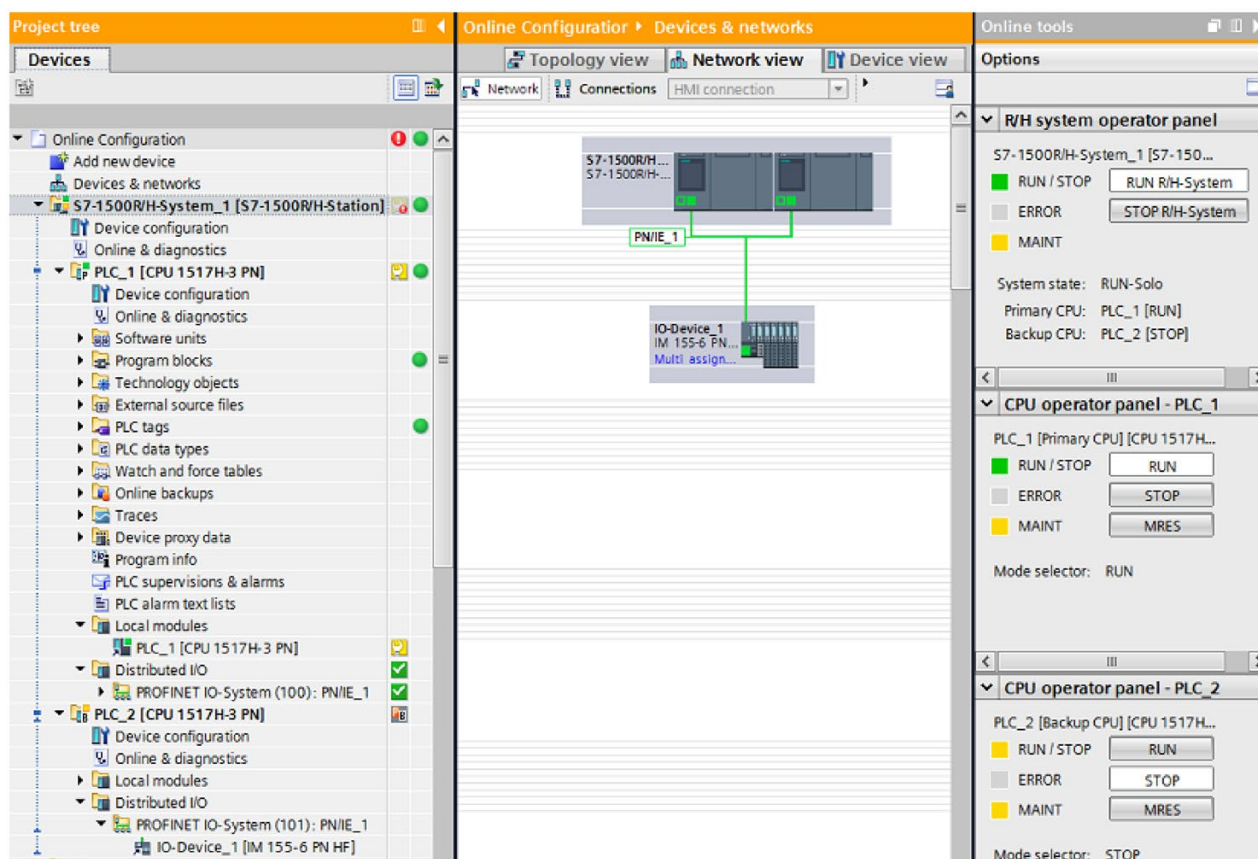


Figure 7-15 Diagnostics of the primary CPU and backup CPU in RUN-Solo system state

### Diagnostics of the backup CPU

The following restrictions apply to the backup CPU:

- Diagnostics information from the backup CPU is only available when there is an online connection to the backup CPU.
- A memory reset can only be performed with the backup CPU operator panel when an online connection to the backup CPU is available.

## Reference

You can evaluate the diagnostics using the displays of the CPUs via the "Diagnostics" menu as with standard CPUs. You can find additional information in the section Display of the CPU (Page 27).

## 7.6 System diagnostics by means of the user program

### Instructions

Instructions for determining the system diagnostics are listed in the section System diagnostics options in the user program (Page 71).

The following instruction for diagnostics cannot be used for S7-1500R/H redundant systems:

- DPNRM\_DG: Read diagnostics data from a DP slave

### Organization blocks

You can find the description of the applicable OBs for S7-1500R/H in the S7-1500R/H redundant system (<https://support.industry.siemens.com/cs/ww/en/view/109754833>) system manual.

# Glossary

## Alarm

An message sent to the operator due to events or states of the system.

## Backup CPU

Role of a CPU in the S7-1500R/H redundant system. If the R/H system is in RUN-Redundant system state, the primary CPU controls the process. The backup CPU processes the user program synchronously and can take over the process control if the primary CPU fails.

## Button (WinCC)

Object in WinCC that points out faults in the plant

## Channel fault

Channel-related error of an individual channel - an I/O with inputs, for example, wire break or short circuit

## Device

Modules with a network connection are referred to as device. Devices are installed on racks where they can be interconnected with other modules.

## Diagnostics buffer

A buffered memory area in the CPU; it stores diagnostics events in the order of their occurrence

## Firmware of the CPU

In SIMATIC, a distinction is made between the firmware of the CPU and user programs.

The firmware is a software embedded in electronic devices, which means it is permanently connected with the hardware functionally. It is usually saved in a flash memory, such as EPROM, EEPROM or ROM, and cannot be replaced by the user or only with special means or functions.

User program: see glossary entry "User program"

## Global screen (WinCC)

A screen that is opened in the system diagnostics window is a global screen.

## HMI device

Human Machine Interface, device for visualization and control of automation processes.

## HMI diagnostics view (WinCC)

The HMI diagnostics view is an object in WinCC. The HMI diagnostics view can only be used with Comfort Panels and WinCC Advanced RT.

## I/O module

Device of the distributed I/O that is used as interface between the controller and the process.

## Industrial Ethernet

Guideline for setting up Ethernet in an industrial environment. The main difference to the standard Ethernet is the mechanical current carrying capacity and interference immunity of the individual components.

## Memory reset

Procedure to set the memories of the CPU to a defined initial state.

## Operating states

Operating states describe the behavior of a single CPU at a specific time.

The CPUs of the SIMATIC standard systems feature the STOP, STARTUP and RUN operating states.

The primary CPU of the S7-1500R/H features the STOP, STARTUP, RUN, RUN-Syncup and RUN-Redundant operating states. The backup CPU features the STOP, SYNCUP and RUN-Redundant operating states.

## PLC

**Programmable Logic Controller:** Component of the CNC by which the machine manufacturer coordinates the interaction between the NC requirements (part program), the inputs of the machine operator and the current machine state.

## Primary CPU

Role of a CPU in the S7-1500R/H redundant system. If the R/H system is in RUN-Redundant system state, the primary CPU controls the process. The backup CPU processes the user program synchronously and can take over the process control if the primary CPU fails.

## PROFIBUS

Standard for fieldbus communication in automation technology.



**PROFINET**

PROcess Field NETwork, open industrial Ethernet standard which further develops PROFIBUS and industrial Ethernet. A cross-manufacturer communication, automation, and engineering model defined by PROFIBUS International e.V., as an automation standard.

**Redundant systems**

Redundant systems are identified by the fact that important automation components are available in multiple units (redundant). Process control is maintained if a redundant component fails.

**Subnet**

Part of a network whose parameters must be synchronized with the devices (e.g., with PROFINET). It includes the bus components and all connected stations. Subnets can be linked by means of gateways, for example, to form a network.

**Synchronization module**

The synchronization module is used to provide a redundant connection between the CPUs of the S7-1500H redundant system. You require two synchronization modules per CPU, which you connect using a fiber-optic cable.

**System diagnostics**

In the SIMATIC environment, the term "system diagnostics" refers to diagnostics of devices and modules. System diagnostics is used, for example, to monitor the states of the following components in the system: Power supply, device, I/O.

**System diagnostics indicator (WinCC)**

The system diagnostics indicator is a predefined graphic symbol of the library which alerts you to errors in your plant and displays two states: No error, error

**System states**

The system states of the S7-1500R/H redundant system result from the operating states of the primary and backup CPU. The term 'system state' is used as simple expression that identifies the operating states of the two CPUs that occur at the same time. The S7-1500R/H redundant system features the system states STOP, STARTUP, RUN-Solo, SYNCUP and RUN-Redundant.



## Topology

Structure of a network. Common structures include:

- Linear bus topology
- Ring topology
- Star topology
- Tree topology

## User program

In SIMATIC, a distinction is made between user programs and the firmware of the CPU.

The user program contains all instructions, declarations and data by which a plant or process can be controlled. It is assigned to a programmable module (for example, CPU, FM) and can be structured in smaller units.

Firmware: see glossary entry "Firmware of the CPU"

## Value status

The value status describes a specific signal state. The value status is constantly updated and cyclically transmitted by the field device as quality statement together with the measured value.

## Web server

Software/ communication service for data exchange using Ethernet. The web server provides the documents by means of standardized transmission protocols (HTTP, HTTPS) to a web browser. Documents can be static or dynamic upon request by the web browser composed from different sources by the web server.

## WinCC

**Windows Control Center:** a PC-based process visualization system

## WinCC Runtime

Component of the basic software WinCC

# Index

## "

- "Diagnostics" tab
  - Alarm display, 39
  - Connection information, 39
  - Device information, 39
  - Inspector window, 39

## A

- Accessible devices
  - Diagnostics status, 31
  - Offline project, 31
  - S7-1500R/H, 99
- Alarm display
  - Active alarms, 41
  - Archive view, 41
- Alarms
  - Editing in the alarm editor, 79
  - Multilingual, 80
- Application examples
  - Diagnostic overview for SIMATIC S7-1200 and S7-1500, 72

## B

- Backup CPU, 102, 117

## D

- Device information
  - Online status, 39
  - Operating mode, 39
- Devices & networks
  - Current state, 33
  - Go online, 33
- Diagnostics buffer
  - Diagnostic events, 42
  - Retentive memory, 42
- Display of the CPU
  - Display options, 27
  - Input options, 27
  - Status information, 27
- dynamize
  - Object appearance, 68

## F

- FAQs
  - Download certificate, 51
  - Implementing channel diagnostics in the user program, 72

## H

- HMI
  - System diagnostics view, 59
  - System diagnostics window, 59
- HMI diagnostics view
  - Comfort Panels, 59
  - Details view, 63
  - Device view, 63
  - Distributed I/O view, 63
  - Views, 63
  - WinCC Advanced RT, 59

## I

- I/O module
  - Inputs, 47
  - Settings, 47

## L

- LED arrangement, 26
- Library
  - System diagnostics indicator, 66

## O

- Online & diagnostics
  - Activities, 36
  - Information, 36
  - Online access, 36
  - Online mode, 36
  - S7-1500R/H, 100
- Online tools
  - CPU operator panel, 45
  - Cycle time, 45
  - Memory, 45
  - Memory usage, 45

- Online view, 45
- S7-1500R/H, 103
- Task card, 45

## P

- Primary CPU, 102, 117
- Process image inputs, 73
  - Quality Information, 73
  - User datum, 73
  - Value status, 73

## Q

- Quick start, 15
  - Using display, 16
  - Using STEP 7, 18

## R

- Redundancy connection, 115
- Redundant mode
  - Diagnostics, 111
- Redundant system, 100
- RUN-Redundant system state
  - Diagnostics, 111
- RUN-Solo system state
  - Diagnostics, 117

## S

- S7-1500H, 113
- S7-1500R/H
  - Diagnostics, 97
  - Instructions, 118
  - Organization blocks, 118
- Security events, 45
- Setting options, 23
- Symbol
  - For comparison, 30
  - For hardware diagnostics, 29
  - For operating mode, 30
  - For software diagnostics, 30
- Synchronization module, 113
- System diagnostics
  - Advantages, 14
  - Alarm settings, 24
  - Button, 68
  - Display concept, 14
  - Properties, 12

- System diagnostics indicator
  - Button as system diagnostics indicator, 68
  - Inserting, 66
  - System diagnostics window, 66
- System diagnostics view, 59
  - Configuring, 60
  - System diagnostics indicator, 66
- System diagnostics window, 59
  - Configuring, 60
  - Global screen, 60

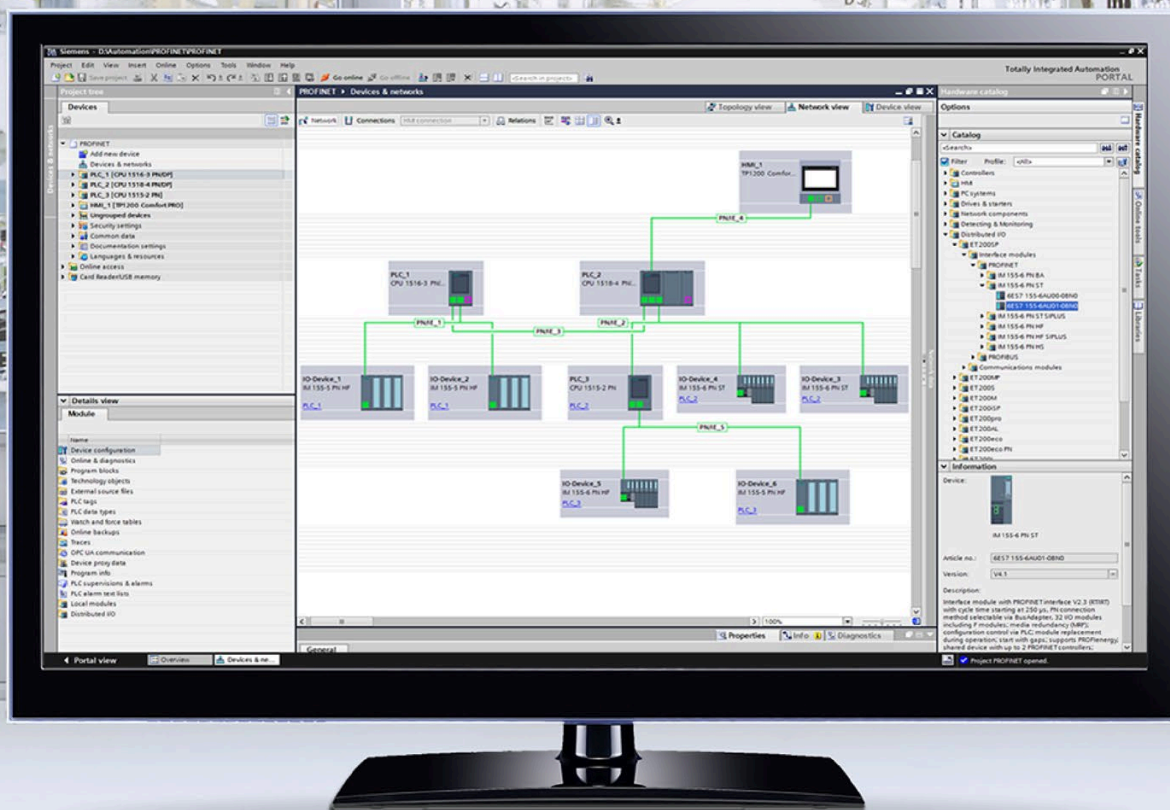
## U

- User program
  - Instructions, 71
  - Response to diagnostics alarms, 71

## W

- Web server
  - Access to, 51
  - Activating, 49
  - Alarms, 54
  - Browser, 48
  - Certificate, 49
  - Configuring, 49
  - Diagnostics, 52
  - Diagnostics buffer, 53
  - HTTPS, 49
  - Integrated Web server, 48
  - Module information, 54
  - Motion Control diagnostics, 57
  - Topology, 56
  - Trace, 58
  - Web pages, 48

# SIEMENS



Function manual

## SIMATIC

### S7-1500, ET 200MP, ET 200SP, ET 200AL, ET 200pro

Communication

Edition

05/2021

[support.industry.siemens.com](https://support.industry.siemens.com)

## SIMATIC

### S7-1500, ET 200MP, ET 200SP, ET 200AL, ET 200pro, ET 200eco PN Communication

#### Function Manual

#### Preface

|                                                          |    |
|----------------------------------------------------------|----|
| Function manuals<br>Documentation Guide                  | 1  |
| Product overview                                         | 2  |
| Communications services                                  | 3  |
| PG communication                                         | 4  |
| HMI communication                                        | 5  |
| Open User Communication                                  | 6  |
| S7 communication                                         | 7  |
| Point-to-point link                                      | 8  |
| OPC UA communication                                     | 9  |
| Addressing via DHCP                                      | 10 |
| Routing                                                  | 11 |
| Connection resources                                     | 12 |
| Diagnostics and fault<br>correction                      | 13 |
| Communication with the<br>redundant system<br>S7-1500R/H | 14 |
| Industrial Ethernet Security<br>with CP 1543-1           | 15 |

## Legal information

### Warning notice system

This manual contains notices you have to observe in order to ensure your personal safety, as well as to prevent damage to property. The notices referring to your personal safety are highlighted in the manual by a safety alert symbol, notices referring only to property damage have no safety alert symbol. These notices shown below are graded according to the degree of danger.

#### **DANGER**

indicates that death or severe personal injury **will** result if proper precautions are not taken.

#### **WARNING**

indicates that death or severe personal injury **may** result if proper precautions are not taken.

#### **CAUTION**

indicates that minor personal injury can result if proper precautions are not taken.

#### **NOTICE**

indicates that property damage can result if proper precautions are not taken.

If more than one degree of danger is present, the warning notice representing the highest degree of danger will be used. A notice warning of injury to persons with a safety alert symbol may also include a warning relating to property damage.

### Qualified Personnel

The product/system described in this documentation may be operated only by **personnel qualified** for the specific task in accordance with the relevant documentation, in particular its warning notices and safety instructions. Qualified personnel are those who, based on their training and experience, are capable of identifying risks and avoiding potential hazards when working with these products/systems.

### Proper use of Siemens products

Note the following:

#### **WARNING**

Siemens products may only be used for the applications described in the catalog and in the relevant technical documentation. If products and components from other manufacturers are used, these must be recommended or approved by Siemens. Proper transport, storage, installation, assembly, commissioning, operation and maintenance are required to ensure that the products operate safely and without any problems. The permissible ambient conditions must be complied with. The information in the relevant documentation must be observed.

### Trademarks

All names identified by ® are registered trademarks of Siemens AG. The remaining trademarks in this publication may be trademarks whose use by third parties for their own purposes could violate the rights of the owner.

### Disclaimer of Liability

We have reviewed the contents of this publication to ensure consistency with the hardware and software described. Since variance cannot be precluded entirely, we cannot guarantee full consistency. However, the information in this publication is reviewed regularly and any necessary corrections are included in subsequent editions.

# Preface

## Purpose of the documentation

This function manual provides you with an overview of the communication options, the CPUs, communication modules and processors and PC systems of the systems SIMATIC S7-1500, ET 200MP, ET 200SP, ET 200AL, ET 200pro and SIMATIC Drive Controller. This function manual describes the connection-oriented, asynchronous communication.

The documentation covers the following:

- Overview of the communication services
- Properties of the communication services
- Overview of the user activities for setting up the communication services

## Basic knowledge required

The following knowledge is required in order to understand the Function manual:

- General knowledge of automation technology
- Knowledge of the industrial automation system SIMATIC
- Knowledge about how to use STEP 7 (TIA Portal)

## Scope of the documentation

This documentation is the basic documentation for all products of the SIMATIC S7-1500, ET 200MP, ET 200SP, ET 200AL and ET 200pro systems. The product documentation is based on this documentation.

## What's new in the Communication Function Manual, Edition 05/2021 as compared to Edition 11/2019?

| What's new?                                                        | What are the customer benefits?                                                                                                                                                                                                                                                                                                                                                                                                                                                  | Where can I find the information?                                   |
|--------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------|
| Improved security for SIMATIC PG/HMI communication                 | <ul style="list-style-type: none"> <li>Allows unique identification of each PLC based on individual certificates</li> <li>Provides additional confidentiality protection through encrypted communication</li> <li>Protection of the configuration data through individual passwords</li> </ul>                                                                                                                                                                                   | Secure PG/HMI communication (Page 92)                               |
| Security wizard for new PLC security mechanisms                    | <ul style="list-style-type: none"> <li>Quick and easy configuration of the new security mechanisms of the PLC in one operation</li> <li>Supporting information to select suitable settings for own application</li> </ul>                                                                                                                                                                                                                                                        | Protection of confidential configuration data (Page 61)             |
| Certificate management via OPC UA<br>Global Discovery Server (GDS) | <ul style="list-style-type: none"> <li>Certificate update during runtime</li> <li>Support of CRLs</li> <li>Access protection for certificate management</li> </ul>                                                                                                                                                                                                                                                                                                               | Certificate management via Global Discovery Server (GDS) (Page 185) |
| Transferring CPU alarms to OPC UA clients                          | <ul style="list-style-type: none"> <li>Subscriptions allow clients to subscribe to CPU alarms as "Alarms and Conditions" from the OPC UA server of the CPU.</li> <li>Program messages including associated values are made available by the OPC UA server</li> <li>Alarms requiring acknowledgement can be acknowledged by the OPC UA client (can be disabled)</li> <li>An alarm burst is displayed as "overload" and clients can be reloaded with the refresh method</li> </ul> | Providing alarms on the OPC UA server (Page 285)                    |



| What's new?                                               | What are the customer benefits?                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  | Where can I find the information? |
|-----------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------|
| Dynamic assignment of the network configuration with DHCP | <p>Deployment of the CPU in IT managed networks using the following functions:</p> <ul style="list-style-type: none"><li>• Connection of the CPU to an existing network without additional manual configuration of the network interface</li><li>• Request for network parameters for the CPU according to RFC 2131 from a DHCPv4 server (IP address and subnet mask, default IP router address and further optional network parameters such as DNS and NTP server addresses)</li></ul>                                                                                                                                          | Addressing via DHCP (Page 359)    |
| Name-based addressing with DNS                            | <ul style="list-style-type: none"><li>• DNS server addresses can be obtained from the CPU via DHCP</li><li>• The CPU can obtain host and domain names from a DHCP server for applications that are implemented with OPC UA or (Secure) OUC.</li><li>• The CPU may transfer configured host or domain names to DHCP servers coupled with DNS servers for dynamic matching (Dynamic DNS).</li><li>• The NTP client of the CPU can address NTP servers with names</li><li>• Network parameters can be written with the new "CommConfig" instruction, for example, IP address parameters, DNS server, host and domain name</li></ul> | DHCP with DNS (Page 363)          |

## What's new in the Communication Function Manual, Edition 11/2019 as compared to Edition 10/2018?

| What's new?             | What are the customer benefits?                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       | Where can I find the information?       |
|-------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------|
| IP forwarding           | Simple access from the control level to the field level for configuration and parameter assignment of devices, e.g. via PDM or Web browser.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           | IP forwarding (Page 378)                |
| OPC UA server expansion | <p>For S7-1500 CPUs as of firmware V2.8 and TIA Portal version 16, with a corresponding Runtime license, you can benefit from the following expansions of the integrated OPC UA server:</p> <ul style="list-style-type: none"> <li>Improved diagnostics: The OPC UA user receives information on the status of the OPC UA server via messages in the diagnostic buffer, an OPC UA category in the Online &amp; Diagnostics area of TIA Portal as well as an improved connection resources display.</li> <li>Download behavior: In RUN mode, the OPC UA server only performs a restart during download from the TIA Portal when the newly downloaded data has an effect on the data management of the OPC UA server.</li> <li>Server interface modeling: It is now possible in the TIA Portal to model server interfaces or import OPC UA Companion Specifications and map them to the PLC data management.</li> </ul> | Section OPC UA communication (Page 152) |

## What's new in the Communication Function Manual, Edition 10/2018 as compared to Edition 12/2017?

| What's new?                                                                      | What are the customer benefits?                                                                                                       | Where can I find information?                                                                                                                                                            |
|----------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Description of communication with the redundant system S7-1500R/H                | You receive information on the particularities of communication with the redundant system S7-1500R/H                                  | Section Communication with the redundant system S7-1500R/H (Page 407)                                                                                                                    |
| Scope of the function manual expanded to include the redundant system S7-1500R/H | Functions with which you are familiar from the SIMATIC S7-1500 automation system are implemented for the redundant system S7-1500R/H. | Redundant System S7-1500R/H System Manual<br>( <a href="https://support.industry.siemens.com/cs/ww/en/view/109754833">https://support.industry.siemens.com/cs/ww/en/view/109754833</a> ) |

## What's new in the Communication Function Manual, Edition 12/2017 compared to Edition 09/2016

| What's new?                                                            | What are the customer benefits?                                                                                                                                                                                                                     | Where can I find the information?                        |
|------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------|
| OPC UA Companion Specification                                         | Through OPC UA Companion Specification, methods can be specified in a uniform and manufacturer-neutral way. Using these specified methods, you can easily integrate devices from various manufacturers into the plant and the production processes. | Section OPC UA server interface configuration (Page 243) |
| Setting up a secure connection to a mail server over the CPU interface | You can set up a secure connection to a mail server without additional hardware.                                                                                                                                                                    | Section Secure OUC via e-mail (Page 88)                  |
| Secure communication over Modbus TCP                                   | You can establish secure TCP connections between a Modbus TCP client and a Modbus TCP server.                                                                                                                                                       | Section Secure OUC with Modbus TCP (Page 87)             |

## What's new in the Communication Function Manual, Edition 09/2016 compared to Edition 12/2014

| What's new?                    | What are the customer benefits?                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | Where can I find the information?                   |
|--------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------|
| OPC UA server                  | <p>OPC UA is a uniform standard for data communication and is independent of any particular operating system platforms.</p> <p>OPC UA uses integrated safety mechanisms on various automation systems, for example with data exchange, at application level, for the legitimization of the user.</p> <p>The OPC UA server provides a large amount of data:</p> <ul style="list-style-type: none"> <li>• Values of PLC tags that clients can access</li> <li>• Data types of these PLC tags</li> <li>• Information about the OPC UA server itself and the CPU</li> </ul> <p>In this way, clients can gain an overview of the tag management and can read and write values.</p> | Section OPC UA communication (Page 152)             |
| Secure Open User Communication | Secure data exchange with other devices.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      | Section Secure Open User Communication (Page 73)    |
| Certificate handling in STEP 7 | <p>You can manage certificates for the following applications in STEP 7:</p> <ul style="list-style-type: none"> <li>• OPC UA server</li> <li>• Secure Open User Communication</li> <li>• Web server of the CPU</li> </ul>                                                                                                                                                                                                                                                                                                                                                                                                                                                     | Section Managing certificates with STEP 7 (Page 49) |
| Deactivating SNMP for the CPU  | You can deactivate SNMP for the CPU. This can make sense under certain conditions, for example if the security guidelines in your network do not permit SNMP.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 | Section Disabling SNMP (Page 104)                   |

## Conventions

**STEP 7:** We refer to "STEP 7" in this documentation as a synonym for the configuration and programming software "STEP 7 as of V12 (TIA Portal)".

"S7-1500 CPUs" also refers to the CPU variants S7 1500F, S7 1500T, S7 1500TF, S7 1500C, S7-1500R/H, S7 1500pro, ET200S, S7 1500 Software Controller as well as SIMATIC Drive Controller.

This documentation contains pictures of the devices described. The figures may differ slightly from the device supplied.

You should also pay particular attention to notes such as the one shown below:

---

### Note

A note contains important information on the product, on handling of the product and on the section of the documentation to which you should pay particular attention.

---

## See also

Requirements for secure communication (Page 61)

## Security information

Siemens provides products and solutions with industrial security functions that support the secure operation of plants, systems, machines and networks.

In order to protect plants, systems, machines and networks against cyber threats, it is necessary to implement – and continuously maintain – a holistic, state-of-the-art industrial security concept. Siemens' products and solutions constitute one element of such a concept.

Customers are responsible for preventing unauthorized access to their plants, systems, machines and networks. Such systems, machines and components should only be connected to an enterprise network or the internet if and to the extent such a connection is necessary and only when appropriate security measures (e.g. firewalls and/or network segmentation) are in place.

For additional information on industrial security measures that may be implemented, please visit (<https://www.siemens.com/industrialsecurity>).

Siemens' products and solutions undergo continuous development to make them more secure. Siemens strongly recommends that product updates are applied as soon as they are available and that the latest product versions are used. Use of product versions that are no longer supported, and failure to apply the latest updates may increase customers' exposure to cyber threats.

To stay informed about product updates, subscribe to the Siemens Industrial Security RSS Feed visit (<https://www.siemens.com/industrialsecurity>).

## Siemens Industry Online Support

You can find current information on the following topics quickly and easily here:

- **Product support**

All the information and extensive know-how on your product, technical specifications, FAQs, certificates, downloads, and manuals.

- **Application examples**

Tools and examples to solve your automation tasks – as well as function blocks, performance information and videos.

- **Services**

Information about Industry Services, Field Services, Technical Support, spare parts and training offers.

- **Forums**

For answers and solutions concerning automation technology.

- **mySupport**

Your personal working area in Industry Online Support for messages, support queries, and configurable documents.

This information is provided by the Siemens Industry Online Support in the Internet (<http://www.siemens.com/automation/service&support>).

## Industry Mall

The Industry Mall is the catalog and order system of Siemens AG for automation and drive solutions on the basis of Totally Integrated Automation (TIA) and Totally Integrated Power (TIP).

You can find catalogs for all automation and drive products on the Internet (<https://mall.industry.siemens.com>).

# Table of contents

|          |                                                                                   |           |
|----------|-----------------------------------------------------------------------------------|-----------|
|          | <b>Preface</b> .....                                                              | <b>3</b>  |
| <b>1</b> | <b>Function manuals Documentation Guide</b> .....                                 | <b>15</b> |
| <b>2</b> | <b>Product overview</b> .....                                                     | <b>20</b> |
| <b>3</b> | <b>Communications services</b> .....                                              | <b>25</b> |
| 3.1      | Overview of communication options.....                                            | 25        |
| 3.2      | Communications protocols and port numbers used for Ethernet communication .....   | 28        |
| 3.3      | Overview of connection resources .....                                            | 32        |
| 3.4      | Setting up a connection .....                                                     | 33        |
| 3.5      | Data consistency.....                                                             | 37        |
| 3.6      | Secure Communication.....                                                         | 40        |
| 3.6.1    | Basics of Secure Communication.....                                               | 40        |
| 3.6.1.1  | Basics of Secure Communication.....                                               | 40        |
| 3.6.1.2  | Confidentiality through encryption .....                                          | 43        |
| 3.6.1.3  | Authenticity and integrity through signatures .....                               | 45        |
| 3.6.1.4  | Managing certificates with STEP 7 .....                                           | 49        |
| 3.6.1.5  | Examples for the management of certificates. ....                                 | 52        |
| 3.6.1.6  | Example: HTTP over TLS .....                                                      | 57        |
| 3.6.2    | Requirements for secure communication .....                                       | 61        |
| 3.6.2.1  | Protection of confidential configuration data.....                                | 61        |
| 3.6.2.2  | Useful information for the protection of confidential PLC configuration data..... | 63        |
| 3.6.2.3  | Changing your password .....                                                      | 65        |
| 3.6.2.4  | Resetting the password.....                                                       | 67        |
| 3.6.2.5  | Assign password via SIMATIC Memory Card .....                                     | 68        |
| 3.6.2.6  | Special features when backing up and restoring a CPU .....                        | 70        |
| 3.6.2.7  | Tips for error avoidance and error handling .....                                 | 71        |
| 3.6.2.8  | Rules for the replacement parts scenario .....                                    | 72        |
| 3.6.3    | Secure Open User Communication .....                                              | 73        |
| 3.6.3.1  | Secure OUC of an S7-1500 CPU as TLS client to an external PLC (TLS server) .....  | 73        |
| 3.6.3.2  | Secure OUC of an S7-1500 CPU as TLS server to an external PLC (TLS client) .....  | 75        |
| 3.6.3.3  | Secure OUC between two S7-1500 CPUs .....                                         | 78        |
| 3.6.3.4  | Secure OUC via CP interface .....                                                 | 81        |
| 3.6.3.5  | Secure OUC with Modbus TCP .....                                                  | 87        |
| 3.6.3.6  | Secure OUC via e-mail.....                                                        | 88        |
| 3.6.4    | Secure PG/HMI communication .....                                                 | 92        |
| 3.6.4.1  | PG/HMI communication based on standardized security mechanisms .....              | 92        |
| 3.6.4.2  | Additional settings for the secure PG/HMI communication .....                     | 94        |
| 3.6.4.3  | Tip for certificate-based communication between PG and CPU.....                   | 95        |
| 3.6.4.4  | CPU behavior from loading to operational readiness.....                           | 96        |
| 3.6.4.5  | Using secure HMI communication .....                                              | 99        |
| 3.6.4.6  | Using Legacy PG/PC communication for TIA Portal .....                             | 101       |
| 3.6.4.7  | Information about compatibility.....                                              | 102       |

|          |                                                                           |            |
|----------|---------------------------------------------------------------------------|------------|
| 3.7      | SNMP .....                                                                | 104        |
| 3.7.1    | Disabling SNMP .....                                                      | 104        |
| 3.7.2    | Example: Disabling SNMP for a CPU 1516-3 PN/DP .....                      | 105        |
| <b>4</b> | <b>PG communication .....</b>                                             | <b>107</b> |
| <b>5</b> | <b>HMI communication .....</b>                                            | <b>110</b> |
| <b>6</b> | <b>Open User Communication.....</b>                                       | <b>112</b> |
| 6.1      | Overview of Open User Communication .....                                 | 112        |
| 6.2      | Protocols for Open User Communication .....                               | 113        |
| 6.3      | Instructions for Open User Communication .....                            | 115        |
| 6.4      | Open User Communication with addressing via domain names .....            | 119        |
| 6.5      | Setting up Open User Communication via TCP, ISO-on-TCP, UDP and ISO ..... | 122        |
| 6.6      | Setting up communication over FDL.....                                    | 128        |
| 6.7      | Setting up communication with Modbus TCP.....                             | 130        |
| 6.8      | Setting up communication via e-mail .....                                 | 133        |
| 6.9      | Setting up communication via FTP .....                                    | 134        |
| 6.10     | Establishment and termination of communications relations .....           | 137        |
| <b>7</b> | <b>S7 communication .....</b>                                             | <b>138</b> |
| <b>8</b> | <b>Point-to-point link.....</b>                                           | <b>147</b> |
| <b>9</b> | <b>OPC UA communication.....</b>                                          | <b>152</b> |
| 9.1      | What you need to know about OPC UA.....                                   | 152        |
| 9.1.1    | OPC UA and Industrie 4.0.....                                             | 152        |
| 9.1.2    | General features of OPC UA.....                                           | 153        |
| 9.1.3    | OPC UA for S7-1200/S7-1500 CPUs .....                                     | 156        |
| 9.1.4    | Access to OPC UA applications .....                                       | 157        |
| 9.1.5    | Addressing nodes .....                                                    | 161        |
| 9.1.6    | What you need to know about OPC UA clients .....                          | 165        |
| 9.1.7    | Mapping of data types .....                                               | 169        |
| 9.2      | Security at OPC UA.....                                                   | 172        |
| 9.2.1    | Security settings .....                                                   | 172        |
| 9.2.2    | Certificates pursuant to ITU X.509 .....                                  | 173        |
| 9.2.3    | Certificates with OPC UA .....                                            | 177        |
| 9.2.4    | Creating self-signed certificates.....                                    | 178        |
| 9.2.5    | Generating PKI key pairs and certificates yourself .....                  | 179        |
| 9.2.6    | Secure transfer of messages.....                                          | 182        |
| 9.2.7    | Certificate management via Global Discovery Server (GDS).....             | 185        |
| 9.2.7.1  | Automated certificate management with GDS.....                            | 185        |
| 9.2.7.2  | Configuration limits for Push function .....                              | 188        |
| 9.2.7.3  | Setting and loading GDS parameters .....                                  | 189        |
| 9.2.7.4  | GDS commissioning .....                                                   | 190        |
| 9.2.7.5  | Address model for the push certificate management .....                   | 194        |
| 9.2.7.6  | CertificateGroups in the address model .....                              | 199        |

|          |                                                                                |     |
|----------|--------------------------------------------------------------------------------|-----|
| 9.3      | Using the S7-1500 as an OPC UA server.....                                     | 201 |
| 9.3.1    | Interesting information about the OPC UA server of the S7-1500 CPUs .....      | 201 |
| 9.3.1.1  | The OPC UA server of the S7-1500 CPUs.....                                     | 201 |
| 9.3.1.2  | End points of the OPC UA server.....                                           | 203 |
| 9.3.1.3  | Runtime behavior of the OPC UA server.....                                     | 205 |
| 9.3.2    | Configuring access to PLC tags .....                                           | 208 |
| 9.3.2.1  | Managing write and read rights .....                                           | 208 |
| 9.3.2.2  | Managing write and read rights for a complete DB .....                         | 209 |
| 9.3.2.3  | Coordinating write and read rights for CPU tags .....                          | 211 |
| 9.3.2.4  | Consistency of CPU tags.....                                                   | 213 |
| 9.3.2.5  | Accessing OPC UA server data .....                                             | 216 |
| 9.3.2.6  | MinimumSamplingInterval attribute.....                                         | 217 |
| 9.3.2.7  | Export OPC UA XML file.....                                                    | 217 |
| 9.3.3    | Configuring the OPC UA server.....                                             | 218 |
| 9.3.3.1  | Enabling the OPC UA server .....                                               | 218 |
| 9.3.3.2  | Access to the OPC UA server.....                                               | 220 |
| 9.3.3.3  | General settings of the OPC UA server .....                                    | 222 |
| 9.3.3.4  | Settings of the server for subscriptions.....                                  | 224 |
| 9.3.3.5  | Handling client and server certificates .....                                  | 227 |
| 9.3.3.6  | Generating server certificates with STEP 7 .....                               | 233 |
| 9.3.3.7  | User authentication .....                                                      | 237 |
| 9.3.3.8  | Users and roles with OPC UA function rights.....                               | 238 |
| 9.3.3.9  | Diagnostic settings of the server .....                                        | 241 |
| 9.3.3.10 | License for OPC UA .....                                                       | 242 |
| 9.3.4    | OPC UA server interface configuration.....                                     | 243 |
| 9.3.4.1  | What is a server interface? .....                                              | 243 |
| 9.3.4.2  | Using OPC UA companion specifications.....                                     | 245 |
| 9.3.4.3  | Creating a server interface for companion specification .....                  | 253 |
| 9.3.4.4  | Creating a user-defined server interface .....                                 | 259 |
| 9.3.4.5  | Data types for companion specifications .....                                  | 265 |
| 9.3.4.6  | Rules for OPC UA XML files.....                                                | 269 |
| 9.3.4.7  | Creating a server interface for reference namespace .....                      | 270 |
| 9.3.4.8  | Generating OPC UA nodes based on local data mappings of FB types and UDTs..... | 273 |
| 9.3.4.9  | Notes on configuration limits when using server interfaces .....               | 277 |
| 9.3.5    | Providing methods on the OPC UA server .....                                   | 279 |
| 9.3.5.1  | Useful information about server methods .....                                  | 279 |
| 9.3.5.2  | Boundary conditions for using server methods .....                             | 283 |
| 9.3.6    | Providing alarms on the OPC UA server.....                                     | 285 |
| 9.3.6.1  | Useful information on alarms.....                                              | 285 |
| 9.3.6.2  | OPC UA Events.....                                                             | 290 |
| 9.3.6.3  | OPC UA conditions and OPC UA alarms.....                                       | 293 |
| 9.3.6.4  | Activating Alarms and Conditions.....                                          | 295 |
| 9.3.6.5  | Subscribing to events of an OPC UA server .....                                | 296 |
| 9.3.6.6  | Methods for OPC UA Alarms and Conditions .....                                 | 297 |
| 9.3.6.7  | Handling memory limits for OPC UA Alarms and Conditions.....                   | 301 |
| 9.3.7    | Using diagnostics options .....                                                | 304 |
| 9.3.7.1  | Diagnostics of the OPC UA server .....                                         | 304 |
| 9.3.7.2  | Server state transition diagnostics .....                                      | 306 |
| 9.3.7.3  | Session state transition diagnostics .....                                     | 307 |
| 9.3.7.4  | Check for security events .....                                                | 308 |
| 9.3.7.5  | Request of a remote client failed .....                                        | 309 |
| 9.3.7.6  | Subscription diagnostics .....                                                 | 311 |

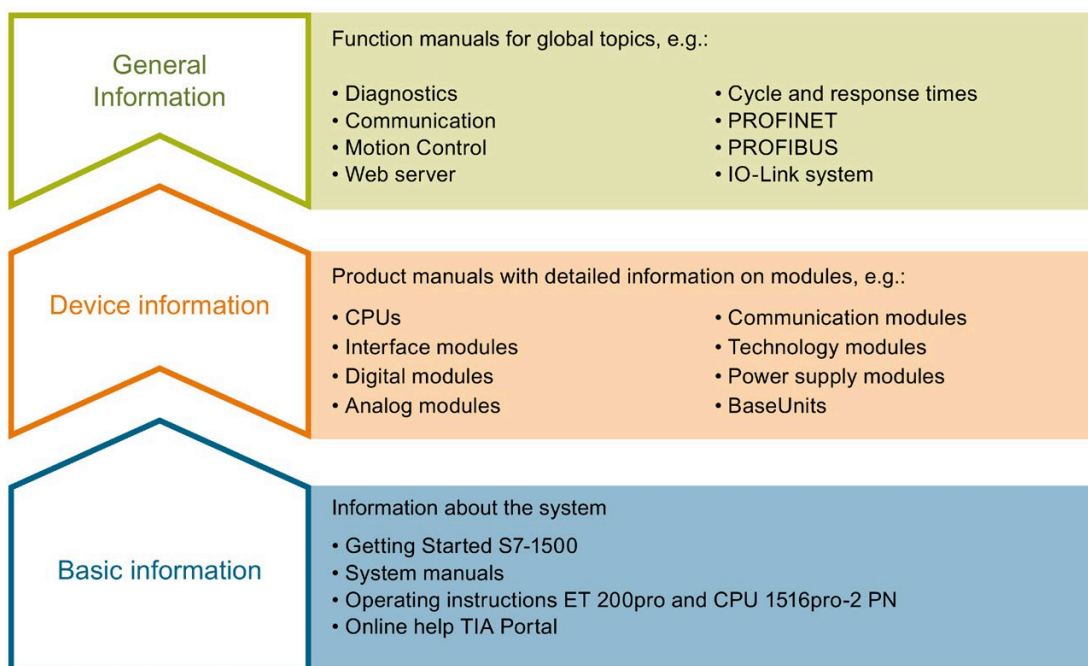


|           |                                                                     |            |
|-----------|---------------------------------------------------------------------|------------|
| 9.3.7.7   | Summarizing diagnostics .....                                       | 314        |
| 9.4       | Using the S7-1500 CPU as an OPC UA client .....                     | 316        |
| 9.4.1     | Overview and requirements .....                                     | 316        |
| 9.4.2     | Useful information about the client instructions .....              | 317        |
| 9.4.3     | Number of client instructions that can be used simultaneously ..... | 319        |
| 9.4.4     | Example configuration for OPC UA .....                              | 320        |
| 9.4.5     | Creating client interfaces .....                                    | 322        |
| 9.4.6     | Determine server interface online .....                             | 331        |
| 9.4.7     | Using multilingual texts .....                                      | 336        |
| 9.4.8     | Rules for the access to structures .....                            | 338        |
| 9.4.9     | Using connection parameter assignment.....                          | 339        |
| 9.4.9.1   | Creating and configuring connections.....                           | 339        |
| 9.4.9.2   | Handling of the client certificates of the S7-1500 CPU .....        | 344        |
| 9.4.9.3   | User authentication .....                                           | 347        |
| 9.4.9.4   | Using a configured connection.....                                  | 348        |
| 9.5       | Tips and recommendations .....                                      | 354        |
| 9.5.1     | Rules for subscriptions .....                                       | 355        |
| 9.5.2     | Rules for the user program.....                                     | 356        |
| 9.5.3     | Master copies for OPC UA communication.....                         | 357        |
| <b>10</b> | <b>Addressing via DHCP .....</b>                                    | <b>359</b> |
| 10.1      | Principle of address assignment via DHCP.....                       | 361        |
| 10.2      | DHCP with DNS.....                                                  | 363        |
| 10.3      | Activate DHCP.....                                                  | 368        |
| 10.4      | Configuring the client ID .....                                     | 368        |
| 10.5      | Get addresses of the DNS servers via DHCP.....                      | 370        |
| 10.6      | Get addresses of the NTP servers via DHCP .....                     | 370        |
| 10.7      | Obtain host and domain name via DHCP .....                          | 371        |
| <b>11</b> | <b>Routing .....</b>                                                | <b>372</b> |
| 11.1      | Overview of the routing mechanisms of S7-1500 CPUs.....             | 372        |
| 11.2      | S7 routing .....                                                    | 373        |
| 11.3      | IP forwarding .....                                                 | 378        |
| 11.4      | Data record routing.....                                            | 385        |
| 11.5      | Virtual interface for IP-based applications .....                   | 387        |
| <b>12</b> | <b>Connection resources .....</b>                                   | <b>391</b> |
| 12.1      | Connection resources of a station .....                             | 391        |
| 12.2      | Allocation of connection resources.....                             | 395        |
| 12.3      | Display of the connection resources .....                           | 399        |
| <b>13</b> | <b>Diagnostics and fault correction.....</b>                        | <b>403</b> |
| 13.1      | Connection diagnostics.....                                         | 403        |
| 13.2      | Emergency address.....                                              | 406        |

|           |                                                                                                    |            |
|-----------|----------------------------------------------------------------------------------------------------|------------|
| <b>14</b> | <b>Communication with the redundant system S7-1500R/H .....</b>                                    | <b>407</b> |
| 14.1      | System IP addresses .....                                                                          | 408        |
| 14.2      | Response to Snycup .....                                                                           | 414        |
| 14.3      | Response to primary-backup switchover .....                                                        | 414        |
| 14.4      | Connection resources of the redundant system S7-1500R/H .....                                      | 415        |
| 14.5      | HMI communication with the redundant system S7-1500R/H .....                                       | 416        |
| 14.5.1    | HMI connection via the system IP address .....                                                     | 416        |
| 14.6      | Open User Communication with the redundant system S7-1500R/H .....                                 | 419        |
| 14.6.1    | Setting up the connection of the Open User Communication with the redundant S7-1500R/H system..... | 419        |
| <b>15</b> | <b>Industrial Ethernet Security with CP 1543-1.....</b>                                            | <b>425</b> |
| 15.1      | Firewall .....                                                                                     | 426        |
| 15.2      | Logging .....                                                                                      | 427        |
| 15.3      | NTP client .....                                                                                   | 427        |
| 15.4      | SNMP .....                                                                                         | 428        |
| 15.5      | VPN .....                                                                                          | 428        |
|           | <b>Glossary .....</b>                                                                              | <b>429</b> |
|           | <b>Index.....</b>                                                                                  | <b>441</b> |

# Function manuals Documentation Guide

The documentation for the SIMATIC S7-1500 automation system, the CPUs 1513/1516pro-2 PN based on SIMATIC S7-1500, and the distributed I/O systems SIMATIC ET 200MP, ET 200SP and ET 200AL is divided into three areas. This division allows you easier access to the specific information you require.



## Basic information

System manuals and Getting Started manuals describe in detail the configuration, installation, wiring and commissioning of the SIMATIC S7-1500, ET 200MP, ET 200SP and ET 200AL systems. Use the corresponding operating instructions for the CPUs 1513/1516pro-2 PN. The STEP 7 online help supports you in the configuration and programming.

## Device information

Product manuals contain a compact description of the module-specific information, such as properties, terminal diagrams, characteristics and technical specifications.

### General information

The function manuals contain detailed descriptions on general topics such as diagnostics, communication, Motion Control, Web server, OPC UA.

You can download the documentation free of charge from the Internet (<https://support.industry.siemens.com/cs/ww/en/view/109742705>).

Changes and additions to the manuals are documented in product information sheets.

You will find the product information on the Internet:

- S7-1500/ET 200MP (<https://support.industry.siemens.com/cs/us/en/view/68052815>)
- ET 200SP (<https://support.industry.siemens.com/cs/us/en/view/73021864>)

### Manual Collections

The Manual Collections contain the complete documentation of the systems put together in one file.

You will find the Manual Collections on the Internet:

- S7-1500/ET 200MP (<https://support.industry.siemens.com/cs/ww/en/view/86140384>)
- ET 200SP (<https://support.industry.siemens.com/cs/ww/en/view/84133942>)
- ET 200AL (<https://support.industry.siemens.com/cs/ww/en/view/95242965>)

### "mySupport"

With "mySupport", your personal workspace, you make the best out of your Industry Online Support.

In "mySupport", you can save filters, favorites and tags, request CAx data and compile your personal library in the Documentation area. In addition, your data is already filled out in support requests and you can get an overview of your current requests at any time.

You must register once to use the full functionality of "mySupport".

You can find "mySupport" on the Internet (<https://support.industry.siemens.com/My/ww/en>).

### "mySupport" - Documentation

With "mySupport", your personal workspace, you make the best out of your Industry Online Support.

In "mySupport", you can save filters, favorites and tags, request CAx data and compile your personal library in the Documentation area. In addition, your data is already filled out in support requests and you can get an overview of your current requests at any time.

You must register once to use the full functionality of "mySupport".

You can find "mySupport" on the Internet (<https://support.industry.siemens.com/My/ww/en/documentation>).

## "mySupport" - CAx data

In the CAx data area of "mySupport", you can access the latest product data for your CAx or CAe system.

You configure your own download package with a few clicks.

In doing so you can select:

- Product images, 2D dimension drawings, 3D models, internal circuit diagrams, EPLAN macro files
- Manuals, characteristics, operating manuals, certificates
- Product master data

You can find "mySupport" - CAx data on the Internet  
(<https://support.industry.siemens.com/my/ww/en/CAxOnline>).

## Application examples

The application examples support you with various tools and examples for solving your automation tasks. Solutions are shown in interplay with multiple components in the system - separated from the focus on individual products.

You will find the application examples on the Internet  
(<https://support.industry.siemens.com/cs/ww/en/ps/ae>).

## TIA Selection Tool

With the TIA Selection Tool, you can select, configure and order devices for Totally Integrated Automation (TIA).

This tool is the successor of the SIMATIC Selection Tool and combines the known configurators for automation technology into one tool.

With the TIA Selection Tool, you can generate a complete order list from your product selection or product configuration.

You can find the TIA Selection Tool on the Internet  
(<https://support.industry.siemens.com/cs/ww/en/view/109767888>).

## SIMATIC Automation Tool

You can use the SIMATIC Automation Tool to perform commissioning and maintenance activities simultaneously on various SIMATIC S7 stations as a bulk operation independent of TIA Portal.

The SIMATIC Automation Tool provides a multitude of functions:

- Scanning of a PROFINET/Ethernet system network and identification of all connected CPUs
- Address assignment (IP, subnet, gateway) and station name (PROFINET device) to a CPU
- Transfer of the date and the programming device/PC time converted to UTC time to the module
- Program download to CPU
- RUN/STOP mode switchover
- CPU localization by means of LED flashing
- Reading out of CPU error information
- Reading of the CPU diagnostics buffer
- Reset to factory settings
- Firmware update of the CPU and connected modules

You can find the SIMATIC Automation Tool on the Internet

(<https://support.industry.siemens.com/cs/ww/en/view/98161300>).

## PRONETA

SIEMENS PRONETA (PROFINET network analysis) allows you to analyze the plant network during commissioning. PRONETA features two core functions:

- The topology overview automatically scans the PROFINET and all connected components.
- The IO check is a fast test of the wiring and the module configuration of a plant.

You can find SIEMENS PRONETA on the Internet

(<https://support.industry.siemens.com/cs/ww/en/view/67460624>).

## SINETPLAN

SINETPLAN, the Siemens Network Planner, supports you in planning automation systems and networks based on PROFINET. The tool facilitates professional and predictive dimensioning of your PROFINET installation as early as in the planning stage. In addition, SINETPLAN supports you during network optimization and helps you to exploit network resources optimally and to plan reserves. This helps to prevent problems in commissioning or failures during productive operation even in advance of a planned operation. This increases the availability of the production plant and helps improve operational safety.

The advantages at a glance

- Network optimization thanks to port-specific calculation of the network load
- Increased production availability thanks to online scan and verification of existing systems
- Transparency before commissioning through importing and simulation of existing STEP 7 projects
- Efficiency through securing existing investments in the long term and the optimal use of resources

You can find SINETPLAN on the Internet (<https://www.siemens.com/sinetplan>).

## Product overview

CPUs, communications modules and processors, and PC systems of the S7-1500, , ET 200MPET 200SPET 200pro and ET 200AL systems provide you with interfaces for communication via PROFINET, PROFIBUS and point-to-point connections.

### CPUs, communications modules and communications processors

PROFINET and PROFIBUS DP interfaces are integrated in the S7-1500 CPUs. The CPU 1516-3 PN/DP for example has two PROFINET interfaces and one PROFIBUS DP interface. Other PROFINET and PROFIBUS DP interfaces are available by using communications modules (CM) and communications processors (CP).

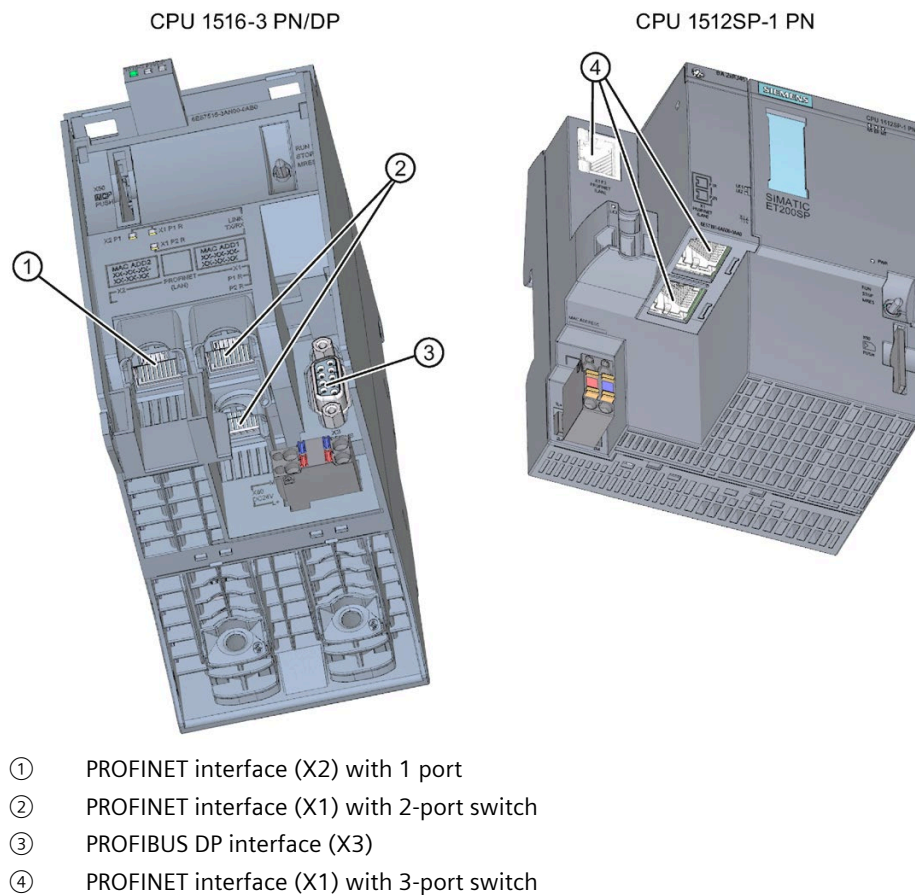


Figure 2-1 Interfaces of the CPU 1516-3 PN/DP and CPU 1512SP-1 PN



## Interfaces of communications modules

Interfaces of communications modules (CMs) extend the interfaces of CPUs (for example, the communication module CM 1542-5 adds a PROFIBUS interface to S7-1500 automation system).

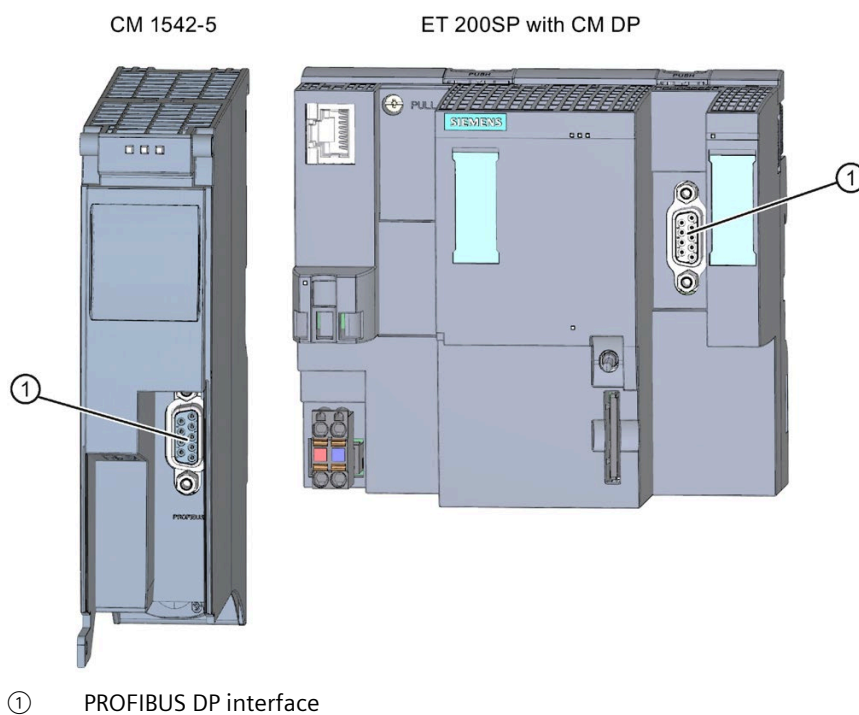
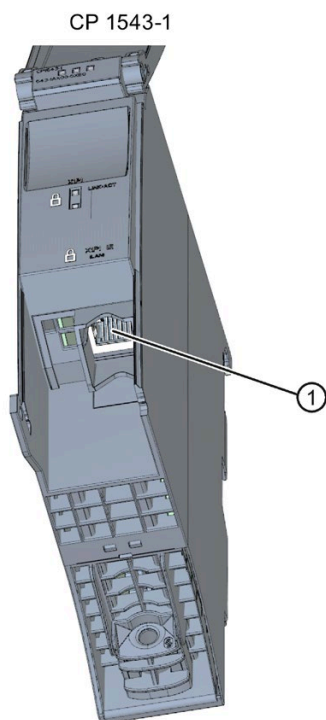


Figure 2-2 PROFIBUS DP interface of the CM 1542-5 and CM DP (to an ET 200SP CPU)

## Interfaces of communications processors

Interfaces of communication processors (CP) offer additional functionality to what is provided by the integrated interfaces of the CPUs. CPs allow special applications, for example the CP 1543-1 provides Industrial Ethernet security functions for protecting Industrial Ethernet networks via its Industrial Ethernet interface.



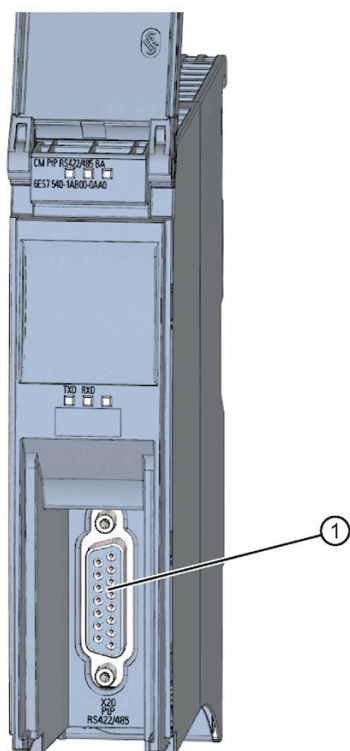
- ① Industrial Ethernet interface

Figure 2-3 Industrial Ethernet interface of the CP 1543-1

## Interfaces of communications modules for point-to-point connections

The communication modules for point-to-point connections provide communication via their RS 232-, RS 422- and RS 485 interfaces, for example, Freeport or Modbus communication.

CM PtP RS422/485 BA

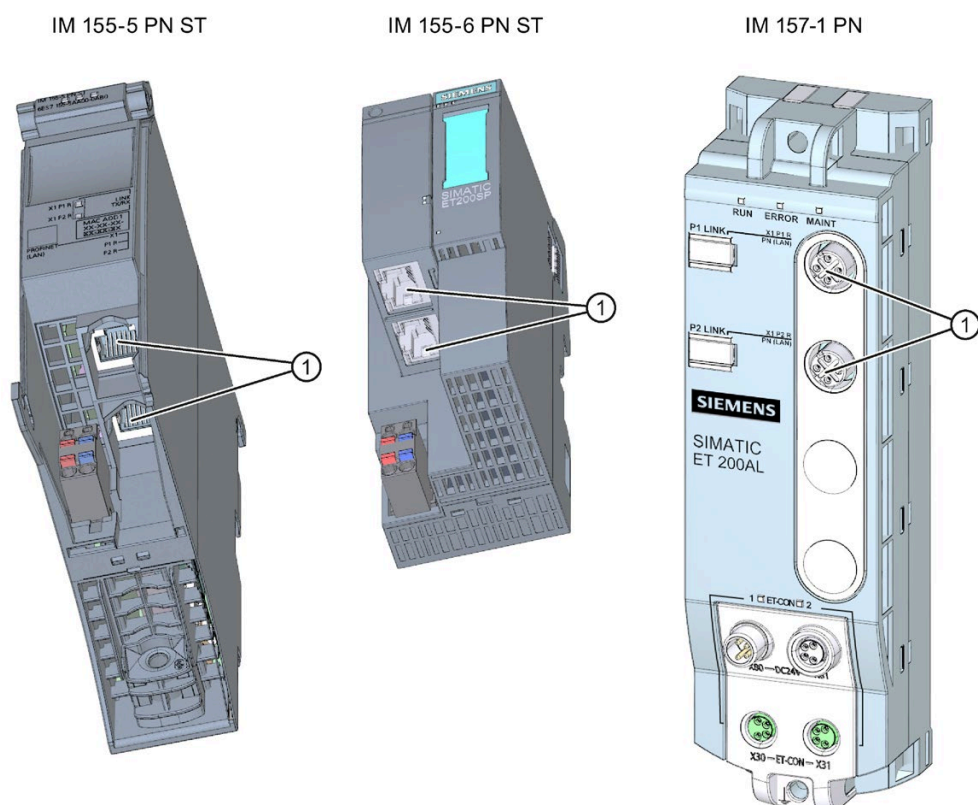


- ① Interface for point-to-point connections

Figure 2-4 Example of interface for point-to-point connection at the CM PtP RS422/485 BA

## Interfaces of interface modules

PROFINET and PROFIBUS DP interfaces of the interface modules (IM) in ET 200MP, ET 200SP and ET 200AL are used to connect the distributed I/O ET 200MP, ET 200SP and ET 200AL to PROFINET or PROFIBUS of the higher-level IO controller or DP master.



① PROFINET interface with 2-port switch

Figure 2-5 PROFINET interfaces IM 155-5 PN ST (ET 200MP), IM 155-6 PN ST (ET 200SP), and IM 157-1 PN (ET 200AL)

## Communications services

The communications services described below use the interfaces and communication mechanisms provided by the system via CPUs, communication modules and processors.

## Communications services

### 3.1 Overview of communication options

#### Overview of communications options

The following communications options are available for your automation task.

Table 3- 1 Communications options

| Communications options                           | Functionality                                                                                                                                                                                                   | Via interface:     |    |        |
|--------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------|----|--------|
|                                                  |                                                                                                                                                                                                                 | PN/IE <sup>1</sup> | DP | serial |
| PG communication <sup>2</sup>                    | On commissioning, testing, diagnostics                                                                                                                                                                          | X                  | X  | -      |
| HMI communication <sup>2</sup>                   | On operator control and monitoring                                                                                                                                                                              | X                  | X  | -      |
| Open communication via TCP/IP <sup>2</sup>       | Data exchange via PROFINET/Industrial Ethernet with TCP/IP<br>Instructions:<br><ul style="list-style-type: none"> <li>• TSEND_C/TRCV_C</li> <li>• TSEND/TRCV</li> <li>• TCON</li> <li>• T_DISCON</li> </ul>     | X                  | -  | -      |
| Open communication using ISO-on-TCP <sup>2</sup> | Data exchange via PROFINET/Industrial Ethernet with ISO-on-TCP<br>Instructions:<br><ul style="list-style-type: none"> <li>• TSEND_C/TRCV_C</li> <li>• TSEND/TRCV</li> <li>• TCON</li> <li>• T_DISCON</li> </ul> | X                  | -  | -      |
| Open communication via UDP <sup>2</sup>          | Data exchange via PROFINET/Industrial Ethernet with UDP<br>Instructions:<br><ul style="list-style-type: none"> <li>• TSEND_C/TRCV_C</li> <li>• TUSEND/TURCV</li> <li>• TCON</li> <li>• T_DISCON</li> </ul>      | X                  | -  | -      |

## 3.1 Overview of communication options

| Communications options                                                            | Functionality                                                                                                                                                                                                             | Via interface:     |    |        |
|-----------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------|----|--------|
|                                                                                   |                                                                                                                                                                                                                           | PN/IE <sup>1</sup> | DP | serial |
| Open communication via ISO (only CPs with PROFINET/Industrial Ethernet interface) | Data exchange via PROFINET/Industrial Ethernet with the ISO protocol<br>Instructions:<br><ul style="list-style-type: none"> <li>• TSEND_C/TRCV_C</li> <li>• TSEND/TRCV</li> <li>• TCON</li> <li>• T_DISCON</li> </ul>     | X                  | -  | -      |
| Open communication with FDL (only CM 1542-5 as of firmware V2.0)                  | Data exchange via PROFIBUS with the FDL protocol<br>Instructions:<br><ul style="list-style-type: none"> <li>• TSEND_C/TRCV_C</li> <li>• TSEND/TRCV</li> <li>• TUSEND/TURCV</li> <li>• TCON</li> <li>• T_DISCON</li> </ul> | -                  | X  | -      |
| OPC UA server <sup>3</sup>                                                        | Data exchange with OPC UA clients                                                                                                                                                                                         | X                  | -  | -      |
| Communication via Modbus TCP                                                      | Data exchange via PROFINET with Modbus TCP protocol<br>Instructions:<br><ul style="list-style-type: none"> <li>• MB_CLIENT</li> <li>• MB_SERVER</li> </ul>                                                                | X                  | -  | -      |
| E-mail                                                                            | Sending process alarms via e-mail<br>Instruction:<br><ul style="list-style-type: none"> <li>• TMAIL_C</li> </ul>                                                                                                          | X                  | -  | -      |
| FTP (only CPs with PROFINET/Industrial Ethernet interface)                        | File management and file access via FTP (File Transfer Protocol); CP can be FTP client and FTP server<br>Instruction:<br><ul style="list-style-type: none"> <li>• FTP_CMD</li> </ul>                                      | X                  | -  | -      |
| Fetch/Write (only CPs with PROFINET/Industrial Ethernet interface)                | Server services via TCP/IP, ISO-on-TCP and ISO<br>Via special instructions for Fetch/Write                                                                                                                                | X                  | -  | -      |
| S7 communication                                                                  | Data exchange via PROFINET/PROFIBUS with the S7 protocol.<br>Instructions:<br><ul style="list-style-type: none"> <li>• PUT/GET</li> <li>• BSEND/BRCV</li> <li>• USEND/URCV</li> </ul>                                     | X                  | X  | -      |
| Serial point-to-point connection                                                  | Data exchange via point-to-point with Freeport, 3964(R), USS or Modbus protocol<br>Via special instructions for PtP, USS or Modbus RTU                                                                                    | -                  | -  | X      |
| Web server                                                                        | Data exchange via HTTP(S), for example for diagnostics                                                                                                                                                                    | X                  | -  | -      |

| Communications options                    | Functionality                                                                                                                          | Via interface:     |    |        |
|-------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------|--------------------|----|--------|
|                                           |                                                                                                                                        | PN/IE <sup>1</sup> | DP | serial |
| SNMP (Simple Network Management Protocol) | For monitoring and error recognition of IP networks, possibly parameterization of the IP network components via standard SNMP protocol | X                  | -  | -      |
| Time-of-day synchronization               | Via PN/IE interface: CPU is NTP client (Network Time Protocol)                                                                         | X                  | -  | -      |
|                                           | Via DP interface: CPU/CM/CP is time-of-day master or time slave                                                                        | -                  | X  | -      |

<sup>1</sup> IE - Industrial Ethernet

<sup>2</sup> Observe the special characteristics for S7-1500R/H

<sup>3</sup> Only via internal PROFINET interface of the CPU and via Ethernet interface CP 1543 1 with activated "Access to PLC via communication module" function.

## Information on S7-1500R/H

You can find information on the communication possibilities with the redundant system S7-1500R/H in the section Communication with the redundant system S7-1500R/H (Page 407).

## Additional information

- Application example: CPU-CPU communication with SIMATIC controllers (compendium)  
You can find the application example on the Internet (<https://support.industry.siemens.com/cs/ww/en/view/20982954>).
- This FAQ (<https://support.industry.siemens.com/cs/ww/en/view/102420020>) describes how to configure fetch/write communication via CP1543-1 with S7-1500.
- Additional information about the Fetch/Write services is available in the STEP 7 online help.
- You can find additional information on the PtP link in the function manual CM PtP - Configurations for Point-to-Point Connections (<http://support.automation.siemens.com/WW/view/en/59057093>).
- You will find the description of the web server functionality in the function manual Web server (<http://support.automation.siemens.com/WW/view/en/59193560>).
- You will find information about the standard protocol SNMP on the Service & Support pages on the Internet (<http://support.automation.siemens.com/WW/view/en/15166742>).
- You will find information about time-of-day synchronization in this FAQ (<https://support.industry.siemens.com/cs/ww/en/view/86535497>).

## 3.2 Communications protocols and port numbers used for Ethernet communication

This section provides an overview of the supported protocols and port numbers used for communication over PN/IE interfaces. For each protocol the address parameters, the respective communications layer as well as the communications role and the communications direction are specified.

This information makes it possible to match the security measures for protection of the automation system to the used protocols (for example firewall). Because the security measures are limited to Ethernet or PROFINET networks, the tables do not include PROFIBUS protocols.

### Note

#### Port numbers used

The specified port numbers are the standard port numbers used by the S7-1500 CPU. Many communication protocols and implementations enable you to use other port numbers.

The following tables show the different layers and protocols used in the S7-1500 CPUs and S7 1500 communication modules.

The following table shows the protocols supported by the S7-1500 CPUs, ET 200SP CPUs and the CPUs 1513/1516pro 2 PN. The S7-1500 software controllers also support the protocols listed in the following table for the Ethernet interfaces that are assigned to the software controller.

Table 3- 2 Layers and protocols of the S7-1500 CPUs and software controllers (via PROFINET interface of the CPU)

| Protocol                                          | Port number  | (2) Link layer<br>(4) Transport layer   | Function                                                         | Description                                                                                                                                                                   |
|---------------------------------------------------|--------------|-----------------------------------------|------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>PROFINET protocols</b>                         |              |                                         |                                                                  |                                                                                                                                                                               |
| DCP<br>Discovery and basic configuration protocol | Not relevant | (2) Ethertype 0x8892 (PROFINET)         | Accessible devices<br>PROFINET Discovery and configuration       | DCP is used by PROFINET to discover PROFINET devices and provide basic settings.                                                                                              |
| LLDP<br>Link Layer Discovery protocol             | Not relevant | (2) Ethertype 0x88CC (LLDP)             | PROFINET Link Layer Discovery protocol                           | LLDP is used by PROFINET to discover and manage neighbor relationships between PROFINET devices. LLDP uses the special multicast MAC address: 01-80-C2-00-00-0E               |
| MRP<br>Media Redundancy Protocol                  | Not relevant | (2) Ethertype 0x88E3 (IEC 62493-2-2010) | PROFINET medium redundancy                                       | MRP provides control of redundant transmission paths by means of a ring topology. MRP uses standard-compliant Multicast MAC addresses.                                        |
| PTCP<br>Precision Transparent Clock Protocol      | Not relevant | (2) Ethertype 0x8892 (PROFINET)         | PROFINET send clock and time synchronization, based on IEEE 1588 | PTCP provides a time delay measurement between RJ45 ports and thus send clock synchronization and time synchronization. PTCP uses standard-compliant Multicast MAC addresses. |



## 3.2 Communications protocols and port numbers used for Ethernet communication

| Protocol                                                    | Port number       | (2) Link layer<br>(4) Transport layer | Function                                                       | Description                                                                                                                                                              |
|-------------------------------------------------------------|-------------------|---------------------------------------|----------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| PROFINET IO data                                            | Not relevant      | (2) Ethertype 0x8892 (PROFINET)       | PROFINET Cyclic IO data transfer                               | The PROFINET IO frames are used to transmit IO data cyclically between PROFINET IO controller and IO devices via Ethernet.                                               |
| PROFINET Context Manager                                    | 34964             | (4) UDP                               | PROFINET connection less RPC                                   | The PROFINET Context Manager provides an endpoint mapper in order to establish an application relation (PROFINET AR).                                                    |
| <b>Connection-oriented communications protocols</b>         |                   |                                       |                                                                |                                                                                                                                                                          |
| SMTP<br>Simple mail transfer protocol                       | 25                | (4) TCP                               | Simple mail transfer protocol                                  | SMTP is used for sending e-mails.                                                                                                                                        |
| SMTPS (SMTP over TLS)                                       | 465               | (4) TCP                               | Secure SMTP                                                    | SMTP is used for sending e-mails over secure connections.                                                                                                                |
| SMTP with STARTTLS                                          | 25<br>587         | (4) TCP                               | Simple mail transfer protocol with the SMTP command "STARTTLS" | SMTP with STARTTLS is used for sending e-mails over secure connections.                                                                                                  |
| HTTP<br>Hypertext transfer protocol                         | 80                | (4) TCP                               | Hypertext transfer protocol                                    | HTTP is used for communication with the CPU-internal web server.                                                                                                         |
| ISO-on-TCP (according to RFC 1006)                          | 102               | (4) TCP                               | ISO-on-TCP protocol                                            | ISO-on-TCP (according to RFC 1006) is used for message-oriented data exchange with remote CPU or software controller.<br>S7 communication with ES, HMI, OPC server, etc. |
| NTP<br>Network time protocol                                | 123               | (4) UDP                               | Network time protocol                                          | NTP is used for synchronization of the CPU system time with the time of an NTP server.                                                                                   |
| SNMP<br>Simple network management protocol                  | 161<br>162 (trap) | (4) UDP                               | Simple network management protocol                             | SNMP is used for reading and setting of network management data (SNMP managed Objects) by the SNMP Manager.                                                              |
| HTTPS<br>Secure Hypertext transfer protocol                 | 443               | (4) TCP                               | Secure Hypertext transfer protocol                             | HTTPS is used for communication with the CPU-internal web server via Secure Socket Layer (SSL).                                                                          |
| Modbus TCP<br>Modbus Transmission Control Protocol          | 502               | (4) TCP                               | Modbus/TCP protocol                                            | Modbus/TCP is used by MB_CLIENT/MB_SERVER instructions in the user program.                                                                                              |
| OPC UA<br>Open Platform Communications Unified Architecture | 4840              | (4) TCP                               | Based on the TCP/IP protocol                                   | Communication standard ranging from the enterprise level to the field level.                                                                                             |

## 3.2 Communications protocols and port numbers used for Ethernet communication

| Protocol                                                         | Port number                                                  | (2) Link layer<br>(4) Transport layer | Function                                                                  | Description                                                                                                            |
|------------------------------------------------------------------|--------------------------------------------------------------|---------------------------------------|---------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------|
| OUC <sup>1</sup><br>Open User Communication<br>and<br>Secure OUC | 1 ... 1999<br>can be used to limited extent <sup>2</sup>     | (4) TCP<br>(4) UDP                    | Open User Communication (TCP/UDP)<br>Secure Open User Communication (TLS) | OUC instructions provide connection establishment, connection termination and data transfer based on the socket layer. |
|                                                                  | 2000 ... 5000<br>Recommended                                 |                                       |                                                                           |                                                                                                                        |
|                                                                  | 5001 ... 49151<br>can be used to limited extent <sup>2</sup> |                                       |                                                                           |                                                                                                                        |
| IGMPv2<br>Internet Group Management Protocol                     | Not relevant                                                 | (3) Network layer                     | Internet Group Management Protocol                                        | Network protocol for the organization of multicast groups.                                                             |
| Reserved                                                         | 49152 ... 65535                                              | (4) TCP<br>(4) UDP                    | -                                                                         | Dynamic port area used for active connection end point if the application does not determine the local port number.    |

<sup>1</sup> Note: The open communication provides direct access to the UDP/TCP for the user. The user is responsible for observing the port restrictions/definitions of the IANA (Internet Assigned Numbers Authority).

<sup>2</sup> Do not use ports for OUC, which are already used by other protocols.

The following table shows the protocols that are supported by the S7-1500 software controller via the Ethernet interfaces assigned to Windows.

Table 3- 3 Layers and protocols of the S7-1500 Software Controller (via Ethernet interface on the Windows side)

| Protocol                                            | Port number             | (2) Link layer<br>(4) Transport layer | Function                                                   | Description                                                                                                                                                                                                                                   |
|-----------------------------------------------------|-------------------------|---------------------------------------|------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>PROFINET protocols</b>                           |                         |                                       |                                                            |                                                                                                                                                                                                                                               |
| DCP<br>Discovery and basic configuration protocol   | Not relevant            | (2) Ethertype 0x8892 (PROFINET)       | Accessible devices<br>PROFINET Discovery and configuration | DCP is used by PROFINET to discover PROFINET devices and provide basic settings.                                                                                                                                                              |
| <b>Connection-oriented communications protocols</b> |                         |                                       |                                                            |                                                                                                                                                                                                                                               |
| SMTP<br>Simple mail transfer protocol               | 25                      | (4) TCP                               | Simple mail transfer protocol                              | SMTP is used for sending e-mails.                                                                                                                                                                                                             |
| HTTP<br>Hypertext transfer protocol                 | Adjustable <sup>1</sup> | (4) TCP                               | Hypertext transfer protocol                                | HTTP is used for communication with CPU-internal web server. You can change the port number to avoid conflict with other web servers on Windows.<br>If you want to use web server access, you must activate the port in the Windows Firewall. |

## 3.2 Communications protocols and port numbers used for Ethernet communication

| Protocol                                                         | Port number                                                                                                                                                                         | (2) Link layer<br>(4) Transport layer | Function                                                                     | Description                                                                                                                                                                                                                      |
|------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------|------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| ISO-on-TCP<br>(according to RFC 1006)                            | 102                                                                                                                                                                                 | (4) TCP                               | ISO-on-TCP protocol                                                          | ISO-on-TCP (according to RFC 1006) for S7 communication with PG/PC or HMI.                                                                                                                                                       |
| OUC <sup>2</sup><br>Open User Communication<br>and<br>Secure OUC | 1 ... 1999<br>can be used to limited extent <sup>3, 4</sup><br><br>2000 ... 5000<br>recommended <sup>4</sup><br><br>5001 ... 49151<br>can be used to limited extent <sup>3, 4</sup> | (4) TCP<br>(4) UDP                    | Open User Communication<br>(TCP/UDP)<br>Secure Open User Communication (TLS) | OUC instructions provide connection establishment, connection termination and data transfer based on the socket layer.<br>If you want to use OUC, you must activate the ports in the Windows Firewall.                           |
| IGMPv2<br>Internet Group Management Protocol                     | Not relevant                                                                                                                                                                        | (3) Network layer                     | Internet Group Management Protocol                                           | Network protocol for the organization of multicast groups.                                                                                                                                                                       |
| Reserved                                                         | 49152 ... 65535                                                                                                                                                                     | (4) TCP<br>(4) UDP                    | -                                                                            | Dynamic port range that is used for the active connection end point, if the application does not determine the local port number.<br>If you wish to use this communication, you must activate the ports in the Windows Firewall. |

<sup>1</sup> Default setting for Windows assigned interfaces: 81

<sup>2</sup> Note: The open user communication provides direct access to the UDP/TCP for the user. The user is responsible for observing the port restrictions/definitions of the IANA (Internet Assigned Numbers Authority).

<sup>3</sup> Do not use ports for OUC, which are already used by other protocols.

<sup>4</sup> Do not use ports for OUC, which are already used by other Windows applications.

### 3.3 Overview of connection resources

The following table shows the protocols that are supported in addition to those listed in the tables for the S7-1500 communications modules (e.g. CP 1543-1).

Table 3- 4 Layers and protocols of S7-1500 communications modules

| Protocol                                            | Port number               | (2) Link layer<br>(4) Transport layer | Function                            | Description                                                                                                       |
|-----------------------------------------------------|---------------------------|---------------------------------------|-------------------------------------|-------------------------------------------------------------------------------------------------------------------|
| <b>PROFINET/Industrial Ethernet protocols</b>       |                           |                                       |                                     |                                                                                                                   |
| <b>Connection-oriented communications protocols</b> |                           |                                       |                                     |                                                                                                                   |
| FTP<br>File transfer protocol                       | 20 (data)<br>21 (control) | (4) TCP                               | File transfer protocol              | FTP is used for the transmission of files (only in connection with CP 1543-1).                                    |
| secureFTP<br>File transfer protocol                 | 20 (data)<br>21 (control) | (4) TCP                               | File transfer protocol              | SecureFTP is used for the transmission of files by means of a TLS connection (only in connection with CP 1543-1). |
| DHCP<br>Dynamic Host Configuration Protocol         | 68                        | (4) UDP                               | Dynamic Host Configuration Protocol | DHCP is used to retrieve the IP Address Suite from a DHCP server when starting up the IE interface.               |
| Secure NTPv3<br>Network time protocol               | 123                       | (4) UDP                               | Network time protocol               | Secure NTP is used to synchronize the CP 1543-1 internal system clock with an NTP server.                         |
| SNMP<br>Simple network management protocol          | 161<br>162 (trap)         | (4) UDP                               | Simple network management protocol  | SNMPv3 permits the CP 1543-1 to read network management data (MIBs) from SNMPv3 agent with authentication.        |

Special consideration S7-1500 MFP:

Port 111: The S7-1500 MFP uses Port 111 to the NFS service for internal communication.

## 3.3 Overview of connection resources

### Connection resources

Some communications services require connections. Connections allocate resources on the CPUs, CPs and CMs involved (for example memory areas in the CPU operating system). In most cases one resource per CPU/CP/CM is allocated for a connection. In HMI communication, up to 3 connection resources are required per HMI connection.

The connection resources available depend on the CPU being used, the CPs and CMs and must not exceed a defined high limit for the automation system.

### Available connection resources in a station

The maximum number of resources of a station is determined by the CPU.

Each CPU has reserved connection resources for PG, HMI and web server communication. In addition, there are available resources for other communication services, e.g. for SNMP, e-mail connections, HMI and S7 communication as well as for open communication.

### When are connection resources allocated?

The time for allocation of connection resources depends on how the connection is set up, automatic, programmed or configured (see section Setting up a connection (Page 33)).

### Additional information

You will find more detailed information on the allocation of connection resources and the display of connection resources in STEP 7 in the section Connection resources (Page 391).

## 3.4 Setting up a connection

### Automatic connection

STEP 7 sets up a connection automatically (for example PG or HMI connection) if you have connected the PG/PC interface to an interface of the CPU physically and have made the interface assignment in STEP 7 in the "Go online" dialog.

### Setting up a programmed connection

You set up the programmed connection in the program editor of STEP 7 in the context of a CPU by assigning instructions for communication, for example TSEND\_C.

When specifying the connection parameters (in the Inspector window, in the properties of the instruction), you are supported by the easy-to-use user interface.

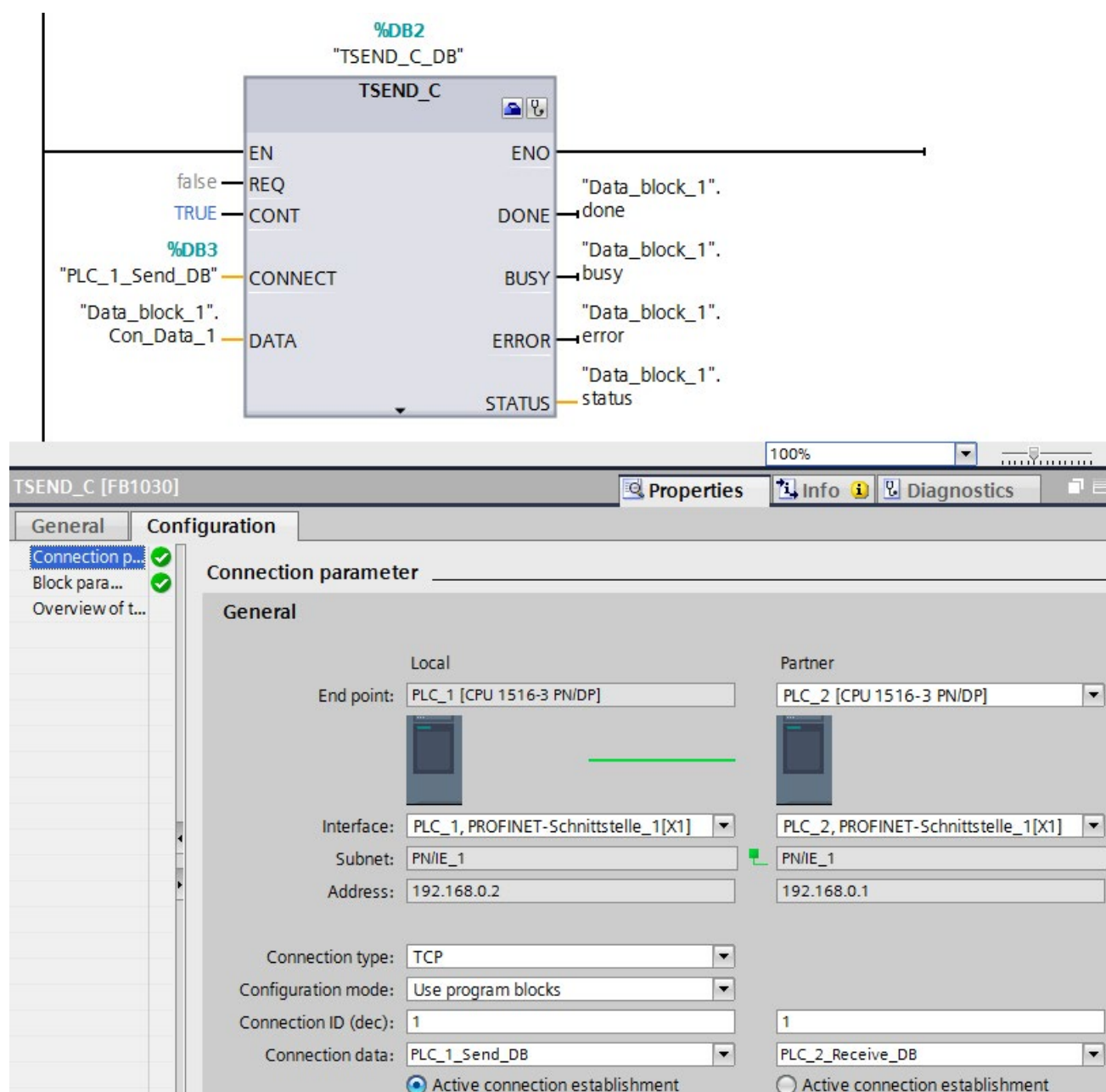


Figure 3-1 Programmed setup

## Setting up a configured connection

You set up the configured connection in the network view of the Devices & networks editor of STEP 7 in the context of a CPU or a software controller.

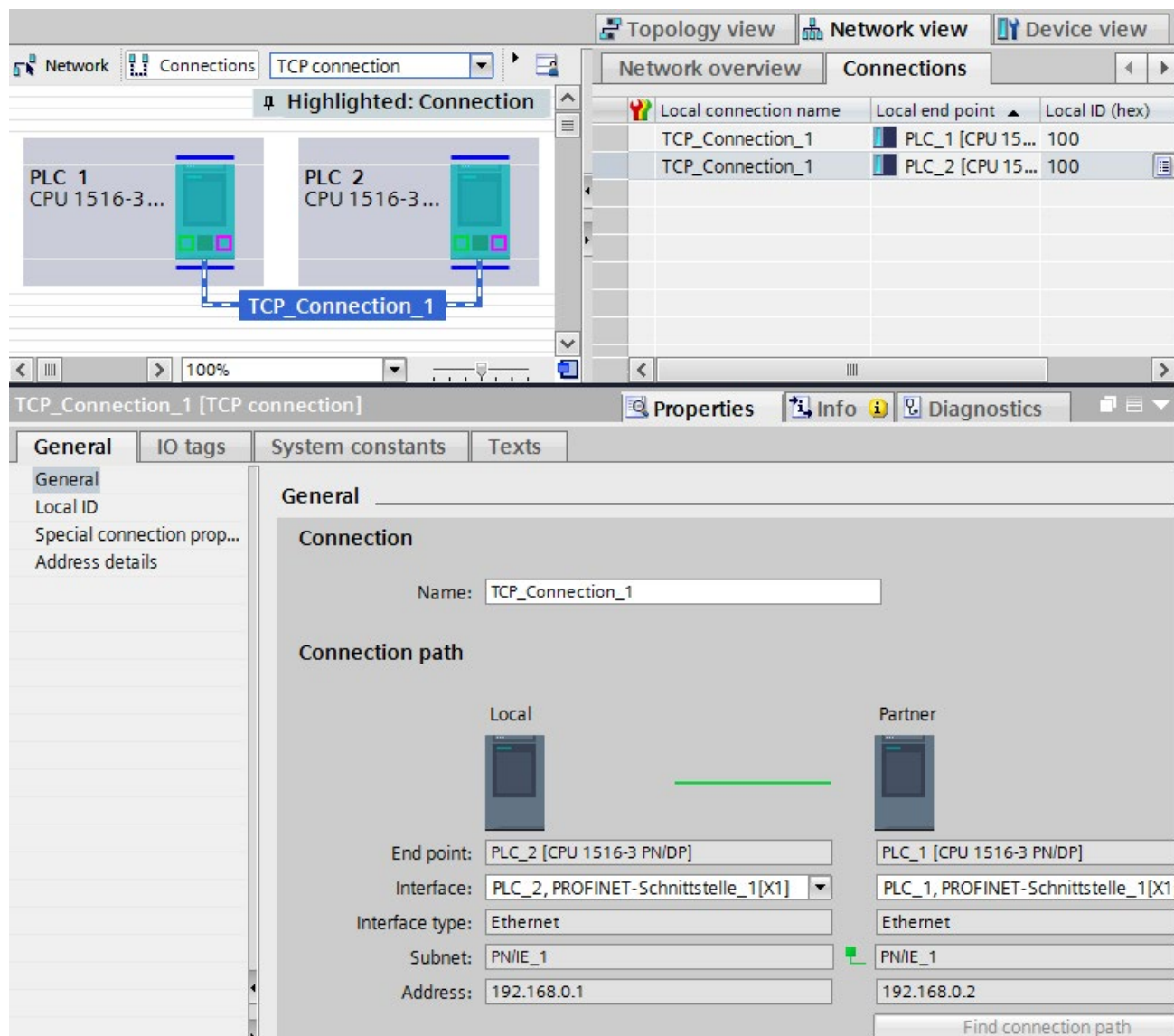


Figure 3-2 Configured setup

## Effects on the connection resources of the CPU

You can often choose between a configured or a programmed connection. Programmed connection setup allows connection resources to be released following data transfer. Like routed connections, programmed connections are not guaranteed, meaning that they are only established when resources are available. With configured connection setup, the resource is available after download of the configuration until the configuration changes again. Corresponding resources are therefore reserved for connection establishment via configured connections. The "Connection resources" table in the Inspector window of the CPU displays an overview of connection resources already used and those still available.

## How do I set up a connection?

Table 3- 5 Setting up the connection

| Connection                                   | Automatically | Programmed setup | Configured setup |
|----------------------------------------------|---------------|------------------|------------------|
| Programming device connection                | X             | -                | -                |
| HMI connection                               | X             | -                | X                |
| Web communication                            | X             | -                | -                |
| OPC UA server communication                  | X             | -                | -                |
| OPC UA client communication                  | -             | X                | -                |
| Open communication via TCP/IP connection     | -             | X                | X                |
| Open communication via ISO-on-TCP connection | -             | X                | X                |
| Open communication via UDP connection        | -             | X                | X                |
| Open communication via ISO connection        | -             | X                | X                |
| Open communication via FDL connection        | -             | X                | X                |
| Communication via Modbus TCP connection      | -             | X                | -                |
| E-mail connection                            | -             | X                | -                |
| FTP connection                               | -             | X                | -                |
| S7 connection*                               | -             | -                | X                |

\* Note that for an S7-1500 CPU you must enable the use of PUT/GET communication in the properties of the CPU. You can find more information on this topic in the STEP 7 online help.

## Additional information

You will find further information on the allocation of connection resources and the display of connection resources in STEP 7 in the section Connection resources (Page 391).



## 3.5 Data consistency

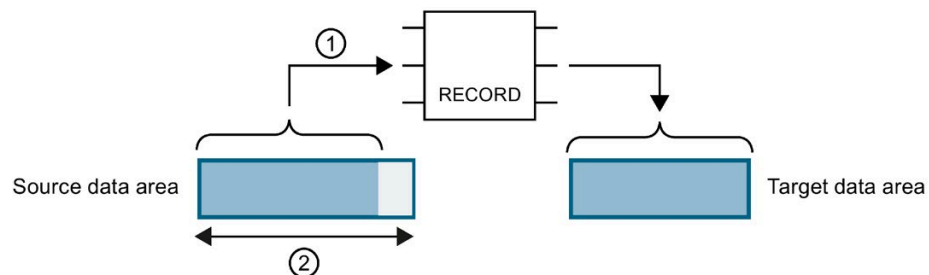
### Definition

Data consistency is important for data transfer and you need to take this into account when configuring the communication task. Otherwise, malfunctions may occur.

A data area which cannot be modified by concurrent processes is called a consistent data area. This means that a data area which belongs together and which is larger than the maximum size of the consistent data area can consist in part of new and of old data at the same time.

An inconsistency can occur when an instruction for communication is interrupted, for example by a hardware interrupt OB with higher priority. This interrupts the transfer of the data area. If the user program in this OB now changes the data that has not yet been processed by the communication instruction, the transferred data originates from different times:

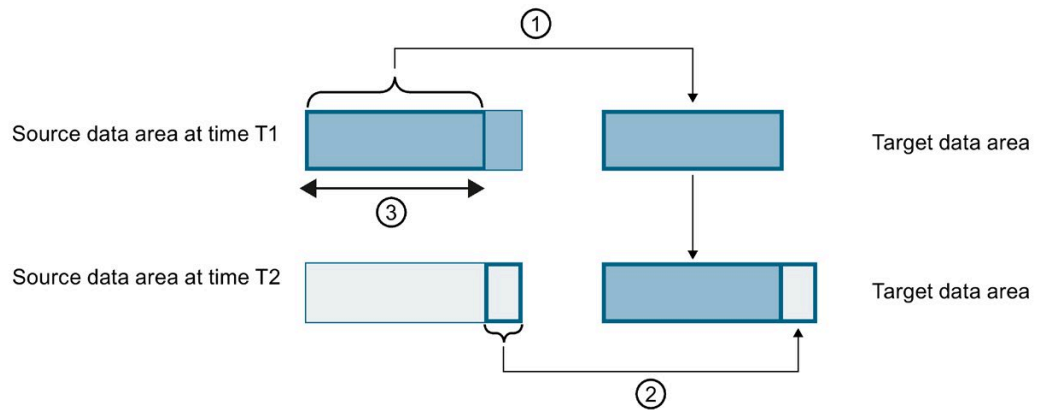
The following figure shows a data area that is smaller than the maximum size of the consistent data area. In this case, when transferring the data area, it is ensured that there is no interruption by the user program during data access so that the data is not changed.



- ① The source data area is smaller than the maximum size of the consistent data area (②). The instruction transfers the data together to the destination data area.
- ② Maximum size of the consistent data area

Figure 3-3 Consistent transfer of data

The following figure shows a data area that is larger than the maximum size of the consistent data area. In this case, the data can be changed during an interruption of the data transfer. An interruption also occurs if, for example, the data area needs to be transferred in several parts. If the data is changed during the interruption, the transferred data originates from different times.

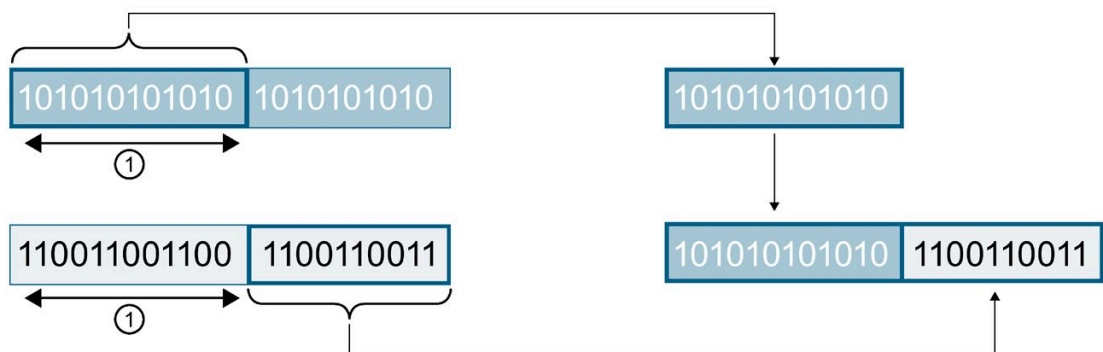


- ① The source data area is larger than the maximum size of the consistent data area (③). At time T1, the instruction only transfers as much data from the source data area into the destination data area as fits in the consistent data area.
- ② At time T2, the instruction transfers the rest of the source data area to the destination data area. After the transfer, data from different points in time exist in the destination data area. If the data in the source data area has changed in the meantime, an inconsistency may result.
- ③ Maximum size of the consistent data area

Figure 3-4 Transfer of data larger than the maximum consistency area

### Example of an inconsistency

The figure below shows an example of changing data during the transfer. The destination data area contains data from different points in time.



- ① Maximum size of the consistent data area

Figure 3-5 Example: Changing data during the transfer

**System-specific maximum data consistency for S7-1500:**

No inconsistency occurs if the system-specific maximum size of the consistent data is kept to. With an S7-1500, communication data is copied consistently into or out of the user memory in blocks of up to 512 bytes during the program cycle. Data consistency is not ensured for larger data areas. Where defined data consistency is required, the length of communication data in the user program of the CPU must not exceed 512 bytes. You can then access these data areas consistently, for example from an HMI device by reading/writing tags.

If more data than the system-specific maximum size needs to be transferred consistently, you yourself must ensure the data consistency with suitable measures in the user program.

**Ensuring data consistency****Use of instructions for access to common data:**

If the user program contains instructions for communication that access common data, for example TSEND/TRCV, you can coordinate access to this data area yourself, for example using the "DONE" parameter. The data consistency of the data areas that are transferred with an instruction for communication can therefore be ensured in the user program.

---

**Note****Measures in the user program**

To achieve data consistency, you can copy transferred data to a separate data area (for example, global data block). While the user program continues to work with the original data, you can transfer the data saved in the separate data area consistently with the communication instruction.

For the copying, use uninterruptible instructions such as UMOVE\_BLK or UFILL\_BLK. These instructions ensure data consistency up to 16 KB.

---

**Use of PUT/GET instructions or Write/Read via HMI communication:**

In S7 communication with the PUT/GET instructions or Write/Read via HMI communication, you need to take into account the size of the consistent data areas during programming or configuration. In the user program of an S7-1500 as server, there is no instruction available that can coordinate the data transfer in the user program. The data exchanged using PUT/GET instructions updates the S7-1500 while the user program is running. There is no point in time within the processing of the cyclic user program at which the data is exchanged consistently. The length of the data area to be transferred should be smaller than 512 bytes.

**Additional information**

- You will also find the maximum amount of consistent data in the device manuals of the communications modules in the Technical Specifications.
- You will find further information on data consistency in the description of the instructions in the STEP 7 online help.

## 3.6 Secure Communication

### 3.6.1 Basics of Secure Communication

#### 3.6.1.1 Basics of Secure Communication

For STEP 7 (TIA Portal) as of V14 and for S7-1500 CPUs as of firmware V2.0, the options for secure communication have been broadened considerably.

"S7-1500 CPUs" also refers to CPU versions S7-1500F, S7-1500T, S7-1500C as well as S7-1500pro CPUs and ET200SP CPUs.

In subsequent versions, additional components will support Secure Communication (secure OUC), see next section.

As of firmware Version V4.4, S7-1200 CPUs also support Secure Communication (Secure OUC).

#### Requirement

- CPUs that support connection description DBs with the structure of the SDT TCON\_IP\_V4\_SEC or SDT TCON\_QDN\_SEC. These are the following CPUs:
  - S7-1200 as of firmware V4.4
  - S7-1500 as of firmware V2.0
- Also optional via the following CPs:
  - CP 1243-1 as of firmware V3.2
  - CP 1243-8 IRC as of firmware V3.2
  - CP 1543-1 as of firmware V2.0
  - CP 1545-1
  - CP 1543SP-1

Secure Communication via CP 1242-7 GPRS V2 is not possible.

#### Public Key Infrastructure (PKI)

The attribute "secure" is used for the identification of communication mechanisms that are based on a Public Key Infrastructure (PKI) (for example RFC 5280 for Internet X.509 Public Key Infrastructure Certificate and Certificate Revocation List Profile). A Public Key Infrastructure (PKI) is a system that can issue, distribute and check digital certificates. The digital certificates issued are used in the PKI to secure computer-based communication. If a PKI uses asymmetric key cryptography, the messages in a network can be digitally signed and encrypted.

Components that you have configured in STEP 7 (TIA Portal) for secure communication use an asymmetric key encryption scheme with a public key (Public Key) and a private key (Private Key). TLS (Transport Layer Security) is used as the encryption protocol. TLS is the successor for the SSL (Secure Sockets Layer) protocol.

## Objectives of secure communication

Secure communication is used to achieve the following objectives:

- Confidentiality  
i.e. the data are secret / cannot be read by eavesdroppers.
- Integrity  
i.e. the message that reaches the recipient is the same message, unchanged, that the sender sent. The message has not been altered on the way.
- End point authentication  
i.e. the end point communication partner is exactly who it claims to be and the party who is to be reached. The identity of the partner has been checked.

These objectives were in the past primarily relevant to IT and networked computers. Now, industrial machinery and control systems with sensitive data are at equally high risk, as they are also networked, and consequently pose strict security requirements for data exchange.

Protection of the automation cell by means of the cell protection concept through firewall, or via connection through VPN, for example with the security module, was common in the past and remains so.

However, it is becoming increasingly necessary to also transfer data to external computers in encrypted form via Intranet or public networks.

## Common principles of secure communication

Independent of the context, secure communication is based on the concept of the Public Key Infrastructure (PKI) and contains the following components:

- An asymmetric encryption scheme that allows:
  - Encryption or decryption of messages using public or private keys.
  - The verification of signatures in messages and certificates.  
The messages/certificates are signed by the sender/certificate subject with their private key. The recipient/verifier checks the signature with the public key of the sender/certificate subject.
- Transport and storage of the public key using X.509 certificates:
  - X.509 certificates are digitally signed data that allow public key authentication in terms of the bound identity.
  - X.509 certificates can contain information that describes in more detail or restricts use of the public key. For example the date as of which a public key in a certificate is valid and when it expires.
  - X.509 certificates contain information about the issuer of the certificate in secure form.

The following paragraphs give an overview of these basic concepts, which are required for managing certificates in STEP 7 (TIA Portal), for example, and for programming communication instructions for secure Open User Communication (sOUC).

## Secure communication with STEP 7

STEP 7 as of V14 provides the required PKI for the configuration and operation of secure communication.

Examples:

- The Hypertext Transfer Protokoll (HTTP) turns into Hypertext Transfer Protokoll Secure (HTTPS) with the help of the TLS (Transport Layer Security) protocol. Since HTTPS is a combination of HTTP and TLS, it is called "HTTP over TLS" in the corresponding RFC. You can see in the browser that HTTPS is being used; this is indicated by the URL "https://" instead of "http://" in the address bar of the browser. Most browsers highlight such secure connections.
- Open User Communication turns into secure Open User Communication. The underlying protocol is also TLS.
- E-mail providers also offer access over the "Secure SMTP over TLS" protocol to increase the security of e-mail communication.

The figure below shows the TLS protocol in the context of communication layers.

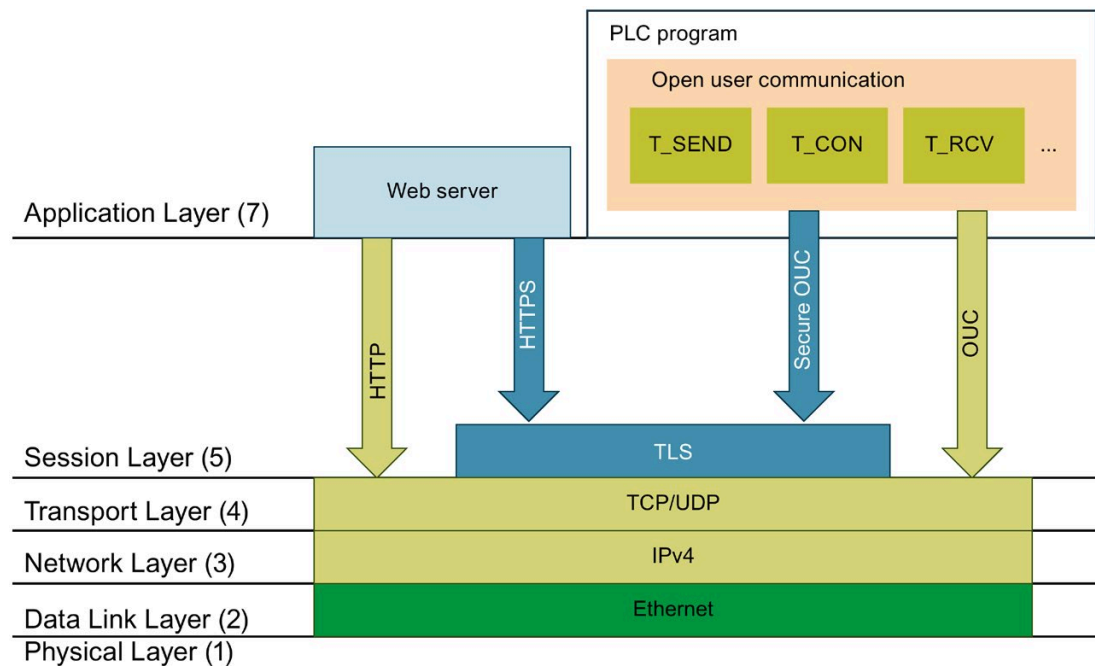


Figure 3-6 TLS protocol in the context of communication layers

## Secure communication with OPC UA

An OPC UA server is implemented in S7-1500 CPUs as of firmware V2.0. OPC UA Security also covers authentication, encryption and data integrity with digital X.509 certificates and also uses a Public Key Infrastructure (PKI). Depending on the requirements placed by the application, you can select different security levels for the end point security. The description of the OPC UA server functionality is covered in a separate section.

## Secure communication for PG/HMI communication

With the central components of the TIA Portal, STEP 7 and WinCC, an innovative and standardized Secure PG/PC and HMI Communication - PG/HMI communication for short - is implemented starting with version V17 together with the latest controllers and latest HMI devices.

### See also

Using the S7-1500 as an OPC UA server (Page 201)

### 3.6.1.2 Confidentiality through encryption

Message encryption is an important element of data security. When encrypted messages are intercepted by third parties during communication, these potential eavesdroppers cannot access the information they contain.

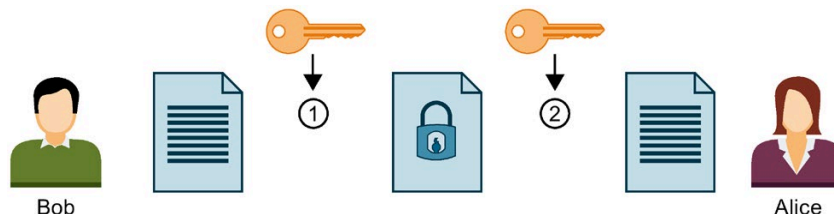
There is a wide range of mathematical processes (algorithms) for encrypting messages.

All algorithms process a "key" parameter to encrypt and decrypt messages.

- Algorithm + key + message => encrypted message
- Encrypted message + key + algorithm => (decrypted) message

### Symmetric encryption

The central aspect of symmetric encryption is that both communication partners use the same key for message encryption and decryption, as shown in the figure below. Bob uses the same key for encryption as Alice uses for decryption. In general, we also say that the two sides share the secret key with which they encrypt or decrypt a message as a secret.



- ① Bob encrypts his message with the symmetric key
- ② Alice decrypts the encrypted message with the symmetric key

Figure 3-7 Symmetric encryption

The process can be compared to a briefcase to which the sender and recipient have the same key, which both locks and opens the case.

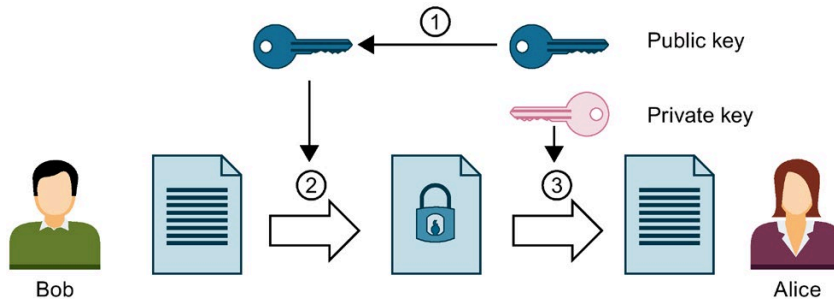
- Advantage: Symmetric encryption algorithms (such as AES, Advanced Encryption Algorithm) are fast.
- Disadvantages: How can the key be sent to a recipient without getting into the wrong hands? This is a key distribution problem. If enough messages are intercepted, the key can also be worked out and must therefore be changed regularly.

If there are a large number of communication partners, there is also a large number of keys to distribute.

## Asymmetric encryption

Asymmetric encryption works with a pair of keys consisting of one public key and one private key. Used with a PKI, it is also known as Public Key cryptography or simply PKI cryptography. A communication partner, Alice in the figure below, has a private key and a public key. The public key is provided to the public, in other words any potential communication partner. Anyone with the public key can encrypt messages for Alice. In the figure below, this is Bob.

Alice's private key, which she must not disclose, is used by Alice to decrypt an encrypted message addressed to her.



- ① Alice provides Bob with her public key. No precautionary measures are required to this purpose: Anyone can use the public key for messages to Alice if they are sure that it is actually Alice's public key.
- ② Bob encrypts his message with Alice's public key.
- ③ Alice decrypts the encrypted message from Bob with her private key. As only Alice has the private key and never discloses it, only she can decrypt the message. With her private key, she can decrypt any message encrypted with her public key - not only messages from Bob.

Figure 3-8 Asymmetric encryption

The system can be compared to a mailbox into which anyone can put a message, but from which only the person with the key can remove messages.

- **Advantages:** A message encrypted with a public key can only be decrypted by the owner of the private key. As another (private) key is required for decryption, it is also much harder to work out the decryption key on the basis of large numbers of encrypted messages. This means that the public key does not have to be kept strictly confidential, unlike with symmetric keys.

Another advantage is easier distribution of public keys. No specially secured channel is required in asymmetric cryptography to transfer the public key from the recipient to the sender encrypting the messages. Less work is thus required in managing the keys than would be the case in symmetric encryption procedures.

- **Disadvantages:** Complex algorithm (e.g. RSA, named after the three mathematicians Rivest, Shamir and Adleman), and therefore poorer performance than with symmetric encryption.



## Encryption processes in practice

In practice, for example with a CPU Web server and Secure Open User Communication, the TLS protocol is used below the relevant application layer. Application layers are HTTP or SMTP, for example, as detailed above.

TLS (Transport Layer Security) uses a combination of asymmetric encryption and symmetric encryption (hybrid encryption) for secure data transfer, for example, over the Internet, and uses the following subprotocols:

- TLS Handshake Protocol, responsible for authentication of communication partners and negotiation of the algorithms and keys to be used for subsequent data transfer on the basis of asymmetric encryption.
- TLS Record Protocol, responsible for encryption of user data with symmetric encryption and data exchange.

Both asymmetric and symmetric encryption are considered secure encryption schemes - there is basically no difference in security between the two procedures. The degree of security depends on parameters such as the selected key length.

## Abuse of encryption

You cannot tell what identity is assigned to a public key from the bit string. A fraud could provide their public key and claim to be someone else. If a third party then uses this key thinking that they are addressing their required communication partner, confidential information could end up with the fraud. The fraud then uses their private key to decrypt the message that was not intended for them, and sensitive information falls into the wrong hands.

To prevent this type of abuse, the communication partners must be confident that they are dealing with the right communication partner. This trust is established by using digital certificates in a PKI.

### 3.6.1.3 Authenticity and integrity through signatures

Attacks from programs that intercept communication between the server and client and act as if they themselves were client or server, are called man-in-the-middle attacks. If the false identity of these programs is not detected, they can obtain important information about the S7 program, for example, or set values in the CPU and attack a machine or plants. Digital certificates are used to avoid such attacks.

Secure communication uses digital certificates that meet the X.509 standard of the International Telecommunication Union (ITU). This allows the identity of a program, a computer or an organization to be checked (authenticated).

## How certificates establish trust

The main role of X.509 certificates is to bind an identity with the data of a certificate subject (for example, e-mail address or computer name) to the public key of the identity. Identities can be people, computers or machines.

Certificates are issued by certificate authorities (Certificate Authority, CA) or by the subject of a certificate itself. PKI systems specify how users can trust the certificate authorities and the certificates that they issue.

The certificate process:

1. Anyone wishing to own a certificate submits a certificate application to a registration authority linked to the certificate authority.
2. The certificate authority assesses the application and applicant on the basis of set criteria.
3. If the identity of the applicant can be clearly established, the certificate authority confirms that identity by issuing a signed certificate. The applicant has now become the certificate subject.

The figure below is a simplified overview of the process. It does not show how Alice can check the digital signature.

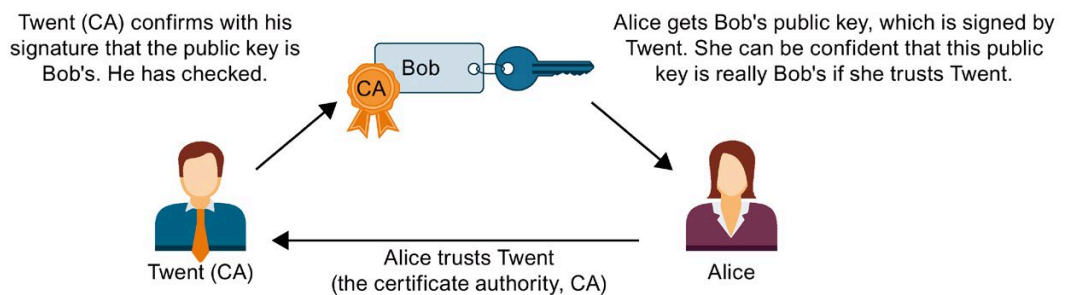


Figure 3-9 Signing of a certificate by a certificate authority

## Self-signed certificates

Self-signed certificates are certificates whose signature comes from the certificate subject and not from an independent certificate authority.

Examples:

- You can create and sign a certificate yourself, for example, to encrypt messages to a communication partner. In the example above, Bob (instead of Twent) could himself sign his certificate with his private key. Using Bob's public key, Alice can check that the signature and public key from Bob match. This procedure is sufficient for simple internal plant communication that is to be encrypted.
- A root certificate is, for example, a self-signed certificate, signed by the certificate authority (CA), that contains the public key of the certificate authority.

## Features of self-signed certificates

The "CN" (Common Name of Subject) for the certificate subject and "Issuer" attributes of self-signed certificates are identical: You have signed your certificate yourself. The field "CA" (Certificate Authority) must be set to "False"; the self-signed certificate should not be used to sign other certificates.

Self-signed certificates are not embedded in a PKI hierarchy.

## Certificate content

A certificate to the X.509 V3 standard, the standard that is also used by STEP 7 and the S7-1500 CPUs, consists primarily of the following elements:

- Public key
- Details of the certificate subject (i.e. the holder of the key), for example, the Common Name (CN) of Subject .
- Attributes such as serial number and validity period
- Digital signature from the certificate authority (CA) confirming that the information is correct.

There are also extensions, for example:

- Specification of what the public key may be used for (Key Usage), for example, signing or key encryption.  
When you create a new certificate with STEP 7, for example in the context of Secure Open User Communication, select the correct entry from the list of possible usages, e.g. "TLS".
- Specification of a Subject Alternative Name (SAN), which is used in secure communication with Web servers (HTTP over TLS), for example, to ensure that the certificate in the address bar of the Web browser also belongs to the Web server specified in the URL.

## How signatures are generated and verified

Asymmetric key usage ensures that certificates can be verified: The example of the "MyCert" certificate illustrates the "Sign" and "Verify signature" processes.

Generating a signature:

1. The issuer of the "MyCert" certificate generates a hash value from the certificate data using a specific hash function (for example SHA-1, Secure Hash Algorithm).  
The hash value is a bit string of a constant length. The advantage of the constant length of the hash value is that it always takes the same amount of time to sign.
2. Using the hash value generated in this way and the private key, the issuer of the certificate then generates a digital signature. The RSA signature scheme is often used.
3. The digital signature is saved in the certificate. The certificate is now signed.

Verifying a signature:

1. The authenticator of the "MyCert" certificate obtains the certificate of the issuer and thus the public key.
2. A new hash value is formed from the certificate data with the same hash algorithm that was used for signing (for example SHA-1).

3. This hash value is then compared with the hash value that is determined by means of the public key of the certificate issuer and the signature algorithm for checking the signature.
4. If the signature check produces a positive result, both the identity of the certificate subject as well as the integrity, meaning authenticity and genuineness, of the certificate content are proven. Anyone who has the public key, i.e. the certificate from the certificate authority, can check the signature and thus recognize that the certificate was actually signed by the certificate authority.

The figure below shows how Alice uses the public key in the certificate from Twent (who represents the certificate authority, CA) to verify the signature on Bob's public key. All that is required for verification is therefore the availability of the certificate from the certificate authority at the moment of checking. The validation itself is executed automatically in the TLS session.

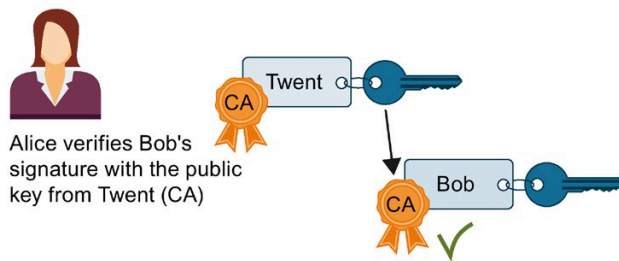


Figure 3-10 Verification of a certificate with the public key of the certificate of a certificate authority

## Signing messages

The method described above for signing and verifying also uses the TLS session for signing and verifying messages.

If a hash value is generated by a message and this hash value is signed with the private key of the sender and attached to the original message, the recipient of the message is able to check the integrity of the message. The recipient decrypts the hash value with the public key of the sender, puts together the hash value from the message received and compares the two values. If the values are not the same, the message has been tampered with on the way.

### Chain of certificates to root certificate

The certificates of a PKI are often organized hierarchically: The top of the hierarchy is formed by root certificates. Root certificates are certificates that are not signed by a higher-level certificate authority. The certificate subject and certificate issuer of root certificates are identical. Root certificates enjoy absolute trust. They form the "anchor" of trust and must therefore be known to the receiver as trusted certificates. They are stored in an area provided for trusted certificates.

Depending on the PKI, the function of root certificates is, for example, to sign certificates from lower-level certificate authorities, so-called intermediate certificates. This transfers the trust from the root certificate to the intermediate certificate. An intermediate certificate can sign a certificate just like a root certificate; both are therefore referred to as "CA certificates".

This hierarchy can be continued over multiple intermediate certificates until the end-entity certificate. The end-entity certificate is the certificate of the user who is to be identified.

The validation process runs through the hierarchy in the opposite direction: As described above, the certificate issuer is established and the signature checked with the issuer's public key, then the certificate of the higher-level certificate issuer is established along the entire chain of trust to the root certificate.

Conclusion: The chain of intermediate certificates to the root certificate, the certificate path, must be available in every device that is to validate an end-entity certificate of the communication partner, irrespective of the type of secure communication that you configure.

#### 3.6.1.4 Managing certificates with STEP 7

STEP 7 as of version V14 together with the S7-1500-CPU as of firmware version 2.0 support the Internet PKI (RFC 5280) in as far as an S7-1500-CPU is able to communicate with devices that also support the Internet PKI.

The usage of X.509 certificates for verifying certificates as described in the preceding sections, for example, is a result of this.

STEP 7 as of V14 uses a PKI similar to Internet PKI. Certificate Revocation Lists (CRLs), for example, are not supported.

### Creating or assigning certificates

You create certificates for various applications in STEP 7 for devices with security properties, such as an S7-1500 CPU as of firmware V2.0.

The following areas in the Inspector window of the CPU allow the creation of new certificates or the selection of existing ones:

- "Web server > Security" - for the generation and assignment of Web server certificates.
- "Protection & Security > Connection mechanisms" - for the generation or assignment of PLC communication certificates (Secure PG/HMI communication, as of TIA Portal V17).
- "Protection & Security > Certificate manager" - for the generation and assignment of all types of certificates. TLS certificates for Secure Open User Communication are preset for the generation of certificates.
- "OPC UA > Server > Security" - for the generation or assignment of OPC UA server certificates.

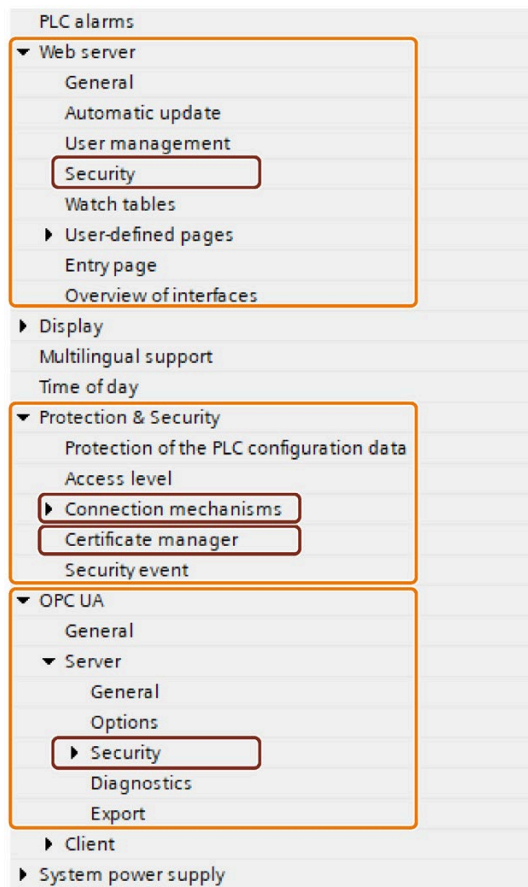


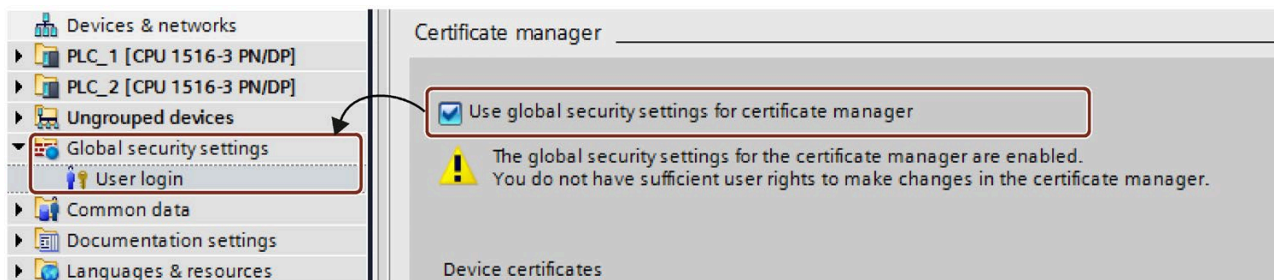
Figure 3-11 Security settings for an S7-1500 CPU in STEP 7

### Special features of the section "Protection & Security > Certificate manager"

Only in this section of the Inspector window do you switch between the global, i.e. project-wide, and the local, i.e. device-specific, certificate manager (option "Use global security settings for the certificate manager"). The option decides whether you have access to all the certificates in the project or not.

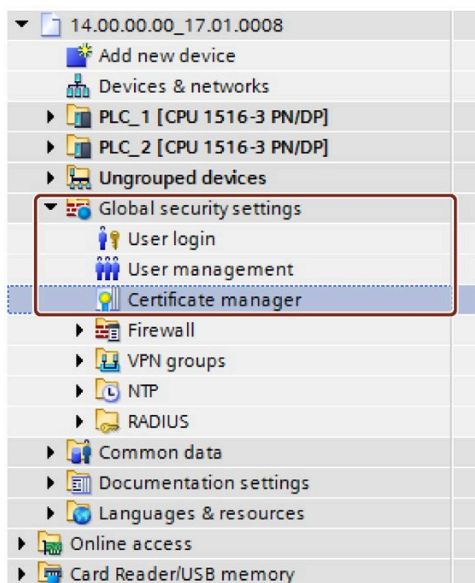
- If you do **not** use the certificate manager in the global security settings, you only have access to the local certificate memory of the CPU. You do not have access, for example, to imported certificates or root certificates. Without these certificates only a restricted functionality is available. You can, for example, only generate self-signed certificates.
- If you use the certificate manager in the global security settings and you are logged on as an administrator, you have access to the global, project-wide certificate memory. You can, for example, assign imported certificates to the CPU, or create certificates that are issued and signed by the project CA (certificate authority of the project).

The figure below shows how the "Global security settings" are shown in the project tree after the "Use global security settings for certificate manager" option has been activated in the Inspector window of the CPU.



When you double-click "User login" in the project tree below the global security settings and log in, a line called "Certificate manager" is displayed, among other data.

When you double-click the "Certificate manager" line, you obtain access to all the certificates in the project, divided into the tabs "CA" (certificate authorities), "Device certificates" and "Trusted certificates and root certificate authorities".



## Private keys

STEP 7 generates private keys while generating device certificates and server certificates (end-entity certificates). The location where the private key is stored encrypted depends on the use of the global security settings for the certificate manager:

- If you use global security settings, the private key is stored encrypted in the global (project-wide) certificate memory.
- If you do not use global security settings, the private key is stored encrypted in the local (CPU-specific) certificate memory.

The existence of the private key, which is required to decrypt data, for example, is displayed in the "Private key" column of the "Device certificates" tab of the certificate manager in the global security settings.

When the hardware configuration is loaded, the device certificate, the public key as well as the private key are loaded into the CPU.

|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |
|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>NOTICE</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |
| <b>Enabling the "Use global security settings for certificate manager" option - Consequences</b>                                                                                                                                                                                                                                                                                                                                                                                                                           |
| The "Use global security settings for certificate manager" option influences the previously used private key: If you have already created certificates without using the certificate manager in the global security settings and then change the option for using the certificate manager, the private keys are lost and the certificate ID can change. A warning draws your attention to this fact. Therefore specify at the beginning of the project configuration which option is required for the certificate manager. |

### 3.6.1.5 Examples for the management of certificates.

As explained in the preceding sections, certificates are required for every type of secure communication. The following section shows as an example how you handle the certificates with STEP 7 so that the requirements for Secure Open User Communication are fulfilled.

The devices which are involved at the respective communication partners are differentiated below. The respective steps for supplying the required certificates to the communications participants are described. An S7-1500 CPU or an S7-1500 software controller as of firmware version 2.0 is always required.

The general rule is:

While a secure connection is being established (handshake), the communication partners as a rule only communicate their end-entity certificates (device certificates).



Therefore the CA certificates required to verify the transmitted device certificate must be located in the certificate memory of the respective communication partner.

---

**Note**

The current date/time must be set in the CPU.

When using secure communication (for example, HTTPS, secure OUC, OPC UA), make sure that the corresponding modules have the current time of day and the current date. Otherwise, the modules will evaluate the certificates used as invalid and secure communication will not work.

---

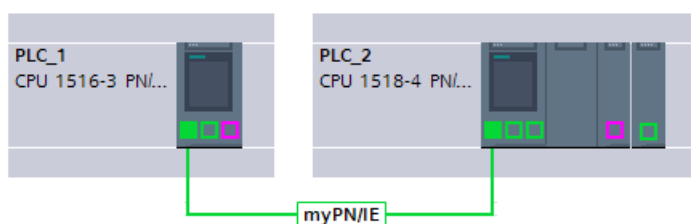
## Secure Open User Communication between two S7-1500 CPUs

Two S7-1500-CPU, PLC\_1 and PLC\_2, are to exchange data with each other via Secure Open User Communication.

You generate the required device certificates with STEP 7 and assign them to the CPUs as described below.

STEP 7 project certificate authorities (CA of the project) are used to sign the device certificates.

The certificates are to be referenced by their certificate ID in the user program (TCON communication instruction in combination with the associated system data type, for example TCON\_IPV4\_SEC). STEP 7 assigns the certificate ID automatically during the generation or creation of certificates.



## Procedure

STEP 7 automatically loads the required CA certificates together with the hardware configuration to the participating CPUs so that the requirements for certificate verification exist for both CPUs. You therefore only have to generate the device certificates for the respective CPU; STEP 7 does the rest for you.

1. Mark PLC\_1 and activate the "Use global security settings for certificate manager" option in the "Protection & Security" section.
2. Log in as a user in the project tree in the "Global security settings" section. For a new project, the "Administrator" role is planned for the first login.
3. Return to the PLC-1 in the "Protection & Security" section. Click in an empty line in the "Certificate subject" column in the "Device certificates" table to add a new certificate.

4. In the drop-down list for selecting a certificate click the "Add" button.

The "Create Certificate" dialog opens.

5. Leave the default settings in this dialog. They are tailored to the usage of Secure Open User Communication (usage: TLS).

Tip: Supplement the default name of the certificate subject, in this case the CPU name. In order to differentiate you better leave the default CPU name in case you have to manage a large number of device certificates.

Example: PLC\_1/TLS becomes PLC\_1-SecOUC-Chassis17FactoryState.

6. Compile the configuration.

The device certificate and the CA certificate are part of the configuration.

7. Repeat the steps described above for PLC\_2.

In the next step you have to create the user programs for the data exchange and load the configurations together with the program.

### Using self-signed certificates instead of CA certificates

When creating device certificates you can select the "Self-signed" option. You can create self-signed certificates without being logged in for the global security settings. This procedure is not recommended because the resulting certificates do not exist in the global certificate memory and can therefore not be assigned directly to a partner CPU.

As described above, you should select the name of the certificate subject with care so that the right certificate can be assigned to a device without any doubt.

Verification with the CA certificates of the STEP 7 project is not possible for self-signed certificates. To ensure that self-signed certificates can be verified you have to include the self-signed certificates of the communication partner into the list of trusted partner devices for each CPU. To this purpose you must have activated the "Use global security settings for certificate manager" option and be logged in as a user in the global security settings.

Proceed as follows to add the self-signed certificate of the communication partner of the CPU:

1. Mark PLC\_1 and navigate to the "Certificates of partner devices" table in the "Protection & Security" section.
2. Click in an empty line in the "Certificate subject" column in the "Device certificates" table to add a new certificate.
3. Select the self-signed certificate of the communication partner from the drop-down list and confirm the selection.

In the next step you have to create the user programs for the data exchange and load the configurations together with the program.

## Secure Open User Communication between S7-1500 CPU as a TLS client and an external device as a TLS server

Two devices are to exchange data with each other via TLS connection or TLS session, for example, exchanging recipes, production data or quality data:

- An S7-1500 CPU (PLC\_1) as TLS client; the CPU uses Secure Open User Communication
- An external device, for example a Manufacturing Execution System (MES), as TLS server

The S7-1500 CPU establishes the TLS connection / session to the MES system as TLS client.



- ① TLS client
- ② TLS server

The S7-1500 CPU requires the CA certificates of the MES system to authenticate the TLS server: The root certificate and, if appropriate, the intermediate certificates for verifying the certificate path.

You have to import these certificates into the global certificate memory of the S7-1500 CPU.

Proceed as follows to import certificates of the communication partner:

1. Open the certificate manager in the global security settings in the project tree.
2. Select the appropriate table (trusted certificates and root certificate authorities) for the certificate to be imported.
3. Right-click in the table to open the shortcut menu. Click "Import" and import the required certificate or the required CA certificates.

Through the import the certificate has a certificate ID assigned to it and can be assigned to a module in the next step.

4. Mark PLC\_1 and navigate to the "Certificates of partner devices" table in the "Protection & Security" section.
5. Click in an empty line in the "Certificate subject" column to add the imported certificates.
6. Select the required CA certificates of the communication partner from the drop-down list and confirm the selection.

Optionally the MES system can also request a device certificate of the CPU to authenticate the CPU (i.e., the TLS client). In this case, the CA certificates of the CPU must be made available to the MES system. The prerequisite for importing the certificates into the MES system is a preceding export of the CA certificates from the STEP 7 project of the CPU. Follow these steps:

1. Open the certificate manager in the global security settings in the project tree.
2. Select the matching table (CA certificate) for the certificate to be exported.

3. Right-click the selected certificate to open the shortcut menu.
4. Click "Export".
5. Select the export format of the certificate.

In the next step you have to create the user programs for the data exchange and load the configurations together with the program.

### Secure Open User Communication between an S7-1500 CPU as TLS server and an external device as TLS client

If the S7-1500 CPU acts as TLS server and the external device, for example an ERP system (Enterprise Resource Planning System) establishes the TLS connection / session, you require the following certificates:

- For the S7-1500 CPU, you generate a device certificate (server certificate) with a private key and download it with the hardware configuration into the S7-1500 CPU. You use the "Signed by certificate authority" option when generating the server certificate.

The private key is required for the key exchange as explained in the figure for the example "HTTP over TLS".

- You have to export the CA certificate of the STEP 7 project for the ERP system and import / load it into the ERP system. With the CA certificate the ERP system verifies the server certificate of the S7-1500 that was transferred from the CPU to the ERP system during the establishment of the TLS connection / session.



- ① TLS server  
② TLS client

Figure 3-12 Secure OUC between an S7-1500 CPU and ERP system

The required steps are described in the preceding sections.

### Secure Open User Communication to a mail server (SMTP over TLS)

An S7-1500 CPU can establish a secure connection to an e-mail server with the communication instruction TMAIL-C.

The system data types TMail\_V4\_SEC and TMail\_QDN\_SEC allow you to determine the partner port of the e-mail server and thus to reach the e-mail server via "SMTP over TLS".



Figure 3-13 Secure OUC between a S7-1500 CPU and a mail server

Requirement for secure e-mail connection is the importing of the root certificate and the intermediate certificates of the mail server (provider) into the global certificate memory of the S7-1500 CPU. By means of these certificates the CPU can check the server certificate that is sent by the mail server during the establishment of the TLS connection / session.

Proceed as follows to import certificates of the mail server:

1. Open the certificate manager in the global security settings in the project tree.
2. Select the appropriate table (trusted certificates and root certificate authorities) for the certificate to be imported.
3. Right-click in the table to open the shortcut menu. Click "Import" and import the required certificate or the required CA certificates.

As a result of the import, the certificate has a certificate ID assigned to it and can be assigned to a module in the next step.

4. Mark PLC\_1 and navigate to the "Certificates of partner devices" table in the "Protection & Security" section.
5. Click in an empty line in the "Certificate subject" column to add the imported certificates.
6. Select the required CA certificates of the communication partner from the drop-down list and confirm the selection.

In the next step you have to create the user programs for the e-mail client function of the CPU and load the configurations together with the program.

#### 3.6.1.6 Example: HTTP over TLS

The following paragraphs show how the mechanisms described are used to establish a secure communication between a Web browser and the Web server of an S7-1500 CPU.

Initially the changes for the "Permit access only with HTTPS" option in STEP 7 are described. As of STEP 7 V14 you have the possibility to influence the server certificate of the Web server of an S7-1500 CPU as of firmware V2.0: The server certificate is generated as of these versions with STEP 7.

In addition it illustrates the processes that are executed when a website of the CPU Web server is called with a Web browser of a PC through an encrypted HTTPS connection.

### Using Web server certificates for S7-1500 CPUs, FW V2.0 or higher

For S7-1500 CPUs with a firmware version before V2.0, you were able to set "Permit access only with HTTPS" when setting the Web server properties, without specific requirements applying.

You did not have to handle certificates for these CPUs; the CPU automatically generates the certificates required for the Web server.

For S7-1500 CPUs as of firmware V2.0, STEP 7 generates the server certificate (end-entity certificate) for the CPU. You assign a server certificate to the Web server in the properties of the CPU (Web server > Security).

Because a server certificate name is always preset, there is no change to the easy configuration of the Web server: You activate the Web server. The "Permit access only with HTTPS" option is enabled by default - STEP 7 generates a server certificate with the default name during compiling.

Irrespective of whether you use the certificate manager in the global security settings or not: STEP 7 has all the information required to generate the server certificate.

In addition, you have the possibility to determine the properties of the server certificate, for example, the name or the validity period.

---

#### Note

The current date/time must be set in the CPU.

When using secure communication (for example, HTTPS, secure OUC, OPC UA), make sure that the corresponding modules have the current time of day and the current date. Otherwise, the modules will evaluate the certificates used as invalid and secure communication will not work.

---

### Loading the Web server certificate

The server certificate generated by STEP 7 is then automatically also loaded to the CPU when the hardware configuration is loaded.

- If you use the certificate manager in the global security settings, the certificate authority of the project (CA certificate) signs the server certificate of the Web server: During loading the CA certificate of the project is loaded as well automatically.
- If you do not use the certificate manager in the global security settings, STEP 7 generates the server certificate as a self-signed certificate.

When you address the Web server of the CPU over the IP address of the CPU, a new server certificate (end-entity certificate) must be generated and loaded with each change in the IP address of an Ethernet interface of the CPU. This is necessary because the identity of the CPU changes with the IP address – and the identity requires a signature in accordance with the PKI rules.

You can avoid this problem by addressing the CPU with a domain name instead of its IP address, for example "myconveyer-cpu.room13.myfactory.com". For this purpose, you have to manage the domain names of the CPU via a DNS server.

Supplying a Web browser with a CA certificate of the Web server

In the Web browser the user who accesses the websites of the CPU through HTTPS should install the CA certificate of the CPU. If no certificate is installed, a warning is output recommending that you do not use the page. To view this page, you must explicitly "Add an exception".

The user receives the valid root certificate for download from the "Intro" Web page of the CPU Web server under "Download certificate".

STEP 7 offers a different possibility: Export the CA certificate of the project with the certificate manager into the global security settings in STEP 7. Subsequently import the CA certificate into the browser.

### Course of the secure communication

The figure below shows, in simplified terms, how communication is established ("handshake") focusing on the negotiation of keys used for data exchange (here with HTTP over TLS).

However, the course can be applied to all communication options that are based on the usage of TLS, i.e. also for Secure Open User Communication (see Basics for secure communication).

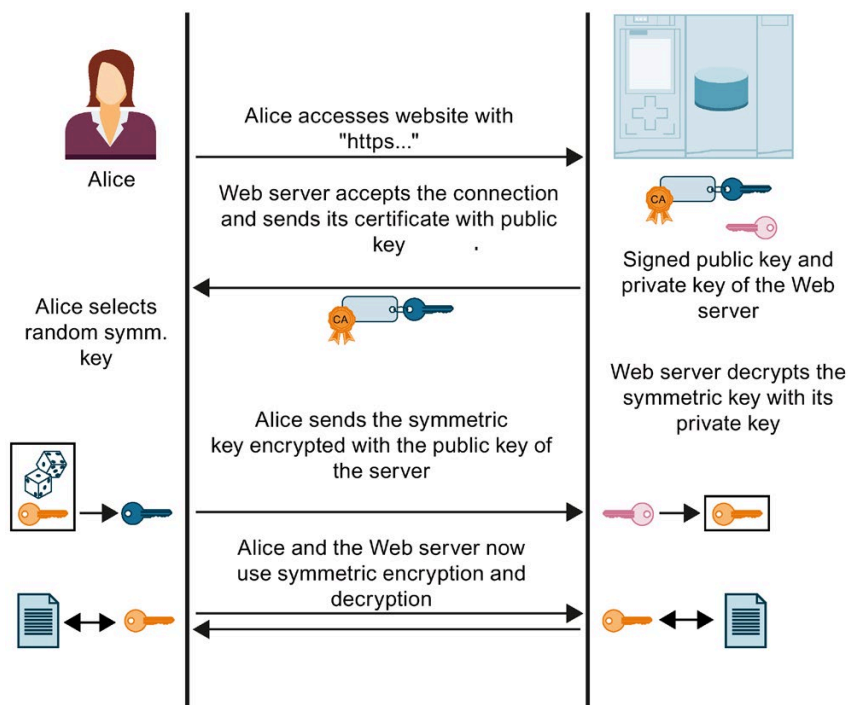


Figure 3-14 Handshake with https

The figure does not show the measures taken at Alice's end (browser) to verify the certificate sent by the Web server. Whether Alice can trust the Web server certificate received and therefore the identity of the Web server, and can accept the exchange of data, depends on positive verification.

The steps for verifying the authenticity of the Web server:

1. Alice must know the public keys of all relevant certificate authorities, which means she requires the complete certificate chain to verify the Web server certificate (i.e. the end-entity certificate of the Web server):

Alice will generally have the required root certificate in her certificate memory. When a Web browser is installed, a range of trusted root certificates is also installed. If she does not have the root certificate, she must download it from the certificate authority and install it in the certificate authority of the browser. The certificate authority can also be the device on which the Web server is located.

You have the following options for obtaining the intermediate certificates:

- The server itself sends the required intermediate certificates to Alice along with its end-entity certificate – in the form of a signed message so that Alice can verify the integrity of the certificate chain.
- The certificates often contain the URLs of the certificate issuer. Alice can load the required intermediate certificates from these URLs.

When you work with certificates in STEP 7 it is always assumed that you have imported the intermediate certificates and the root certificate into the project and assigned them to the module.

2. Alice validates the signatures in the certificate chain with the public keys of the certificates.
3. The symmetric key must be generated and transferred to the Web server.
4. If the Web server is addressed by its domain name, Alice also verifies the identity of the Web server in accordance with the Internet PKI rules defined in RFC 2818. She is able to do this because the URL of the Web server, in this case the "Fully Qualified Domain Name" (FQDN), is saved in the end-entity certificate of the Web server. If the certificate entry in the "Subject Alternative Name" field corresponds to the entry in the address bar of the browser, everything is fine.

The process continues with the exchange of data with the symmetric key, as shown in the figure above.



## 3.6.2 Requirements for secure communication

### 3.6.2.1 Protection of confidential configuration data

As described in the basic information on secure communication, the proper functioning of certificate-based protocols requires private keys that must be protected as best as possible.

As of STEP 7 V17, you can use a password to protect these keys and other data worth protecting: The password to protect confidential PLC configuration data.

It is possible to do without the password if you have implemented measures to prevent unauthorized access to the TIA Portal project and the configuration of the CPU.

independently of whether you assign a password or not: The TIA Portal generates a key information that provides for the protection of the confidential PLC configuration data. This password has no influence on the secure communication process. However, the complexity of the password for the protection of confidential PLC configuration data determines how well the private keys, for example, are protected.

The presence of key information is a prerequisite for secure communication such as TLS-based secure PG/HMI communication: The CPU can handle certificates which are required for Secure Communication only if this key information is available.

The following figure shows the relationships described.

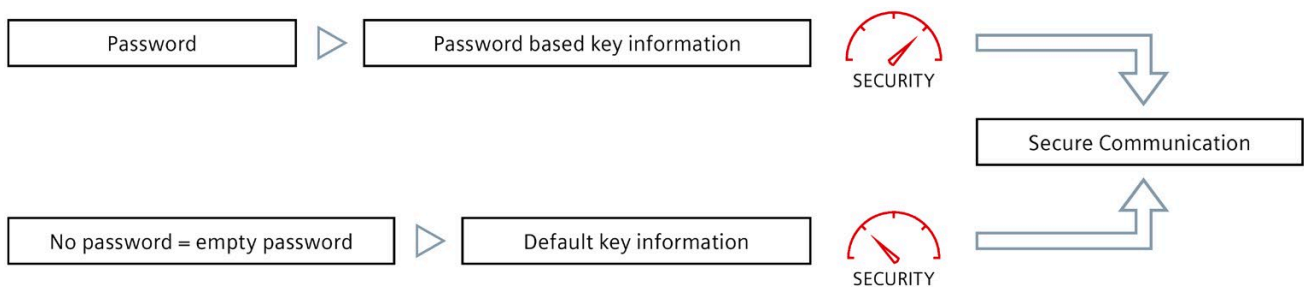


Figure 3-15 Contexts for protecting confidential configuration data

### Security settings wizard

When you add a CPU to the project that supports secure PG/HMI communication in the TIA Portal from the hardware catalog, a wizard starts for the security settings of the CPU.

The wizard guides you step-by-step through the following CPU settings:

- Password to protect confidential PLC configuration data
- PG/PC and HMI communication mode
- Access level

Each of these settings is explained in detail in the wizard. At the end, all settings are once again summarized in an overview.

The wizard also starts, for example, when you replace a module in the network view of the TIA Portal and the new CPU, unlike the replaced CPU, supports secure PG/HMI communication.

All settings in the wizard are applied in the Inspector window (CPU properties).

You can start the wizard at any time using a Start button in the "Protection & Security" area of the CPU properties.

## Requirement

- TIA Portal as of version V17
- CPU supports secure PG/HMI communication (for S7-1500 CPUs as of firmware version 2.9)
- The CPU is not yet loaded or the CPU is reset to factory settings with the option "Delete password for protection of confidential PLC configuration data"

## Procedure

1. Open the CPU properties in the network view or in the device view.
2. Navigate to the area "Protection & Security > Protection of the PLC configuration data".  
**Result:** The "Protect confidential PLC configuration data" option is enabled first and the empty field for password entry is highlighted in red.
3. Configure the password (recommended) via the "Set" button or disable the "Protect confidential PLC configuration data" option.
4. Complete the configuration and create the user program.
5. Load the CPU.  
When loading the hardware configuration, you will be asked once to re-enter the password.  
**Background:** The configured password is used in the TIA Portal to generate the key information to protect confidential configuration data and thus to protect this data. For security reasons, however, neither the password nor the key information is saved in the project. In order for the key information to reach the CPU, it is re-generated when the hardware configuration is loaded, so that the password must be entered once at this point.

## Certificate-based communication also between PG/HMI and CPU

Because, as of TIA Portal version V17 and CPU firmware version V2.9 (S7-1500) or V4.5 (S7-1200), the PG/HMI communication is also certificate-based, you will be prompted to accept the server certificate in the course of the commissioning.

### Tips and rules for password management

- Manage your passwords in a password manager.
- Use TIA Portal's password policy verification settings to check newly entered passwords for compliance and prevent trivial passwords, for example:
  - In the project tree, navigate to the area "<Project name> > Security settings > Settings" area and select the "Password policies" area.
  - Specify, for example, the minimum number of characters the password must have or the minimum number of special characters.
- You do not have to assign different passwords for each CPU in a system or machine. If the requirements are met, you can also define the same password for a group of CPUs. This strategy also has advantages in the replacement parts scenario: If the group password is also assigned to the replacement CPU, the workload of replacing the CPU is reduced.

Note here the risk that if the password of one of these CPUs is compromised, all CPUs with the same password are vulnerable.

- The definition of passwords also has an impact on the replacement part case, as the password for confidential PLC configuration data must be transferred to the new (replacement) CPU in addition to the configuration (see Rules for the replacement parts scenario (Page 72)).
- With **S7-1500R/H CPUs**, the password for confidential PLC configuration data is only loaded onto one of the two CPUs during loading. In order that the sync-up process works and that the partner CPU also works properly, the password must be transferred to the partner CPU before the sync-up, using the Online and Diagnostics editor:
  - In the Online and diagnostics view, you specify the area "Password to protect confidential PLC configuration data".
  - Enter the required password and click the "Set" button.If the correct password has been entered, the partner CPU can use the protected PLC configuration data and start the sync-up process.

### See also

Useful information for the protection of confidential PLC configuration data (Page 63)

#### 3.6.2.2 Useful information for the protection of confidential PLC configuration data

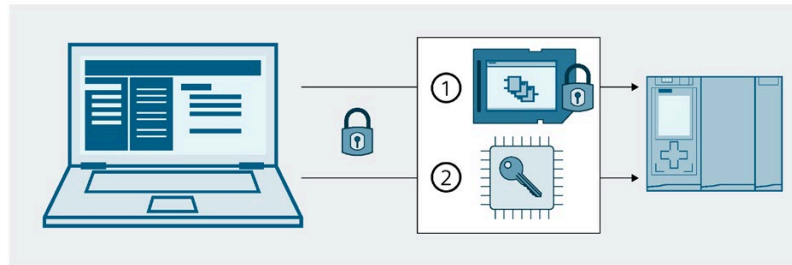
The concept for Secure Communication protected by security standards comprises the following components:

- A password-based key information that is used for protecting confidential configuration data (e.g. private keys for certificates, passwords).
- A standardized log (TLS) that ensures communication between the participants (e.g. programming device and CPU).

### "Protection of confidential configuration data" principle

The following figure shows in a simplified way how confidential configuration data, for example of a standard S7-1500 CPU, is protected: The two components project and key information are placed in different memory areas when loaded for the first time. The project in the load memory (memory card), the key information in a memory area in the CPU.

For other target systems (e.g. S7-1200 CPU, software controller) with different storage concepts, the implementation is adapted to the corresponding storage concepts, but the principle is the same.



- ① Project with password-protected confidential configuration data (here: in load memory = memory card)
- ② Key information (generated from password) to use the protected confidential configuration data (here: in the memory area in the CPU)

Figure 3-16 Principle for protection of confidential configuration data

### Two memory areas for more security

The charged components are related to each other like two matching puzzle pieces: The project is bound to the loaded key information, the loaded key information is bound to the password that was assigned during configuration.

Project and key information must match, otherwise the CPU will not start.

The principle of two separate memory areas also applies to the S7-1200 CPUs and S7-1500 CPU versions without a memory card, e.g. for the SW controller or PLCSim/ PLCSim Advanced. In the versions without memory card, two separate partitions are used so that the two items of information can be managed independently of one another.

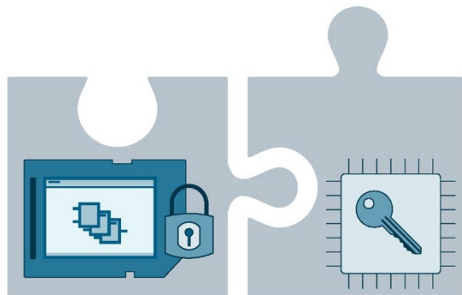


Figure 3-17 Principle of two separate memory areas

### 3.6.2.3 Changing your password

It makes a difference whether the CPU has already been loaded or not. If the CPU has already been loaded, it has the key information with which the password-protected PLC configuration data can be used.

#### Change password - configuration not yet loaded

As long as you have not yet loaded a configuration into the CPU, you can change an entered password or you can revoke the activation of the password protection.

##### Requirement

- The CPU is not yet loaded

##### Procedure

1. Open the CPU properties in the network view or in the device view.
2. Navigate to the area "Protection & Security > Protection of the PLC configuration data".
3. Click the "Change" button or deactivate the option "Protect confidential PLC configuration data".
4. Enter the previously valid password in the dialog. In case of a password change, also enter the new password and confirm the new password.

As long as you have not yet loaded a configuration into the CPU, the CPU is in a provisioning phase (see CPU behavior from loading to operational readiness (Page 96)) and you can load any valid configuration with your configured password.

#### Change password - configuration is already loaded

If the CPU has already been loaded with a configuration and the configuration is protected with a password for confidential PLC configuration data, you must first either reset the CPU to the factory settings and delete the password for confidential PLC configuration data in the CPU or delete it directly online and then set it.

##### Requirements

- You have write access to the CPU
- The CPU must be in STOP mode.

##### Procedure

1. Select the CPU in the network view.
2. Select the "Online & Diagnostics" command from the shortcut menu.

3. If you also change the project on the memory card, i.e. then want to reload the configuration:
  - Select the "Reset to factory settings" area in the opened online and diagnostics view.
  - Activate the option "Delete password to protect confidential PLC configuration data". To avoid a repeated start-up of the CPU, also select the "Format memory card" option.
  - Then load the project with the changed configuration and the desired password.
4. If you do not have to change the project on the memory card, i.e. only the wrong password is set:
  - In the Online and diagnostics view, you specify the area "Password for the protection of confidential PLC configuration data".
  - Click the "Delete" button. If the "Delete" button is not available, no password has been set in the CPU yet.
  - Enter the required password and click the "Set" button.

If the correct password has been entered, the CPU can use the protected PLC configuration data.

#### **No write access to the CPU**

If you do not have write access to the load memory (read access level), remove the memory card from the CPU or delete the memory card externally, e.g. in your computer, before you reset to factory settings with the option "Delete password to protect confidential PLC configuration data".

---

#### **Note**

##### **Reset to factory settings with mode selector of the CPU**

Restoring the factory settings of the CPU via the mode selector also deletes the IP address of the CPU, but not the password for protecting confidential PLC configuration data.

---

#### **See also**

Rules for the replacement parts scenario (Page 72)

### 3.6.2.4 Resetting the password

The protection of the confidential PLC configuration data can be reset. This may be necessary, for example, if you want to change the password but no longer know the current password.

#### Password lost - configuration not yet loaded

Since you have to enter the password when loading the CPU via TIA Portal for the first time, the CPU configuration for this CPU can no longer be used. To change the password in the CPU properties, you must also enter the previously valid password. If you forget your password, do the following:

##### Requirement

- The CPU is not yet loaded

##### Procedure

1. Open the CPU properties in the network view or in the device view.
2. Navigate to the area "Protection & Security > Protection of the PLC configuration data".
3. Click "Reset".

Please note that the certificates of the CPU (e.g. certificates for web server, for OPC UA server, for PG/PC communication and HMI communication) may no longer be used after the reset and may have to be created again and reassigned.

- If you use the global security settings for the certificate manager, you must reassign the certificates from the certificate manager.
- If you do not use the global security settings for the certificate manager, you must recreate and reassign the certificates.

4. Confirm the reset of the password.

The option for the protection of confidential PLC configuration data is still activated.

#### Delete password – Configuration is already loaded

If the CPU has already been loaded with a configuration and the configuration is protected with a password for confidential PLC configuration data, you can, for loading a new project, delete the password for confidential PLC configuration data online and then specify a new password.

##### Requirements

- You have write access to the CPU
- The CPU must be in STOP mode.

##### Procedure

1. Select the CPU in the network view.
2. Select the "Online & Diagnostics" command from the shortcut menu.

3. In the area "Password to protect confidential PLC configuration data", click the "delete" button.  
If the "Delete" button is not available, no password has been set in the CPU yet.

**NOTICE****Deleting the password for confidential configuration data**

If the password is deleted and a loaded project requires a corresponding password, this project may no longer work without password.

4. If required, now enter a new password via the "Set" button.
5. Perform a restart of the CPU.

**See also**

Changing your password (Page 65)

**3.6.2.5 Assign password via SIMATIC Memory Card**

If you want to transfer the password to protect confidential PLC configuration data to a CPU without using TIA Portal, you can also use a SIMATIC memory card for this function.

The use of a SIMATIC memory card is suitable for the following purposes:

- Preparing a new CPU  
If a CPU is set up again, it should be configured with a password to protect the confidential PLC configuration data. After this configuration is completed, it is possible to use another SIMATIC memory card with the desired project.  
(S7-1200 CPU: A "transfer" card with transfer job can also be used to install the program on the CPU).
- CPU has a password to protect confidential PLC configuration data, but the password does not match the project  
If the passwords are not identical, you can set the correct password with the memory card in the CPU.  
(S7-1200 CPU: equipped either with SIMATIC "transfer" card or with SIMATIC "Program" card).
- reset the password for the protection of confidential PLC configuration data in the CPU  
As preparation for a disposal of the CPU or as preparation for a new project for the CPU.

**Requirement**

- TIA Portal as of version V17



## Basic procedure

1. Creating a SIMATIC memory card with "SET PASSWORD" job

This action creates a folder and file structure following a special pattern and writes a password for the protection of the confidential PLC configuration data as plain text to a special file on the SIMATIC memory card. See description below.

2. Insertion of a prepared SIMATIC memory card in the CPU and switch on the CPU.

The PLC reads the password, processes it and stores the result in the internal memory. Any existing entry is overwritten.

3. Remove the SIMATIC memory card and restart the CPU.

Results (S7-1500): While the CPU is reading the SIMATIC memory card, the LED shows the same behavior as with a firmware update. The RUN/STOP LED flashes while the CPU is setting the password. After the process has been completed successfully, the RUN/STOP LED lights up yellow and the MAINT LED flashes yellow.

The result of the operation is displayed in the diagnostics buffer as success or error message. If the password could not be set, the error LED flashes together with the other LEDs.

## Creating a SIMATIC memory card with "SET PASSWORD" job

1. Create a folder in the root directory named "SET\_PWD.S7S".
2. Create a text file named "PWD.TXT" with the password as text-only in the folder just created on the memory card.
3. Create a text file named "S7\_JOB.S7S" in the root directory of the memory card with the content "SET\_PWD".

This file is the "Job file" for assigning a password for the protection of the confidential PLC configuration data of the PLC.

4. The file structure on the SIMATIC memory card then looks as follows:



---

### Note

#### Safe storage of the SIMATIC memory card

Store the SIMATIC memory card in a safe location to which only authorized persons have access.

---

### Rules and recommendations

- Setting the password must be done in a secure environment.
- The content of the text file "PWD.TXT" defines the password for the protection of confidential PLC configuration data. It must match the password that you have also assigned in the CPU configuration.
- To reset an existing password of a PLC, the text file "PWD.TXT" must be empty, i.e. the file size is 0 bytes.
- Use any text editor to create the text file. The recommended text format is "UTF-8".
- The folder and file names are not case-sensitive. However, the password itself is case-sensitive.
- Do not enter a CR/LF character at the end (PWD.TXT or S7\_JOB.S7S).

#### 3.6.2.6 Special features when backing up and restoring a CPU

You can back up a functional configuration of a CPU in the TIA Portal and access it at a later time; this means you can then restore the originally backed-up configuration. This allows you to load a modified configuration, for example, to test product enhancements, to change programs for troubleshooting in the system or you can replace components on a test basis. You can then restore the originally backed-up configuration of the CPU.

### Backing up the configuration

In backing up a CPU ("Online" menu, "Load backup from online device" in TIA Portal), the password for the protection of confidential PLC configuration data is backed up as well.

### Restoring the backup

When restore the backup of a CPU (menu "Online", command "Download to device" with marked backup in TIA Portal) the CPU can only communicate with a PG/PC or HMI if the following condition is fulfilled:

- After the restoration of a configuration protected with a password to protect confidential PLC configuration data, exactly this password must be present in the CPU.

Otherwise the CPU cannot access the configuration data and therefore does not start.

#### Remedy

If the above error occurs, that is, the password for protecting confidential PLC configuration data does not match the backup, you must delete the password to protect confidential PLC configuration data in the CPU and then set the correct password. After a restart the CPU, the backup is functional.

### See also

Changing your password (Page 65)

### 3.6.2.7 Tips for error avoidance and error handling

The following description lists some use cases that may result in CPU error messages.

#### Diagnostic buffer provides information

The CPU detects when the password protecting confidential configuration data and the loaded configuration do not match. A message in the diagnostic buffer indicates possible causes and remedies and usually leads to a solution of the problem.

#### Typical "pitfalls"

You should pay attention to the following circumstances in order to avoid or correct errors:

- Configuration loaded?  
Regardless of whether you protect your confidential configuration data with a password or not: without a loaded configuration, the CPU does not leave the provisioning phase.
- You are trying to load the CPU with a configured password and the CPU has already received another password.  
Example: CPU is exchanged for another CPU from the stock. The replacement CPU was not completely reset (reset to factory settings with option "Delete password for protection of confidential PLC configuration data").  
Remedy:
  - Always prepare replacement CPUs with the appropriate option (password deleted).
  - For the configuration to be loaded, use the same password that was already used for the configuration already loaded.
  - It is also possible that the wrong project / CPU configuration was loaded. Check whether the correct CPU configuration is available.
  - Use the online function "Set password to protect confidential PLC configuration data" to delete the password or to set the same password as in the CPU configuration. Then, restart the device.
- The same error occurs if your CPU configuration does not use a password and the already loaded configuration requires a user-defined password.  
Remedy:
  - Use the online function "Set password to protect confidential PLC configuration data" to delete the password or to set the same password as in the CPU configuration. Then, restart the device.

### 3.6.2.8 Rules for the replacement parts scenario

The assignment of passwords to protect confidential PLC configuration data also has an impact on the replacement parts scenario.

#### Rules for the replacement parts scenario

Observe the following rules for the replacement parts scenario:

##### Configuration of the replacement CPU via TIA Portal

- A CPU as replacement for an existing CPU should not have a configuration or a configured password to protect confidential PLC configuration data.  
Advantage: You can load the project into the replacement CPU without any further preparation - regardless of whether a password is configured or not.
- If the replacement CPU has already been configured, you must reset the CPU to the factory settings with the following options set:
  - "Delete password for protection of confidential PLC configuration data"
  - "Format memory card"

##### Replacement CPU is supplied with configuration data via memory card

- If you have **not** assigned a password to a CPU in your project to protect confidential PLC configuration data, you can insert the memory card of the CPU to be replaced into a brand-new, unused CPU without any further action needed.  
If the replacement CPU has already been configured with a password to protect confidential PLC configuration data, you must first reset this CPU to the factory settings using the option "Delete password for protection of confidential PLC configuration data".
- If you have assigned the same password to a group of CPUs, you can also assign the group password to the replacement CPU via the TIA Portal or via an appropriately prepared memory card (see Protection of confidential configuration data (Page 61)).  
In this case you can, for example, insert a memory card with the current project into the CPU and put it into operation without any further password handling.
- If you assign different passwords to each CPU in your project, you must first set the password valid for the respective CPU with the online and diagnostics editor when using the replacement CPU (area "Set password for protection of confidential PLC configuration data", see Changing your password (Page 65)).

#### See also

Assign password via SIMATIC Memory Card (Page 68)

### 3.6.3 Secure Open User Communication

#### 3.6.3.1 Secure OUC of an S7-1500 CPU as TLS client to an external PLC (TLS server)

The following section describes how you can set up Open User Communication via TCP from an S7-1500 CPU as TLS client to a TLS server.

#### Setting up a secure TCP connection from an S7-1500 CPU as TLS client to a TLS server

S7-1500 CPUs as of firmware version V2.0 support secure communication with addressing via a Domain Name System (DNS).

For secure TCP communication over the domain name you need to create a data block with the TCON\_QDN\_SEC system data type yourself, assign parameters and call it directly at one of the instructions TSEND\_C, TRCV\_C or TCON.

Requirements:

- Current date and time are set in the CPU.
- Your network includes at least one DNS server.
- You have configured at least one DNS server for the S7-1500 CPU.
- TLS client and TLS server have all the required certificates.

To set up a secure TCP connection to a TLS server, follow these steps:

1. Create a global data block in the project tree.
2. Define a tag of the data type TCON\_QDN\_SEC in the global data block.

The example below shows the global data block "Data\_block\_1" in which the tag "DNS ConnectionSEC" of the data type TCON\_QDN\_SEC is defined.

| Data_block_1 |                        |              |                     |                                                    |
|--------------|------------------------|--------------|---------------------|----------------------------------------------------|
|              | Name                   | Data type    | Start value         | Comment                                            |
| 1            | Static                 |              |                     |                                                    |
| 2            | DNS Connection SEC     | TCON_QDN_SEC |                     |                                                    |
| 3            | ConnPara               | TCON_QDN     |                     | parameter of the TCP connection                    |
| 4            | Interfaceld            | HW_ANY       | 0                   | not relevant                                       |
| 5            | ID                     | CONN_OUC     | 5                   | connection reference / identifier                  |
| 6            | ConnectionType         | Byte         | 11                  | type of connection: 16#0B=11=TCP/IP, 16#13         |
| 7            | ActiveEstablished      | Bool         | true                | active/passive connection establishment            |
| 8            | RemoteQDN              | String[254]  | 'plc_1.factory127.' | fully or partially qualified domain name of rem    |
| 9            | RemotePort             | UInt         | 4000                | remote UDP / TCP port number                       |
| 10           | LocalPort              | UInt         | 0                   | local UDP / TCP port number                        |
| 11           | ActivateSecureConn     | Bool         | true                | activate the security functionality of that conn   |
| 12           | TLSServerReqClientCert | Bool         | false               | Just for server side: The TLS server requests a    |
| 13           | ExtTlSCapabilities     | Word         | 16#0                | Bit 0: Just for client side: validate given IPv4 a |
| 14           | TLSServerCertRef       | UDInt        | 7                   | for Server side: Reference to own X.509 V3 se      |
| 15           | TLSClientCertRef       | UDInt        | 0                   | for Client side: add id of own X.509 V3 client c   |

Figure 3-18 Data type TCON\_QDN\_SEC

3. Set the connection parameters of the TCP connection in the "Start value" column. Enter the fully qualified domain name (FQDN) of the TLS server, for example, for "RemoteQDN".

4. Set the parameters for secure communication in the "Start value" column.
  - "ActivateSecureConn": Activation of secure communication for this connection. If this parameter has the value FALSE, the subsequent security parameters are irrelevant. You can set up a non-secure TCP or UDP connection in this case.
  - "ExtTlSCapabilities": If you enter the value 1, the client validates the subjectAlternateName in the X.509-V3 certificate of the server to verify the identity of the server. This validation is executed in the context of the instruction.
  - "TLSServerCertRef": ID of the X.509-V3 certificate (usually a CA certificate) that is used by the TLS client to validate the TLS server authentication. If this parameter is 0, the TLS client uses all (CA) certificates currently loaded in the client certificate store to validate the server authentication.

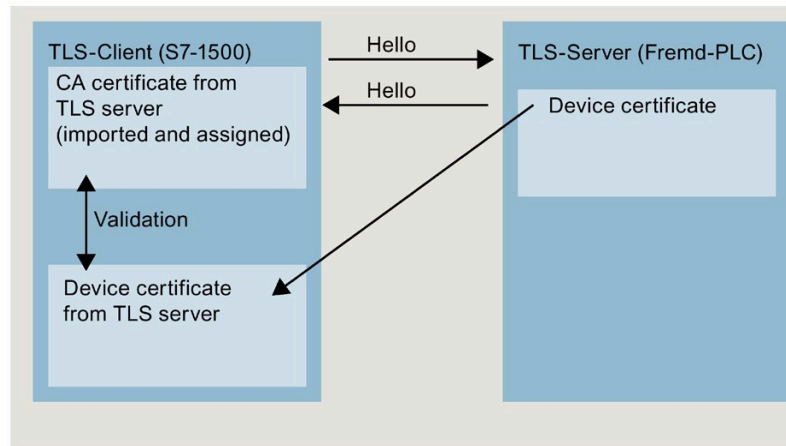


Figure 3-19 Certificate handling from the perspective of the S7-1500 as a TLS client

- "TLSClientCertRef": ID of the own X.509-V3 certificate.

5. Create one of the instructions TSEND\_C, TRCV\_C or TCON in the program editor.
6. Interconnect the CONNECT parameter of one of the instructions TSEND\_C, TRCV\_C or TCON with the tags of the data type TCON\_QDN\_SEC.

In the example below, the CONNECT parameter of the TCON instruction is interconnected with the tag "DNS connectionSEC" (data type TCON\_QDN\_SEC).

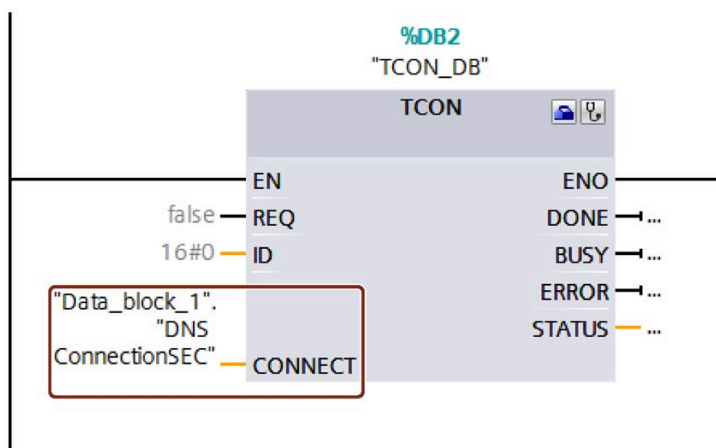


Figure 3-20 TCON instruction

### Additional information

You can find more information on the TCON\_QDN\_SEC system data type in the STEP 7 online help.

For additional information on secure communication, refer to the section Secure Communication (Page 40).

### 3.6.3.2 Secure OUC of an S7-1500 CPU as TLS server to an external PLC (TLS client)

The following section describes how you can set up Open User Communication via TCP from an S7-1500 CPU as TLS server to a TLS client.

#### Setting up a secure TCP connection via the domain name of the communication partner

S7-1500 CPUs as of firmware version V2.0 support secure communication with addressing via a Domain Name System (DNS).

For secure TCP communication over the domain name you need to create a data block with the TCON\_QDN\_SEC system data type yourself, assign parameters and call it directly at one of the instructions TSEND\_C, TRCV\_C or TCON.

Requirements:

- Current date and time are set in the CPU.
- Your network includes at least one DNS server.
- You have configured at least one DNS server for the S7-1500 CPU.
- TLS client and TLS server have all the required certificates.

To set up a secure TCP connection to a TLS client, follow these steps:

1. Create a global data block in the project tree.
2. Define a tag of the data type TCON\_QDN\_SEC in the global data block.

The example below shows the global data block "Data\_block\_1" in which the tag "DNS ConnectionSEC" of the data type TCON\_FDL\_SEC is defined.

| Data_block_1 |                        |              |             |                                                                    |
|--------------|------------------------|--------------|-------------|--------------------------------------------------------------------|
|              | Name                   | Data type    | Start value | Comment                                                            |
| 1            | Static                 |              |             |                                                                    |
| 2            | DNS Connection SEC2    | TCON_QDN_SEC |             |                                                                    |
| 3            | ConnPara               | TCON_QDN     |             | parameter of the TCP connection                                    |
| 4            | InterfaceId            | HW_ANY       | 0           | not relevant                                                       |
| 5            | ID                     | CONN_OUC     | 8           | connection reference / identifier                                  |
| 6            | ConnectionType         | Byte         | 11          | type of connection: 16#0B=11=TCP/IP, 16#13=...                     |
| 7            | ActiveEstablished      | Bool         | false       | active/passive connection establishment                            |
| 8            | RemoteQDN              | String[254]  | "           | fully or partially qualified domain name of remote                 |
| 9            | RemotePort             | UInt         | 0           | remote UDP / TCP port number                                       |
| 10           | LocalPort              | UInt         | 2010        | local UDP / TCP port number                                        |
| 11           | ActivateSecureConn     | Bool         | true        | activate the security functionality of that connection             |
| 12           | TLSServerReqClientCert | Bool         | false       | Just for server side: The TLS server requests a client certificate |
| 13           | ExtTLSCapabilities     | Word         | 16#0        | Bit 0: Just for client side: validate given IPv4 address           |
| 14           | TLSServerCertRef       | UDInt        | 5           | for Server side: Reference to own X.509 V3 server certificate      |
| 15           | TLSClientCertRef       | UDInt        | 0           | for Client side: add id of own X.509 V3 client certificate         |

Figure 3-21 TCON\_QDN\_SEC\_Server

3. Set the connection parameters of the TCP connection in the "Start value" column. Enter, for example, the local ID of the TCP connection for "ID".



4. Set the parameters for secure communication in the "Start value" column.
  - "ActivateSecureConn": Activation of secure communication for this connection. If this parameter has the value FALSE, the subsequent security parameters are irrelevant. You can set up a non-secure TCP or UDP connection in this case.
  - "TLSServerReqClientCert": Request for an X.509-V3 certificate from the TLS client.
  - "TLSServerCertRef": ID of the own X.509-V3 certificate.

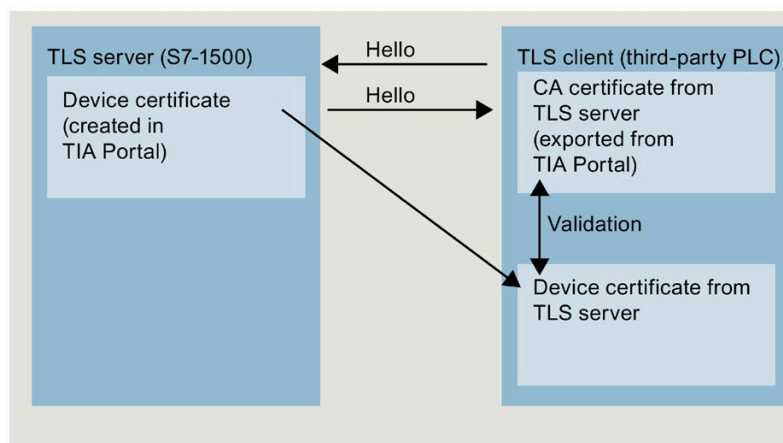


Figure 3-22 Certificate handling from the perspective of the S7-1500 as TLS server

- "TLSClientCertRef": ID of the X.509-V3 certificate (or a group of X.509-V3 certificates) that is used by the TLS server to validate TLS client authentication. If this parameter is 0, the TLS server uses all (CA) certificates currently loaded in the server certificate store to validate the client authentication.
5. Create one of the instructions TSEND\_C, TRCV\_C or TCON in the program editor.
  6. Interconnect the CONNECT parameter of one of the instructions TSEND\_C, TRCV\_C or TCON with the tags of the data type TCON\_QDN\_SEC.

In the example below, the CONNECT parameter of the TCON instruction is interconnected with the tag "DNS connectionSEC" (data type TCON\_QDN\_SEC).

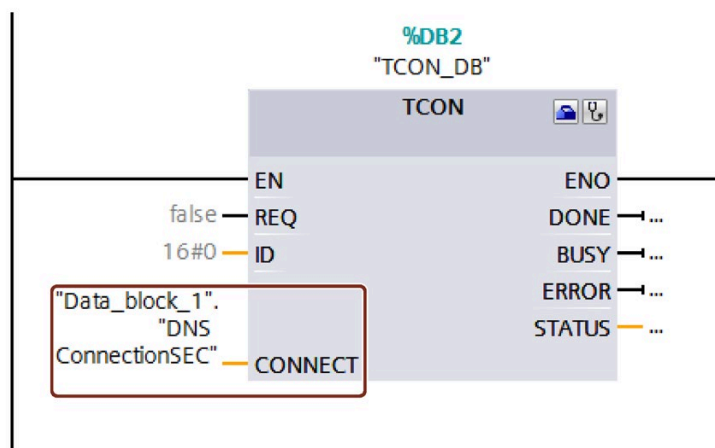


Figure 3-23 TCON instruction

### Additional information

You can find more information about the system data types TCON\_QDN\_SEC in the STEP 7 online help.

For additional information on secure communication, refer to the section Secure Communication (Page 40).

#### 3.6.3.3 Secure OUC between two S7-1500 CPUs

The following section describes how you can set Secure Open User Communication via TCP between two S7-1500 CPUs. In the process one S7-1500 CPU acts as TLS client (active establishing of the connection) and the other S7-1500 CPU as TLS server (passive establishing of the connection).

#### Setting up a secure TCP connection between two S7-1500 CPUs

For secure TCP communication between two S7-1500 CPUs you need to create a data block with the TCON\_IP\_V4\_SEC system data type yourself in every CPU, assign parameters and call it directly at one of the instructions TSEND\_C, TRCV\_C or TCON.

Requirements:

- Current date and time are set in the CPU.
- Both S7-1500 CPUs have at least firmware version V2.0
- TLS client and TLS server have all the required certificates.

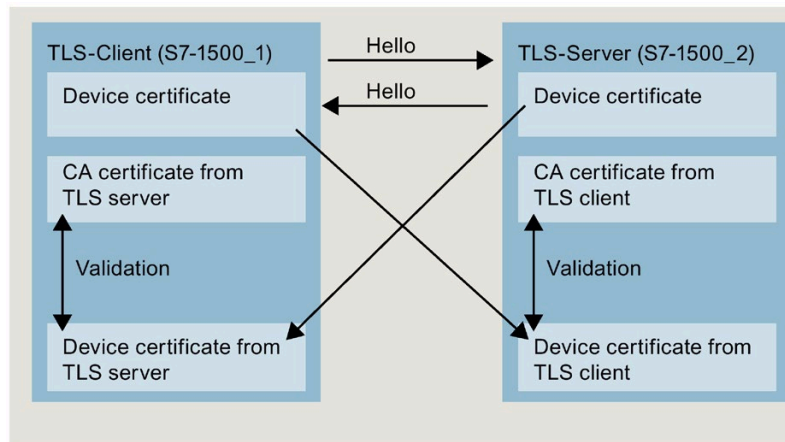


Figure 3-24 Certificate handling for Secure OUC between two S7-1500 CPUs

### Settings at the TLS client

To set up a secure TCP connection in the TLS client, follow these steps:

1. Create a global data block in the project tree.
2. Define a tag of the data type TCON\_IP\_V4\_SEC in the global data block.

The example below shows the global data block "Data\_block\_1" in which the tag "SEC connection 1 TLS-Client" of the data type TCON\_IP\_V4\_SEC is defined.

| Data_block_1 |                               |                     |             |                                                                     |
|--------------|-------------------------------|---------------------|-------------|---------------------------------------------------------------------|
|              | Name                          | Data type           | Start value | Comment                                                             |
| 1            | ▼ Static                      |                     |             |                                                                     |
| 2            | ▼ SEC connection 1 TLS-Client | TCON_IP_V4_SEC      |             |                                                                     |
| 3            | ▼ ConnPara                    | TCON_IP_v4          |             | parameter of the TCP connection                                     |
| 4            | InterfaceId                   | HW_ANY              | 72          | HW-identifier of IE-interface submodule                             |
| 5            | ID                            | CONN_OUC            | 10          | connection reference / identifier                                   |
| 6            | ConnectionType                | Byte                | 11          | type of connction: 11=TCP/IP, 19=UDP (17=TCP/IP)                    |
| 7            | ActiveEstablished             | Bool                | true        | active/passive connection establishment                             |
| 8            | ▼ RemoteAddress               | IP_V4               |             | remote IP address (IPv4)                                            |
| 9            | ▼ ADDR                        | Array[1..4] of Byte |             | IPv4 address                                                        |
| 10           | ADDR[1]                       | Byte                | 192         | IPv4 address                                                        |
| 11           | ADDR[2]                       | Byte                | 168         | IPv4 address                                                        |
| 12           | ADDR[3]                       | Byte                | 1           | IPv4 address                                                        |
| 13           | ADDR[4]                       | Byte                | 100         | IPv4 address                                                        |
| 14           | RemotePort                    | UInt                | 4711        | remote UDP/TCP port number                                          |
| 15           | LocalPort                     | UInt                | 4711        | local UDP/TCP port number                                           |
| 16           | ActivateSecureConn            | Bool                | true        | activate the security functionality of that connection in general   |
| 17           | TLSServerReqClientCert        | Bool                | false       | Just for server side: The TLS server requests a client certificate  |
| 18           | ExtTLSCapabilities            | Word                | 16#0        | Bit 0: Just for client side: validate given IPv4 address against th |
| 19           | TLSServerCertRef              | UDInt               | 1           | for Server side: Reference to own X.509 V3 server certificate; fo   |
| 20           | TLSClientCertRef              | UDInt               | 5           | for Client side: add id of own X.509 V3 client certificate; for Sen |

Figure 3-25 IP\_V4\_SEC\_Client

3. Set the connection parameters of the TCP connection in the "Start value" column. For example, enter the IPv4 address of the TLS server for "RemoteAddress".

#### Note

##### Connection parameter Interface ID

Note that you can enter the value "0" for the interface ID in the data type TCON\_IP\_V4\_SEC. In this case, the CPU itself searches for a suitable local CPU interface.

4. Set the parameters for secure communication in the "Start value" column.
  - "ActivateSecureConn": Activation of secure communication for this connection. If this parameter has the value FALSE, the subsequent security parameters are irrelevant. You can set up a non-secure TCP or UDP connection in this case.
  - "TLSServerCertRef": Enter the value 2 (reference to the CA certificate of the TIA Portal project (SHA256) or the value 1 (reference to the CA certificate of the TIA Portal project (SHA1)). If you use a different CA certificate, enter the corresponding ID from the certificate manager of the global security settings.
  - "TLSClientCertRef": ID of the own X.509-V3 certificate.

5. Create one of the instructions TSEND\_C, TRCV\_C or TCON in the program editor.
6. Interconnect the CONNECT parameter of one of the instructions TSEND\_C, TRCV\_C or TCON with the tags of the data type TCON\_IP\_V4\_SEC.

### Settings at the TLS server

To set up a secure TCP connection in the TLS server, follow these steps:

1. Create a global data block in the project tree.
2. Define a tag of the data type TCON\_IP\_4\_SEC in the global data block.

The example below shows the global data block "Data\_block\_1" in which the tag "SEC connection 1 TLS-Server" of the data type TCON\_IP\_V4\_SEC is defined.

| Data_block_1 |                               |                     |             |                                                                      |
|--------------|-------------------------------|---------------------|-------------|----------------------------------------------------------------------|
|              | Name                          | Data type           | Start value | Comment                                                              |
| 1            | ▼ Static                      |                     |             |                                                                      |
| 2            | ▼ SEC connection 1 TLS-Server | TCON_IP_V4_SEC      |             |                                                                      |
| 3            | ▼ ConnPara                    | TCON_IP_v4          |             | parameter of the TCP connection                                      |
| 4            | InterfaceId                   | HW_ANY              | 120         | HW-identifier of IE-interface submodule                              |
| 5            | ID                            | CONN_OUC            | 10          | connection reference / identifier                                    |
| 6            | ConnectionType                | Byte                | 11          | type of connetion: 11=TCP/IP, 19=UDP (17=TCP/IP)                     |
| 7            | ActiveEstablished             | Bool                | false       | active/passive connection establishment                              |
| 8            | ▼ RemoteAddress               | IP_V4               |             | remote IP address (IPv4)                                             |
| 9            | ▼ ADDR                        | Array[1..4] of Byte |             | IPv4 address                                                         |
| 10           | ADDR[1]                       | Byte                | 192         | IPv4 address                                                         |
| 11           | ADDR[2]                       | Byte                | 168         | IPv4 address                                                         |
| 12           | ADDR[3]                       | Byte                | 1           | IPv4 address                                                         |
| 13           | ADDR[4]                       | Byte                | 10          | IPv4 address                                                         |
| 14           | RemotePort                    | UInt                | 4711        | remote UDP/TCP port number                                           |
| 15           | LocalPort                     | UInt                | 4711        | local UDP/TCP port number                                            |
| 16           | ActivateSecureConn            | Bool                | true        | activate the security functionality of that connection in general    |
| 17           | TLSReqClientCert              | Bool                | true        | Just for server side: The TLS server requests a client certificate   |
| 18           | ExtTLSCapabilities            | Word                | 16#0        | Bit 0: Just for client side: validate given IPv4 address against the |
| 19           | TLSReqServerCertRef           | UDInt               | 6           | for Server side: Reference to own X.509 V3 server certificate; for   |
| 20           | TLSClientCertRef              | UDInt               | 1           | for Client side: add id of own X.509 V3 client certificate; for Serv |

Figure 3-26 IP\_V4\_SEC\_Server

3. Set the connection parameters of the TCP connection in the "Start value" column. For example, enter the IPv4 address of the TLS client for "RemoteAddress".
4. Set the parameters for secure communication in the "Start value" column.
  - "ActivateSecureConn": Activation of secure communication for this connection. If this parameter has the value FALSE, the subsequent security parameters are irrelevant. You can set up a non-secure TCP or UDP connection in this case.
  - "TLSReqClientCert ": Request for an X.509-V3 certificate from the TLS client. Enter the value "true".
  - "TLSReqServerCertRef": ID of the own X.509-V3 certificate.
  - "TLSClientCertRef": Enter the value 2 (reference to the CA certificate of the TIA Portal project (SHA256) or the value 1 (reference to the CA certificate of the TIA Portal project (SHA1)). If you use a different CA certificate, enter the corresponding ID from the certificate manager of the global security settings.

5. Create one of the instructions TSEND\_C, TRCV\_C or TCON in the program editor.
6. Interconnect the CONNECT parameter of one of the instructions TSEND\_C, TRCV\_C or TCON with the tags of the data type TCON\_IP\_V4\_SEC.

In the example below, the CONNECT parameter of the TSEND\_C instruction is interconnected with the "SEC connection 1 TLS client" tags (data type TCON\_IP\_4\_SEC).

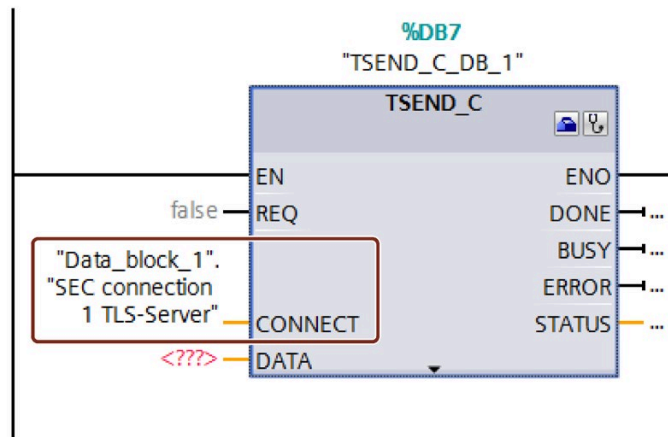


Figure 3-27 TSEND\_C

### Additional information

You can find more information about the system data types TCON\_IP\_4\_SEC in the STEP 7 online help.

For additional information on secure communication, refer to the section Secure Communication (Page 40).

### 3.6.3.4 Secure OUC via CP interface

The following sections describes the particular points to be taken into consideration in the case of Secure Open User Communication via a CP interface. At least one station is an S7-1500 station with the following modules:

- S7-1500 CPU as of firmware version V2.0 (with the exception of S7-1500 Software Controller)
- CP 1543-1 as of firmware version V2.0 or CP 1543SP-1 as firmware version V1.0

The CP acts in an S7-1500 station as a TLS client (active connection establishment) or a TLS server (passive connection establishment).

The fundamental procedure and the concept for using secure communication via a CP interface is similar to that of secure communication via the interfaces of the S7-1500 CPUs. Essentially, you have to assign the certificates to the CPU in the role of a TLS server or TLS client and not to the CPU. Other rules and procedures therefore apply. These are described below.

## Handling certificates for CPs

The following applies in general: You have to be logged on at the certificate manager in the global security settings. The generation of self-signed certificates also requires logon for the global security settings. You have to have sufficient rights as a user (administrator or user with the "Standard" role with the right to "Configure security").

The starting point for the generation or assignment of certificates at the CP is the section "Security > Security properties". In this section, you log on for the global security settings.

### Procedure:

1. In the network view of STEP 7, mark the CP and select the section "Security > Security properties" in the Inspector window.
2. Click on the "User logon" button.
3. Log on using your user name and password.
4. Enable the "Activate security functions" option.  
The security properties are initialized.
5. Click in the first line of the "Device certificates" table to generate a new certificate or select an existing device certificate.
6. If the communication partner is also an S7-1500 station, you also have to assign a device certificate to the communication partner with STEP 7 as described here or for the S7-1500 CPU.

## Example: Setting up a secure TCP connection between two S7-1500 CPUs via CP interfaces

For secure TCP communication between two S7-1500 CPUs you need to create a data block with the TCON\_IP\_V4\_SEC system data type yourself in every CPU, assign parameters and call it directly at one of the instructions TSEND\_C, TRCV\_C or TCON.

### Requirements:

- Both S7 1500 CPUs have at least firmware version V2.0. If you use the CP 1543SP-1: Firmware version as of V1.0.
- Both CPs (for example CP 1543-1) must have at least firmware version V2.0
- TLS client and TLS server have all the required certificates.
  - A device certificate (end-entity certificate) for the CP must be generated and be located in the certificate memory of the CP. If a communication partner is an external device (for example an MES or ERP system), a device certificate also has to exist for this device.
  - The root certificate (CA certificate) with which the device certificate of the communication partner is signed must also be located in the certificate memory of the CP or in the certificate memory of the external device. If you use intermediate certificates, you have to ensure that the complete certificate path exists in the validating device. A device uses these certificates to validate the device certificate of the communication partner.
- The communication partner must always be addressed via its IPv4 address, not via its domain name.

The following figure shows the different certificates in the devices for the case that both communication partners communicate via a CP 1543-1. In addition, the figure shows the transfer of the device certificates during establishment of the connection ("Hello").

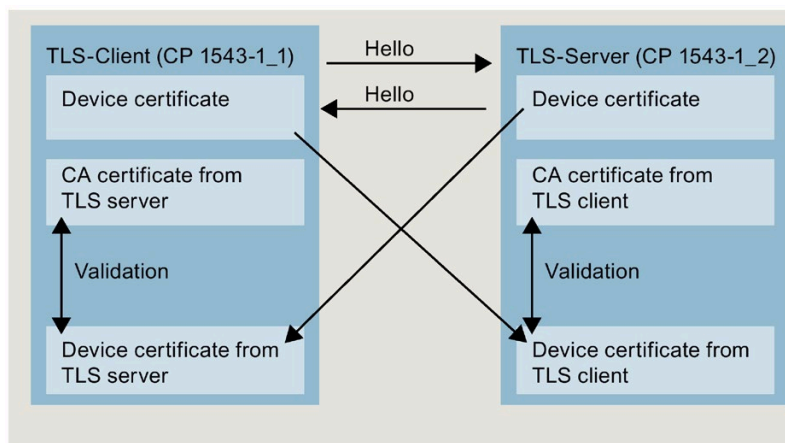


Figure 3-28 Certificate handling in secure OUC between two S7-1500 CPUs via CP interfaces.



### Settings at the TLS client

To set up a secure TCP connection in the TLS client, follow these steps:

1. Create a global data block in the project tree.
2. Define a tag of the data type TCON\_IP\_4\_SEC in the global data block. To do so, enter the string "TCON\_IP\_V4\_SEC" in the "Data type" field.

The example below shows the global data block "Data\_block\_1" in which the tag "SEC connection 1 TLS-Client" of the data type TCON\_IP\_V4\_SEC is defined.

The Interface ID has the value of the HW identifier of the IE interface of the local CP (TLS client).

| Data_block_1 |                               |                     |             |                                                                      |
|--------------|-------------------------------|---------------------|-------------|----------------------------------------------------------------------|
|              | Name                          | Data type           | Start value | Comment                                                              |
| 1            | ▼ Static                      |                     |             |                                                                      |
| 2            | ▼ SEC connection 1 TLS-Client | TCON_IP_V4_SEC      |             |                                                                      |
| 3            | ▼ ConnPara                    | TCON_IP_v4          |             | parameter of the TCP connection                                      |
| 4            | InterfaceId                   | HW_ANY              | 258         | HW-identifier of IE-interface submodule                              |
| 5            | ID                            | CONN_OUC            | 10          | connection reference / identifier                                    |
| 6            | ConnectionType                | Byte                | 11          | type of connetion: 11=TCP/IP, 19=UDP (17=TCP/IP)                     |
| 7            | ActiveEstablished             | Bool                | true        | active/passive connection establishment                              |
| 8            | ▼ RemoteAddress               | IP_V4               |             | remote IP address (IPv4)                                             |
| 9            | ▼ ADDR                        | Array[1..4] of Byte |             | IPv4 address                                                         |
| 10           | ADDR[1]                       | Byte                | 192         | IPv4 address                                                         |
| 11           | ADDR[2]                       | Byte                | 168         | IPv4 address                                                         |
| 12           | ADDR[3]                       | Byte                | 1           | IPv4 address                                                         |
| 13           | ADDR[4]                       | Byte                | 100         | IPv4 address                                                         |
| 14           | RemotePort                    | UInt                | 4711        | remote UDP/TCP port number                                           |
| 15           | LocalPort                     | UInt                | 4711        | local UDP/TCP port number                                            |
| 16           | ActivateSecureConn            | Bool                | true        | activate the security functionality of that connection in general    |
| 17           | TLSServerReqClientCert        | Bool                | false       | Just for server side: The TLS server requests a client certificate   |
| 18           | ExtTLSCapabilities            | Word                | 16#0        | Bit 0: Just for client side: validate given IPv4 address against the |
| 19           | TLSServerCertRef              | UDInt               | 1           | for Server side: Reference to own X.509 V3 server certificate; for   |
| 20           | TLSClientCertRef              | UDInt               | 5           | for Client side: add id of own X.509 V3 client certificate; for Sen  |

Figure 3-29 IP\_V4\_SEC\_Client

3. Set the connection parameters of the TCP connection in the "Start value" column. For example, enter the IPv4 address of the TLS server for "RemoteAddress".
4. Set the parameters for secure communication in the "Start value" column.
  - "ActivateSecureConn": Activation of secure communication for this connection. If this parameter has the value FALSE, the subsequent security parameters are irrelevant. You can set up a non-secure TCP or UDP connection in this case.
  - "TLSServerCertRef": Enter the value 2 (reference to the CA certificate of the TIA Portal project (SHA256) or the value 1 (reference to the CA certificate of the TIA Portal project (SHA1)). If you use a different CA certificate, enter the corresponding ID from the certificate manager of the global security settings.
  - "TLSClientCertRef": ID of the own X.509-V3 certificate.



5. Create one of the instructions TSEND\_C, TRCV\_C or TCON in the program editor.
6. Interconnect the CONNECT parameter of one of the instructions TSEND\_C, TRCV\_C or TCON with the tags of the data type TCON\_IP\_V4\_SEC.

### Settings at the TLS server

To set up a secure TCP connection in the TLS server, follow these steps:

1. Create a global data block in the project tree.
2. Define a tag of the data type TCON\_IP\_4\_SEC in the global data block.

The example below shows the global data block "Data\_block\_1" in which the tag "SEC connection 1 TLS-Server" of the data type TCON\_IP\_V4\_SEC is defined.

The interface ID has the value of the HW identifier of the IE interface of the local CP (TLS server).

| Data_block_1 |                               |                     |             |                                                                      |
|--------------|-------------------------------|---------------------|-------------|----------------------------------------------------------------------|
|              | Name                          | Data type           | Start value | Comment                                                              |
| 1            | ▼ Static                      |                     |             |                                                                      |
| 2            | ▼ SEC connection 1 TLS-Server | TCON_IP_V4_SEC      |             |                                                                      |
| 3            | ▼ ConnPara                    | TCON_IP_v4          |             | parameter of the TCP connection                                      |
| 4            | Interfaceld                   | HW_ANY              | 260         | HW-identifier of IE-interface submodule                              |
| 5            | ID                            | CONN_OUC            | 10          | connection reference / identifier                                    |
| 6            | ConnectionType                | Byte                | 11          | type of connetion: 11=TCP/IP, 19=UDP (17=TCP/IP)                     |
| 7            | ActiveEstablished             | Bool                | false       | active/passive connection establishment                              |
| 8            | ▼ RemoteAddress               | IP_V4               |             | remote IP address (IPv4)                                             |
| 9            | ▼ ADDR                        | Array[1..4] of Byte |             | IPv4 address                                                         |
| 10           | ADDR[1]                       | Byte                | 192         | IPv4 address                                                         |
| 11           | ADDR[2]                       | Byte                | 168         | IPv4 address                                                         |
| 12           | ADDR[3]                       | Byte                | 1           | IPv4 address                                                         |
| 13           | ADDR[4]                       | Byte                | 10          | IPv4 address                                                         |
| 14           | RemotePort                    | UInt                | 4711        | remote UDP/TCP port number                                           |
| 15           | LocalPort                     | UInt                | 4711        | local UDP/TCP port number                                            |
| 16           | ActivateSecureConn            | Bool                | true        | activate the security functionality of that connection in general    |
| 17           | TLSServerReqClientCert        | Bool                | true        | Just for server side: The TLS server requests a client certificate   |
| 18           | ExtTLSCapabilities            | Word                | 16#0        | Bit 0: Just for client side: validate given IPv4 address against the |
| 19           | TLSServerCertRef              | UDInt               | 6           | for Server side: Reference to own X.509 V3 server certificate; for   |
| 20           | TLSCClientCertRef             | UDInt               | 1           | for Client side: add id of own X.509 V3 client certificate; for Serv |

Figure 3-30 IP\_V4\_SEC\_Server

3. Set the connection parameters of the TCP connection in the "Start value" column. For example, enter the IPv4 address of the TLS client for "RemoteAddress".

4. Set the parameters for secure communication in the "Start value" column.
  - "ActivateSecureConn": Activation of secure communication for this connection. If this parameter has the value FALSE, the subsequent security parameters are irrelevant. You can set up a non-secure TCP or UDP connection in this case.
  - "TLSServerReqClientCert ": Request for an X.509-V3 certificate from the TLS client. Enter the value "true".
  - "TLSServerCertRef": ID of the own X.509-V3 certificate.
  - "TLSClientCertRef": Enter the value 2 (reference to the CA certificate of the TIA Portal project (SHA256) or the value 1 (reference to the CA certificate of the TIA Portal project (SHA1)). If you use a different CA certificate, enter the corresponding ID from the certificate manager of the global security settings.
5. Create one of the instructions TSEND\_C, TRCV\_C or TCON in the program editor.
6. Interconnect the CONNECT parameter of the instruction TSEND\_C, TRCV\_C or TCON with the tags of the data type TCON\_IP\_V4\_SEC.

### Upload device as new station

When you upload a configuration with certificates and configured secure Open User Communication as a new station into your STEP 7 project, the certificates of the CP are not uploaded, in contrast to the certificates of the CPU. After the device has been loaded as a new station, no more certificates are contained in the corresponding tables of the CPs for the device certificates.

You have to perform configuration of certificates again after the upload. Otherwise, renewed loading of the configuration results in the certificates that originally exist in the CP being deleted so that secure communication does not function.

### Secure OUC connections via CPU and CP interfaces - similarities

- Connection resources:  
No differences between OUC and secure OUC. A programmed secure OUC connection uses a connection resource just like an OUC connection, irrespective of which IE/PROFINET interface communicates with the station.
- Connection diagnostics:  
No differences between OUC and secure OUC connection diagnostics.
- Loading of projects with secure OUC connections into the CPU:  
Only possible in STOP of the CPU, if certificates are loaded as well.  
Recommendation: Load to device > Hardware and software. Reason: Ensuring the consistency between the program with secure OUC, hardware configuration and certificates.  
Certificates are loaded with the hardware configuration - therefore loading requires a stop of the CPU. The reloading of blocks that utilize further secure OUC connections is only possible in RUN if the certificates required for this purpose are already located on the module.

### 3.6.3.5 Secure OUC with Modbus TCP

For secure Modbus TCP connection you need to create a data block with one of the system data types TCON\_IP\_V4\_SEC or TCON\_QDN\_SEC yourself, assign parameters and call it directly at the MB\_Server or MB\_CLIENT instruction.

#### Requirements:

- S7-1500 CPU CPU firmware version V2.5 or higher
- The Modbus client (TLS client) can reach the Modbus server (TLS server) over IP communication in the network.
- TLS client and TLS server have all the required certificates.

#### Example of setting up a secure Modbus TCP connection to a Modbus TCP server

The following section describes how you can set up a Secure Open User Communication over Modbus TCP from a Modbus TCP client to a Modbus TCP server.

To set up a secure connection from a Modbus TCP client (TLS client) to a Modbus TCP server (TLS server) and set up the IPv4 address of the mail server, follow these steps:

1. Create a global data block in the project tree.
2. Define a tag of the data type TCON\_IP\_V4\_SEC in the global data block.

| Data_block_1 |                    |                     |             |                                                                                                                                                                                       |
|--------------|--------------------|---------------------|-------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|              | Name               | Data type           | Start value | Comment                                                                                                                                                                               |
| 1            | ▼ Static           |                     |             |                                                                                                                                                                                       |
| 2            | ▼ SEC_ModbusTCP_1  | TCON_IP_V4...       |             |                                                                                                                                                                                       |
| 3            | ▼ ConnPara         | TCON_IP_v4          |             | parameter of the TCP connection                                                                                                                                                       |
| 4            | Interfaceld        | HW_ANY              | 64          | HW-identifier of IE-interface submodule                                                                                                                                               |
| 5            | ID                 | CONN_OUC            | 15          | connection reference / identifier                                                                                                                                                     |
| 6            | ConnectionType     | Byte                | 11          | type of connection: 11=TCP/IP, 19=UDP (17=TCP/IP)                                                                                                                                     |
| 7            | ActiveEstablished  | Bool                | true        | active/passive connection establishment                                                                                                                                               |
| 8            | ▼ RemoteAddress    | IP_V4               |             | remote IP address (IPv4)                                                                                                                                                              |
| 9            | ▼ ADDR             | Array[1..4] of B... |             | IPv4 address                                                                                                                                                                          |
| 10           | ADDR[1]            | Byte                | 192         | IPv4 address                                                                                                                                                                          |
| 11           | ADDR[2]            | Byte                | 168         | IPv4 address                                                                                                                                                                          |
| 12           | ADDR[3]            | Byte                | 10          | IPv4 address                                                                                                                                                                          |
| 13           | ADDR[4]            | Byte                | 100         | IPv4 address                                                                                                                                                                          |
| 14           | RemotePort         | UInt                | 502         | remote UDP/TCP port number                                                                                                                                                            |
| 15           | LocalPort          | UInt                | 502         | local UDP/TCP port number                                                                                                                                                             |
| 16           | ActivateSecureConn | Bool                | true        | activate the security functionality of that connection in general                                                                                                                     |
| 17           | TLSReqClientCert   | Bool                | false       | Just for server side: The TLS server requests a client certificate                                                                                                                    |
| 18           | ExtTLSCapabilities | Word                | 0           | Bit 0: Just for client side: validate given IPv4 address against the subjectAltName                                                                                                   |
| 19           | TLSReqServerCert   | UDInt               | 2           | for Server side: Reference to own X.509 V3 server certificate; for Client side: add id of own X.509 V3 client certificate; for Server side: add id of own X.509 V3 server certificate |
| 20           | TLSClientCertRef   | UDInt               | 7           | for Client side: add id of own X.509 V3 client certificate; for Server side: add id of own X.509 V3 server certificate                                                                |

Figure 3-31 TCON\_IP\_V4\_SEC

3. Set the connection parameters of the TCP connection in the "Start value" column. Enter the IPv4 address of the mail server, for example, for the "MailServerAddress".

### 3.6 Secure Communication

4. Set the parameters for secure communication in the "Start value" column. Enter the certificate ID of the CA certificate of the communication partner, for example, for "TLSServerCertRef".
  - "ActivateSecureConn": Activation of secure communication for this connection. If this parameter has the value FALSE, the subsequent security parameters are irrelevant. In this case you can set up an unsecured Modbus TCP connection.
  - "TLSServerCertRef": Reference to the X.509 V3 (CA) certificate of the Modbus TCP server, which is used by the TLS client to validate the authentication of the Modbus TCP server.
5. Create an MB\_CLIENT instruction in the program editor.
6. Interconnect the CONNECT parameter of the MB\_Client instruction with the tags of the data type TCON\_IP\_4\_SEC.

#### 3.6.3.6 Secure OUC via e-mail

##### Setting up a secure connection to a mail server over the CPU interface

For secure communication to a mail server you need to create a data block with one of the system data types TMAIL\_V4\_SEC, TMAIL\_QDN\_SEC yourself, assign parameters and call it directly at the TMAIL\_C instruction.

##### Requirements:

- TMAIL\_C instruction version V5.0 or higher
- STEP 7 V15 and higher
- S7-1500 CPU V2.5 and higher
- You have assigned all the CA certificates of the mail server (TLS server) to the CPU (TLS client) and have downloaded the configuration to the CPU.
- Current date and time are set in the CPU.

## Process for establishing a secure connection to the mail server

You can choose between two processes for establishing the secure connection to the mail server:

- **SMTPS:** The client attempts to immediately establish a TLS connection to the mail server ("handshake" process). If the mail server does not support TLS, then no connection is established.
- **STARTTLS:** Client establishes a TCP connection to the mail server. The client sends a request to "upgrade" the existing connection to a secure TLS connection over the TCP connection. If the mail server supports TLS, the client sends the command to establish a secure connection. The mail server uses the SMTP command "STARTTLS" to do this. The client then establishes a secure connection to the mail server. Advantage: If the mail server does not support TLS, client and mail server can communicate unsecured with each other.

You use the "Remote Port" setting in the data types at the block parameter "MAIL\_ADDR\_PARAM" to define which process is used for the communication.

Table 3- 6 Port numbers for the SMTPS and STARTTLS processes

| Process  | Port                    |
|----------|-------------------------|
| SMTPS:   | 465 <sup>1</sup>        |
| STARTTLS | Any (≠465) <sup>2</sup> |

<sup>1</sup> The instruction TMAIL\_C uses SMTPS only for Port 465. For all other ports STARTTLS is used.

<sup>2</sup> According to RFC, mail servers use Ports 25 and 587 for secure connections with STARTTLS. The use of other port numbers for SMTP is not RFC-compliant, successful communication with such a mail server is not guaranteed.

## Example: Setting up a secure connection to a mail server over IPv4

The following section describes how to set up a secure connection to an IPv4 mail server with the TMAIL\_C communication instruction.

To set up a secure connection via the IP4 address of the mail server, follow these steps:

1. Create a global data block in the project tree.
2. Define a tag of the data type TMAIL\_V4\_SEC in the global data block.

The example below shows the global data block "MailConnDB" in which the tag "MailConnectionSEC" of the data type TMAIL\_V4\_SEC is defined.

| MailConnDB         |      |                     |                                              |                                                                |
|--------------------|------|---------------------|----------------------------------------------|----------------------------------------------------------------|
|                    | Name | Datentyp            | Startwert                                    | Kommentar                                                      |
| Static             |      |                     |                                              |                                                                |
| MailConnectionSEC  |      | TMail_V4_SEC        |                                              |                                                                |
| InterfaceId        |      | HW_ANY              | "Local~CP_1543-1_1~Ethernet-Schnittstelle_1" | Use HW-identifier of the IE-interface to specify the           |
| ID                 |      | CONN_OUC            | 100                                          | connection reference / identifier                              |
| ConnectionType     |      | Byte                | 16#20                                        | type of connection 16#20=32=TMail_V4 or TMail_V4               |
| ActiveEstablished  |      | Bool                | true                                         | active / passive connection establishment                      |
| WatchDogTime       |      | Time                | T#5000ms                                     | watchdog time to monitor SMTP server association               |
| MailServerAddress  |      | IP_V4               |                                              | IPv4 address of mail server                                    |
| ADDR               |      | Array[1..4] of Byte |                                              | IPv4 address                                                   |
| ADDR[1]            |      | Byte                | 144                                          | IPv4 address                                                   |
| ADDR[2]            |      | Byte                | 145                                          | IPv4 address                                                   |
| ADDR[3]            |      | Byte                | 2                                            | IPv4 address                                                   |
| ADDR[4]            |      | Byte                | 20                                           | IPv4 address                                                   |
| UserName           |      | String[254]         | 'myName'                                     | user name which is necessary to login into the                 |
| PassWord           |      | String[254]         | 'myPW'                                       | user password which is necessary to login into                 |
| From               |      | EMAIL_ADDR          |                                              | source mail address                                            |
| LocalPartPlusAt... |      | String[64]          | 'Mustermann@'                                | local part of e-mail address plus "@" sign                     |
| FullQualifiedD...  |      | String[254]         | 'siemens.com'                                | full qualified domain name part of e-mail address              |
| RemotePort         |      | UInt                | 587                                          | remote TCP port number                                         |
| ActivateSecureConn |      | Bool                | TRUE                                         | activate the security functionality of that connection         |
| ExtTLSCapabilities |      | Byte                | 16#0                                         | for further capability extensions of the TLS handshake         |
| TLSServerCertRef   |      | UDInt               | 7                                            | Reference to the X.509 V3 (CA-) certificate of the mail server |

Figure 3-32 Data type TMAIL\_V4\_SEC

3. Set the connection parameters of the TCP connection in the "Start value" column. Enter the IPv4 address of the mail server, for example, for the "MailServerAddress".

#### Note

##### Connection parameter Interface ID

Note that as of instruction version V5.0 of TMAIL\_C instruction in the TMAIL\_V4\_SEC data type, you need to enter the value "0" for the Interface ID. In this case, the CPU itself searches for a suitable local CPU interface.

4. Set the parameters for secure communication in the "Start value" column. Enter the certificate ID of the CA certificate of the communication partner, for example, for "TLSServerCertRef".
  - "ActivateSecureConn": Activation of secure communication for this connection. If this parameter has the value FALSE, the subsequent security parameters are irrelevant. You can set up a non-secure TCP or UDP connection in this case.
  - "TLSServerCertRef": Reference to the X.509 V3 (CA) certificate of the mail server, which is used by the TLS client to validate the authentication of the mail server.

5. Create a TMAIL\_C instruction in the program editor.
6. Interconnect the MAIL\_ADDR\_PARAM parameter of the TMAIL\_C instruction with the tag of the data type TMAIL\_V4\_SEC.

In the following example the MAIL\_ADDR\_PARAM parameter of the TMAIL\_C instruction is interconnected with the tag "MailConnectionSEC" (data type TMAIL\_V4\_SEC).

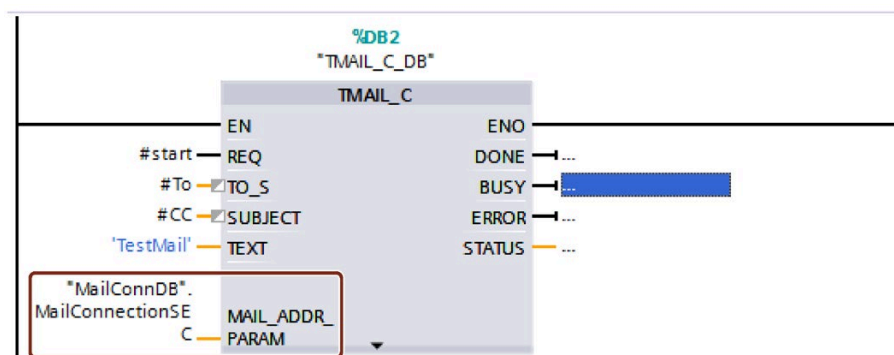


Figure 3-33 TMAIL\_C instruction

## Setting up a secure connection to a mail server over the interface of a communication module

For secure communication to a mail server over a communication module, you need to create a data block with one of the system data types TMAIL\_V4\_SEC, TMAIL\_QDN\_SEC or TMAIL\_V6\_SEC yourself, assign parameters and call it directly at the TMAIL\_C instruction.

Requirements:

- TMAIL\_C instruction with version **V4.0**
- S7-1500 CPU as of firmware version V2.0 with communication module CP 1543-1 as of firmware version V2.0
- ET 200SP CPU as of firmware version V2.0 with communication module CP 1542SP-1 (IRC) as of firmware version V1.0
- You have assigned all the CA certificates of the mail server (TLS server) to the CP (TLS client) and have downloaded the configuration to the CPU.
- Current date and time are set in the CPU.

The STEP 7 online help describes how to set up a secure connection to a mail server over the interface of a communication module.

## Application example

This application example (<https://support.industry.siemens.com/cs/ww/en/view/46817803>) shows how you can use the CP of an S7-1500 or S7-1200 station to set up a secure connection to an email server and send an email with the default application "TMAIL\_C" from the S7 CPU.

### Additional information

You can find more information about the system data types TMail\_V4\_SEC and TMAIL\_QDN\_SEC in the STEP 7 online help.

For additional information on secure communication, refer to the section Secure Communication (Page 40).

## 3.6.4 Secure PG/HMI communication

### 3.6.4.1 PG/HMI communication based on standardized security mechanisms

With the central components of the TIA Portal, STEP 7 and WinCC, an innovative and standardized Secure PG/PC and HMI Communication - PG/HMI communication for short - is implemented starting with version V17 together with the latest controllers and latest HMI devices.

The following CPU families are referred to in detail:

- S7-1500 controller family as of firmware version V2.9
- S7-1200 controller family as of firmware version V4.5
- Software controllers as of firmware version V21.9
- SIMATIC Drive controllers as of firmware version V2.9
- PLCSim and PLCSim Advanced Version V4.0

HMI components have also been updated to support Secure PG/HMI Communication:

- Panels or PCs configured with WinCC Basic, Comfort and Advanced
- PCs with WinCC RT Professional
- WinCC Unified PCs and Comfort Panels

Also updated are SINAMICS RT SW as of version V6.1 and STARTDRIVE as of version V17.

### Properties of PG/HMI communication

One characteristic of PG communication and HMI communication above all is their simplicity: Establishing an online connection from a programming device with installed TIA Portal to a CPU, for example, to load a program, requires little effort. This online connection also meets criteria such as confidentiality and integrity - based on a proven SIMATIC communication standard.

In the course of integrating machines and systems into an open IT environment, however, it must be ensured that the communication between the programming device / HMI device and the CPU is not only secure in the sense of maintaining integrity and confidentiality for sensitive data but also that this security meets generally accepted standards and is thus ready for the challenges of the future.

With TIA Portal version V14, the "Open User Communication" procedure for communication based on user programs has already been extended by the "**Secure** Open User Communication" variant. Other certificate-based communication mechanisms have become established (HTTPS, Secure SMTP over TLS or OPC UA). As of TIA Portal Version V17, PG/HMI communication has also been upgraded: Here, too, the TLS (Transport Layer Security) protocol is used to secure PG/HMI communication using standardized security mechanisms.



## What has changed

### Additional optional password for more security

The most noticeable change in the frame of the configuring of the above devices is the ability to assign a password to protect sensitive configuration data of the respective CPU. This refers to data such as private keys that are required for the proper functioning of certificate-based protocols (Secure Communication) - as of TIA Portal V17 also for the PG/HMI communication. You can use a policy setting to check the assigned passwords as they are entered into the TIA Portal. This will ensure that your company complies with prescribed password policies.

If your machine or system does not require this protection based on the Siemens Industrial Defense-in-Depth concept, you can dispense with password assignment, for example, because another equivalent protection is present. It is possible to do without the password if you have implemented measures to prevent unauthorized access to the TIA Portal project and the configuration of the CPU.

#### **WARNING**

##### **Without password, weak protection of private keys**

Note that without a password to protect trusted configuration data, the private keys for certificates required for secure communication are only weakly protected.

### Certificate-based communication between PG/HMI and CPU

Because PG/HMI communication is certificate-based, you will be asked to accept the server certificate during commissioning.

Additional parameter assignment options allow you to determine the behavior of the CPU during operation: For example, you can specify that the CPU also allows connection to devices that do not support Secure PG/HMI communication.

### Maintenance / replacement parts scenario

For the problem-free exchange of the CPU in replacement parts scenario, you must observe specific rules (see Rules for the replacement parts scenario (Page 72)).

## See also

Protection of confidential configuration data (Page 61)

### 3.6.4.2 Additional settings for the secure PG/HMI communication

In addition to the assignment of a password to protect confidential PLC configuration data, you have further setting options for the behavior of the CPU during operation.

#### PG/PC and HMI communication mode

You can set how the CPU can communicate with programming devices and HMI devices:

- Only via secure PG/HMI communication
- Both via Secure PG/HMI communication and via the previously used PG/HMI communication, "Legacy PG/HMI communication" for short.

##### Procedure

1. In the CPU properties, navigate to the area "Protection & Security > Connection mechanisms".
2. Select the option you want to use.

#### Select certificate or generate a new certificate

If you select the connection mechanism for PG/HMI communication, you can select a PLC communication certificate for the protection of the connection in the same context or have it generated by the TIA Portal. If you have assigned a password or if you have deactivated the option to protect confidential PLC configuration data (i.e. no password has been set), then a certificate with suitable settings and a valid default name is already preset in the "Protection & Security > Connection mechanisms" area.

##### Procedure

If you want to have a new certificate generated by the TIA Portal or if you want to select another existing certificate:

1. In the "PLC communication certificate" field, click the three points to expand the field.
2. Select the certificate you want or click the "Add" button.
3. When adding a certificate, a dialog appears with setting options for the certificate. The purpose is set to "TLS server", you can change other parameters (such as name, hash algorithm).

The general rules for certificate management apply. For example, if you want to generate a CA certificate, the option "Global settings for the certificate manager" must be selected. You also have the option of generating a self-signed PLC certificate.

#### See also

Managing certificates with STEP 7 (Page 49)

### 3.6.4.3 Tip for certificate-based communication between PG and CPU

The certificate-based PG/PC communication (Secure PG/PC communication) means that the communication partner of the CPU – the programming device with installed TIA Portal – must trust the device certificate of the CPU so that a connection can be loaded.

To put it simply, from the TIA Portal perspective you have the following options to trust the certificate of a CPU:

- The PG with TIA Portal is in possession of the device certificate of the CPU because it was, for example, created or imported in the project. In this case, the certificate check runs automatically and without prompting.
- The PG with TIA Portal is not in possession of the device certificate of the CPU, because the CPU was determined via "Accessible stations", for example, and is not available in the project. In this case, the TIA Portal asks the TIA Portal user whether the certificate can be trusted. This may be possible only with great effort because the CPU is not in sight, for example, and the authenticity can therefore not be checked immediately.
- The PG with TIA Portal is in possession of the CA certificate (certification authority) and all CPUs that can be reached in the network from the TIA Portal have device certificates issued by this CA certificate.

Advantage of this solution: TIA Portal can check device certificates automatically, even if the device certificates of the communication partners are not available in TIA Portal.

The solution with a CA certificate (certification authority) is explained in more detail below.

### Requirement

You can use the certification authority of the TIA Portal to create device certificates for a CPU and use the existing CA certificates to sign the device certificates. However, you can also import another certification authority into TIA Portal and use it.

Enabling the global security policies for the certificate manager is a requirement. Only with this setting you can generate CA-signed certificates.

See also here: Managing certificates with STEP 7 (Page 49)

### Exporting CA certificate for programming devices

To export the corresponding CA certificate after creating and assigning a certificate, follow these steps:

1. Open the certificate manager in the global security settings in the project tree.
2. Select the table "CA certificates" for the certificate to be exported.
3. Right-click to open the shortcut menu of the selected certificate.
4. Click "Export".
5. Select the export format of the certificate and the storage location.

### Store CA certificate in the TIA Portal

To make the exported certificate known to a PG with TIA Portal and thus enable automatic certificate checking, follow these steps:

1. Copy the CA certificate exported in the previous step to the following directory:

C:\ProgramData\Siemens\Automation\Certstore\Trusted

2. Start TIA Portal.

In the "Info" tab of the Inspector window, a message appears for each CA certificate which provides information on whether the CA certificate could be successfully transferred to the CA store of TIA Portal.

However, no detailed causes are output in case of failure.

### Adding device certificates to the TIA Portal certificate revocation list (CRL)

You have the option to add individual device certificates to a certificate revocation list (CRL), for example, because the associated key is no longer considered secure.

When the TIA Portal establishes a connection to a CPU whose device certificate is in the certificate revocation list, a dialog appears in the TIA Portal asking whether you still want to trust the certificate. If you decline, the connection will not be established.

To add a device certificate to the certificate revocation list, follow these steps:

1. Copy the device certificate to the following directory:

C:\ProgramData\Siemens\Automation\Certstore\CRL

2. Start TIA Portal.

In the "Info" tab of the Inspector window, a message appears for each certificate which provides information about whether the certificate could be successfully transferred to the CRL store of TIA Portal.

However, no detailed causes are output in case of failure.

### See also

Examples for the management of certificates. (Page 52)

#### 3.6.4.4 CPU behavior from loading to operational readiness

To ensure that communication between the CPU and a programming device or HMI device is secure, it must first have a certificate. However, the certificate for productive operation is only issued when the project is loaded into the CPU.

To ensure that the initial loading is also secured, the CPU first creates a self-signed certificate. The following description explains the different phases of establishing a connection.

**Requirement for the initial establishment of connection to load the CPU**

- No password for confidential PLC configuration data available in the CPU.  
If the CPU has already been loaded and therefore already has a password for confidential PLC configuration data, this password must then match the project that is to be loaded.
- Project with CPU configuration (including password for confidential PLC configuration data) and user program is available.
- The CPU is in STOP mode.
- Programming device and CPU are directly connected to each other and are located in a protected environment; i.e. you can identify the CPU to be loaded and control the connection between CPU and programming device.

**Initial establishment of connection to the CPU - provisioning phase**

The first connection establishment for loading the CPU is secured by the TLS procedure in terms of Secure PG/HMI Communication.

However, the CPU uses its manufacturer device certificate (if available) or a self-signed certificate to establish this connection. The CPU can only be used to a limited extent in this phase. In this phase, the CPU waits for the provision of the password-based key information - or more simply stated, it is expecting the password for confidential PLC configuration data. In the following, this phase is also called the provisioning phase. A message in the diagnostic buffer indicates that the CPU is in the provisioning phase.

When a project is loaded into the CPU, the CPU receives the project data:

- Hardware configuration including configured certificates for secure communication (OPC UA, HTTPS, Secure OUC, Secure PG/HMI Communication)
- User program

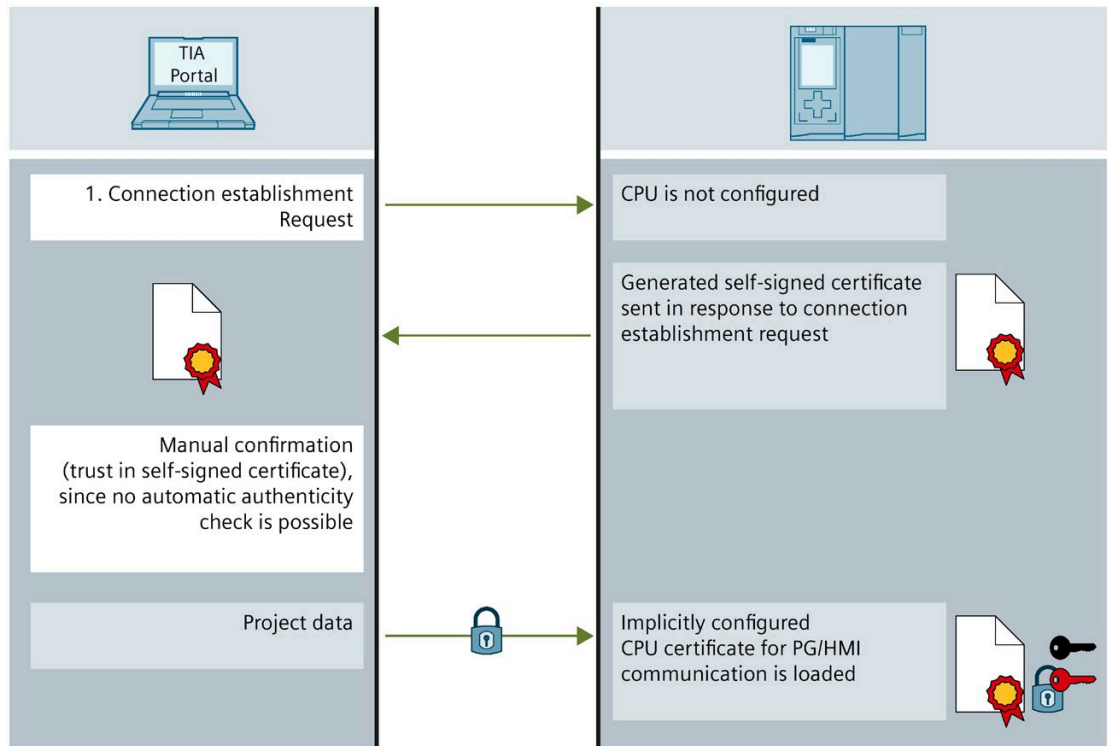


Figure 3-34 Connection establishment, provisioning phase

### Ending the provisioning phase

TIA Portal does not store the password for confidential PLC configuration data itself or the key information generated from the password in the project.

Therefore, the password is requested in a dialog when loading the project for the first time or when loading a new project and transferred to the CPU as key information. Only after this step the CPU is able to use the protected PLC configuration data - this completes the provisioning phase and the CPU can start operating.

If you do not protect the confidential PLC configuration data with a password, there is no need to enter the password when loading the CPU for the first time. This has no influence on the flow of the PG/HMI communication but you have to consider that the confidential PLC configuration data (e.g. private keys) offer almost no protection against unauthorized access in this case.

### Startup of PG/HMI communication

When the CPU is loaded and has received the CPU certificate for Secure PG/HMI Communication, the programming device connects again - this time based on the loaded CA certificate.

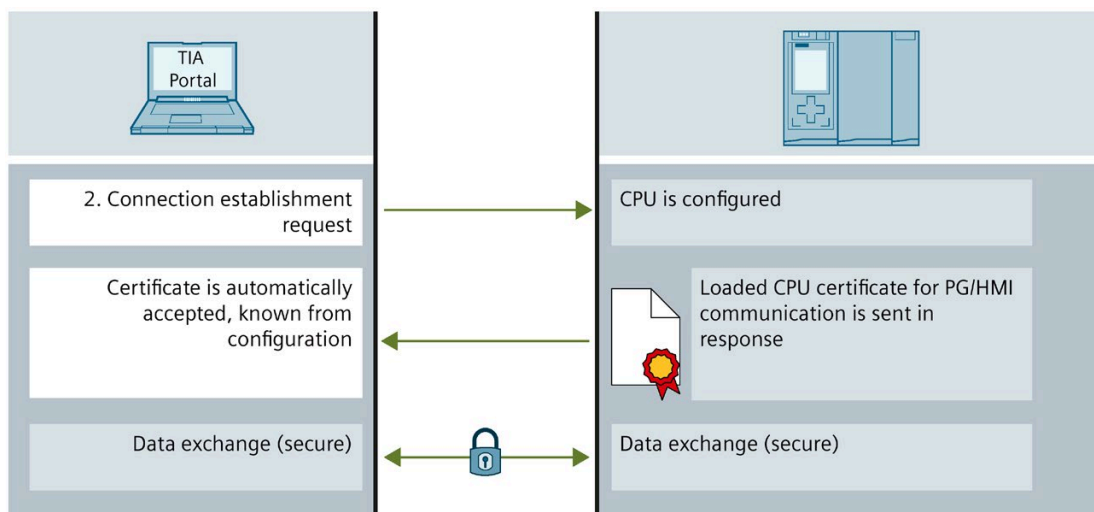


Figure 3-35 Startup of PG/HMI communication

#### 3.6.4.5 Using secure HMI communication

As of TIA Portal version V17, the CPU and the HMI device communicate via secure HMI communication if both devices meet the requirements for this type of communication.

The basis of secure HMI communication is that the HMI device can verify the authenticity of the CPU, using the PLC communication certificate that the CPU sends when establishing communication, and considers the CPU to be "trustworthy". Secure HMI communication is only possible when this turns out to be the case.

This section describes the measures you must take for the various HMI devices to manually label the PLC communication certificate as "trustworthy".

#### Requirement

- CPU and HMI device support secure HMI communication.
- A current project is available on the CPU (TIA Portal V17 and higher).

## Configuring secure HMI communication

1. Configure the HMI device with an alarm view.

---

### Note

Without an alarm view you cannot identify the errors during connection establishment.

---

2. Configure the CPU with the required security settings. Select a PLC communication certificate to protect the HMI connection or have the TIA Portal generate a PLC communication certificate.
3. Configure the HMI connection between the CPU and the HMI device.
4. Download the project to the CPU and the HMI device. During the project transfer, the PLC communication certificate and, if necessary, a CA (Certificate Authority) certificate is transferred to the CPU and the HMI device.

## Trusting the PLC communication certificate

During connection setup, the CPU transfers the PLC communication certificate to the HMI device.

- When the PLC communication certificate is already available on the HMI device with the "trustworthy" status, a secure HMI communication is automatically set up between the CPU and the HMI device.
- When the PLC communication certificate is not available in the "trustworthy" status on the HMI device, you will see a message in the alarm view of the HMI device informing you that the CPU is not trusted along with an error code.

In this case, you must label the PLC communication certificate on the HMI device as "trustworthy".

Depending on the type of your HMI device, follow these steps.

### Basic Panels 2nd Generation

1. In the Start Center, select "Settings > Internet Settings > Certificate store".
2. In the "Available certificates in Device" list, select the PLC communication certificate of the CPU.
3. Press "Trust".
4. Restart the HMI runtime software.

### Unified Comfort Panels

1. Open the Control Panel.
2. Select "Security > Certificates".
3. In the "Certificate store" selection list, select the entry "Other Certificates".
4. In the "Other certificates" list, select the PLC communication certificate of the CPU.
5. Press "Trust".
6. Restart the HMI runtime software.



**Comfort Panels, Mobile Panels 2nd Generation**

1. Open the file manager via the Windows CE desktop icon "My Device".
2. Navigate to the directory "\\flash\\simatic\\SystemRoot\\OMS\\Untrusted". There you will find the PLC communication certificate of the CPU.
3. Copy the PLC communication certificate of the CPU to the directory "\\flash\\simatic\\SystemRoot\\OMS\\Trusted".
4. Restart the HMI runtime software.

When the PLC communication certificate is already available on the HMI device with the "trustworthy" status, secure HMI communication can be set up. You can find additional information in the operating instructions of the HMI device.

**3.6.4.6 Using Legacy PG/PC communication for TIA Portal**

As of TIA Portal version V17, the TIA Portal and the S7-1200/S7-1500 CPU as of firmware version V4.5/V2.9 automatically communicate "securely" - the connection partners set their connection mechanisms automatically to the highest possible security method.

Only special circumstances (see Information about compatibility (Page 102)) cause a fallback to the old PG/PC communication, called "Legacy PG/PC communication".

There may be some cases in which the higher security is not desirable because it can impact the transmission rate of CPUs with weak communication performance.

**Requirement**

- There may be no online connections to the CPUs.
- For CPUs that are to be reached online, the option "Only permit secure PG/PC and HMI communication" must be disabled (CPU parameters in the area "Connection mechanisms").
- The communication partners are in a protected environment, for example, during the commissioning phase.

**Setting the Legacy PG/PC communication**

1. In the "Online" menu, select the command "Use only Legacy PG/PC communication".
2. Select the check box in front of the menu command.

**Result:** All online connections are set up as for TIA Portal versions < V17.

The setting remains active for the duration of the session. When you open a project, the option "Use only Legacy PG/PC communication" is not set.

### Behavior with enabled option "Use only Legacy PG/PC communication"

- A password to protect confidential PLC configuration data cannot be specified, modified or deleted online for CPUs. These functions require disabling the "Use only Legacy PG/PC communication" option.
- A CPU that is set to only permit secure PG/PC and HMI communication can no longer be reached online.

#### 3.6.4.7 Information about compatibility

The following description provides information about the interaction between different TIA Portal versions with different CPU firmware versions and the effects on the type of PG/HMI connection.

#### Projects created with TIA Portal < V17

For example, if you have created a project with TIA Portal version V16 for an S7-1500 CPU (e.g. version V2.8), then the corresponding configuration with TIA Portal V17 can also be loaded into an S7-1500 CPU V2.9, e.g. in a spare part scenario - with the same behavior as a configuration on an S7-1500 CPU V2.8.

Even projects created with TIA Portal < V17 and transferred to a memory card work without problems in an S7-1500 CPU V2.9.

However, the concept of protecting confidential PLC configuration data applies as soon as you open the project with TIA Portal  $\geq$  V17, update the firmware version of the CPU via a device replacement and thus save it as a CPU with a firmware version  $\geq$  V2.9 (see Useful information for the protection of confidential PLC configuration data (Page 63)). The project can no longer be edited with previous versions of TIA Portal V17.

### PG/HMI and CPU connected differently

As explained in the previous sections, the secure PG/HMI connection as of V17 between the PG/HMI device and CPU (current version) is characterized by the employed standardized communication procedure, TLS (Transport Layer Security).

You have the option of connecting a V2.9 CPU to a current programming device with TIA Portal V17 or higher and additionally, for example, to an HMI device with a runtime from the previous version: The devices automatically adjust their connection mechanisms accordingly. In order to be able to better differentiate between the two connection mechanisms, we call the previous procedure, which is based on a variant of S7 communication, "Legacy procedure" for short.

In summary ("PG" here stands for a programming device with TIA Portal):

- PG/HMI and CPU come with the V17 (or subsequent version): TLS procedure is used.
- PG/HMI comes from a predecessor version (< V17): Legacy procedure is used - provided that you have deactivated the option "Only allow secure PG/PC and HMI communication" in the CPU properties.
- CPU comes with V17 (or higher), several PGs/HMIs are connected and come from both V17 (or higher) and previous versions: TLS + legacy procedures are used - provided that you have deactivated the option "Only allow secure PG/PC and HMI communication" in the CPU properties.

### When the CPU state changes

The diagnostics buffer provides you with information if its status changes due to events in connection with the Secure PG/HMI Communication.

Examples:

- After successfully loading a configuration with a configured password, the diagnostics buffer reports that the CPU is changing from the provisioning phase to Secure Mode (TLS procedure).
- You have connected a PG with TIA Portal V17 to a CPU V2.9. Secure PG/HMI communication (TLS procedure) is established automatically.

## 3.7 SNMP

### 3.7.1 Disabling SNMP

The network management protocol SNMP (Simple Network Management Protocol) is a protocol that uses various services and tools for detection and diagnostics of the network topology.

Which SNMP requests the S7-1500 CPUs and the S7-1200 CPUs can receive, is described in this FAQ (<https://support.industry.siemens.com/cs/ww/en/view/79993228>).

SNMP uses the transport protocol UDP. SNMP recognizes two network components, the SNMP manager and the SNMP client. The SNMP manager monitors the network nodes: The SNMP clients collect the various network-specific information in the individual network nodes and store it in a structured form in the MIB (Management Information Base). Various services and tools can run detailed network diagnostics with the help of these data.

Under certain conditions, it is useful to disable SNMP. Examples:

- The security guidelines in your network do not allow the use of SNMP.
- You use your own SNMP solution, e.g. with your own communications instructions.

If you disable SNMP for a device, various diagnostics options for the network topology (e.g. in the PRONETA tool or in the Web server of the CPU) are no longer available.

### Disabling SNMP

To disable SNMP for one of the integrated interfaces of an S7 1500 CPU, proceed as follows:

1. In STEP 7, create a data block that contains the structure of data record B071<sub>H</sub>.
  - The following table shows the structure of the data record B071<sub>H</sub>.

| Byte | Element         | Code                | Explanation                                                                                       |
|------|-----------------|---------------------|---------------------------------------------------------------------------------------------------|
| 0-1  | BlockID         | F003 <sub>H</sub>   | Header<br>The data record length is counted starting at byte 4 "Version".                         |
| 2-3  | BlockLength     | 8                   |                                                                                                   |
| 4    | Version         | 01 <sub>H</sub>     |                                                                                                   |
| 5    | Subversion      | 00 <sub>H</sub>     |                                                                                                   |
| 6-7  | Reserved        | -                   | -                                                                                                 |
| 8-11 | SNMP controller | Disable/enable SNMP | If you want to disable SNMP, enter the value 0.<br>If you want to enable SNMP, enter the value 1. |

2. Transfer the data record B071<sub>H</sub> in the startup OB (OB100) with the WRREC instruction (write data record) to the CPU.  
Use the hardware ID of an integrated interface of the CPU here.

### 3.7.2 Example: Disabling SNMP for a CPU 1516-3 PN/DP

#### Task

As the security guidelines in your network do not allow SNMP, you want to disable SNMP for a CPU 1516-3 PN/DP.

#### Requirements

- CPU 1516-3 PN/DP with firmware version V2.0
- STEP 7 as of V14

#### Solution

First, create a data block that contains the structure of data record B071<sub>H</sub>. The figure below shows the data block "Deactivate SNMP". The data block "Deactivate SNMP" contains the data record B071<sub>H</sub> as well as additional tags that you use to transfer the data record. The tag "snmp\_deactivate" is used to trigger the job for WRREC. Place this tag in the retentive memory area so that the value is also available in the startup OB (OB100).

| Deactivate SNMP |                 |           |             |                                     |                                     |                          |                                     |                      |  |
|-----------------|-----------------|-----------|-------------|-------------------------------------|-------------------------------------|--------------------------|-------------------------------------|----------------------|--|
|                 | Name            | Data type | Start value | R...                                | A...                                | W..                      | V...                                | Comment              |  |
| 1               | Static          |           |             | <input type="checkbox"/>            | <input type="checkbox"/>            | <input type="checkbox"/> | <input type="checkbox"/>            |                      |  |
| 2               | snmp_deactivate | Bool      | TRUE        | <input checked="" type="checkbox"/> | <input checked="" type="checkbox"/> | <input type="checkbox"/> | <input checked="" type="checkbox"/> | Tag for deactivation |  |
| 3               | snmp_record     | Struct    |             | <input checked="" type="checkbox"/> | <input checked="" type="checkbox"/> | <input type="checkbox"/> | <input checked="" type="checkbox"/> | Data record 16#B071  |  |
| 4               | BlockID         | UInt      | 16#F003     | <input checked="" type="checkbox"/> | <input checked="" type="checkbox"/> | <input type="checkbox"/> | <input checked="" type="checkbox"/> |                      |  |
| 5               | BlockLenght     | UInt      | 8           | <input checked="" type="checkbox"/> | <input checked="" type="checkbox"/> | <input type="checkbox"/> | <input checked="" type="checkbox"/> |                      |  |
| 6               | Version         | USInt     | 1           | <input checked="" type="checkbox"/> | <input checked="" type="checkbox"/> | <input type="checkbox"/> | <input checked="" type="checkbox"/> |                      |  |
| 7               | Subversion      | USInt     | 0           | <input checked="" type="checkbox"/> | <input checked="" type="checkbox"/> | <input type="checkbox"/> | <input checked="" type="checkbox"/> |                      |  |
| 8               | Reserved        | UInt      | 0           | <input checked="" type="checkbox"/> | <input checked="" type="checkbox"/> | <input type="checkbox"/> | <input checked="" type="checkbox"/> |                      |  |
| 9               | SNMPControl     | UDInt     | 0           | <input checked="" type="checkbox"/> | <input checked="" type="checkbox"/> | <input type="checkbox"/> | <input checked="" type="checkbox"/> |                      |  |
| 10              | snmp_done       | Bool      | false       | <input type="checkbox"/>            | <input checked="" type="checkbox"/> | <input type="checkbox"/> | <input checked="" type="checkbox"/> |                      |  |
| 11              | snmp_error      | Bool      | false       | <input type="checkbox"/>            | <input checked="" type="checkbox"/> | <input type="checkbox"/> | <input checked="" type="checkbox"/> |                      |  |
| 12              | snmp_status     | DWord     | 16#0        | <input type="checkbox"/>            | <input checked="" type="checkbox"/> | <input type="checkbox"/> | <input checked="" type="checkbox"/> |                      |  |

Figure 3-36 Example: Data block for disabling SNMP

Transfer the data record B071<sub>H</sub> in the startup OB (OB100) to CPU 1516-3 PN/DP with the WRREC instruction (write data record).

In the following program code, the data record B071<sub>H</sub> is transferred with the WRREC instruction in a REPEAT UNTIL loop.

```
ORGANIZATION_BLOCK "Startup"
TITLE = "Complete Restart"
{ S7_Optimized_Access := 'TRUE' }
VERSION : 0.1
BEGIN
  REPEAT
    "WRREC_DB_1"
    (REQ := "Deactivate SNMP".snmp_deactivate,
      //Transfer data record
      INDEX:=16#B071,
      //Data record number for SNMP deactivation
      ID:= "Local~PROFINET_interface_1",
      //any integrated PROFINET Interface
      DONE => "Deactivate SNMP".snmp_done,
      ERROR => "Deactivate SNMP".snmp_error,
      STATUS => "Deactivate SNMP".snmp_status,
      RECORD := "Deactivate SNMP".snmp_record)
      //Data record
    UNTIL "Deactivate SNMP".snmp_done OR "Deactivate SNMP".snmp_error
  END_REPEAT;
END_ORGANIZATION_BLOCK
```

### Using program code

You will find the full program code here.

Follow these steps to apply the program code to your project:

1. Copy the entire program code to the clipboard with Ctrl+A, Ctrl+C.
2. Open a text editor (e.g. "Editor").
3. Paste the content of the clipboard to the text editor with Ctrl+V.
4. Save the document as an scl file, e.g. SNMP\_DEACT.scl.
5. Open your project in STEP 7.
6. Import the scl file as an external source.  
You will find further information on importing external sources in the STEP 7 online help.
7. Generate the startup OB and the data blocks. (right-click on the scl file, shortcut menu: "Generate blocks from source")

### Re-enabling SNMP

With small changes, you can use the program code used above to enable SNMP.

In the user program, assign the "Deactivate SNMP".snmp\_record.SNMPControl tag the value "1":

```
"Deactivate SNMP".snmp_record.SNMPControl := 1;
```

SNMP will then be enabled again the next time the CPU is started.

# PG communication

## Properties

Using PG communication, the CPU or another module capable of communication exchanges data with an engineering station (for example PG, PC). The data exchange is possible via PROFIBUS and PROFINET subnets. The gateway between S7 subnets is also supported.

PG communication provides functions needed to load programs and configuration data, run tests, and evaluate diagnostic information. These functions are integrated in the operating system of the module capable of communication.

---

### Note

As of TIA Portal version V17, the TLS (Transport Layer Security) protocol is supported for PG/HMI communication to secure the data exchange between PG/PC and CPU using standardized security mechanisms.

For more information, refer to the following sections:

- Requirements for secure communication (Page 61)
  - Secure PG/HMI communication (Page 92)
- 

## Requirements

- The PG/PC is physically connected to the communication-capable module.
- If the communication-capable module is to be reached via S7 routing, the hardware configuration has to be loaded in the participating stations (S7 router and end point).

## Procedure for connecting online

You must establish an online connection to the CPU for the programming device communication:

1. Select the CPU in the project tree in STEP 7.
2. Select the "Online > Go online" menu command.

3. In the "Go online" dialog, make the following settings for your online connection:
  - Select interface type (e.g. PN/IE) in the "Type of PG/PC interface" drop-down list.
  - In the "PG/PC interface" drop-down list, select the PG/PC interface (e.g. Ind. Ethernet card) you want to use to establish the online connection.
  - Select the interface or the S7 subnet with which the programming device/PC is physically connected from the "Connection to interface/subnet" drop-down list.
  - If the communication-capable module can be reached via an S7 router (gateway), select the S7 router that connects the subnets in question from the "1st gateway" drop-down list.

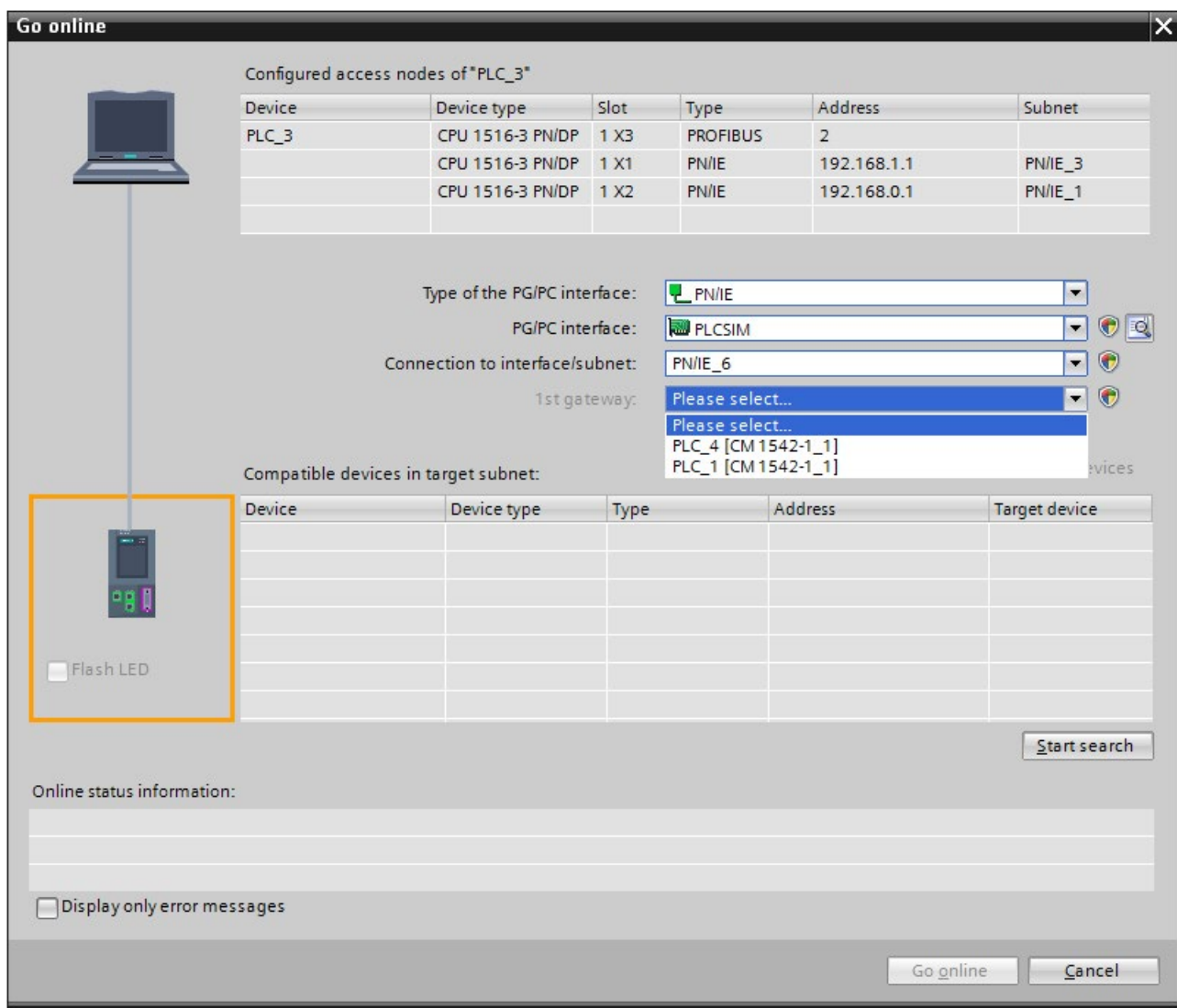


Figure 4-1 Setting up PG communication



4. Click "Start search".  
All devices that you can address with PG communication appear shortly thereafter in the table "Compatible devices in target subnet".
5. In the "Compatible devices in target subnet" table, select the relevant CPU and confirm with "Go online".

### **Additional information**

You can find more information on "Go online" in the STEP 7 online help.

# HMI communication

## Properties

Using HMI communication, one or more HMI devices (for example HMI Basic/Comfort/Mobile Panel) exchanges data with a CPU for operator control and monitoring with via the PROFINET or PROFIBUS DP interface. The data exchange is via HMI connections.

If you want to set up several HMI connections to a CPU, use for example:

- The PROFINET and PROFIBUS DP interfaces of the CPU
- CPs and CMs with the relevant interfaces

---

### Note

As of TIA Portal version V17, the TLS (Transport Layer Security) protocol is supported for PG/HMI communication to secure the data exchange between PG/PC and CPU using standardized security mechanisms.

For more information, refer to the following sections:

- Requirements for secure communication (Page 61)
  - Secure PG/HMI communication (Page 92)
- 

## Procedure for setting up HMI communication

As soon as you drag-and-drop a tag, for example a tag from a global data block into an HMI screen or into the HMI tag table, STEP 7 automatically sets up an HMI connection. Alternatively, you can also set up the HMI connection yourself.

To set up an HMI connection, follow these steps.

1. Configure the HMI device in an existing configuration with a CPU in the network view of the Devices & networks editor of STEP 7.
2. Select the "Connections" button and then "HMI connection" from the drop-down list.
3. Drag-and-drop a line between the end points of the connection (HMI device and CPU). The end points are highlighted in color. If the required S7 subnet does not yet exist, it is created automatically.

4. In the "Connections" tab, select the row of the HMI connection.

In the "General" area of the "Properties" tab, you see the properties of the HMI connection, some of which you can change.

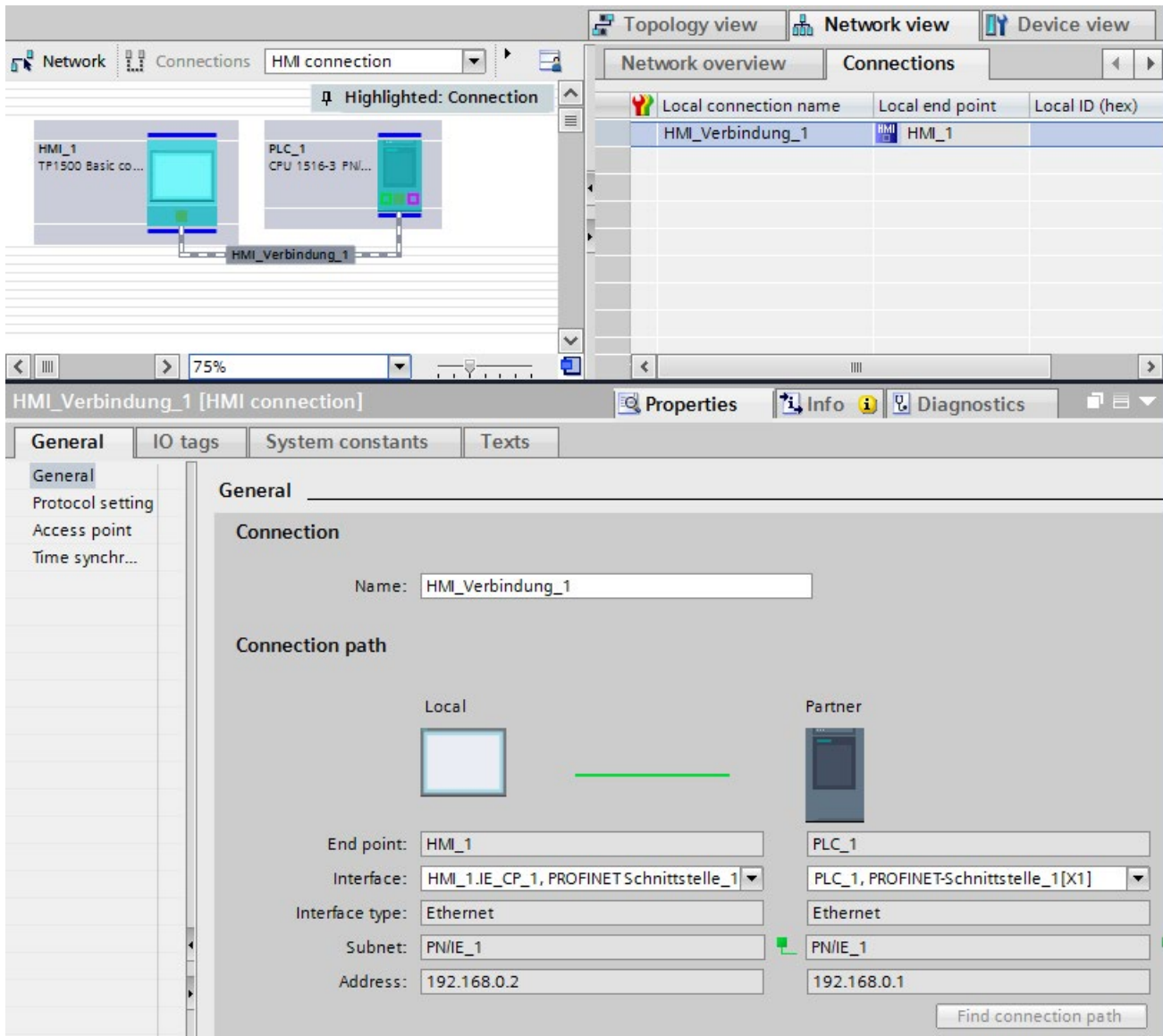


Figure 5-1 Setting up HMI communication

5. Download the hardware configuration to the CPU.
6. Download the hardware configuration to the HMI device.

## Additional information

You can find information on S7 routing for HMI connections in the section S7 Routing (Page 373).

You can find more information on setting up HMI connections in the STEP 7 online help.

# Open User Communication

## 6.1 Overview of Open User Communication

### Features of Open User Communication

Through Open User Communication, also called "open communication", the CPU exchanges data with another device capable of communication. Open User Communication has the following features and characteristics:

- Open standard (communication partners can be two SIMATIC CPUs or a SIMATIC CPU and a suitable third-party device).
- Communication via various protocols (in STEP 7 known as "Connection types")
- High degree of flexibility in terms of the data structures transferred; this allows open data exchange with any communications devices as long as these support the connection types available.
- Secure Communication: To protect your automation system, you can exchange data securely over Open User Communication. With Secure Open User Communication, the data is sent signed and encrypted, see also Secure Open User Communication (Page 73).
- Open User Communication is possible in various automation systems, see technical specifications of the respective manuals.

Examples:

- Integrated PROFINET / Ind. Ethernet interfaces of CPUs (S7-1500, ET 200SP CPU, S7-1500 Software Controller, CPUs 1513/1516pro 2 PN)
- PROFINET / Ind. Ethernet interfaces of communications modules (for example CP 1543-1, CM 1542-1, CP 1543SP-1)

Information on Secure Open User Communication is available in the section Secure Communication (Page 40).

### Information on S7-1500R/H

You can find information on Open User Communication with the S7-1500R/H redundant system in section Communication with the redundant system S7-1500R/H (Page 407).

## 6.2 Protocols for Open User Communication

### Protocols for Open User Communication

The following protocols are available for open communication:

Table 6- 1 Transport protocols for open communication

| Transport protocol                         | Via interface                        |
|--------------------------------------------|--------------------------------------|
| TCP according to RFC 793                   | PROFINET/Industrial Ethernet         |
| ISO-on-TCP according to RFC 1006 (Class 4) | PROFINET/Industrial Ethernet         |
| ISO according to ISO/IEC 8073              | Industrial Ethernet (only CP 1543-1) |
| UDP according to RFC 768                   | PROFINET/Industrial Ethernet         |
| FDL                                        | PROFIBUS                             |

Table 6- 2 Application protocols for open communication

| Application protocol | Used transport protocol  |
|----------------------|--------------------------|
| Modbus TCP           | TCP according to RFC 793 |
| E-mail               | TCP according to RFC 793 |
| FTP                  | TCP according to RFC 793 |

### TCP, ISO-on-TCP, ISO, UDP

Prior to data transfer, these protocols (except UDP) establish a transport connection to the communications partner. Connection-oriented protocols are used when potential loss of data needs to be avoided.

The following is possible with UDP:

- Unicast to one device or broadcast to all devices on PROFINET via the PROFINET interface of the CPU or the Industrial Ethernet interface of the CP 1543-1
- Multicast to all recipients of a multicast group via the PROFINET interface of the CPU\* or the PROFINET / Industrial Ethernet interface of the CP 1543-1

\* As of firmware version V2.0, the PROFINET interface of the CPU supports a maximum of 5 multicast groups

Maximum user data length: You can find the maximum user data lengths supported in the technical specifications of the respective device manuals.

### Protocol for communication via PROFIBUS: FDL

Data transfer via an FDL connection (Fieldbus Data Link) is suitable for the transfer of related blocks of data to a communications partner on PROFIBUS that supports the sending and receiving of data according to the FDL service SDA (Send Data with Acknowledge) according to EN 50170, Vol 2. Both partners have the same rights; in other words, each partner can initiate sending and receiving event-driven.

In keeping with the FDL service SDN (Send Data with No Acknowledge) according to EN 50170, Vol 2, the following is possible with FDL:

- Broadcast to all devices on PROFIBUS via the PROFIBUS interface of the CM 1542-5
- Multicast to all recipients of a multicast group via the PROFIBUS interface of the CM 1542-5

### Modbus TCP

The Modbus protocol is a communication protocol with linear topology based on a master/slave architecture. In the Modbus TCP (Transmission Control Protocol), the data is transmitted as TCP/IP packets.

Communication is controlled solely by suitable instructions in the user program.

### E-mail and FTP

You can use email to send for example, data block contents (e.g. process data) as an attachment.

You can use the FTP connection (FTP = File Transfer Protocol) to transmit files to and from S7 devices.

The communication is controlled by instructions in the user program at the client end.

### Application example: MQTT Publisher for the SIMATIC S7-1500 CPU

The "Message Queue Telemetry Transport" (MQTT) is a simple protocol on the TCP/IP level. It is suitable for the exchange of messages between devices with lower functionality and for the transfer via unreliable networks.

The application example provides a function block with which you can implement the MQTT protocol into the SIMATIC S7-1500.

You can find the application example on the Internet (<https://support.industry.siemens.com/cs/ww/en/view/109772284>).

### Block library for SYSLOG messages

Syslog is a simply structured binary profile on UDP/IP level. It enables applications to send messages, warnings or error states to a Syslog server. Syslog is typically used for computer system management and security monitoring, and has established itself as a standard in the field of protocols.

The "LSyslog" library offers you a solution to implement the Syslog protocol in an S7-1500. In addition to the library, an application example is provided that shows you how to generate Syslog messages in your controller and send them to the Syslog server.

You can find the block library "LSyslog" and the associated application example on the Internet (<https://support.industry.siemens.com/cs/ww/en/view/51929235>).

## 6.3 Instructions for Open User Communication

### Introduction

You set up Open User Communication via the corresponding connection (for example, TCP connection) as follows:

- By programming in the user programs of the communications partners or
- By configuring the connection in STEP 7 in the hardware and network editor

Regardless of whether you set up the connection by programming or configuring, instructions are always required in the user programs of both communications partners for sending and receiving the data.

### Setting up the connection via the user program

If the connection is set up by programming, the connection establishment and termination is implemented using instructions in the user program.

In certain application areas, it is advantageous not to set up the communication connections statically via hardware configuration, but via the user program instead. You can set up the connections via a specific application program-controlled and therefore when necessary. Programmed connection setup also allows connection resources to be released following data transfer.

A data structure is necessary for each communications connection that contains the parameters for establishing the connection (for example system data type "TCON\_IP\_v4" for TCP).

The system data types (SDT) are provided by the system and have a predefined structure that cannot be changed.

The various protocols have their own data structures (see table below). The parameters are stored in a data block ("connection description DB") for example of the system data type TCON\_IP\_v4.

There are two ways in which you can specify the DB with the data structure:

- Recommendation: Have the data block created automatically in the properties in the program editor during parameter assignment of the connection for the TSEND\_C, TRCV\_C and TCON instructions.
- Create the data block manually, assign parameters to it and write it directly to the instruction  
Necessary for:
  - Secure OUC
  - Connection over DNS
  - E-mail
  - FTP

You can modify the connection parameters in the "connection description DB".

This FAQ (<https://support.industry.siemens.com/cs/ww/en/view/58875807>) describes how to program the TCON instruction to set up a connection for Open User Communication between two S7-1500 CPUs.

### Protocols, system data types and employable instructions for programmed setup

The following table shows the protocols of the Open User Communication and the matching system data types and instructions.

Table 6- 3 Instructions for programmed setup of the connection

| Protocol                                | System data type                                                                                                                        | Instructions                                                                                                                                                                                                                  |
|-----------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| TCP                                     | <ul style="list-style-type: none"> <li>• TCON_QDN</li> <li>• TCON_IP_v4</li> </ul>                                                      | Establish connection and send/receive data via:                                                                                                                                                                               |
| ISO-on-TCP                              | <ul style="list-style-type: none"> <li>• TCON_IP_RFC</li> </ul>                                                                         | <ul style="list-style-type: none"> <li>• TSEND_C/TRCV_C or</li> <li>• TCON, TSEND/TRCV or</li> </ul>                                                                                                                          |
| ISO according to ISO/IEC 8073 (Class 4) | <ul style="list-style-type: none"> <li>• TCON_ISOnative<sup>1</sup></li> <li>• TCON_Configured</li> </ul>                               | <ul style="list-style-type: none"> <li>• TCON, TUSEND/TURCV (connection can be terminated via TDISCON)</li> </ul>                                                                                                             |
| UDP                                     | <ul style="list-style-type: none"> <li>• TCON_IP_v4</li> <li>• TADDR_Param</li> <li>• TADDR_SEND_QDN</li> <li>• TADDR_RCV_IP</li> </ul> | Establish connection and send/receive data via: <ul style="list-style-type: none"> <li>• TSEND_C/TRCV_C</li> <li>• TUSEND/TURCV/TRCV (connection can be terminated via TDISCON)</li> </ul>                                    |
| FDL <sup>1</sup>                        | <ul style="list-style-type: none"> <li>• TCON_FDL</li> </ul>                                                                            | Establish connection and send/receive data via: <ul style="list-style-type: none"> <li>• TSEND_C/TRCV_C or</li> <li>• TCON, TSEND/TRCV or</li> <li>• TCON, TUSEND/TURCV (connection can be terminated via TDISCON)</li> </ul> |



| Protocol         | System data type                                                                                                                                                 | Instructions                                                                       |
|------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------|
| Modbus TCP       | <ul style="list-style-type: none"> <li>• TCON_IP_v4</li> <li>• TCON_QDN</li> <li>• TCON_Configured</li> </ul>                                                    | <ul style="list-style-type: none"> <li>• MB_CLIENT</li> <li>• MB_SERVER</li> </ul> |
| E-mail           | <ul style="list-style-type: none"> <li>• TMAIL_v4</li> <li>• TMAIL_v6</li> <li>• TMAIL_FQDN</li> </ul>                                                           | <ul style="list-style-type: none"> <li>• TMAIL_C</li> </ul>                        |
| FTP <sup>2</sup> | <ul style="list-style-type: none"> <li>• FTP_CONNECT_IPV4<sup>3</sup></li> <li>• FTP_CONNECT_IPV6<sup>3</sup></li> <li>• FTP_CONNECT_NAME<sup>3</sup></li> </ul> | <ul style="list-style-type: none"> <li>• FTP_CMD</li> </ul>                        |

<sup>1</sup> This protocol can only be used with the CM 1542-5

<sup>2</sup> This protocol can only be used with the CP 1543-1

<sup>3</sup> User-defined data type

The following table shows you the different connections of the Secure Open User Communication and the matching system data types and instructions.

| Secure OUC connection                                                                     | System data type                                                                          | Instructions                                                                                   |
|-------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------|
| Secure TCP connection from an S7-1500 CPU as TLS client to a third-party PLC (TLS server) | <ul style="list-style-type: none"> <li>• TCON_QDN_SEC</li> </ul>                          | <ul style="list-style-type: none"> <li>• TSEND_C/TRCV_C</li> <li>• TCON, TSEND/TRCV</li> </ul> |
| Secure TCP connection from an S7-1500 CPU as TLS server to a third-party PLC (TLS client) |                                                                                           |                                                                                                |
| Secure TCP connection between two S7-1500 stations                                        | <ul style="list-style-type: none"> <li>• TCON_IP_V4_SEC<sup>1</sup></li> </ul>            |                                                                                                |
| Secure connection to a mail server <sup>2</sup>                                           | <ul style="list-style-type: none"> <li>• TMAIL_V4_SEC</li> <li>• TMAIL_QDN_SEC</li> </ul> | <ul style="list-style-type: none"> <li>• TMAIL_C (V5.0 or higher)</li> </ul>                   |
| Secure Modbus TCP connection                                                              | <ul style="list-style-type: none"> <li>• TCON_IP_V4_SEC<sup>1</sup></li> </ul>            | <ul style="list-style-type: none"> <li>• MB_Client</li> <li>• MB_Server</li> </ul>             |
|                                                                                           | <ul style="list-style-type: none"> <li>• TCON_QDN_SEC</li> </ul>                          |                                                                                                |

<sup>1</sup> Also possible for CP 1543-1

<sup>2</sup> Secure connection to a mail server also possible with CP1543-1 und TMAIL\_C (V4.0)

### Setting up the connection with connection configuration

When setting up through the configuration of the connection, the address parameters of the connection are specified in the hardware and network editor of STEP 7.

To send and receive the data, use the same instructions as when the connections are set up by programming:

Table 6- 4 Instructions for sending/receiving with configured connections

| Protocol                                | Send/receive with configured connections                                                                                                      |
|-----------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Supported instructions:</b>          |                                                                                                                                               |
| TCP                                     | Send/receive data via: <ul style="list-style-type: none"> <li>• TSEND_C/TRCV_C or</li> <li>• TSEND/TRCV or</li> <li>• TUSEND/TURCV</li> </ul> |
| ISO-on-TCP                              |                                                                                                                                               |
| ISO according to ISO/IEC 8073 (Class 4) |                                                                                                                                               |
| UDP                                     | Send/receive data via: <ul style="list-style-type: none"> <li>• TSEND_C/TRCV_C or</li> <li>• TUSEND/TURCV</li> </ul>                          |
| FDL                                     | Send/receive data via: <ul style="list-style-type: none"> <li>• TSEND_C/TRCV_C or</li> <li>• TSEND/TRCV or</li> <li>• TUSEND/TURCV</li> </ul> |
| Modbus TCP                              | Not supported                                                                                                                                 |
| E-mail                                  | Not supported                                                                                                                                 |
| FTP                                     | Not supported                                                                                                                                 |

### Additional instructions for open communication

You can use the following instructions for connections set up in the user program as well as for configured connections:

- T\_RESET: Terminating and establishing a connection
- T\_DIAG: Check the connection

### Basic examples for Open User Communication

The Siemens Online Support offers you function blocks (FBs) that facilitate the handling of the instructions of the Open User Communication. You can find the function block with corresponding examples on the Internet

(<https://support.industry.siemens.com/cs/ww/en/view/109747710>).

**Additional information**

The STEP 7 online help describes:

- The user and system data types
- The instructions for open communication
- The connection parameters

You will find information about the allocation and release of connection resources in the section Allocation of connection resources (Page 395).

**See also**

Secure Open User Communication (Page 73)

## **6.4 Open User Communication with addressing via domain names**

As of firmware version V2.0, S7-1500 CPUs, ET 200SP CPUs and the CPUs 1513/1516pro-2 PN support Open User Communication with addressing via Domain Name System (DNS). A DNS client is integrated in the CPU. In the case of communication via DNS, you use domain names as an alias for IP addresses to address communication partners. Addressing of the communication partners via domain names is possible for open communication via TCP and UDP.

At least one DNS server must be located in your network as a requirement for communication via DNS.

The S7-1500 software controller supports communication via DNS for all interfaces that are assigned to the software controller.

## Setting up communication via DNS

The DNS client of the CPU must know the IPv4 address of at least one DNS server so that a CPU can establish a connection to a communication partner via its domain name. The CPU supports up to 4 different DNS servers.

To set up communication via domain names for an S7-1500 CPU, follow these steps:

1. Select the CPU in the network view of STEP 7.
2. In the Inspector window, navigate to "Properties" > "General" > "Advanced configuration" > "DNS configuration".
3. Enter the IPv4 address of a DNS server in the "DNS server addresses" column of the "Server list" table.

You can enter up to 4 IPv4 addresses of DNS servers.

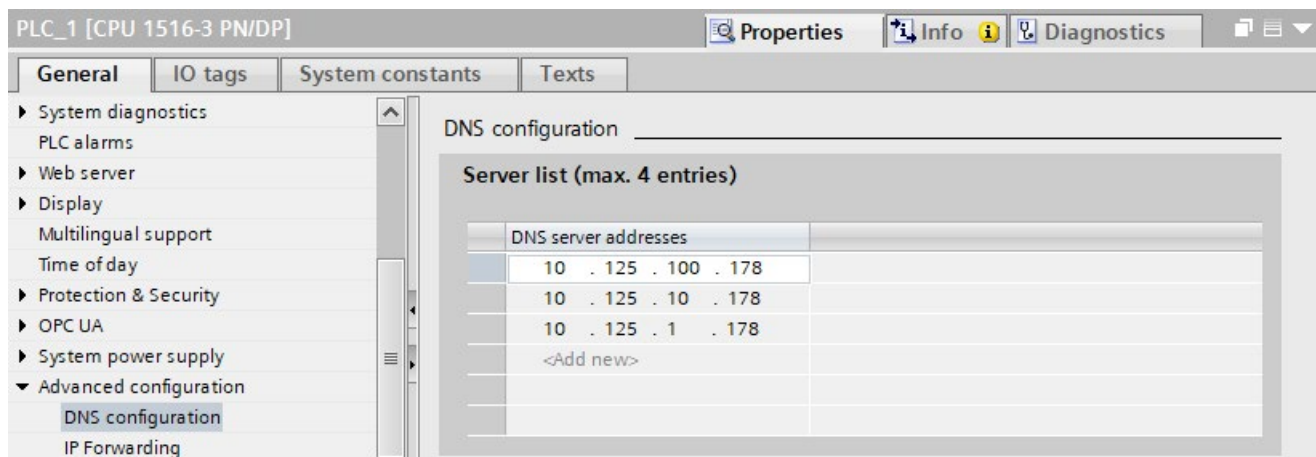


Figure 6-1 Entering DNS server addresses using a CPU 1516-3 PN/DP as an example

### Setting up a TCP connection via the domain name of the communication partner

For TCP communication via the domain name you need to create a data block with the TCON\_QDN system data type yourself, assign parameters and call it directly at the instruction. The TCON, TSEND\_C and TRCV\_C instructions support the system data type TCON\_QDN. To set up a TCP connection via the domain name of the communication partner, follow these steps:

1. Create a global data block in the project tree.
2. Define a tag of the data type TCON\_QDN in the global data block.

The example below shows the global data block "Data\_block\_1" in which the tag "DNS Connection1" of data type TCON\_QDN is defined.

| Data_block_1 |                   |             |           |                                                            |
|--------------|-------------------|-------------|-----------|------------------------------------------------------------|
|              | Name              | Datentyp    | Startwert | Kommentar                                                  |
| 1            | Static            |             |           |                                                            |
| 2            | DNS Connection1   | TCON_QDN    |           |                                                            |
| 3            | Interfaceld       | HW_ANY      | 0         | not relevant                                               |
| 4            | ID                | CONN_OUC    | 16#0      | connection reference / identifier                          |
| 5            | ConnectionType    | Byte        | 16#0B     | type of connection: 16#0B=11=TCP/IP, 16#13=19=UDP          |
| 6            | ActiveEstablished | Bool        | false     | active/passive connection establishment                    |
| 7            | RemoteQDN         | String[254] | "         | fully or partially qualified domain name of remote partner |
| 8            | RemotePort        | UInt        | 0         | remote UDP / TCP port number                               |
| 9            | LocalPort         | UInt        | 0         | local UDP / TCP port number                                |

Figure 6-2 Data type TCON\_QDN

3. Program the parameters of the TCP connection (for example the fully qualified domain name (FQDN)) in the tag of data type TCON\_QDN.
4. Create a TCON instruction in the program editor.
5. Interconnect the CONNECT parameter of the TCON instruction with the tag of the data type TCON\_QDN.

In the example below, the CONNECT parameter of the TCON instruction is interconnected with the tag "DNS connection1" (data type TCON\_QDN).

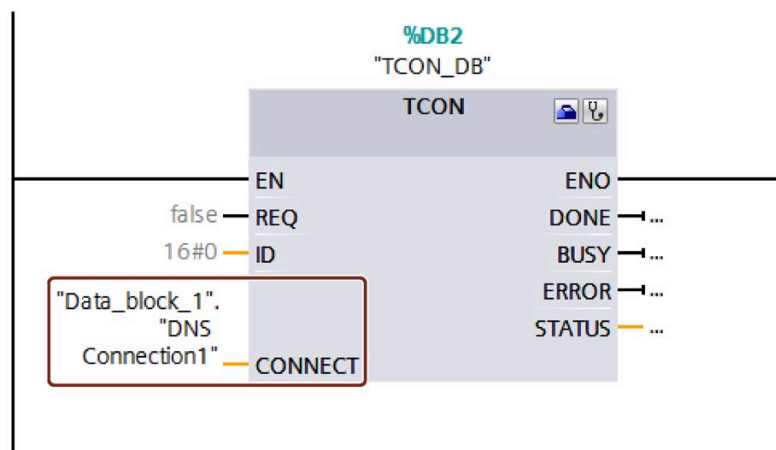


Figure 6-3 TCON instruction

### Addressing a UDP connection via the domain name of the communication partner

For S7-1500 CPUs as of firmware version V2.0, you can address the recipient with its fully qualified domain name (FQDN) when sending data via UDP. With the instruction TUSEND at the parameter ADDR, you hereby reference a structure of the type TADDR\_SEND\_QDN.

The receiver can return an IPv4 or an IPv6 address. With the TURCV instruction at the ADDR parameter, you therefore reference a structure of the TADDR\_RCV\_IP type. Only this structure can include both IP address types.

---

#### Note

##### Network load

In contrast to the TCP the UDP protocol does not work connection-oriented. For every edge at the block parameter REQ, the TUSEND or TURCV command performs queries of the DNS server. This can lead to high network load or load on the DNS server.

---

### Additional information

You can find more information about the system data types TCON\_QDN, TADDR\_SEND\_QDN and TADDR\_RCV\_IP in the STEP 7 online help.

How to set up a secure TCP connection via the domain name of the communication partner is described in the section Secure Open User Communication (Page 73).

## 6.5 Setting up Open User Communication via TCP, ISO-on-TCP, UDP and ISO

### Configuring a connection for the TSEND\_C, TRCV\_C or TCON instructions

Requirement: A TSEND\_C, TRCV\_C or TCON instruction is created in the programming editor.

1. Select a TCON, TSEND\_C or TRCV\_C block of Open User Communication in the program editor.
2. Open the "Properties > Configuration" tab in the inspector window.

3. Select the "Connection parameters" group. Until you select a connection partner, only the empty drop-down list for the partner end point is enabled. All other input options are disabled.

The connection parameters already known are displayed:

- Name of the local end point
- Interface of the local end point
- IPv4 address of the local end point

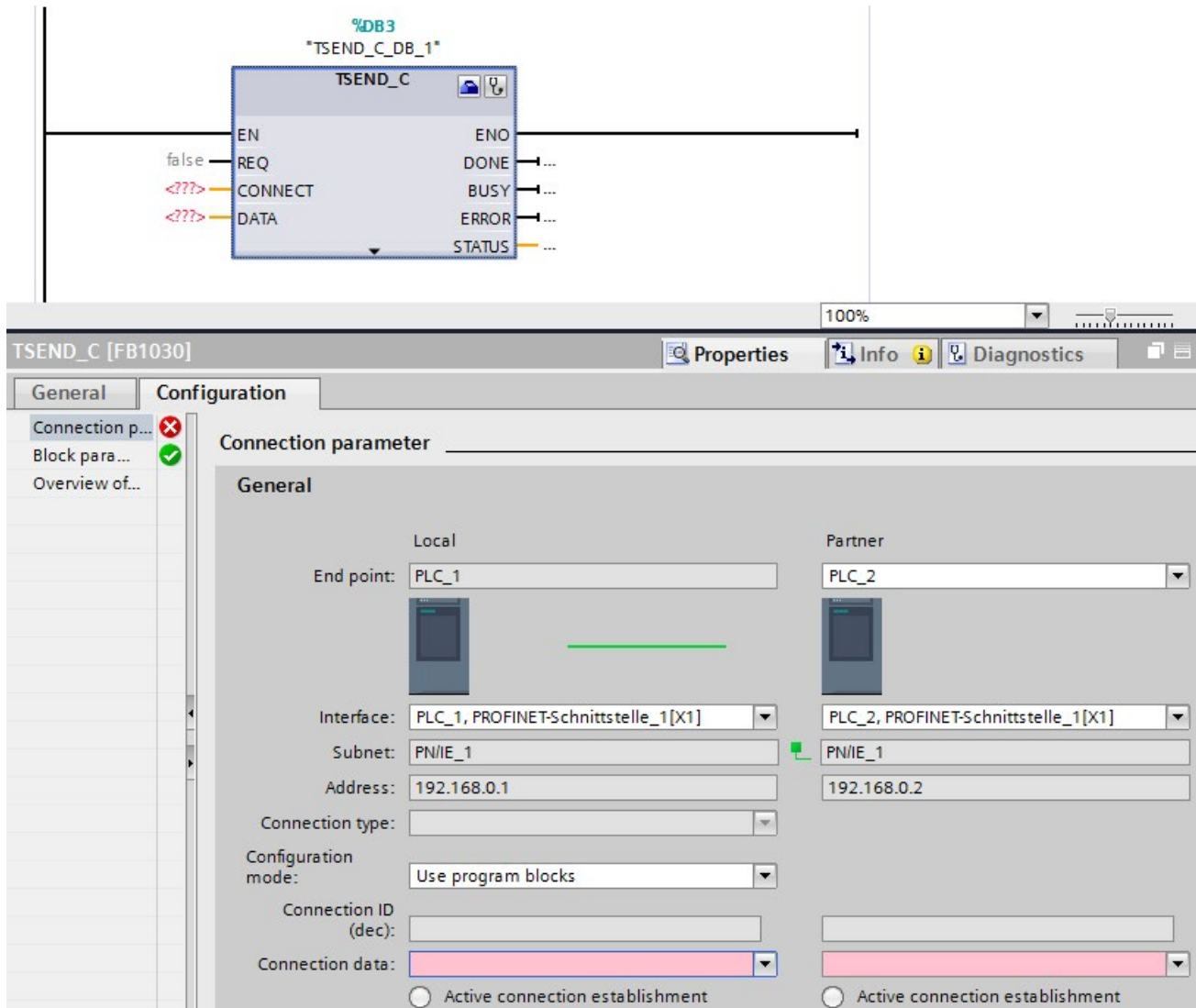


Figure 6-4 Connection parameters for TSEND\_C

## 6.5 Setting up Open User Communication via TCP, ISO-on-TCP, UDP and ISO

4. In the drop-down list box of the partner end point, select a connection partner. You can select an unspecified device or a CPU in the project as the communication partner. Certain connection parameters are then entered automatically.

The following parameters are set:

- Name of the partner end point
- Interface of the partner end point
- IPv4 address of the partner end point

If the connection partners are networked, the name of the subnet is displayed.

5. In the "Configuration type" drop-down list, select between using program blocks or configured connections.



6. Select an existing connection description DB in the "Connection data" drop-down list or for configured connections select an existing connection under "Connection name". You can also create a new connection description DB or a new configured connection. Later, you can still select other connection description DBs or configured connections or change the names of the connection description DBs in order to create new data blocks:
  - You can also see the selected data block at the interconnection of the CONNECT input parameter of the selected TCON, TSEND\_C or TRCV\_C instruction.
  - If you have already specified a connection description DB for the connection partner using the CONNECT parameter of the TCON, TSEND\_C or TRCV\_C instruction, you can either use this DB or create a new DB.
  - If you edit the name of the displayed data block in the drop-down list, a new data block with the changed name but with the same structure and content is generated and used for the connection.
  - Changed names of a data block must be unique in the context of the communication partner.
  - A connection description DB must have the structure TCON\_Param, TCON\_IP\_v4 or TCON\_IP\_RFC, depending on CPU type and connection.
  - A data block cannot be selected for an unspecified partner.

Additional values are determined and entered after the selection or creation of the connection description DB or configured connection.

The following is valid for specified connection partners:

- ISO-on-TCP connection type
- Connection ID with default of 1
- Active connection establishment by local partner
- TSAP ID  
for S7-1200/1500: E0.01.49.53.4F.6F.6E.54.43.50.2D.31

The following is valid for unspecified connection partners:

- TCP connection type
- Partner port 2000

The following applies for a configured connection with a specified connection partner:

- TCP connection type
- Connection ID with default of 257
- Active connection establishment by local partner
- Partner port 2000

The following applies for a configured connection with an unspecified connection partner:

- TCP connection type
- Local port 2000

7. Enter a connection ID as needed for the connection partner. No connection ID can be assigned to an unspecified partner.

---

**Note**

You must enter a unique value for the connection ID at a known connection partner. The uniqueness of the connection ID is not checked by the connection parameter settings and there is no default value entered for the connection ID when you create a new connection.

---

8. Select the desired connection type in the relevant drop-down list. Default values are set for the address details depending on the connection type. You can choose between the following:
  - TCP
  - ISO-on-TCP
  - UDP
  - ISO (only with Configuration mode "Use configured connection")

You can edit the input boxes in the address details. Depending on the selected protocol, you can edit the ports (for TCP and UDP) or the TSAPs (for ISO-on-TCP and ISO).

9. Use the "Active connection establishment" check box to set the connection establishment characteristics for TCP, ISO and ISO-on-TCP. You can decide which communication partner establishes the connection actively.

Changed values are checked immediately for input errors by the connection configuration and entered in the data block for the connection description.

---

**Note**

Open User Communication between two communication partners can only work when the program section for the partner end point has been downloaded to the hardware. To achieve fully functional communication, make sure that you load not only the connection description of the local CPU on the device but also that of the partner CPU as well.

---

## Configuring connections, e.g. for TSEND/TRCV

If you want to use the instructions for TSEND/TRCV for open communication, for example, you first need to configure a connection (e.g. TCP connection).

To configure a TCP connection, follow these steps:

1. Configure the communications partners in the network view of the Devices & networks editor of STEP 7.
2. Click the "Connections" button and select the "TCP connection" connection type from the drop-down list.
3. Using drag-and-drop, connect the communication partner with each other (via an interface or local end point). If the required S7 subnet does not yet exist, it is created automatically.

You can also set up a connection to unspecified partners.

4. Select the created connection in the network view.
5. Set the properties of the connection in the "Properties" tab in the "General" area, for example the name of the connection and the interfaces of the communications partner that will be used.

For connections to an unspecified partner, set the address of the partner.

You can find the local ID (reference of the connection in the user program) in the "Local ID" area.

6. In the Project tree, select the "Program blocks" folder for one of the CPUs and open OB1 in the folder by double-clicking on it. The program editor opens.
7. Select the required instruction from the "Instructions" task card, "Communication" area, "Open user communication", for example TSEND and drag it to a network of OB1.
8. At the ID parameter of the instruction, assign the local ID of the configured connection to be used for the transmission of data.
9. Interconnect the "DATA" parameter of the TSEND instruction with the user data, for example in a data block.
10. Download the hardware configuration and user program to the CPU.

Based on the procedure described above, set up the connection on the partner CPU with the instruction for receiving, TRCV, and download it to the CPU.

### Point to note with ISO connections with CP 1543-1

If you use the "ISO connection" connection type, you will need to select the "Use ISO protocol" check box in the properties of the CP so that addressing using MAC addresses will work.

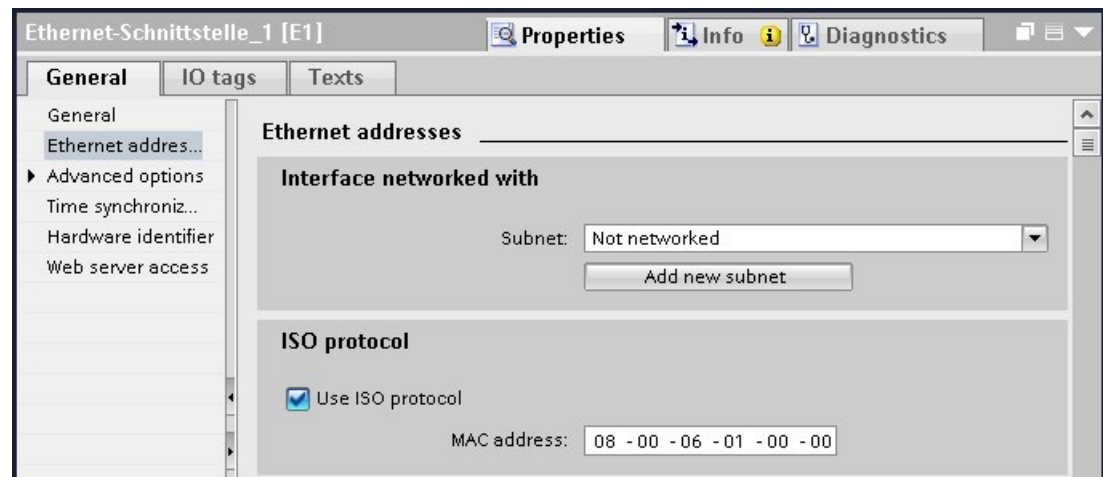


Figure 6-5 Select CP 1543-1 ISO protocol

### Additional information

The STEP 7 online help describes:

- The instructions for open communication
- The connection parameters

This FAQ (<https://support.industry.siemens.com/cs/ww/en/view/109479564>) describes how the instructions TSEND\_C and TRCV\_C behave in the S7-1500.

## 6.6 Setting up communication over FDL

### Requirements

- Configuration software: STEP 7 Professional V14
- End point of the connection: CPU S7-1500 firmware version V2.0 or higher with communication module CM 1542-5 with firmware version V2.0

### Setting up a configured FDL connection

Proceed as follows to set up a configured FDL connection in STEP 7:

1. Create a TSEND\_C instruction in the program editor.
2. Select the TSEND\_C instruction and go to "Properties" > "General" > "Connection parameters" in the Inspector window.
3. Under End point, select the partner end point. Use one of the two partner end points below:
  - CPU S7-1500 with CM 1542-5
  - Unspecified
4. Under Configuration type, select "Use configured connection".
5. Under Connection type, select "FDL".
6. Under Interface, select the following interfaces:
  - Local: PROFIBUS interface of CM 1542-5
  - Specified partner: PROFIBUS interface of CM 1542-5
7. Under Connection data, select the setting <new>.

The figure below shows a fully configured FDL connection in STEP 7.

The screenshot displays the 'General' tab of the connection configuration window in STEP 7. It is divided into two main sections: 'Local' and 'Partner'. A pink line connects the two sections, indicating the communication link.

| Local                                                 | Partner                                               |
|-------------------------------------------------------|-------------------------------------------------------|
| End point: PLC_1 [CPU 1516-3 PN/DP]                   | PLC_2 [CPU 1516-3 PN/DP]                              |
| Interface: CM 1542-5_1, PROFIBUS-Schnittstelle[P1]    | CM 1542-5_1, PROFIBUS-Schnittstelle[P1]               |
| Subnet: PROFIBUS_1                                    | PROFIBUS_1                                            |
| Address: 2                                            | 3                                                     |
| Connection type: FDL                                  |                                                       |
| Configuration mode: Use configured connection         |                                                       |
| Connection ID (dec): 256                              |                                                       |
| Connection data: FDL_Verbindung_1                     |                                                       |
| <input type="radio"/> Active connection establishment | <input type="radio"/> Active connection establishment |

Figure 6-6 Configuring the FDL connection

## Setting up an FDL connection in the user program

For communication via FDL, you need to create the data block of the TCON\_FDL system data type yourself in each case, assign parameters and call it directly at the instruction. Follow these steps:

1. Create a global data block in the project tree.
2. In the global data block, define a tag of the data type TCON\_FDL.

The example below shows the global data block "FDL\_connection" in which the tag "FDL\_connection" of the data type TCON\_FDL is defined.

| FDL_connection |                   |           |              |                          |                                     |                                     |                                     |                          |          |                                           |
|----------------|-------------------|-----------|--------------|--------------------------|-------------------------------------|-------------------------------------|-------------------------------------|--------------------------|----------|-------------------------------------------|
|                | Name              | Data type | Start val... | R...                     | A...                                | ...                                 | V...                                | S...                     | Super... | Comment                                   |
| 1              | Static            |           |              | <input type="checkbox"/> | <input type="checkbox"/>            | <input type="checkbox"/>            | <input type="checkbox"/>            | <input type="checkbox"/> |          |                                           |
| 2              | FDL_connection    | TCON_FDL  |              | <input type="checkbox"/> | <input checked="" type="checkbox"/> | <input checked="" type="checkbox"/> | <input checked="" type="checkbox"/> | <input type="checkbox"/> |          |                                           |
| 3              | InterfaceId       | HW_ANY    | 0            | <input type="checkbox"/> | <input checked="" type="checkbox"/> | <input checked="" type="checkbox"/> | <input checked="" type="checkbox"/> | <input type="checkbox"/> |          | HW identifier of PB interface submodule   |
| 4              | ID                | CONN_OUC  | 16#0         | <input type="checkbox"/> | <input checked="" type="checkbox"/> | <input checked="" type="checkbox"/> | <input checked="" type="checkbox"/> | <input type="checkbox"/> |          | connection reference / identifier         |
| 5              | ConnectionType    | Byte      | 16#15        | <input type="checkbox"/> | <input checked="" type="checkbox"/> | <input checked="" type="checkbox"/> | <input checked="" type="checkbox"/> | <input type="checkbox"/> |          | type of connection: 21= FDL connection    |
| 6              | ActiveEstablished | Bool      | false        | <input type="checkbox"/> | <input checked="" type="checkbox"/> | <input checked="" type="checkbox"/> | <input checked="" type="checkbox"/> | <input type="checkbox"/> |          | active/passive connection establishment   |
| 7              | ServiceId         | Byte      | 16#0         | <input type="checkbox"/> | <input checked="" type="checkbox"/> | <input checked="" type="checkbox"/> | <input checked="" type="checkbox"/> | <input type="checkbox"/> |          | service id: 0 – default, 1 – SDA, 2 – SDN |
| 8              | RemotePBAddress   | Byte      | 16#0         | <input type="checkbox"/> | <input checked="" type="checkbox"/> | <input checked="" type="checkbox"/> | <input checked="" type="checkbox"/> | <input type="checkbox"/> |          | remote Profibus partner address           |
| 9              | LocalPBAddress    | Byte      | 16#0         | <input type="checkbox"/> | <input checked="" type="checkbox"/> | <input checked="" type="checkbox"/> | <input checked="" type="checkbox"/> | <input type="checkbox"/> |          | local Profibus partner address            |
| 10             | RemoteLSAP        | Byte      | 16#0         | <input type="checkbox"/> | <input checked="" type="checkbox"/> | <input checked="" type="checkbox"/> | <input checked="" type="checkbox"/> | <input type="checkbox"/> |          | remote PB link-layer service access point |
| 11             | LocalLSAP         | Byte      | 16#0         | <input type="checkbox"/> | <input checked="" type="checkbox"/> | <input checked="" type="checkbox"/> | <input checked="" type="checkbox"/> | <input type="checkbox"/> |          | local PB link-layer service access point  |

Figure 6-7 Programming an FDL connection

3. Program the parameters of the FDL connection (e.g. the PROFIBUS addresses) in the tag of the data type TCON\_FDL.
4. Create a TCON instruction in the program editor.
5. Interconnect the CONNECT parameter of the TCON instruction with the tag of the data type TCON\_FDL.

In the example below, the CONNECT parameter of the TCON instruction is interconnected with the tag "FDL\_connection" (data type TCON\_FDL).

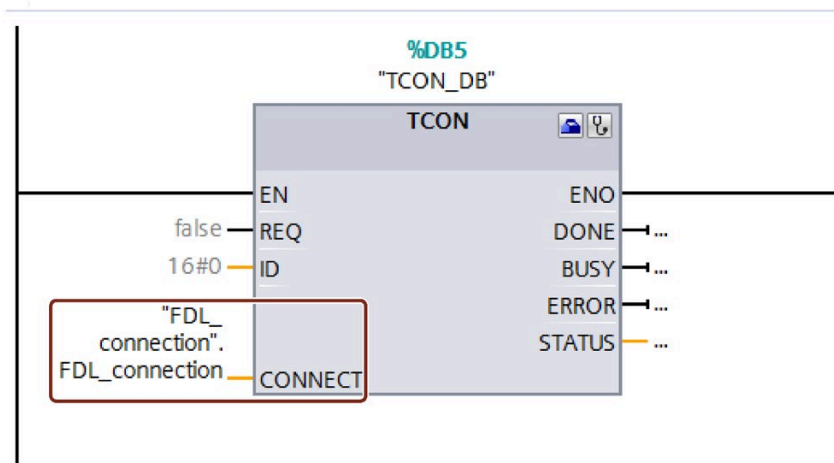


Figure 6-8 Example: TCON Instruction for FDL connection

## 6.7 Setting up communication with Modbus TCP

### Setting up a connection for Modbus TCP via the user program

The parameter assignment takes place in the program editor at the instruction MB\_CLIENT or MB\_SERVER.

### Procedure for setting up communication using Modbus TCP

The MB\_CLIENT instruction communicates as a Modbus TCP client via the TCP connection. You establish a connection between the client and the server with the instruction, send Modbus requests to the server and receive the corresponding Modbus responses. You also control the setup of the TCP connection with this instruction.

The MB\_SERVER instruction communicates as a Modbus TCP server via the TCP connection. The instruction processes connection requests of a Modbus client, receives and processes Modbus requests and sends responses. You also control the setup of the TCP connection.

**Requirement:** The client can reach the server via IP communication in the network.

1. Configure an S7-1500 automation system with CPU in the network view of the Devices & networks editor of STEP 7.
2. In the Project tree, select the "Program blocks" folder and open OB1 in the folder by double-clicking on it. The program editor opens.
3. Select the required instruction, for example MB\_CLIENT, from the "Instructions" task card, "Communication" area, "Other", "MODBUS TCP" and drag it to a network of OB1.

- Assign the parameters of the MB\_CLIENT or MB\_SERVER instruction. Observe the following rules:

An IPv4 server address must be specified for each MB\_CLIENT connection.

Each MB\_CLIENT or MB\_SERVER connection must use a unique instance DB with one of the data structures TCON\_IP\_v4, TCON\_QDN or TCON\_Configured.

Each connection requires a unique connection ID. The connection ID and instance DB belong together in pairs and must be unique for each connection.

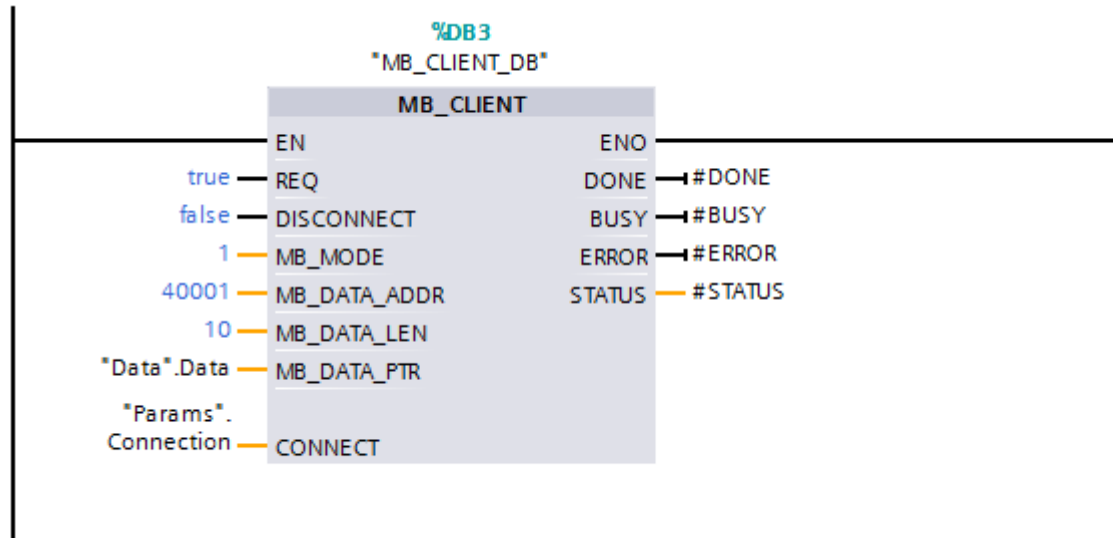


Figure 6-9 MB\_CLIENT

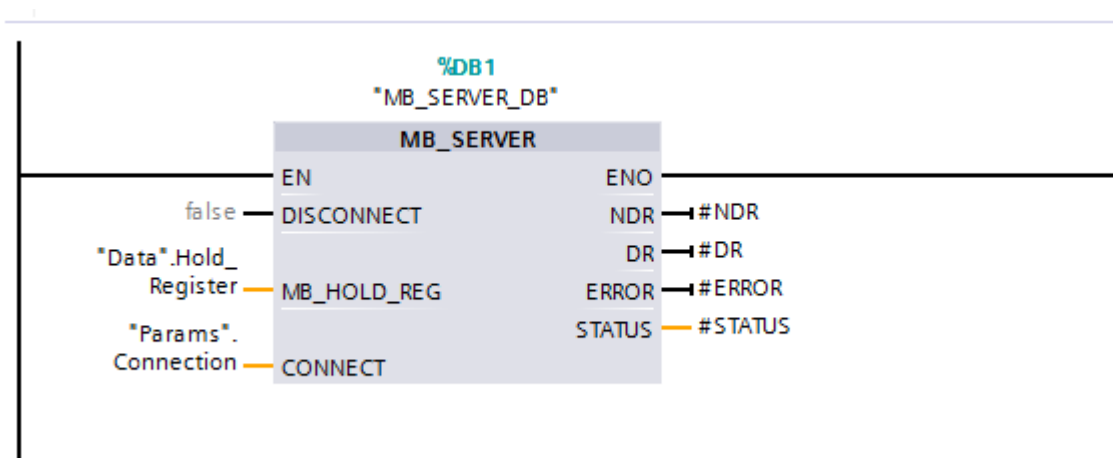


Figure 6-10 MB\_SERVER

- Download the hardware configuration and user program to the CPU.

### Redundant communication over Modbus TCP

Assign parameters for redundant communication via Modbus TCP using the MB\_RED\_CLIENT or MB\_RED\_SERVER instructions:

**Instruction MB\_RED\_CLIENT** You use the instruction "MB\_RED\_CLIENT" to establish a redundant connection between the client and the server, send Modbus requests, receive responses and control connection termination of the Modbus TCP client.

**Instruction MB\_RED\_SERVER** The "MB\_RED\_SERVER" instruction processes connection requests of a Modbus TCP client, receives and processes Modbus requests and sends responses. The CPUs can:

- processing multiple server connections and
- accepting multiple connections from different clients simultaneously at one server port.

For more information on the MB\_RED\_CLIENT or MB\_RED\_SERVER instructions, refer to the STEP 7 online help.

### Modbus TCP server as gateway to Modbus RTU

If you use a Modbus TCP server as a gateway to a Modbus RTU protocol, address the slave device in the serial network using the static parameter, MB\_UNIT\_ID. The MB\_UNIT\_ID parameter corresponds to the field of the slave address in the Modbus RTU protocol. The MB\_UNIT\_ID parameter in this case would forward the request to the correct Modbus RTU slave address.

You do not have to program the gateway function yourself.

You can find the MB\_UNIT\_ID parameter in the instance data block associated with MB\_CLIENT instruction.

You can find more information on the MB\_UNIT\_ID parameter in the STEP 7 online help.

### Reference

- This FAQ (<https://support.industry.siemens.com/cs/ww/en/view/94766380>) describes how to program and configure the Modbus TCP communication between two S7-1500 CPUs.
- This FAQ (<https://support.industry.siemens.com/cs/ww/en/view/102020340>) describes how to program and configure Modbus TCP communication between an S7-1500 CPU and an S7-1200 CPU.



## 6.8 Setting up communication via e-mail

### Setting up a connection for e-mail via the user program

For communication using e-mail, you need to create the data block of the relevant system data type yourself, assign parameters and call the instruction directly. This procedure is introduced below.

### Procedure for setting up communication using e-mail

A CPU can send e-mails. To send e-mails from the user program of the CPU, use the TMAIL\_C instruction.

**Requirement:** The SMTP server can be reached via the IPv4 network.

1. Configure an S7-1500 automation system with CPU in the network view of the Devices & networks editor of STEP 7.
2. Assign parameters to the instruction TMAIL\_C, for example enter the subject of the e-mail in Subject.
3. In a global data block create a variable of the type TMAIL\_v4, TMAIL\_v6 (only CP 1543-1) or TMAIL\_FQDN (only CP 1543-1).
4. Set the connecting parameters of the TCP connection in the variable in the "Start value" column. Enter the IPv4 address of the mail server, for example, for the "MailServerAddress" (for TMAIL\_v4)

---

#### Note

##### Connection parameter Interface ID

Note that you can enter the value "0" for the interface ID with instruction version V5.0 or higher of the instruction TMAIL\_C in the data type TMAIL\_V4\_SEC. In this case, the CPU itself searches for a suitable local CPU interface.

---

Interconnect the variable to the MAIL\_ADDR\_PARAM parameter of the TMAIL\_C instruction.

5. Download the hardware configuration and user program to the CPU.

### Additional information

The STEP 7 online help describes:

- The system data types
- The instructions for open communication
- The connection parameters

## 6.9 Setting up communication via FTP

### Setting up a connection for FTP via the user program

For communication via FTP, you need to create the data block of the relevant system data type yourself, assign parameters and call the instruction directly. This procedure is introduced below.

### FTP client and server functionality

Files can be sent by a CPU to an FTP server and can be received from the FTP server. Communication with FTP is only possible for the S7-1500 using the CP 1543-1. The CP can be an FTP server, FTP client or both. FTP clients can also be third-party systems/PCs.

For the FTP server functionality, configure the CP accordingly in STEP 7.

You can use the FTP client functionality to implement, for example, the establishment and termination of an FTP connection, the transfer and deletion of files on the server. For the FTP client functionality, use the FTP\_CMD instruction.

## Procedure for setting up FTP server functionality

**Requirement:** The FTP server can be reached via the IPv4 network.

1. Configure an S7-1500 automation system with CPU and CP 1543-1 in the device view of the Devices & networks editor of STEP 7.

At the same time, you need to select the option "Permit access with PUT/GET communication from remote partner (PLC, HMI, OPC, ...)" in the HW configuration of the S7-1500 CPU under the "Protection" area navigation in the section "Connection mechanisms".

2. Make the following settings in the properties of the CP under "FTP configuration":
  - Select the "Use FTP server for S7 CPU data" check box.
  - Assign the CPU, a data block and a file name under which the DB for FTP will be stored.

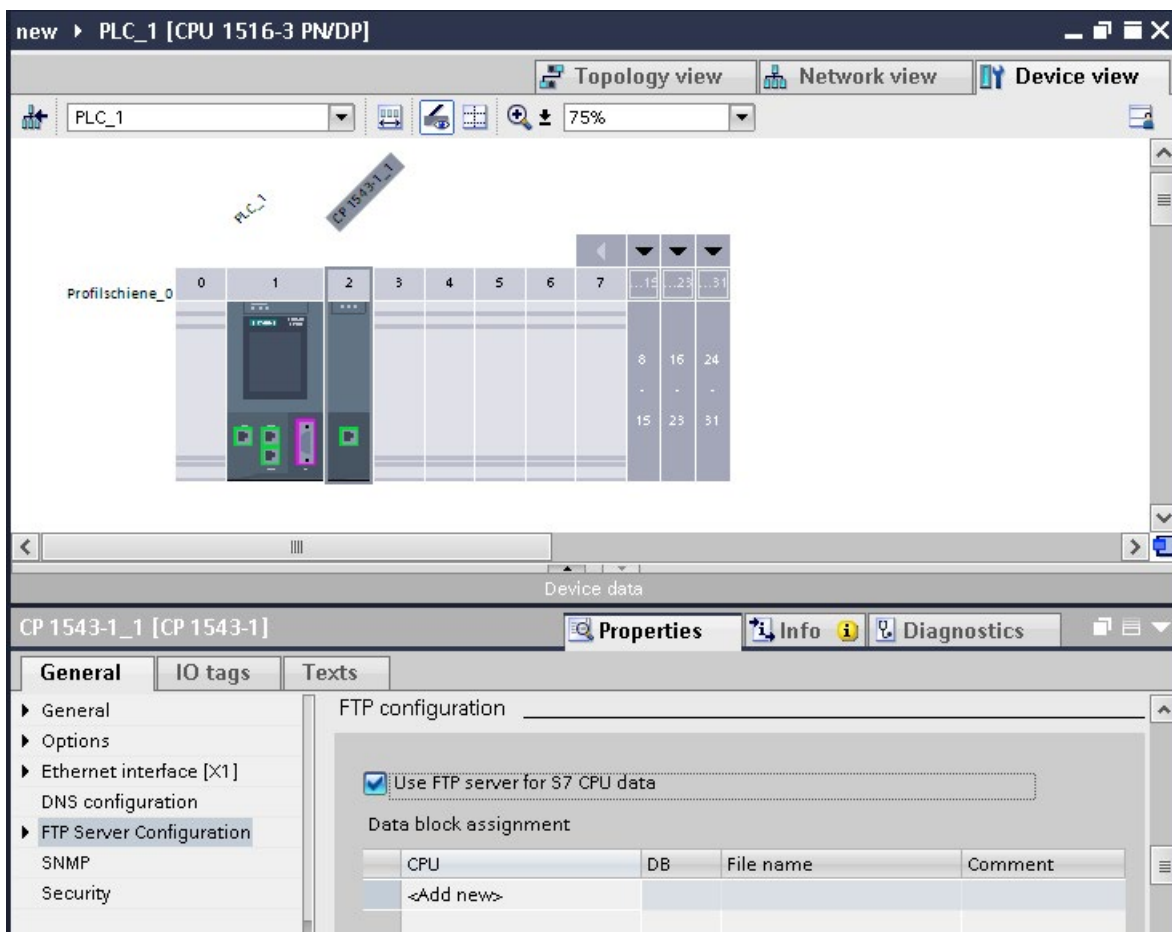


Figure 6-11 Setting up the FTP configuration

3. Download the hardware configuration to the CPU.

### Procedure for setting up FTP client functionality

**Requirement:** The FTP server can be reached via the IPv4 network.

1. Configure an S7-1500 automation system with CPU and CP 1543-1 in the device view of the Devices & networks editor of STEP 7.

At the same time, you need to select the check box "Permit access with PUT/GET communication from remote partner (PLC, HMI, OPC, ...)" in the HW configuration of the S7-1500 CPU under the "Protection" area navigation in the section "Connection mechanisms".

2. Call the FTP\_CMD instruction in the user program of the CPU.
3. Set the connection parameters for the FTP server in the FTP\_CMD instruction.
4. Create a global DB and within this DB a tag of the type FTP\_CONNECT\_IPV4, FTP\_CONNECT\_IPV6 or FTP\_CONNECT\_NAME.
5. Interconnect the tag within the data block with the FTP\_CMD instruction.
6. For the connection to the FTP server, specify the following in the DB:
  - The user name, the password and the IP address for the FTP access in the relevant data type (FTP\_CONNECT\_IPV4, FTP\_CONNECT\_IPV6 or FTP\_CONNECT\_NAME)
7. Download the hardware configuration and user program to the CPU.

### Application examples

- Application example: FTP communication with S7-1500 and CP 1543-1  
You can find the application example on the Internet  
(<https://support.industry.siemens.com/cs/ww/en/view/103550797>).
- Application example: FTP client communication with S7-1200/1500  
You can find the application example on the Internet  
(<https://support.industry.siemens.com/cs/ww/en/view/81367009>).

### Additional information

The STEP 7 online help describes:

- The system data types
- The instructions for open communication
- The connection parameters

## 6.10 Establishment and termination of communications relations

### Establishment and termination of communications

The table below shows the establishment and termination of communications as part of open communication.

Table 6- 5 Establishment and termination of communications

| Setting up the connection          | Establishing communication                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  | Terminating communication                                                                                                                                                                                  |
|------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>With the user program</b>       | <p>After downloading the user program to the CPUs:</p> <p>The passive communications partner sets up the local connection access by calling TSEND_C/TRCV_C or TCON. Calling TSEND_C/TRCV_C or TCON on the active partner starts connection establishment. If the connection could be established, there is positive feedback to the instructions in the user program.</p> <p>After you have terminated a connection using the instruction T_RESET, the connection is reestablished.</p> <p>If the connection aborts, the active partner attempts to re-establish the connection. This applies only if the connection was successfully established beforehand with TCON.</p> | <ul style="list-style-type: none"> <li>Using the TSEND_C/TRCV_C, TDISCON and T_RESET instructions</li> <li>When the CPU changes from RUN to STOP mode</li> <li>With POWER OFF/POWER ON on a CPU</li> </ul> |
| <b>By configuring a connection</b> | After downloading the connection configuration and the user program to the CPUs.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            | By deleting the connection configuration in STEP 7 and downloading the changed configuration to the CPU.                                                                                                   |

# S7 communication

## Characteristics of S7 communication

S7 communication as homogeneous SIMATIC communication is characterized by vendor-specific communication between SIMATIC CPUs (not an open standard). S7 communication is used for migration and for connecting to existing systems (S7-300, S7-400).

For data transfer between two S7-1500 automation systems, we recommend that you use open communication (see section Open User Communication (Page 112)).

## Properties of S7 communication

Using S7 communication, the CPU exchanges data with another CPU. Once the user has received the data at the receiver end, the reception data is automatically acknowledged to the sending CPU.

The data is exchanged via configured S7 connections. S7 connections can be configured at one end or at both ends.

S7 communication is possible via:

- Integrated PROFINET or PROFIBUS DP interface of a CPU
- Interface of a CP/CM

## S7 connections configured at one end

For an S7 connection configured at one end, the configuration for this connection takes place in only one communication partner and is only downloaded to it.

A one-sided S7 connection can be configured to a CPU that is only a server of an S7 connection (e.g. CPU 315-2 DP). The CPU is configured and the address parameters and interfaces are thus known.

In addition, a one-sided S7 connection can be configured to a partner who is not in the project and whose address parameters and interface and therefore are not known. You need to enter the address; it is not checked by STEP 7. The partner is initially unspecified (no partner address is registered when you create the S7 connection). Once you enter the address, it is "unknown" (i.e. it is named, but the project is unknown).

This makes it possible to use S7 connections beyond the boundaries of a project. The communication partner is unknown to the local project (unspecified) and is configured in another STEP 7 or third-party project.

## S7 connections configured at both ends

When an S7 connection is configured at both ends, the configuration and download of the configured S7 connection parameters takes place in both communication partners.

## Instructions for S7 communication

For S7 communication with S7-1500, the following instructions can be used:

- **PUT/GET**

You write data to a remote CPU with the PUT instruction. You can use the GET instruction to read data from a remote CPU. The PUT and GET instructions are one-sided instructions, i.e. you need only an instruction in one communication partner. You can easily set up the PUT and GET instructions via the connection configuration.

---

### **Note**

#### **Data blocks for PUT/GET instructions**

When using the PUT/GET instructions, you can only use data blocks with absolute addressing. Symbolic addressing of data blocks is not possible.

You must also enable this service for protection in the CPU configuration in the "Protection" area.

---

This FAQ (<https://support.industry.siemens.com/cs/ww/en/view/82212115>) provides information about how to configure and program an S7 instruction and the GET and PUT communication instructions for data exchange between two S7-1500 CPUs.

- **BSEND/BRCV**

The BSEND instruction sends data to a remote partner instruction of the type BRCV. The BRCV instruction receives data from a remote partner instruction of the type BSEND. You use the S7 communication via the BSEND/BRCV instruction pair for secure transmission of data.

- **USEND/URCV**

The USEND instruction sends data to a remote partner instruction of the type URCV. The URCV instruction receives data from a remote partner instruction of the type USEND. You use the S7 communication via the USEND/URCV instruction pair for fast, non-secure transmission of data regardless of the timing of the processing by the communications partner; for example for operating and maintenance messages.

## S7 communication via PROFIBUS DP interface in slave mode

You can find the "Test, commissioning, routing" check box in STEP 7 in the properties of the PROFIBUS DP interface of communications modules (e.g. CM 1542-5). Using this check box, you decide whether the PROFIBUS DP interface of the DP slave is an active or passive device on PROFIBUS.

- Check box selected: The slave is an active device on PROFIBUS.
- Check box cleared: The DP slave is a passive device on PROFIBUS. You can only set up S7 connections configured at one end for this DP slave.

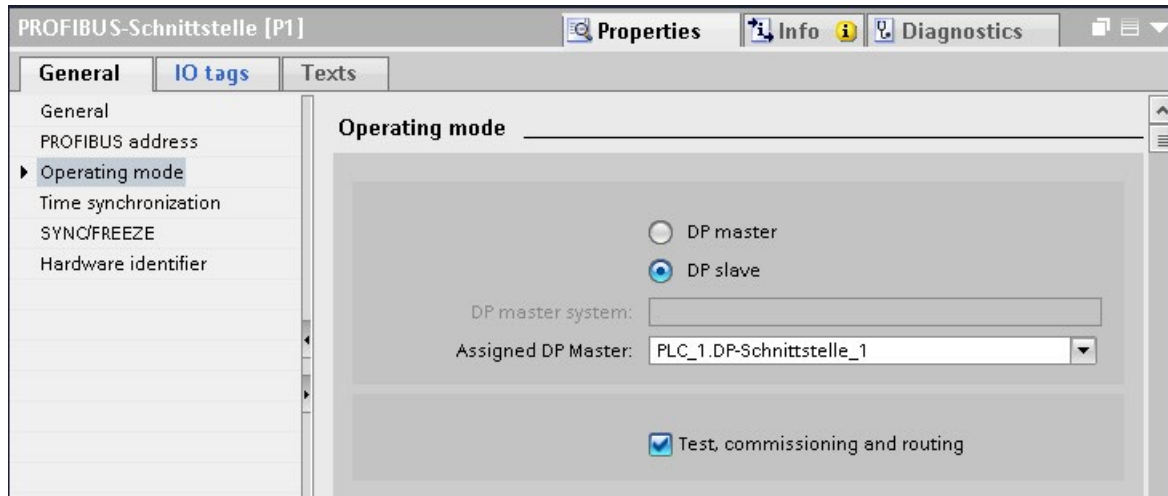


Figure 7-1 "Test, commissioning, routing" check box

## Configuring S7 connections for PUT/GET instructions

You can create S7 connections and assign the parameters for these in the connection parameter assignment of the PUT/GET instructions. Changed values are checked immediately by the connection parameter assignment for input errors.

Requirement: A PUT or GET instruction is created in the programming editor.

To configure an S7 connection using PUT/GET instructions, follow these steps:

1. In the program editor, select the call of the PUT or GET instruction.
2. Open the "Properties > Configuration" tab in the inspector window.



3. Select the "Connection parameters" group. Until you select a connection partner, only the empty drop-down list for the partner end point is enabled. All other input options are disabled.

The connection parameters already known are displayed:

- Name of the local end point
- Interface of the local end point
- IPv4 address of the local end point

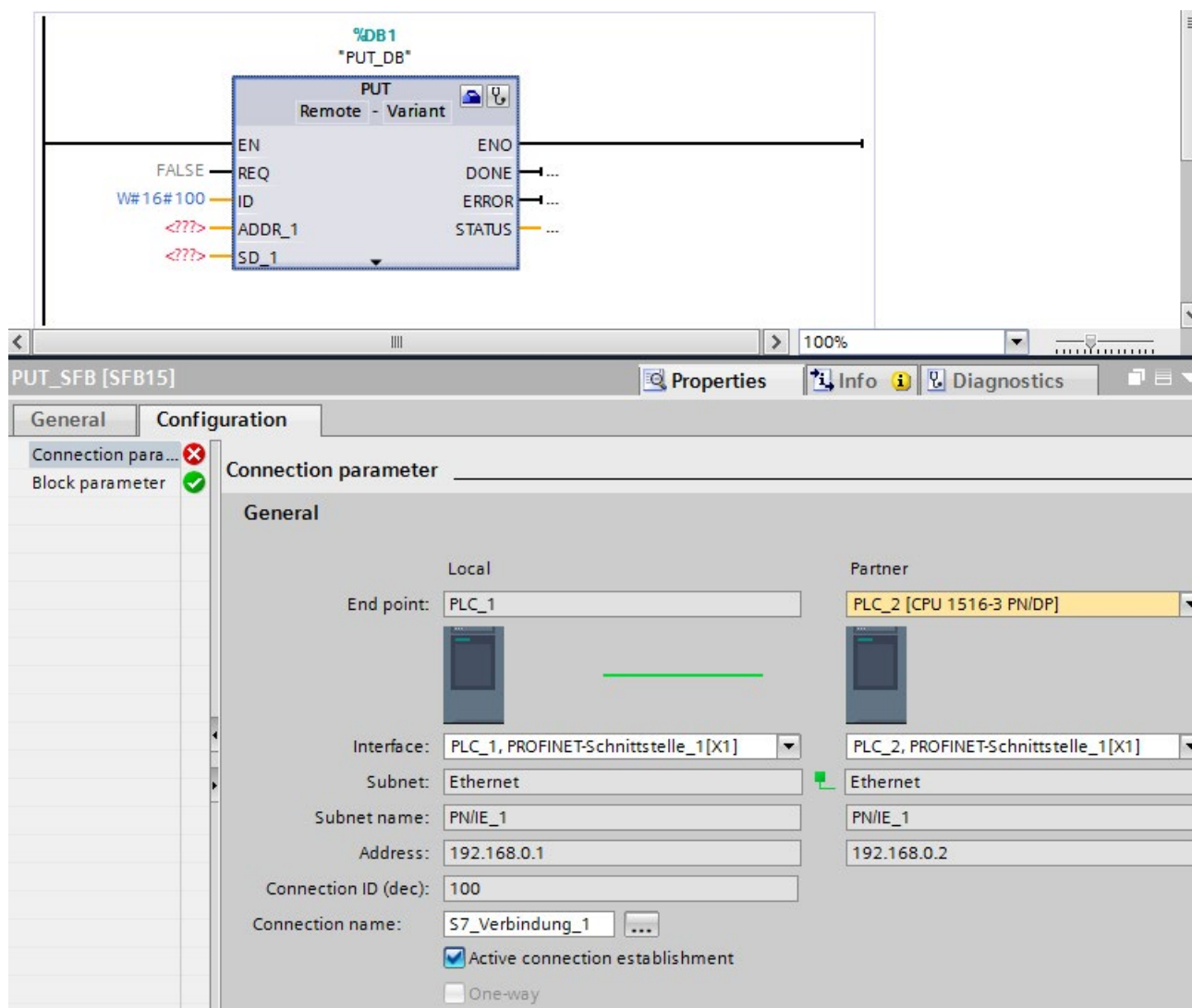


Figure 7-2 Connection configuration for PUT instruction

4. In the drop-down list box of the partner end point, select a connection partner. You can select an unspecified device or a CPU in the project as the communication partner.

The following parameters are automatically entered as soon as you have selected the connection partner:

- Name of the partner end point
  - Interface of the partner end point. If several interfaces are available, you can change the interface as required.
  - Interface type of the partner end point
  - Subnet name of both end points
  - IPv4 address of the partner end point
  - Name of the connection which is used for the communication.
5. If required, change the connection name in the "Connection name" input box. If you want to create a new connection or edit an existing connection, click on the "Select connection" button on the right side next to the input box for the connection name.

---

**Note**

The PUT and GET instructions between two communication partners can only run if both the hardware configuration and the program part for the partner end point have been loaded into the hardware. To achieve fully functional communication, make sure that you load not only the connection description of the local CPU on the device but also that of the partner CPU as well.

---

## Configuring S7 connections for e.g. BSEND/BRCV

If you want to use the instructions for BSEND/BRCV for S7 communication, for example, you first need to configure an S7 connection.

To configure a S7 connection, follow these steps:

1. Configure the communications partners in the network view of the Devices & networks editor of STEP 7.
2. Select the "Connections" button and the "S7 connection" entry from the drop-down list.
3. Using drag-and-drop, connect the communication partner with each other (via an interface or local end point). If the required S7 subnet does not yet exist, it is created automatically.

You can also set up a connection to unspecified partners.

4. In the "Connections" tab, select the row of the S7 connection.
5. Set the properties of the S7 connection in the "Properties" tab in the "General" area, for example the name of the connection and the interfaces of the communications partner that will be used.

For S7 connections to an unspecified partner, set the address of the partner.  
You can find the local ID (reference of the S7 connection in the user program) in the "Local ID" area.

6. In the Project tree, select the "Program blocks" folder for one of the CPUs and open OB1 in the folder by double-clicking on it. The program editor opens.

7. In the program editor, call the relevant instructions for S7 communication in the user program of the communication partner (configured at one end) or in the user programs of the communication partners (configured at both ends). Select the BSEND and BRCV instructions from the "Communication" area of the "Instructions" task card, for example, and drag them to a network of OB1.
8. At the ID parameter of the instruction, assign the local ID of the configured connection to be used for the transmission of data.
9. Assign the parameters for the instructions indicating which data will be written to where and which data will be read from where.
10. Download the hardware configuration and user program to the CPU(s).

### S7 communication via CP 1543-1

If you set up S7 communication via the Industrial Ethernet interface of the CP 1543-1, you can select the transport protocol for data transfer in the properties of the S7 connection under "General":

- "TCP/IP" check box selected (default): ISO-on-TCP (RFC 1006): for S7 communication between S7-1500 CPUs
- "TCP/IP" check box cleared: ISO protocol (ISO/IEC 8073): Addressing using MAC addresses

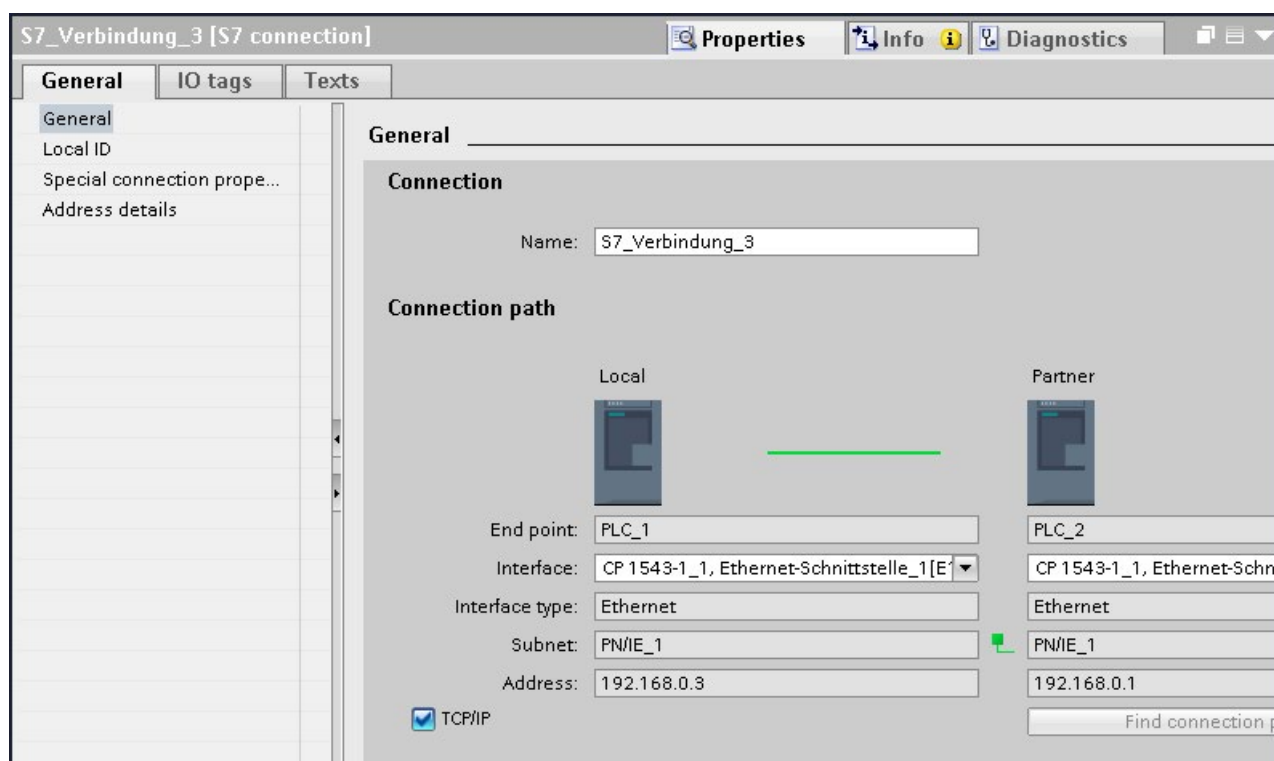


Figure 7-3 Selecting the CP 1543-1 transport protocol

### **Procedure for setting up an S7 connection via different S7 subnets**

You have the option of using an S7 connection over multiple S7 subnets (PROFIBUS, PROFINET/Industrial Ethernet) (S7 routing (Page 373)).

1. Configure the communications partners in the network view of the Devices & networks editor of STEP 7.
2. Select the "Network" button.
3. Connect the relevant interfaces with the S7 subnets (PROFIBUS, PROFINET/Industrial Ethernet) using drag-and-drop.

4. Select the "Connections" button and the "S7 connection" entry from the drop-down list.
5. Using drag-and-drop in our example, connect PLC\_1 in the left S7 subnet (PROFIBUS) to PLC\_3 in the right S7 subnet (PROFINET).

The S7 connection between CPU 1 and CPU 3 is configured.

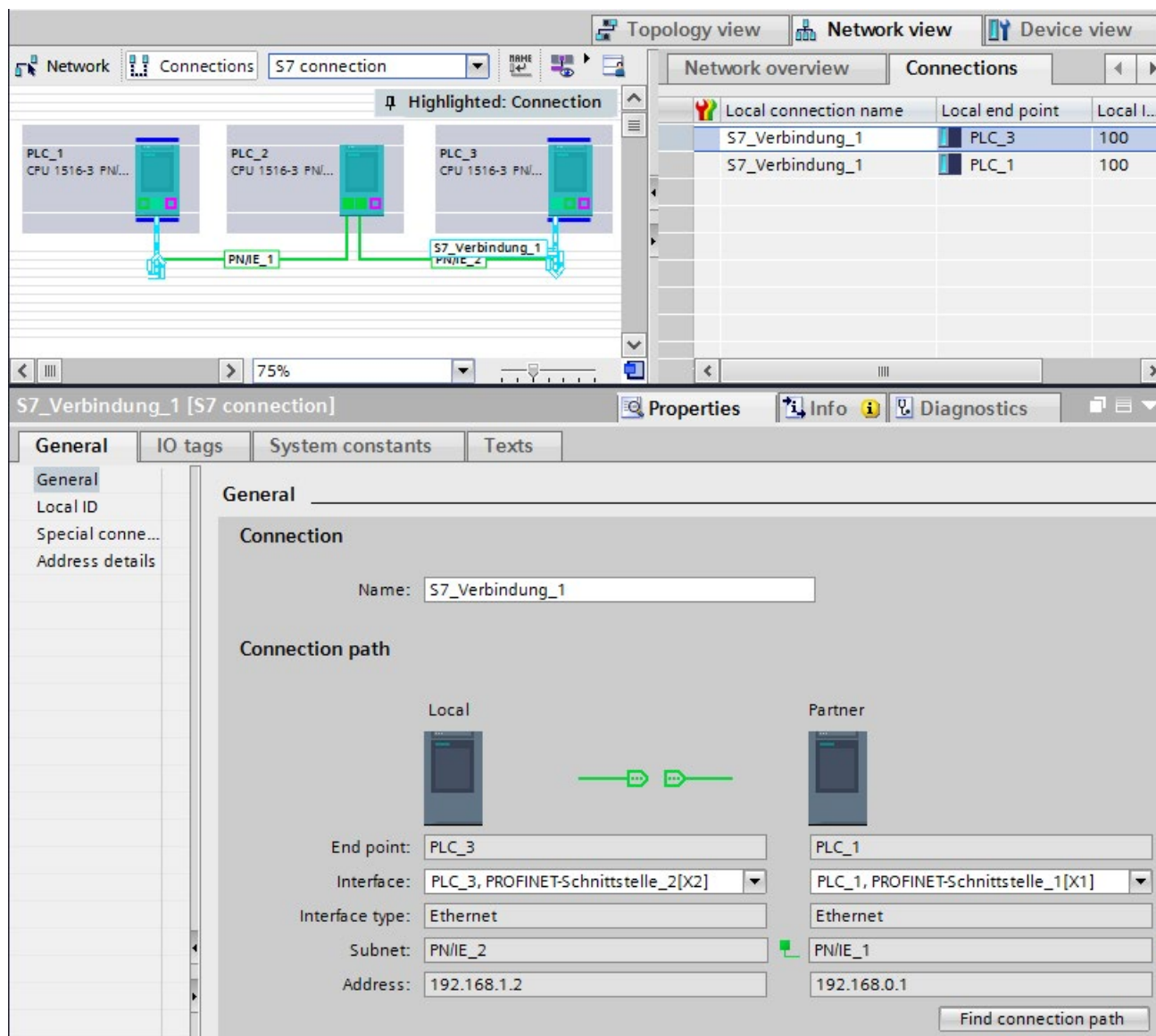


Figure 7-4 S7 connections via different subnets

## ET 200SP Open Controller as router for S7 connections

If you assign the "PROFINET onboard [X2]" interface to the CPU 1515SP PC (F) of the SIMATIC PC station, the CPU 1515SP PC (F) can be used as a router for S7 connections. If you use the CP interface for "None, or a different Windows setting", you cannot use the Open Controller as a router for routed S7 connections.

An existing S7 connection routed by the CPU 1515SP PC (F) becomes invalid if the assignment of the interface of the CPU 1515SP PC (F) is changed from "SIMATIC PC station" to "None, or a different Windows setting". Since the PLC now no longer handles routing functions for this connection, when the CPU 1515SP PC (F) is compiled, no message relating to the invalid connection is displayed. The invalid routed S7 connection is displayed only when the end points of the connection are compiled.

The interfaces required for routed S7 connections must remain explicitly assigned on the CPU 1515SP PC (F). You can edit the assignment of the interface of the CPU 1515SP PC (F) in the properties under "PROFINET onboard [X2] > Interface assignment".

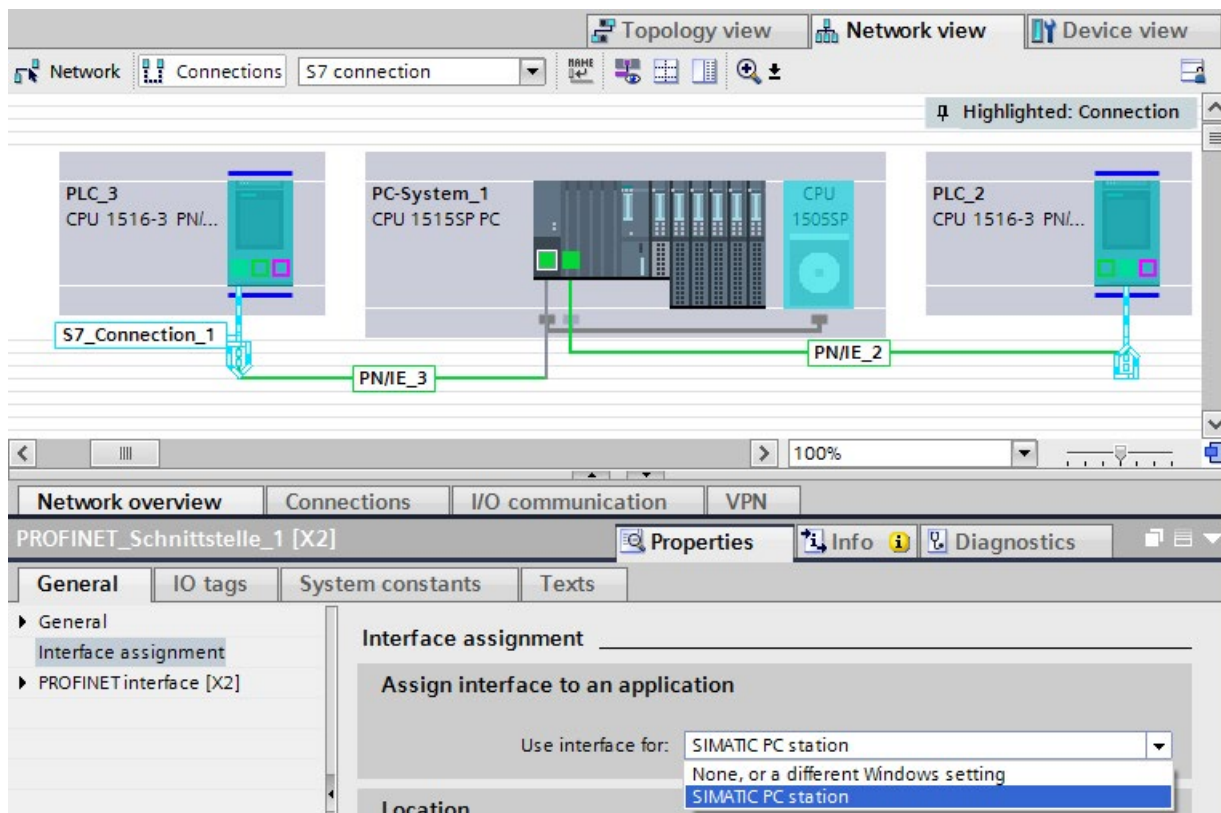


Figure 7-5 S7 routing PC station

## Additional information

You can find detailed information on configuring S7 connections and how to use the instructions for S7 communication in the user program in the STEP 7 online help.

# Point-to-point link

## Functionality

A point-to-point connection for S7-1500, ET 200MP and ET 200SP is established via communications modules (CMs) with serial interfaces (RS232, RS422 or RS485):

- S7-1500/ET 200MP:
  - CM PtP RS232 BA
  - CM PtP RS422/485 BA
  - CM PtP RS232 HF
  - CM PtP RS422/485 HF
- ET 200SP:
  - CM PtP

The bidirectional data exchange via a point-to-point connection works between communications modules or third-party systems or devices capable of communication. At least 2 communication partners are required for communication ("point-to-point"). With RS422 and RS485, more than two communications partners are possible.

## Protocols for communication via a point-to-point connection

- Freeport protocol (also called ASCII protocol)
- Procedure 3964(R)
- Modbus protocol in RTU format (RTU: Remote Terminal Unit)
- USS protocol (universal serial interface protocol)

The protocols use different layers according to the ISO/OSI reference model:

- Freeport: Uses layer 1 (physical layer)
- 3964 (R), USS and Modbus: Use layer 1 and 2 (physical layer and data link layer; therefore greater transmission reliability than with Freeport). USS and Modbus use additionally layer 4.

## Properties of the Freeport protocol

- The recipient recognizes the end of the data transfer by means of a selectable end criterion (e.g. character delay time elapsed, receipt of end character, receipt of a fixed amount of data).
- The sender cannot recognize whether the sent data arrived free of errors at the recipient.

### Properties of procedure 3964 (R)

- When the data is sent, control characters are added (start, end and block check characters). Make sure that these control characters are not included as data in the frame.
- Connection establishment and termination makes use of control characters.
- If transfer errors occur, data transfer is automatically repeated.

### Data exchange using Freeport or 3964 (R) communication

The data to be sent is stored in the user program of the corresponding CPU in data blocks (send buffer). A receive buffer is available on the communications module for the received data. Check the properties of the receive buffer and adapt them if necessary. You must create a data block for receiving in the CPU.

In the user program of the CPU, the "Send\_P2P" and "Receive\_P2P" instructions handle the data transfer between the CPU and CM.

### Procedure for setting up Freeport or 3964 (R) communication

1. Configure an S7-1500 configuration with CPU and CM in the device view of the hardware and network editor of STEP 7.
2. Select the interface of the CM in the device view of STEP 7.
3. Assign the parameters of the interface (for example connection communication, configuration of message sending) in the Inspector window of STEP 7 under "Properties" > "General".
4. Select the "Send\_P2P" or "Receive\_P2P" instruction in the "Instructions" task card under "Communication" > "Communications processor" and drag-and-drop the instruction into the user program (for example into a FB).
5. Assign the parameters for the instructions according to your configuration.
6. Download the hardware configuration and user program to the CPU.

### Otherwise: Dynamic parameter assignment of the communications module

In certain types of application it is an advantage to set up communication dynamically; in other words, program-controlled by a specific application.

Typical applications for this, could be, for example manufacturers of serial machines. To make the user interfaces as convenient as possible for their customers, these manufacturers adapt the communications services to the particular operator entries.



## Instructions for Freeport communication

There are 3 instructions available for the dynamic configuration in the user program for Freeport communication. The following applies to all 3 instructions: the previously valid configuration data is overwritten but not stored permanently in the target system.

- The "Port\_Config" instruction is used for the program-controlled configuration of the relevant port of the communications module.
- The "Send\_Config" instruction is used for the dynamic configuration, for example of time intervals and breaks in transmission (serial transmission parameters) for the relevant port.
- The "Receive\_Config" instruction is used for dynamic configuration, for example of conditions for the start and end of a message to be transferred (serial receive parameters) for the relevant port.

## Instructions for 3964 (R) communication

There are 2 instructions available for dynamic configuration in the user program for 3964 (R) communication. The following applies to the instructions: the previously valid configuration data is overwritten but not stored permanently in the target system.

- The "Port\_Config" instruction is used for the program-controlled configuration of the relevant port of the communications module.
- The "P3964\_Config" instruction is used for the dynamic configuration of protocol parameters.

## Properties of the USS protocol

- Simple, serial data transfer protocol with cyclic message frame traffic in half duplex mode that is tailored to the requirements of drive technology.
- Data transfer works according to the master-slave principle.
  - The master has access to the functions of the drive and can, among other things, control the drive, read status values and read and write the drive parameters.

## Data exchange using USS communication

The communications module is the master. The master continuously sends frames (job frames) to the up to 16 drives and expects a response frame from each addressed drive.

A drive sends a response frame under the following conditions:

- When a frame is received without errors
- When the drive is addressed in this frame

A drive must not send if these conditions are not met or the drive was addressed in the broadcast.

The connection to the relevant drives exists for the master once it receives a response frame from the drive after a specified processing time (response delay time).

### Procedure for setting up USS communication

1. Configure an S7-1500 configuration with CPU and CM in the device view of the hardware and network editor of STEP 7.
2. In the Project tree, select the "Program blocks" folder and open OB1 in the folder by double-clicking on it. The program editor opens.
3. Select the instructions for USS communication according to your task in the "Communication" area, "Communications processor" folder of the "Instructions" task card and drag them to a network of OB1:
  - The "USS\_Port\_Scan" instruction allows you to communicate via the USS network.
  - The "USS\_Drive\_Control" instruction prepares send data for the drive and evaluates the response data of the drive.
  - The "USS\_Read\_Param" instruction is used to read out parameters from the drive.
  - The "USS\_Write\_Param" instruction is used to change parameters on the drive.
4. Assign the parameters for the instructions according to your configuration.
5. Download the hardware configuration and user program to the CPU.

### Properties of the Modbus protocol (RTU)

- Communication takes the form of serial, asynchronous transfer with a transmission speed of up to 115.2 kbps, half duplex.
- Data transfer works according to the master-slave principle.
- The Modbus master can send jobs for reading and writing operands to the Modbus slave:
  - Reading inputs, timers, counters, outputs, memory bits, data blocks
  - Writing outputs, memory bits, data blocks
- Broadcast to all slaves is possible.

### Data exchange using Modbus communication (RTU)

The communications module can be a Modbus master or Modbus slave. A Modbus master can communicate with one or more Modbus slaves (the number depends on the physical interface). Only the Modbus slave explicitly addressed by the Modbus master is permitted to return data to the Modbus master. The slave detects the end of the data transfer and acknowledges it. If an error occurs, it provides an error code to the master.

## Procedure for setting up Modbus communication (RTU)

1. Configure an S7-1500 configuration with CPU and CM in the device view of the hardware and network editor of STEP 7.
2. In the Project tree, select the "Program blocks" folder and open OB1 in the folder by double-clicking on it. The program editor opens.
3. Select the instructions for Modbus communication according to your task in the "Communication" area, "Communications processor" folder of the "Instructions" task card and drag them to a network of OB1:
  - The "Modbus\_Comm\_Load" instruction configures the port of the CM for Modbus communication.
  - The "Modbus\_Master" instruction is used for Modbus master functionality.
  - The "Modbus\_Slave" instruction is used for Modbus slave functionality.
4. Assign the parameters for the instructions according to your configuration.
5. Download the hardware configuration and user program to the CPU.

## Additional information

- You can find more detailed information on communication via point-to-point connections and basics of serial data transmission in the function manual CM PtP communication module - Configurations for point-to-point connections (<http://support.automation.siemens.com/WW/view/en/59057093>).
- You can find a description of how to use the instructions for point-to-point connections in the user program in the STEP 7 online help.
- You can find information about the communications modules with a serial interface in the manual of the particular communications module.

## OPC UA communication

### 9.1 What you need to know about OPC UA

#### 9.1.1 OPC UA and Industrie 4.0

##### Uniform standard for information and data exchange

Industry 4.0 stands for the intensive utilization, evaluation and analysis of the large volumes of data from production in IT systems at the enterprise level. With Industry 4.0, data exchange between the production and enterprise levels is rapidly increasing. However, a prerequisite for success is a uniform standard for the information and data exchange.

Classic OPC only runs on Windows operating systems. To get around this restriction, the OPC Foundation developed the OPC UA (OPC Unified Architecture) standard.

The OPC UA standard is particularly suitable for data exchange across different levels thanks to its independence from specific operating systems, its secure transfer procedures and the semantic description of data. Machine data (controlled variables, measured values or parameters) can also be transferred in this way.

An important component of this concept is that OPC UA communication can take place in parallel with real-time communication for time-critical, machine-level data transfer.

OPC UA is highly scalable so that a consistent information exchange between sensors, controllers and MES or ERP systems is possible.

OPC UA makes available not only data but also information about the data (data types), at the same time making possible machine-interpretable access to the data.

##### OPC UA topic page

For an overview of the most important articles and links on the subject of OPC UA, refer to the SIEMENS Industry Online Support.

OPC UA topic page (<https://support.industry.siemens.com/cs/ww/en/view/109770435>)

## 9.1.2 General features of OPC UA

### OPC UA and PROFINET

OPC UA and PROFINET can be used together. The two protocols use the same network infrastructure.

### Independence from the operating system

The OPC UA standard is platform-independent and uses an optimized TCP-based binary protocol for high-performance applications.

OPC UA can be used, for example, under Windows, Linux, Mac OS X, a realtime operating system or a mobile operating system (Android or iOS).

### Independence of a specific transport layer

OPC UA currently supports the following transport mechanisms and protocols:

- The transfer of messages as a binary stream directly via TCP/IP
- The transfer of messages with XML via TCP/IP and HTTP. This transport mechanism allows only a slow transfer and is therefore almost never used. S7-1500 CPUs do not support this transport mechanism.

Binary data exchange is supported by all OPC UA applications (required in OPC UA specification).

### Simple client-server principle

An OPC UA server provides a great deal of information within a network, e.g. relating to the CPU, the OPC UA server itself, the data and the data types. An OPC UA client accesses this information.

### Implementation in different programming languages

The OPC Foundation has implemented the OPC UA standard in several programming languages: Stacks for .NET, ANSI C and Java are available, although maintenance has been discontinued for the stacks for ANSI C and Java.

The OPC Foundation offers the .NET stack as well as example programs as open source software. See Github (<https://github.com/opcfoundation>).

A number of companies offer Software Development Kits (SDK). These development packages contain the stacks of the OPC Foundation and other functionalities that facilitate the development of solutions.

Advantages of using SDKs:

- Support from the supplier
- Tested software
- Detailed documentation
- Clear license conditions (important for selling of solutions)

## Scalability

OPC UA can be used for devices of different performance classes:

- Sensors
- Embedded systems
- Controllers
- PC systems
- Smartphones
- Servers running MES or ERP applications.

The performance class of the devices is differentiated by profiles. Different OPC UA profiles offer the possibility to scale OPC UA for very small and simple devices as well as for very high-performance devices.

An OPC UA profile describes functions and services that must be supported by the server and client. In addition, other functionalities/services that are not required by the profile can be optionally provided.

OPC UA profiles differ from PROFINET profiles; the latter define additional cross-vendor properties and behavior for installations and systems in the sense of a vendor-neutral software interface.

### **Nano Embedded Device 2017 Server Profile**

For the smallest devices with severely limited functionality, there is the "Nano Embedded Device 2017 Server Profile" of the OPC Foundation. This profile is functionally equivalent to the core server facet and defines the OPC UA TCP binary protocol as the required transport profile. The profile allows for connections without UA Security and does not allow subscriptions or method calls. Support for diagnostic objects and variables is optional for this profile.

Additional profiles build on the "Nano Embedded Device 2017 Server Profile", requiring more resources and offering more functionality.

### **Micro Embedded Device 2017 Server Profile**

This profile provides limited functionality; it requires at least two parallel connections. Additionally, it allows subscriptions/data monitoring, but no UA Security and no method calls.

- S7-1200 Basic Controllers support the "Micro Embedded Device 2017 Server Profile". The S7-1200 additionally supports UA Security.

### **Embedded 2017 UA Server Profile**

This profile has been developed for devices with more than 50 MB RAM and a more high-performance processor. It is based on the Micro Embedded Device Server profile. In addition, it requires UA security and method calls.

In addition, the servers must make their used type model (data types, reference types, variable types, etc.) available.

- S7-1500 Advanced Controllers support the "Embedded 2017 UA Server Profile".

### Standard and global discovery profiles

The "OPC UA Specification Part 7" defines additional profiles:

- The "Standard 2017 UA Server Profile", which is suitable for PC-based OPC UA servers
- 2 global profiles, "Global Discovery Server 2017 Profile" and "Global Discovery and Certificate Management 2017 Server Profile", that cover the required service and information models of a Global Discovery Server

### Type-instance concept

OPC UA offers a fully networked (full-meshed network), object-oriented information model for namespaces, including metadata for the object description. Any object structures can be generated via referencing of the instances among each other and their types. Because servers disclose their instance and type systems, clients can navigate through this network and obtain all the information they need. Both instances and their type definitions are available in runtime.

Procedures or concepts on how to handle references to types are optimized over time. These optimizations lead to new versions of the OPC UA Specification (e.g. V1.03 => V1.04).

### PLC tag mapping

The information of the OPC UA server (for example the PLC tags) is modeled as nodes connected to one another via references. The semantics are displayed by the server in the address space and can be acquired by clients (while navigating). This makes it possible to browse from node to node with an OPC UA client and find out what content can be read, monitored or written.

### Integrated security mechanisms

OPC UA uses security mechanisms at various levels:

- A secure connection can only be established between an OPC UA server and an OPC UA client if the client and server can register with X.509-v3 certificates and accept each other's certificates (security at the application level). Various security policies are possible, including an unsecured connection between server and client (Security Policy: "No security").
- A server can always request the following information from the user for authorized access (authentication):
  - A user certificate (not configurable in STEP 7)
  - User name and password
  - No user authorization

The security mechanisms are optional and configurable.

### See also

OPC Foundation (<https://opcfoundation.org>)

### 9.1.3 OPC UA for S7-1200/S7-1500 CPUs

In OPC UA, one system operates as a server and provides data the existing information to other systems (clients).

OPC UA clients, for example, have read and write access to data on an OPC UA server. OPC UA clients call methods on the OPC UA server.

You can access this data online with a client, including e.g. information on performance and diagnostics. In OPC UA terminology, this function is called "Browse". The "Subscription" function eliminates regular reading of a tag; with this function, the server informs a client about value changes.

A system can be both a client and a server at the same time.

#### OPC UA server of the S7-1500 CPU

As of firmware version 2.0, an S7-1500 CPU is equipped with an OPC UA server.

The following sections describe how you configure the OPC UA server of the S7-1500 CPU to make data and methods available for OPC UA clients so that clients have read or write access to PLC tags on the CPU and can call server methods.

The following sections also set out how to integrate companion specifications into the address space of the OPC UA server.

#### OPC UA server of the S7-1200 CPU

As of firmware V4.4, an S7-1200 CPU is equipped with an OPC UA server.

The OPC UA server is generally configured as it is for an S7-1500 CPU; the scope of functions and the quantity limits are limited according to the supported "Micro Embedded Device 2017 Server Profile". Unlike for an S7-1500 CPU, the functions "Registered Read" and "Registered Write" are **not** available.

As of firmware V4.5, S7-1200 CPUs support server methods as well as structured data types (structures and arrays).

You can find additional information in the STEP 7 online help.

#### OPC UA client of the S7-1500 CPU

As of firmware version V2.6, an S7-1500 CPU is additionally equipped with an OPC UA client.

The following sections show how to use standardized instructions (PLCopen function blocks) to create a user program that, as an OPC UA client, provides the following functions:

- Reading data from an OPC UA server
- Writing data to an OPC UA server
- Calling methods of an OPC UA server

STEP 7 (TIA Portal) assists you in creating user programs by providing an editor for client interfaces and a parameter assignment for OPC UA connections.

The OPC UA instructions for an S7-1500 CPU as client are described in detail in the help to the instructions (Instructions > Communication > OPC UA).



## OPC UA client for test purposes

The following description uses various different OPC UA clients to illustrate the use of OPC UA clients:

- "UaExpert" of Unified Automation. An extensive client that can be used free of charge:  
Link for downloading UaExpert (<https://www.unified-automation.com/downloads/opc-ua-clients.html>)
- "UA Sample Client" of the OPC Foundation. This client is available free of charge for users who are registered with the OPC Foundation :  
Link for downloading the example client of the OPC Foundation (<https://opcfoundation.org>)

## Application example in Industry online support

Siemens Industry Online Support provides a free application example with a client API for various applications. You use the functions of this interface to create your own OPC UA clients that match your application. To simplify handling the API, we offer a higher-level .NET helper class.

The client API is based on the .NET OPC UA stack of the OPC Foundation.

The application example shows how to establish connections between servers and clients, for example. It also demonstrates the reading and writing of PLC tags.

Link to download: OPC UA .NET client for the SIMATIC S7-1500 OPC UA Server (<http://support.automation.siemens.com/WW/view/en/109737901>)

### 9.1.4 Access to OPC UA applications

The access possibilities that an S7-1500 CPU with an OPC UA application (client or server) has via a CP in the same station are described below. In addition, an approach for combining these access possibilities with the "IP Forwarding" function to allow access to devices of another IP subnet via an S7-1500 station is presented.

All the settings for this can be found in the CPU properties, "Advanced configuration" area in the Inspector window.

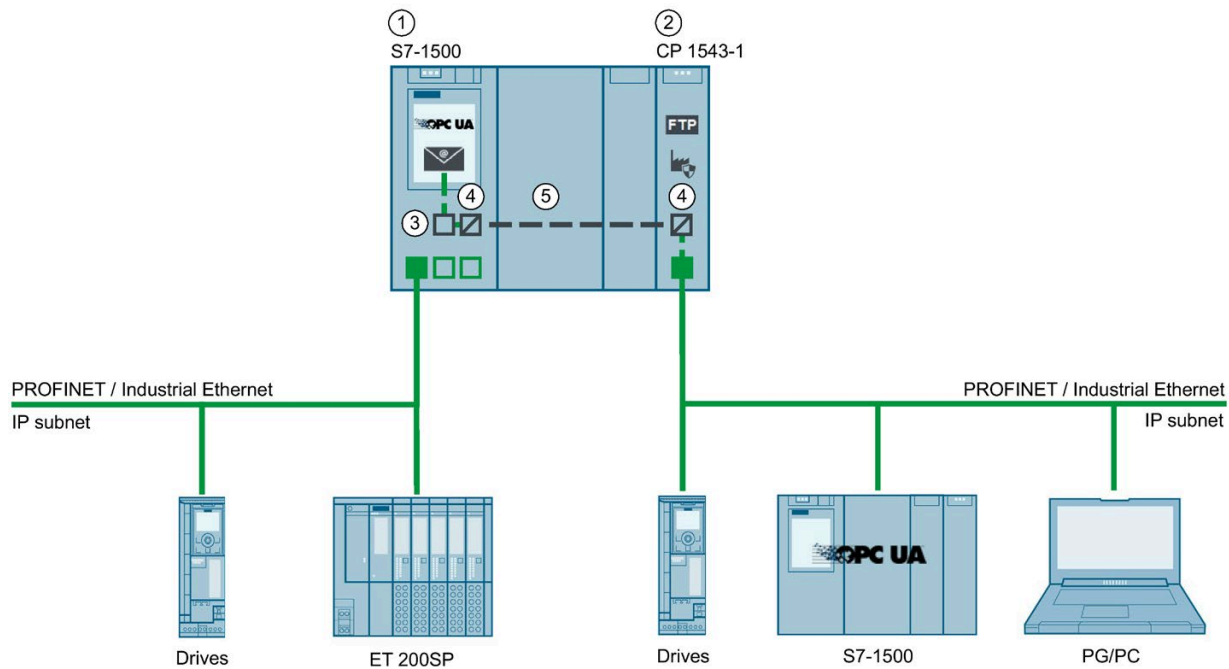
The possibility of accessing the OPC UA application in the CPU via CP interface is subject to the following requirements:

- S7-1500 CPU (except S7-1500 R/H) as of firmware version V2.8
- CP 1543-1 firmware version V2.2 or higher

### Principle: Interface for access via communication module

For a CPU application, such as OPC UA, to be accessed via CP interface, you must configure a virtual interface (W1). IP-based applications can then be accessed via the IP address parameters of this virtual interface.

The schematic is shown in the following figure.



- ① CPU S7-1500 FW V2.8 or higher (e.g. CPU 1515-2 PN)
- ② CP 1543-1 (FW V2.2 or higher)
- ③ Virtual interface (W1)
- ④ Protocol conversion PROFINET / Industrial Ethernet on backplane bus or backplane bus on PROFINET / Industrial Ethernet
- ⑤ Backplane bus

Figure 9-1 Principle: Interface for access via communication module

### Example: Access of OPC UA clients to the OPC UA server of the CPU

For access of an OPC UA client to the OPC UA server of the CPU, the following interfaces of the S7-1500 station are available:

- The local PROFINET interfaces of the S7-1500 CPU
- The Ethernet interface of a CP 1543-1 (firmware version V2.2 and higher)

The following figure shows an example of a possible configuration: The CPU could also have the role OPC UA client and the device on the subnet of the CP could have the role OPC UA server.

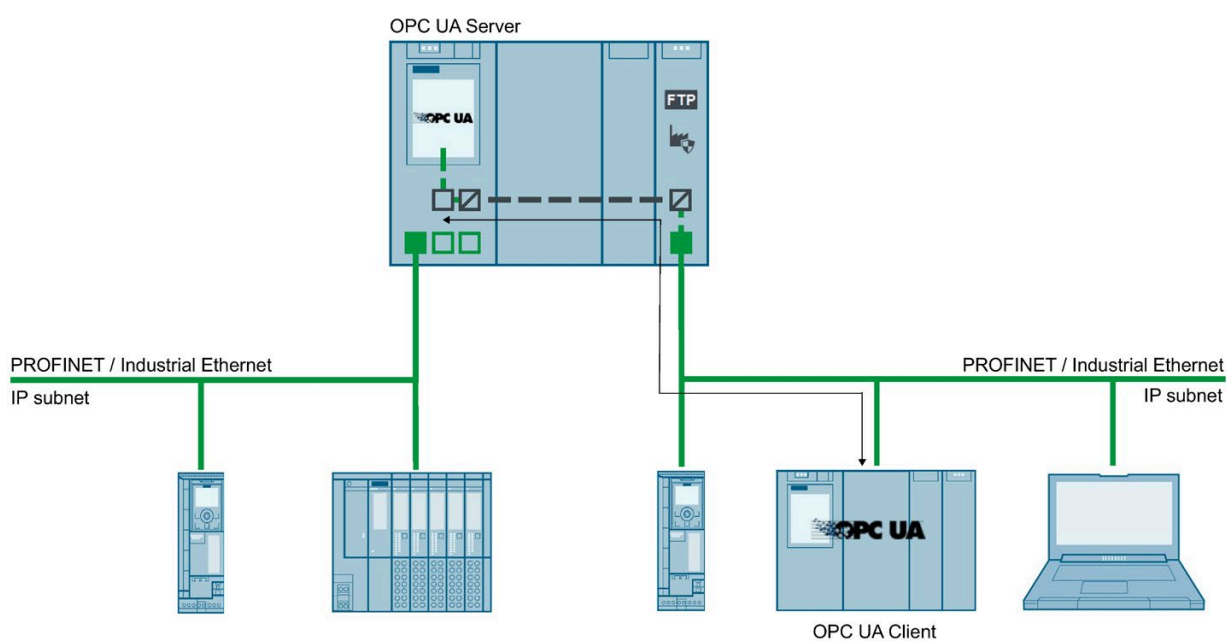


Figure 9-2 Example: Access of OPC UA clients to the OPC UA server of the CPU

### Example: Access of OPC UA clients to OPC UA servers via S7-1500 CPU with activated IP Forwarding

OPC UA client and OPC UA server can also be connected to one another via an S7-1500 CPU, in which case the S7-1500 CPU operates as an IP Forwarder. This configuration option allows for flexible expansion of existing systems.

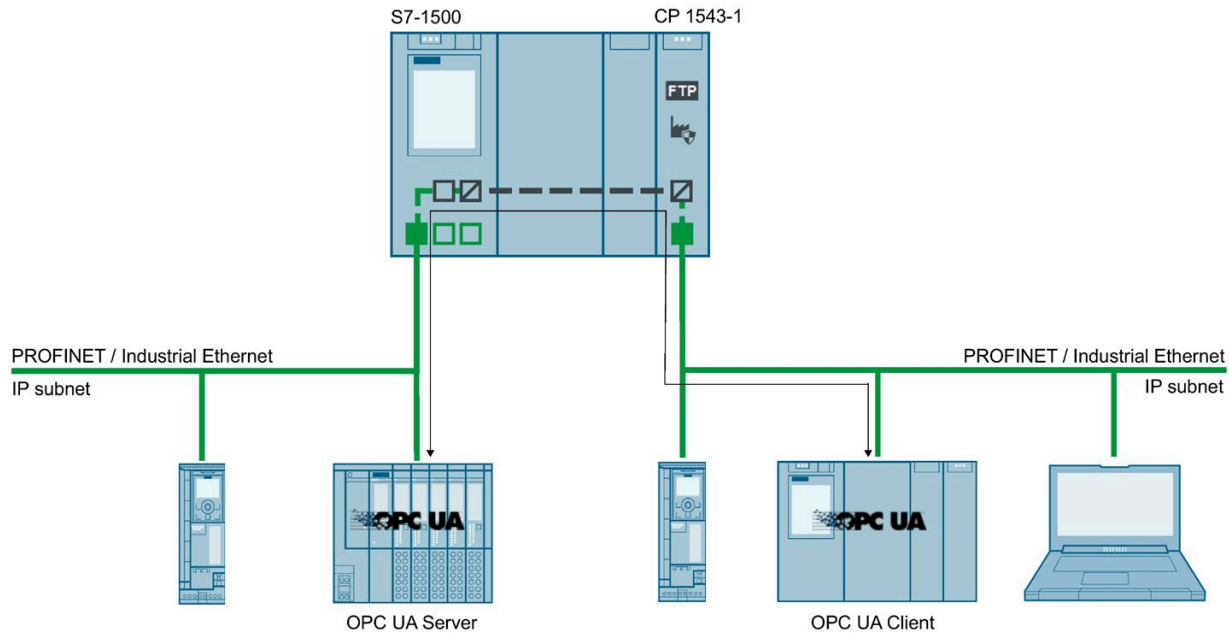


Figure 9-3 Example: Access of OPC UA clients to OPC UA servers via S7-1500 CPU with activated IP Forwarding

### Additional information

Additional information on access options via the virtual interface and via IP forwarding can be found in the following sections:

- IP forwarding (Page 378)
- Virtual interface for IP-based applications (Page 387)

### 9.1.5 Addressing nodes

Nodes are the basic elements of OPC UA, they are comparable with objects from object-oriented programming. Nodes are used, for example, for user data (tags) or other metadata. Nodes are used to model an OPC UA address space that also contains a type model with type definitions.

#### Node ID (NodeId)

Nodes in the OPC UA address space are uniquely identified by a NodeId (Node Identifier).

The NodeId consists of an identifier, identifier type and a namespace index. Namespaces are used to avoid naming conflicts.

The OPC Foundation has defined a wide range of nodes that provide information about the given OPC UA server. These nodes can be found in the namespace of the OPC Foundation and have the index 0.

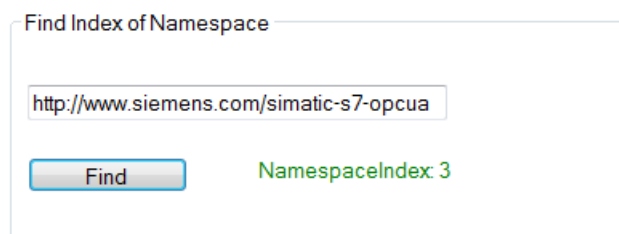
The OPC Foundation also defines data types and tag types.

#### Namespace (Namespace)

In addition to the above-described namespace of the OPC Foundation, the namespace for accessing CPU data is of interest: All the tags or methods of an S7-1500 OPC UA server are contained in the namespace (Namespace) of the standard server interface "http://www.siemens.com/simatic-s7-opcua".

By default this namespace has the Index 3. The index may change later if additional namespaces are inserted into the server or if existing ones are deleted. It is therefore necessary for an OPC UA client to request the current index of the namespace (e.g. "http://www.siemens.com/simatic-s7-opcua") from the server before reading or writing its values.

The following figure shows an example of the result of such a request.



## Identifier

The Identifier corresponds to the name of the PLC tag in quotation marks. The quotation mark is the only sign that is not permitted as part of a name in STEP 7. Quotation marks avoid naming conflicts.

The following example reads the value of the "StartTimer" tag:

|       |                  |      |        |
|-------|------------------|------|--------|
| Index | Boolean Variable |      | Result |
| 3     | "StartTimer"     | Read | True   |

The Identifier can consist of several components. The individual components are then separated by a dot.

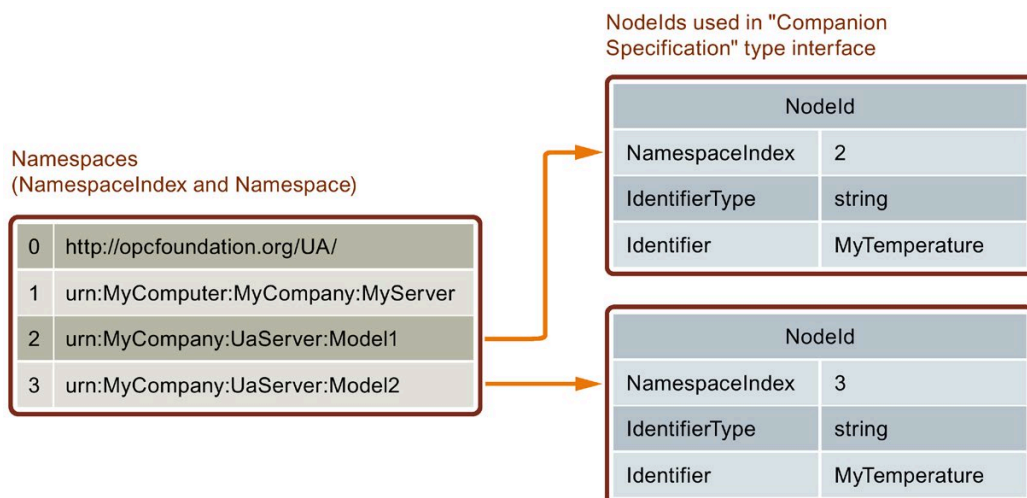
The following example reads the "MyDB" array data block completely. This data block contains an array with ten integer values. All ten values should be read in one pass. Therefore, "0:9" is entered at the array range.

| Index | Array Datablock of Int16       |      | Results                                                                                                                                                                                                                                                                                                                                                                                                                                           |       |        |   |      |   |      |   |      |   |      |   |      |   |      |   |      |   |      |   |      |   |      |
|-------|--------------------------------|------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------|--------|---|------|---|------|---|------|---|------|---|------|---|------|---|------|---|------|---|------|---|------|
| 3     | "MyDB"."THIS"                  | Read | <table border="1"> <thead> <tr> <th>Index</th> <th>Values</th> </tr> </thead> <tbody> <tr><td>0</td><td>7050</td></tr> <tr><td>1</td><td>7051</td></tr> <tr><td>2</td><td>7052</td></tr> <tr><td>3</td><td>7053</td></tr> <tr><td>4</td><td>7054</td></tr> <tr><td>5</td><td>7055</td></tr> <tr><td>6</td><td>7056</td></tr> <tr><td>7</td><td>7057</td></tr> <tr><td>8</td><td>7058</td></tr> <tr><td>9</td><td>7059</td></tr> </tbody> </table> | Index | Values | 0 | 7050 | 1 | 7051 | 2 | 7052 | 3 | 7053 | 4 | 7054 | 5 | 7055 | 6 | 7056 | 7 | 7057 | 8 | 7058 | 9 | 7059 |
| Index | Values                         |      |                                                                                                                                                                                                                                                                                                                                                                                                                                                   |       |        |   |      |   |      |   |      |   |      |   |      |   |      |   |      |   |      |   |      |   |      |
| 0     | 7050                           |      |                                                                                                                                                                                                                                                                                                                                                                                                                                                   |       |        |   |      |   |      |   |      |   |      |   |      |   |      |   |      |   |      |   |      |   |      |
| 1     | 7051                           |      |                                                                                                                                                                                                                                                                                                                                                                                                                                                   |       |        |   |      |   |      |   |      |   |      |   |      |   |      |   |      |   |      |   |      |   |      |
| 2     | 7052                           |      |                                                                                                                                                                                                                                                                                                                                                                                                                                                   |       |        |   |      |   |      |   |      |   |      |   |      |   |      |   |      |   |      |   |      |   |      |
| 3     | 7053                           |      |                                                                                                                                                                                                                                                                                                                                                                                                                                                   |       |        |   |      |   |      |   |      |   |      |   |      |   |      |   |      |   |      |   |      |   |      |
| 4     | 7054                           |      |                                                                                                                                                                                                                                                                                                                                                                                                                                                   |       |        |   |      |   |      |   |      |   |      |   |      |   |      |   |      |   |      |   |      |   |      |
| 5     | 7055                           |      |                                                                                                                                                                                                                                                                                                                                                                                                                                                   |       |        |   |      |   |      |   |      |   |      |   |      |   |      |   |      |   |      |   |      |   |      |
| 6     | 7056                           |      |                                                                                                                                                                                                                                                                                                                                                                                                                                                   |       |        |   |      |   |      |   |      |   |      |   |      |   |      |   |      |   |      |   |      |   |      |
| 7     | 7057                           |      |                                                                                                                                                                                                                                                                                                                                                                                                                                                   |       |        |   |      |   |      |   |      |   |      |   |      |   |      |   |      |   |      |   |      |   |      |
| 8     | 7058                           |      |                                                                                                                                                                                                                                                                                                                                                                                                                                                   |       |        |   |      |   |      |   |      |   |      |   |      |   |      |   |      |   |      |   |      |   |      |
| 9     | 7059                           |      |                                                                                                                                                                                                                                                                                                                                                                                                                                                   |       |        |   |      |   |      |   |      |   |      |   |      |   |      |   |      |   |      |   |      |   |      |
|       | Array Range (for instance 0:9) |      |                                                                                                                                                                                                                                                                                                                                                                                                                                                   |       |        |   |      |   |      |   |      |   |      |   |      |   |      |   |      |   |      |   |      |   |      |
|       | 0:9                            |      |                                                                                                                                                                                                                                                                                                                                                                                                                                                   |       |        |   |      |   |      |   |      |   |      |   |      |   |      |   |      |   |      |   |      |   |      |

## Example of NodeIds, identifiers and namespaces

The following figure illustrates the relation between NodeIds, identifiers and namespaces: It is no problem if two nodes have the same identifiers but belong to different namespaces.

STEP 7 (TIA Portal) allows you to easily import namespaces via a server interface.



## PLC tags in the address space of the OPC UA server

The figure below shows where the PLC tags in the example are located in the address space of the OPC UA server (excerpt from UA client):

The "MyDB" data block is a global data block. The data block is therefore located below the node "DataBlocksGlobal". "StartTimer" is a memory tag and is therefore stored below the "Memory" node.



Figure 9-4 PLC tags in the address space of the OPC UA server

## Methods in the address space of the OPC UA server

If you implement a method via your user program, it takes the following form in the address space of the OPC UA Server

(see Providing methods on the OPC UA server (Page 279)):

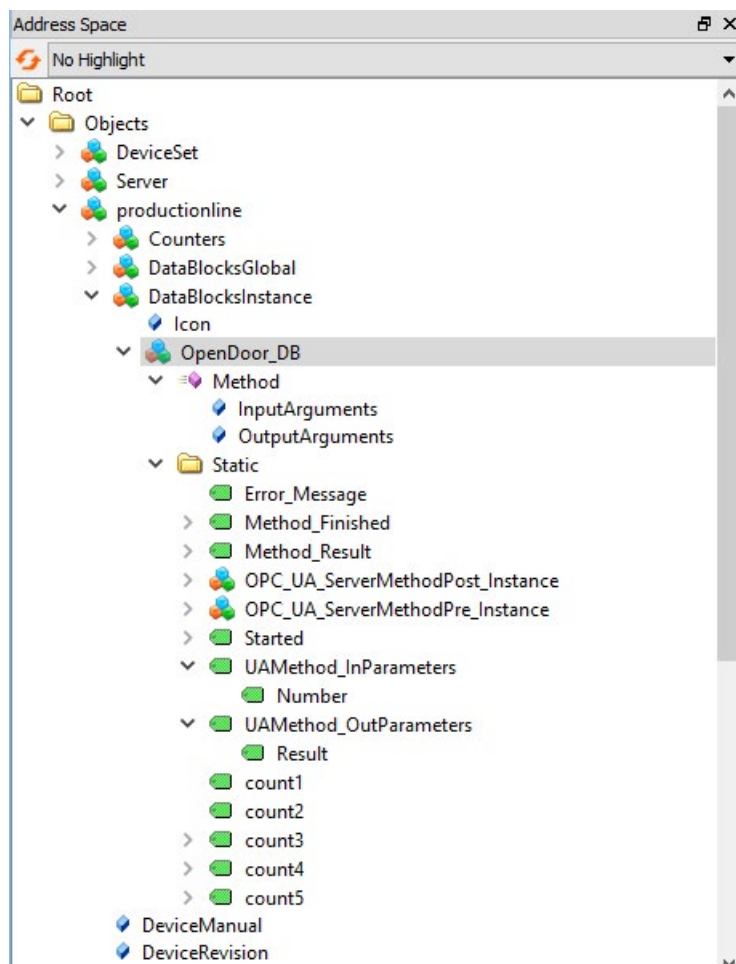


Figure 9-5 Methods in the address space of the OPC UA server



## 9.1.6 What you need to know about OPC UA clients

### Basics of OPC UA clients

OPC UA clients are programs that do the following:

- Access the information from an OPC UA server (for example an S7-1500 CPU):  
read/browse access, write access, subscriptions
- Execute methods through the OPC UA server

However, OPC UA clients can only access data that is enabled for this purpose (see "Managing write and read rights (Page 208)").

You need the endpoint of the server to establish a connection to an OPC UA server (see "Endpoints of the OPC UA servers (Page 203)").

### Reading out information from the OPC UA server

When a connection to an end point of the server exists, you can use the navigation function of the client: You navigate starting from a defined starting point (from the "root" node) through the address space of the server.

The following information is provided in the process:

- Enabled PLC tags, data blocks and data block components
- Namespace index and identifiers of these PLC tags, data blocks and DB components
- Data types of the PLC tags and DB components
- Number of components in arrays (required for reading and writing arrays)

In addition, you receive information about the OPC UA server itself as well as information about the S7-1500 based on the "OPC UA for Devices" standard of the OPC Foundation (for example, serial number, firmware version).

## Reading data from the server and writing to the server

You now know the namespace, identifier and data type of PLC tags. This means that you can now specifically read individual PLC tags and DB components as well as complete arrays and structures.

You can find examples of the reading of Boolean tags and array data blocks in Addressing nodes (Page 161).

Rules for access to structures are available here (Page 338).

With the information that you obtain while navigating through the address space of the server (index, identifier and data type), you can also transfer values to the S7-1500 with the OPC UA client. The following example overwrites the first three values in the array data block "MyDB".

|                                |                                              |                                                 |                                      |                                   |
|--------------------------------|----------------------------------------------|-------------------------------------------------|--------------------------------------|-----------------------------------|
| Index                          | Array Datablock of Int16                     | Values                                          |                                      | Status Code                       |
| <input type="text" value="3"/> | <input ."this"="" type="text" value="MyDB"/> | <div><div>1</div><div>2</div><div>3</div></div> | <input type="button" value="Write"/> | <input type="text" value="Good"/> |
|                                | Array Range (for instance 0:9)               |                                                 |                                      |                                   |
|                                | <input type="text" value="0:2"/>             |                                                 |                                      |                                   |

For "Array Range" you specify which components of the array you want to overwrite. The "Good" status code indicates that the values were transferred successfully. However, you can only write the values to the S7-1500 but not the time stamps of these values. The time stamps can only be read.

## Faster access through registration

Registered Read/Write lends itself to repeated, optimized access to data – with maximum performance. When tag nodes are registered, the OPC UA server creates a numerical Identifier (numerical NodeId) that directly references the registered node. For read or write jobs of the client to this numerical Identifier, the server does not have to resolve any strings as Identifier and can access the requested tag in an optimized manner.

This Identifier applies solely to the current session and has to be queried again when the session connection is terminated/lost.

In the following example, the "StartTimer" tag is first registered on the server. Afterwards, the rapid function "RegisteredWrite" is used for setting the value.

|                                |                                         |                                         |                                     |                                           |                                      |
|--------------------------------|-----------------------------------------|-----------------------------------------|-------------------------------------|-------------------------------------------|--------------------------------------|
| Index                          | Boolean Variable                        |                                         | Value                               |                                           | Status Code                          |
| <input type="text" value="3"/> | <input type="text" value="StartTimer"/> | <input type="button" value="Register"/> | <input checked="" type="checkbox"/> | <input type="text" value="True"/>         | <input type="button" value="Write"/> |
|                                |                                         |                                         |                                     |                                           | <input type="text" value="Good"/>    |
|                                |                                         |                                         |                                     | <input type="button" value="Unregister"/> |                                      |

In accordance with the same scheme, the "RegisteredRead" function can also be used, which is particularly useful for recurring data readouts. Take into account, however, that depending on the application it may be advisable to use a Subscription instead.

Recommendation: It is best to place registrations in the startup program of the OPC UA client, since the registration takes up time.

Please note that you can set the maximum number of registered nodes in the properties of the S7-1500 CPU and that the Clients have to respect this number, see General settings of the OPC UA server (Page 222).

## Subscription

The term "Subscription" is used for a function in which only those tags for which an OPC UA client has registered at the OPC UA server are transferred. The OPC UA server only sends a message to the OPC UA client for these registered tags (monitored Items) when a value has changed. The monitoring of these tags makes constant sampling by the OPC UA client (Polling) superfluous, which reduces the network load.

You have to create a Subscription to use this function. For this purpose, you specify the "Publishing Interval" at the UA client and click the "Create" button. The publishing interval is the time interval in which the server sends new values to the client in a notification (data change notification).

In the following example a subscription has been created: The client receives a message with the new values (publishing interval 50 ms) every 50 milliseconds here.

Create a Subscription

Publishing Interval  (ms)

Status: Active Subscription

### Preventing server overload

You can set the OPC UA server of the S7-1500 CPU by means of the "Minimum publishing interval" so that it does not serve extremely short send intervals requested by the client, see Settings of the server for subscriptions (Page 224).

**Example:** A client wants to be operated at a publishing interval of 50 ms as detailed above. Such a short publishing interval would, however, result in a high network and server load. You should therefore set 1000 ms as the "Minimum publishing interval" for the server. Clients whose subscription requires shorter publishing intervals are "slowed" to 1000 ms and the server is protected from overload.

Sampling and transmission (Sampling & Publishing) within the scope of a subscription are communication processes which, like other communication processes (TCP/UDP/Web server communication...), are processed by the CPU with priority 15. OBs with higher priority interrupt the communication. If you set the sampling and transmission intervals too short, this setting causes a high communication load. Therefore, select intervals as large as possible, which are still sufficient for the application.

For information about the consistency of tags, refer to Consistency of CPU tags (Page 213).

### Monitoring of PLC tags

When the Subscription has been created, you inform the server which tags are to be monitored with it. In the following example, the "Voltage" tag was added to the subscription.

| Index      | LREAL Variable | Sampling Interval |                 | Value      |
|------------|----------------|-------------------|-----------------|------------|
| 3          | "Voltage"      | -1                | Add and Monitor | 2.21426504 |
| Queue Size |                | Deadband          |                 |            |
| 1          |                | 0.1               |                 |            |

The "Voltage" tag contains the value of a voltage that is detected by an S7-1500 CPU.

The sampling interval ("Sampling Interval") contains a negative value (-1). This determines that the default setting of the OPC UA server is used for the sampling interval. The default setting is defined by the transmission interval ("Publishing Interval") of the subscription. If you want to set the smallest possible sampling interval, select the value "0".

In this example, the length of the queue is set to "1": Only one value is read from the CPU at an interval of 50 milliseconds and subsequently sent to the OPC UA client when the value has changed.

The "Deadband" parameter in this example is "0.1": Changes in value have to amount to 0.1 Volt; only then does the sender send the new value to the client. The server does not send smaller changes in value. You can use this parameter, for example, to disable signal noise: Slight changes in a process variable which do not have a real meaning.

## 9.1.7 Mapping of data types

### SIMATIC and OPC UA data types

SIMATIC data types do not always correspond with OPC UA data types.

S7-1500 CPUs provide SIMATIC tags (with SIMATIC data types) to their own OPC UA server as OPC UA data types. OPC UA clients can then access these tags with OPC UA data types via the server interface.

A client can read the attribute "DataType" from such a tag and reconstruct the original data type in SIMATIC.

#### Example

A tag has the SIMATIC data type "COUNTER". You read COUNTER → UInt16 in the table. You now know that you do not need to convert; the COUNTER value is sent over the line as a UInt16 data type.

The client detects from the attribute "DataType" that the tag is actually the SIMATIC data type "COUNTER". With this knowledge, the client reconstructs the data type.

Table 9- 1 SIMATIC and OPC UA data types

| SIMATIC data type | OPC UA data type   |
|-------------------|--------------------|
| BOOL              | Boolean            |
| BYTE              | BYTE<br>→ Byte     |
| WORD              | WORD<br>→ UInt16   |
| DWORD             | DWORD<br>→ UInt32  |
| LWORD             | LWORD<br>→ UInt64  |
| SINT              | SByte              |
| INT               | Int16              |
| DINT              | Int32              |
| LINT              | Int64              |
| USINT             | Byte               |
| UINT              | UInt16             |
| UDINT             | UInt32             |
| ULINT             | UInt64             |
| REAL              | Float              |
| LREAL             | Double             |
| S5TIME            | S5TIME<br>→ UInt16 |
| TIME              | TIME<br>→ Int32    |
| LTIME             | LTIME<br>→ Int64   |

## 9.1 What you need to know about OPC UA

| SIMATIC data type                                                                                                                                                        | OPC UA data type    |
|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------|
| DATE                                                                                                                                                                     | DATE<br>→ UInt16    |
| TIME_OF_DAY (TOD)                                                                                                                                                        | TOD<br>→ UInt32     |
| LTIME_OF_DAY (LTOD)                                                                                                                                                      | LTOD<br>→ UInt64    |
| DATE_AND_TIME (DT)                                                                                                                                                       | DT<br>→ Byte[8]     |
| LDT                                                                                                                                                                      | DateTime            |
| DTL<br>Special note: You can only describe the structure completely with an OPC UA client. You have read-only access individual elements of this structure (e.g. "YEAR") | mapped as structure |
| CHAR                                                                                                                                                                     | CHAR<br>→ Byte      |
| WCHAR                                                                                                                                                                    | WCHAR<br>→ UInt16   |
| STRING<br>(Code page 1252 or Windows-1252)                                                                                                                               | STRING<br>→ String  |
| WSTRING<br>(UCS-2; Universal Coded Character Set)                                                                                                                        | String              |
| TIMER                                                                                                                                                                    | TIMER<br>→ UInt16   |
| COUNTER                                                                                                                                                                  | COUNTER<br>→ UInt16 |

### Arrays

A read or write job with OPC UA is always an array access, which means that it always has an index and length. A single tag is a special case of an array (index 0 and length 1). The data type is simply sent repeatedly on the line. For the tags, the "DataType" attribute indicates the basic data type. The attributes "ValueRank" and "ArrayDimensions" show whether or not you are dealing with an array and how large the array is.

### Data types based on arrays

There are SIMATIC data types for which an OPC UA value is mapped to an array of bytes. An array of these data types is then mapped to a two-dimensional array.

Example: The SIMATIC data type DATE\_AND\_TIME (DT) is mapped on the OPC UA side to an 8-byte array (Byte[8]), see table above. When you define an array of the SIMATIC data type DATE\_AND\_TIME (DT), then it is considered as two-dimensional array.

This fact affects the use of system data types such as OPC-UA-NodeAdditionalInfo and OPC-UA-NodeAdditionalInfoExt, for example:

For the data types described above, you must use the system data type OPC-UA-NodeAdditionalInfoExt for multidimensional arrays instead of OPC-UA-NodeAdditionalInfo.

## Structures

Structures are transferred as ExtensionObject. The S7-1500 server uses binary representation for transmission of the ExtensionObjects over the line; the individual structure elements come one after the other. At the front is the NodeId of the data type; this is used by the client to establish the structure.

For OPC UA Specification <= V1.03, a client has to read, decode and interpret the complete DataTypeDictionary for this (unless it has already learned this library offline through an XML import).

Starting in OPC UA V1.04, the DataTypeDescription attribute is also available for this, which can be read and interpreted more quickly and easily. A client only determines the setup of the structure once, before or during the first access, and then uses this information for the duration of the session.

## Special SIMATIC data types

SIMATIC data types that are not in the table above and cannot be defined as elements of a structure or PLC data type are not supported by the OPC UA client.

These are, for example, "ANY" or "POINTER" pointers, function block "Block\_FB", function "Block\_FC" or hardware data type "REMOTE".

The selection of an unsupported data type leads to an error message.

## Additional information

More details on mapping of basic data types, arrays and structures can be found in the OPC UA Specification Part 6, "Mappings" (see OPC UA BINARY there).

What must be considered with arrays and data types DTL and LDT in the OPC UA server of a SIMATIC S7-1500? FAQ (<https://support.industry.siemens.com/cs/ww/en/view/109766726>)

## 9.2 Security at OPC UA

### 9.2.1 Security settings

#### Addressing risks

OPC UA allows the exchange of data between different systems, both within the process and production levels and to systems at the control and enterprise level.

This possibility also entails security risks. That is why OPC UA provides a range of security mechanisms:

- Verification of the identity of OPC UA server and clients.
- Checking of the identity of the users.
- Signed/encrypted data exchange between OPC UA server and clients.

These security policies should only be bypassed in cases where it is absolutely necessary:

- During commissioning
- In stand-alone projects without external Ethernet connection

If you have selected the endpoint "None" for "UA Sample Client" of the OPC Foundation, for example, the program issues a clear warning:

Warning: Selected Endpoint has no security.

When STEP 7 compiles your project it also checks whether you have considered the setting options for the protection and warns you of possible risks. This also includes an OPC UA security policy with the setting "no security", which corresponds to the end point "None".

---

#### Note

##### Disabling security policies you do not want

If you have enabled all security policies in the secure channel settings of the S7-1500 OPC UA server – thus, also the end point "None" (no security) – unsecured data traffic (neither signed nor encrypted) between the server and client is also possible. The OPC UA server of the S7-1500 CPU also sends its public certificate to the client at "None" (No security). And some clients check this certificate. However, the client is not forced to send a certificate to the server. The identity of the client may possibly remain unknown. Each OPC UA client can then connect to the server irrespective of any subsequent security settings.

When configuring the OPC UA server, make sure that only security policies that are compatible with the security concept of your machine or plant are selected. All other security policies should be disabled.

Recommendation: Use the setting "Basic256Sha256 - Sign and Encrypt", which means that the server only accepts Sha256 certificates. The security policies "Basic128Rsa15" and "Basic256" are deactivated by default and should not be used as an end point. Select end points with a higher security policy.

---



### Additional security rules

- Only use the end point "None" in exceptional cases.
- Only use the "guest authentication" of the user in exceptional cases.
- Only allow access to PLC tags and DB components via OPC UA if it is genuinely necessary.
- Use the list of trusted clients in the settings of the S7-1500 OPC UA client to allow access to certain clients only.

### 9.2.2 Certificates pursuant to ITU X.509

Security mechanisms are integrated in several layers in OPC UA. Digital certificates have an important role here. An OPC UA client can only establish a secure connection to an OPC UA server when the server accepts the digital certificate of the client and classifies it as trusted.

See section Handling client and server certificates (Page 227).

The client must also check and trust the certificate of the server. The server and client must show their identities and prove that they are what they claim to be: They must prove their identity. Mutual authentication of client and server, for example, prevents man-in-the-middle attacks.

### Man-in-the-middle attacks

A "man-in-the-middle" could have positioned itself between server and client. A man-in-the-middle is a program that intercepts communication between server and client and claims to be a client or server, and is thus able to obtain information about the S7 program or to set values in the CPU and attack a machine or plant.

OPC UA uses digital certificates that meet standard X.509 of the International Telecommunication Union (ITU).

This allows the identity of a program, a computer or an organization to be proven (authenticated).

## X.509 certificates

An X.509 certificate includes the following information:

- Version number of the certificate
- Serial number of the certificate
- Information on the algorithm used by the certificate authority to sign the certificate.
- Name of the certificate authority
- Start and end of the validity period of the certificate
- Name of the program, person or organization for which/whom the certificate has been signed by the certificate authority.
- The public key of the program, person or organization.

An X509 certificate thus links an identity (name of a program, person or an organization) to the public key of the program, person or organization.

### Check during connection establishment

When a connection is being established between the client and server, the devices check all information from the certificate that is required to determine its integrity, such as signature, period of validity, application name (URN) and, in case of firmware version V2.5 only, also the IP address of the client in the client certificate.

---

#### Note

The validity period stored in the certificate is also checked. The CPU clock must therefore be set and date/time must be within the validity period, otherwise no communication takes place.

---

## Signing and encryption

To allow you to check whether a certificate has been manipulated, certificates are signed.

There are various possible procedures here:

- Within the TIA Portal you have the possibility to generate and sign certificates. If you have protected your project and are logged in as a user with the function right to make security settings, you can use the global security settings. The global security settings allow access to the certificate manager and therefore to the certificate authority (CA) of the TIA Portal.
- Additional options are available for creating and signing certificates. In the TIA Portal, you can import certificates into the global certificate manager.

- You contact a certificate authority (CA) and have your certificate signed.

In this case, the certificate authority checks your identity and signs your certificate with the private key of the certificate authority. For this purpose you send a CSR (Certificate Signing Request) to the certificate authority.

- You yourself create a certificate and sign it.

To this purpose you use, for example, the "Opc.Ua.CertificateGenerator" program of the OPC Foundation. Alternatively, you use OpenSSL.

You can find additional information in Generating PKI key pairs and certificates yourself (Page 179).

## Useful information: Certificate types

- Self-signed certificate:

Each device generates and signs its own certificate. Application examples: Static configuration with limited number of communication nodes.

No new certificates can be derived from a self-signed certificate. However, you need to load all self-signed certificates from partner devices to the CPU (STOP required).

- CA certificate:

All certificates are generated and signed by a certificate authority. Application examples: Dynamically growing plants.

You only need to download the certificate from the certificate authority to the CPU. The certificate authority can generate new certificates (partner devices can be added without CPU STOP).

## Signing

The signature makes it possible to prove the integrity and source of a message as detailed below.

Signing starts with the sender creating a hash value from the plain text (plain text message). The sender then encrypts the hash value with its private key and subsequently transfers the plain text together with the encrypted hash value to the recipient. To verify the signature, the recipient needs the public key of the sender (this is contained in the X509 certificate of the sender). The recipient uses the sender's public key to decrypt the hash value received. The recipient then forms the hash value themselves from the plain text received (the hash process is contained in the sender's certificate). The recipient compares the two hash values:

- If the two hash values are identical, the plain text message has reached the receiver unchanged and has not been manipulated.
- If the two hash values do not match, the plain text message has not reached the receiver unchanged. The plain text message has been manipulated or has been distorted during transfer.

## Encryption

Encrypting data prevents unauthorized parties from reading the content. X509 certificates are not encrypted; they are public and can be viewed by anyone.

Encryption involves the sender encrypting the plain text message with the public key of the recipient. To do so, the sender requires the recipient's X509 certificate, as it contains the public key of the recipient. The recipient decrypts the message with their private key. Only the recipient can decrypt the message: They alone hold the private key. The private key must therefore never be disclosed.

## Secure channel

OPC UA uses the private and public key of client and server to establish a secure connection, the secure channel. Once the secure connection has been established, the client and server generate an internal key only known to them which they both use for signing and encrypting messages. This symmetric process (a shared key) is much faster than asymmetric processes (private and public key).

## See also

Creating self-signed certificates (Page 178)

Certificates with OPC UA (Page 177)

Secure Communication (Page 40)

Using certificates with TIA Portal

(<https://support.industry.siemens.com/cs/ww/en/view/109769068>)

### 9.2.3 Certificates with OPC UA

#### Usage of X509 certificates with OPC UA

OPC UA uses various types of X.509 certificates for establishing a connection from client to server:

- OPC UA application certificates

Such X.509 certificates identify the software instance, the installation of client or server software. For the "Organization name" attribute, you enter the name of the company that uses the software.

---

**Note**

The OPC UA server of the S7-1500 uses application certificates even for the security setting "None" (no security). This ensures compatibility to OPC UA V1.1 and earlier versions.

---

- OPC UA software certificates

This X-509 certificate identifies a specific version of the client or server software. These certificates contain attributes that describe which tests this version of the software has passed during certification by the OPC Foundation (or recognized test laboratories). For the "Organization name" attribute, you enter the name of the company that has developed or markets the software.

---

**Note**

Software certificates are not supported in STEP 7.

---

- OPC UA user certificates

This X.509 certificate identifies the specific user who, for example, retrieves process data from the OPC UA server. This certificate is not required if the user can authenticate itself with a password, or if anonymous access is configured.

---

**Note**

User certificates are not supported in STEP 7.

---

The described certificates are end-entity certificates: They identify, for example, a person, an organization, a company or an instance (installation) of a software.

## 9.2.4 Creating self-signed certificates

### Using the client's certificate generator

Many OPC UA client applications or SDKs are integrated in a sample application that allows you to generate certificates for the client from this application.

The description for certificate generation can generally be found in the context for describing the OPC UA client application.

#### Example client from the online support

The OPC UA .NET client for the SIMATIC S7-1500 OPC UA server (<https://support.industry.siemens.com/cs/ww/en/view/109737901>) creates a self-signed software certificate of the client application in the Windows Certificate Store during the first program start. The documentation for this example describes the procedure for handling these certificates.

### Using the certificate generator of the TIA Portal

If you use an OPC UA client that does not generate a client certificate, you can create self-signed certificates with STEP 7.

To do this, follow these steps:

1. In the properties of the CPU, double-click "<Add new>" under "Protection & Security > Certificate manager > Device certificates".
2. Click "Add".
3. In the "Create a new certificate" dialog, select the "OPC UA client" option for "Usage".
4. Click "OK".

In the field "Subject Alternative Name" STEP 7 automatically enters the URI for the generated certificate. In the program-specific certificate generation by means of the .NET stack of the OPC Foundation, the field is called, for example, "ApplicationUri" - it can have a different name in other tools for certificate generation.

### See also

Handling of the client certificates of the S7-1500 CPU (Page 344)

### 9.2.5 Generating PKI key pairs and certificates yourself

This section is only relevant if you want to use an OPC UA client that cannot itself create a PKI key pair and a client certificate. In this case, you generate a private and a public key using OpenSSL, generate an X.509 certificate, and sign the certificate yourself.

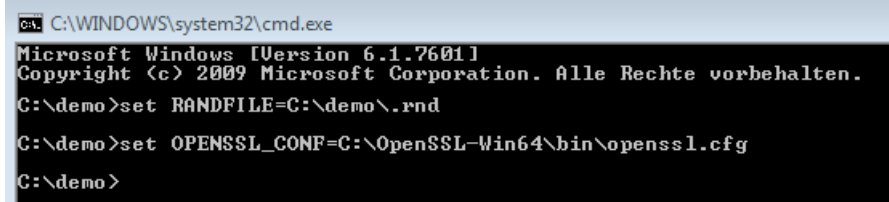
#### Using OpenSSL

OpenSSL is a tool for Transport Layer Security that you can use to create certificates. You can also use other tools, for example XCA, a type of key management software with a graphical user interface for an improved overview of certificates issued.

To work with OpenSSL under Windows, follow these steps:

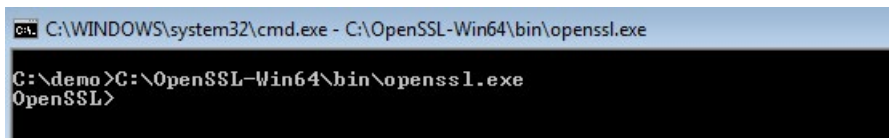
1. Install OpenSSL under Windows. If you are using a 64-bit version of the operating system, install OpenSSL in the "C:\OpenSSL-Win64" directory, for example. You can obtain OpenSSL-Win64 as a download from various providers for open source software.
2. Create a directory, for example "C:\demo".
3. Open the command prompt. To do so, click "Start" and enter "cmd" or "command prompt" in the search field. Right-click "cmd.exe" in the results list and run the program as an administrator. Windows opens the command prompt.
4. Change to the "C:\demo" directory. To do this, enter the following command: "cd C:\demo".
5. Set the following network variables:
  - set RANDFILE=c:\demo\.rnd
  - set OPENSSL\_CONF=C:\OpenSSL-Win64\bin\openssl.cfg

The figure below shows the command line with the following commands:



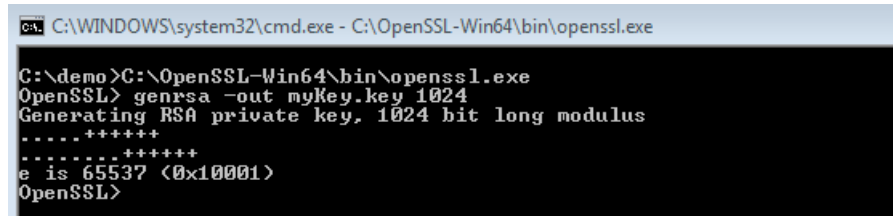
```
C:\WINDOWS\system32\cmd.exe
Microsoft Windows [Version 6.1.7601]
Copyright (c) 2009 Microsoft Corporation. Alle Rechte vorbehalten.
C:\demo>set RANDFILE=C:\demo\.rnd
C:\demo>set OPENSSL_CONF=C:\OpenSSL-Win64\bin\openssl.cfg
C:\demo>
```

6. Now start OpenSSL. If OpenSSL has been installed in the C:\OpenSSL-Win64 directory, enter the following: C:\OpenSSL-Win64\bin\openssl.exe The figure below shows the command line with the following command:



```
C:\WINDOWS\system32\cmd.exe - C:\OpenSSL-Win64\bin\openssl.exe
C:\demo>C:\OpenSSL-Win64\bin\openssl.exe
openssl>
```

7. Generate a private key. Save the key to the "myKey.key" file. The key in this example is 1024 bits long; for greater RSA security, use 2048 bits in practice. Enter the following command: "genrsa -out myKey.key 1024" ("genrsa -out myKey.key 1024" in the example). The figure below shows the command line with the command and the output of OpenSSL:



```
C:\WINDOWS\system32\cmd.exe - C:\OpenSSL-Win64\bin\openssl.exe
C:\demo>C:\OpenSSL-Win64\bin\openssl.exe
openssl> genrsa -out myKey.key 1024
Generating RSA private key, 1024 bit long modulus
.....+++++
.....+++++
e is 65537 (0x10001)
openssl>
```

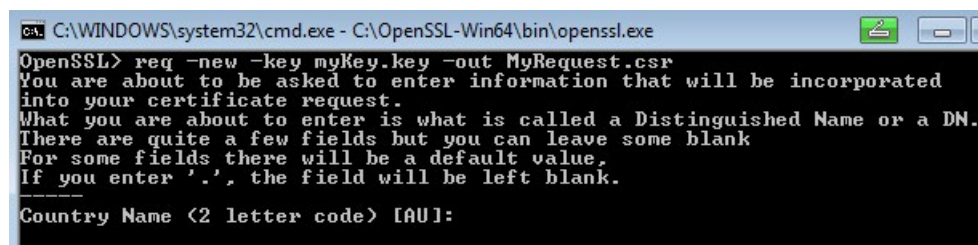
8. Generate a CSR (Certificate Signing Request). To do this, enter the following command: "req -new -key myKey.key -out myRequest.csr". During execution of this command, OpenSSL queries information about your certificate:
  - Country name: for example "DE" for Germany, "FR" for France
  - State or province name: for example "Bavaria".
  - Location Name: for example "Augsburg".
  - Organization Name: Enter the name of your company.
  - Organizational Unit Name: for example "IT"
  - Common Name: for example "OPC UA client of machine A"
  - Email Address:

## Note

### Note for S7-1500 CPU as server with firmware version V2.5

The IP address of the client program has to be stored in the "Subject Alternative Name" field of the created certificate for S7-1500 CPUs version V2.5 (only for this version); otherwise, the CPU will not accept the certificate.

The information you enter is added to the certificate. The figure below shows the command line with the command and the output of OpenSSL:



```
C:\WINDOWS\system32\cmd.exe - C:\OpenSSL-Win64\bin\openssl.exe
openssl> req -new -key myKey.key -out MyRequest.csr
You are about to be asked to enter information that will be incorporated
into your certificate request.
What you are about to enter is what is called a Distinguished Name or a DN.
There are quite a few fields but you can leave some blank
For some fields there will be a default value,
If you enter '.', the field will be left blank.
-----
Country Name <2 letter code> [AU]:
```

The command creates a file in the C:\demo directory containing the Certificate Signing Request (CSR); in the example, this is "myRequest.csr".



## Using the CSR

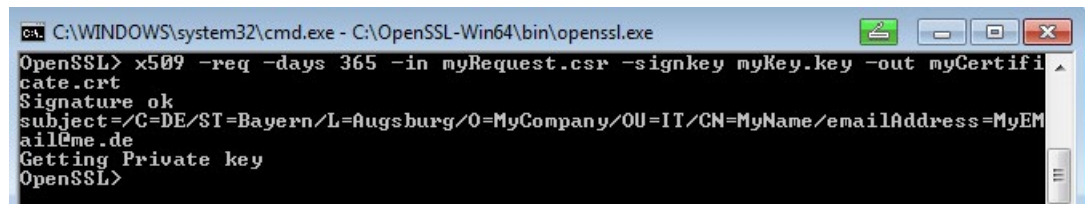
There are two ways to use a CSR:

- You send the CSR to a certificate authority (CA): Read the information of the respective certification authority. The certificate authority (CA) checks your information and identity (authentication) and signs the certificate with the private key of the certificate authority. You receive the signed X.509 certificate and use this certificate for OPC UA, HTTPS or Secure OUC (secure open user communication), for example. Your communication partners use the public key of the certificate authority to check whether your certificate was really issued and signed by that CA (i.e. that the certificate authority has confirmed your information).
- You sign the CSR yourself: Using your private key. This option is shown in the next step.

## Signing the certificate yourself

Enter the following command so that you can generate and sign your certificate (self-signed certificate) yourself: "x509 -req -days 365 -in myRequest.csr -signkey myKey.key -out myCertificate.crt".

The figure below shows the command line with the command and OpenSSL:



```
C:\WINDOWS\system32\cmd.exe - C:\OpenSSL-Win64\bin\openssl.exe
OpenSSL> x509 -req -days 365 -in myRequest.csr -signkey myKey.key -out myCertificate.crt
Signature ok
subject=C=DE/ST=Bayern/L=Augsburg/O=MyCompany/OU=IT/CN=MyName/emailAddress=MyEmail@me.de
Getting Private key
OpenSSL>
```

The command generates an X.509 certificate with the attributes that you transfer with the CSR (in the example "myRequest.csr"), for example with a validity of one year (-days 365). The command also signs the certificate with your private key ("myKey.key" in the example). Your communication partners can use your public key (contained in your certificate) to check that you are in possession of the private key that belongs to this public key. This also prevents your public key from being misused by an attacker.

With self-signed certificates, you yourself confirm that the information in your certificate is correct. There is no independent body that checks your information.

## See also

Handling of the client certificates of the S7-1500 CPU (Page 344)

## 9.2.6 Secure transfer of messages

### Establishing secure connections with OPC UA

OPC UA uses secure connections between client and server. OPC UA checks the identity of the communication partners. OPC UA uses certificates in accordance with X.509-V3 from the ITU (International Telecommunication Union) for client and server authentication. Exception: A secure connection is not established with the "No security" security policy.

### Message security mode

OPC UA uses the following security policies to protect messages:

- No security  
All messages are unsecured. In order to use this security policy, establish a connection to a None end point of a server.
- Signing  
All message are signed. This allows the integrity of the messages received to be checked. Manipulations are detected. In order to use this security policy, establish a connection to a Sign end point of a server.
- Sign & Encrypt  
All messages are signed and encrypted. This allows the integrity of the messages received to be checked. Manipulations are detected. What is more, no attacker can read the content of the message (protection of confidentiality). In order to use this security policy, establish a connection to a "SignAndEncrypt" end point of a server.

The security policies are also named according to the algorithms used. Example: "Basic256Sha256 - Sign & Encrypt" means: Secure endpoint, supports a series of algorithms for 256-bit hashing and 256-bit encryption.

## Layers required

The figure below shows the three layers that are always required for establishing a connection: the transport layer, the secure channel and the session.

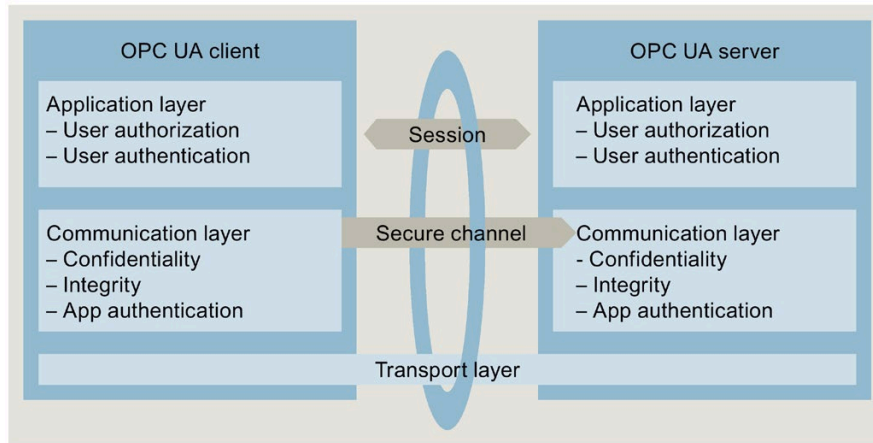


Figure 9-6 Necessary layers: transport layer, secure channel and session

- Transport layer:

This layer sends and receives messages. OPC UA uses an optimized TCP-based binary protocol here. The transport layer is the basis for the subsequent secure channel.

- Secure channel

The secure channel receives the data received from the transport layer, and forwards that data to the session. The secure channel forwards data of the session that is to be sent to the transport layer.

In "Sign" security mode, the secure channel signs the data (messages) that is sent. When a message is received, the secure channel checks the signature to detect any manipulations.

With a "SignAndEncrypt" security policy, the secure channel signs and encrypts the send data. Data received is decrypted by the secure channel, and the secure channel then checks the signature.

With the "No security" security policy, the message packages pass the secure channel unchanged (the messages are received and sent in plain text).

- Session

The session forwards the messages from the secure channel to the application, or receives from the application the messages that are to be sent. The application uses the process values or provides the values.

## Establishing the secure channel

The secure channel is established as follows:

1. The server starts establishing the secure channel when it receives a request to this effect from the client. This request is signed or signed and encrypted, or the message is sent in plain text (security mode of the selected server end point). With "Sign" and "Sign & Encrypt", the client sends a "secret" (random number) with the request.
2. The server validates the client certificate (contained in the request, unencrypted) and checks the identity of the client. If the server trusts the client certificate,
  - it decrypts the message and checks the signature ("Sign & Encrypt"),
  - checks the signature only ("Sign"),
  - or leaves the message unchanged ("No security")
3. The server then sends a response to the client (same level of security as the request). The server secret is contained in the response. The client and server calculate a symmetric key from the client and server secret. The secure channel is now established.

The symmetric key (instead of the private and public key of client and server) is now used for signing and encrypting messages.

## Establishment of the session

The session is executed as follows:

1. The client starts establishing the session by sending a CreateSessionRequest to the server. This message contains a Nonce, a random number that is only used once. The server must sign this random number (Nonce) to prove that it is the owner of the private key. The private key belongs to the certificate that the server uses to establish the secure channel. This message (and all subsequent messages) is secured in line with the security policies of the selected server endpoint (selected security policies).
2. The server responds with the CreateSession Response. This message contains the public key of the server and the signed Nonce. The client checks the signed Nonce.
3. If the server passes the test, the client sends a SessionActivateRequest to the server. This message contains the information that is required for user authentication:
  - User name and password, or
  - X.509 certificate of the user (not supported in STEP 7), or
  - No data (if anonymous access is configured).
4. If the user has the necessary rights, the server returns a message to the client (ActivateSessionResponse). This activates the session.

The secure connection between the OPC UA client and server has been established.

## Establishing a connection to PLCopen function block

The PLCopen specification defines a range of IEC 61131 function blocks for OPC UA clients. The instruction UA\_Connect initiates both a secure channel and a session following the pattern described above.

## 9.2.7 Certificate management via Global Discovery Server (GDS)

### 9.2.7.1 Automated certificate management with GDS

The OPC UA server of the S7-1500 CPU with firmware V2.9 or higher supports certificate management services that can be used, for example, by a Global Discovery Server (GDS).

OPC UA certificates, trust lists and certificate revocation lists (CRLs) for the OPC UA server of the S7-1500 CPU can be updated automatically using GDS push management functions. The automation of the certificate management eliminates any manual work required for reconfiguring the CPU, for example, after a certificate has expired, and a new download of the CPU. You can also use the GDS push management functions to transfer updated certificates and lists in the STOP and RUN operating states of the CPU.

The certificate management information model is specified in OPC UA Part 12 (OPC 10000-12: OPC Unified Architecture, Part 12: Discovery and Global Services).

The following sections provide a general overview of Global Discovery Services and the function of an automated certificate update supported as of TIA Portal V17 / CPU firmware version V2.9.

#### Discovery server

To connect to an OPC UA server, an OPC UA client requires information about its endpoint such as the endpoint URL and the security policy. When a large number of possible servers are available in the network, a discovery server can take over the search and management of this server information.

- OPC UA servers register with the discovery server.
- OPC UA clients request a list of accessible servers from the discovery server and then connect to the desired OPC UA server.

#### Global Discovery Server (GDS)

The OPC UA GDS concept allows the configuration of cross-subnet discovery services on the one hand and provides interfaces for central certificate management on the other hand.

A Global Discovery Server (GDS) makes mechanisms available for the central management of the following components:

- CA-signed certificates and self-signed certificates
- Trusted Lists and Certificate Revocation Lists (CRL)

A GDS thus provides an access point to central certificate management and takes over the task of a security server within an OPC UA network.

The main application of GDS is the management of CA-signed certificates with the corresponding CRLs:

- Initial creation of an OPC UA application certificate
- Regular update of the trust list and the CRLs
- Renewal of the OPC UA application certificate

## Certificate management

Certificate management has the task of automating the administration and distribution of certificates and trust lists for OPC UA applications.

In this context, a distinction is made between the following roles:

- Certificate manager - an OPC UA application that provides certificate management functions
- Certificate recipient – an OPC UA application that receives certificates, trust lists and CRLs from the certificate manager.

There are two models for certificate management: Pull and push management.

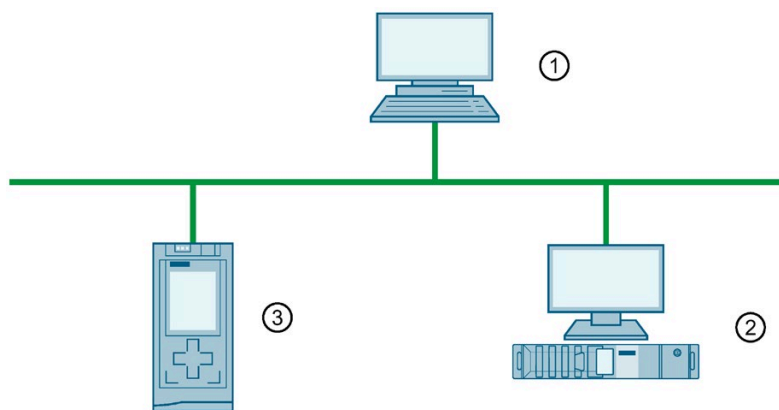
- With pull management, the OPC UA application acts as a client of the GDS server and uses certificate management methods to request certificate updates and trust list updates.
- With push management, the OPC UA application acts as a server and provides methods for an OPC UA GDS as OPC UA client. The GDS in the role of certificate manager uses these methods to transfer ("push") certificates and trusted list updates, see explanation of the concept for automated certificate update below.

As of firmware version V2.9, the S7-1500 CPU currently only supports push management for the OPC UA server of the CPU.

You cannot transfer certificates for the OPC UA client instructions of the CPU to the CPU via push management.

## System configuration with GDS

The figure below shows an example of the tasks of the devices involved in combination with a GDS that provides certificate management functions.



- ① Root CA - device that issues certificates for the system (these certificates can also be transmitted in other ways, for example, by email)
- ② OPC UA GDS with certificate manager creates or signs device certificates, manages trust lists and certificate revocation lists (CRLs), and writes certificates and lists to the devices (push function). This device requires OPC UA client functionality for the push function.
- ③ Device with OPC UA application receives "pushed" certificates and lists

## Concept for automated certificate update for STEP 7 version V17 and higher

GDS and certificate manager are usually combined into one application; however, in the figure below, they are two separate components.

Devices such as "normal" OPC UA clients are also suitable as certificate managers, but they need to support the Bytestring data type that is required to transfer certificates, for example, an S7-1500 CPU firmware V2.9 and higher as OPC UA client or the UA Expert tool (Unified Automation) with GDS plugin.

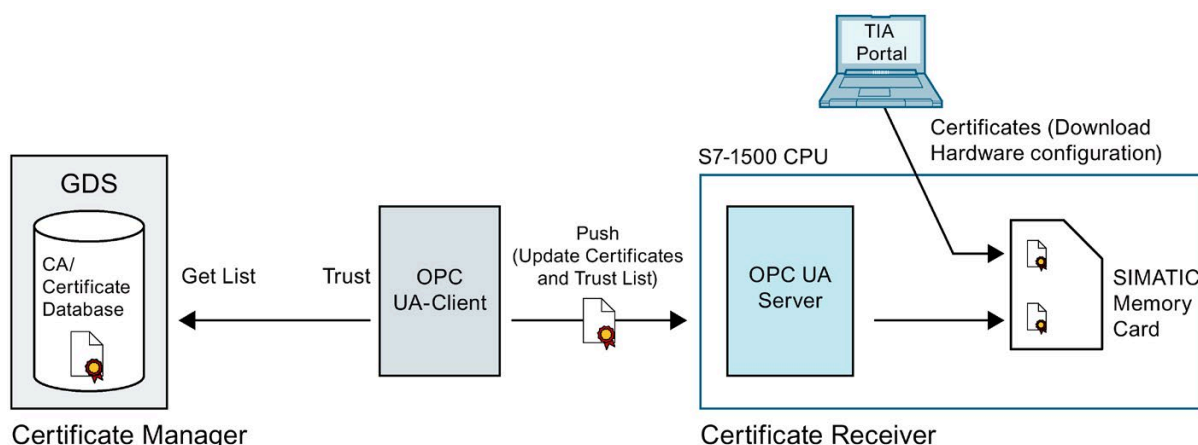
The OPC UA server of the S7-1500 CPU as certificate receiver provides the standardized methods and attributes that the OPC UA client certificates need to read and write trust lists and CRLs.

The focus in the context of the OPC UA server of the S7-1500 CPU is the description of the push function in contrast to the usual manner in which certificates are provided to the CPU: By loading the hardware configuration.

The figure below shows how to transfer certificates and lists for OPC UA in an S7-1500 CPU FW V2.9 or higher:

- Either by loading the hardware configuration in STOP of the CPU; the certificates are part of the hardware configuration.
- Or via GDS push methods in RUN or in STOP mode of the CPU.

It is not possible to use both transmission paths in parallel.



## See also

Certificates with OPC UA (Page 177)

### 9.2.7.2 Configuration limits for Push function

#### Number of certificates for Push function

For the OPC UA Push function, an S7-1500 CPU, regardless of the type, with firmware version V2.9 has a configuration limit of 62 trust list entries.

A Certificate Revocation List entry (CRL) counts just as an entry in the list of trusted certificates.

#### Size of elements for Push function (e.g. certificates)

Max. 4096 bytes

#### Example

You want to grant access to the OPC UA server for up to 62 OPC UA clients and fill the trusted list accordingly.

When you add a Certificate Revocation List entry in the trusted list, you can only trust up to 61 client certificates.

Additional OPC UA certificates can **not** be transferred by loading the hardware configuration to the CPU.

#### Tip

To keep the number of required certificates low, we recommend having the OPC UA client certificates signed by the same CA.

In this case, the CPU as OPC UA server only needs the corresponding CA certificate and CRLs. With these elements, the OPC UA server can then verify all client certificates signed by the CA. This means you do not have to add the individual client certificates to the trusted list.



### 9.2.7.3 Setting and loading GDS parameters

The following describes the settings required for the certificate update.

#### Requirement

- STEP 7 (TIA Portal) V17 or higher
- S7-1500 CPU firmware V2.9 or higher
- Time/date of the CPU is set (generally applies to certificate-based communication)
- The OPC UA server is enabled.
- At least one endpoint with the "Sign & Encrypt" security policy must be configured. The partner must use this endpoint.
- An authenticated user with sufficient function rights is configured  
The user must have a role that has the function right "Manage certificates".  
This function right, in turn, has the following requirements:
  - **Project protection** must be enabled in the project tree: Project tree: "Security settings > Settings > Project protection".
  - In the "OPC UA > General" area of the CPU settings, the following general user management setting must be enabled: "Enable additional user management via project security settings"

The Users and roles with OPC UA function rights (Page 238) section describes how to set the function rights.

#### Activating GDS

When the requirements listed above are met, you must still enable the GDS:

1. In the Inspector window (CPU parameters), go to the "OPC UA > Server > General" area.
2. Enable the "Enable Global Discovery Services (Push)" option.

#### Determining the certificate store used

Certificates that are managed using GDS, are in a different memory area than the certificates that are downloaded via the TIA Portal (STEP 7). When GDS is enabled, the OPC UA server of the CPU should also use certificates from the certificate store whose certificates are managed during runtime.

1. In the CPU settings, go to the "OPC UA > Server > Security > Certificates" area.
2. Select the option "Use certificates managed by certificate management server during runtime".

The other option (use certificates configured and downloaded using TIA Portal) uses the certificates that are downloaded to the CPU from the TIA Portal with the configuration in CPU STOP. Certificates or trust lists cannot be updated in this certificate store during runtime.

## Download to CPU

When downloading the configuration to the CPU, you can delete the certificates that are managed via GDS before the download. When you confirm the deletion, the download is followed by a provisioning phase (see section on commissioning).

When you download the memory card outside of the CPU (card reader), this certificate store is always deleted.

When Global Discovery Services (Push) is activated and no pushed certificates are available, then no separate certificate, trust list or CRL is available for the OPC UA server.

## See also

GDS commissioning (Page 190)

### 9.2.7.4 GDS commissioning

Part 12 of the OPC UA specification distinguishes between a provisioning phase and a run time phase during certificate management.

In the provisioning phase, a GDS or OPC UA client provides initial trust lists and CRLs for clients of the OPC UA server. In this phase, the OPC UA server of the CPU accepts all client certificates and lists it is offered – similar to the "Trusted clients" setting for the OPC UA server that all client certificates are accepted during runtime. This is the only way in which a connection to clients not known to the server is possible. For example, clients that the server cannot authenticate using existing certificates or trust lists until it has received the corresponding client certificate or the corresponding trust list.

The provisioning phase is characterized by lower security; therefore, the provisioning phase is indicated by a lit Maintenance LED and a corresponding diagnostics buffer entry (Maintenance demanded).

During the runtime phase, the existing CRLs are updated, for example, and the certificates and trust lists are renewed. Communication is secure in this phase.

## Requirement

Only authorized users with sufficient function rights can set up a connection in the provisioning phase. The users must have a role with the function right "Manage certificates".

See also Setting and loading GDS parameters (Page 189).

## Rules for the provisioning phase

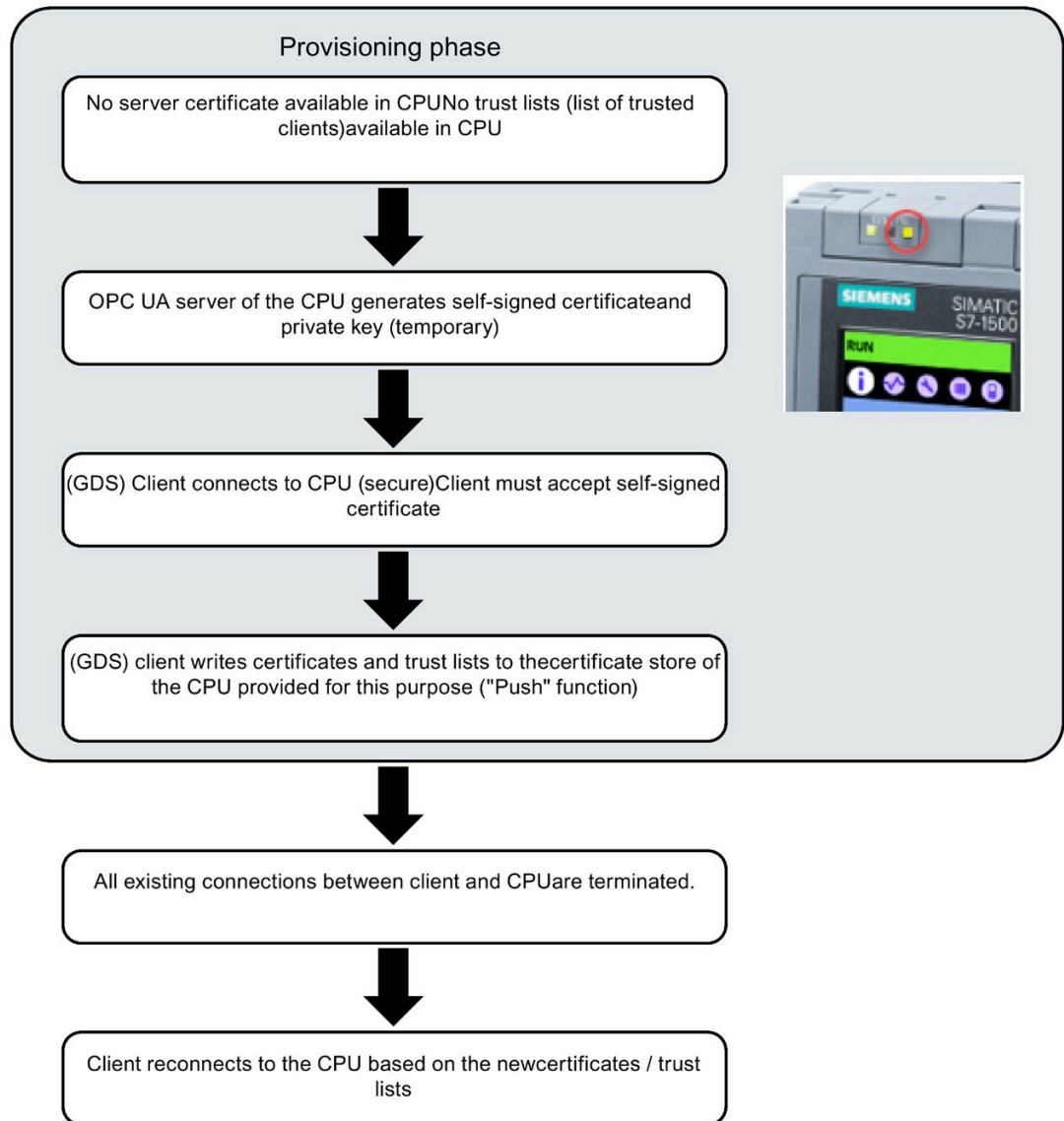
In the provisioning phase, the OPC UA server of the CPU cannot authenticate the OPC UA clients that initiate connection establishment. Therefore, the following rules must be observed:

- Provide a secure environment, for example, access to the CPU is limited to commissioning personnel. Check that the right devices are communicating with one another.
- Limit the time for this phase.

The CPU signals that it is in the provisioning phase by the lit Maintenance LED as well as a corresponding diagnostics buffer entry (Maintenance demanded).

## Sequence of the provisioning phase

The sequence of the provisioning phase is described below.



## Entering the provisioning phase

After startup of the OPC UA server, the CPU automatically enters the provisioning phase when one of the following conditions is met:

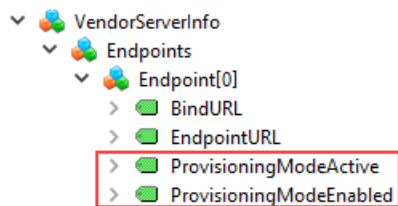
- The OPC UA server certificate is the initial self-signed certificate generated by the CPU and has not yet been replaced by a valid server certificate.
- The trust list (list of trustworthy clients) is empty.

The OPC UA server certificate generated by the CPU contains the most important parameters of the OPC UA server and is re-generated, including the private key, after each startup of the OPC UA server following POWER ON - until the valid server certificate is present. For this reason, the OPC UA server may take longer to start up after a POWER ON.

After the hardware configuration is downloaded, the certificate store for certificates that can be updated during runtime is deleted on download or the certificates are retained, depending on the setting. In other words, if GDS is activated and the certificate store has been deleted, the CPU is in the provisioning phase after loading the hardware configuration.

## Provisioning phase diagnostics

In addition to the lit Maintenance LED, the GDS address model has two nodes that provide information on whether the OPC UA server of the CPU is in the provisioning phase:



You can only use the two nodes as marked in the figure for diagnostics if the requirements for GDS are met (endpoint security signed & encrypted plus administrator function rights available).

ProvisioningModeEnabled: Indicates that a provisioning phase is supported

ProvisioningModeActive: Indicates that the OPC UA server of the CPU is in the provisioning phase.

## End of the provisioning phase

The CPU ends the provisioning phase automatically when the following conditions are met:

- The certificate generated and self-signed by the CPU for the provisioning phase has been overwritten by a valid server certificate. This valid server certificate can be a self-signed certificate or a CA-signed certificate.
- The trust list in the CPU is not empty, i.e. client certificates of the OPC UA clients to be trusted or CA certificates for checking the client certificates are available.

If the OPC UA client transfers a CA-signed certificate and also adds the CA certificate to the trust list, the OPC UA server of the CPU can automatically accept all other certificates from OPC UA clients that were signed by the same CA.

## Request of a valid server certificate

A valid server certificate receives the OPC UA server of the CPU in the following steps:

1. A certificate manager (OPC UA client) calls the "CreateSigningRequest" method to request a server certificate with a Certificate Signing Request (CSR).
2. This CSR must be signed by a Certificate Authority (CA).
3. The signed CSR must then be transferred back to the OPC UA server on the CPU as a server certificate.

The OPC UA server of the CPU makes this method available if the client has the required function right "Manage certificates".

The "CreateSigningRequest" method allows for the following variants:

- Certificate update without creating a new key pair (internal CPU keys that are already available are used)
- Certificate update with creation of a new key pair (CPU-internal)

There is also the possibility to generate certificates with externally created key pairs.

### NOTICE

#### Recommended procedure to generate certificates

Transport of private keys should be avoided; a private key should not leave a device.

We, therefore, recommend the generation of a certificate without creating a new key pair or with the creation of a key pair inside the CPU.

## Create certificate without key pair

- The "CreateSigningRequest" method returns a Certificate Signing Request (CSR), that is, a file (\*.csr) with specific information on the server, for example, application name and URL.
- Outside of the CPU, this CSR must be validated and signed by a Certificate Authority (CA) and returned as a server certificate.
- The server certificate must then be transferred ("pushed") to the CPU using the "UpdateCertificate" method.

The key does not leave the CPU in this scenario.

### Create certificate with internally created key pair

The procedure is similar to the method explained in the previous section; the only difference is that a key pair is generated in addition to the CSR. You specify in the parameter of the "CreateSigningRequest" method that it is to generate a key pair.

The private key does not leave the CPU in this procedure either.

The generation of a new key pair creates a very heavy load on the CPU. The CPU processes this request over a longer period of time with lower priority in the reserved area for the communication load. The duration of this time period depends on the performance of the CPU.

Because the share of the set communication load is fully utilized during key generation over a longer period of time, set the "Scan cycle load due to communication" share so that the maximum cycle time is not exceeded and sufficient reserves are available. For this, use the web server page "Diagnostics > Runtime information" of the CPU. This page shows information about the current program/communication load and cycle time of your user program. Via a controller, you can get help on the effects of a changed communication load on the cycle time.

### Create certificate with externally created key pair

The certificate is generated with the help of tools, for example, that can generate additional keys.

Certificate and keys are transferred to the CPU using the "UpdateCertificate" method.

Due to low security, this procedure is not recommended.

#### NOTICE

#### Different keys for different target systems

Always use newly generated keys for a production system. If you simulate and test your project, e.g. with PLCSIM Advanced on your PC, do not under any circumstances use the keys used for the simulation also for a productive system.

Restrict the access to PC-based controllers by setting up appropriate permissions.

### 9.2.7.5 Address model for the push certificate management

The OPC UA specification Part 12 (OPC 10000-12: Discovery, Global Services) defines methods and attributes for OPC UA servers, for example, that enable GDS or OPC UA clients to update certificates and trust lists on the server ("Push certificate management"). These methods and attributes are also included in the address model of the OPC UA server.

The relevant section in the address model of the OPC UA server of the S7-1500 CPU is explained below.

## Requirement

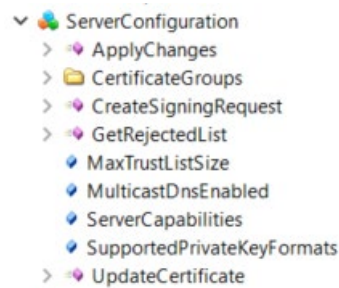
The following requirements must be met for the relevant methods and attributes to become visible for the GDS push functionality:

- GDS is enabled
- The set security policy supports the integrity and confidentiality of the data through a signature and encryption (Sign & Encrypt)
- Access with runtime function right "Manage certificates"

## Address model for the GDS push functionality

The address model for the GDS push functionality corresponds to the "Information Model for Push Certificate Management" of the OPC UA specification OPC 10000-12: Discovery, Global Services.

You will find the following structure below the "ServerConfiguration" node:



## Methods and attributes for access to the address model

The methods and attributes are briefly described below with special features and restrictions of the specific address model of the S7-1500 CPU. The OPC UA specification listed above contains the general description.

You can find a detailed description of the individual methods below this overview table.

| Method / Attribute (Variable) | Description                                                                                                                                                                                                                                                                                                                                                                                                                   |
|-------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| CreateSigningRequest          | Method for generating a PKCS#10-encoded certificate request signed with the private key of the OPC UA server.                                                                                                                                                                                                                                                                                                                 |
| UpdateCertificate             | Method for updating the server certificate for the OPC UA server.                                                                                                                                                                                                                                                                                                                                                             |
| ApplyChanges                  | <p>Method for applying a security-relevant change if the "ApplyChangesRequired" attribute was set when executing a previously executed method.</p> <p><b>Note</b></p> <p>If, as a result of "ApplyChanges", a certificate is changed, the CPU interrupts the connections/sessions that are secured via this certificate.</p> <p>Background: The basis for the secured connections - the certificate - is no longer valid.</p> |

| Method / Attribute (Variable) | Description                                                                                                                                                                                                                                                                                                                                                                                                                                             |
|-------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| GetRejectedList               | Method that returns a list of certificates that were rejected by the OPC UA server.<br>Rejected certificates are currently not stored by the OPC UA server of the S7-1500 CPUs. The method returns an empty array (Rejected-List).                                                                                                                                                                                                                      |
| ServerCapabilities            | Variable is not supported by the OPC UA server of the S7-1500 CPU.                                                                                                                                                                                                                                                                                                                                                                                      |
| SupportedPrivateKeyFormats    | Variable that specifies permitted formats of the private key. For S7-1500 CPUs only "PEM" (String Array)                                                                                                                                                                                                                                                                                                                                                |
| MaxTrustListSize              | Variable that specifies the maximum size of the trust list.                                                                                                                                                                                                                                                                                                                                                                                             |
| MulticastDnsEnabled           | Variable that specifies whether multicast DNS is supported. For S7-1500 CPUs, the value is "False".                                                                                                                                                                                                                                                                                                                                                     |
| CertificateGroups             | Object (directory) that organizes all certificate groups supported by the OPC UA server. The certificate groups contain the objects that can be updated dynamically during runtime: One trust list each and one or multiple certificates that are assigned to an OPC UA application.<br><br>Details on the structure of the CertificateGroups object and the methods and attributes that are available in the object are described in the next section. |

## CreateSigningRequest

The method has the following parameters:

| Parameter                 | Data type  | Description                                                                                                                                                                                                                |
|---------------------------|------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| [in] certificateGroupId   | NodeId     | NodeId of the CertificateGroup object. Only one certificate groups is currently supported by the CPU (DefaultApplicationGroup).                                                                                            |
| [in] certificateTypeId    | NodeId     | Requested certificate type.<br>List of permitted certificate types is specified by the "CertificateTypes" variable of the certificate group.<br>Currently only the certificate type "RsaSha256ApplicationCertificateType". |
| [in] subjectName          | String     | Subject Name that is requested in the Certificate Request. If not specified, the current Subject Name of the certificate is used.                                                                                          |
| [in] regeneratePrivateKey | Boolean    | True: Server generates a new private key. This key is saved until the UpdateCertificate methods with the matching signed certificate is called.<br>False: Server uses the available private key.                           |
| [in] nonce                | ByteString | Additional nonce for generating the new private key (see regeneratePrivateKey). Must be at least 32 bytes long.                                                                                                            |
| [out] certificateRequest  | ByteString | PKCS #10 - DER coded Certificate Request.                                                                                                                                                                                  |



### Method Result Codes

| Result Code          | Description                                                       |
|----------------------|-------------------------------------------------------------------|
| Bad_InvalidArgument  | certificateTypeId, certificateGroupId or subject-Name is invalid. |
| Bad_UserAccessDenied | The current user does not have the required function rights.      |

### UpdateCertificate

Applications:

- Generation of certificate with CreateSigningRequest. No private key is available.
- New private key and new certificate were generated outside of the server. Both are updated with UpdateCertificate.
- Certificate generated and signed with the private key of the existing certificate. No private key is available.

| Parameter                  | Data type  | Description                                                                                                                                                                                                                |
|----------------------------|------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| [in] certificateGroupId    | NodeId     | NodeId of the CertificateGroup object. Only one certificate groups is currently supported by the CPU (DefaultApplicationGroup).                                                                                            |
| [in] certificateTypeId     | NodeId     | Requested certificate type.<br>List of permitted certificate types is specified by the "CertificateTypes" variable of the certificate group.<br>Currently only the certificate type "RsaSha256ApplicationCertificateType". |
| [in] certificate           | ByteString | DER-coded certificate that replaces the existing certificate.                                                                                                                                                              |
| [in] issuerCertificates    | ByteString | Issuer certificates                                                                                                                                                                                                        |
| [in] privateKeyFormat      | String     | Format of the private key. Currently only PEM is supported. If the privateKey is not specified: zero or empty string.                                                                                                      |
| [in] privateKey            | ByteString | Private key coded as specified in privateKeyFormat.                                                                                                                                                                        |
| [out] applyChangesRequired | Boolean    | Indicates that the "ApplyChanges" method must be called before you use the new certificate.                                                                                                                                |

### Method Result Codes

| Result Code              | Description                                                     |
|--------------------------|-----------------------------------------------------------------|
| Bad_InvalidArgument      | certificateTypeId or certificateGroupId is invalid.             |
| Bad_CertificateInvalid   | The certificate is invalid or the format is not supported.      |
| Bad_NotSupported         | The private key is invalid or the format is not supported.      |
| Bad_UserAccessDenied     | The current user does not have the required function rights.    |
| Bad_SecurityChecksFailed | Error occurred when verifying the integrity of the certificate. |

### Apply Changes

The method has no parameters.

### Method Result Codes

| Result Code          | Description                                                  |
|----------------------|--------------------------------------------------------------|
| Bad_UserAccessDenied | The current user does not have the required function rights. |

### GetRejectedList

The method has the following parameters:

| Parameter          | Data type   | Description                                                                                                                                         |
|--------------------|-------------|-----------------------------------------------------------------------------------------------------------------------------------------------------|
| [out] certificates | ByteStrings | DER-coded list of rejected certificates.<br>The method currently returns an empty list (empty array), because rejected certificates are not stored. |

### Method Result Codes

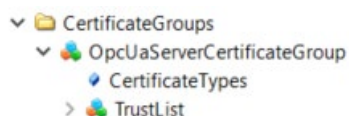
| Result Code          | Description                                                  |
|----------------------|--------------------------------------------------------------|
| Bad_UserAccessDenied | The current user does not have the required function rights. |

### 9.2.7.6 CertificateGroups in the address model

Certificates and trust lists for the OPC UA server that can be updated during runtime are located in the address model in the "CertificateGroups" object - for the OPC UA server of the S7-1500 CPU there is exactly one certificate group called "OpcUaServerGroup".

#### CertificateGroup in the address model

The following figure shows the structure of the "CertificateGroups" object below the "ServerConfiguration" node.



You can change the Display Name of the "OpcUaServerGroup" group in STEP 7 (TIA Portal):

1. In the Inspector window (CPU properties), go to the "OPC UA > Server > Certificates" area.
2. Select the option "Use certificates managed by certificate management server during runtime".
3. Change the group name (DisplayName) of the certificate group in the table below. 1-64 characters in 7-bit ASCII format are permitted.

#### "CertificateTypes" node

The "CertificateTypes" variable specifies the NodeIds of the certificate types that are assigned to the server application.

Currently, only "RsaSha256ApplicationCertificateType" is supported.

#### "TrustList" node

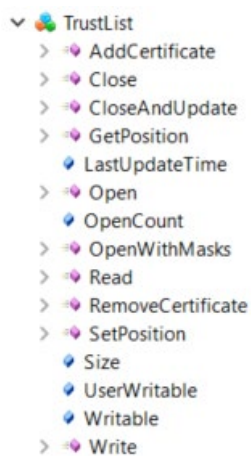
The node for the trust list object (TrustList file) defines an OPC UA file type (Binary encoded stream) that contains information on the certificates and CRLs that can be read and updated in the "pki store\trusted\issuer" directory of the Memory Card. This node provides methods and attributes that make reading and updating possible.

The node is an instance of the OPC UA data type "TrustListDataType" with the following structure:

| Parameter           | Data type       | Description                                                                               |
|---------------------|-----------------|-------------------------------------------------------------------------------------------|
| specifiedLists      | TrustListsMasks | Bit mask that shows which lists contain information.                                      |
| trustedCertificates | ByteStrings     | List of the trusted application certificates and CA certificates.                         |
| trustedCrls         | ByteStrings     | CRLs for the certificates in the "trustedCertificates" list.                              |
| issuerCertificates  | ByteStrings     | List of the CA certificates that are necessary for validating the CA-signed certificates. |
| issuerCrls          | ByteStrings     | CRLs of the CA certificates in the "issuerCertificates" list.                             |

## Structure of the "TrustList" node

The "TrustList" node has the following structure:



## Methods and attributes for the "TrustList" node

Below is a description of the nodes under "TrustList" that supplement the methods of the Object Type "FileType". The TrustList Type is derived from FileType (see OPC 10000-5: OPC Unified Architecture, Part 5: Information Model).

| Method / Attribute (Variable) | Description                                                        |
|-------------------------------|--------------------------------------------------------------------|
| LastUpdateTime                | Variable that shows the time of the last update.                   |
| OpenWithMasks                 | Method that permits a client to only read a part of the TrustList. |
| CloseAndUpdate                | Method for closing the TrustList file and applying the changes.    |
| AddCertificate                | Method for adding a single certificate to the TrustList.           |
| RemoveCertificate             | Method for removing a single certificate from the TrustList.       |

## Description of the methods

The description of the methods with their result codes, attributes and types of the TrustList object is available in the OPC UA specification Part 12, Discovery and Global Services.

## 9.3 Using the S7-1500 as an OPC UA server

### 9.3.1 Interesting information about the OPC UA server of the S7-1500 CPUs

#### 9.3.1.1 The OPC UA server of the S7-1500 CPUs

The S7-1500 CPUs as of firmware V2.0 are equipped with an OPC UA server. Apart from the Standard-S7-1500 CPUs this applies to the variants S7-1500F, S7-1500T, S7-1500C, S7-1500pro CPUs, ET 200SP CPUs, SIMATIC S7-1500 SW controllers and PLCSIM Advanced.

Convention: "S7-1500 CPUs" also includes the above-mentioned CPU variants.

#### S7-1500 CPU OPC UA server basics

Access to the OPC UA server of the CPU is possible via all integrated PROFINET interfaces of the S7-1500 CPU.

Direct access to the OPC UA server of the CPU over the backplane bus of the automation system is not possible via CPs under the following conditions:

- Configuration with TIA Portal Version V16 or higher
- S7-1500 CPU firmware version 2.8 or higher and CP 1543-1 firmware version V2.2 or higher

For configuration, see Access to OPC UA applications (Page 157).

Direct access to the OPC UA server of the CPU over the backplane bus of the automation system is not possible via CMs.

For access by clients, the server saves the enabled PLC tags and other information in the form of nodes (see Configuring access to PLC tags (Page 208)). These nodes are interconnected and form a network. OPC UA defines access points to this network (well-known nodes) that enable navigation to subordinate nodes.

With an OPC UA client you can read, observe or write values of tags of the PLC program as well as call methods that are available to the server. As of firmware version 2.5 you can implement methods, see Useful information about server methods (Page 279).

## Node classes

OPC UA servers provide information in the form of nodes. A node can be, for example, an object, a tag, a method or a property.

The example below shows the address space of the OPC UA server of an S7-1500 CPU (extract from the OPC UA client "UaExpert" from Unified Automation).

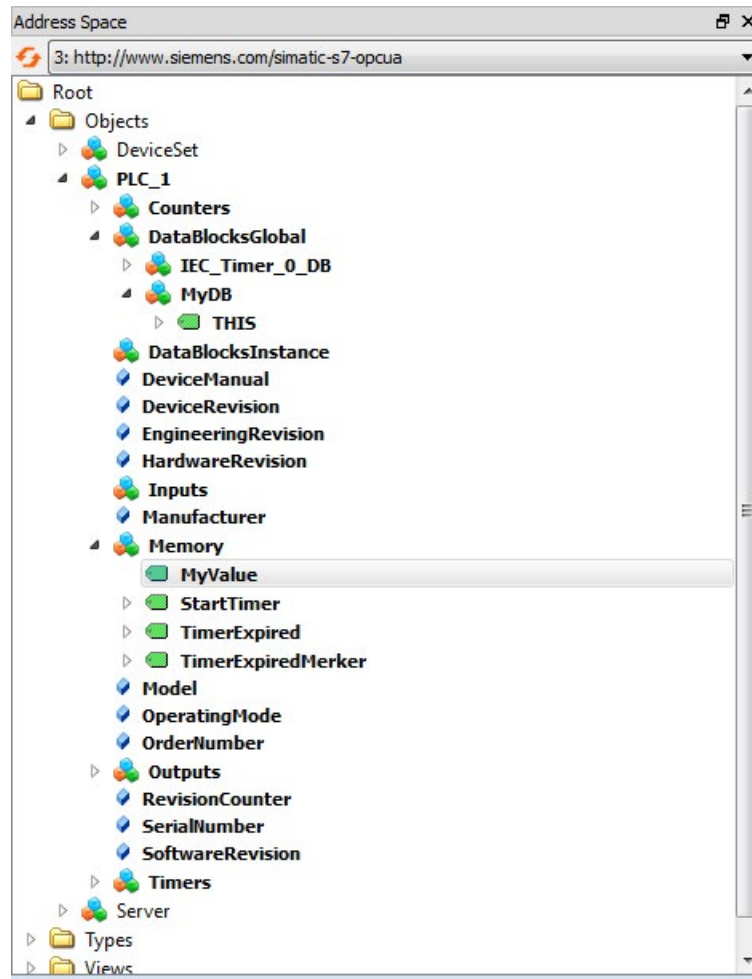


Figure 9-7 Example of the address space of the OPC UA server of an S7-1500 CPU

In the figure above, the "MyValue" tag is selected (highlighted in gray).

This tag is located below the "Memory" node, which has the node class "Object".

"Memory" is below the "PLC\_1" node (also an Object).

## Address space

The nodes are linked over references, for example, the reference "HasComponent", which represents a hierarchical relationship between a node and its subordinate nodes. With their references, the nodes form a network that can, for example, take the form of a tree.

A network of nodes is also called an address space. Starting from the root, all nodes can be reached in the address space.

### 9.3.1.2 End points of the OPC UA server

The end points of the OPC UA server define the security level for a connection. Depending on the purpose of use or desired security level, you have to carry out the corresponding settings for the connection at the end point.

## Different security settings

Before establishing a secure connection, OPC UA clients ask the server with which security settings connections are possible. The server returns a list with all the security settings (endpoints) that the server offers.

## Structure of end points

End points consist of the following components:

- Identifier for OPC: "opc.tcp"
- IP address: 192.168.178.151 (in the example)
- Port number for OPC UA: 4840 (standard port)  
The port number can be configured.
- Security setting for messages (Message Security Mode): None, Sign, SignAndEncrypt.
- Encryption and hash procedures (Security Policy): None, Basic128Rsa15, Basic256, Basic256Sha256 (in the example).

The following figure shows the "UA Sample Client" of the OPC Foundation.

The client has established a secure connection to the OPC UA server of an S7-1500 CPU to the end point "opc.tcp://192.168.178.151:4840 - [SignAndEncrypt: Basic256Sha256:Binary]". The security settings "SignAndEncrypt:Basic256Sha256" are contained in the end point.

---

### Note

#### Select an endpoint with as strict as possible a security policy

Select an application-appropriate security policy for the end point and disable the less strict security policy at the OPC UA server.

A Sha256 certificate is required for the most secure end points (Basic256Sha256) of the S7-1500 CPU OPC UA server.

---

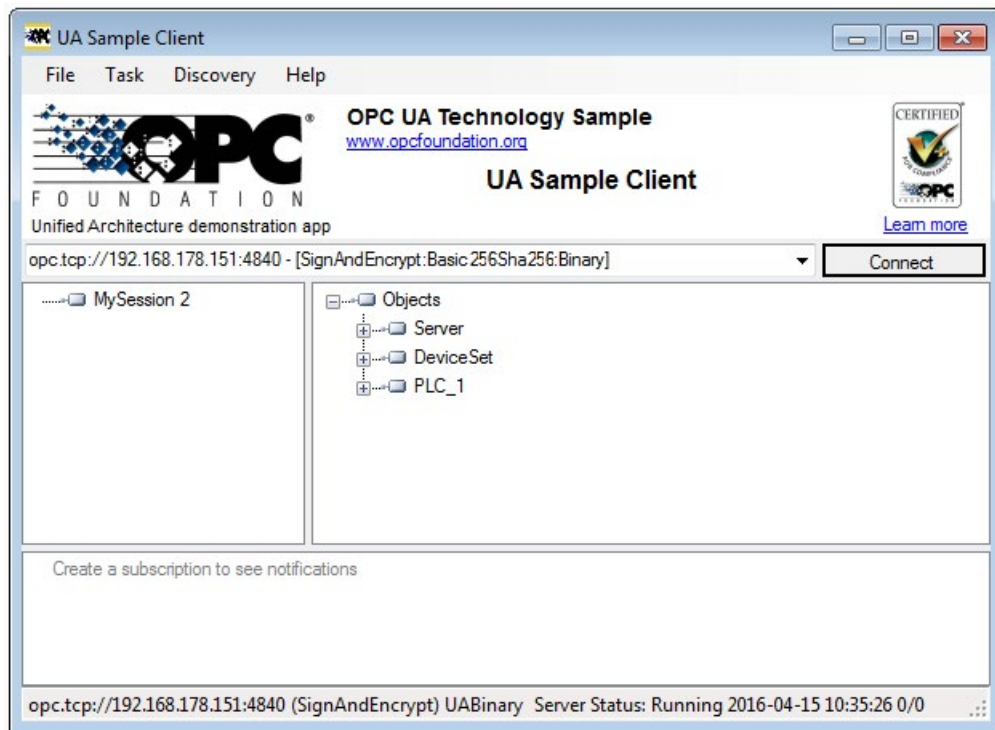


Figure 9-8 "UA Sample Client" program of the OPC Foundation

A connection to a server end point is only established if the OPC UA client complies with the security policies of that end point.

### Through the information provided by the OPC UA server

OPC UA servers provide a wide range of information:

- The values of PLC tabs and DB components which clients may access.
- The data types of these PLC tags and DB components.
- Information on the OPC UA server itself and on the CPU.

This gives clients an overview and allows them to read out specific information. Previous knowledge of the PLC program and the CPU data is not required. You do not need to ask the developer of the PLC program when PLC tags are to be read. All necessary information is stored on the server itself (for example, the data types of the PLC tags).



## Display of the information of the OPC UA server

You have the following options:

- Online: You have all the available information displayed during the runtime of the OPC UA server. To do so, navigate (browse) the address space of the server.
- Offline: You export an XML file that is based on the XML schemes of the OPC Foundation. Server methods created by the user (FB instance that can be called by an OPC UA client) are not exported as of STEP 7 V15.1), see Providing methods on the OPC UA server (Page 279).
- Offline with the Openness API: In your program, you use the API (Application Programming Interface) of the TIA Portal to access the function for exporting all PLC tags that can be read by OPC UA. This requires .NET Framework 4.0; see TIA Portal Openness, Automating SIMATIC projects with scripts (<https://support.industry.siemens.com/cs/ww/en/view/109477163>).
- If you already know the syntax and the PLC program, you can access the OPC UA server without first researching the information.

### 9.3.1.3 Runtime behavior of the OPC UA server

#### OPC UA server in operation

The OPC UA server of the S7-1500 CPU starts when you activate the server and download the project to the CPU.

How to activate the OPC UA server is described here.

#### Behavior in the operating state STOP of the CPU

An activated OPC UA server remains in operation even if the CPU switches to "STOP". The OPC UA server continues to respond to requests from OPC UA clients.

Server response in detail:

- If you request the values of PLC tags, you will get what were the latest values before the CPU switched to or was set to "STOP".
- If you write values to the OPC UA server, the OPC UA server will accept those values.

However, the CPU will not process the values because the user program is not executed in "STOP" mode.

An OPC UA client can nonetheless read the values written at STOP from the OPC UA server of the CPU.

During restart, the CPU overwrites the values written at STOP with the start of the PLC tags.

- If you call a server method, the error message 16#00AF\_0000 (BadInvalidState) is output because the server method (user program) is not running.
- Connections to the OPC UA server remain active during an operating mode transition (STOP > RUN or RUN > STOP). Exception: OPC UA-relevant data is loaded, see next section.

## Download to the CPU may affect OPC UA server

If you load a CPU with running OPC UA server, you may need to stop and restart the server depending on the loaded objects. In this case, active connections are interrupted and must be re-established once the server restarts.

The duration of the restart depends mainly on the following parameters:

- The scope of the data structure
- The number of variables visible in the OPC UA address space
- The setting for downward compatible data type definition according to OPC UA specification to V1.03 (TypeDictionary enabled)
- Settings for the communication load and minimum cycle time, you can find additional information here (Page 354)

With CPU FW versions older than V2.8, the OPC UA server was stopped at each download to the CPU and then restarted.

As of FW version V2.8, the behavior of the OPC UA server has been optimized as follows:

- When objects are downloaded in STOP operating state of the CPU, the OPC UA server still always stops and then restarts. STEP 7 does not show a warning in this case.
- When objects are downloaded in RUN operating state of the CPU, the OPC UA server only stops if the downloaded objects are, or could be, OPC UA-relevant. The OPC UA server restarts after re-initialization due to the modified OPC UA data.

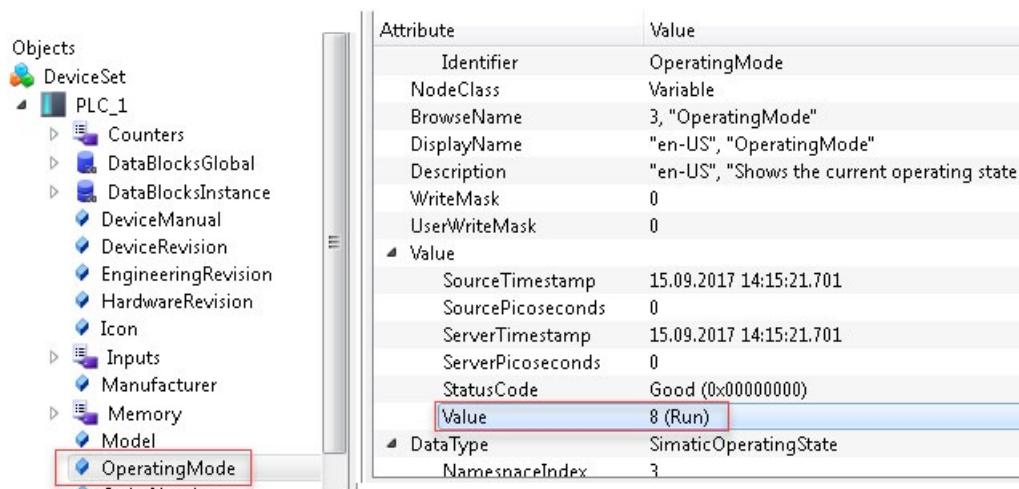
Before OPC-UA-relevant objects are loaded into the CPU and stop the OPC UA server, STEP 7 displays a warning in the preview dialog for loading. You can then decide whether a server restart is compatible for the running process or whether you want to cancel the download. These warnings are only displayed when the OPC UA server is running. If the OPC UA server is not enabled, modified OPC UA data have no influence on the download process.

### Examples

- You only want to add another code module to the program.  
Neither data blocks nor inputs, outputs, flags, times or counters are affected.  
Reaction during loading: A running OPC UA server is not interrupted.
- You want to load a new data module and you have flagged the data module as non-OPC-UA-relevant:  
Reaction during loading: A running OPC UA server is not interrupted.
- You want to overwrite a data module.  
Reaction during loading: A warning appears that the server will be restarted.  
Background: STEP 7 cannot determine whether the changes refer to OPC-UA-relevant data or not.

## Reading CPU operating mode over OPC UA server

The OPC UA server allows you to read out the CPU mode, see figure below:



| Attribute         | Value                                        |
|-------------------|----------------------------------------------|
| Identifier        | OperatingMode                                |
| NodeClass         | Variable                                     |
| BrowseName        | 3, "OperatingMode"                           |
| DisplayName       | "en-US", "OperatingMode"                     |
| Description       | "en-US", "Shows the current operating state" |
| WriteMask         | 0                                            |
| UserWriteMask     | 0                                            |
| Value             | 8 (Run)                                      |
| SourceTimestamp   | 15.09.2017 14:15:21.701                      |
| SourcePicoSeconds | 0                                            |
| ServerTimestamp   | 15.09.2017 14:15:21.701                      |
| ServerPicoSeconds | 0                                            |
| StatusCode        | Good (0x00000000)                            |
| DataType          | SimaticOperatingState                        |
| NamespaceIndex    | 3                                            |

Figure 9-9 Reading CPU operating mode over OPC UA server

In addition to the operating mode of the CPU you can, for example, read out information in the manual (DeviceManual) or firmware version (HardwareRevision).

## 9.3.2 Configuring access to PLC tags

### 9.3.2.1 Managing write and read rights

#### Enabling PLC tags and DB tags for OPC UA

OPC UA clients can have read and write access to PLC tags and DB tags if the tags are enabled for OPC UA (default setting). For an enabled tag the check box "Accessible from HMI/OPC UA" is activated.

You can change the default setting in the settings of the TIA Portal: Command "Settings > PLC programming > General" in "Options" menu. You will find the corresponding options in the "Block interface/data block elements" area.

The following example shows an array data block:

| MyDB    |                  |                                     |                                     |                                     |  |
|---------|------------------|-------------------------------------|-------------------------------------|-------------------------------------|--|
| Name    | Data type        | Accessible from HMI/OPC UA          | Writable from HMI/OPC UA            | Visible in HMI engineering          |  |
| MyDB    | Array[0..9] o... | <input checked="" type="checkbox"/> | <input checked="" type="checkbox"/> | <input checked="" type="checkbox"/> |  |
| MyDB[0] | Int              | <input checked="" type="checkbox"/> | <input checked="" type="checkbox"/> | <input checked="" type="checkbox"/> |  |
| MyDB[1] | Int              | <input checked="" type="checkbox"/> | <input checked="" type="checkbox"/> | <input checked="" type="checkbox"/> |  |
| MyDB[2] | Int              | <input checked="" type="checkbox"/> | <input checked="" type="checkbox"/> | <input checked="" type="checkbox"/> |  |
| MyDB[3] | Int              | <input checked="" type="checkbox"/> | <input checked="" type="checkbox"/> | <input checked="" type="checkbox"/> |  |
| MyDB[4] | Int              | <input checked="" type="checkbox"/> | <input checked="" type="checkbox"/> | <input checked="" type="checkbox"/> |  |
| MyDB[5] | Int              | <input checked="" type="checkbox"/> | <input checked="" type="checkbox"/> | <input checked="" type="checkbox"/> |  |
| MyDB[6] | Int              | <input checked="" type="checkbox"/> | <input checked="" type="checkbox"/> | <input checked="" type="checkbox"/> |  |
| MyDB[7] | Int              | <input checked="" type="checkbox"/> | <input checked="" type="checkbox"/> | <input checked="" type="checkbox"/> |  |
| MyDB[8] | Int              | <input checked="" type="checkbox"/> | <input checked="" type="checkbox"/> | <input checked="" type="checkbox"/> |  |
| MyDB[9] | Int              | <input checked="" type="checkbox"/> | <input checked="" type="checkbox"/> | <input checked="" type="checkbox"/> |  |

Figure 9-10 Enabling PLC tags and DB tags for OPC UA tags

This array can be read completely in one pass by OPC UA clients (see Addressing nodes (Page 161)). The check boxes at "Accessible from HMI/OPC UA" and "Writable from HMI/OPC UA" are activated for all the components of the array.

Result: OPC UA clients can both read and write these components.

#### Removing write rights

If you want to write-protect a tag, deselect the "Writable from HMI/OPC UA" option for that tag. This removes the write right for the OPC UA clients and HMI devices.

Result: Only read access by OPC UA clients and HMI devices is possible. OPC UA clients cannot assign values to this tag and therefore cannot influence execution of the S7 program.

#### Removing write and read rights

To write-protect and read-protect a tag, disable the "Accessible from HMI/OPC UA" option for that tag (checkbox not selected). This makes the OPC UA server remove the tag from its address space. OPC UA clients can no longer see that CPU tag.

Result: OPC UA clients and HMI devices can neither read nor write the tag.

## Write and read rights of structures

If you remove the read or write right for the component of a structure, the structure or the data block cannot be written or read as a whole.

If you remove read and write rights for individual components of a PLC data type (UDT), the rights will also be removed from any data block based on that data type!

## Visible in HMI engineering

The option "Visible in HMI Engineering" applies to Siemens engineering tools. If you disable the option "Visible in HMI Engineering" (check mark not set), you can no longer configure the tag in WinCC (TIA Portal).

The option does not have any effect on OPC UA.

## Rules

- Only allow read access to PLC tags and tags of data blocks in STEP 7 if this is necessary for communication with other systems (controllers, embedded systems or MES).  
You should not enable other PLC tags.
- Only allow write access over OPC UA if write rights are genuinely necessary for specific PLC tags and tags of data blocks.
- If you have reset the "Accessible from HMI/OPC UA" option for all elements of a data block, the data block for an OPC UA client is no longer visible in the address space of the OPC UA server of the S7-1500 CPU.
- You can also prevent access to an entire data block centrally (see Managing write and read rights for a complete DB (Page 209)). This setting "overrides" the settings for the components in the DB editor.

## See also

Coordinating write and read rights for CPU tags (Page 211)

### 9.3.2.2 Managing write and read rights for a complete DB

#### Hiding DBs or DB contents for OPC UA clients

You can easily prevent access to a complete data block by an OPC UA client.

With this option, the data of the corresponding DB, including instance DBs of function blocks, remains hidden for OPC UA clients.

In the default setting, data blocks can be read and written from OPC UA clients. You can change this default setting in the settings of the TIA Portal: Command "Settings > PLC programming > General" in "Options" menu. You will find the corresponding option in the "Default settings for new blocks" area.

## Procedure

Proceed as follows to completely hide a data block for OPC UA clients or to protect a data block from write access from OPC UA clients:

1. Select the data block to be protected in the project tree.
2. Select the "Properties" shortcut menu.
3. Select the "Attributes" area.
4. Select/clear the "DB accessible from OPC UA" checkbox as required.

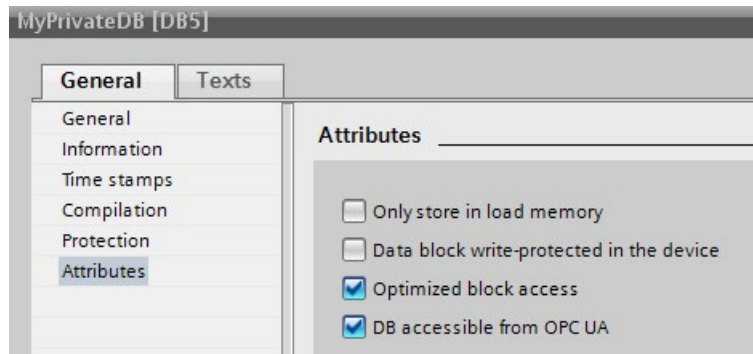


Figure 9-11 Hiding DBs or DB contents for OPC UA clients

### Note

#### Effect on settings in the DB editor

If you hide a DB using the DB attribute described here, the settings for the components in the DB editor are no longer relevant; individual components can no longer be accessed or written.

## Tip: Using the overview of all program blocks

If you are using multiple data blocks, it is appropriate to use the detailed overview of the "Program blocks" folder for selective activation or deactivation of the OPC UA accessibility.

Follow these steps:

1. Select the "Program blocks" folder in the project tree.
2. Select the "Overview" command in the "View" menu.
3. Select the "Details" tab.

An overview of the blocks with their attributes is displayed.

4. Ensure that the "Data block accessible via OPC UA" column is selected.
5. Select only the data blocks that are to be accessible via OPC UA.

|                        | Name               | Data block accessible from OPC UA   | Comment         |
|------------------------|--------------------|-------------------------------------|-----------------|
| Projekt761             | Add new block      | <input type="checkbox"/>            |                 |
| PLC_1 [CPU 1518-4 P... | Main [OB1]         | <input type="checkbox"/>            |                 |
| Software units         | myPrivateDB1 [DB1] | <input checked="" type="checkbox"/> | OPC UA relevant |
| Program blocks         | myPrivateDB2 [DB1] | <input type="checkbox"/>            | local data      |
| Technology objects     | myPrivateDB3 [DB1] | <input checked="" type="checkbox"/> | OPC UA relevant |

Figure 9-12 Overview of the program blocks

### 9.3.2.3 Coordinating write and read rights for CPU tags

#### Definition of write and read rights in the information model (OPC UA XML)

In the OPC UA information model, the attribute "AccessLevel" regulates access to tags.

AccessLevel is defined bit by bit:

Bit 0 = CurrentRead and Bit 1 = CurrentWrite. The meaning of the bit combinations is as follows:

- AccessLevel = 0: no access
- AccessLevel = 1: read only
- AccessLevel = 2: write only
- AccessLevel = 3: read+write

#### Example of the assignment of write and read rights (read+write)

```
<UAVariable NodeId="ns=3;s="Data_block_2";."Static_1";"
BrowseName="3:Static_1"
ParentNodeId="ns=3;s="Data_block_2";"
DataType="INT"
AccessLevel="3">
  <DisplayName>Static_1</DisplayName>
```

#### Definition of write and read rights in STEP 7

When you define tags, you specify the access rights using the properties "Accessible from HMI/OPC UA" and "Writable from HMI/OPC UA".

#### Example of the assignment of write and read rights

| Name      | Data type                                                                           | Accessible from HMI/OPC UA          | Writable from HMI/OPC UA            |
|-----------|-------------------------------------------------------------------------------------|-------------------------------------|-------------------------------------|
| Static_1  | Int                                                                                 | <input checked="" type="checkbox"/> | <input checked="" type="checkbox"/> |
| <Add new> |  | <input checked="" type="checkbox"/> | <input checked="" type="checkbox"/> |

Figure 9-13 Example of the assignment of write and read rights

## Interaction between write and read rights

If you have imported an OPC UA server interface and AccessLevel attributes are set in this OPC UA XML file, the write and read rights are defined by the following rule: The least extensive access rights for each setting apply.

### Example

- AccessLevel = 1 (read only) in the OPC UA server interface
- Both "Accessible from HMI/OPC UA" and "Writable from HMI/OPC UA" are selected in the PLC tag table

Result: This tag can only be read.

## Rules

If write rights are required:

- AccessLevel = 2 oder 3
- "Writable from HMI/OPC UA" enabled

If read rights are required:

- AccessLevel = 1 (AccessLevel 3 is also possible, but misleading. The settings suggests that an OPC UA client has write and read rights)
- "Accessible from HMI/OPC UA" enabled, "Writable from HMI/OPC UA" disabled

If neither read nor write rights are to be granted (no access):

- AccessLevel = 0
- "Accessible from HMI/OPC UA" disabled

Only one of the two conditions needs to be met to block all access. In this case, review whether the tag in the OPC UA server interface is actually necessary at all.



## Access table

"Accessible from HMI/OPC UA" must be set if access over OPC UA is to be possible at all.  
 "Writable from HMI/OPC UA" must be set to allow an OPC UA client to write a tag / DB element.

Please see the table for the resulting access right.

Table 9- 2 Access table

| OPC UA XML  | STEP 7 (TIA Portal), for example tag table |                          |                        |
|-------------|--------------------------------------------|--------------------------|------------------------|
| AccessLevel | Accessible from HMI/OPC UA                 | Writable from HMI/OPC UA | Resulting access right |
| 0           | x                                          | x                        | No access              |
| x           | 0                                          | x                        | No access              |
| 1           | Enabled                                    | x                        | Read only              |
| 2           | Enabled                                    | Disabled                 | No access              |
| 3           | Enabled                                    | Disabled                 | Read only              |
| 2           | Enabled                                    | Enabled                  | Write only             |
| 3           | Enabled                                    | Enabled                  | Read+write             |

(x = don't care)

## See also

Consistency of CPU tags (Page 213)

Managing write and read rights (Page 208)

### 9.3.2.4 Consistency of CPU tags

#### "AccessLevelEx" attribute extends access properties

As of firmware version V2.6, the OPC UA server of the S7-1500 CPU supports not only the attribute "AccessLevel" (see Coordinating write and read rights for CPU tags (Page 211)) but also the attribute "AccessLevelEx" which, in addition to the already explained bits for read access and write access, provides information on the consistency of a OPC UA tag. The new attribute was introduced with version V1.04 of the OPC UA specification (Part 3, Address Space Model).

## Reading consistency properties

In the OPC UA information model of the OPC UA server, the attribute "AccessLevel" defines the access.

AccessLevelEx is defined bit by bit; in this case the relevant bits are:

- Bit 0 = CurrentRead
- Bit 1 = CurrentWrite
- Bits 2 to 7 are not relevant for the OPC UA server of an S7-1500 CPU

The meaning of the bit combinations is explained in the section on read and write rights.

The following bits for consistency are also added:

- Bit 8 = NonatomicRead; the bit is set if the tag cannot be read consistently. For read consistency of tags, bit 8=0.
- Bit 9 = NonatomicWrite; is set if the tag cannot be written consistently. For write consistency of tags, or if no write access is granted, bit 9=0.

### Examples

An OPC UA tag (structure) is readable and writable; but inconsistent for reading and writing access.

Consequently: Bits 0, 1, 8 and 9 are set: AccessLevelEx = "771" (1+2+256+512).

Another structure is read-only.

Consequently: Bits 0 and 8 are set, bit 1 and bit 9 are not set: AccessLevelEx = "257" (1+0+256+0).

## Handling of the attribute in the server

The "AccessLevelEx" attribute is only available in the OPC UA server. The attribute is not present in a node set file (XML export file).

However, the attribute "AccessLevel", which is exported, includes the information from "AccessLevelEx", see next section.

### Export

During XML export of the standard SIMATIC server interface, the server sets the "AccessLevel" attribute, which was expanded to 32 bits in V1.04 compared to V1.03, to the value of the "AccessLevelEx" attribute.

### Import

When importing a node set file (e.g. from an export of a server interface), the S7-1500 CPU sets the attribute "AccessLevelEx" according to its own estimate of the consistency of the imported data type, see next section. The imported value is ignored.

## Consistency of data types at the server interface

The consistency of tags ("atomicity" in the language usage of OPC UA) within a program cycle of an S7-1500 CPU is ensured at the nodes of the server interface for the following data types:

- BOOL, BYTE, WORD, DWORD, LWORD
- SINT, INT, LINT, DINT, USINT, UINT, ULINT, UDINT
- REAL, LREAL
- DATE, LDT, TIME, LTIME, TIME\_OF\_DAY, LTIME\_OF\_DAY, S5TIME
- CHAR, WCHAR
- System data types and hardware data types that are based on the above-mentioned data types are also consistent.

Example: HW\_ANY, derived from UINT (UInt16).

**Tip:** If you browse in the address space of the S7-1500 CPU (e.g. with the OPC UA Client UaExpert), you can find the consistent data types under Types > BaseDataType > Enumeration/Number/String.

Tags of the following data types are **not** consistent ("nonatomic" in the language usage of OPC UA):

- SIMATIC structures are generally not consistent. This means that all tags which, for example, have unknown structures or a UDT data type are not consistent.
- System data types such as DTL, IEC\_Counter, IEC\_TIMER, etc. are data types that are derived from structures.

**Tip:** If you browse in the address space of the S7-1500 CPU (e.g. with the OPC UA Client UaExpert), you can find data types based on structures under Types > BaseDataType > Structure.

### 9.3.2.5 Accessing OPC UA server data

#### High performance in line with application

OPC UA is designed for the transfer of a high volume of data within a short period of time. You can increase the performance significantly if you do not access individual PLC tags, but rather read and write arrays and structures as a whole.

It is fastest to access arrays. Therefore, you should combine the data for OPC UA clients into arrays.

#### Recommendations for access to the OPC UA server by the OPC UA client

- For one-off or infrequent data access, use standard read/write access.
- For cyclic access to small amounts of data (up to ca. every 5 seconds), use subscriptions.

Optimize the settings for the smallest publishing interval and the smallest sampling interval at the OPC UA server.

- If you access specific tags regularly (recurring access), you should use the functions "RegisteredRead" and "RegisteredWrite".

Allow a greater communication load for the PLC by increasing the value for "Cycle load due to communication". Make sure that your application still works properly with the changed settings.

#### Procedure for creating an array DB

You can create arrays for example in global data blocks, in the instance data block of a function block or as an array DB. The following sections describe how to create an Array-DB.

To create a data block with an array (array data block), follow these steps:

1. Select the CPU with the OPC UA server in the project tree.
2. Double-click "Program blocks".
3. Double-click "Add new block".
4. Click "Data block".
5. Select a unique name for the data block and accept the name that is already entered.
6. Select the "Array DB" entry from the drop-down list for "Type".
7. Select the data type for the individual components of the array from the drop-down list for "Array data type".
8. Enter the high limit of the array for "Array limit".
9. Click "OK".

### 9.3.2.6 MinimumSamplingInterval attribute

#### MinimumSamplingInterval attribute of tags

In addition to "Value", "DataType" and "AccessLevel", you can also set the "MinimumSamplingInterval" attribute for a tag in the XML file that represents the server address space.

The attribute specifies how fast the server can sample the tag value.

The OPC UA server of the S7-1500 CPU handles the values for MinimumSamplingInterval as follows:

- Negative values and values greater than 4294967 are set to -1; this means: The minimum sampling rate is indeterminate. The server does not specify how fast the tag value can be sampled.
- Decimal numbers are rounded to three decimal places.

### 9.3.2.7 Export OPC UA XML file

#### Generating an OPC UA export file

The OPC Foundation has specified a standard XML-based format for describing information models. It allows the information model of an OPC UA server to be provided to a client in advance, or information models can be downloaded to an OPC UA server. A file in this format is called a nodeset file because it describes an information model as a set of nodes.

With STEP 7 (TIA Portal) you can easily export the standard SIMATIC information model of the S7-1500 CPU as a server to an OPC UA XML file (node set file); including all PLC variables and methods you have enabled for OPC UA.

You use the OPC UA XML file for the offline configuration of an OPC UA client; it is structured according to the OPC UA specification and acts as a standard SIMATIC server interface.

To create and export the OPC UA XML file, follow these steps:

1. Select the CPU. Click on the CPU symbol (for example in the network view).
2. Click "General > OPC UA > Server > Export" in the properties of the CPU.
3. Click "Export OPC UA XML file".
4. Select the directory in which you want to save the export file.
5. Select a new name for the file or keep the name that is already entered.
6. Click "Save".

---

#### Note

As of STEP 7 (TIA Portal) V15.1, server methods are contained in the OPC UA export file (node set) together with their input and output parameters.

---

### Exporting all array elements separately

If the "Export all array elements as separate nodes" option is selected in the CPU properties under "OPC UA > Server > Export", the OPC UA XML file contains all elements of arrays as individual XML elements. In addition, the arrays themselves are each described in an XML element in the XML file.

If an array contains many array elements, the XML file can be very large.

#### Tip

The following FAQ contains a converter with which you can convert the export file into CSV format. You then obtain a list of the tags of the CPU that can be accessed by OPC UA.

You can find the FAQ on the Internet

(<https://support.industry.siemens.com/cs/ww/en/view/109742903>).

## 9.3.3 Configuring the OPC UA server

### 9.3.3.1 Enabling the OPC UA server

#### Requirement

- If you use **certificates** for secured communication, e.g. HTTPS, Secure OUC, OPC UA, make sure that the modules involved have the **current time of day and the current date**. Otherwise, the modules evaluate the used certificates as invalid and secure communication does not work.
- You have acquired a runtime license for the operation of the OPC UA functions, see License for OPC UA (Page 242).

#### Commissioning an OPC UA server

By default, the OPC UA server of the CPU is not enabled for reasons of security: OPC UA clients have neither write nor read access to the S7-1500 CPU.

Follow these steps to activate the OPC UA server of the CPU:

1. Select the CPU. Click on the CPU symbol (for example in the network view).
2. Click "OPC UA > Server" in the properties of the CPU.
3. Activate the OPC UA server of the CPU.
4. Confirm the security notes.
5. Go to the CPU properties, select "Runtime licenses" and set the runtime license acquired for the OPC UA server.
6. Compile the project.
7. Download the project to the CPU.

The OPC UA server of CPU now starts.

## Settings remain stored

If you have already enabled the server and made settings, those settings are not lost if the server is disabled. The settings are saved as before and are available when you enable the server again.

## Application name

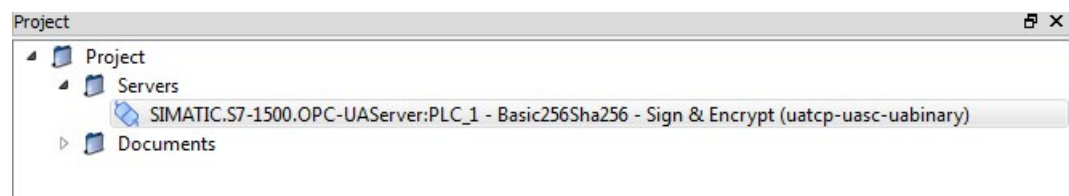
The application name is the name of the OPC UA application and applies to the server and the client. The name is displayed under "OPC UA > General":

- The default for the application name is: "SIMATIC.S7-1500.OPC-UA.Application:PLC\_1".
- The default consists of "SIMATIC.S7-1500.OPC-UA.Application:" and the name of the CPU selected under "General > Product information > Name", in this case "PLC\_1".
- The OPC UA server uses this application name to identify itself to a communication partner (OPC UA client), for example, when an OPC UA client uses the discovery service to detect accessible servers.
- The displayed application name uses the OPC UA client of the CPU when connecting to an OPC UA Server. This means that the CPU enters this application name automatically as "ApplicationName" for the instruction "OPC-UA\_Connect" (tag of type "OPC-UA\_SessionConnectInfo" at the parameter "SessionConnectInfo" of the instruction "OPC-UA\_Connect").

When you program the instruction "OPC-UA\_Connect" you must therefore assign an empty string to the "ApplicationName". You can use the application name, for example, to identify the client and its sessions (SessionNames) for diagnostic purposes.

If you have activated the server, you can also use a different name that is meaningful in your project and that fulfills the requirements of your project, e.g. for worldwide uniqueness.

The example below originates from UaExpert:



## Changing the application name

To change the application name, follow these steps:

1. Select the CPU. Click on the CPU symbol (for example in the network view).
2. Click "OPC UA > General" in the properties of the CPU.
3. Enter a meaningful name.

Please note that the application name is also entered on the certificate (Subject Alternative Name) and you may have to generate an existing certificate again after changing the application name.

### 9.3.3.2 Access to the OPC UA server

#### Server addresses

The OPC UA server of the S7-1500 CPU can be reached over all integrated PROFINET interfaces of the CPU (firmware V2.0 and higher).

Direct access to the OPC UA server of the CPU over the backplane bus of the automation system is not possible via CPs under the following conditions:

- Configuration with TIA Portal Version V16 or higher, S7-1500 CPU firmware version 2.8 or higher and CP 1543-1 firmware version V2.2 or higher.

For configuration, see Access to OPC UA applications (Page 157).

Direct access to the OPC UA server of the CPU over the backplane bus of the automation system is not possible via CMs.

With SIMATIC S7-1500 SW controllers, access to the OPC UA server is possible via PROFINET interfaces that are assigned to the software PLC.

Additional access options of SW controllers are described in the following application example: Internal and external OPC UA connection via the virtual Ethernet interface of the software controller V2.5 or higher

(<https://support.industry.siemens.com/cs/ww/en/view/109760541>).

Example for URLs (Uniform Resource Locator) that can be used to set up connections to the OPC UA server of the CPU:

| Accessibility of the server    |  |
|--------------------------------|--|
| Server addresses:              |  |
| Address                        |  |
| opc.tcp://192.168.178.151:4840 |  |
| opc.tcp://192.168.1.1:4840     |  |

Figure 9-14 Display of the server addresses



The URLs are structured as follows:

- Protocol identifier "opc.tcp://"
- IP address

- 192.168.178.151

The IP address at which the OPC UA server can be accessed from the Ethernet subnet 192.168.178.

- 192.168.1.1

The IP address at which the OPC UA server can be accessed from the Ethernet subnet 192.168.1.

- TCP Port number

- Default: 4840 (standard port)

The port number can be changed under "OPC > UA > Server > Port".

## Dynamic IP addresses

In the example below, the IP address for the PROFINET interface [X2] has not yet been specified.

| Accessibility of the server    |  |
|--------------------------------|--|
| Server addresses:              |  |
| Address                        |  |
| opc.tcp://192.168.178.151:4840 |  |
| opc.tcp://<dynamically>:4840   |  |

Figure 9-15 Display of the server addresses with dynamic IP address

The placeholder "<dynamically>" appears in the table.

The IP address of this PROFINET interface is set later on the device, e.g. via the display of the CPU.

### Activating the standard SIMATIC Server interface

If the "Enable standard SIMATIC server interface" option is selected, the OPC UA server of the CPU provides the enabled PLC tags and server methods to the clients, as was specified by SIEMENS in the self-defined namespace.

This option is selected in the default setting.

Leave the option selected so that OPC UA clients can automatically connect to the OPC UA server of the CPU and exchange data.

If you do not select this option, you must add the server interface by entering the "OPC UA communication" entry in the project tree. This interface is then used as OPC UA server interface, see OPC UA server interface configuration (Page 243).

---

#### Note

#### General device information is readable even with deactivated standard SIMATIC server interface

Even if you disable the standard SIMATIC server interface, OPC UA clients can read general device information about the OPC UA server of the CPU.

Examples of such device information: DeviceManual, DeviceRevision, OrderNumber. In this case, however, all objects of the application program remain invisible to clients.

If you want to prevent that this device information is not visible, you have to disable the OPC UA server of the CPU.

---

### 9.3.3.3 General settings of the OPC UA server

#### TCP port for OPC UA

By default, OPC UA uses TCP port 4840. You can, however, select a different port. Entries from 1024 to 49151 are possible. You must, however, make sure that there are no conflicts with other applications. OPC UA clients must use the selected port when establishing a connection.

In the example below, port 48400 is selected:

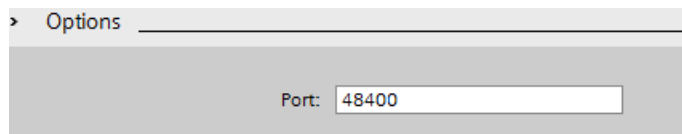


Figure 9-16 TCP port for OPC UA

An overview of the supported protocols and the port numbers used by the S7-1500 CPUs can be found in section Communications protocols and port numbers used for Ethernet communication (Page 28).

## Settings for sessions

- Maximum timeout for sessions

In this field, you specify the maximum time period before the OPC UA server closes a session without data exchange.

Possible values between 1 and 600000 seconds.

- Maximum number of OPC UA sessions

In this field, you specify the maximum number of sessions the OPC UA server starts and simultaneously operates.

The maximum number of sessions is dependent on the performance capability of the CPU. Each session ties up resources.

## Maximum number of registered nodes

In this field, you specify the maximum number of nodes the OPC UA server registers.

The maximum number of registered nodes depends on the capacity of the CPU and is displayed when you configure the field content (place cursor in field). Each registration ties up resources.

---

### Note

#### **No error message following attempt to register more than the configured maximum number of registrable nodes**

If a client tries to register more nodes during runtime than the configured maximum number, the server of the S7-1500 CPU only registers the configured maximum number. Starting from the configured maximum number of registrable nodes, the server returns the regular string node IDs unchanged to the client so that the speed advantage gained by registration for these nodes is lost. The client does not receive an error message.

When configuring, make sure you have a sufficient reserve by taking into account the maximum number of nodes that can be registered (for example, using the technical data of the CPU).

---

## Additional information

Details on which ports are used by the various services for data transfer via TCP and UDP, and what are the points to note when using routers and firewalls can be found in the FAQ (<https://support.industry.siemens.com/cs/ww/en/view/8970169>).

### Backward compatible data type definitions according to OPC UA specification ≤ V1.03

The OPC UA specification (<= V1.03) defines mechanisms in order to read out data type definitions, for example for user-defined structures (UDTs), from a server by means of the TypeDictionaries.

In the OPC UA server properties of the CPU, you can set whether the CPU generates these backward compatible data type definitions according to the OPC UA specification ≤ V1.03 for the standard SIMATIC server interface or not.

Because TypeDictionaries are complex and result in large OPC UA XML files (server interfaces) which the client has to interpret, a simpler solution was introduced with OPC UA Specification V1.04 (attribute "DataTypeDefinition" at the data type node). If your client supports the OPC UA specification V1.04 or higher, then disable the option.

Advantages of the data type definitions according to OPC UA specification as of V1.04:

- The server starts faster
- The memory is used more efficiently
- The "Browse" function is faster

#### 9.3.3.4 Settings of the server for subscriptions

##### Subscription instead of cyclic queries

An alternative to cyclic queries for a PLC tag (polling) is to monitor this value. Use a Subscription: The server informs the client if the value of PLC tags changes. See "The OPC UA client".

One server usually monitors a large number of PLC values. For this reason, the server sends notifications to the client at regular intervals containing the new values of the PLC tags.

Advantages of subscriptions:

- The server starts faster
- The memory is used efficiently

### How frequently does the server send notifications?

When a Subscription is set up, the OPC UA client specifies the intervals at which it wants to be sent the new values in the event of changes. To limit the communication load through OPC UA, set a minimum interval for the messages. For this purpose, use the parameters for the minimum publishing interval and the minimum sampling interval.

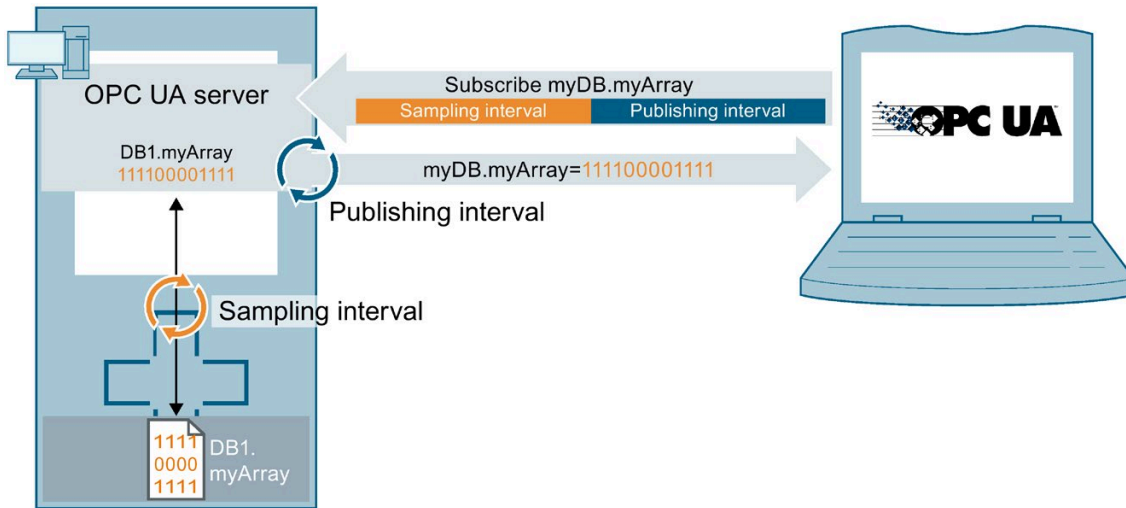


Figure 9-17 Principle of a subscription

### Minimum publishing interval

With "Minimum publishing interval", you set the time intervals at which the server sends a message to the client with the new values in the event of changes.

250 ms is used as the "Minimum sampling interval" in the figure below. The value 200 ms is entered as the "Minimum publishing interval".

**Subscriptions**

Minimum sampling interval: 250 ms

Minimum publishing interval: 200 ms

Max. number of monitored items: 2000

Figure 9-18 Subscription settings

In the example, following a value change the OPC UA server will send a new message every 200 ms if the OPC UA client requests an update.

If the OPC UA client requests an update every 1000 ms, the OPC UA server will only send a message with the new values once every 1000 ms (one second).

If the OPC UA client requests an update every 100 ms, the server will still only send a message every 200 ms (minimum publishing interval).

### Minimum sampling interval

With "Minimum sampling interval", you set the time intervals at which the OPC UA server records the value of a CPU tag and compares it with the previous value to detect any changes.

If the sampling interval is selected smaller than the publishing interval and an OPC UA client requests a high sampling rate for certain PLC tags, two or more values may be measured during each publishing interval.

In this case, the OPC UA server writes the value changes into the queue and sends all value changes to the client after the completion of the publishing interval. If more value changes occur in the publishing interval than fit in the queue, the OPC UA server overwrites the oldest values (depending on the set "Discard Policy" of the client subscribing to the data, the option "Discard Oldest" has to be activated in this case). The most recent values are sent to the client.

### Maximum number of monitored elements (monitored items)

In this field, you specify the maximum number of elements that the OPC UA server of the CPU simultaneously monitors for a value change.

The monitoring ties up resources. The maximum number of monitored elements is dependent on the utilized CPU.

### Additional information

Information about the system limits of the OPC UA server of the S7-1500 CPUs (firmware V2.0 and V2.1) regarding subscriptions, sampling intervals and publishing intervals can be found in the following FAQ

(<https://support.industry.siemens.com/cs/ww/en/view/109755846>).

When using subscriptions, certain status codes of errors provide information on the error that occurred. For information on causes and remedies for status codes of OPC UA client that appear, see the list of error codes in the online help of STEP 7 (TIA Portal) or in the following FAQ (<https://support.industry.siemens.com/cs/ww/en/view/109755860>).

### See also

Rules for subscriptions (Page 355)

Subscription diagnostics (Page 311)

### 9.3.3.5 Handling client and server certificates

A secure connection between the OPC UA server and an OPC UA client is only established when the server can prove its identity to the client. This is done with the server certificate.

#### Certificate of the OPC UA server

When you have activated the OPC UA server and have confirmed the security prompts, STEP 7 automatically generates the certificate for the server and saves it in the local certificate directory of the CPU. You can view and manage this directory with the local certificate manager of the CPU (exporting or deleting certificates).

The figure below shows the local certificate manager of the CPU with the automatically generated certificate for the OPC UA server:

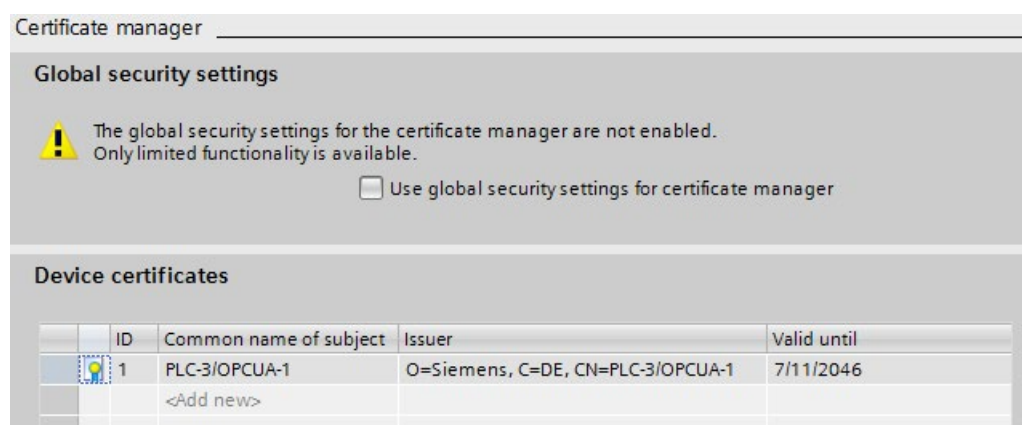


Figure 9-19 Local certificate manager of the CPU

Alternatively, you can also generate a server certificate yourself.

The certificate of the server is transferred from the server to the client during establishment of a connection. The client checks the certificate.

### The client user decides whether the server certificate is to be trusted.

The user at the client side now has to decide whether the server certificate is to be trusted. If the user trusts the server certificate, the client stores the server certificate in its directory containing the trusted server certificates.

The following example shows a dialog of the client "UA Sample Client". When the user clicks the "Yes" button, the client trusts the server certificate:

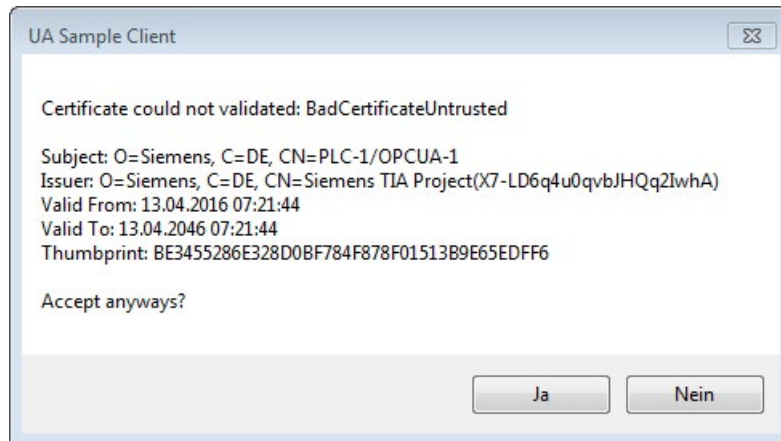


Figure 9-20 Dialog of the client "UA Sample Client"

### Where does a client certificate come from?

#### Client of the S7-1500

If you are using the OPC UA client of an S7-1500 CPU (OPC UA client enabled), you can create certificates for these clients with STEP 7 V15 and higher.

1. In the project tree, select the CPU you want to use as a client.
2. Double-click "Device configuration".
3. In the properties of the CPU, click "Protection & Security > Certificate manager".
4. Double-click "<Add new>" in the "Device certificates" table.

STEP 7 opens a dialog.

5. Click the "Add" button.
6. Select the "OPC UA client" entry from the "Usage" list.

Note:

The IP addresses under which the CPU can be accessed in your system must be entered under "Subject Alternative Name (SAN)".

You must therefore configure the IP interfaces of the CPU before you generate a client certificate.

7. Click "OK".

STEP 7 now shows the client certificate in the "Device certificates" table.



8. Right-click this line and select the "Export certificate" entry from the shortcut menu.
9. Select a directory where you will store the client certificate.

### Clients of other manufacturers

When you use UA clients from manufacturers or the OPC Foundation, a client certificate is generated automatically during installation or upon the first program call. You have to import these certificates via the global certificate manager in STEP 7 and use them for the corresponding CPU (as shown above).

When you program an OPC UA client yourself, you can have the certificates generated by the program; see the section "Instance certificate for the client". Alternatively, you can generate certificates with tools, for example with OpenSSL or the certificate generator of the OPC Foundation:

- The procedure for OpenSSL is described here: "Generating PKI key pairs and certificates yourself".
- Working with the certificate generator of the OPC Foundation is described here: "Creating self-signed certificates".

### Announcing client certificates to the server

You need to send client certificates to the server to allow a secure connection to be established.

To do this, follow these steps:

1. Select the "Use global security settings for certificate manager" option in the local certificate manager of the server. This makes the global certificate manager available.

You will find this option under "Protection & Security > Certificate manager" in the properties of the CPU that is acting as server.

If the project is not yet protected, select "Security settings > Settings" in the STEP 7 project tree, click the "Protect this project" button and log on.

The "Global security settings" item is now displayed under "Security settings" in the STEP 7 project tree.

2. Double click "Global security settings".
3. Double click "Certificate manager".
4. Click on the "Trusted certificates" tab.
5. Right-click in the tab on a free area (not on a certificate).
6. Select the "Import" command from the shortcut menu.

The dialog for importing certificates is displayed.

7. Select the client certificate that the server is to trust.
8. Click "Open" to import the certificate.

The certificate of the client is now contained in the global certificate manager.

Note the ID of the client certificate just imported.

9. Click the "General" tab in the properties of the CPU that is acting as server.
10. Click "OPC UA > Server > Security > Secure Channel".
11. Scroll down in the "Secure Channel" dialog to the section "Trusted clients".
12. Double-click in the table on the empty row with "<add new>". A browse button is displayed in the row.
13. Click this button.
14. Select the client certificate that you have imported.
15. Click the button with the green check mark.
16. Compile the project.
17. Load the configuration onto the S7-1500 CPU.

**Result:**

The server now trusts the client. If the server certificate is also considered trusted, the server and client can establish a secure connection.

### Accepting client certificates automatically

When you select the option "Automatically accept all client certificates during runtime" (below the "Trusted clients" list), the server automatically accepts all client certificates.

**NOTICE**

**Setting after commissioning**

In order to avoid security risks, deactivate the "Automatically accept client certificates during runtime" option again after commissioning.

## Configuring security settings of the server

The figure below shows the available server security settings for signing and encrypting messages.



Figure 9-21 Configuring security settings of the server

By default, a server certificate is created that uses SHA256 signing. The following security policies are enabled:

- None  
Unsecured end point

---

### Note

#### Disabling security policies you do not want

If you have enabled all security policies in the secure channel settings of the S7-1500 OPC UA server (default setting) – thus, also the end point "None" (no security) – unsecured data traffic (neither signed nor encrypted) between the server and client is also possible. The identity of the client remains unknown with "No security". Each OPC UA client can then connect to the server irrespective of any subsequent security settings.

When configuring the OPC UA server, make sure that only security policies that are compatible with the security concept of your machine or plant are selected. All other security policies should be disabled.

Recommendation: If possible, use the setting "Basic256Sha256".

---

- **Basic128Rsa15 -Sign**  
Insecure end point, supports a series of algorithms that use the hash algorithm RSA15 and 128-bit encryption.  
This endpoint protects the integrity of the data through signing.
- **Basic128Rsa15 -Sign & Encrypt**  
Secure endpoint, supports a series of algorithms that use the hash algorithm RSA15 and 128-bit encryption.  
This endpoint protects the integrity and confidentiality of the data through signing and encrypting.
- **Basic256Rsa15 -Sign**  
Secure endpoint, supports a series of algorithms that use the hash algorithm RSA15 and 256-bit encryption.  
This endpoint protects the integrity of the data through signing.
- **Basic256Rsa15 -Sign & Encrypt**  
Secure endpoint, supports a series of algorithms that use the hash algorithm RSA15 and 256-bit encryption.  
This end point protects the integrity and confidentiality of the data through signing and encrypting.
- **Basic256Sha256 - Sign**  
Secure endpoint, supports a series of algorithms for 256-bit hashing and 256-bit encryption.  
This endpoint protects the integrity of the data through signing.
- **Basic256Sha256 - Sign & Encrypt**  
Secure endpoint, supports a series of algorithms for 256-bit hashing and 256-bit encryption.  
This endpoint protects the integrity and confidentiality of the data through signing and encryption.

To enable the security setting, click the check box in the relevant line.

---

#### Note

If you use the settings "Basic256Sha256 -Sign" and "Basic256Sha256 -Sign & Encrypt", the OPC UA server and OPC UA clients must use "SHA256"-signed certificates.

For the settings "Basic256Sha256 -Sign" and "Basic256Sha256 -Sign & Encrypt", the certificate authority of STEP 7 automatically signs the certificates with "SHA256".

---

### "No Security" security policy and authentication via user name and password

You can set the following combination:

Security policy = "No Security" and authentication via user name and password.

- The OPC UA server of the S7-1500 supports this combination. OPC UA clients can connect and encrypt the authentication data or not.
- OPC UA client of the S7-1500 CPU also supports this combination: However, in runtime it only connects if it can send the authentication data encrypted via cable!

#### See also

Generating server certificates with STEP 7 (Page 233)

### 9.3.3.6 Generating server certificates with STEP 7

The description below shows the procedure for generating new certificates with STEP 7 and applies in principle to various uses of the certificates. STEP 7 sets the appropriate purpose - in this case "OPC UA Client & Server" - depending on which area of the CPU properties is used to start the following dialog.

Recommendation: To use the full functionality for the security of the OPC UA server, use the global security settings.

The global security settings are enabled in the CPU properties under "Protection & Security > Certificate manager".

### Customizing server certificates

STEP 7 automatically generates a certificate for the OPC UA server of the S7-1500 when you activate the server (see "Activating the OPC UA server (Page 218)"). In the process STEP 7 uses the default values for the parameters of the certificate. If you want to change the parameters, follow these steps:

1. Click the Browse button under "General > OPC UA > Server > Security > Secure channel > Server certificate" in the properties of the CPU. A dialog is displayed that shows the certificates available locally.
2. Click the "Add" button.

3. The dialog for generating new certificates is displayed (figure below). The values for an example are already entered:

**Create a new certificate**

**CA**

Choose how the new certificate is to be signed:

☐ Self signed

☒ Signed by certificate authority

CA name: 1: Siemens TIA Project(pmaV1z-yY0O'FbuNN

**Certificate parameter**

Enter the parameters for the new certificate:

Common name of subject: PLC-1/OPCUA-1-6

Signature: sha256RSA

Valid from: October 11, 2017 11:13:52 AM

Valid until: October 11, 2037 12:00:00 AM

Usage: OPC UA server

Subject Alternative Name (SAN):

| Type    | Value               |
|---------|---------------------|
| URI     | urn:SIMATIC.S7-1... |
| IP      | 192.168.0.1         |
| IP      | 192.168.1.1         |
| Add new |                     |

OK Cancel

Figure 9-22 Customizing server certificates

4. Use other parameters if this is necessary in accordance with the security specifications in your company or your customer.

## Explanation of fields for certificate generation

- CA

Select whether the certificate is to be self-signed or signed by one of the CA certificates of the TIA Portal. The certificates are described under "Certificates with OPC UA". If you want to generate a certificate that is to be signed by one of the CA certificates of the TIA-Portal, the project must be protected and you must be logged in as a user with all the required function rights. Further information can be found under "Basics of user administration in the TIA Portal".

- Certificate holder

The default setting always consists of the name of the project and "\OPCUA-1". In the example, the project name is "PLC1". In the properties of the CPU set the project name under "General > Project information" > Name". Keep the default or enter a different name that is more meaningful for the OPC-UA server under "Certificate holder".

- Signature

Here you select the hash and encryption process that is to be used when signing the server certificate. The following entries are available:

- "sha1RSA",
- "sha256RSA".

- Valid from

Here you enter the date and time for the beginning of the validity of the server certificate.

- Valid until

Here you enter the date and time for the end of the validity of the server certificate. Ensure that the certificate is valid not only for one year or a few years. In the example the certificate is valid for 30 years. However, for reasons of security you should renew the certificate at much shorter intervals. The long period of validity gives you the opportunity to decide when a suitable moment would be, for example, when the system is being serviced.

- Usage

The default is "OPC UA client & server". Keep this default for the OPC UA server. The "Create a new certificate" dialog can be called from several points in STEP 7. If, for example, you call this dialog for the Web server of the CPU, "Web server" is entered under "Usage". The following entries are available in the Usage drop-down list:

- "OPC UA client"
- "OPC UA client & server"
- "OPC UA server"
- "TLS"
- "Web server"

- Subject Alternative Name (SAN)

The following is entered in the example above: "URI:urn:SIMATIC.S7-1500.OPC-  
UAServer:PLC1,IP:192.168.178.151,IP:192.168.1.1". This URI must be correctly entered because it is checked against the communicated application description.

The following entry would also be valid: "IP: 192.168.178.151, IP: 192.168.1.1". The important thing here is that the IP addresses via which the OPC UA server of the CPU can be accessed are entered here.

See "Access to the OPC UA server (Page 220)".

This allows OPC UA clients to verify whether a connection to the OPC UA server of the S7-1500 is really to be established or whether in fact an attacker is trying to send manipulated values from another PC to the OPC UA client.



### 9.3.3.7 User authentication

#### Types of user authentication

For the OPC UA server of the S7-1500, you can set what authentication is required for a user of the OPC UA client wishing to access the server.

You have the following options:

- **Guest authentication**

The user does not have to prove their authorization (anonymous access). The OPC UA server does not check the authorization of the client user

If you want to use this type of user authentication, select the "Enable guest authentication" option under "OPC UA > Server > Security > User authentication".

---

#### Note

To increase security, you should only allow access to the OPC UA server with user authentication.

---

- **User name and password authentication**

The user has to prove their authorization (no anonymous access). The OPC UA server checks whether the client user is authorized to access the server. Authorization is given by the user name and the correct password.

If you want to use this type of user authentication, select the "Enable user name and password authentication" option under "OPC UA > Server > Security > User authentication".

Deactivate the guest authentication.

Enter the user in the "User management" table.

To do so, click the "<Add new user>" entry. A new user is created with an automatically assigned name. You can edit the user name and enter the password for the user name. You can add a maximum of 21 users.

- **Additional user administration via the security settings of the project**

The "Enable additional user administration via the security settings of the project" option can be found under the general OPC UA settings (CPU properties: OPC UA > General). If you select this option, the user management for the open project will also be used for user authentication for the OPC UA server: The same user names and passwords are then valid in OPC UA as in the current project.

Proceed as follows to activate user management for the project:

- Click "Security settings > Settings" in the project tree.
- Click the "Protect this project" button.
- Enter your user name and your password.
- Enter additional users under "Security settings > Users and roles".

If you configure an additional OPC UA server in your project, also select the option "Enable additional user administration via the security settings of the project". Repeated input of user names and passwords is then unnecessary.

## See also

User authentication (Page 347)

Users and roles with OPC UA function rights (Page 238)

### 9.3.3.8 Users and roles with OPC UA function rights

The following options for user authentication use central project settings for project users:

- For the server:
 

For configuration of CPU properties (OPC UA > Server > Security > User authentication).  
Option: "Enable additional user administration via the security settings of the project"
- For the client:
 

For configuration of client interface ("Configuration" tab, "Security"). Option: "User (TIA Portal - security settings)"

## Requirement

Before you can edit the security settings, the project must be protected and you must be logged on with sufficient rights, for example as administrator.

## Settings in the project tree > "Security settings"

You access the central user settings and roles in the protected project in the project tree under "Security settings". This is where you centrally define users with user name, password and function rights. You can simply use these settings elsewhere.



Figure 9-23 Setting user and roles

## Reusing central security settings

Examples for reusing elsewhere:

- User selection for user authentication for OPC UA server
 

With this setting, you tell the server which client (user) with which user name and which password is allowed to access the server.
- User selection for OPC UA client authentication
 

With this setting, you tell the client the user name and password that it is to use for client authentication for the server.

The settings for the client and server must correspond: The user name and password used by the client to log on must have been set up on the server and assigned the required authorizations.

## Function rights for server and client

The corresponding function rights for the client or the server must also be enabled for users of the client function and users of the server function on an S7-1500 CPU. It is not enough simply to save the user name and password centrally.

Here is an example to illustrate this type of rights use.

1. Under "Security settings > Users and roles", you define a new role in the "Roles" tab with the name "PLC-opcua-role-all-inclusive", for example.

**Tip:** The tab may be covered by an information window ("The current status has not yet been checked..."). In this case, first close the information window.

2. In the "Function rights categories" section, you navigate to the runtime rights and then to the CPU function rights, and select the CPU whose function rights you want to set.

3. You will find the following function rights in the "Function rights" section:

– **OPC UA server access**

This function right applies on the OPC UA server of the S7-1500 CPU. Only when this option is selected, can the user with the role "PLC-opcua-role-all-inclusive" transfer certificates, CRLs or trusted lists to the CPU at runtime (push function). This function right is required for automated certificate handling, for example, in the context of GDS (Global Discovery Service).

– **Managing certificates**

This function right applies on the OPC UA server of the S7-1500 CPU. Only when this option is enabled, can the user with the role "PLC-opcua-role-all-inclusive" transfer certificates, CRLs or trusted lists to the CPU at runtime (push function). This function right is required for automated certificate handling, for example, in the context of GDS (Global Discovery Service).

– **User authentication of the OPC UA client**

This function right applies on the OPC UA client of the S7-1500 CPU (with client instructions). Only when this option is selected, can the user with the role "PLC-opcua-role-all-inclusive" use the user name and password for authentication to establish a session with a server.

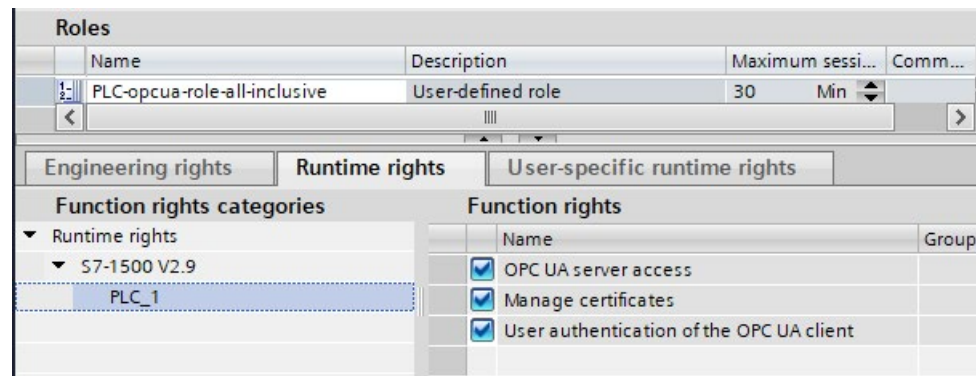


Figure 9-24 Setting function rights

4. The role "PLC-opcua-role-all-inclusive" still needs to be assigned to the relevant users ("Users" tab under "Security settings" in the project tree).

**Note**

**"Session duration" for users with OPC UA function rights**

The value in the column "Session duration" in the table for user configuration does not evaluate the CPU for OPC UA runtime rights.

Therefore, a user is not automatically logged out after a certain period of time. For this purpose use OPC UA specific mechanisms such as the parameter "Max. session timeout" (area OPC UA > Server > Settings).

### 9.3.3.9 Diagnostic settings of the server

#### Diagnostics

You can specify the scope of the diagnostics of the OPC UA server in the CPU settings.  
To change the diagnostics scope, navigate to the "OPC UA > Server > Diagnostics" area.

> Diagnostics

**Diagnostics on status changes**

- ☒ Change of OPC UA server status
- ☒ Change of session status

**Diagnostics of additional events**

- ☒ Check on security events
- ☐ Request of remote OPC UA client failed
- ☐ Subscriptions: Change of status
- ☐ Subscriptions: Sampling time errors

**Summarize diagnostics**

- ☒ Summarize diagnostics in case of high message volume

Length of an interval: 20 s

Figure 9-25 Diagnostic settings of OPC UA server

#### Default setting

The default setting is a diagnostics behavior that supports the most important diagnostics without appreciably increasing the communication load.

You enable diagnostics for subscriptions when the OPC UA server also uses subscriptions, i.e. if necessary during the commissioning phase only.

Reason: A large volume of diagnostic activity generates a high communication load in the CPU and may suppress other important messages. Or, the high volume of diagnostics may result in important messages disappearing in the mass of messages and being ignored.

#### Additional information

You will find additional information on the meaning and effect of the settings shown above here (Page 304).

### 9.3.3.10 License for OPC UA

#### Runtime licenses

A license is required to run the OPC UA server of the S7-1500 CPU. The type of license required depends on the performance of the respective CPU. The following license types are differentiated:

- SIMATIC OPC UA S7-1500 small (required for CPU 1511, CPU 1512, CPU 1513, ET 200SP CPUs, CPU 1515SP PC)
- SIMATIC OPC UA S7-1500 medium (required for CPU 1515, CPU 1516, Software Controller CPU 1507, CPU 1516pro-2PN)
- SIMATIC OPC UA S7-1500 large (required for CPU 1517, CPU 1518)

The required license type is displayed under "Properties > General > Runtime licenses > OPC-UA > Type of required license":

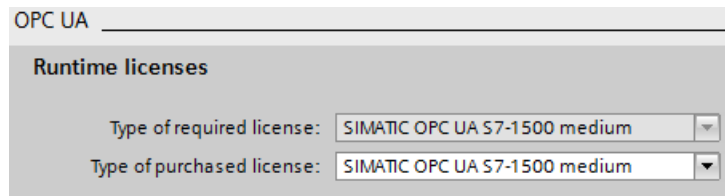


Figure 9-26 OPC UA server Runtime licenses

To confirm purchase of the required license, follow these steps:

1. Click "Runtime licenses > OPC UA" in the properties of the CPU.
2. Select the required license from the "Type of purchased license" drop-down list.

## 9.3.4 OPC UA server interface configuration

### 9.3.4.1 What is a server interface?

#### Definition

A server interface combines nodes of an OPC UA address space of a CPU into a unit, so that a specific view on this CPU is provided for OPC UA clients.

Each server interface defines one or more namespaces in the OPC UA server of the CPU.

STEP 7 (TIA Portal) differentiates between the following types of server interfaces:

- Companion specification

For this type of server interface, you use a Companion Specification created by a workgroup, for example.

The workgroup is typically composed of members of the OPC Foundation and another industry organization who have jointly specified an OPC UA information model for a specific purpose (for example, for data exchange with RFID devices or with injection molding machines).

This information model is realized in the form of OPC UA nodes in the address space of an OPC UA server. OPC UA clients can access these OPC UA nodes.

You can also use the server interface type "Companion specification", for example, to download company-internal information models, e.g. in SiOME.

If you implement a certain companion specification in your project, you apply the specifications of this companion specification into your project as server interface.

For "Companion specification"-type server interfaces, you can import multiple namespaces which the Companion specification uses.

Additional information on companion specifications is available here (Page 245).

Additional information on SiOME is available here  
(<https://support.industry.siemens.com/cs/ww/en/view/109755133>).

- When companion specifications refer to type definitions in dependent specifications, use the reference namespaces for this. You import reference namespaces as you would the actual companion specifications.

See Creating a server interface for companion specification (Page 253).

- If you want to make instance data from FBs or UDTs of the CPU accessible to OPC UA clients, you can have these instance data assignments automatically made as of TIA Portal version V17. You only need to map the FB types or the UDTs to suitable OPC UA data types of an imported reference namespace. For this mapping to be possible, enable the option "Generate OPC UA nodes based on the local data mapping" in the dialog for creating an OPC UA server interface of the type companion specification/reference namespace.

See Generating OPC UA nodes based on local data mappings of FB types and UDTs (Page 273)

- User-defined server interface:

For this type of server interface you combine OPC UA nodes of an OPC UA server into a unit.

To do this, use the specifications for your project or the requirements for your machine or your plant as a basis.

Additional information on the user-defined server interface is available here (Page 259).

## Injection molding machine as an example for companion specification

In this example, a server interface contains the following elements:

- OPC UA nodes which you can write with an OPC UA client to receive information about this injection molding machine (in readable PLC tags)
- OPC UA nodes which you can write with an OPC UA client to transfer values to the injection molding machine (in writable PLC tags)
- OPC UA nodes which you can call with an OPC UA client to start functions of the injection molding machine (via server methods)

This server interface enables a default view of a CPU, which can be used to control an injection molding machine.

For injection molding machines, the companion specifications "OPC UA specifications for plastics and rubber machines" (previously "Euromap") define a whole series of OPC UA nodes which you can apply as a server interface.

Other OPC UA nodes of the CPU are not included in this server interface. This provides a better overview.



### Example of user-defined server interface

A CPU should control the production of workpieces. Production begins when a production job arrives from the higher-level control system.

The production jobs are transferred via a server method: A control system transmits information on a workpiece by calling the server method in the CPU. This server method also starts production.

The control system, i.e. the connected OPC UA client, should only see this one server method. Therefore, you create a user-defined server interface in the CPU and assign the server method to this server interface. You enable only this server interface for OPC UA clients and thus limit the view of the CPU to this one function.

### 9.3.4.2 Using OPC UA companion specifications

#### Introduction

OPC UA is universally applicable: The standard itself does not, for example, specify how PLC tags are to be named. It is also up to the individual user (application developer) to program and name server methods that can be called over OPC UA.

#### Information modeling and standardization for devices and sectors

For applications of the same kind, it is worth standardizing your device or machine interface with the "OPC UA toolkit".

Many different bodies and working groups have driven forward standardization and developed a range of companion specifications.

These specifications define:

- The objects, methods and tags with which a typical device or machine is to be described.
- The namespace intended for the specified objects.

Machines are typically structured in functional or technological units, and these units are then standardized.

Companion specifications offer machine and plant operators the benefits of a standardized interface. For example, all RFID readers that comply with the AutoID specifications can be integrated in the same way. This means that all RFID readers that comply with the AutoID specifications can be addressed by OPC UA clients in the same way irrespective of manufacturer.

Another example of companion specifications is the Euromap 77 Companion Specifications from the injection molding machinery sector.

The following section uses the example of Euromap 77 to detail how to apply companion specifications in STEP 7 (TIA Portal) and create the necessary PLC tags.

---

**Note**

**EUROMAP and the OPC Foundation have established the Joint Working Group "OPC UA Plastics and Rubber Machinery".**

The existing EUROMAP recommendations EUROMAP 77 (data exchange between injection moulding machines and MES), 82.1 (temperature control devices) and 83 (general definitions) were published under the neutral umbrella of the OPC Foundation as OPC 40077, 40082-1 and 40083.

A major change is the change of the namespace, for example, for EUROMAP 77: Currently "http://opcfoundation.org/UA/PlasticsRubber/IMM2MES/".

The examples listed below use the previously valid designations and references.

---

### Example Euromap 77 (currently: OPC 40077)

Euromap 77 or the successor standard OPC 40077 standardizes the exchange of data between injection molding machines and the higher-level MES (Manufacturing Execution System). This allows the MES to connect all lower-level injection molding machines in the same way.

The standardized data interface facilitates the integration of injection molding machines into a plant.

### Using companion specifications: Overview

Euromap 77 is described in the OPC UA XML file "Opc\_Ua.EUROMAP77.NodeSet2.xml".

---

**Note**

**Euromap 77, Euromap 83 and OPC UA for Devices (DI)**

With Release Candidate 2, some of the Euromap definitions have been transferred from Euromap 77 to Euromap 83 (currently OPC 40083). You will therefore also need to import the OPC UA server interface of Euromap 83.

"OPC UA for Devices" is a generally applicable information model for the configuration of hardware and software components. The information model also serves as the basis for other companion standards and is therefore also imported.

---

The OPC UA XML files are available here:

Euromap77 (<http://www.euromap.org/euromap77>)

Euromap83 (<http://www.euromap.org/euromap83>)

OPC UA for Devices (<https://opcfoundation.org/UA/schemas/DI/>)

These XML files define an OPC UA interface of an injection molding machine that complies with Euromap 77.

## Using Euromap 77: Overview

To use Euromap 77, proceed as follows:

1. Generate an XML file by creating an instance of the type "IMM\_MES\_InterfaceType" using the SiOME program.  
How to proceed is described below in "Step 1: Create instances in SiOME".
2. In STEP 7 (TIA Portal), create PLC tags and server methods that correspond to the instance of the type "IMM\_MES\_InterfaceType" (created in Step 1).  
See below for information on how to proceed in "Step 2: Create PLC tags in STEP 7".  
An example of OPC UA nodes and the corresponding PLC tags can be found in section "Creating a server interface for companion specification (Page 253)".
3. In STEP 7 (TIA Portal), add a new server interface of companion specification type and import the XML file you created in step 1.  
The "Creating a server interface for companion specification (Page 253)" section describes how to proceed.
4. Assign the OPC UA nodes of the new server interface to the corresponding PLC tags, which you created in step 2.  
The "Creating a server interface for companion specification (Page 253)" section describes how to proceed.

### Step 1: Create instances in SiOME

The following section describes how to use the free program "SiOME", the "Siemens OPC UA Modeling Editor".

With SiOME, you can create an OPC UA XML file, which describes the server interface (an information model).

Download link and explanations about SiOME are available here (<https://support.industry.siemens.com/cs/ww/en/view/109755133>).

#### Procedure in STEP 7

To use the new server interface, import the server interface into the STEP 7 project, see section "Creating a server interface for companion specification (Page 253)".

When the project is loaded into the CPU, the new server interface is available for OPC UA clients.

### Procedure in SiOME 1.7.3

#### Note

The following description shows the work steps in SiOME 1.7.3.

Follow-up versions of SiOME make it easier for you, for example, to create corresponding DBs, structures, variables or methods in the user program. Using a drag-and-drop operation, you can transfer data, for example, from SiOME to the TIA Portal (user program). In this case, the variables, etc. are already mapped correctly or, for methods, the corresponding FB elements are also generated correctly in the user program.

Download the current SiOME version using the download link listed above, and follow the instructions in the documentation included in the download.

The following description shows the work steps in SiOME 1.7.3.

To use Euromap 77, create an XML file with an instance of "IMM\_MES\_InterfaceType".

The object type must be instantiated in order for the information model of the specific machine to appear in the address space of the OPC UA server.

The object type "IMM\_MES\_InterfaceType" is the root object type of Euromap 77. "IMM" stands for "Injection Moulding Machine".

Follow these steps:

1. Download the files "Opc\_Ua.EUROMAP77.NodeSet2.xml" and "Opc\_Ua\_EUROMAP83\_NodeSet2.xml" from the Euromap website (see above).
2. Download the file "Opc.Ua.Di.NodeSet2.xml" from the OPC Foundation website.  
The "Opc.Ua.Di.NodeSet2.xml" file contains type definitions which Euromap 77 uses.
3. Start SiOME.
4. First, import the namespace "http://opcfoundation.org/UA/DI/".

To do so, click the "Import XML" button in the "Information model" area.



Figure 9-27 "Import XML" button in SiOME

SiOME displays the dialog for the opening files.

5. To import the file, select the "Opc.Ua.Di.NodeSet2.xml" file and click "Open".  
Result: SiOME imports the XML file and shows the namespace "http://opcfoundation.org/UA/DI/" in the "Namespaces" area.

The standard namespace "http://opfoundation.org/UA/" is always available in SiOME and does not have to be imported.

6. Now import the namespace "http://www.euromap.org/euromap83/"

To do so, click the "Import XML" button again in the "Information model" area.

Select the file "Opc\_Ua.EUROMAP83.NodeSet2.xml".

Result: SiOME imports the XML file and shows the namespace "http://www.euromap.org/euromap83/" in the "Namespaces" area.

7. Now import the namespace "http://www.euromap.org/euromap77/"

To do so, click the "Import XML" button again in the "Information model" area.

Select the file "Opc\_Ua.EUROMAP77.NodeSet2.xml".

8. Create your own namespace for your project.

To do this, right-click in the "Namespaces" area on "OPC UA Modelling Editor Project" or on "Namespaces" and select "Add Namespace".

SiOME opens the "Add Namespace" dialog.

9. Enter the name of a new namespace.

The "YourCompany.org" namespace is used in the example.

SiOME now also displays the new namespace:

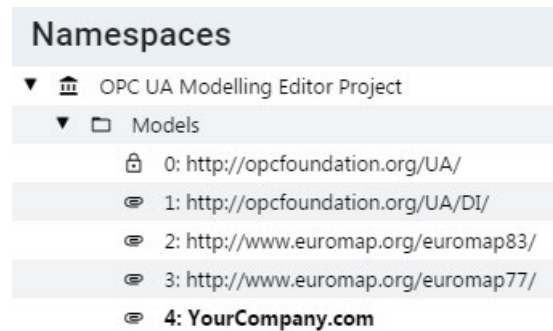


Figure 9-28 Display of the namespace in SiOME

10. Create an instance from the root object type IMM\_MES\_InterfaceType of the Companion specification Euromap 77.

To do so, in the "Information model" area, right-click the "DeviceSet" directory and select "Add Instance".

SiOME displays the "Add Instance" dialog.

11. For "Name", enter a meaningful name for your instance.

In the example, enter "IMM\_Manufacturer\_01234".

For "TypeDefinition", select "IMM\_MES\_InterfaceType".

This object type is the root object type of Euromap 77: If you generate an instance of this object type, then use the Euromap 77 once in the address space of your OPC UA server.

12. Click "OK".

SiOME shows the new instance "IMM\_Manufacturer\_01234" in the "Information model" area under "DeviceSet":

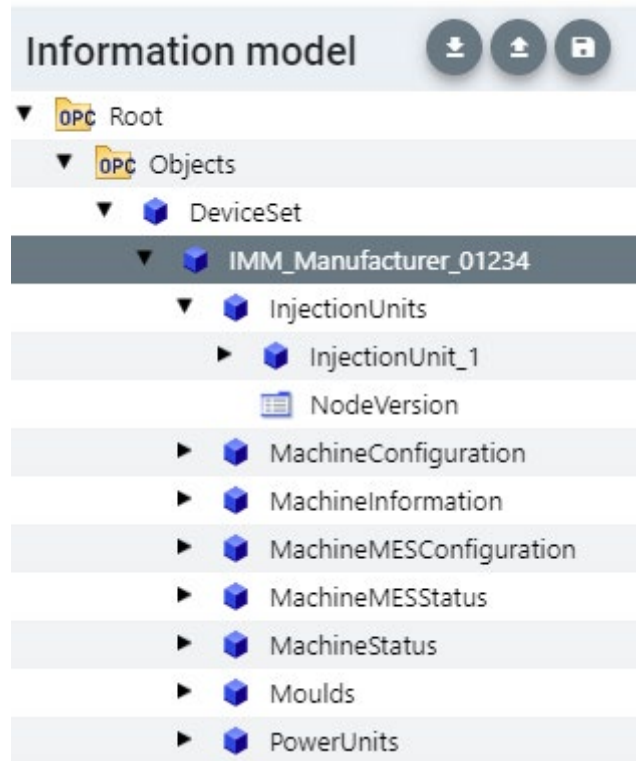


Figure 9-29 Display information model

13. Create an instance of the data type "InjectionUnitType".

To do this, right-click on the "InjectionUnits" directory in the "Information model" area and select "Add Instance".

SiOME displays the "Add Instance" dialog.

For "Name", enter a meaningful name for the instance.

In the example, enter "InjectionUnit\_1".

For "TypeDefinition", select "InjectionUnitType".

Click "OK".

14. Create a new "Mould\_1" instance of the "MouldType" object type in the "Moulds" directory.

15. Create a new instance "PowerUnit\_1" of the "PowerUnitType" object type in the "PowerUnits" directory.

16. Save the XML file.

To do so, click the "Quick save" button in the "Information model" area:



Figure 9-30 "Quick save" button in SiOME

17. Export the XML file.

To do so, click the "Export XML" button in the "Information model" area.



Figure 9-31 "Export XML" button in SiOME

SiOME shows the "Export XML" dialog.

18. Leave all namespaces activated and click "OK".

SiOME displays the "Save as" dialog.

19. Select a meaningful name and save the exported file.

In the example, name the XML file "IMM\_Manufacturer\_01234".

**Result:**

You have now created an XML file which uses the companion specification "Euromap 77" once (with one instance).

## Step 2: Creating PLC tags for the Euromap 77 instance in STEP 7.

For Euromap 77, you must provide PLC tags and server methods in your user program and assign the instance of the "IMM\_MES\_InterfaceType" type.

To create PLC tags for the instance of the "IMM\_MES\_InterfaceType" type, proceed as follows.

1. Create a user-defined data type (UDT).

The figure below shows the beginning of the user-defined data type "InjectionUnit" as example.

This data type has the same structure as "InjectionUnit" in the type "IMM\_MES\_InterfaceType".

Make sure that you use SIMATIC data types that are compatible with the OPC UA data types (see "Mapping of data types" below).

| InjectionUnit                                                                     |              |                                                                                        |               |                                     |                                     |
|-----------------------------------------------------------------------------------|--------------|----------------------------------------------------------------------------------------|---------------|-------------------------------------|-------------------------------------|
|                                                                                   | Name         | Data type                                                                              | Default value | Accessible from HMI/OPC UA          | Writable from HMI/OPC UA            |
|  | BarrelId     | String                                                                                 | "             | <input checked="" type="checkbox"/> | <input checked="" type="checkbox"/> |
|  | Index        | UDInt                                                                                  | 0             | <input checked="" type="checkbox"/> | <input checked="" type="checkbox"/> |
|  | InProduction | Bool                                                                                   | false         | <input checked="" type="checkbox"/> | <input checked="" type="checkbox"/> |
|  | IsPresent    | Bool  | false         | <input checked="" type="checkbox"/> | <input checked="" type="checkbox"/> |

Figure 9-32 Creating a UDT in STEP 7

2. Add a new global data block to your STEP 7 project.

In the example, name the data block "IMM\_Manufacturer\_01234", so that there is a reference to the injection molding machine of the respective manufacturer and the serial number.

3. Create a new element in this data block.

In the example, name this element "InjectionUnit\_1"

4. Assign the new user-defined data type "InjectionUnit" to this element.

## Result

In your STEP 7 project, you have created a tag for the Euromap 77 in the "IMM\_Manufacturer\_01234" data block.



### 9.3.4.3 Creating a server interface for companion specification

For basic information on companion specifications, refer to the section "Using OPC UA companion specifications (Page 245)". The benefits of the Euromap 77 companion specification, which provides a model for injection molding machines, is also discussed in detail there.

Using this companion standard, the S7-1500 CPU can control an injection molding machine, for example, and provide an OPC UA client, such as a higher-level MES system, with an interface for accessing the functions and tags of injection molding machine.

An OPC UA server interface of the type "Companion Standard" limits the access of clients to exactly those functions and tags that are required, for example, for higher-level systems (MES systems).

The following description shows how to create a server interface in STEP 7 (TIA Portal) which contains only the Euromap 77 companion specification.

If you want to make OPC UA clients accessible to other tags or methods than those required for the management of an injection molding machine, simply create another OPC UA server interface. In this way, you can clearly arrange the functionality of the CPU as OPC UA server.

### Creating a server interface for a companion specification

To create a server interface for a companion specification with STEP 7 (TIA Portal), proceed as follows:

1. Select the CPU that you want to use as an OPC UA server.
2. In the project tree, click "OPC UA communication > Server interfaces".
3. Double-click "Add new server interface".
4. To select this type of server interface, click "Companion specification".

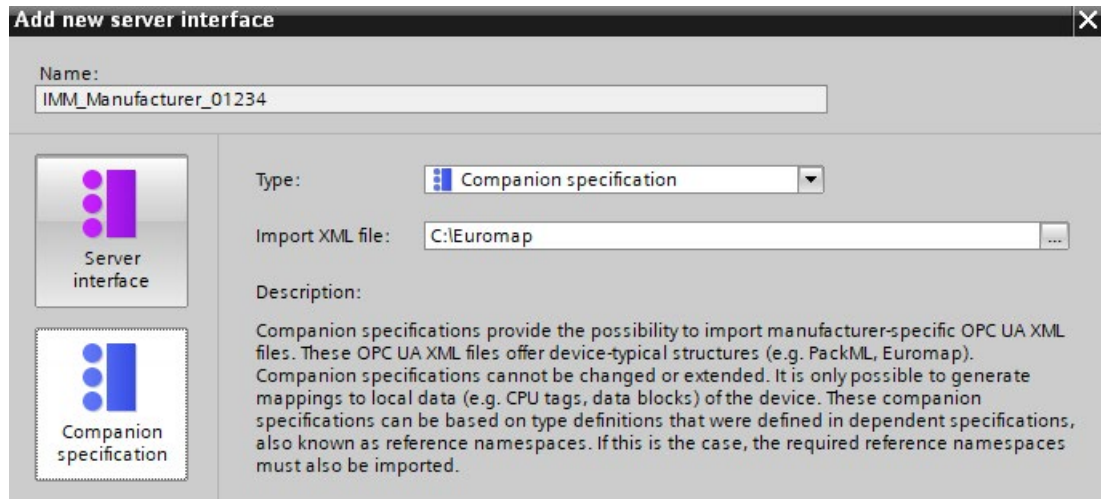
A general name for the new server interface is entered in the dialog, for example "Server\_Interface\_1".

5. Change the name of the new server interface so that it is descriptive in your project.

The name should have the following structure according to Euromap 77:

"IMM\_<Manufacturer>\_<Serial number>".

The example uses the name "IMM\_Manufacturer\_01234".

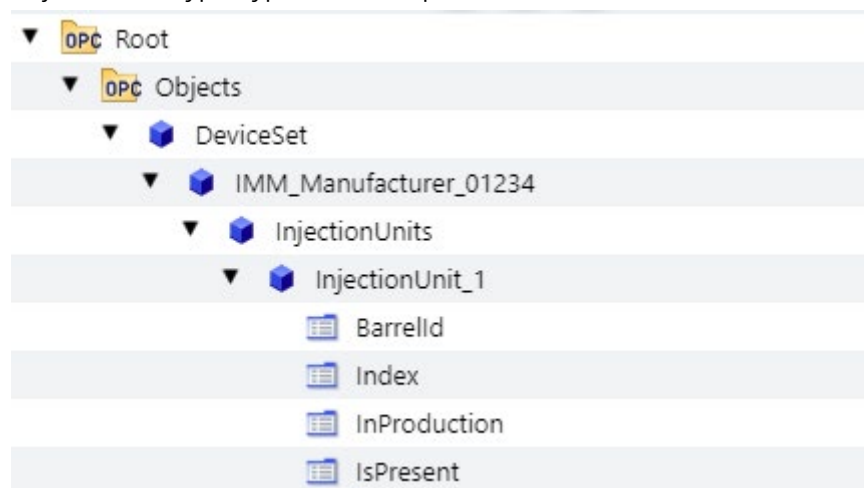


6. In the "Import XML file" field, select an XML file that describes an information model.

The "Using OPC UA companion specifications (Page 245)" section describes how to create such an XML file with the SiOME tool.

The figure below shows a section from the information model:

"IMM\_MANUFACTURER\_0123456" an instance (use) of the type "IMM\_MES\_InterfaceType" which was defined by Euromap 77 . "InjectionUnit\_1" is an instance of the "InjectionUnitType" type of Euromap 77.



7. Click "OK".

STEP 7 (TIA Portal) imports the information model described in the selected XML file.

An error occurs when type definitions are used in the imported XML file that are not yet present in STEP 7 (TIA Portal) and that are also not contained in the imported XML file.

In the example, an XML file is imported that uses type definitions defined in the following namespaces (Namespaces):

- <http://opcfoundation.org/UA/DI/>
- <http://www.euromap.org/euromap83/>
- <http://www.euromap.org/euromap77/>

**Tip:** STEP 7 displays missing namespaces in the lower area of the OPC UA interface editor ("Properties" tab).

To do this, select the server interface in the project tree (here: IMM\_Manufacturer\_01234) and select the "Namespaces" area in the inspector window. Missing namespaces are selected.

If one or more namespaces are missing in your STEP 7 project, create a new server interface of the "Reference namespace" type for each namespace.

The "Creating a server interface for reference namespace (Page 270)" section describes the procedure.

If all reference namespaces are available, STEP 7 displays the table without errors:

|                            |         |
|----------------------------|---------|
| ▼ DeviceSet                | Object  |
| ■ ▼ IMM_Manufacturer_01234 | Object  |
| ■ ▼ InjectionUnits         | Object  |
| ■ ▼ InjectionUnit_1        | Object  |
| ■ ▶ TemperatureZones       | Object  |
| ■ BarrelId                 | String  |
| ■ Index                    | UInt32  |
| ■ InProduction             | Boolean |
| ■ IsPresent                | Boolean |

8. Drag the OPC UA elements from the right area of the table (OPC UA elements) to the left part of the table (OPC UA server interface) so that the respective OPC UA elements (the local PLC tags) are assigned to the respective OPC UA nodes of Euromap 77.

The figure below shows a section from the assignment of the local data (PLC tags) to the OPC UA nodes of the Euromap 77:

| OPC UA-Server-Schnittstelle |           |                                                           |           |  |
|-----------------------------|-----------|-----------------------------------------------------------|-----------|--|
| Name                        | Node type | Local data                                                | Data type |  |
| ▼ DeviceSet                 | Object    |                                                           |           |  |
| ■ ▼ IMM_Manufacturer_01234  | Object    |                                                           |           |  |
| ■ ■ ▼ InjectionUnits        | Object    |                                                           |           |  |
| ■ ■ ■ ▼ InjectionUnit_1     | Object    |                                                           |           |  |
| ■ ■ ■ ■ ▼ TemperatureZones  | Object    |                                                           |           |  |
| ■ ■ ■ ■ ■ NodeVersion       | String    |                                                           |           |  |
| ■ ■ ■ ■ ■ BarrelId          | String    | "IMM_Manufacturer_01234"."InjectionUnit_1"."BarrelId"     | String    |  |
| ■ ■ ■ ■ ■ Index             | UInt32    | "IMM_Manufacturer_01234"."InjectionUnit_1"."Index"        | UDInt     |  |
| ■ ■ ■ ■ ■ InProduction      | Boolean   | "IMM_Manufacturer_01234"."InjectionUnit_1"."InProduction" | Bool      |  |
| ■ ■ ■ ■ ■ IsPresent         | Boolean   | "IMM_Manufacturer_01234"."InjectionUnit_1"."IsPresent"    | Bool      |  |

#### NOTICE

##### Checking the mapping of CPU local data on nodes of the OPC UA server interface

When invalid assignments (mappings) exist in the server interface, they can result in incorrect read and write operations. Check the assignments and run a consistency check.

## Information on the server interface

The editor for configuring the OPC UA server interface is structured as a table and provides the following information:

- **Name**

The top node (root node) is named "IMM\_Manufacturer\_01234" in the example. If a client browses in the address space of the server, this node is the container for all lower-level nodes. BrowseName and the DisplayName of this node depend on the name you have assigned for the server interface.

In this case, for example, this name stands for the injection molding machine as a whole. It is the name of the instance of the Euromap 77 companion specification that is used here. According to the companion specification, the instance name should begin with "IMM", followed by the name of the manufacturer of the injection molding machine; the serial number of the machine is added to the end. This allows a unique identification of the machine.

The names of all other (lower-level) nodes are defined by the specification (in the example above by Euromap 77). These node names must not be changed. This ensures a uniform view of all injection molding machines, which complies with the specification.

- **Node type**

Type of the OPC UA node. The type is specified by the companion specification that is used.

In the following cases, STEP 7 marks a node type in the table in color:

- No definition is included for this in the imported XML file or
- The namespace in which the type was defined is not available in STEP 7.

In this case, create a server interface of the "Reference namespace" type for the missing namespace or for each of the missing namespaces.

The missing namespaces can be found under "Namespaces" in the properties of the server interface.

- **Local data**

STEP 7 displays the data block which is assigned to the OPC UA node: The CPU reads the value of the OPC UA node from this data block.

If a data block is highlighted in color (e.g. after a consistency check), the specified data block is not available in the CPU.

In this case, you have to create the missing data block in the CPU (of user program) and supply it with values.

- **Data type**

The SIMATIC data type of the PLC tag (e.g. element of a data block) in the CPU, from which the value of an OPC UA node (UAVariable type) is read, or to which a value is assigned.

## Generate local data

You have the option of generating local data for all or for selected nodes of the server interface that are not already assigned ("mapped") to local data of the CPU. The newly created local data are mapped automatically.

You trigger the automatic generation of local data by clicking the "Generate local data" button (all nodes that are not already mapped) or by selecting individual nodes and then clicking the "Generate local data" shortcut menu.

"Generate local data" button:

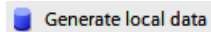


Figure 9-33 "Generate local data" button:

You can only generate nodes that can be mapped to local data, which means no objects, no folders, no methods or input/output arguments of methods.

After you have clicked the button or selected the shortcut menu, you must select in the follow-up dialog box whether the local data should be created in a new DB or in an existing DB.

## Consistency check

You have the option to check the server interface.

STEP 7 (TIA Portal) checks whether the OPC UA node of the server interface PLC tags (data blocks) has been assigned compatible SIMATIC data types.

To check the consistency of the server interface, click on the following icon in the toolbar of the OPC UA server interface editor:

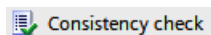


Figure 9-34 "Consistency check" button

## Export interface

You have the option of exporting the OPC UA server interface as an XML file. This XML file contains all data type definitions referenced by the server interface.

To export the OPC UA server interface, click on the following icon in the toolbar of the OPC UA server interface editor:



Figure 9-35 "Export interface" button

#### 9.3.4.4 Creating a user-defined server interface

##### Introduction

The description is based on the following example:

A protective fence surrounds the production cell "Cell\_1". The fence is equipped with the gate "Gate\_1".

An S7-1500 CPU controls the entire production cell and also controls access through Gate\_1.

A robot packs drugs into boxes in the production cell and then stacks the boxes on pallets.

Self-driving vehicles for automated material transport move the pallets to the central warehouse, thereby passing through Gate\_1.

The CPU publishes a server interface via which the driverless transport systems arrange for Gate\_1 to open.

The server interface contains the server method "smOpenGate" for opening the gate and the tag "Gate\_1\_State" which indicates the status of the gate (open or closed).

##### Creating a user-defined server interface

To create an Server interface, follow these steps:

1. Select the CPU that you have used and configured as OPC UA server.
2. Click "OPC UA communication > Server interfaces".
3. Double-click "Add new server interface".

STEP 7 displays the following dialog.

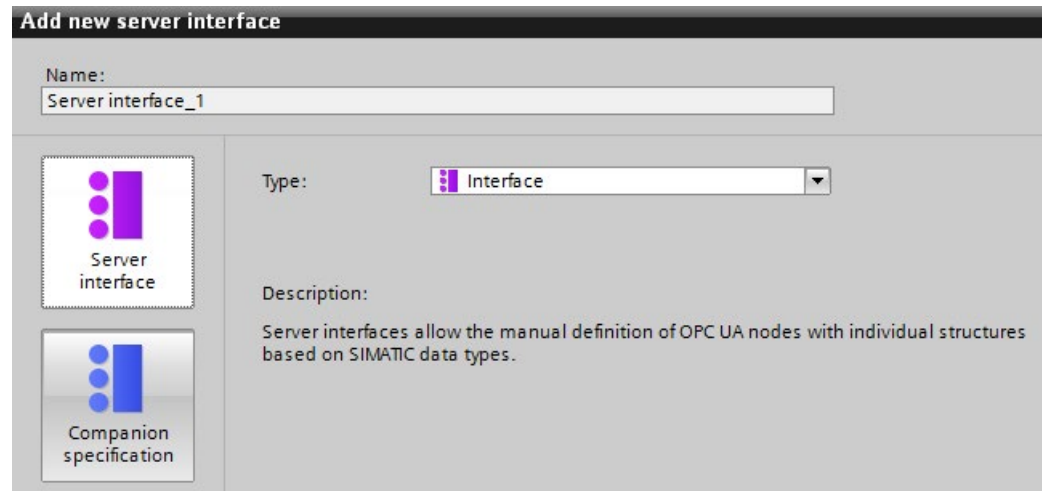


Figure 9-36 Adding the server interface

4. Change the name of the new server interface so that it is descriptive in your project.  
In the example, change the name "Server-interface\_1" suggested by STEP 7 to "Cell\_1".
5. Click "Server interface" and then "OK".

6. Click on the triangle in front of "Program blocks" in the area "OPC UA elements" to open the "Program blocks" folder.

STEP 7 displays the following table for editing:

| OPC UA server interface |             |           |            | OPC UA elements     |               |
|-------------------------|-------------|-----------|------------|---------------------|---------------|
|                         | Browse Name | Node type | Local data | Project data        | Data type     |
| 1                       | Cell_1      | Interface |            | Software units      |               |
| 2                       | <Add new>   |           |            | Program blocks      |               |
|                         |             |           |            | Cell_1 [DB1]        | Cell_1        |
|                         |             |           |            | Robot_1 [DB2]       | Robot_1       |
|                         |             |           |            | smOpenGate_DB [DB3] | smOpenGate_DB |
|                         |             |           |            | Technology objects  |               |
|                         |             |           |            | PLC tags            |               |

Figure 9-37 Editing the server interface

The editor is divided into two areas.

– **OPC UA server interface**

On the left is the root node of the server interface "Cell\_1".

This interface is currently still empty: No OPC UA elements have been added to the server interface yet.

– **OPC UA elements**

On the right are the OPC UA elements.

OPC UA elements are objects that have been created so far in the STEP 7 project and have the property "Accessible from HMI/OPC UA".

You can add the OPC UA elements to the new server interface "Cell\_1".

7. Drag the OPC UA elements into the "<Add new>" line of the new server interface.

**Note**

The following applies in general: If you store data blocks or technology objects in the left area of the table, STEP 7 (TIA Portal) creates an object in the server interface. The elements of the data blocks are arranged as separate nodes below this.

If you store structures in the left area of the table, STEP 7 creates a node for the structure as a whole and nodes for each element of the structure.

The same applies to arrays: Again, STEP 7 creates a node for the array as a whole and nodes for each element of the array.

When you place a method in the left area of the table, STEP 7 creates a single node; the arguments of the inserted method are displayed for information purposes.



In the example, you drag the "Gate\_1\_State" tag from the right area to the left area to "<Add new>".

Then, drag the server method into the left area.

This server method is located within the "smOpenGate\_DB [DB3]" data block in the right area.

STEP 7 (TIA Portal) displays the dialog as follows:

| Name         | Node type | Local data              |    | Project data        | Data type  |
|--------------|-----------|-------------------------|----|---------------------|------------|
| Cell_1       | Interface |                         | 1  | Software units      |            |
| Gate_1_State | BOOL      | "Cell_1"."Gate_1_State" | 2  | Program blocks      |            |
| Method       | Method    | "smOpenGate_DB".Method  | 3  | Cell_1 [DB1]        | Cell_1     |
| <Add new>    |           |                         | 4  | Gate_1_State        | Bool       |
|              |           |                         | 5  | Robot_1 [DB2]       | Robot_1    |
|              |           |                         | 6  | smOpenGate_DB [DB3] | smOpenGate |
|              |           |                         | 7  | Method              | Method     |
|              |           |                         | 8  | Static              |            |
|              |           |                         | 9  | Technology objects  |            |
|              |           |                         | 10 | PLC tags            |            |

Figure 9-38 Adding OPC UA elements to the server interface

#### NOTICE

##### Checking the mapping of CPU local data on nodes of the OPC UA server interface

When invalid assignments (mappings) exist in the server interface, they can result in incorrect read and write operations. Check the assignments and run a consistency check.

### Limiting the view to OPC UA servers

By selecting the OPC UA elements, you limit the view to the OPC UA server and the options of the OPC UA clients.

In the server interface of the example, the "Robot\_1" data block is missing because industrial trucks do not need access to the server methods and tags of the robot.

In this case, it is best to disable the standard server interface (SIMATIC namespace) in the OPC UA properties of the S7-1500 CPU so that the filtered nodes cannot be accessed any other way.

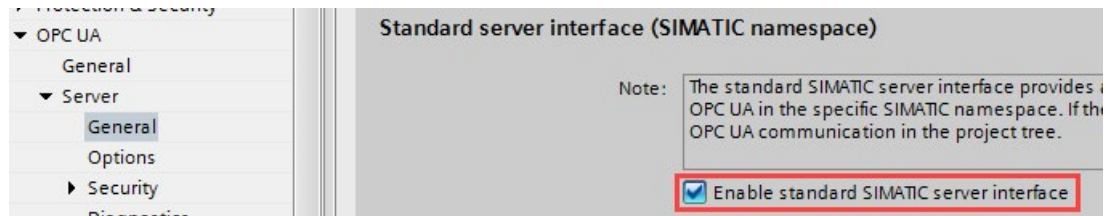


Figure 9-39 Disabling the standard server interface

You can also disable the visibility of each configured OPC UA server interface in the properties of the server interface and thus prevent that this server interface can be used by clients during operation.

- To do this, select the server interface and right-click on the "Properties" command.

This option lets you define multiple server interfaces centrally, for example, and enable and download only the required server interface.

Once a server interface has been defined, you can drag it to another CPU in the project tree.

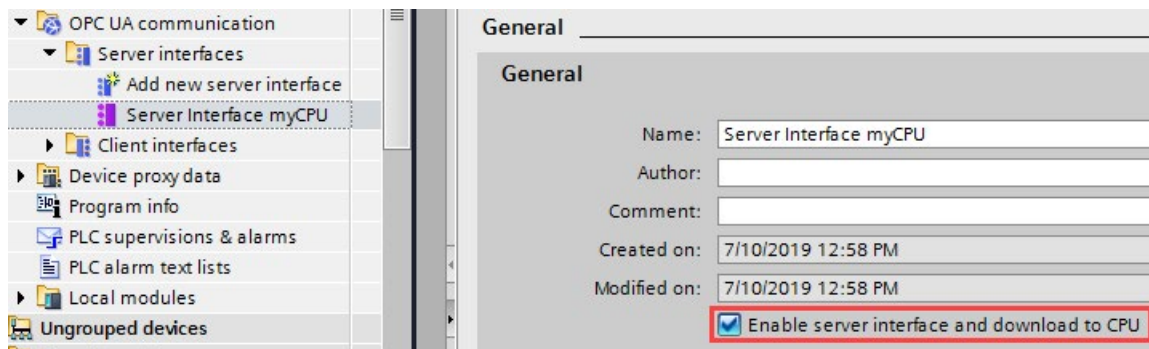


Figure 9-40 Disabling the visibility of the server interface

## Information on the server interface

The "OPC UA Server Interface" dialog is structured as a table and provides the following information:

Note that not all columns are displayed initially. You determine what is displayed by right-clicking on the header line of the table.

When a row is selected, you can display the OPC UA attributes of the node in the Inspector window ("OPC UA attributes" area), such as node ID, node class, node type, and description.

- **BrowseName**

The language neutral name of the user-defined server interface is at the top (BrowseName). This name can be freely selected.

The names (BrowseNames) of the individual OPC UA nodes that have been added to the server interface are under the name of the interface.

You cannot change the name of an OPC UA node in this dialog. The names come from the STEP 7 project.

You can delete an OPC UA node from the table. This means that it no longer belongs to the server interface and is no longer visible to OPC UA clients.

- **DisplayName**

Similar to BrowseName. However, the name can be translated and is displayed, if available, in the corresponding language.

- **Node ID**

NodeId of the OPC UA node, e.g. `http://Server-Node_1; i=1`

- **Node type**

Type of the OPC UA node, for example BOOL, BYTE, INT.

These node types were defined by Siemens, not by the OPC Foundation. For example, the OPC Foundation uses the Boolean node type for BOOL. BOOL is directly derived from Boolean.

The specified node type cannot be changed in this dialog: If you want to use a different node type, you must change the type of the respective PLC tags in the STEP 7 project.

- **Data type**

The SIMATIC data type used in the STEP 7 project is specified, for example, Bool, Byte, Int, etc.

- **Access level**

- If an OPC UA node is a tag (UAVariable type), the node can only be readable (RD) or readable and writable (RD/WR).
- If an OPC UA node is a method (UAMethod type), this node can always be called.

- **Local data**

The SIMATIC data type of the data block in the CPU, from which the value of an OPC UA node (UAVariable type) is read, or to which a value is written.

## Generate local data

You have the option of generating local data for all or for selected nodes of the server interface that are not already assigned ("mapped") to local data of the CPU. The newly created local data are mapped automatically.

You trigger the automatic generation of local data by clicking the "Generate local data" button (all nodes that are not already mapped) or by selecting individual nodes and then clicking the "Generate local data" shortcut menu.

"Generate local data" button:

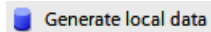


Figure 9-41 "Generate local data" button:

You can only generate nodes that can be mapped to local data, which means no objects, no folders, no methods or input/output arguments of methods.

After you have clicked the button or selected the shortcut menu, you must select in the follow-up dialog box whether the local data should be created in a new DB or in an existing DB.

## Consistency check

You have the option to check the server interface.

During the consistency check, STEP 7 checks whether the OPC UA nodes of the server interface are each assigned to a suitable OPC UA element (identical data type) or whether the used element still exists in the CPU.

To check the consistency of the server interface, click on the following icon in the toolbar of the OPC UA server interface editor:

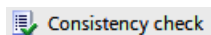


Figure 9-42 "Consistency check" button

## Export interface

You have the option of exporting the OPC UA server interface as an XML file. This XML file contains all data type definitions referenced by the server interface.

To export the OPC UA server interface, click on the following icon in the toolbar of the OPC UA server interface editor:



Figure 9-43 "Export interface" button

## See also

Master copies for OPC UA communication (Page 357)

### 9.3.4.5 Data types for companion specifications

#### Mapping of data types

The table below shows the compatible SIMATIC data type for each OPC UA data type.

Assign the data types as shown below (SIMATIC data type - OPC UA data type). Other assignments are not permitted. STEP 7 does not check the observance of this rule and does not prevent an incorrect assignment. You are responsible for the rule-compliant selection and assignment of the data types.

You can also use the listed data types, for example, as elements of structures/UDTs for input and output parameters of self-created server methods (UAMethod\_InParameters and UAMethod\_OutParameters).

Table 9- 3 Mapping of data types

| SIMATIC data type                                                                                                                                                                                                                                                               | OPC UA data type                                        |
|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------|
| BOOL                                                                                                                                                                                                                                                                            | Boolean                                                 |
| SINT                                                                                                                                                                                                                                                                            | SByte                                                   |
| INT                                                                                                                                                                                                                                                                             | Int16                                                   |
| DINT                                                                                                                                                                                                                                                                            | Int32                                                   |
| LINT                                                                                                                                                                                                                                                                            | Int64                                                   |
| USINT                                                                                                                                                                                                                                                                           | Byte                                                    |
| UINT                                                                                                                                                                                                                                                                            | UInt16                                                  |
| UDINT                                                                                                                                                                                                                                                                           | UInt32                                                  |
| ULINT                                                                                                                                                                                                                                                                           | UInt64                                                  |
| REAL                                                                                                                                                                                                                                                                            | Float                                                   |
| LREAL                                                                                                                                                                                                                                                                           | Double                                                  |
| LDT                                                                                                                                                                                                                                                                             | DateTime                                                |
| WSTRING                                                                                                                                                                                                                                                                         | String                                                  |
| DINT                                                                                                                                                                                                                                                                            | Enumeration (Encoding Int32) and all derived data types |
| User-defined data type required (UDT, user-defined data type)<br>The user-defined data type must be created with the prefix "Union_", for example "Union_MyDatatype". See example below the table.<br>The first element (Selector) in this UDT must have the data type "UDINT". | UNION and all derived data types                        |

### User-defined data type for UNION required

The figure below shows the tag "MyVariable", which has the "Union\_MyDatatype" data type.

This SIMATIC data type corresponds to an OPC UA tag with the data type UNION.

The figure shows an example of the declaration: When Selector = 1, Union takes a ByteArray; when Selector = 2, Union takes a WString.

| Name          | Data type           |
|---------------|---------------------|
| ▼ Static      |                     |
| ■ Selector    | UDInt               |
| ■ ▶ ByteArray | Array[0..1] of Byte |
| ■ WString     | WString[42]         |

### Using other OPC UA basic data types

Apart from the OPC UA data types listed in the section "Mapping of data types" and their correspondences on the SIMATIC side, there are the following OPC UA basic data types which you can also use:

- OpcUa\_NodeId
- OpcUa\_QualifiedName
- OpcUa\_Guid
- OpcUa\_LocalizedText
- OpcUa\_ByteString
- OpcUa\_XmlElement

Requirement for the use of the basic data types listed above as variables in the application program: The basic data types have to exist as complex data types that are structured exactly like the corresponding OPC UA basic data types.

- OpcUa\_NodeId and OpcUa\_QualifiedName exist as system data types; that's why you can use these data types not only for single variables but also as elements of a structure.
- For the remaining basic types you have to create a PLC data type in accordance with the OPC UA specification and subsequently use it as an element in a structure so that the data types of the elements can be resolved. What each PLC data type must look like is described below for every single basic data type. "EUInformation" is an example of a data structure in which, for example, the UDT "LocalizedText" is used. EUInformation contains information on EngineeringUnits. You can find an example of the implementation of the EUInformation data structure at the end of the PLC data type descriptions.

### System data type "OPC-UA\_Nodetd"

For the OPC UA basic data type "OpcUa\_Nodetd", please refer to the following table for the meaning of the parameters. Use OPC-UA\_Nodetd for the identification of a node in the OPC UA server.

| Parameter      | S7 data type | Meaning                                                                                                                                                                                                                                                                                                                                             |
|----------------|--------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| NamespaceIndex | UINT         | Namespace index of the node in the OPC UA server. A node can, for example, be a tag.                                                                                                                                                                                                                                                                |
| Identifier     | WSTRING[254] | The designation of the node (object or tag) depends on the identifier type: <ul style="list-style-type: none"> <li>Numeric identifier: The node is labeled with a number, for example "12345678".</li> <li>String identifier: The node is labeled with a name, for example "MyTag". No distinction is made between upper and lower case.</li> </ul> |
| IdentifierType | UDINT        | Type of identifier <ul style="list-style-type: none"> <li>0: Numeric identifier</li> <li>1: String identifier</li> <li>2: GUID</li> <li>3: Opaque</li> </ul>                                                                                                                                                                                        |

### System data type "OPC-UA\_QualifiedName"

See the following table for the structure of the system data type "OPC-UA\_QualifiedName":

| Name           | S7 data type | Meaning                          |
|----------------|--------------|----------------------------------|
| NamespaceIndex | UINT         | The namespace index of the name. |
| Name           | WSTRING[64]  | Name of the node or tag.         |

### UDT "Guid"

For the basic data type "Guid", create the following PLC data type. The default values used as examples can also be set differently.

| Guid |        |           |                     |
|------|--------|-----------|---------------------|
|      | Name   | Data type | Default value       |
| 1    | Data 1 | UDInt     | 16#11223344         |
| 2    | Data 2 | UInt      | 16#5566             |
| 3    | Data 3 | UInt      | 16#7788             |
| 4    | Data 4 | ULInt     | 16#99AABBCDDDEEFF11 |

Figure 9-44 "Guid" UDT

**UDT "LocalizedText"**

For the basic data type "LocalizedText", create the following PLC data type:

| LocalizedText |              |              |                 |
|---------------|--------------|--------------|-----------------|
|               | Name         | Data type    | Default value   |
| 1             | EncodingByte | Byte         | 16#3            |
| 2             | Locale       | WString[5]   | WSTRING#'de-DE' |
| 3             | Text         | WString[255] | WSTRING#'Text'  |

Figure 9-45 "LocalizedText" UDT

The EncodingByte indicates which fields (Locale or Text) are available:

| EncodingByte | Meaning                                               |
|--------------|-------------------------------------------------------|
| 0            | The fields Locale and Text are empty                  |
| 1            | The field Locale has content, the field Text is empty |
| 2            | The field Locale is empty, the field Text has content |
| 3            | The fields Locale and Text have content               |

**UDT "ByteString"**

For the basic data type "ByteString", create the following PLC data type; in this case, for example, a ByteString array with 12 elements:

| ByteString |                |                      |               |
|------------|----------------|----------------------|---------------|
|            | Name           | Data type            | Default value |
| 1          | ByteString     | Array[0..11] of Byte |               |
| 2          | ByteString[0]  | Byte                 | 16#0          |
| 3          | ByteString[1]  | Byte                 | 16#0          |
| 4          | ByteString[2]  | Byte                 | 16#0          |
| 5          | ByteString[3]  | Byte                 | 16#0          |
| 6          | ByteString[4]  | Byte                 | 16#0          |
| 7          | ByteString[5]  | Byte                 | 16#0          |
| 8          | ByteString[6]  | Byte                 | 16#0          |
| 9          | ByteString[7]  | Byte                 | 16#0          |
| 10         | ByteString[8]  | Byte                 | 16#0          |
| 11         | ByteString[9]  | Byte                 | 16#0          |
| 12         | ByteString[10] | Byte                 | 16#0          |
| 13         | ByteString[11] | Byte                 | 16#0          |

Figure 9-46 "ByteString" UDT



### UDT "XmlElement"

An XmlElement is a serialized XML fragment (UTF-8 string).

For the basic data type "XmlElement", create the following PLC data type:

| XmlElement |            |           |               |
|------------|------------|-----------|---------------|
|            | Name       | Data type | Default value |
| 1          | XmlElement | WString   | WSTRING#"     |

Figure 9-47 "XmlElement" UDT

### Example: Structure of EUInformation with UDT "LocalizedText"

|                 |                 |                                       |                                                                                              |
|-----------------|-----------------|---------------------------------------|----------------------------------------------------------------------------------------------|
| ▼ Velocity      | "EUInformation" |                                       |                                                                                              |
| ■ NamespaceUri  | WString[255]    | WSTRING#'http://yourorganization.org' | Identifies the organization (company, standards organization) that defines the EUInformation |
| ■ UnitId        | DInt            | 1                                     | Identifier for programmatic evaluation. -1 is used if a unitId is not available.             |
| ■ ▼ DisplayName | "LocalizedText" |                                       |                                                                                              |
| ■ Encoding...   | Byte            | 16#3                                  |                                                                                              |
| ■ Locale        | WString[5]      | WSTRING#'en-EN'                       |                                                                                              |
| ■ Text          | WString[255]    | WSTRING#'m/s'                         |                                                                                              |
| ■ ▼ Description | "LocalizedText" |                                       |                                                                                              |
| ■ Encoding...   | Byte            | 16#3                                  |                                                                                              |
| ■ Locale        | WString[5]      | WSTRING#'en-EN'                       |                                                                                              |
| ■ Text          | WString[255]    | WSTRING#'meter per second'            |                                                                                              |

Figure 9-48 Example: Structure of EUInformation with UDT "LocalizedText"

#### 9.3.4.6 Rules for OPC UA XML files

##### Importing exported OPC UA XML files to an S7-1500 CPU

Please note the following information when importing server interfaces that come from the OPC UA XML export of an S7-1500.

#### Note

##### Import blocked for namespace "http://www.siemens.com/simatic-s7-opcua"

You cannot import server interfaces with the namespace "http://www.siemens.com/simatic-s7-opcua" to an S7-1500 CPU because this namespace is reserved for S7-1500 CPUs (standard SIMATIC server interface) and is not available for imports.

If you want to import a server interface with the namespace "http://www.siemens.com/simatic-s7-opcua", open the server interface to be imported (OPC UA XML file) and change the namespace in the relevant places. The file thus changed can then be imported.

## Integrity of the OPC UA XML files

OPC UA XML files represent the server address space. These files are, for example, imported by you in the context of OPC UA Companion specifications as a server interface after adaptation to the application, loaded with the hardware configuration into the S7-1500 CPU and tested.



### **WARNING**

#### **No checking of imported OPC UA XML files**

Protect these OPC UA XML files against unauthorized manipulation since STEP 7 does not check the integrity of these files.

### **Recommendation**

To minimize risks in the case of an extension or adaptation of the server address space, follow these steps:

1. Protect the project (project navigation: Security settings > Settings).
2. Export the corresponding server interface before the extension or adaptation.
3. Revise this OPC UA XML file.
4. Import the file again as a server interface.

### 9.3.4.7 Creating a server interface for reference namespace

#### **Companion specifications and referenced namespaces**

A series of OPC UA object types (as well as additional definitions) are defined in a companion specification. These object types are each defined in namespaces so that the names of the object types (type definitions) are unique.

To use a companion specification in your project, create instances of object types of this companion specification.

To do this the object definitions must be available in your STEP 7 project. If this is not the case, you must import the object definitions. To import all definitions of a namespace, create a server interface of type "Reference namespace" for each namespace in STEP 7.

#### **Note**

**EUROMAP and the OPC Foundation have established the Joint Working Group "OPC UA Plastics and Rubber Machinery".**

The existing EUROMAP recommendations EUROMAP 77 (data exchange between injection moulding machines and MES), 82.1 (temperature control devices) und 83 (general definitions) were published under the neutral umbrella of the OPC Foundation as OPC 40077, 40082-1 and 40083. However, the examples listed below use the previously valid designations and references.

### Example Euromap 77 (currently OPC 40077)

You have added a server interface for the companion specification Euromap 77 (currently OPC 40077).

The server interface uses object types defined in OPC UA DI as well as in Euromap 83 and Euromap 77 in their corresponding namespaces.

Therefore, in addition to the server interface Euromap 77 of the "Companion Specification" type, create additional server interfaces of "Reference namespace" type in STEP 7, in each case for the following namespaces:

- <http://opcfoundation.org/UA/DI/>
- <http://www.euromap.org/euromap83/>
- <http://www.euromap.org/euromap77/>

The following description shows you how to proceed.

### Creating a server interface for a reference namespace

To create a server interface for a namespace, proceed as follows:

1. Select the CPU that you want to use as an OPC UA server.
2. Click "OPC UA communication > Server interfaces".
3. Double-click "Add new server interface".

STEP 7 (TIA) now displays the dialog "Add new server interface".

A general name for the new server interface is entered in the dialog, for example "Server\_Interface\_1".

4. Assign a descriptive name for the new server interface.

In the example, select the name "OPC.Ua.Di" or a similar name that clearly references the namespace "<http://opcfoundation.org/UA/DI/>".

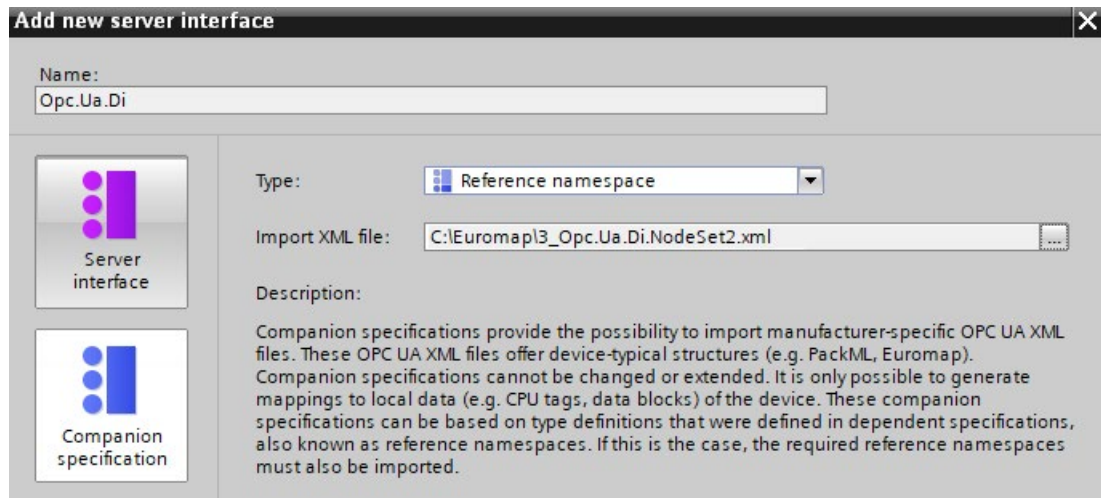
This namespace must be imported first. It contains basic definitions (for example, the UAObjectType "DeviceType").

5. For "Import XML file", select an XML file that contains the definitions of the namespace "http://opcfoundation.org/UA/DI/".

Select the file "Opc.Ua.Di.NodeSet2.xml" in the example. You can download this file here: (<https://opcfoundation.org/UA/schemas/DI/>)

Opc.Ua.Di.NodeSet2.xml (<https://opcfoundation.org/UA/schemas/DI/>)

The figure below shows the dialog with the entries:



6. Click "OK".

STEP 7 (TIA) now generates the new server interface.

You can find the server interface in the project navigation of STEP 7 (TIA Portal), under "OPC UA Communication > Server interfaces > Namespace references".

If a companion specification uses additional namespaces, add a new server interface for each namespace.

### Add additional server interfaces for Euromap77

For Euromap 77, you still need the following namespaces:

- <http://www.euromap.org/euromap83/>
- <http://www.euromap.org/euromap77/>

First, add a server interface for the namespace "http://www.euromap.org/euromap83/".

This namespace contains basic definitions for Euromap 77, therefore it is required here first. All definitions of this namespace are included in the XML file "Opc\_Ua.EUROMAP83NodeSet2.xml", which you can download from the Euromap website ([www.euromap.org/en/euromap83](http://www.euromap.org/en/euromap83)).

Then add a server interface for the namespace "http://www.euromap.org/euromap77". All definitions of this namespace are included in the XML file "Opc\_Ua.EUROMAP77.NodeSet2.xml", which you can also download from the Euromap website ([www.euromap.org/en/euromap77](http://www.euromap.org/en/euromap77)).

### 9.3.4.8 Generating OPC UA nodes based on local data mappings of FB types and UDTs

If you want to make instance data from FBs or UDTs of the CPU accessible to OPC UA clients, you can have these instance data assignments automatically made as of TIA Portal version V17.

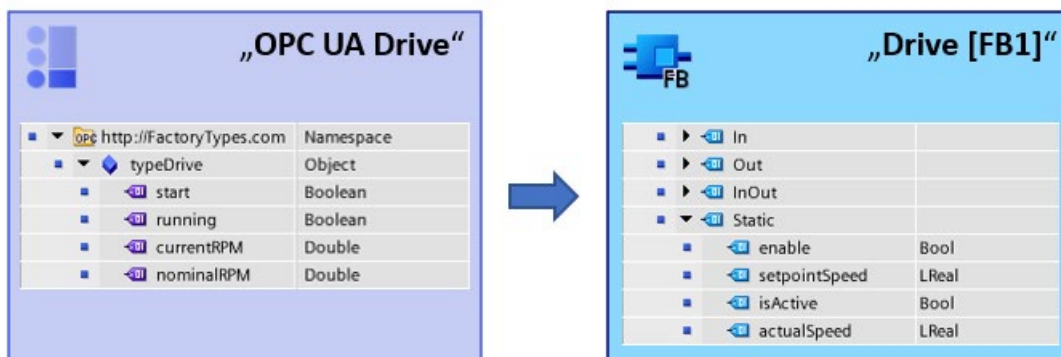
You only have to map the FB types or the UDTs to suitable OPC UA data types of imported reference namespaces. Based on these mappings created in STEP 7 (TIA Portal), generate the required nodes in the server interface for each FB instance or for each UDT usage during the compile.

If you extend your program and add more FB instances or UDT usages, or if you add existing instances delete, you do not need to worry about adapting the server interface: STEP 7 automatically adjusts the server interface when compiling the program.

#### Example

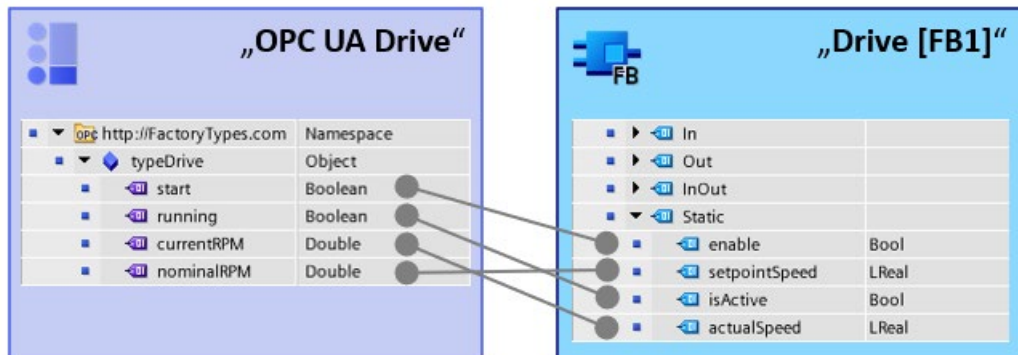
- You create a function block (FB) in the user program of the CPU and define in the "Static" area of the interface of the FB the parameters that form the "memory" of the FB. The instances (values) of this parameter are to be accessible for OPC UA clients.
- You create an OPC UA data type (e.g. with SiOME) with elements that correspond to the data type the parameters in the static area of interface of the FB. The order of the elements does not matter. Then import the reference nodeset file (reference namespace) as a reference name space.

The following figure shows the assignment of elements as comparison of the reference namespace view (server interface) and the OPC UA elements view (program).



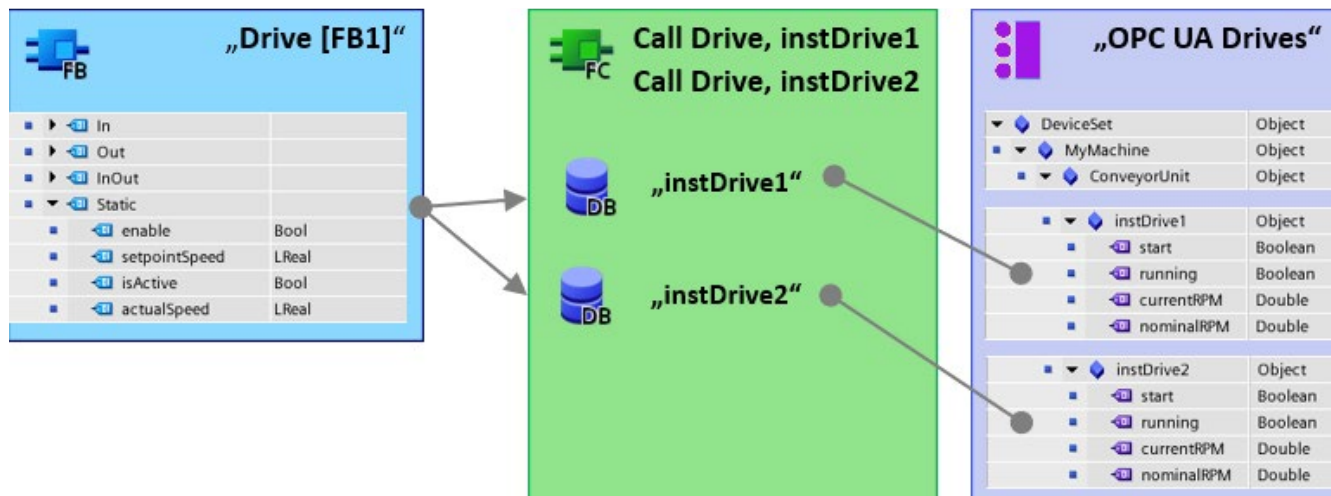
### Mapping of data types (FB interface - OPC UA interface): Principle

The following figure shows the assignment of the elements from the user program of the CPU to the elements of the OPC UA server interface. The order of the elements does not have to match.

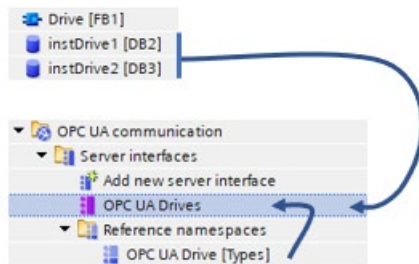


### Automatic generation of the OPC UA server instances in the server interface: Principle

The figure below shows the compilation of the project. The instances of the user program are also generated in the server interface.



By mapping between FB type information / UDT type information and OPC UA type information, STEP 7 is able to create all instances present in the program as nodes in the server interface. You have the option to generate these nodes together with a new server interface or to generate these nodes in an existing server interface.



## Rules

- Only the FB elements in the "Static" area of an FB interface can be mapped to OPC UA type descriptions.
- When mapping the data types, OPC UA elements from the same FB interface or from the same UDT must always be selected for an object. Mapping from different FBs or UDTs to an object is not permitted.

## Requirement

- The FB types used, defined in the "Static" area of an FB, must be configured as "Accessible for OPC UA".
- The UDTs used must be configured as "Accessible for OPC UA".
- A nodeset file (XML file) is available with OPC UA data type definitions that match the FB types or UDTs defined in user program (can be mapped).
- The user program with the FB instances and UDT usages is available.

## Procedure

To map a data type from a reference namespace to an FB type or UDT data type, follow these steps:

1. Select the CPU that you want to use as an OPC UA server.
2. Import the prepared nodeset file (XML file) with the type definitions as a reference namespace

(See AUTOHOTSPOT).

- In the "Add new server interface" dialog, enable the option "Generate OPC UA nodes based on the local data mapping".

Only when this option is enabled can you map FB types or UDTs by dragging them to the OPC UA type descriptions.

3. Double-click the icon for the server interface of the "Reference namespace" type that you just generated.

The editor for mapping between OPC UA server interface and OPC UA elements opens. In the properties area of the editor, in the "Mapping of local data" area, the option "Generate OPC UA nodes based on the local data mapping" is enabled. If not, enable the option now.

Edit the "Interface name" field; to do this, click on the three dots on the right edge of the field.

Select an existing server interface or create a new server interface ("Add" button).

When adding, a new server-interface is created. If you select an existing server interface, you can edit the properties ("Edit" button).

4. Assign the existing FB types or UDTs to the nodes of the server interface (reference namespace) by dragging the OPC UA element (right side of the editor) to the corresponding node of the server interface (reference namespace, "Local data" column).

| OPC UA server interface         |                    |                           | OPC UA elements  |           |
|---------------------------------|--------------------|---------------------------|------------------|-----------|
| Browse name                     | Node type          | Local data                | Project data     | Data type |
| ▼ FactoryTypes4                 | Reference node set |                           | 1 Software units |           |
| ▼ OPC http://automationcompa... | Namespace          |                           | 2 Program blocks |           |
| ▼ Drive                         | Drive              |                           | 3 Drive          | Drive     |
| start                           | Boolean            | ← "Drive"."enable"        | 4 Static         |           |
| running                         | Boolean            | ← "Drive"."isActive"      | 5 enable         | Bool      |
| currentRPM                      | Double             | ← "Drive"."actualSpeed"   | 6 setpointSpeed  | LReal     |
| nominalRPM                      | Double             | ← "Drive"."setpointSpeed" | 7 isActive       | Bool      |
| OPC http://automationcompa...   | Namespace          |                           | 8 actualSpeed    | LReal     |
| OPC http://automationcompa...   | Namespace          |                           | 9 PLC data types |           |

5. Compile the project.

After the compile, the newly generated nodes of the instances are located in the server interface. STEP 7 creates an object for each instance DB. The generated elements are located under each of these objects.

Similarly, STEP 7 also creates an object for each global DB that is created when a UDT is instantiated.



### Create user program with FB types or UDT

How to create FBs and UDTs is not explained in detail here; for this purpose use the description for creating a user program, e.g. declare block interface and declare PLC data types (UDT).

### Consistency check

The consistency check ("Consistency check" button of the editor) also checks the mapping of the data types and updates the display of the data types in the corresponding column of the editor.

#### 9.3.4.9 Notes on configuration limits when using server interfaces

When you use OPC UA server interfaces, you must comply with limits for the following objects in line with the S7-1500 CPU performance class:

- Number of server interfaces
- Number of OPC UA nodes
- Load object data volume
- If you have implemented methods: Number of server methods or server method instances

### Configuration limits for OPC UA server interfaces and methods

The table below sets out the configuration limits for S7-1500 CPUs; these must also be taken into account when you compile and load a configuration (up-to-date technical specifications of the CPUs can be found on the Internet (<https://support.industry.siemens.com/cs/ww/en/ps/td>)).

A violation of configuration limits results in an error message.

Table 9- 4 Configuration limits for OPC UA server interfaces

| Technical specification value                                                                                                                    | CPU 1510SP (F)<br>CPU 1511 (C/F/T/TF)<br>CPU 1512C<br>CPU 1512SP (F)<br>CPU 1513 (F) | CPU 1505 (S/SP/SP F/SP T/SP TF)<br>CPU 1515 (F/T/TF)<br>CPU 1515 SP PC (F/T/TF)<br>CPU 1516 (F/T/TF) | CPU 1507S (F)<br>CPU 1517 (F/T/TF)<br>CPU 1518 (F) |
|--------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------|----------------------------------------------------|
| Use of imported companion specifications (information models)                                                                                    |                                                                                      |                                                                                                      |                                                    |
| Maximum number of OPC UA server interfaces:                                                                                                      |                                                                                      |                                                                                                      |                                                    |
| • "Companion specification" type                                                                                                                 | 10                                                                                   | 10                                                                                                   | 10                                                 |
| • "Reference namespace" type                                                                                                                     | 20                                                                                   | 20                                                                                                   | 20                                                 |
| • "Server interface" type                                                                                                                        | 10                                                                                   | 10                                                                                                   | 10                                                 |
| • Maximum number of OPC UA nodes in user-defined server interfaces                                                                               | 1000                                                                                 | 5000                                                                                                 | 30000                                              |
| • Maximum size of loadable OPC UA server interfaces                                                                                              | 1024 KB                                                                              | 5120 KB                                                                                              | 8192 KB                                            |
| Provision of methods                                                                                                                             |                                                                                      |                                                                                                      |                                                    |
| Maximum number of usable server methods or max. number of server method instances (instructions OPC-UA_ServerMethodPre, OPC-UA_ServerMethodPost) | 20                                                                                   | 50                                                                                                   | 100                                                |

## 9.3.5 Providing methods on the OPC UA server

### 9.3.5.1 Useful information about server methods

#### Providing user program for server methods

On the OPC UA server of an S7-1500 CPU (as of firmware V2.5), you have the option of providing methods via your user program. These methods can be used by OPC UA clients, for example to start a manufacturing job using the method call of the S7-1500 CPU.

OPC UA methods, an implementation of "Remote Procedure Calls", provide an efficient mechanism for interactions between different communication nodes. The mechanism provides both job confirmation and feedback values so you no longer have to program handshaking mechanisms.

Using OPC UA methods, you can transfer data consistently without trigger bits/handshaking, for example, or trigger specific actions on the controller.

#### How does an OPC UA method work?

An OPC UA method in principle operates like a know-how protected function block that is called by an external OPC UA client in runtime.

The OPC UA client only "sees" the defined inputs and outputs. The content of the function block, the method or algorithm, remains hidden to the external OPC UA client. The OPC UA client receives feedback on successful execution and values returned by the function block (method), or an error message if execution has not been successful.

As the programmer, you have full control over and responsibility for the program context in which the OPC UA method runs.

#### Rules for programming a method and runtime behavior

- Make sure that the values returned by the OPC UA method are consistent with the input values provided by the OPC UA client.
- Follow the rules on assigning name and the structure of parameters, and the permitted data types (see description of the OPC UA server instructions).
- Behavior during runtime: The OPC UA server accepts **one** call per instance. The method instance is not available for other OPC UA clients until the call has been processed by the user program or has timed out.

The basic procedure for implementing a user program as a server method is set out below.

### Implementing a server method

A program (function block) for implementing a server method is structured as follows:

#### 1. Querying the server method call with OPC-UA\_ServerMethodPre

You first call the "OPC-UA\_ServerMethodPre" instruction in your user program (i.e. in your server method).

This instruction has the following tasks:

- With this instruction you ask the OPC UA server of the CPU whether your server method was called from an OPC UA client.
- If the method was called and the server method has input parameters, your server method now receives the input parameters.

The input parameters of the server method come from the calling OPC UA client.

#### 2. Editing the server method

In this section of the server method, you provide the actual user program.

You have the same options as in any other user program (for example, access to other function blocks or global data blocks).

If the server method uses input parameters, these parameters are available to you.

This section of the server method should only be executed if an OPC UA client has called the server method.

After successful execution of the method, you set the output parameters of the server method if the method has output parameters.

#### 3. Responding to server method with OPC-UA\_ServerMethodPost

To complete the server method, call the "OPC-UA\_ServerMethodPost" instruction.

Use the parameters to notify the "OPC-UA\_ServerMethodPost" instruction whether or not the user program has been processed.

If the user program has been successfully executed, the OPC UA server is notified via the relevant parameters. The OPC UA server then sends the output parameters of the server method to the OPC UA client.

Always call the instructions "OPC-UA\_ServerMethodPre" and "OPC-UA\_ServerMethodPost" as a pair irrespective of whether the user program is processed by both instructions or continued in the next cycle.

You will find an example of a server method implementation in the STEP 7 online help.

## Integrating the server method

The diagram below shows how an OPC UA client (A) calls the server method "Cool":

The CPU executes the instance "Cool1" of the server method "Cool" in the cyclic user program ⑥.

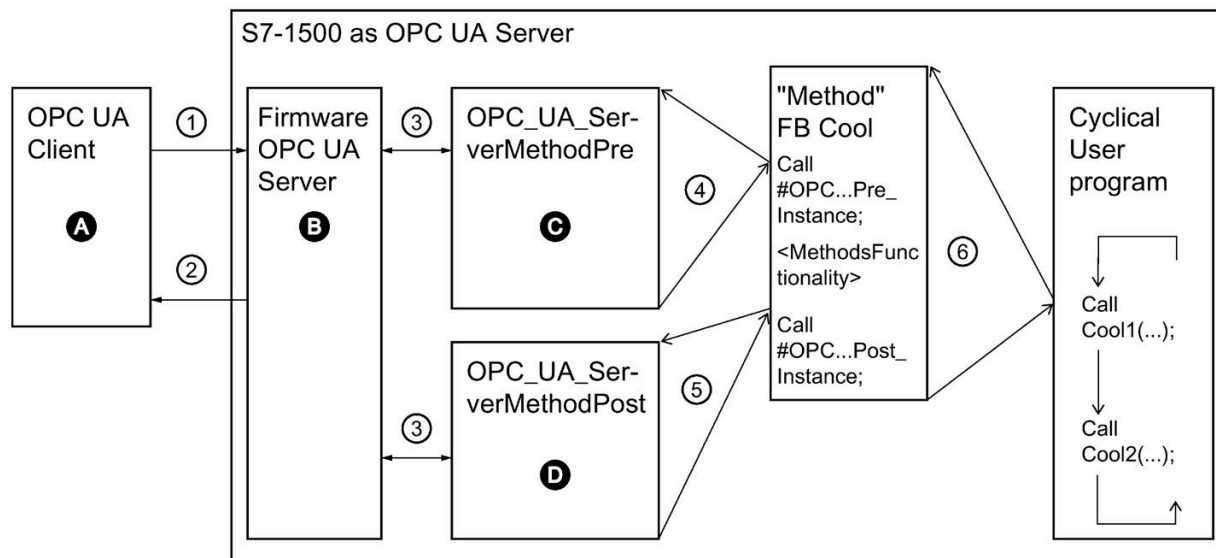
The CPU first uses the instruction "OPC-UA\_ServerMethodPre" to query ④ whether an OPC UA client has called the server method "Cool" ①.

- If the server method has not been called, program execution returns directly to the cyclic user program over ④ and ⑥. The CPU resumes the cyclic user program after "Cool1".
- If the server method has been called, this information is returned to the server method "Cool" over ④. The actual functionality is now executed in the Cool server method, see "<Method Functionality>" in the graphic.

The server method then uses the instruction "OPC-UA\_ServerMethodPost" ⑤ to notify the firmware (B) that the instruction has been executed ③.

The firmware returns this information over ② to the calling OPC UA client (A).

The CPU resumes the cyclic user program after "Cool1".



- A** Call of the server method and management of the "Done" information (method complete)
- ① Asynchronous call of the server method
- ② Asynchronous "Done" information for the method called (method complete)
- B** Wait for OPC UA client calls, management of calls in the queue, forwarding of "Done" information from the cyclic user program to the OPC UA client
- ③ Data transfer from the OPC UA server to the method instances of the user program and vice versa
- C** Check whether method has been called.  
If it has, forwarding of input data from the OPC UA server to the method instance of the user program and feedback to the method instance that the method has been called ("called")
- ④ Synchronous call of the instruction OPC-UA-ServerMethodPre as a multi-instance stating the storage area for the input data from the OPC UA server.  
The return value indicates whether or not the method has been called by the OPC UA client.
- ⑤ Check whether the method has been completed or is still active ("busy").
- D** Check whether the method has been completed.  
If it has, the output data of the method instance is forwarded to the OPC UA server and the method instance is notified that the method has been completed. The OPC UA server is notified.
- ⑥ Call of the method FB (in this case: FB Cool) with the required instance and the process parameters

Figure 9-49 Example: Calling the "Cool" server method

## Information about server instructions

The "OPC-UA-ServerMethodPre" and "OPC-UA-ServerMethodPost" are described in detail in the help to the Instructions > Communication > OPC UA > OPC UA server.

## See also

Boundary conditions for using server methods (Page 283)

### 9.3.5.2 Boundary conditions for using server methods

#### Permitted data types

If you provide server methods, observe the following rule:

- Assign the data types as shown below (SIMATIC data type - OPC UA data type). Other assignments are not permitted.

STEP 7 does not check the observance of this rule and does not prevent an incorrect assignment. You are responsible for the rule-compliant selection and assignment of the data types.

You can also use the listed data types, for example, as elements of structures/arrays/UDTs for input and output parameters of self-created server methods (UAMethod\_InParameters and UAMethod\_OutParameters).

| SIMATIC data type                                                                                                                                                                                                                                  | OPC UA data type                                        |
|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------|
| BOOL                                                                                                                                                                                                                                               | Boolean                                                 |
| SINT                                                                                                                                                                                                                                               | SByte                                                   |
| INT                                                                                                                                                                                                                                                | Int16                                                   |
| DINT                                                                                                                                                                                                                                               | Int32                                                   |
| LINT                                                                                                                                                                                                                                               | Int64                                                   |
| USINT                                                                                                                                                                                                                                              | Byte                                                    |
| UINT                                                                                                                                                                                                                                               | UInt16                                                  |
| UDINT                                                                                                                                                                                                                                              | UInt32                                                  |
| ULINT                                                                                                                                                                                                                                              | UInt64                                                  |
| REAL                                                                                                                                                                                                                                               | Float                                                   |
| LREAL                                                                                                                                                                                                                                              | Double                                                  |
| LDT                                                                                                                                                                                                                                                | DateTime                                                |
| WSTRING                                                                                                                                                                                                                                            | String                                                  |
| DINT                                                                                                                                                                                                                                               | Enumeration (Encoding Int32) and all derived data types |
| User-defined data type required (UDT, user-defined data type)<br>The user-defined data type must be created with the prefix "Union_", for example "Union_MyDatatype".<br>The first element (Selector) in this UDT must have the data type "UDINT". | UNION and all derived data types                        |

### Number of implementable server methods and number of arguments

If you implement server methods via your user program, the number of usable methods is limited depending on the CPU type, see the following table (up-to-date technical data of the CPUs can be found in the Internet (<https://support.industry.siemens.com/cs/ww/en/ps/td>)).

| Technical specification value                                                                                                                                                   | CPU 1510SP (F)<br>CPU 1511 (C/F/T/TF)<br>CPU 1512C<br>CPU 1512SP (F)<br>CPU 1513 (F) | CPU 1505 (S/SP/SP F/SP T/SP TF)<br>CPU 1515 (F/T/TF)<br>CPU 1515 SP PC (F/T/TF)<br>CPU 1516 (F/T/TF) | CPU 1507S (F)<br>CPU 1517 (F/T/TF)<br>CPU 1518 (F) |
|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------|----------------------------------------------------|
| Maximum number of usable server methods or max. number of server method instances (OPC-UA_ServerMethodPre, OPC-UA_ServerMethodPost instructions)                                | 20                                                                                   | 50                                                                                                   | 100                                                |
| Maximum number of arguments per method<br>(More than the specified number of arguments can be configured and loaded into the CPU, but an OPC UA client cannot call the method). | 20                                                                                   | 20                                                                                                   | 20                                                 |

#### Error message when exceeded

If the maximum number of server methods is exceeded, the OPC-UA\_ServerMethodPre or OPC-UA\_ServerMethodPost instructions report the error code 0xB080\_B000 (TooManyMethods).

### Supply of structured data types with nested arrays

If a structured data type (Struct/UDT) contains an array, the OPC UA server does not provide information about the length of this array.

If you use such a structure as the input or output parameter of a server method, for example, you must ensure that the nested array is supplied with the correct length when the method is called.

If you do not adhere to this rule, the method fails with the error code "BadInvalidArgument".



## 9.3.6 Providing alarms on the OPC UA server

### 9.3.6.1 Useful information on alarms

Alarms allow you to detect errors in process control in the automation system quickly, to localize them precisely, and to eliminate them. This leads to a significant reduction in downtimes in a plant. The OPC UA information model "Alarms & Conditions" provides a standardized and platform-independent way of message processing.

As of firmware version V2.9, the OPC UA server of an S7-1500 CPU supports the OPC UA information model "Alarms and Conditions". In this way, the OPC UA server provides access to controller alarms.

The following sections describe which alarm types available in SIMATIC are supported at the OPC UA interface of the OPC UA server.

The following sections also describe how you configure the OPC UA server of the S7-1500 CPU for Alarms & Conditions, the main points of how the Alarms & Conditions model is structured with OPC UA, and which special points must be taken into consideration when using alarms from the address space of the OPC UA server as compared to the SIMATIC controller alarms of the CPU alarm system.

### Basis for the converting alarms to OPC UA Alarms & Conditions

The Alarms and Conditions information model is specified in the "OPC 10000-9: OPC Unified Architecture Part 9: Alarms & Conditions" specification.

### Controller alarms in SIMATIC

The OPC UA server of the S7-1500 CPUs supports the controller alarms listed below, which are available to S7-1500 CPUs. You configure or program these alarms in the usual way, without the need to consider additional rules for use of these alarms by OPC UA clients.

The added benefit of OPC UA Alarms and Conditions is that these alarm types can be displayed not only by HMI devices, web browsers, the CPU display or the TIA Portal, but also by all OPC UA clients that support OPC UA Alarms and Conditions.

- **PLC supervision alarms with ProDiag**  
You can integrate simple supervisions in your program with just a few configuring steps and without having to change the program code. The configuration of the supervisions is independent of the programming languages of the TIA Portal because only individual operands are supervised, and you do not need any additional programming sections.
- **System diagnostics alarms**  
Configuration-dependent module events are known by the hardware configuration of the CPU and can be evaluated by connected display devices. They can only be viewed in the alarm editor and cannot be edited.
- **Program alarms (Program\_Alarm instruction)**  
For reporting program synchronous events, program alarms are assigned to one block at a time. They are created in the program editor and edited in the alarm editor (TIA Portal).
- **GRAPH alarms**  
For GRAPH function blocks, you can also enable alarms; e.g. for interlocks, supervisions and GRAPH warnings (step time monitoring).

## Important information on the alarm types

The following characteristics are significant to the differences in the behavior of alarms:

- Do alarms have a state (e.g. are they incoming, outgoing - with the corresponding time stamps)?
- Do alarms require acknowledgment?

If none of these characteristics apply, which means the alarms have no state and do not require acknowledgment, alarms simply provide information about an event that has occurred ("Fire and Forget"). It is up to the device receiving the alarm to buffer the alarm for further use or only for display.

## Alarm class determines acknowledgment behavior

This section covers the setting options for program alarms. You can also set the behavior of the alarms for system diagnostics alarms and PLC supervision alarms (e.g. ProDiag supervision settings) - refer to the linked additional information for details.

You can find the setting options for program alarms in the alarm editor (double-click on "PLC supervisions and alarms" in the project tree, select the "Alarms" tab).

For the S7-1500 CPU, you set here via the alarm class whether an alarm needs to be acknowledged or not. In addition to the acknowledgment behavior, when creating a new alarm class, you define the default priority of alarms of this alarm class.

You set whether an alarm has a state or not by means of the "Information only" option, for example, at the alarm type; this results in "Fire-and-Forget" behavior of the alarm.

Here is an example with settings in the alarm editor with different alarm classes ("PLC supervisions and alarms" in the project tree):

- First line "Program\_Alarm": Does not require acknowledgment, information only ("Fire and Forget").
- Second line "Program\_Alarm\_1": Requires acknowledgment and has a state, which means the alarm includes information on whether it is incoming or outgoing.
- Third line "Program\_Alarm\_2": Does not require acknowledgment and has a state, which means the alarm includes information on whether it is incoming or outgoing.

| Name                                                                                                | Type      | ID | Location  | Alarm text | Info text | Alarm class        | Acknowledge...                      | Information only                    |
|-----------------------------------------------------------------------------------------------------|-----------|----|-----------|------------|-----------|--------------------|-------------------------------------|-------------------------------------|
|  Program_Alarm   | PLC alarm |    | AlarmType | myText     | myINFO    | No Acknowledgement | <input type="checkbox"/>            | <input checked="" type="checkbox"/> |
|  Program_Alarm_1 | PLC alarm |    | AlarmType |            |           | Acknowledgement    | <input checked="" type="checkbox"/> | <input type="checkbox"/>            |
|  Program_Alarm_2 | PLC alarm |    | AlarmType |            |           | No Acknowledgement | <input type="checkbox"/>            | <input type="checkbox"/>            |

## Display of alarms in the TIA Portal

During runtime, you have the option of viewing the alarms in the TIA Portal: The alarm display is located directly under the alarm editor ("Diagnostics" tab > "Alarm display" tab).

The following applies to the state and acknowledgment behavior:

- When you click on the "Current alarms" button, alarms that have been recently incoming, outgoing or acknowledged are displayed. Only alarms with a state and alarms requiring acknowledgment are displayed here. You can also acknowledge an alarm requiring acknowledgment (blue font) in this view via the shortcut menu or using the "Acknowledge" button.
- If you want to observe the chronological development (e.g. alarm came in, was acknowledged and went out), you need to click the "Alarm archive" button. The three events that belong to this alarm are listed one after another only in this view. You can only find the current state in the "Current alarms" view.
- Info reports (alarms with the "Information only" property) are only displayed in the "Alarm archive" view. Because these alarms are only triggered once and not buffered, they do not appear in the "Current alarms" view.
- PLC supervisions are also shown in the alarm display.
- System alarms usually belong to the "No Acknowledgement" alarm class with the "Information only" option. These alarms are logged in the diagnostics buffer in the CPU and thus allow the sequence of system alarms to be analyzed over a limited period. In contrast, operating state changes that are also logged in the diagnostics buffer have a state, which means it is indicated that or when a CPU went into STOP state and if or when it exited this state again, for example, entered RUN state. This information is displayed with the states "incoming/outgoing".



### Provision of controller alarms by the OPC UA server

When an OPC UA client wants to receive alarms of the S7-1500 CPU, it needs to subscribe to OPC UA events (MonitoredEventItems).

For this purpose, the address space of the OPC UA server of the S7-1500 CPU contains corresponding nodes that are "Event-Notifiers" and create a subscription for the OPC UA clients to receive the alarms.

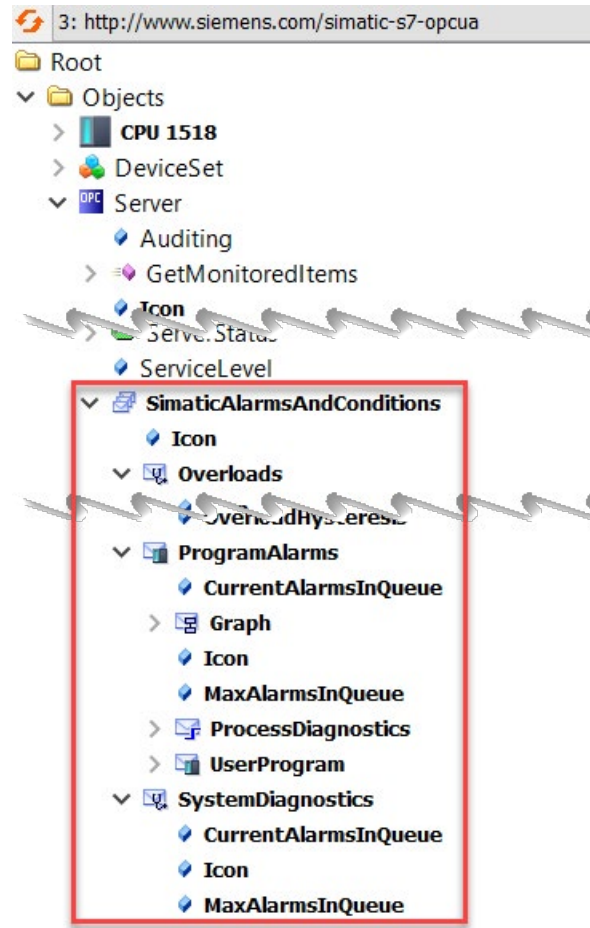
For completeness, we also mention that further type definitions are contained in the server address space for this purpose as nodes under "Types". Type definitions under "BaseEventType" and "ConditionType" ensure that the fields used by SIMATIC alarms are also provided in the OPC UA server.

After the activation of OPC UA Alarms and Conditions (CPU properties in the hardware configuration), the OPC UA address space of the S7-1500 CPU thus reflects the various alarm types (controller alarms) as described above:

- ProcessDiagnostics  
Corresponds to the PLC supervision alarms with ProDiag
- SystemDiagnostics  
Corresponds to the system diagnostics alarms
- UserProgram  
Corresponds to the program alarms
- Graph  
Corresponds to GRAPH alarms

By selecting the node for a subscription, you determine which alarm types are received by the OPC UA client. For example, the "Server" node enables receipt of all alarms, the "UserProgram" node only the receipt of program alarms.

Details about the OPC UA model for Alarms and Conditions are given in the next selection, especially for the "Overloads" node, you can find more information here: Handling memory limits for OPC UA Alarms and Conditions (Page 301).



### Additional information on the alarm types

The concepts and configuration options for controller alarms are not described further here. For information on alarm configuration, alarm display and the associated instructions, such as "Progam\_Alarm", refer to the STEP 7 online help.

### 9.3.6.2 OPC UA Events

The basic concepts for alarm processing in OPC UA are expanded on here - the basic concept of "Events" is covered here. The terms used in the various parts of the OPC UA specification have been retained here.

#### Properties of events

In the address model of the OPC UA server, as of CPU firmware version V2.9, you not only have the option to access PLC tags (read, write) via nodes and to use methods - you can also receive events or alarms via nodes. In OPC UA terminology, these are called "events".

An event includes an event text (Message), time stamp (Time) and event source (SourceNode).

The information supplied with an event from the server depends on the event type. OPC UA defines a BaseEventType in part 5 of the specification (Information Model).

Other event types that provide different alarm behavior are derived from the BaseEventType. This type information of the different event types is visible in the address space of an OPC UA server ("Types" folder). This also applies, for example, to the event types of "Conditions" and "Alarms", which are discussed in the next section.

The OPC UA specification defines for the BaseEventType and for derived EventTypes which properties (fields) of an event are mandatory and which are optional.

The following figure shows the hierarchical structure of BaseEventType.

The following sections show how specialized EventTypes are derived from the root of the derivation hierarchy, the BaseEventType. The SIMATIC-specific derivations ensure that the information supplied in SIMATIC with an alarm and displayed on an HMI device, for example, can also be subscribed to by an OPC UA client in the address space of the OPC UA server.

An event itself is not available as a node in the address space. Events are only triggered by nodes or objects that have the "Event-Notifier" property. These nodes are often also referred to as event signaling objects. Only nodes with this property can be specified as EventMonitoredItem in a subscription to receive corresponding events in the client.

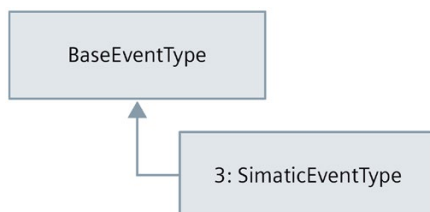
Nodes that can trigger events with an S7-1500 CPU are objects such as "Server", the "SimaticAlarmsAndConditions" object below it, and the three objects below that, ProcessDiagnostics, SystemDiagnostics and UserProgram. The "EventNotifier" attribute is set for these objects in the address space of the OPC UA server of the CPU.

## Definition of SimaticEventType

The figure below shows that the type "SimaticEventType" is derived directly from BaseEventType.

BaseEventType is the basic type definition for events with OPC UA.

All event types for OPC UA can be defined, directly or indirectly, based on BaseEventType.



The "SimaticEventType" type is defined in the SIMATIC namespace (<http://www.siemens.com/simatic-s7-opcua>).

SimaticEventType has all properties of BaseEventType as well as the special properties which are an image of the field structure of SIMATIC alarms.

## Description of the event fields for SimaticEventType

The following table contains information on the fields of SimaticEventType for alarms of the type "Information only". Fields that are optional according to OPC UA and are not used by the OPC UA server of the CPU are omitted. You can also find a general description of the fields in the specification OPC 10000-5: OPC Unified Architecture, Part 5: Information Model, Release 1.04.

| BrowsePath           | DataType                      | Explanations                                                                                                                                                                                |
|----------------------|-------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| EventId              | ByteString                    | Unique Event ID of the event                                                                                                                                                                |
| EventType            | NodeId                        | Node ID of the event type                                                                                                                                                                   |
| Time                 | UtcTime                       | Time stamp of the event (Event occurrence)                                                                                                                                                  |
| ReceiveTime          | UtcTime                       | Current time stamp at which the OPC UA event was generated.                                                                                                                                 |
| Message              | LocalizedText                 | Event text                                                                                                                                                                                  |
| Severity             | UInt16                        | Priority of the alarm from SIMATIC (0..16), spread into a range from 1..1000 with OPC UA, see following table.<br>The priority indicates the urgency with which the event needs a response. |
| 3:AdditionalText_01  | LocalizedText                 | Optional additional text 1                                                                                                                                                                  |
| ...                  | ...                           | ...                                                                                                                                                                                         |
| 3:AdditionalText_09  | LocalizedText                 | Optional additional text 9                                                                                                                                                                  |
| 3:AssociatedValue_01 | 3:SimaticAssociatedAlarmValue | Optional associated value 1 (not for system diagnostics)                                                                                                                                    |
| ...                  | ...                           | ...                                                                                                                                                                                         |
| 3:AssociatedValue_10 | 3:SimaticAssociatedAlarmValue | Optional associated value 10 (not for system diagnostics)                                                                                                                                   |
| 3:InfoText           | LocalizedText                 | Info text                                                                                                                                                                                   |

| BrowsePath     | DataType | Explanations                                                                                               |
|----------------|----------|------------------------------------------------------------------------------------------------------------|
| 3:ID           | UInt16   | Alarm number - A number (ID) assigned by the system that is unique within the CPU and identifies an alarm. |
| 3:DisplayClass | UInt16   | Display class (used by HMI devices. Determines the events displayed on specific HMI devices.               |
| 3:GroupID      | UInt8    | Acknowledgment group for alarms that are acknowledged together.                                            |

### Assignment of Priority (SIMATIC) - Severity (OPC UA)

The following table shows how the 17 priorities that you can assign to alarms in the SIMATIC environment are mapped to the 1000-level Severity with the OPC UA server of the S7-1500 CPU.

This assignment depends on the manufacturer. Different assignments may apply to other devices.

| OPC Range          | Priority 0..16 (SIMATIC) | Severity 1..1000 (OPC UA) |
|--------------------|--------------------------|---------------------------|
| HIGH (667 – 1 000) | 16                       | 1000                      |
|                    | 15                       | 930                       |
|                    | 14                       | 860                       |
|                    | 13                       | 790                       |
|                    | 12                       | 720                       |
| MEDIUM (334 – 666) | 11                       | 650                       |
|                    | 10                       | 600                       |
|                    | 9                        | 550                       |
|                    | 8                        | 500                       |
|                    | 7                        | 450                       |
|                    | 6                        | 400                       |
|                    | 5                        | 350                       |
|                    | 4                        | 300                       |
| LOW (1 – 333)      | 3                        | 225                       |
|                    | 2                        | 150                       |
|                    | 1                        | 75                        |
|                    | 0                        | 1                         |



### 9.3.6.3 OPC UA conditions and OPC UA alarms

The following goes further in depth about the basic concepts for OPC UA Conditions and OPC UA Alarms based on the explanations of events in the previous sections. Again, the terms used in the various parts of the OPC UA specification have been retained here.

#### Properties of Conditions

A prerequisite for understanding is the concept of "Events" in OPC UA.

In OPC UA, if an event alarm object provides status information in addition to its ability to fire Events, we speak of Conditions. Conditions represent a state of a system or one of its components. Basic states are "enabled" and "disabled", other state definitions are also possible.

In turn, interested OPC UA clients are notified of state changes by means of events (Condition Events).

An example of a Condition is state information, for example, that a device requires maintenance.

#### Properties of Alarms

However, the properties of ConditionType are not sufficient to completely map the characteristics of SIMATIC alarms in the OPC UA server.

From the ConditionType, which is derived from the BaseEventType, OPC UA defines further derived event types such as AcknowledgeableConditionType and AlarmConditionType.

AcknowledgeableConditionType supplements the properties of ConditionType with the "Acknowledgeable" characteristic (AckedState).

AlarmConditionType thus adds the "ActiveState" characteristic to the properties of ConditionType and the AcknowledgeableConditionType. In SIMATIC terminology, this is an incoming alarm. The ActiveState signals that the situation, which the Condition represents, is currently present or has occurred.

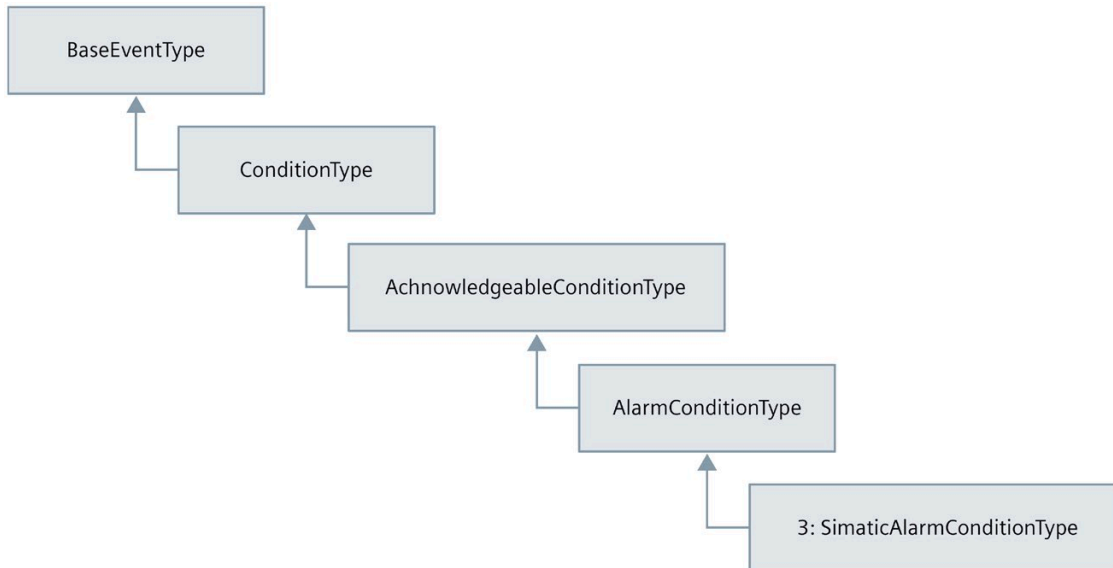
Example: A temperature has exceeded a limit. If "ActiveState" is not set, the situation that represents the condition no longer exists - this is usually referred to as a "normal state". In SIMATIC terminology, this corresponds to an outgoing alarm.

In OPC UA, other statuses such as SilenceState and ShelvingState are defined, but these are not relevant to mapping to the SIMATIC alarm system and will therefore not be described further here.

The SimaticAlarmConditionType is derived from the AlarmConditionType and contains all event fields to map the state and acknowledgment information of SIMATIC messages.

## Definition of SimaticAlarmConditionType

The following figure shows how events of the type "SimaticAlarmConditionType" are defined by a series of expansions to the OPC UA "BaseEventType".



## Description of the event fields for SimaticAlarmConditionType

The following table contains information about the fields of SimaticAlarmConditionType for stateful and acknowledgeable alarms, which are added to the event fields such as SimaticEventType. Fields that are optional according to OPC UA and are not used by the OPC UA server of the CPU are omitted. You can also find a description of the fields in the specification OPC 10000-9: OPC Unified Architecture, Part 9: Alarms & Conditions, Release 1.04.

| BrowsePath              | DataType      | Explanations                                                                                                                                                                                      |
|-------------------------|---------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| ConditionClassId        | NodeId        | Node IDs for SystemConditionClassType, ProcessConditionClassType or BaseConditionClassType are possible                                                                                           |
| ConditionClassName      | LocalizedText | Display name of the ConditionClassId                                                                                                                                                              |
| Retain                  | Boolean       | Indicates that the alarm is still relevant for OPC UA clients (set if alarm is still pending and not acknowledged).                                                                               |
| Comment                 | LocalizedText | <ul style="list-style-type: none"> <li>Most recent comment entered using the "AddComment" or "Acknowledge" method.</li> <li>ZERO after a server restart and if no comment was entered.</li> </ul> |
| Comment.SourceTimestamp | UtcTime       | Time stamp for the last change of the comment field                                                                                                                                               |
| AckedState              | LocalizedText | "Acknowledged" or "Unacknowledged"                                                                                                                                                                |
| AckedState.Id           | Boolean       | Set, if acknowledged                                                                                                                                                                              |

| BrowsePath                | Data Type     | Explanations                                                                                  |
|---------------------------|---------------|-----------------------------------------------------------------------------------------------|
| AckedState.TransitionTime | UtcTime       | Time at which the alarm was acknowledged.<br>ZERO if not acknowledged or not acknowledgeable. |
| ActiveState               | LocalizedText | "Active" or "Inactive"                                                                        |
| ActiveState.Id            | Boolean       | Set when "active"                                                                             |

#### 9.3.6.4 Activating Alarms and Conditions

##### Requirements

- S7-1500 CPU firmware version V2.9 or higher
- Runtime license for OPC UA were purchased according to the license specifications and set in the CPU properties

##### Procedure

To activate alarms through OPC UA Alarms and Conditions, proceed as follows:

1. In the CPU properties, go to the "OPC UA > Server > General" area.
2. Select the "Enable Alarms and Conditions on the OPC UA server" option.  
The corresponding types and objects that can trigger events only become visible in the address space when the option is activated.
3. If required, also activate the option "Allow message acknowledgment by OPC UA client".  
In this case, every connected OPC UA client can acknowledge an alarm requiring acknowledgment with the "Acknowledge" method.



##### Recommendation: Activate diagnostics "Requests of a remote OPC UA client failed"

When the OPC UA server cannot allocate sufficient memory, it is not possible to generate OPC UA alarms in this state; a message loss for OPC UA clients is possible.

Therefore, you should activate the diagnostics "Requests of a remote OPC UA client failed" to diagnose this state (Properties of the CPU > OPC UA > Server > Diagnostics).

In addition, you should also activate the option "Summarize diagnostics in case of high message volume".

As soon as sufficient memory is available again, OPC UA clients should call the ConditionRefresh method to receive the current state of the alarm system.

##### See also

Methods for OPC UA Alarms and Conditions (Page 297)

Request of a remote client failed (Page 309)

### 9.3.6.5 Subscribing to events of an OPC UA server

#### Subscribing to all events via the "Server" node

OPC UA servers provide events via the "Server" node and lower-level nodes. When OPC UA clients subscribe to the "Server" node, they receive all events and alarms of the OPC UA server.

The "Server" node is located in the "Objects" folder below "Root".

OPC UA servers inform OPC UA clients which event types they use (under "Root > Types > EventTypes" in the address space).

#### Filter options for events

OPC UA clients can choose and only subscribe to specific nodes under the "Server" node and thus to specific event types, for example, only the "UserProgram" node. This reduces the number of events from the OPC UA server to program alarms.

Another way of filtering is to select the event fields, known as "Select Clause" in OPC UA terminology.

This means that in the subscription, the OPC UA client makes a selection of the event fields in addition to the event alarm object (e.g. the "UserProgram" node). You select the event fields via the browse name of the corresponding field.

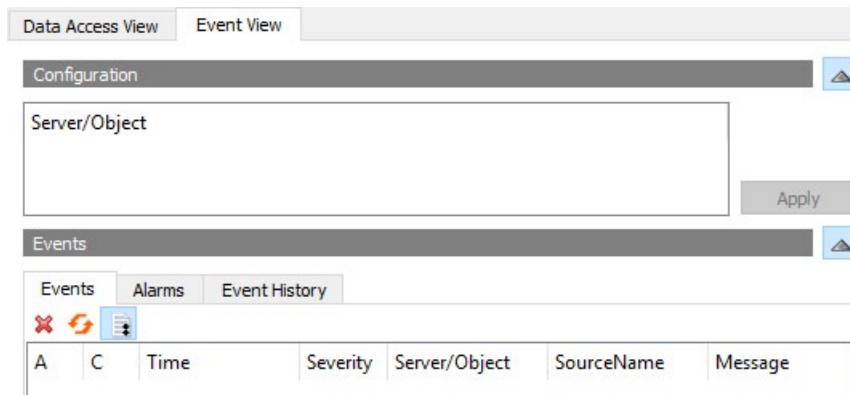
OPC UA also defines so-called "Where Clauses". A Where Clause in the event filter is used to further limit the number of events that are supplied by the OPC UA server for the selected object, for example, by filtering to a severity range.

#### Example client UaExpert

The example of the UaExpert OPC UA client shows how events of an OPC UA server can be received via a subscription. Here is the most important information on the displayed events/alarms:

- Event View is a separate view of events in addition to the Data Access View.
- The "Configuration" area contains the selected event signaling object with the fields for the Select Clause. A configuration of Where clauses is currently not possible in UaExpert.
- In the "Events" area, "Events" tab: Corresponds to the TIA alarm view with activated "Alarm archive" button; events of the "Information only" category and outgoing alarms are also visible there, because UaExpert buffers them in the background for display. These events are not visible in the "Alarms" tab.
- In the "Events" field, "Alarms" tab: Corresponds to the TIA alarm display with activated "Current alarms" button; alarms are visible here with their status, e.g. "active" (corresponds to "incoming") and these alarms can also be acknowledged using the shortcut menu. Outgoing alarms are no longer visible in this view.

In the columns of the Event area, a selection of event fields is offered, for example, the event text (Message) and whether the alarm was acknowledged (A=Acknowledged).



### Special features of the display of alarms via the OPC UA server of the CPU

The following once again summarizes the special features of the alarm display via OPC UA Alarms and Conditions for the current status.

| Topic                                              | Explanation                                                                                                                                                                                                                                             |
|----------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Comment                                            | Via OPC UA, you can add a comment to a alarm using the "Add-Comment" method or the "Acknowledge" method. This comment is no longer available after a server restart.                                                                                    |
| Pending alarms are not lost after a server restart | The OPC UA server supports the "ConditionRefresh" method with which it makes the current state of the system available to the OPC UA client, for example, after download of a new data block (requires server restart and connection re-establishment). |

#### 9.3.6.6 Methods for OPC UA Alarms and Conditions

The OPC UA specification Part 9 (OPC 10000-9: Alarms & Conditions) defines methods for OPC UA servers to enable OPC UA clients to react to state changes, for example.

In the following, the methods are described that are supported by the OPC UA server of the S7-1500 CPU with their special features.

#### Requirement

Using the relevant methods for the Alarms and Conditions functionality requires the following:

- Alarms and Conditions is activated
- For the "Acknowledge" method, the acknowledgment of alarms by OPC UA clients must be allowed on the server side.

## Methods for OPC UA Alarms and Conditions

In the following, the methods are briefly explained with the special features and restrictions caused by the implementation for the OPC UA server of the S7-1500 CPU.

The methods are visible in the type space.

The OPC UA specification listed above contains the general description.

You can find a detailed description of the individual methods below this overview table.

| Method           | Description                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |
|------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Acknowledge      | Method for acknowledging an alarm object that is uniquely identified by a EventId.                                                                                                                                                                                                                                                                                                                                                                                                                                       |
| ConditionRefresh | <p>Method for requesting an update of all alarm objects (in SIMATIC language: updating of all pending alarms). All monitored items of the subscription are updated.</p> <p>Synchronization of pending alarm objects from the OPC UA server of the CPU is indicated e.g. in the following situations:</p> <ul style="list-style-type: none"> <li>Connecting for the first time or resuming the connection (after interrupting the communication)</li> <li>Screen change on an operator screen of an HMI device</li> </ul> |
| AddComment       | Method for adding comments to alarm objects.                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |

## Calling the "Acknowledge" and "AddComment" methods

Method calls in OPC UA use MethodId and ObjectId.

In the case of an alarm object, ObjectId is the node ID for the instance of the alarm object.

Since the address model of Simatic Alarms and Conditions does not provide instances for alarm objects, the OPC UA specification provides in this case that the OPC UA client uses the ConditionId as ObjectId.

You can find information on how to determine the ConditionId using a SimpleAttributeOperands in the SelectClause of the event filter, see also the OPC UA specification Part 9 (OPC 10000-9: Alarms & Conditions):

| Name                   | Type          | Description                      |
|------------------------|---------------|----------------------------------|
| SimpleAttributeOperand |               |                                  |
| typeId                 | NodeId        | NodeId of the ConditionType Node |
| browsePath[]           | QualifiedName | empty                            |
| attributeId            | IntegerId     | Id of the NodeId Attribute       |

## Acknowledge

The Acknowledge method (MethodId: i=9111) has the following parameters:

| Parameter    | Data type     | Description                                                                                                                                                       |
|--------------|---------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| [in] EventId | ByteString    | EventId identifies a specific event notification. Only events whose AckedState.Id field has the value "False", can be acknowledged with the "Acknowledge" method. |
| [in] comment | LocalizedText | Text for commenting the acknowledgment, e.g. by an operator.<br>See also supplementary description of the "AddComment" method.                                    |

### Method Result Codes

| Result Code                   | Description                                                                                                                                               |
|-------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------|
| Good                          | Method was successfully executed.                                                                                                                         |
| BadNotSupported               | Method cannot be called because the option for acknowledging for Alarms and Conditions by OPC UA clients is deactivated in the CPU properties for OPC UA. |
| BadConditionBranchAlreadyAked | Acknowledgment has already been made.                                                                                                                     |
| BadNodeIdUnknown              | Method was called with the wrong ConditionId (see notes on ObjectId).                                                                                     |
| BadEventIdUnknown             | Method was called with the wrong EventId.                                                                                                                 |

## ConditionRefresh

The ConditionRefresh method (MethodId: i=3875) has the following parameters:

| Parameter           | Data type | Description                                       |
|---------------------|-----------|---------------------------------------------------|
| [in] SubscriptionId | UInt32    | SubscriptionId of the subscription to be updated. |

### Method Result Codes

| Result Code               | Description                                                                                                                            |
|---------------------------|----------------------------------------------------------------------------------------------------------------------------------------|
| Bad_SubscriptionIdInvalid | The SubscriptionId is not valid.                                                                                                       |
| Bad_RefreshInProgress     | The "ConditionRefresh" is currently running.                                                                                           |
| Bad_UserAccessDenied      | The method "ConditionRefresh" runs in the context of a wrong session. This means that the subscription belongs to a different session. |

### Note

#### ConditionRefresh2 method

The OPC UA server of the S7-1500 CPU does not support the ConditionRefresh2 method which can specifically synchronize a monitored item (MonitoredItem) in a subscription. In this case, the OPC UA Server returns the result code "Bad\_MethodInvalid". Use the method "ConditionRefresh" instead.

## AddComment

You have the possibility to add comments to Alarms- objects of the SimaticAlarmConditionType type because the support of comments is mandatory for OPC UA Alarms and Conditions .

A comment was save in the "Comment" event field.

The following time stamp event fields belong to the comment:

- "Comment.SourceTimestamp" for the time when the comment is transferred to the CPU??
- "Time" for the time when the Alarms object was modified

When the "AddComment" method is called, "Time" and "Comment.SourceTimestamp" are identical.

### Special features of Alarms and Conditions comments for the OPC UA server of the CPU

The AddComment method (MethodId: i=9029) has the following parameters:

| Parameter    | Data type     | Description                                                               |
|--------------|---------------|---------------------------------------------------------------------------|
| [in] EventId | ByteString    | EventId identifies the event notification for which a state was reported. |
| [in] comment | LocalizedText | Text for commenting the specified Alarms object.                          |

### Method Result Codes

| Result Code       | Description                                                                                                     |
|-------------------|-----------------------------------------------------------------------------------------------------------------|
| Good              | Method was successfully executed.                                                                               |
| BadNodeIdUnknown  | Method was called with the wrong ConditionId (see notes on calling the methods "Acknowledge" and "AddComment"). |
| BadEventIdUnknown | Method was called with the wrong EventId.                                                                       |



## Special features of Alarms and Conditions comments for the OPC UA server of the CPU

You have the possibility to add comments to alarm objects of the "SimaticAlarmConditionType" type with the AddComment method. A comment is also set when the Acknowledge method is called. The "AddComment" method can be called several times.

- A comment was save in the "Comment" event field. The "Comment.SourceTimestamp" indicates the last time at which a **comment** was set.
- The "Time" time stamp marks the **last modification time of the alarm object**.

When the "AddComment" method is called, "Time" and "Comment.SourceTimestamp" are identical.

When the "Acknowledge" method is called, the two time stamps may differ, since the acknowledgment is asynchronous.

The support of comments for OPC UA Alarms and Conditions is mandatory. The SIMATIC alarm system does not know corresponding comments for alarms. Therefore, some special features have to be considered:

- There is only one comment:  
There is only one comment for an alarm object, so that an existing comment is always overwritten when several method calls are made in succession.
- Lifetime and time stamp:  
Comments are only stored at the current alarm object. If the alarm object no longer exists, e.g. after a server restart, the comment no longer exists either. The corresponding "Comment" and "Comment.SourceTimestamp" event fields are then reset (zero). The "Time" event field is then set as if the method call "AddComment" did not exist. Example: If you comment on an unacknowledged Alarms object, the "Time" event field receives the time of this comment change. After a server restart, the "Time" event field does not show the time when the comment was set, but the time when the corresponding Event arrived.

### 9.3.6.7 Handling memory limits for OPC UA Alarms and Conditions

The OPC UA server of the S7-1500 CPU has product-specific limited memory capacity for the "Alarms and Conditions" function (see CPU specifications).

Two memory pools for different categories of alarms are available:

- Pool only for ProgramAlarms (corresponds to program-related alarm originators (producers) such as program alarms via Program\_Alarm, ProDiag, Graph)
- Pool only for SystemDiagnostics (corresponds to system diagnostic alarms)

Under unfavorable conditions (e.g. alarm burst) the CPU cannot make all pending alarms (ProgramAlarms or SystemDiagnostics) from the SIMATIC alarm area available to the OPC UA Alarms and Conditions system. However, alarms are not lost in this case.

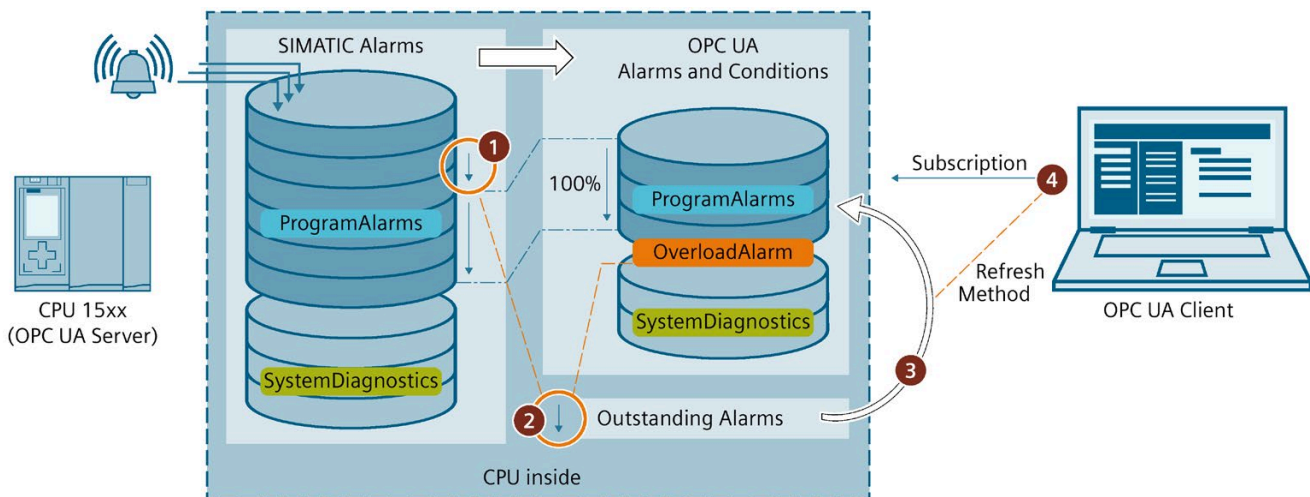
You have the possibility to react to this overload event in the user program. According to your application you can use the "ConditionRefresh" method to make alarms that "did not make it into the OPC UA Alarms and Conditions system" available to the OPC UA Alarms and Conditions system again.

## Requirement

- Alarms and Conditions is activated
- Event subscriptions are set up in the OPC UA client

## Principle

The following figure shows a simplified process for temporarily storing ProgramAlarms to make them available again at another time for the OPC UA Alarms and Condition System. The nodes mentioned in the caption are visible in the following image of the address model.



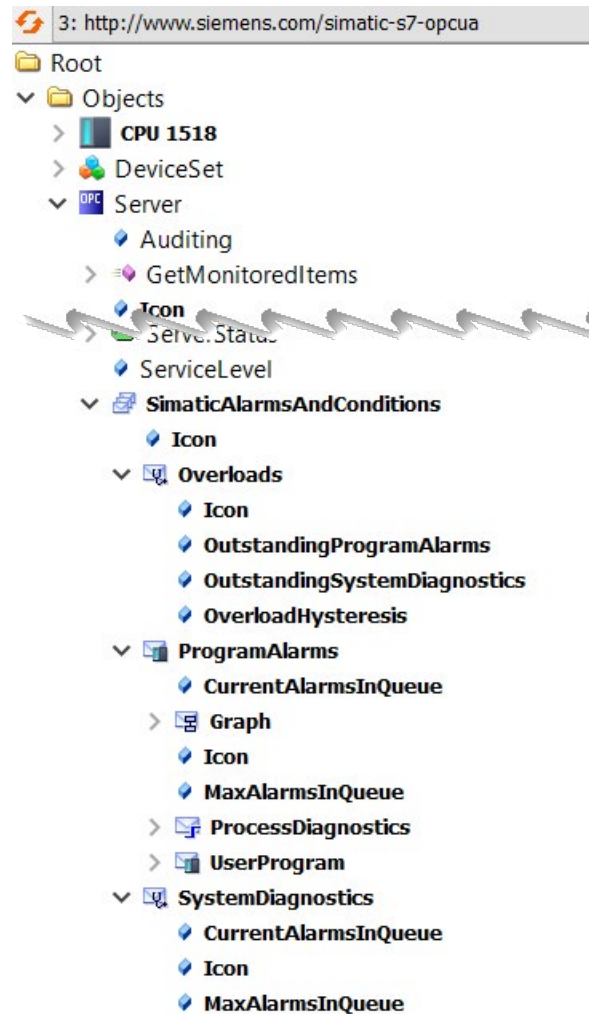
- ① Number of active alarms is too high to make all alarms accessible via OPC UA Alarms and Conditions
- ② Overloads alarm (overload alarm) is triggered. This overload alarm is active until the following situation occurs:
  - No more alarms are pending for the OPC UA Alarms and Conditions system ( $\text{OutstandingProgramAlarms} = 0$ ) and
  - Number of alarms in the OPC UA Alarms and Conditions system  $<$  Hysteresis-cleaned maximum value for OPC UA alarms ( $= \text{MaxAlarmsInQueue} - \text{OverloadHysteresis}$ )

Alarms that are not available in the OPC UA Alarms and Conditions system due to the overload situation are buffered by the CPU as "OutstandingAlarms".

- ③ When an OPC UA client executes the ConditionRefresh method, not only are all alarm objects of the relevant subscription synchronized, but also the alarms outstanding for OPC UA Alarms and Conditions (OutstandingAlarms) are transferred to the Alarms and Conditions memory area - until the maximum number of alarms is reached. "Oldest" alarms are transferred first. After that every subscription to these alarms receives the transferred alarms - not only the OPC UA client that called the ConditionRefresh method.
- ④ The OPC UA client controls the handling of pending alarms via the information of the Overloads nodes.

## Address model for Alarms and Conditions

The following figure shows the nodes of the OPC UA Alarms and Conditions address model.



## Special features

- When pending alarms go out or are acknowledged, they no longer enter the OPC UA Alarms and Conditions system area via the ConditionRefresh method. They are then "invisible" to OPC UA Alarms and Conditions and thus to the connected OPC UA clients. This fact influences e.g. statistical evaluations of alarm progressions.
- To avoid a high alarm frequency for the Overloads Alarm if the number of alarms oscillates around the maximum value, the limit for triggering the alarm is higher than the limit for canceling this alarm: The value for this difference is displayed in the "OverloadHysteresis" node.  
Example: Maximum number of alarms: 200, OverloadHysteresis: 3.  
Overloads alarm is triggered starting with 200 alarms and is only canceled if there are fewer than 197 alarms. If the number of alarms increases again, it will be triggered again when 200 alarms are exceeded.

## 9.3.7 Using diagnostics options

### 9.3.7.1 Diagnostics of the OPC UA server

#### Online diagnostics of the OPC UA server

The S7-1500 CPU OPC UA server can be diagnosed online with standard OPC UA clients, such as UaExpert.

The diagnostic information is subdivided into the following areas:

- Server Diagnostics
- Sessions Diagnostics
- Subscriptions Diagnostics

In the address space of the server, for example, the following nodes are available with diagnostic information:

- **ServerDiagnosticsSummary**: Server diagnostics summary
  - CurrentSessionCount: Number of active sessions
  - SecurityRejectedSessionCount: Number of sessions rejected due to mismatching endpoint security settings between client and server
- **SessionsDiagnosticsSummary**: Session diagnostics summary
  - ActualSessionTimeout: Set time that a session lasts, e.g. in the event of disconnection
- **SubscriptionsDiagnosticsArray**: ARRAY with one element per subscription for each session

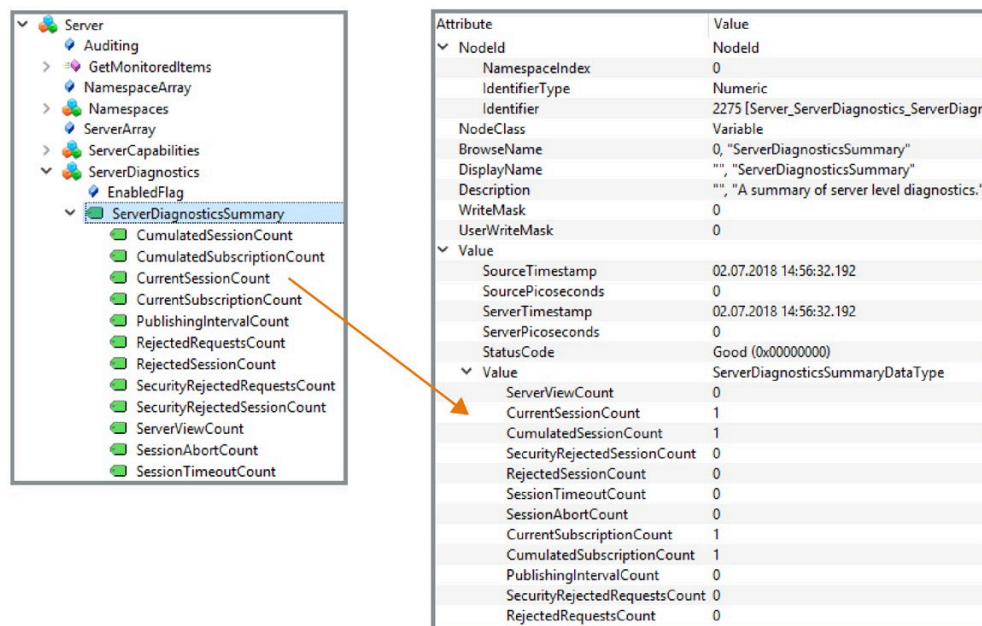


Figure 9-50 Server diagnostics

The SessionsDiagnosticsSummary node also shows the properties of the client application accessing the server within the session.

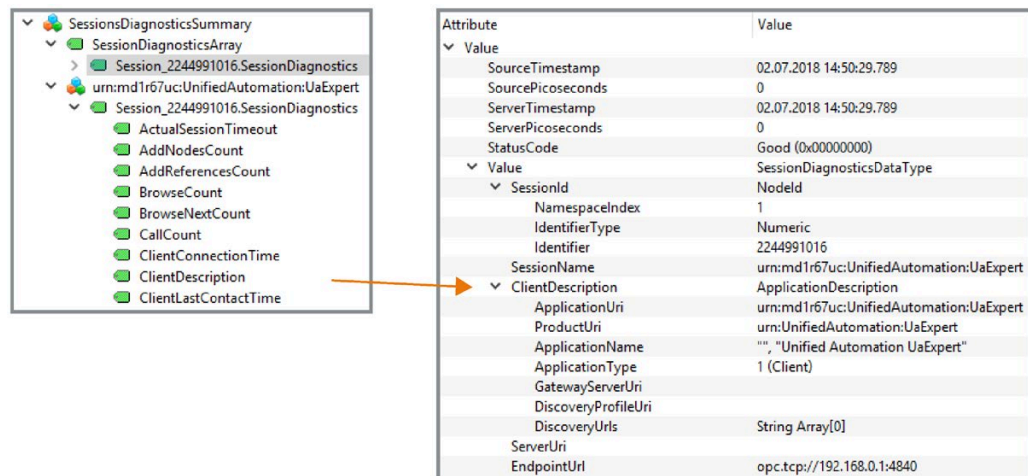


Figure 9-51 Sessions diagnostics with the properties of the client application

## Diagnostics of the connection between client and server

To diagnose the status of the connection during program runtime in the client, use the following instruction:

OPC-UA-ConnectionGetStatus: Read connection status.

### 9.3.7.2 Server state transition diagnostics

#### Information on the server state

S7-1500 CPUs as of firmware version V2.8 are able to create an entry in the diagnostic buffer upon state changes of the OPC UA server.

The diagnostic buffer displays the new state.

The cause of the state change is also displayed, such as download to the CPU, POWER OFF - POWER ON transition, user program instruction or service request from a partner (client).

#### Requirement

The "Change of OPC UA server status" option is selected (OPC UA > Server > Diagnostics) in the OPC UA properties of the CPU.

---

#### Note

If this option is selected, the CPU also automatically enters the lowest set security policy into the diagnostic buffer after startup.

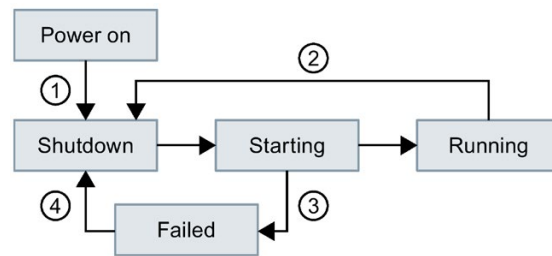
---

#### Examples

If the OPC UA server of the CPU shuts down due to a download process and then starts with a valid new configuration, the diagnostic buffer shows new server state, e.g. Shutdown => Starting => Running.

If the OPC UA server shuts down due to a download process and the server cannot start because the type dictionary is too large, the diagnostic buffer finally shows the state "Failed" (Shutdown => Starting => Failed).

## Server states and state transitions



- ①, ④ POWER ON or Load in RUN, if OPC UA relevant data could be affected.
- ② Loading the hardware configuration with deactivated OPC UA server. The server remains shut down.  
Loading the hardware configuration with activated OPC UA server and faulty OPC UA data (for example, too many structures with the result that the type dictionary becomes too large). In this case, the server cannot start (see ③).
- ③ OPC UA server cannot start due, for example, to faulty configuration.

Figure 9-52 Server states and state transitions

## Description of the server states

The individual states that the OPC UA server can assume are explained below.

| Server states | Explanation                                                                                                                                                                                                                |
|---------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Shutdown      | Initial status <ul style="list-style-type: none"> <li>After POWER ON</li> <li>After loading the hardware configuration with activated or deactivated OPC UA server.</li> <li>After loading OPC UA relevant data</li> </ul> |
| Starting      | OPC UA address space in server is initialized.                                                                                                                                                                             |
| Running       | OPC UA server running (normal productive state for OPC UA server).                                                                                                                                                         |
| Failed        | Error state. OPC UA server cannot start due, for example, to faulty configuration.                                                                                                                                         |

### 9.3.7.3 Session state transition diagnostics

#### Information on the session state

S7-1500 CPUs as of firmware version V2.8 are able to create an entry in the diagnostic buffer for state changes of an OPC UA session.

The diagnostic buffer displays the new state. The corresponding session ID is also displayed.

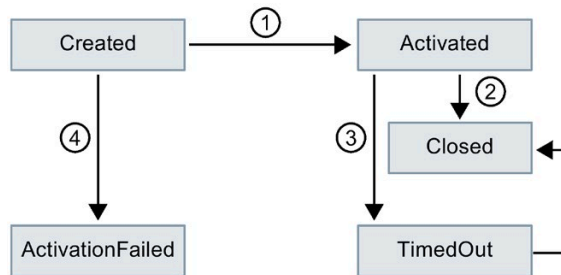
#### Requirement

The "Change of session states" option (OPC UA > Server > Diagnostics) is selected in the OPC UA properties of the CPU.

### Example

A client transmits incorrect authentication data (for example, incorrect password) when a connection is established. The new state of the "ActivationFailed" session is entered with the corresponding session ID in the diagnostic buffer.

### Subscription states and state transitions



- ① Client connects to server, login with correct authentication data (correct credentials).
- ② Client closes connection correctly.
- ③ Client no longer sends messages; session ends with timeout.
- ④ Client connects to server, login with incorrect authentication data.

Figure 9-53 Session states and state transitions

#### 9.3.7.4 Check for security events

If the CPU diagnostics detects a security event during the OPC UA communication, it can enter it in the diagnostic buffer.

### Requirements

- S7-1500 CPUs as of firmware version 2.8
- The "Check for security events" option is activated (properties of the CPU > OPC UA > Server > Diagnostics).

### Security events detected in diagnostics

S7-1500 CPUs perform diagnostics on the following OPC UA relevant security events:

- Client-certificate is invalid (for example, syntactically or semantically incorrect, incorrect signature, current date is not in the validity period)
- User name/password login failed (deactivated or incorrect data)
- Client wants to use a specific security policy or a specific message security mode; the server does not support the security policy or the requested security mode.
- Client does not establish connection according to specification (OPC UA Spec) (for example, unexpected SecureChannelID/SessionID/client Nonce)



## Example

If an attempt is made to compromise communications (for example, by session hijacking, man-in-the-middle attacks etc.), the server detects this via analysis.

### 9.3.7.5 Request of a remote client failed

S7-1500 CPUs as of firmware version V2.8 are able to create an entry in the diagnostic buffer for the following events:

- Bad client requests (incorrect use)
- Service error occurred
- CPU-specific high limits of the OPC UA server were violated

## Example of a faulty client request

For example, there is an incorrect request when a client addresses a node (tag) that does not exist or if a resource is requested that does not exist.

In this case, the corresponding service that caused the fault is entered in the diagnostic buffer and the corresponding session ID is also entered.

## Service fault

If a service itself fails, the server returns a ServiceFault. In this case, the status code (Bad...) and the according session ID are entered in the diagnostics buffer.

## Example of limit violations

If a service request exceeds a CPU-specific limit, for example, number of sessions, number of monitored items, number of subscriptions, etc., this diagnostics is entered in the diagnostics buffer. Together with the message, it is indicated which limit has been violated.

Exception: If you summarize diagnostics and the message occurs frequently, the limit causing the error is not entered. You receive general information that the supported configuration limit has been violated.

### Possible entries for the service that is causing the error

Depending on the client application used, requests to the server can be triggered differently from the user's viewpoint, for example, by an online tool with a graphical user interface or by instructions in a client's program.

With its service-oriented architecture, OPC UA follows a request-response paradigm, therefore the respective client application converts the requests into the service requests defined in OPC UA.

The names of these services are defined and grouped according to their use, see also [opcfoundation.org](http://opcfoundation.org).

In the case of an incorrect use, you can find precisely these names of the services, together with the corresponding session ID, in the diagnostic buffer as the service that caused the error.

The services available with OPC UA are listed below.

#### **Discovery Service Set**

FindServers

GetEndpoints

#### **Session Service Set**

CreateSession

ActivateSession

CloseSession

Cancel

#### **View Service Set**

Browse

BrowseNext

TranslateBrowsePathsToNodeIds

RegisterNodes

UnregisterNodes

#### **Attribute Service Set**

Write

Read

#### **Method Service Set**

Call

#### **Monitored Item Service Set**

CreateMonitoredItems  
 ModifyMonitoredItems  
 DeleteMonitoredItems  
 SetMonitoringMode  
 SetTriggering

#### **Subscription Service Set**

CreateSubscription  
 ModifySubscription  
 DeleteSubscriptions  
 Publish  
 Republish  
 SetPublishingMode

### **9.3.7.6 Subscription diagnostics**

#### **Information about a subscription**

S7-1500 CPUs as of firmware version V2.8 are able to create an entry in the diagnostic buffer at state changes of a subscription.

The diagnostic buffer displays the new state; exception: "KeepAlive".

#### **Requirement**

In the OPC UA properties of the CPU, the option "Subscriptions: Change of status" (OPC UA > Server > Diagnostics) is selected.

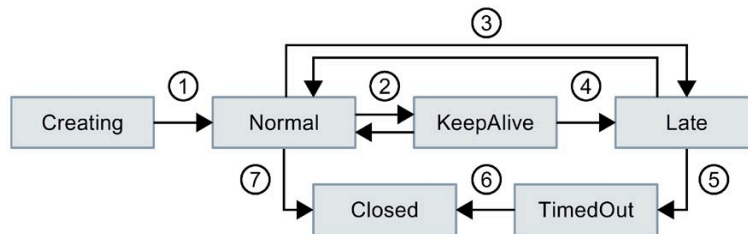
#### **Example**

An OPC UA client is connected to an S7-1500 CPU as OPC UA server and generates a subscription in the server.

The diagnostic options for subscriptions are selected in the OPC UA properties of the CPU.

The "Creating" and "Normal" states are entered one after the other with the corresponding subscription ID in the diagnostic buffer.

## Subscription states and state transitions



- ① Subscription is generated and is then active.
- ② Status change is not entered in the diagnostic buffer because too many entries may be made in the diagnostic buffer depending on the amount of data.
- ③ See explanation in table for "Late"; for example, no requests to send from client.
- ④ Maximum KeepAlive value reached.
- ⑤ See explanation in table for "TimedOut".
- ⑥ Maximum lifetime of subscription reached.
- ⑦ Client has deleted subscription.

Figure 9-54 Subscription states and state transitions

## Description of the subscription states

A subscription in the OPC UA server can have the following states:

| Status    | Meaning                                                                                                                                                                                                                                                                                                                          |
|-----------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Creating  | Client has requested a subscription in the server; the server creates the subscription.                                                                                                                                                                                                                                          |
| Normal    | Subscription is created in the server and active.                                                                                                                                                                                                                                                                                |
| Closed    | Client has deleted the subscription.                                                                                                                                                                                                                                                                                             |
| KeepAlive | Status if the monitored items do not change over a long period of time. These state transitions are not entered in the diagnostic buffer.                                                                                                                                                                                        |
| Late      | Client has generated a subscription with minimal sampling and publishing intervals. The amount of monitored items is not transmitted to the client during this time.<br>Client no longer transmits requests to send (for example, due to failure).                                                                               |
| TimedOut  | The client has requested a subscription.<br>The server can only honor the subscription (send Publish Response) when there is a sufficient number of send requests (Publish Requests) from the client.<br>When the client stops sending subscription requests, the subscription enters the "TimedOut" state after a certain time. |

## Subscription: Error in the sampling times

As of firmware V2.5 of the SIMATIC S7-1500 CPU, the OPC UA server can transmit the status code "GoodOverload" when using subscriptions, if an overload of the CPU occurs when sampling the items.

As of firmware V2.8 of the SIMATIC S7-1500 CPU, the OPC UA server can also enter this event into the diagnostic buffer.

## Requirement

In the OPC UA properties of the CPU, the option "Subscriptions: Sampling time errors" (OPC UA > Server > Diagnostics) is selected.

## Error-free subscription

In the case of an OPC UA subscription to various elements (such as tags), the OPC UA server of the SIMATIC S7-1500 must check the elements for value changes at specified intervals (sampling interval). This check, referred to as "sampling", requires some time, which depends on the number and the data type of the items. After the sampling is completed and a publishing request has been received, the server sends the elements to the client.

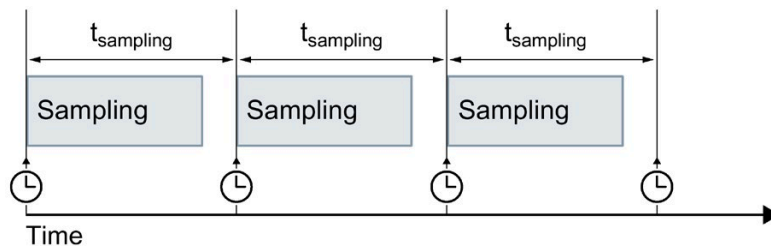
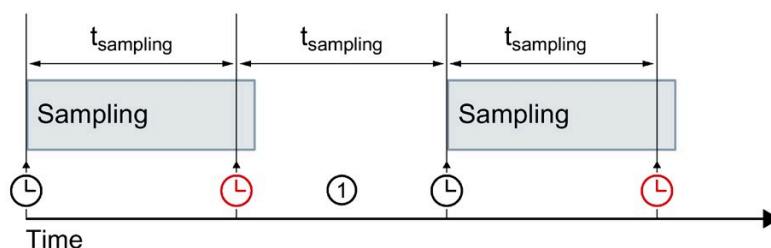


Figure 9-55 Error-free subscription

## Subscription with error

If there are too many elements in the queue, there may be an overload of the communication stack. The CPU cannot check all elements in the given sampling interval and must therefore skip the next sampling job.

In this case, the CPU sends the status code "GoodOverload" (0x002F0000) per element, even though the elements were not checked. The meaning of the status code according to IEC 61131-3 is as follows: "Sampling has slowed down due to resource limitations".



① Sampling job is skipped

Figure 9-56 Subscription with error

See also FAQ 109763090 (<https://support.industry.siemens.com/cs/ww/en/view/109763090>).

## See also

Settings of the server for subscriptions (Page 224)

### 9.3.7.7 Summarizing diagnostics

To prevent the diagnostics buffer being "swamped" by large numbers of identical OPC UA diagnostics, as of STEP 7 V16 service pack 1, you can set parameters so that these diagnostics are entered in the diagnostics buffer as group alarm. Per interval (monitoring time), the CPU then only generates one group alarm per OPC UA diagnostics.

The following sections describe which diagnostics the CPU groups together and how the process runs with a high message volume.

#### Requirement

The "Summarize diagnostics in case of high message volume" option is activated in the OPC UA properties of the CPU (OPC UA > Server > Diagnostics, "Summarize diagnostics" area).

#### Example

An OPC UA client repeatedly "overloads" an S7-1500 CPU as OPC UA server with a sampling rate that the server cannot handle (overload).

The "Summarize diagnostics in case of high message volume" setting is activated.

A message appears in the diagnostics buffer for this diagnostic option. It states that the sampling rate cannot be reached; followed by the number of these events within the configured interval.

#### OPC UA diagnostics that can be summarized

The diagnostics listed below each form their own groups (type). Diagnostic events from the same group are combined using the setting "Summarize diagnostics in case of high message volume":

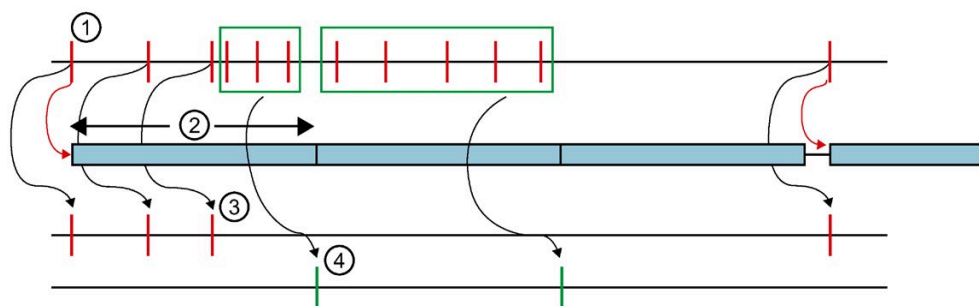
- Incorrect use of an OPC UA service
- OPC UA Service error
- Subscription status has changed
- Sampling rate could not be achieved (subscriptions, overload)
- OPC UA security check failed
- Configuration limit of the OPC UA server violated

## Principle of operation

The CPU enters the first three events of an event type in the diagnostics buffer. It then ignores all subsequent diagnostics of this group.

At the end of the monitoring time (interval), the CPU generates a group alarm in which it enters the diagnostics and the frequency of this diagnostics during the elapsed interval. If these diagnostics also occur in the intervals that follow, the CPU only generates one group alarm per subsequent interval.

A diagnostic surge leaves the following pattern in the diagnostics buffer: Three individual messages followed by a series of group alarms. This series can consist of two, three or more group alarms depending on the selected monitoring time and duration of the diagnostic surge.



- ① Diagnostic results of a group (of a type), for example "Sampling rate could not be reached".
- ② Interval (monitoring time): When a diagnostic event occurs the first time (or reoccurs), the monitoring time is started (or restarted).
- ③ Single alarms: The first three diagnostic events from the same group are entered in the diagnostics buffer immediately. Starting with the fourth diagnostic event, the CPU generates only group alarms. If a diagnostic event of this group occurs after a pause of at least one interval, the CPU enters a single alarm in the diagnostics buffer and restarts the monitoring time.
- ④ Group alarms: After three diagnostic events, the CPU only generates a group alarm as a summary of all additional diagnostic events in this interval. If these diagnostic events also occur in the intervals that follow, the CPU only generates one group alarm per subsequent interval.

Figure 9-57 Summary of diagnostics

## 9.4 Using the S7-1500 CPU as an OPC UA client

### 9.4.1 Overview and requirements

With STEP 7 (TIA Portal) Version V15.1 and higher, you can assign parameters and program an OPC UA client that can read PLC tags in an OPC UA server. Furthermore it is possible to transfer new values for PLC tags to an OPC UA server. In addition, you can call methods that an OPC UA server provides in your user program. You use the instructions for OPC UA clients in your user program for this.

The instructions of the OPC UA client are based on the standard "PLCopen OPC UA Client for IEC61131-3".

#### PLCopen specification

With these standardized instructions, you can develop an OPC UA client functions in your user program that can be executed in an S7-1500 CPU.

In addition, it is possible with just a few adaptations to run this user program in controllers of other manufacturers if these manufacturers have also implemented the OPC UA Specification "PLCopen OPC UA client for IEC61131-3".

#### Convenient editors in STEP 7

For the parameter assignment of the instructions for OPC UA clients, a convenient editor is available in the TIA Portal – the connection parameter assignment (Page 218).

As of Version 15.1, STEP 7 also features an editor for client interfaces (Page 322).

This section describes how you work with these editors.

First, you will be shown how to create and configure a new interface with the interface editor, because you need this type of interface for the subsequent connection parameter assignment.

The description uses an example for better comprehensibility, see Description of the example (Page 320).

#### Requirements

- You have the required runtime license for OPC UA and have configured the license in STEP 7 (CPU Properties > Runtime Licenses).
- The client of the S7-1500 CPU is activated.

To use the client of the S7-1500 CPU, you must enable it:

1. Select the area "OPC UA > Client" in the properties of the CPU.
2. Select the "Enable OPC UA client" option.

If you do not enable the client, the connection is not established. You receive a corresponding error message at the instructions, for example "OPC-UA\_Connect".

For information about the application name, which also applies to the server and the client, see here (Page 218).



## Overview

To use the editor and the connection parameter assignment, follow these steps:

1. First, specify a client interface. Add to this the PLC tags and PLC methods interface that you want to access ("First step (Page 322)").
2. Next, configure the connection to the OPC UA server (Second step (Page 339)).
3. Finally, use the configured connection for the OPC UA client instructions (Third step (Page 348)).

### 9.4.2 Useful information about the client instructions

With the standardized OPC UA client instructions you are able to control communication for the following tasks with the S7-1500 CPU as an OPC UA client:

- Read/write tags of the OPC UA server
- Call methods in the OPC UA server

Optional instructions can be used to determine the following information:

- The status of the connection between the OPC UA client and OPC UA server
- Node IDs of nodes with known hierarchy of the address space

### Standardized sequence of OPC UA communication

The sequence of the communication, and thus the order of the instructions, follows a pattern that is illustrated in the following.

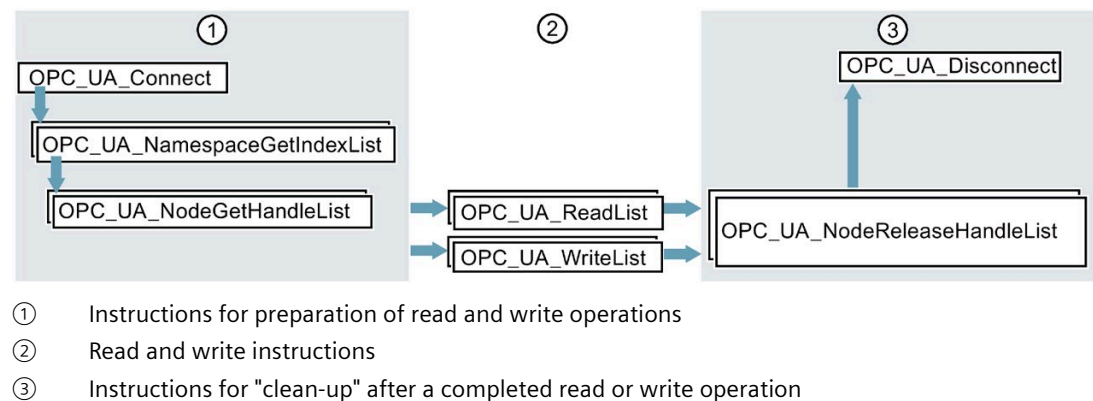


Figure 9-58 Run sequence for a read or write operation

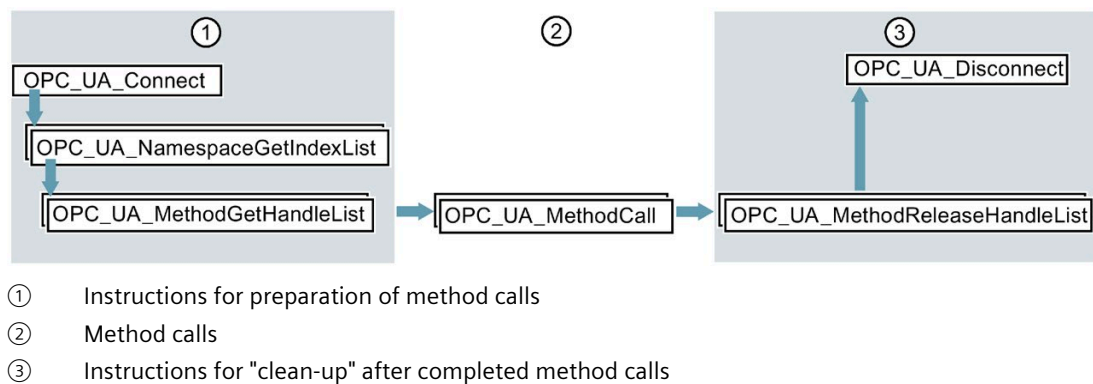


Figure 9-59 Run sequence for a method call in the OPC UA server

**Optional instructions (reading out the status of a connection / reading out node IDs of nodes with known hierarchy of the address space)**

- OPC-UA\_ConnectionGetStatus
- OPC-UA\_TranslatePathList

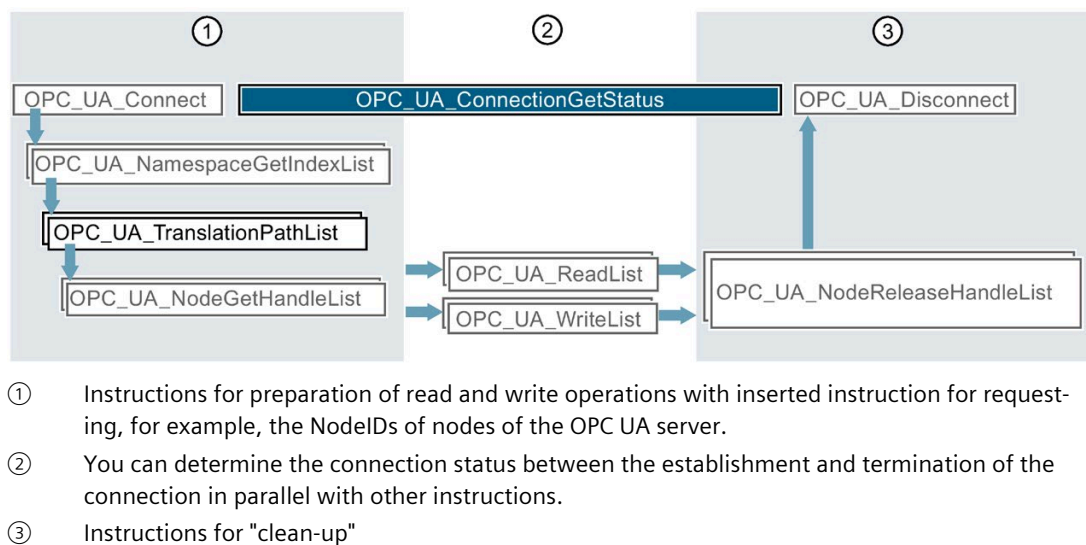


Figure 9-60 Run sequence of optional instructions

## Convenient editors in STEP 7

The OPC UA client instructions are described in detail in the reference part (STEP 7 information system). For parameter assignment of the instructions, a convenient editor is available in the TIA Portal – the connection parameter assignment (Page 339).

We recommend starting with the connection parameter assignment for the first program draft and using additional instructions and manually optimizing the program as required.

## Information about the client instructions

The client instructions are described in detail in the help to the Instructions > Communication > OPC UA > OPC UA client.

## Application example in Online Support

This application example (<https://support.industry.siemens.com/cs/ww/en/view/109762770>) provides you with an S7 user block "OpcUaClient" that summarizes the most important functions of the OPC UA instructions, accelerates the implementation for you and simplifies the programming. The OPC UA server in the example is an S7-1500 controller with a simple simulation program for process values.

The S7 user block performs the following:

- Establishment and termination of the connection to the server
- Diagnostics of the connection and automatic reconnection after connection terminations
- Registered Read
- Registered Write
- Registered Method Call

### 9.4.3 Number of client instructions that can be used simultaneously

#### SIMATIC error codes for OPC UA client instructions

The following limits apply to the simultaneous use of OPC UA client instructions (up-to-date technical specifications of the CPUs can be found on the Internet (<https://support.industry.siemens.com/cs/ww/en/ps/td>)):

Table 9- 5 Quantity structures for OPC UA client instructions

| OPC UA instruction           | Maximum number for<br>CPU 1510SP (F)<br>CPU 1511 (C/F/T/TF)<br>CPU 1512C<br>CPU 1512SP (F)<br>CPU 1513 (F) | Maximum number for<br>CPU 1505<br>(S/SP/SP F/SP T/SP TF)<br>CPU 1515 (F/T/TF)<br>CPU 1515 SP PC (F/T/TF)<br>CPU 1516 (F/T/TF) | Maximum number for<br>CPU 1507S (F)<br>CPU 1517 (F/T/TF)<br>CPU 1518 (F) |
|------------------------------|------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------|
| OPC_UA_Connect               | 4                                                                                                          | 10                                                                                                                            | 40                                                                       |
| OPC_UA_NamespaceGetIndexList | 4*                                                                                                         | 10*                                                                                                                           | 40*                                                                      |
| OPC_UA_NodeGetHandleList     | 4*                                                                                                         | 10*                                                                                                                           | 40*                                                                      |
| OPC_UA_MethodGetHandleList   | 4*                                                                                                         | 10*                                                                                                                           | 40*                                                                      |
| OPC_UA_TranslatePathList     | 4*                                                                                                         | 10*                                                                                                                           | 40*                                                                      |
| OPC_UA_ReadList              | 20 in total (max. 5 per connection, see OPC_UA_Connect)                                                    | 50 in total (max. 5 per connection, see OPC_UA_Connect)                                                                       | 200 in total (max. 5 per connection, see OPC_UA_Connect)                 |

| OPC UA instruction             | Maximum number for<br>CPU 1510SP (F)<br>CPU 1511 (C/F/T/TF)<br>CPU 1512C<br>CPU 1512SP (F)<br>CPU 1513 (F) | Maximum number for<br>CPU 1505<br>(S/SP/SP F/SP T/SP TF)<br>CPU 1515 (F/T/TF)<br>CPU 1515 SP PC (F/T/TF)<br>CPU 1516 (F/T/TF) | Maximum number for<br>CPU 1507S (F)<br>CPU 1517 (F/T/TF)<br>CPU 1518 (F) |
|--------------------------------|------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------|
| OPC-UA_WriteList               | 20 in total (max. 5 per connection, see OPC-UA_Connect)                                                    | 50 in total (max. 5 per connection, see OPC-UA_Connect)                                                                       | 200 in total (max. 5 per connection, see OPC-UA_Connect)                 |
| OPC-UA_MethodCall              | 20 in total (max. 5 per connection, see OPC-UA_Connect)                                                    | 50 in total (max. 5 per connection, see OPC-UA_Connect)                                                                       | 200 in total (max. 5 per connection, see OPC-UA_Connect)                 |
| OPC-UA_NodeReleaseHandleList   | 4*                                                                                                         | 10*                                                                                                                           | 40*                                                                      |
| OPC-UA_MethodReleaseHandleList | 4*                                                                                                         | 10*                                                                                                                           | 40*                                                                      |
| OPC-UA_Disconnect              | 4*                                                                                                         | 10*                                                                                                                           | 40*                                                                      |
| OPC-UA_ConnectionGetStatus     | 4*                                                                                                         | 10*                                                                                                                           | 40*                                                                      |

\* maximum 1 per connection

### Maximum number of usable OPC UA client interfaces

If you create OPC UA client interfaces using the connection parameter assignment, the number of client interfaces is limited to 40.

Create the OPC UA client interfaces by double-clicking the "Add new client interface" symbol in the project tree of the "OPC UA communication" area.

The maximum number of OPC UA client interfaces is independent of whether you also use the CPU as OPC UA server.

#### 9.4.4 Example configuration for OPC UA

The following sections describe how you can use the client interfaces editor and the connection parameter assignment.

The description is based on a specific example: Two S7-1500 CPUs operate in the system: One CPU serves as the OPC UA client and the other as the OPC UA server.

You can, of course, also use controllers, sensors and IT systems of other manufacturers as OPC UA clients or servers. In particular, the data exchange between different systems (interoperability) is a major advantage of OPC UA.

### Connection parameter assignment using an example:

The plant produces blanks in a production line.

The following controllers are used:

1. An S7-1511 CPU serves as the controller of the production line.

The controller is named "**Productionline**" in the example.

The OPC UA server of the controller is enabled.

The CPU has the IP address 192.168.1.1 in the example.

This CPU publishes the values of following tags via the OPC UA server:

- **NewProduct**

The tag has the data type "BOOL".

When this PLC tag has the value TRUE, the production line has processed a blank.

The blank is ready for pick-up.

- **ProductNumber**

This tag contains the identification number of the blank.

The tag has the data type "Int".

- **Temperature**

This tag contains temperature values recorded during the production of the blank.

The tag is an array with elements of the "Real" data type.

In addition, this CPU provides the following writable tag:

- **ProductionEnabled**

The tag is set by the OPC UA client.

The tag has the data type "BOOL".

If the value is set to TRUE, the production line is released and may produce blanks.

In addition, this CPU provides the following method via the OPC UA server:

- **OpenDoor.**

OPC UA clients can hereby arrange for an access door to be opened to the production line.

2. An S7-1516 CPU controls the interaction with other production lines.

This CPU is named "**Supervisor**" in the example.

The OPC UA client of this CPU is enabled.

Using OPC UA, this CPU can read the NewProduct and ProductNumber tags, set the ProductionEnabled tag and call the OpenDoor method.

The CPU has the IP address 192.168.1.2 in the example.

The following figure shows the example in the network view of the TIA Portal:

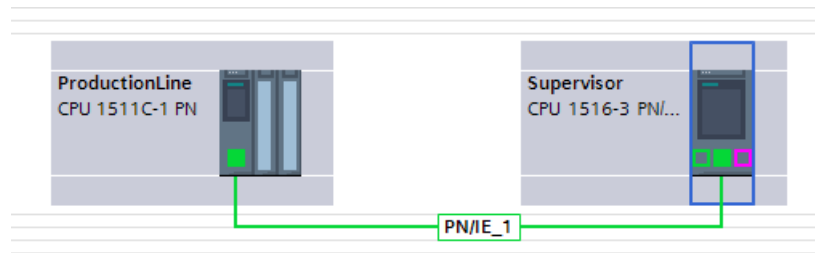


Figure 9-61 Example of assigning connection parameters in the network view

### 9.4.5 Creating client interfaces

As of Version 15.1, the TIA Portal has an editor for client interfaces.

You group all PLC tags that you want to read or write from an OPC UA server in a client interface.

In addition, the client interface contains all methods that the OPC UA server provides and that you want to call with your user program (that acts as an OPC UA client).

If you create a client interface, STEP 7 also creates data blocks for the parameter assignment of the connection to the OPC UA server from which you want to read data or to which you want to write data.

#### Maximum number of client interfaces

You can create a maximum of 40 client interfaces.

#### Editor for client interfaces

To create a client interface, follow these steps:

1. Select the project view in the TIA Portal.
2. In the "Devices" area, select the CPU you want to use as an OPC UA client.
3. Click "OPC UA communication > Client interfaces".

4. Double-click "Add new client interface".

STEP 7 creates a new client interface and display in the editor.

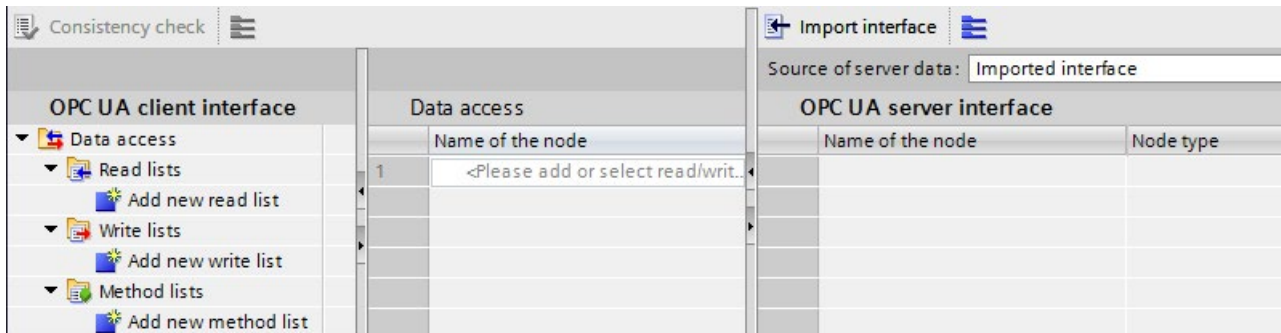


Figure 9-62 Adding OPC UA client interface

STEP 7 names the new interface "Client interface\_1". If a "Client interface\_1" already exists, the new interface receives the designation "Client interface\_2" etc.

In addition, STEP 7 creates the following data blocks:

- Client\_Interface\_1\_Configuration

The data block already contains all system data types that are needed for the instructions of the OPC UA client.

This data block is filled when you configure the connection to the OPC UA server.

You configure a connection in the properties of the client interface, see: Example configuration for OPC UA (Page 320).

- Client\_Interface\_1\_Data

A data block for the PLC tags that you want to read or write from an OPC UA server as well as for methods that you want to call in the OPC UA server.

You use this data block in your user program.

This data block is currently still empty.

5. Select a descriptive name for the new client interface.

Select "Productionline" in the example.

This also changes the names of the associated data blocks to:

- Productionline\_Data
- Productionline\_Configuration

6. To import an OPC UA server interface, click the "Import interface" button in the top right of the editor.

This allows you to import an XML file which describes the server interface of an OPC UA server.

Alternative: To determine online the server interface of a connected OPC UA server, see: Determine server interface online (Page 331).

7. STEP 7 displays a dialog with which you can select an XML file.

This XML file describes a address space of an OPC UA server.

The address space of an OPC UA server contains all PLC tags and server methods published by an OPC UA server.

OPC UA clients can access this address space:

- Read PLC tags
- Write PLC tags
- Calling Server Methods

The address space of an OPC UA server can be divided into one or more server interfaces.

For creating server interfaces, see: Creating a server interface for companion specification (Page 253).

8. Create a **read list** in this client interface.

To do this, follow these steps:

- Click "Add new read list" in the left section of the editor.

STEP 7 adds a new list named "ReadList\_1".

For the example, change the name to "ReadListProduct"

- Now add the new read list of the PLC tags that you want to read from the OPC UA server.

In the example the "NewProduct" and "ProductNumber" tags are added to the "ReadListProduct" read list.

Select the "NewProduct" tag in the right-hand field of the editor ("OPC UA Server interface"). Drag the "NewProduct" tag to the "ReadProduct" read list in the middle field of the editor. Follow the same procedure with the "ProductNumber" tag.

The figure below shows the right field of the editor.

| OPC UA server interface |                          |                |              |                   |
|-------------------------|--------------------------|----------------|--------------|-------------------|
|                         | Name of the node         | Node type      | Access level | Node ID           |
| ■ ▼                     | Productionline           | Object         |              | http://www.sie... |
| ■ ▼                     | opc DataBlocksGlobal     | Folder         |              | http://www.sie... |
| ■ ▼                     | Data_for_OPC_UA_Clients  | Object         |              | http://www.sie... |
| ■                       | NewProduct               | Boolean        | RD           | http://www.sie... |
| ■                       | ProductNumber            | Int16          | RD           | http://www.sie... |
| ■ ▶                     | Temperature              | Array of Float | RD           | http://www.sie... |
| ■ ▼                     | Data_from_OPC_UA_Clients | Object         |              | http://www.sie... |
| ■                       | ProductionEnabled        | Boolean        | RD/WR        | http://www.sie... |
| ■ ▼                     | opc DataBlocksInstance   | Folder         |              | http://www.sie... |
| ■ ▼                     | OpenDoor_DB              | Object         |              | http://www.sie... |
| ■ ▶                     | opc InOuts               | Folder         |              | http://www.sie... |
| ■ ▶                     | opc Static               | Folder         |              | http://www.sie... |
| ■ ▶                     | Method                   | Method         |              | http://www.sie... |

Figure 9-63 Read list in the OPC UA server interface



### Alternative:

You can also select a new read list by dragging the right field of the editor ("OPC UA Server interface") to a node of the type Object or Folder and then dragging it to "Add new read list" in the left field of the editor. The new read list then contains all PLC tags of the node that has been moved.

In the example, select the object "Data\_for\_OPC\_UA\_Clients", which contains the tags "NewProduct" and "ProductNumber". STEP 7 generates the new read list "Data\_for\_OPC\_UA\_Clients". In addition, the object contains the tag "Temperature". Delete the "Temperature" tag from the read list. Since they should not be read in the example.

Change the name of the read list in "ReadListProduct".

The following figure shows the content of the read list:

| ReadListProduct |                                                                                                 |           |              |                       |
|-----------------|-------------------------------------------------------------------------------------------------|-----------|--------------|-----------------------|
|                 | Name of the node                                                                                | Node type | Access level | Node ID               |
|                 |  NewProduct    | BOOL      | RD           | http://www.siemens... |
|                 |  ProductNumber | INT       | RD           | http://www.siemens... |

Figure 9-64 Read list

### Note

#### Read and write lists do not support all node types.

The OPC UA client of the S7-1500 CPU does not support all OPC UA data types (node types) that can be made available via an OPC UA server interface. If you place an unsupported node type, for example, in a read list or write list a corresponding error signal appears. In this case, you cannot include the corresponding node in the read or write list.

Which types are supported is described here: Mapping of data types (Page 169)

9. If you want assign new values to PLC tags, create a **write list** in this client interface.

To do this, follow these steps:

- Click "Add new write list" in the left section of the editor.

STEP 7 adds a new list with the name "ReadList\_1".

For the example, change the name to "WriteListStatus".

- Now add the new write list of all OPC UA server tags to which you want to assign new values.

In the example, add the "WriteListStatus" tag to the write list "ProductionEnabled".

Select the Tag of right field of the editor ("OPC UA Server interface"). Drag the tag to the write list in the middle field of the editor.

#### Alternative:

You can also create a new write list by selecting a node of the type Object or Folder in the right field of the editor ("OPC UA server interface") and then dragging to "Add new write list" in the left field of the editor.

The new write list then contains all tags of the relevant node.

In the example, select the object "Data\_from\_OPC\_UA\_Clients", which contains the tag "ProductionEnabled". STEP 7 generates the new write list "Data\_from\_OPC\_UA\_Clients". Change the name in "WriteListStatus".

The following figure shows the content of the write list:

| WriteListStatus                                                                                       |           |              |                       |
|-------------------------------------------------------------------------------------------------------|-----------|--------------|-----------------------|
| Name of the node                                                                                      | Node type | Access level | Node ID               |
|  ProductionEnabled | BOOL      | RD/WR        | http://www.siemens... |

Figure 9-65 Write list

10.If you want to call a method of this OPC UA server, generate a new method list.

To do this, follow these steps:

- In the left section of the editor, click "Add new method list".

STEP 7 adds a new list with the name "Method list\_1".

For the example, change the name to "MethodListOpenDoor".

- Now add a method of the OPC UA server to the new method list.

In this example, add the method "OpenDoor" to the method list "MethodListOpenDoor".

Select the method of right field of the editor ("OPC UA Server interface"). Drag the method to the method list in the middle field of the editor.

#### Alternative:

You can also generate a new method list by selecting a method (node of the type Object) in the right field of the editor (OPC UA Server interface) and then dragging it to "Add new method list" in the left field of the editor. The new method list then contains the method of the relevant node.

The following figure shows the content of the method list:

| MethodListOpenDoor |           |              |                       |
|--------------------|-----------|--------------|-----------------------|
| Name of the node   | Node type | Access level | Node ID               |
| ► Method           |           |              | http://www.siemens... |

Figure 9-66 Methods list

If you want to call another method of the OPC UA server, you must create a new method list. Each method list contains only one method.

See also Useful information about server methods (Page 279).

11.Compile the project.

To do so, select the project and click the following button in the toolbar:



STEP 7 compiles the project and updates the data blocks that belong to the "Productionline" client interface.

---

#### Note

During compilation, STEP 7 overwrites all data in the data blocks belonging to the client interface. For this reason, you should neither add to nor correct these data blocks manually.

---

---

**Note**

**Renaming node names (DisplayNames)**

In read lists, write lists and method lists you can rename the name of a node by means of the shortcut menu. This is the "DisplayName" in the OPC UA language usage.

If you rename the name of a method list node and the node is already used in a programmed block for the method call "OPC-UA-MethodCall", the compilation of the project leads to consistency errors: During the compilation the UDTs of the method are generated with the changed name. The references to the method used in the program are then no longer correct.

To correct the consistency errors, you can either undo the name change of the method in the client interface or navigate to the method call and assign the relevant parameters again there under "Properties > Block parameters" ("Configuration" tab).

---

## Data blocks of client interface

The following data blocks belong to the "Productionline" client interface:

- **Productionline\_Configuration**

A data block for the configuration.

In the example, this data block is called "Productionline\_Configuration".

The data block already contains all system data types that are needed for the instructions of the OPC UA client.

In addition, the data block contains general default values for parameter assignment of the connection to an OPC UA server.

If you are working with connection parameter assignment, this data block will be filled.

- **ProductionLine\_Data**

A data block for the PLC tags that you have entered in the client interface editor.

In the example, this data block is called "Productionline\_Data".

The figure below shows the data block.

|                       |                                                    |
|-----------------------|----------------------------------------------------|
| Static                |                                                    |
| ▼ ReadListProduct     | Struct                                             |
| ■ ▼ Variable          | "Productionline.ReadListProduct"                   |
| ■ NewProduct          | Bool                                               |
| ■ ProductNumber       | Int                                                |
| ■ ▼ NodeStatusList    | Array[0..1] of DWord                               |
| ■ NodeStatusList[0]   | DWord                                              |
| ■ NodeStatusList[1]   | DWord                                              |
| ■ ▼ TimeStamps        | Array[0..1] of LDT                                 |
| ■ TimeStamps[0]       | LDT                                                |
| ■ TimeStamps[1]       | LDT                                                |
| ▼ WriteListStatus     | Struct                                             |
| ■ ▼ Variable          | "Productionline.WriteListStatus"                   |
| ■ ProductionEnabled   | Bool                                               |
| ■ ▼ NodeStatusList    | Array[0..0] of DWord                               |
| ■ NodeStatusList[0]   | DWord                                              |
| ▼ MethodListOpenDoor  | Struct                                             |
| ■ ▼ MethodStatusList  | Array[0..0] of DWord                               |
| ■ MethodStatusList[0] | DWord                                              |
| ■ ▼ MethodResultList  | Array[0..0] of DWord                               |
| ■ MethodResultList[0] | DWord                                              |
| ■ ▼ Method            | Struct                                             |
| ■ ▼ Inputs            | "Productionline.MethodListOpendoor.Method.Inputs"  |
| ■ Number              | Int                                                |
| ■ ▼ Outputs           | "Productionline.MethodListOpendoor.Method.Outputs" |
| ■ Result              | Int                                                |

Figure 9-67 "Productionline\_Data" data block

Use the "Productionline\_Data" data block in your user program and access the read values of the "NewProduct" and "ProductNumber" PLC tags. This is explained in the following section using an example.

## Reading and writing PLC tags of the client interface

### Example: Reading the "ProductNumber" value

For example, you write in an SCL program:

```
#MyLocalVariable :=  
"Productionline_Data".ReadListProduct.Variable.ProductNumber;
```

You use this, for example, to assign the number of the blank that was just produced in the production line to the local tag "#MyLocalVariable".

Requirements:

- A connection exists to the OPC UA server of the CPU, which controls the production line.
- The OPC UA client has read the current values.

For this reason you check whether a read value is valid:

- Check whether the value in "Productionline\_Data".ReadListProduct.NodeStatusList[1] is equal to 0.
- Optional: Check when this value was sent from the OPC UA server. This value is in "Productionline\_Data".Product.TimeStamps[1]. If no time stamp is requested, the communication load is reduced.

### Example: Writing the "ProductEnabled" value

Transfer the new values for PLC tags, in the example for the "ProductionEnabled" tag, to the OPC UA server using the data block.

With the following assignment, you enable the production line in the example plant:

```
"Productionline_Data".WriteListStatus.Variable.ProductionEnabled :=  
TRUE;
```

This is only successful, however, if the following requirements are met:

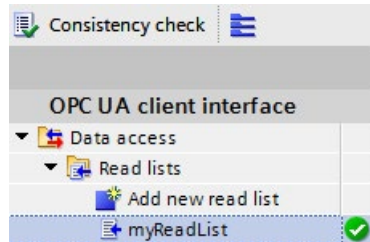
- A connection exists to the OPC UA server of the CPU, which controls the production line.
- Current values are being written via the OPC UA client

## Consistency check

Finally, check the consistency of the read/write list or method list.

1. Select the list that you want to check.
2. Click the "Consistency check" button above the "OPC UA client interface" area.

A green check mark indicates an error-free assignment of the tags or methods to the corresponding elements of the server interface.



You can assume that the data exchange between client and server and method calls operate without problem in runtime.

In the event of an error a list appears in the Inspector window. From this list you can jump to the respective error.

During the consistency check, STEP 7 checks:

- Whether all elements that you use in the respective list are also present in the server.
- Do the data types used match?
- For methods: Do the number, name, order, and data types of method arguments match?

### 9.4.6 Determine server interface online

With STEP 7 (TIA Portal) you can determine the interface of an OPC UA server online. This provides information on which tags of a connected OPC UA server you can read or set (write) with OPC UA clients. It also provides information on which server methods of the OPC UA server are available for OPC UA clients.

If you are work offline you can create the interface of the OPC UA server by means of an OPC UA XML file. The address space of the server is described in the OPC UA XML file, see: Export OPC UA XML file (Page 217).

## Determine online server interfaces

To determine a server interface online, follow these steps:

1. In the STEP 7 project tree, select the CPU which is configured as OPC UA client (Supervisor in the example).
2. Select the client interface (in the example, OPC UA Communication > Client interfaces > Productionline).

If no client interface has been created, double-click "Add new client interface".

3. Double-click the selected client interface.

The editor for client interfaces is displayed.

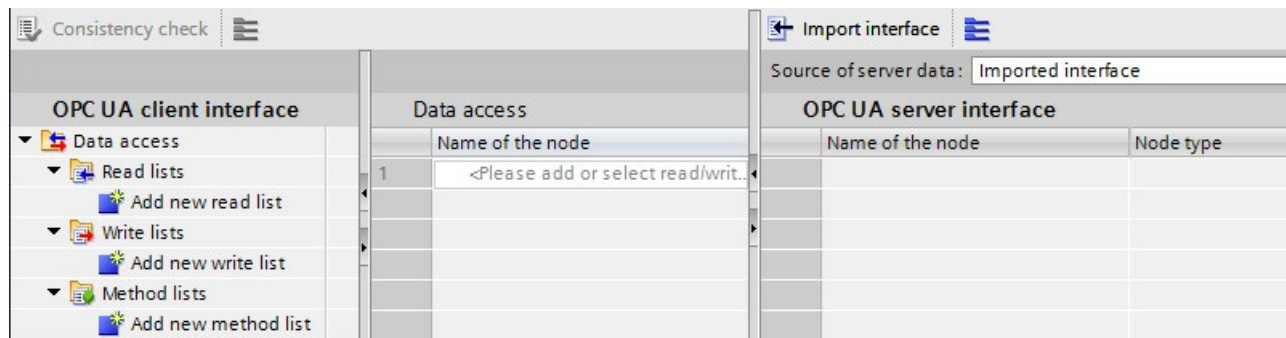


Figure 9-68 Editor for client interface

4. In the left section of the editor, click "Add new read list", "Add new write list", or "Add new method list".
5. In the right field of the editor, select "Online[]" as data source for "Source of server data":





6. Click the "Online Access" button.

STEP 7 displays the "Connect to OPC UA server" dialog.

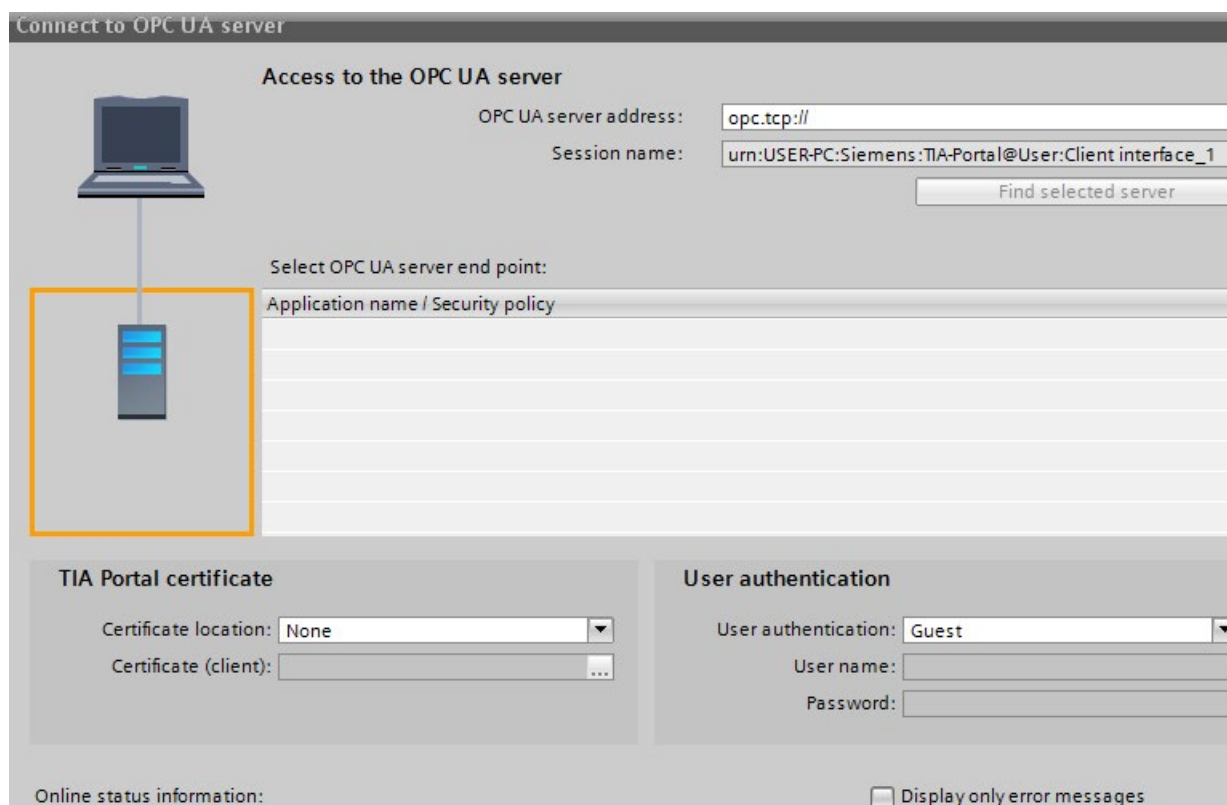


Figure 9-69 "Connect to OPC UA server" dialog

**Tip:** When establishing an online connection to an OPC UA server for the first time, use the "Online access" button. When reconnecting after a disconnection, select the "Connect to Online Server" button next to the "Online" selection field.

In the top right, enter the IP address of the OPC UA server whose server interface you want to determine online.

7. Click "Find selected server".

STEP 7 establishes a connection to the OPC UA server and determines all security settings (server endpoints) that the server holds in readiness.

STEP 7 displays the end points as list:

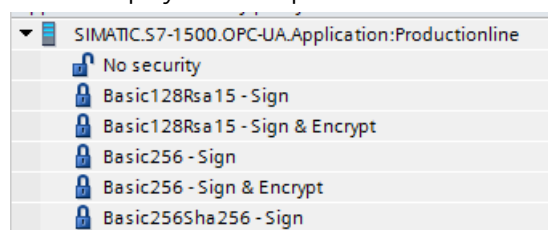


Figure 9-70 Found OPC UA server with all server endpoints

8. Click on the end point you want to use for a connection of STEP 7 to the OPC UA server.

9. Do you want to use a secure connection?

- If you have selected a secure end point, then select the entry "TIA Portal" for the "Certificate location".

And under "Certificate (Client)", select a client certificate for your PC on which STEP 7 (TIA Portal) is currently running.

If a client certificate does not yet exist for your PC, you can generate a client certificate here in the TIA Portal.

Proceed as follows to generate a certificate for your PC:

- Click on the button in the "Certificate (Client)" input field.
- Click "Add".
- For "Certificate owners" enter "STEP 7 (TIA Portal)".
- Select the "OPC UA client" entry at "Usage".
- For "Subject Alternative Name (SAN)", enter the IP address of your PC, on which you are currently running STEP 7 (TIA Portal), under "Value". Overwrite the already entered IP address.
- If your PC uses a second IP address, enter this address as well. If your PC does not use a second IP address, delete the second IP address already entered.
- Click "OK".
- If you have not selected a secure end point, then keep the default ("None").

10. How do you want log on?

- If you want to log onto the OPC UA server as guest, then apply the default with "User authentication".
- If you want to log on with user name and password, select "User name and password".

Use the user name and password which was stored during the configuration of the OPC UA server in the properties of the CPU under "General > OPC UA > Server > Security > User authentication > User management".

11. Click on the "Go online" button.

When a secure connection is established, a message appears that you must accept the server certificate for the secure connection to be established. In the message window, you can display further details about the server certificate via a link.

This standard Windows window only provides information about the server certificate. If you click on the button to install the server certificate, the server certificate is not saved to the certificate memory of the TIA Portal, i.e. at the next connection attempt you will be prompted again to accept the server certificate.

STEP 7 then establishes a connection to the OPC UA server and again displays the editor for client interfaces.

In the right field of the editor, STEP 7 displays the uppermost level of the address space of the OPC UA server:



12. Click on the small black triangle next to "Objects".

STEP 7 now also displays the level below Objects.

13. Click on the small black triangle next to "Productionline".

STEP 7 now also displays the level below Productionline.

14. Now open additional lower-level folders:

| OPC UA server interface    |                |              |  |
|----------------------------|----------------|--------------|--|
| Name of the node           | Node type      | Access level |  |
| ▶ Server                   | Object         |              |  |
| ▶ DeviceSet                | Object         |              |  |
| ▼ Productionline           | Object         |              |  |
| ▶ Counters                 | Object         |              |  |
| ▼ DataBlocksGlobal         | Object         |              |  |
| Icon                       | ImagePNG       | RD           |  |
| ▼ Data_from_OPC_UA_Clients | Object         |              |  |
| ProductionEnabled          | Boolean        | RD/WR        |  |
| ▼ Data_for_OPC_UA_Clients  | Object         |              |  |
| ProductNumber              | Int16          | RD           |  |
| ▶ Temperature              | Array of Float | RD           |  |
| NewProduct                 | Boolean        | RD           |  |
| ▼ DataBlocksInstance       | Object         |              |  |
| Icon                       | ImagePNG       | RD           |  |
| ▶ OpenDoor_DB              | Object         |              |  |
| DeviceManual               | String         | RD           |  |

Figure 9-71 Online view of OPC UA server interface

## See also

Mapping of data types (Page 169)

Creating client interfaces (Page 322)

### 9.4.7 Using multilingual texts

In the client interface editor, you are also importing texts that can be displayed in different languages with the OPC UA XML files (information models). Multilingualism is optional, and each node can be defined differently regarding the languages it offers.

In the XML file, these are the following fields that can be prepared for different languages:

- Display name
- Description

#### Example for multilingual texts in an OPC UA XML file

In the XML file below, the display name and the description, for example, are entered with a "default" text and multiple localizable texts.

- Default text is the first entry without localization information.
- Localized text is the text after "Locale=" followed by a language code, e.g. "it-IT" for Italian

```
<UAVariable NodeId="ns=3;i=6070" BrowseName="3:EngineeringRevision" ParentNodeId="ns=3;i=1002"
  DataType="String">
  <DisplayName>EngineeringRevision</DisplayName>
  <DisplayName Locale="en-US">EngineeringRevision</DisplayName>
  <DisplayName Locale="de-DE">Revisionsstand</DisplayName>
  <Description>Revision Level of the engineering environment.</Description>
  <Description Locale="en-US">Revision Level of the engineering environment.</Description>
  <Description Locale="de-DE">Revisionsstand der Engineeringumgebung.</Description>
  <Description Locale="fr-FR">Niveau de révision de l'environnement d'ingénierie.</Description>
  <Description Locale="it-IT">Livello di revisione dell'ambiente di ingegneria.</Description>
</UAVariable>
```

Figure 9-72 Example of multilingual texts in an OPC UA XML file

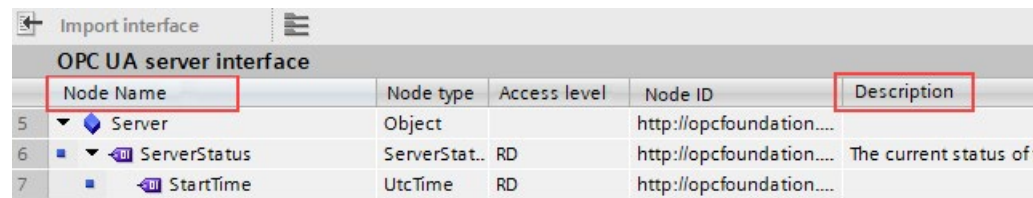
## Display of multilingual texts

When importing a server interface, the available multilingual texts are saved internally and downloaded to a CPU together with the project.

The client editor displays the text from the OPC UA XML file in the columns "Name of the node" (corresponds to "DisplayName") and "Description" (corresponds to "Description").

The following cascading rules determine which language is shown for a node:

- When the node contains text in the currently used editing language, the text is also displayed in the editing language.  
(Setting the editing language: In the project tree, select the area "Languages & resources > Project languages")
- When the node does not contain text in the editing language but a default text is defined there (without language code), the default text is displayed.
- "Name of the node" column: If no default text is defined either but a text in any other language exists, the DisplayName text is displayed in the first available language. This rule does not apply to description texts.
- If none of the conditions listed above is met, no text is displayed.



| OPC UA server interface |                |              |              |                          |                       |
|-------------------------|----------------|--------------|--------------|--------------------------|-----------------------|
|                         | Node Name      | Node type    | Access level | Node ID                  | Description           |
| 5                       | ▼ Server       | Object       |              | http://opcfoundation.... |                       |
| 6                       | ▼ ServerStatus | ServerStat.. | RD           | http://opcfoundation.... | The current status of |
| 7                       | ▼ StartTime    | UtcTime      | RD           | http://opcfoundation.... |                       |

Figure 9-73 Display for multilingual texts

When you change the editing language, the multilingual text in the imported interface will also change according to the rules explained above.

You can then apply the nodes in the corresponding lists (read list, write list, method list) with drag and drop.

You cannot change the language in the lists (read list, write list, method list).

## Applying the displayed description texts as comment in PLC data types

When you compile the program, STEP 7 automatically creates PLC data types (UDTs) for each read list, for each write list and for inputs or outputs of each method. These UDTs each have one element for each node.

The UDTs apply the description text as comment according to the rules stated above. STEP 7 creates the comment in only one language, just like the texts in the OPC UA server interface can only be displayed in one language.

### 9.4.8 Rules for the access to structures

The rules for the access to structures are explained below. Note these rules when reading and writing values of complete structures provided by an OPC UA server.

#### How the client of the S7-1500 CPU accesses structures

The OPC UA client of the S7-1500 CPU uses neither TypeDictionaries nor DataTypeDefinition attributes, which a server offers for the resolution of these structures.

These options of the OPC UA client for checking structural elements in runtime are limited in the client.

#### Rules for the access to structures

If you use the client interfaces to configure the read and write lists (connection parameterization) and assign the PLC data types to the imported or online determined address model of the server, the read and write accesses to structures operate trouble-free in runtime.

The configuration by means of client interface automatically ensures that the sequence and the data type of the structural elements are coordinated on client and server side.

Recommendation: Update an S7-1500 CPU (as server) to the current firmware version (e.g. V2.0 > V2.5.2 or higher).

In runtime the OPC UA client only checks the total length of the transmitted value; more detailed checks are not possible.

Mapping rules apply to the assignment of OPC UA structures to PLC tags or DB tags (see Mapping of data types (Page 169)). Non-executed data type (such as OPC UA byte strings) are not supported.

#### Example of an error-free assignment of the structure elements

In the imported node set file (XML export), the structure is defined as follows:

|               |                                |
|---------------|--------------------------------|
| opcUaStruct   | Object                         |
| allOk         | Boolean                        |
| myOPCstruct1  | myOPCUAstruct                  |
| varA          | Int64                          |
| VarB          | Byte                           |
| nestedStructZ | *myOPCUAstruct*.nestedStructZ* |
| varD          | Float                          |
| varE          | Double                         |
| varC          | Double                         |
| DeviceManual  | String                         |

The structure mapped in the read list matches, both in the order and in the assigned data types, the corresponding nodes of the node set file.

|                   |                                 |
|-------------------|---------------------------------|
| ▼ myOPCstruct1    | myOPCUAstruct                   |
| ■ varA            | LINT                            |
| ■ VarB            | USINT                           |
| ■ ▼ nestedStructZ | "myOPCUAstruct"."nestedStructZ" |
| ■ varD            | REAL                            |
| ■ varE            | LREAL                           |
| ■ varC            | LREAL                           |

If the structure now changes on the server, for example tagA and tagB are swapped, and the read list remains the same in the client, the assignment is no longer correct:

- The total length of the data remains the same (only the order has changed)
- The configuration of the structure is different for client and server!

|                                                                                                                                                                                                                                                                                                                                                                                                                                      |
|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|  <b>WARNING</b>                                                                                                                                                                                                                                                                                                                                     |
| <p><b>No error message in the case of different structure configuration between client and server</b></p> <p>If the structures of client and server do not match, this rule violation will possibly not generate any error during compilation and also not in runtime.</p> <p>Make sure not to change the configured assignments for structures in runtime. If required, reconfigure the assignment in the read and write lists!</p> |

## 9.4.9 Using connection parameter assignment

### 9.4.9.1 Creating and configuring connections

With the instructions for OPC UA clients, you create a user program that exchanges data with an OPC UA server. A series of system data types are required for this.

To simplify your work with these system data types, a connection parameter assignment for OPC UA clients is available starting in STEP 7 (TIA Portal) Version 15.1.

Use of the connection parameter assignment is optional and not mandatory. You can also manually create the required system data types.

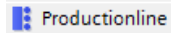
We use an example to make the description easier to follow, see description of the example (Page 320).

## Opening the connection parameter assignment

To configure the connection to an OPC UA server, follow these steps:

1. In the "OPC UA communication" area, double-click the client interface whose parameters you want to assign in the project tree.

For the example configuration: Double-click the "ProductionLine" client interface.



The section "Create client interface (Page 322)" describes how to create a client interface.

2. Click the "Properties" tab (Inspector window) if the tab is not already displayed.

STEP 7 now displays the connection parameter assignment for the instructions of the OPC UA client.

The "General" tab is open.

3. Click on the "Configuration" tab and set the connection to the OPC UA server.

## Setting the connection parameters

1. Select a descriptive name for the session. For the example, select the name "OPC UA Connection to ProductionLine".
2. In the "Address" field, enter the IP address of the OPC UA server to which your user program (that operates as an OPC UA client) is to establish a connection. In the example configuration, the CPU that controls the production line has the IP address "192.168.1.1". A connection to the OPC UA server of this CPU is to be established. For this reason, you enter this IP address in the "Address" field. In this case, the OPC UA server uses the default port 4840.

Alternatively, you can enter a valid DNS name in the "Address" field. The length of the DNS name is limited to 242 characters.

If the address is not valid, the error message is shown: "Enter a valid address".

If the string of the "Address", "Port" and "Path" fields contains more than 254 characters, an error message is also displayed.



3. Enter a path within the OPC UA server to restrict access to this path. The information is optional. However, some servers only establish a connection if a server path is specified.

When you specify a path, it is automatically entered at the "ServerEndpointUrl" entry in the configuration DB for the client interface. The entry then consists of the components "OPC Schematic Prefix", "IP address", "Port number" and "Server path", for example: "opc.tcp://192.168.0.10:4840/example/path".

The following figure shows the entry of the IP address for the OPC UA server:

**Connection parameter**

|                  | Client                              | Server                     |
|------------------|-------------------------------------|----------------------------|
| Session name:    | OPC UA connection to Productionline |                            |
| Device:          | Supervisor [CPU 1516-3 PN/DP]       | Unspecified device         |
| Address:         |                                     | 192.168.1.1                |
| Port:            |                                     | 4840                       |
| Path (optional): |                                     |                            |
| Server address:  |                                     | opc.tcp://192.168.1.1:4840 |
| Session timeout: | 30                                  | s                          |
| Monitoring time: | 5                                   | s                          |

Figure 9-74 Connection parameters

4. If the OPC UA server is not using the standard port 4840, you must insert the port number here.

For example, enter the number 65535 in the field, if the OPC UA server to which you want to establish a connection uses this port number.

5. In addition, you accept the default settings for session timeout (30 seconds) and monitoring time (5 seconds).

## Setting the security parameters

1. Click the "Security" area in the "Configuration" tab.

This area contains all security settings for the connection to the OPC UA server.

The following settings are possible:

### "General" area

#### Security mode:

Select the security mode that the connection to the OPC UA server must meet from the drop-down list.

If the server does not meet the selected mode, a session is not established.

The following settings are available:

- No security: No secure connection!
- Sign: OPC UA server and OPC UA client sign the data transmission (all messages): Manipulations can thus be detected.
- Sign & Encrypt: OPC UA server and OPC UA client sign and encrypt the data transmission (all messages):

#### Security policy:

Set the encryption techniques for the signing and encryption of messages.

The following settings are possible:

- No security
- Basic128Rsa15
- Basic256
- Basic256Sha256

To configure a secure connection, you must observe the following items:

- A certificate is required for the client for a secure connection.
- You have to make the client certificate known to the server.

To find out how to proceed, see the section "Handling client and server certificates (Page 227)" under "Certificate of the OPC UA client".

### "Certificates" area

#### Client certificate:

The certificate confirms the authenticity of the OPC UA client.

To select a certificate, click the following symbol:



STEP 7 displays a list of certificates.

Select the certificate that you have made known to the server.

Click the symbol with the green check mark:



Or, create a new certificate. To do so, click the "Add" symbol.

If you create a new certificate, you must make this certificate known to the server.

#### **"User authentication" area**

The following settings are possible for user authentication:

- Guest
- User name and password
- Users (TIA Portal - Security Settings)

For more information, see Users and roles with OPC UA function rights (Page 238).

### **Setting languages**

UA tags of the String type can be localized with OPC UA, that is, texts (values for the UA tag) can be available in different languages for the server. For example, localized texts can be available for DisplayName (Name of the node) and Description (Description).

In the "Languages" area of the "Configuration" tab you can, for example, influence the language of the texts returned by the server as follows:

In the "Languages" area, enter a number of languages that the server transfers to the client during connection setup.

The language or the local ID ("language code") associated with it that you enter in the first line is the language preferred by the client.

- If the server can provide the UA tag in the requested language, it is transferred to the client.
- If the server cannot provide the UA tag in the requested language, it checks whether it can provide the UA tag in the language you have entered in the second line (first substitute language).
- The server works its way down the list, and when it can provide neither the requested language nor a substitute language, it will provide the default language.

### **Additional information**

What causes the connection to an OPC UA server to fail? FAQ  
(<https://support.industry.siemens.com/cs/ww/en/view/109766709>)

### **See also**

Handling of the client certificates of the S7-1500 CPU (Page 344)

### 9.4.9.2 Handling of the client certificates of the S7-1500 CPU

#### Where does the client certificate come from?

If you are using the OPC UA client of an S7-1500 CPU (OPC UA client enabled), you can create certificates for these clients with STEP 7 V15.1 and higher as described in the following sections.

When you use UA clients from manufacturers or the OPC Foundation, a client certificate is generated automatically during installation or upon the first program call. You have to import these certificates with the global certificate manager in STEP 7 and use them for the respective CPU.

If you program an OPC UA client yourself, you can generate certificates through the program. Alternatively, you can generate certificates with tools, for example with OpenSSL or the certificate generator of the OPC Foundation:

- The procedure for OpenSSL is described here: "Generating PKI key pairs and certificates yourself (Page 179)".
- Working with the certificate generator of the OPC Foundation is described here: "Creating self-signed certificates (Page 178)".

#### Certificate of the OPC UA client of the S7-1500 CPU

A secure connection between the OPC UA server and an OPC UA client is only established if the server classifies the certificate of the client as trusted.

Therefore you have to make the client certificate known to the server.

The following sections describe how you can initially generate a certificate for the OPC UA client of the S7-1500 CPU and then make it available to the server.

#### 1. Generate and export a certificate for the client

For a secure connection you have to generate a client certificate and - if the server and client are located in different projects - export the certificate.

If client and server are in the same project, exporting the client certificate and subsequent import are not necessary.

##### Requirements

The IP interface of the CPU is configured, an IP address is available.

Background: The IP address under which the CPU can be accessed in your system is entered under "Subject Alternative Name (SAN)".

##### Creating an OPC UA Client certificate

The easiest way to generate a client certificate for an S7-1500 CPU is to configure a client interface.

The configuration of the client interface provides for the selection or generation of a client certificate, see Creating and configuring connections (Page 339).

Alternatively, you can generate the client certificate as follows:

1. In the project tree, select the CPU you want to use as a client.
2. Double-click "Device configuration".
3. In the properties of the CPU, click "Protection & Security > Certificate manager".
4. Double-click "<Add new>" in the "Device certificates" table.

STEP 7 opens a dialog.

5. Click the "Add" button.
6. Select the "OPC UA client" entry from the "Usage" list.
7. Click "OK".

STEP 7 now shows the client certificate in the "Device certificates" table.

8. If the server is in another project: Right-click this line and select "Export certificate" from the shortcut menu.
9. Select a directory where you will store the client certificate.

## 2. Announcing the client certificate to the server

You have to make the client certificate available to the server to allow a secure connection to be established.

To do this, follow these steps:

1. If the client was configured in another project and you created and exported the client certificate there:
  - Select the "Use global security settings for certificate manager" option in the local certificate manager of the server. This makes the global certificate manager available.  
You will find this option under "Protection & Security > Certificate manager" in the properties of the CPU that is acting as server.
  - If the project is not yet protected, select "Security settings > Settings" in the STEP 7 project tree, click the "Protect this project" button and log on.  
The "Global security settings" item is now displayed under "Security settings" in the STEP 7 project tree.
  - Double click "Global security settings".
  - Double click "Certificate manager".  
STEP 7 opens the global certificate manager.
  - Click the "Device certificates" tab.
  - Right-click in the tab on a free area (not on a certificate).
  - Select the "Import" shortcut menu.  
The dialog for importing certificates is displayed.
  - Select the client certificate that the server is to trust.
  - Click "Open" to import the certificate.  
The certificate of the client is now contained in the global certificate manager. Note the ID of the client certificate just imported.
2. Click the "General" tab in the properties of the CPU that is acting as server.
3. Click "OPC UA > Server > Security > Secure Channel".
4. Scroll down in the "Secure Channel" dialog to the section "Trusted clients".
5. Double-click in the table on the empty row with "<add new>". A browse button is displayed in the row.
6. Click this button.
7. Select the prepared client certificate.
8. Click the button with the green check mark.
9. Compile the project.
10. Load the configuration onto the S7-1500 CPU (server).

## Result

The server now trusts the client. If the server certificate is also considered trusted, the server and client can establish a secure connection.

### 9.4.9.3 User authentication

In the OPC UA client interface of the S7-1500, you can set what authentication is required for a user of the OPC UA client wishing to access the server. To do so, you must select the corresponding client interface in the project tree of the requested S7-1500 CPU under "OPC UA communication > Client interfaces" and select the type of user authentication in the Inspector window under "Properties > Configuration > Security".

#### Types of user authentication

The following options are available for user authentication:

- **Guest**

The user does not need to verify authorization (anonymous access). The CPU creates an anonymous session for the user, and the OPC UA server does not check the authorization of the client user.

- **User name and password**

The user must prove authorization (no anonymous access). The OPC UA server checks whether the client user is authorized to access the server. Authorization is given by the user name and the correct password. These inputs cannot be checked by the client interface, which means all values are accepted as being valid.

---

#### **Note**

STEP 7 stores user name and password unencrypted in the data block/instance data block. Recommendation: Use the user authentication "User (TIA Portal - Security Settings)".

---

- **Users (TIA Portal - Security Settings)**

You can enter a user name from the list of users entered in the project for authentication. The names of the registered users for the current project are available in the user administration in the project tree under "Security Settings > Users and roles". There you can also enter additional users.

You can also enter a name that is not listed in the user administration of the project or leave the field blank. This is necessary when the corresponding user name is only provided by a different source during runtime, for example, via HMI or from a different OPC UA client.

### **"No Security" security policy and authentication via user name and password**

You can set the following combination:

Security policy = "No Security" and authentication via user name and password.

- The OPC UA server of the S7-1500 supports this combination. OPC UA clients can connect and encrypt the authentication data or not.
- OPC UA client of the S7-1500 CPU also supports this combination: However, in runtime it only connects if it can send the authentication data encrypted via cable!

Result: With the following configuration, not connection can be established in runtime.

- S7-1500 as OPC UA client
- OPC UA server which supports no encryption of authentication data when "No Security" ("none") is set as security policy.

### **See also**

Users and roles with OPC UA function rights (Page 238)

#### **9.4.9.4 Using a configured connection**

### **Introduction**

This section shows you how to use a configured connection for OPC UA instructions (third step).

### **Requirements**

- You have created a client interface and added PLC tags and PLC methods to this interface, see ("First step (Page 322)").
- You have configured a connection to an OPC UA server (Second step (Page 339)).

### **Overview**

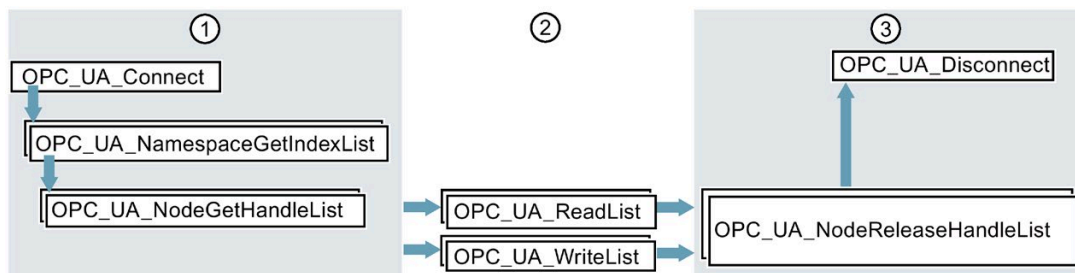
To read data from an OPC UA server or write data to an OPC UA server, use the following instructions:

- OPC\_UA\_Connect
- OPC\_UA\_NamespaceGetIndexList
- OPC\_UA\_NodeGetHandleList
- OPC\_UA\_ReadList or OPC\_UA\_WriteList
- OPC\_UA\_NodeReleaseHandleList
- OPC\_UA\_Disconnect



## Order of the OPC UA instructions

The following figure shows the order in which the OPC UA instructions are called in a user program in order to use these instructions to read or write PLC tags:



- ① Instructions for preparation of read and write operations
- ② Read and write instructions
- ③ Instructions for "clean-up" after a completed read or write operation

The "OPC-UA-NodeReleaseHandleList" instruction can be omitted if "OPC-UA-Disconnect" is called immediately afterwards.

Figure 9-75 Call sequence for write and read operations

STEP 7 (TIA Portal) automatically supplies the parameters of these instructions if you are using a client interface and a configured connection to an OPC UA server.

The procedure is shown in the following section.

## Using a client interface and configured connection

To use a configured OPC UA connection, follow these steps:

1. Open your user program in the TIA Portal.
2. Using drag-and-drop, move the **"UA\_Connect"** instruction into the program editor.

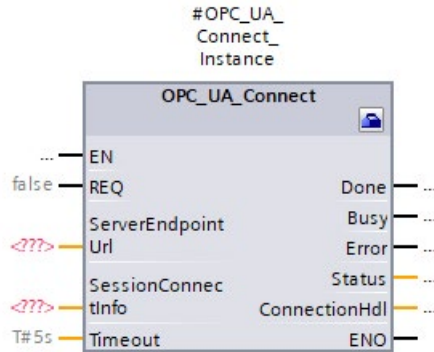
You will find the instruction under "Instructions > Communication > OPC UA" in the TIA Portal.

3. Select a call option for the instruction

The example uses a multi-instance.

STEP 7 displays the instruction in the program editor.

The editor for the Function Block Diagram (FBD) programming language uses the following display:



The editor for the Ladder Logic (LAD) programming language displays the instruction similarly.

4. Click the toolbox symbol in the editor for FBD or LAD.

The symbol is located in the heading of the instruction:



If you are using the editor for STL or SCL: Click the small green rectangle below the first character of the instance name:

█ #OPC-UA-Connect\_Instance

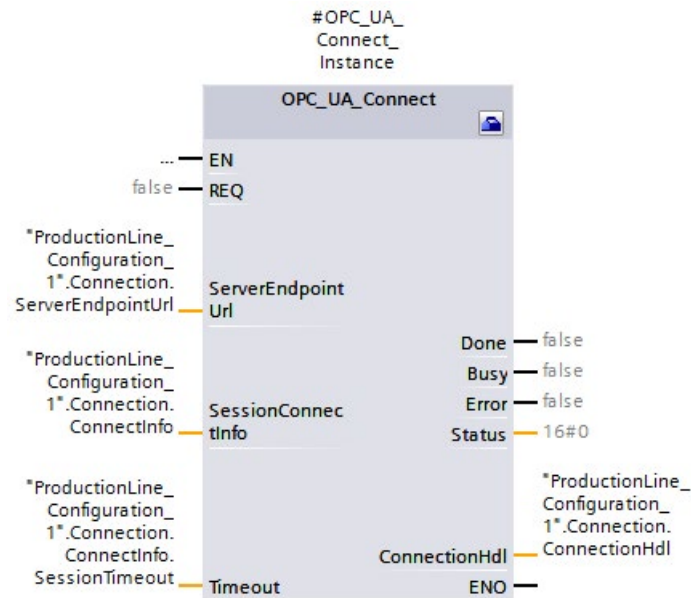
The example (Page 320) uses "#OPC-UA-Connect\_Instance" as the instance name.

STEP 7 displays the properties of the instruction in a separate dialog.

5. For "Client interface" select the client interface that you want to use for the instruction.

We select the "ProductionLine" client interface in the example.

STEP 7 now interconnects the "ProductionLine" client interface with the parameters of the OPC\_UA\_Connect instruction:



"ProductionLine" is the interface that the OPC UA client of the example (Page 320) uses for data exchange with the OPC UA server "ProductionLine".

6. Using drag-and-drop, move the "UA\_NamespaceGetIndexList" instruction into the program editor.

You will find the instruction under "Instructions > Communication > OPC UA" in the TIA Portal.

Select the "Multi-instance" call option.

Click the toolbox symbol (LAD and FBD) or the small green box below the instance name (STL and SCL) if the editor is not already open.

Select the client interface that you want to use ("ProductionLine" in the example).

STEP 7 now automatically interconnects all parameters of the "OPC\_UA\_NamespaceGetIndexList" instruction:

7. Using drag-and-drop, move the "UA\_NodeGetHandleList" instruction into the program editor.

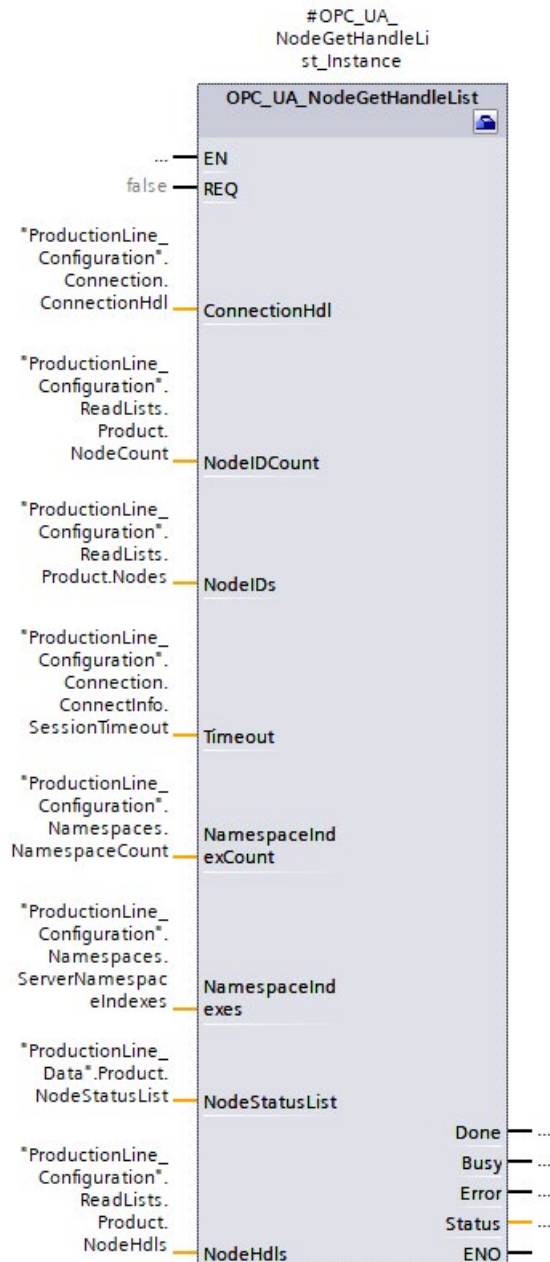
Select the "Multi-instance" call option.

Click the toolbox symbol (LAD and FBD) or the small green box below the instance name (STL and SCL) if the editor is not already open.

Select the client interface that you want to use. The example uses the "ProductionLine" client interface.

Under "Data access > Read/Writelists" select the read list that you want to use (in the example the read list "Product").

STEP 7 now automatically interconnects all parameters of the "OPC-UA\_NodeGetHandleList" instruction:



If you want to write data to an OPC UA server, select the write list you want to use under "Data access > Read/Writelists" (the "ProductionStatus" write list in the example).

8. Using drag-and-drop, move the **"UA\_ReadList"** instruction into the program editor.

Select the "Multi-instance" call option.

Click the toolbox symbol (LAD and FBD) or the small green box below the instance name (STL and SCL) if the editor is not already open.

Select the client interface that you want to use. The example uses the "ProductionLine" client interface.

Under "Data access > Read/Writelist" select the read list that you want to use (in the example the "Product" read list).

STEP 7 now automatically interconnects all parameters of the "OPC-UA\_ReadList" instruction.

If you want to write data to an OPC UA server, use the **"OPC-UA\_Write"** instruction and select the list of tags you want to send to the server under "Data access > Writelist" ("ProductionStatus" write list in the example).

9. If you use different read lists or write lists as program-controlled lists in your user program, move the **"UA\_NodeReleaseHandleList"** instruction to the program editor using drag-and-drop operation.

Select the client interface that you want to use.

Now select a read list or write list that you want to release: Only release read or write lists that you rarely use, since re-registering is time-consuming.

Then, repeat the steps starting with step 7 with the "UA\_NodeGetHandleList" instruction.

10. Using drag-and-drop, move the **"UA\_Disconnect"** instruction into the program editor.

Select the "Multi-instance" call option.

Click the toolbox symbol (LAD and FBD) or the small green box below the instance name (STL and SCL) if the editor is not already open.

Select the client interface that you want to use. The example uses the "ProductionLine" client interface.

STEP 7 now automatically interconnects all parameters of the "OPC-UA\_Disconnect" instruction.

### Supported instructions

For the following instructions, STEP 7 automatically supplies the parameters if you are using a client interface and a configured connection to an OPC UA server:

- OPC-UA\_Connect
- OPC-UA\_NamespaceGetIndexList
- OPC-UA\_NodeGetHandleList
- OPC-UA\_MethodGetHandleList
- OPC-UA\_MethodReleaseHandleList
- OPC-UA\_ReadList
- OPC-UA\_WriteList
- OPC-UA\_MethodCall
- OPC-UA\_NodeReleaseHandleList
- OPC-UA\_Disconnect

## 9.5 Tips and recommendations

### 9.5.1 Rules for subscriptions

The following rules apply to subscriptions:

- Group subscriptions in the client according to different sampling and publishing intervals and distribute the monitored elements (variables) to these groups.

Example: Create a subscription for longer publishing intervals (e.g. 5 seconds) and a subscription for shorter publishing intervals (e.g. 0.1 second).

- Disable unneeded subscriptions.

Reason: The "Deactivated" subscription mode reduces resource consumption.

- Consider the maximum number of monitored items of subscriptions for the corresponding S7-1500 CPU.

The information can be found in the technical specification of the respective CPU. The information is based on a sampling / publishing interval of 1 second.

You can find additional information in the FAQ 109755846 (<https://support.industry.siemens.com/cs/us/en/view/109755846>).

- Select the same sampling and publishing intervals for the OPC UA client and for the OPC UA server.

- Avoid arrays and structures as elements of subscriptions – if the process allows.

Reason: If even one value of an array/structure changes, the entire structure is transferred, creating an unnecessary communication load.

- Occasional non-compliance with the required sampling rate is acknowledged by the OPC UA server of the S7-1500 CPU according to OPC UA specification with a "GoodOverload" error code, see also TIA Portal Help. Different OPC UA clients handle "Good" error codes unequal to "0" differently. Consider this behavior and, if needed, reduce the communication load according to the measures described above.

#### See also

Settings of the server for subscriptions (Page 224)

## 9.5.2 Rules for the user program

### User programs for OPC UA

The following rules apply to user programs:

- If your application allows it and the communication load is high, you should set a minimum time for cycle OBs.

Advantages:

- The cycle time remains constant for the most part
- The CPU has more time for communication tasks throughout

Tip: Use the instruction "Runtime\_Info"; mode 21 or mode 25 (see TIA Portal Help) to analyze the CPU utilization (e.g. communication).

- Reduce the number of variables or data blocks that can be reached from OPC UA/HMI. By default, all variables from OPC UA/HMI are accessible when creating variables/DBs/IDBs. This measure leads to improved performance when loading in RUN.

Tip: Using the detailed object display in the TIA Portal, you can easily mark the non-OPC-UA-relevant data blocks as "not accessible from OPC UA".

- Consistent transfer of data beyond the limits of simple data types is only possible with OPC UA methods. If you use other OPC UA functions (Subscriptions, Read/Write), you must ensure data consistency in the application.
- OPC UA offers the "RegisterNodes" service for repeated read and write accesses to the same variables. Servers can use this service to prepare for optimized access to variables. The instruction "OPC-UA\_NodeGetHandleList" of the S7-1500 as OPC UA client implicitly calls this service to prepare the server for optimized accesses (in OPC UA usage "Registered Read/Write").

### Calling detailed object display in the TIA Portal

To call up the detailed object display, proceed as follows:

1. Switch to the "PLC Programming" portal in the portal view.
2. Select "Show all objects".



3. Switch to the "Details" tab in the selection window.
4. In the "DB accessible from OPC UA" column, disable the accessibility from OPC UA for individual objects.

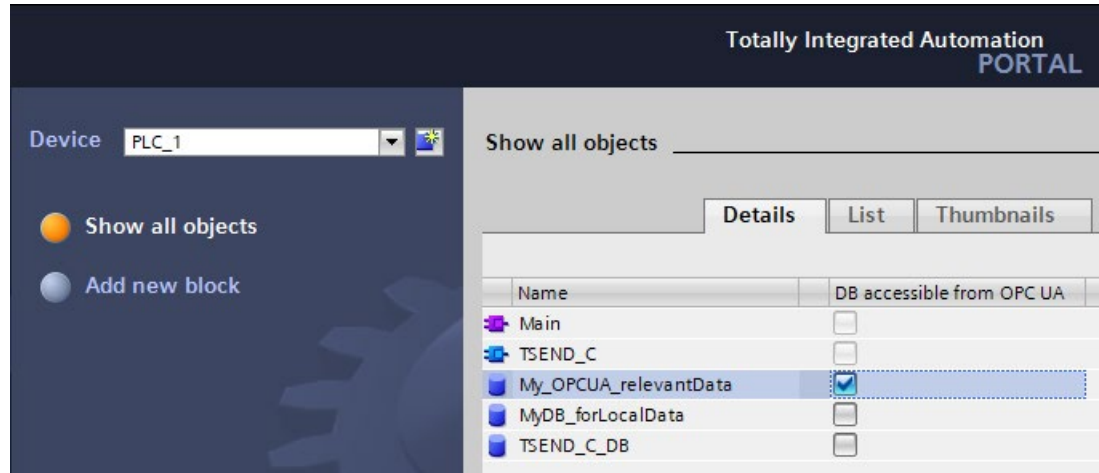


Figure 9-76 Calling detailed object display in the TIA Portal

### 9.5.3 Master copies for OPC UA communication

#### Master copies for the OPC UA interfaces

Interfaces of OPC UA servers and OPC UA clients that you want to use multiple times can be stored either in the project library or in a global library. Master copies in the project library can only be used within the project. When you create the master copy in a global library, it can be used in different projects.

The OPC UA capable CPUs differentiate between 3 interface types of the OPC UA server:

- Standard OPC UA server interface
- Companion specification interface
- Namespace reference

When adding the OPC UA interface in the project tree under "OPC UA Communication" each interface type gets its own symbol. The same symbol is used by the master copy.

Create either single master copies or a master copy with multiple interfaces.

#### Creating multiple master copies from selection

You select one or more elements and create individual master copies from them

1. Open the library in the "Libraries" task card.
2. Select the desired elements.
3. Using a drag-and-drop operation, move the elements to the "Master copies" folder or any subfolder of "Master copies".

## Creating a master copy from selection

You select multiple elements and create a single master copy from them that contains all selected elements.

1. Copy to the clipboard the elements that you want to create as master copies.
2. Right-click on the "Master copies" folder or any of its subfolders in the library.
3. In the shortcut menu, select "Paste as a single master copy" command.

If multiple interfaces are added to a master copy from the OPC UA server or OPC UA client, the label and the symbol in the library are changed accordingly.

A symbol with "+" is displayed instead of the simple symbol.

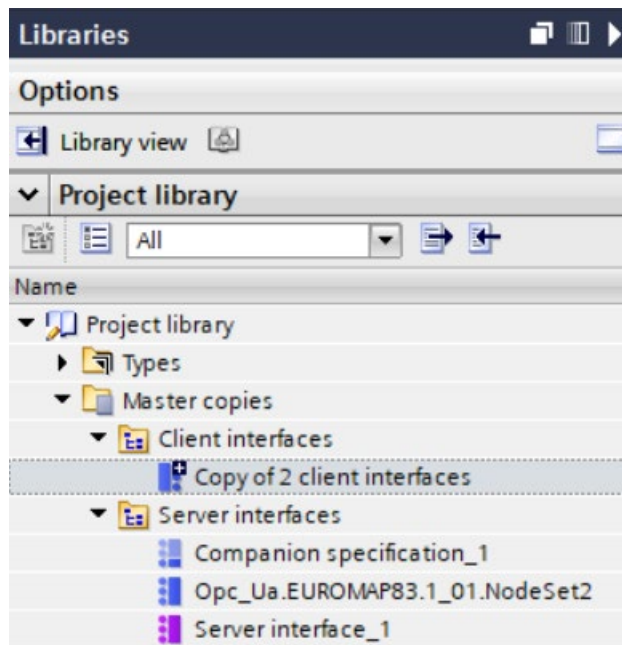


Figure 9-77 Create copy template in STEP 7

## See also

Creating a user-defined server interface (Page 259)

## Addressing via DHCP

In order to provide future-proof, efficient and flexible automation, more and more components from the production area support IT standards. Worldwide Ethernet standards, integrated communication and versatility make IT-supported automation an economical solution for your requirements. Functional expansions of the communication options of the S7-1500 CPUs in this direction give you more freedom for the possible uses of your system or machine. You use IT technology to automate efficiently. With the introduction of DHCP and the expansions of DNS for S7-1500 CPU as of firmware version V2.9, you gain more flexibility for the design of your automation solution.

For the interfaces of an S7-1500 CPU you can set that address parameters such as the IP address with subnet mask, can be got from a DHCPv4 server (hereinafter DHCP server).

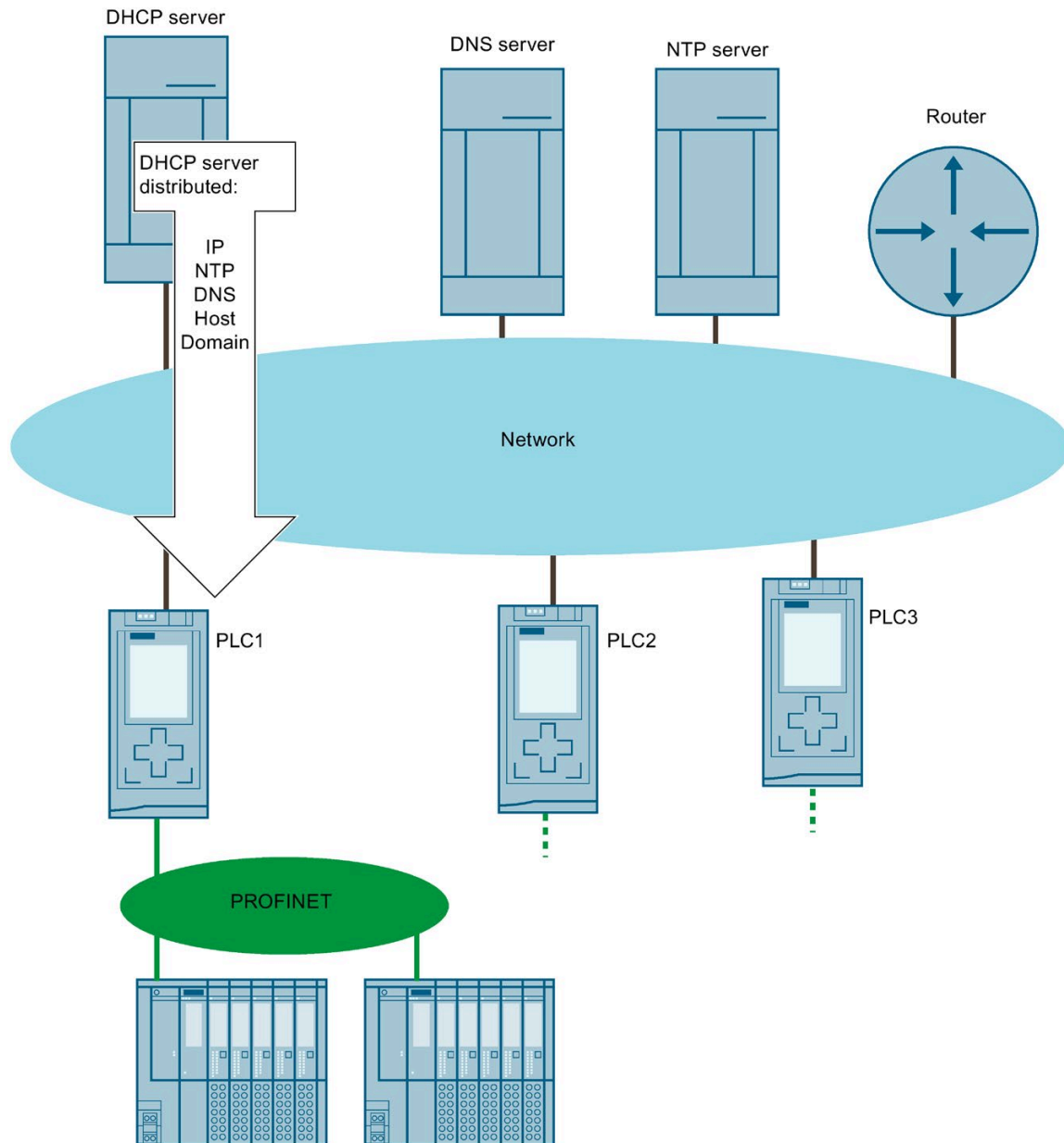


Figure 10-1 Overview of DHCP

## Areas of application

- Use of the S7-1500 CPU in a managed IT environment
- Adding new devices in a modular manufacturing structure

## 10.1 Principle of address assignment via DHCP

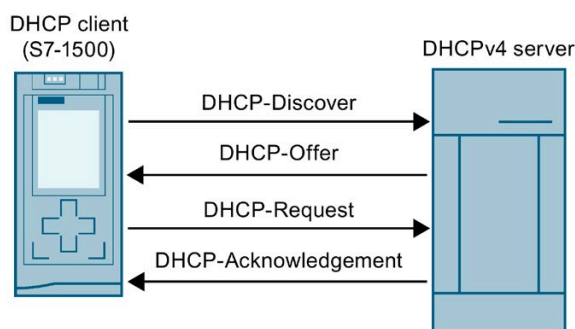
### Requirement configuration

The following requirements must be met so that a PROFINET interface of the S7-1500 CPU can obtain IP address parameters via a DHCP server:

- The address assignment via a DHCP server is configured.  
Activate DHCP (Page 368)
- No PROFINET IO communication may be configured for the interface.

### Principle of DHCP address assignment

The process begins as soon as the project is loaded into the CPU or the CPU is switched on with configured DHCP address assignment and started up, the process of DHCP assignment begins:



|                      |                                                                                                                                                                                                                                                    |
|----------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| DHCP Discover        | The DHCP client searches for a suitable DHCP server via broadcast. The DHCP client identifies itself to the DHCP server with the configured client ID or with its MAC address.                                                                     |
| DHCP Offer           | The DHCP server offers the DHCP-client IP address parameters (IPv4 address, subnet mask, optional default router) and if necessary further data (options).                                                                                         |
| DHCP Request         | The DHCPclient requests the IP address parameters and options offered in the DHCP offer.<br><br>The DHCP client of the S7-1500 CPU always accepts the first DHCP offer of a DHCP server that meets the requirements (IP address with subnet mask). |
| DHCP Acknowledgement | The DHCP server confirms and transmits the IP address parameters and options offered in the DHCP offer.<br><br>The DHCP server also notifies the DHCP client how long the DHCP client can use the address parameters (lease time).                 |

Figure 10-2 Principle of address assignment with DHCP

The IP address parameters and options are stored in the load memory of the CPU. After a general reset or restart of the CPU, the IP address parameters and options are obtained again via DHCP.

### DHCP address assignment options

For the S7-1500 CPU you can configure that the following options are obtained via a DHCP server:

- Addresses of up to four DNS servers  
Get addresses of the DNS servers via DHCP (Page 370)
- Address of up to four NTP servers  
Get addresses of the NTP servers via DHCP (Page 370)
- Host and domain name  
Obtain host and domain name via DHCP (Page 371)

If necessary, the DHCP server also supplies the address of a router (default gateway) as option.

### How long can the S7-1500 CPU use the DHCP address parameters?

In addition to the address parameters, the DHCP server also notifies the S7-1500 CPU (DHCP client) of the lease time. The lease time defines how long the CPU can use the address parameters.

When the lease time has fully expired, the CPU returns the assigned address parameters. The CPU has an internal time monitoring for the lease time.

At certain times when the lease time expires, the CPU has the option of extending the lease time:

- Renewal: Half of the lease time has expired: The CPU contacts the original DHCP server and asks for an extension of the lease time. The original DHCP server can either confirm the existing lease time or assign a new lease time. With a new lease time, the time monitoring in the CPU is reset.
- Rebinding: 7/8 of the lease term has expired: The CPU contacts all available DHCP servers via broadcast and asks for an extension of the lease time. A DHCP server can either confirm the existing lease time or assign a new lease time. With a new lease time, the time monitoring in the CPU is reset.

In the event of a negative response from DHCP server during rebinding or if no DHCP server replies, the CPU returns the address parameters after 8/8 of the lease time.

If the CPU has returned the address parameters after the lease time has expired, the CPU starts a new cycle for DHCP addressing with a new DHCP discover.

### See also

Configuring the client ID (Page 368)

## 10.2 DHCP with DNS

As of STEP 7 V17, the S7-1500 CPU supports the host name and domain address parameters used in name-based communication (DNS).

For specific communication services, name-based addressing via the complete name consisting of host name and domain, is useful:

- The CPU is addressable under the complete name, for example at OPC UA, Open User Communication. In the case of dynamic IP address assignment by the DHCP server, unique addressing is always possible through the DNS name.
- Certificates of the S7-1500 CPU may contain the complete name, for example, for OPC UA communication, web server, secure communication.
  - Only if you configure host name and domain for the S7-1500 CPU in STEP 7, then the complete name is entered in the device certificates in the project as subject alternate name (SAN).
  - As soon as you obtain the host name and/or domain via DHCP or assign it via the user program, the complete name is not stored in the device certificates in the project.

How you set the DNS configuration for your CPU depends on how you assign the host name and domain in your network .

- Central assignment of host name and domain

You assign the host name and domain centrally in your network, for example via a configured DNS server. In STEP 7 you configure that the CPU obtains the host name and domain via DHCP.

In the following configuration, only the client ID is configured in the S7-1500 CPU. At the DHCP address assignment the DHCP-server returns the host name and domain options to the CPU.

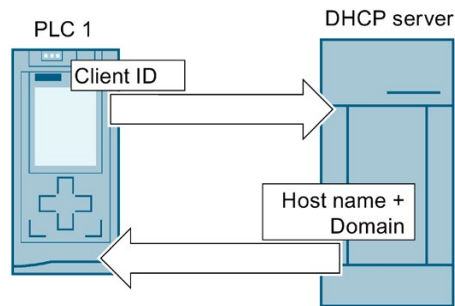


Figure 10-3 Obtain host and domain name via DHCP

For this configuration, you must first activate the host name and domain configuration in STEP 7. You then configure that the host and domain name are obtained via DHCP.

Obtain host and domain name via DHCP (Page 371)

- Local assignment of host name and domain

You can configure the host name and domain in STEP 7 or assign them in the user program.

---

### Note

#### Validity of the data obtained from DHCP

If you change the host name and/or domain in the user program, then all data obtained via DHCP (IP suite, host name, domain, NTP server, DNS server) becomes invalid and is retrieved again from DHCP server. Therefore, you should only change the Hostname and/or Domain in urgent cases and not during operation.

All connections can be dropped if the IP address of the interface changes.

---



In the following configuration, your host name and domain are configured in the S7-1500 CPU in addition to its client ID. When assigning DHCP addresses, the CPU supplies the client ID as well as the host name and the domain to the DHCP server. The DHCP server receives the information to update, for example a DNS server with the address data of the CPU.

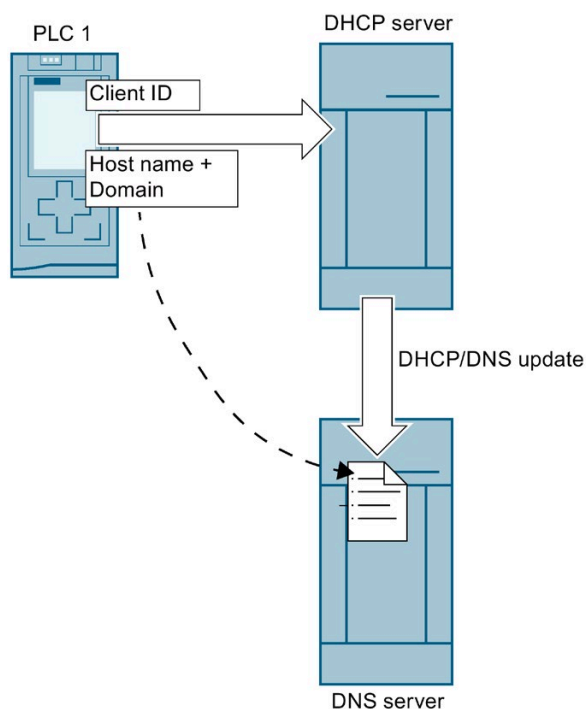


Figure 10-4 Configure host and domain name

For this configuration, you must first activate the host name and domain configuration in STEP 7. You then configure the host name and domain in STEP 7.

- Central assignment of the domain and local assignment of host name.
  - You configure in STEP 7 that the CPU gets the domain via DHCP.
  - You can configure the host name in STEP 7 or assign it via the user program.

In the following configuration, the host name is also configured in the S7-1500 CPU in addition to the client ID. When assigning DHCP addresses, the CPU supplies the client ID as well as the host name to the DHCPv4 server. The DHCP server supplies the domain option to the CPU.

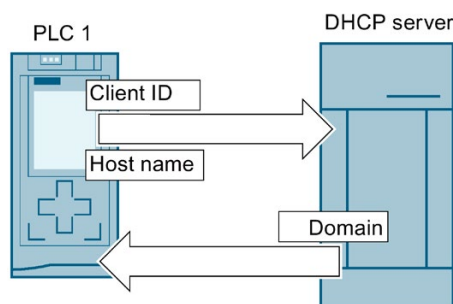


Figure 10-5 Configure host name, obtain domain name via DHCP

For this configuration, you must first activate the host name and domain configuration in STEP 7. Then configure the host name in STEP 7 and configure that the domain is obtained via DHCP.

## Requirements

- You have activated the address assignment via DHCP for at least one interface of the S7-1500 CPU.

## Configuration of host and domain name

To activate the host name and domain configuration in STEP 7, follow these steps:

1. Select the S7-1500 CPU in STEP 7.
2. In the properties of the CPU, navigate to "Advanced configuration" > "Host and domain name" > "Host and domain name configuration".
3. Select the "Enable host name and domain" check box.

## Configuring the host name in STEP 7

To configure the host name in STEP 7, follow these steps:

1. Select the S7-1500 CPU in STEP 7.
2. In the properties of the CPU, navigate to "Advanced configuration" > "Host and domain name" > "Host and domain name configuration" > "Host name".
3. For "Host name configuration:" select "Set host name in the project" from the drop-down list.
4. Enter the host name for "Host name:".
  - Enter your desired host name.
  - If you select the "Host name identical to device name" check box, STEP 7 automatically assigns the device name as the host name.

Only if you have configured the host and domain name in STEP 7, the full name is displayed for "Full name:".

## Assign host name in the user program

To assign the host name in the user program, follow these steps:

1. Select the S7-1500 CPU in STEP 7.
2. In the properties of the CPU, navigate to "Advanced configuration" > "Host and domain name" > "Host and domain name configuration" > "Host name".
3. Under "Host name configuration:" select "Set hostname directly on the device (e.g. PLC program, display)" in the drop-down list.
4. Call the instruction "CommConfig" in the user program. The DATA parameter must point to a UDT "Conf\_Hostname" where the host name is defined.

You can find additional information on the "CommConfig" instruction and on the UDT "Conf\_Hostname" in the STEP 7 online help.

## Configuring a domain in STEP 7

To configure the domain in STEP 7, follow these steps:

1. Select the S7-1500 CPU in STEP 7.
2. In the properties of the CPU, navigate to "Advanced configuration" > "Host and domain name" > "Host and domain name configuration" > "Domain".
3. For "Domain configuration:" select "Set domain in the project" from the drop-down list.
4. Enter your desired domain under "Domain:".

Only if you have configured the host and domain name in STEP 7, the full name is displayed for "Full name:".

## Assigning a domain in the user program

To assign the domain in the user program, follow these steps:

1. Select the S7-1500 CPU in STEP 7.
2. In the properties of the CPU, navigate to "Advanced configuration" > "Host and domain name" > "Host and domain name configuration" > "Domain".
3. Under "Hostname configuration:" select "Set domain directly on the device (for example PLC program, display)" in the drop-down list.
4. Call the instruction "CommConfig" in the user program. The DATA parameter must point to a UDT "Conf\_Domainname" where the domain name is specified.

You can find additional information on the "CommConfig" instruction and on the UDT "Conf-Domainname" in the STEP 7 online help.

## Rules for maximum lengths of host name, domain and client ID

Note the following maximum lengths in bytes. One byte corresponds to one character:

- Host name: Maximum 63 bytes
- Domain: Maximum 252 bytes
- Client ID: Maximum 254 bytes
- Host + Domain name : Maximum 254 bytes
- Host + Domain name + Client ID: Maximum 260 bytes

Applies only when host name and domain must be sent to the DHCP server.

## 10.3 Activate DHCP

### Requirements

- S7-1500 CPU firmware V2.9 or higher

### Procedure

To activate DHCP for the PROFINET interface of an S7-1500 CPU, follow these steps:

1. Select the PROFINET interface of the S7-1500 CPU in STEP 7.
2. In the properties of the interface, navigate to "Ethernet addresses" > "Internet Protocol Version 4 (IPv4)".
3. Select the option "IP address of DHCP server".

### Result

You have set the interface so that it obtains your IP address via a DHCP server.

"Use MAC address as client ID" is set as the operating mode for DHCP on the S7-1500 CPU. How to adjust the client ID is described under Configuring the client ID (Page 368).

## 10.4 Configuring the client ID

### The client ID

The S7-1500 CPU always identifies itself to a DHCP server with the client ID (DHCP option 61). The client ID is interface specific.

The S7-1500 CPU supports the following two operating modes with regard to the client ID:

- Use the MAC address as the client ID: The MAC address of the CPU is used as the client ID for the DHCP client. Note, if you execute a device exchange of the CPU in this operating mode, the MAC address and therefore also the client ID changes.
- User-defined client ID: With this option you specify the client ID in the configuration in STEP 7. You also have the option of adapting the client ID during runtime, for example, in the user program using the "CommConfig" instruction.  
If you perform a device exchange of the CPU in this operating mode, the new CPU is assigned the configured client ID.

### Requirement

- You have activated address assignment via DHCP for the interface.

## Configuring the client ID

To configure the client ID in STEP 7, follow these steps:

1. Select the PROFINET interface of the S7-1500 CPU in STEP 7.
2. In the properties of the interface, navigate to "Ethernet addresses" > "Internet Protocol Version 4 (IPv4)" > "IP address of DHCP server".
3. For "Operating mode:" select the required operating mode from the drop-down list:
  - Use MAC address as client ID (default setting)
  - User-defined client ID

If you have selected the option "Use MAC address as client ID", then you are already finished here. For "User-defined client ID", continue with step 4.

4. Enter a valid client ID for "Client ID".
  - A character string with 7-bit ASCII characters is allowed in the area from 0x21 to 0x7e.
  - Some DHCP servers expect a leading "0" (e.g. some SCALANCE devices). In this case, enter "\ 0" followed by your client ID.
  - You can also leave the field blank. In this case, you must select the "Client ID can be changed at runtime" check box.
5. In order to make the user-defined client ID adaptable during runtime, select the "Client ID can be changed during runtime" check box.

## Adapting the client ID during runtime

You can use the "CommConfig" instruction to adapt the client ID via the user program. Call the instruction. The DATA parameter must point to a UDT "Conf\_ClientId" or a UDT "Conf\_ClientId\_Opaque". The client ID must be specified in the UDT.

If you have left the user-defined client ID free in the configuration in STEP 7, then the CPU uses the MAC address as the client ID until the client ID is adapted for the first time.

---

### Note

#### Validity of data obtained via DHCP

If you change ClientId with "CommConfig", all data obtained via DHCP will be invalid: IP Suite, domain name, NTP server, DNS server. Therefore, you should only change ClientId in urgent cases and not during operation.

---

You can find more information on the instruction "CommConfig" and the UDTs "Conf\_ClientId" and "Conf\_ClientId\_Opaque" in the STEP 7 online help.

## 10.5 Get addresses of the DNS servers via DHCP

### Requirements

- You have activated the address assignment via DHCP for at least one interface of the S7-1500 CPU.

### Get addresses from DNS servers via DHCP

To obtain the addresses of up to 4 DNS servers via DHCP, follow these steps:

1. Select the S7-1500 CPU in STEP 7.
2. In the properties of the CPU, navigate to "Advanced configuration" > "DNS configuration" > "Server list".
3. For "Name resolution via DNS:" select "Set DNS server remotely (e.g. DHCP)" in the drop-down list.

Result: If the DHCP server supplies addresses from DNS servers as option, the CPU uses up to 4 addresses.

## 10.6 Get addresses of the NTP servers via DHCP

### Requirements

- You have activated the address assignment via DHCP for at least one interface of the S7-1500 CPU.

### Obtaining addresses from NTP servers via DHCP

To obtain the addresses of up to four NTP servers via DHCP, follow these steps:

1. Select the S7-1500 CPU in STEP 7.
2. In the properties of the CPU, navigate to "Time of day" > "Time synchronization"> "NTP mode".
3. For "Time synchronization:" select "Set NTP server remotely (e.g. DHCP)" in the drop-down list.

Result: If the DHCP server supplies addresses from NTP servers as option , the CPU uses up to 4 addresses.

## 10.7 Obtain host and domain name via DHCP

### Requirement

- You have activated the address assignment via DHCP for at least one interface of the S7-1500 CPU.
- You have activated the host name and domain configuration in STEP 7.

### Obtain host name via DHCP

To obtain the host name via DHCP, follow these steps:

1. Select the S7-1500 CPU in STEP 7.
2. In the properties of the CPU, navigate to "Advanced configuration" > "Host and domain name" > "Host and domain name configuration" > "Host name".
3. For "Host name configuration:" select "Set host name remotely (e.g. DHCP)" in the drop-down list.

Result: If the DHCP server supplies a host name as option, the CPU uses this host name.

### Obtaining a domain via DHCP

To obtain the domain via DHCP, follow these steps:

1. Select the S7-1500 CPU in STEP 7.
2. In the properties of the CPU, navigate to "Advanced configuration" > "Host and domain name" > "Host and domain name configuration" > "Domain".
3. For "Domain configuration:" select "Set domain remotely (e.g. DHCP)" in the drop-down list.

Result: If the DHCP server delivers a domain as option, the CPU uses this domain.

# Routing

## 11.1 Overview of the routing mechanisms of S7-1500 CPUs

The following table gives an overview of the routing mechanisms of the S7-1500 CPU.

| Routing mechanism   | Description                                                                                                                                                                                                                                                                                                   | Applications                                                                                                                                                                                                                                                           | Section                        |
|---------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------|
| S7 routing          | S7 routing is the transfer of data beyond S7 subnet boundaries. You can send information from a transmitter to a receiver across several s7 subnets.                                                                                                                                                          | Download user programs<br>Load hardware configuration<br>Execute testing and diagnostics functions                                                                                                                                                                     | S7 routing (Page 373)          |
| IP forwarding       | IP forwarding is a function of devices to forward IP packets between two connected IP subnets.                                                                                                                                                                                                                | Simple access from the control level to the field level for configuration and parameter assignment of devices, e.g. via PDM or Web browser.<br>Simplified integration of devices for remote access, e.g. for diagnostics during remote maintenance or firmware update. | IP forwarding (Page 378)       |
| Data record routing | Data can be sent over PROFINET from an engineering station to field devices via multiple networks. Since the engineering station addresses the field devices using standardized records and these records are routed via S7 devices, the term "data record routing" is used to refer to this type of routing. | Data record routing is used, for example, when field devices of different manufacturers are used. The field devices are addressed using standardized data records (PROFINET) for configuration and diagnostics.                                                        | Data record routing (Page 385) |



## 11.2 S7 routing

### Definition of S7 routing

S7 routing is the transfer of data beyond S7 subnet boundaries. You can send information from a transmitter to a receiver across several S7 subnets. The gateway from one S7 subnet to one or more other subnets is provided by the S7 router. The S7 router is a device which has interfaces to the respective S7 subnets. S7 routing is possible via various S7 subnets (PROFINET/Industrial Ethernet and/or PROFIBUS).

### Requirements for S7 routing

- All devices that can be reached in a network have been configured in a project in STEP 7 and downloaded.
- All devices involved in the S7 routing must receive routing information about the S7 subnets that can be reached through specific S7 routers. The devices obtain the routing information by downloading the hardware configuration to the CPUs, since the CPUs play the role of an S7 router.

In a topology with several consecutive S7 subnets, the following order must be kept to when downloading: First download the hardware configuration to the CPU(s) directly connected to the same S7 subnet as the PG/PC, then download one by one the CPUs of the S7 subnets beyond this starting with the nearest S7 subnet through to the S7 subnet furthest away.

- The PG/PC you want to use to establish a connection via a S7 router must be assigned to the S7 subnet it is physically connected to. You can assign the PG/PC to a PG/PC in STEP 7 under Online & Diagnostics > Online accesses > Connection to interface/subnet.
- For S7 subnets of the type PROFIBUS: Either the CPU must be configured as DP master or, if it is configured as a DP slave, the "Test, commissioning, routing" check box must be selected in the properties of the DP interface of the DP slave.
- S7 routing for HMI connections is possible as of STEP 7 V13 SP1.

---

#### Note

##### Firewall and S7 routing

A firewall does not recognize the IP address of the sender during S7 routing when the sender is located outside the S7 subnet adjacent to the firewall.

---

An overview of the devices that support the "S7 routing" function is provided in this FAQ (<https://support.industry.siemens.com/cs/ww/en/view/584459>).

### S7 routing for online connections

With the PG/PC, you can reach devices beyond S7 subnets, for example to do the following:

- Download user programs
- Download a hardware configuration
- Execute test and diagnostics functions

In the following figure, CPU 1 is the S7 router between S7 subnet 1 and S7 subnet 2.

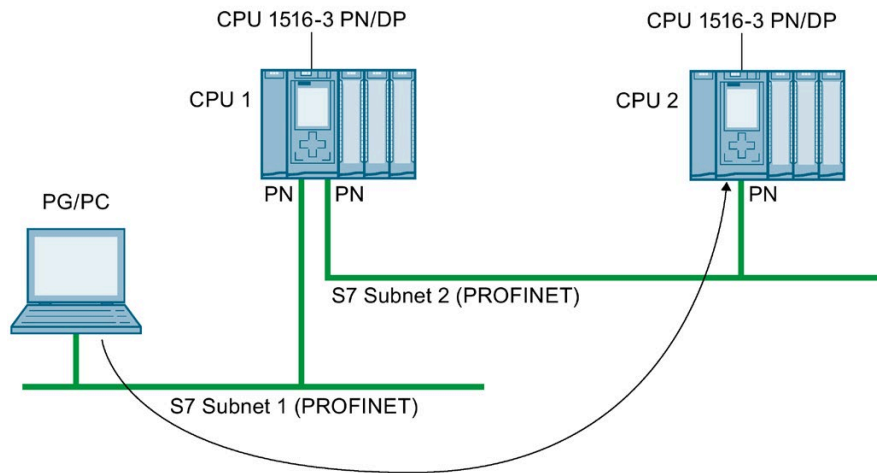


Figure 11-1 S7 routing: PROFINET - PROFINET

The following figure shows the access from a PG via PROFINET to PROFIBUS. CPU 1 is the S7 router between S7 subnet 1 and S7 subnet 2; CPU 2 is the S7 router between S7 subnet 2 and S7 subnet 3.

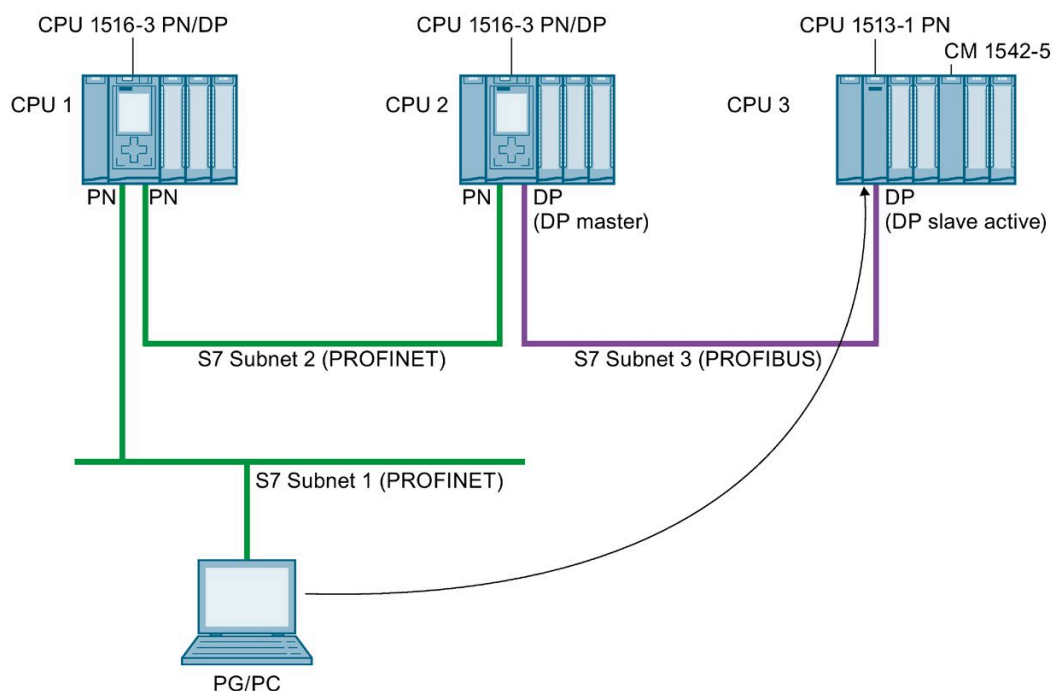


Figure 11-2 S7 routing: PROFINET - PROFIBUS

### S7 routing for HMI connections

You have the option of setting up an S7 connection from an HMI to a CPU via different subnets (PROFIBUS and PROFIBUS or Industrial Ethernet). In the following figure, CPU 1 is the S7 router between S7 subnet 1 and S7 subnet 2.

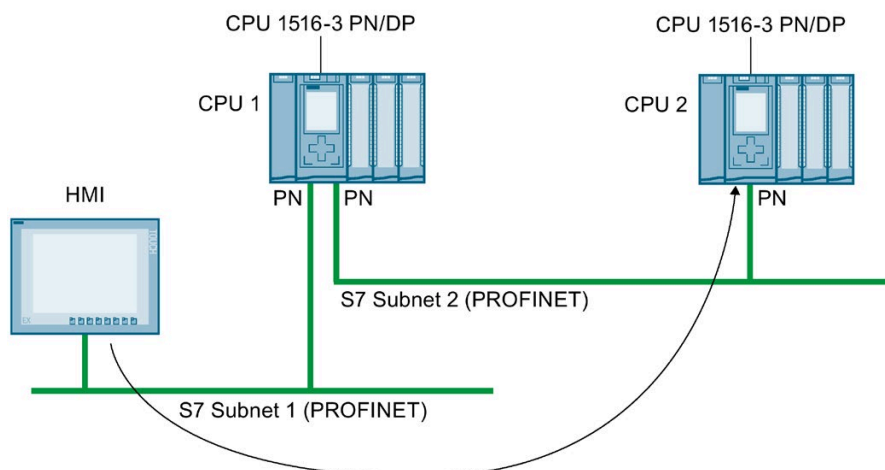


Figure 11-3 S7 routing via HMI connections

### S7 routing for CPU-CPU communication

You have the option of setting up an S7 connection from a CPU to another CPU via different subnets (PROFIBUS and PROFINET or Industrial Ethernet). The procedure is described based on examples in the section S7 communication (Page 138).

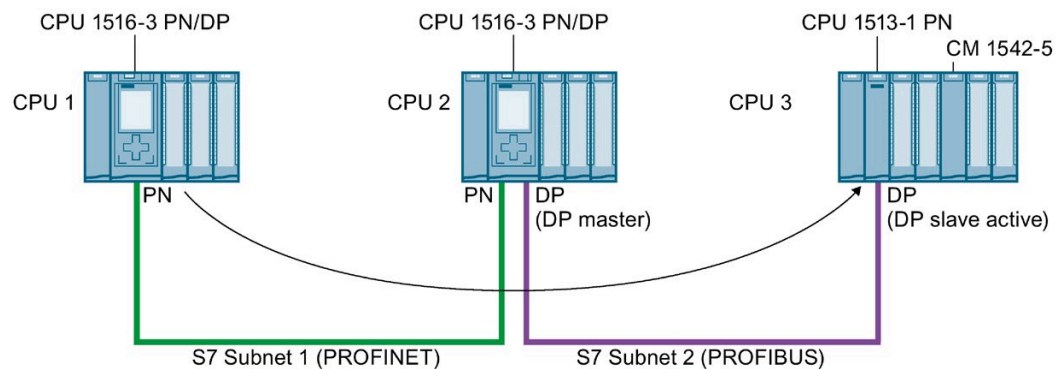


Figure 11-4 S7 routing via CPU-CPU communication

### Using S7 routing

For the CPU, select the PG/PC interface and the S7 subnet in the "Go online" dialog of STEP 7. S7 routing is performed automatically.

### Number of connections for S7 routing

The number of connections available for S7 routing in the S7 routers (CPUs, CMs or CPs) can be found in the technical specifications in the manuals of the relevant CPU/CM/CP.

## S7 routing: Example of an application

The figure below shows the example of an application for remote maintenance of a system using a PG. The connection is made here beyond two S7 subnets via a modem connection.

You configure a remote connection via TeleService in STEP 7 using "Online access" or "Go online".

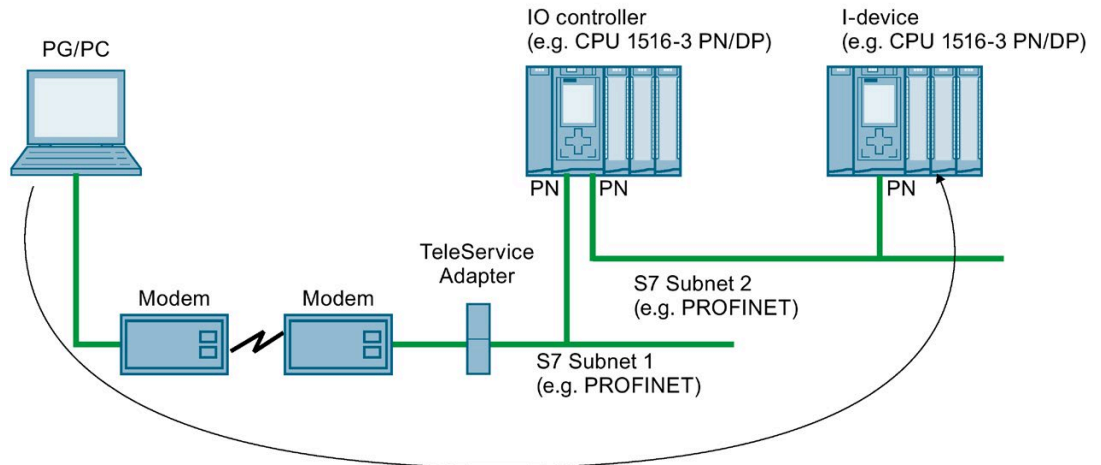


Figure 11-5 Remote maintenance of a plant using TeleService

## Additional information

- The allocation of connection resources with S7 routing is described in the section Allocation of connection resources (Page 395).
- You can find more information on setting up TeleService in the STEP 7 online help.
- You can find more information on S7 routing and TeleService adapters when you search the Internet using the following links:
  - Device manual Industrial Software Engineering Tools TS Adapter IE Basic (<http://support.automation.siemens.com/WW/view/en/51311100>)
  - Downloads for the TS Adapter (<http://support.automation.siemens.com/WW/view/en/10805406/133100>)

## See also

HMI communication (Page 110)

## 11.3 IP forwarding

### Forwarding of IP packets with IP forwarding

IP forwarding is a function of devices to forward IP packets between two connected IP subnets.

Enable/disable the IP forwarding function in STEP 7. When IP forwarding is enabled, the S7-1500 CPU forwards received IP packets not addressed to the CPU to locally connected IP subnets or to a configured router.

The following figure shows how a programming device accesses data of an HMI device. Programming device and HMI device are located in different IP subnets. The IP subnets are connected to the two interfaces X1 and X2 of the CPU.

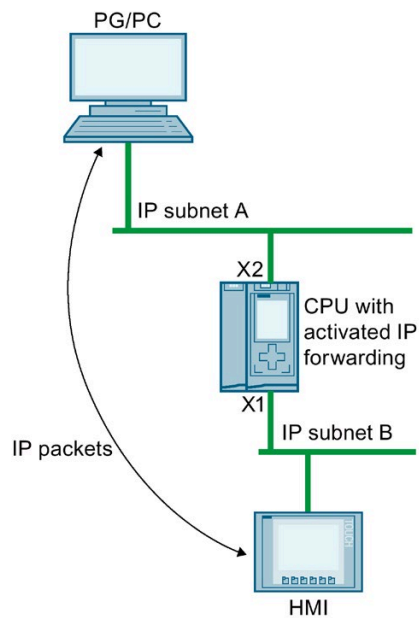


Figure 11-6 Access of a programming device to an HMI via IP forwarding

### Areas of application

- Easy access from the control level to the field level for configuration and parameter assignment of field devices, e.g. via PDM or web browser
- Simplified integration of devices for remote access, e.g. for diagnostics during remote maintenance or firmware update

## Requirements for using IP forwarding

- S7-1500 CPU as of firmware version V2.8
- Number of Ethernet interfaces:
  - The CPU has at least two Ethernet interfaces.
  - Or the CPU has one Ethernet interface, and a CP 1543-1 as of firmware version V2.2 provides the other Ethernet interface. In this case, the "Access to PLC via communication module" function must be enabled for the CP in the CPU.
- IP forwarding is enabled.
- Suitable standard gateways/routes are configured in each participating device along the outgoing and return paths of the IP packets.

## IP route table

When IP forwarding is enabled, the CPU forwards received IP packets that are not addressed to itself. How the CPU forwards the IP packets is defined in its internal IP route table.

The CPU automatically creates the IP route table from the following information of the loaded hardware configuration:

- IP configuration of the Ethernet interfaces
- Configured router

## Example of a configuration with IP forwarding

The following figure shows a sample configuration along with the required IP address settings and router settings.

- A PC on the IP subnet 192.168.4.0 communicates with an HMI device on the IP subnet 192.168.2.0.
- The IP address of a router ("Standard Gateway") is configured at the CPU, Ethernet interface X3; in the figure below it is the device that is designated as "IP Router". In STEP 7, you configure a router in the interface properties under "Ethernet Addresses" > "IP Protocol".

**IP protocol**

☒ Set IP address in the project

IP address: 10 . 10 . 0 . 10

Subnet mask: 255 . 255 . 255 . 0

☒ Use router

Router address: 10 . 10 . 0 . 1

☐ IP address is set directly at the device

Figure 11-7 Configuring the router

- For the PC, the IP router, the IO device and the HMI device, the IP addresses of a standard gateway or the corresponding routes are also entered.

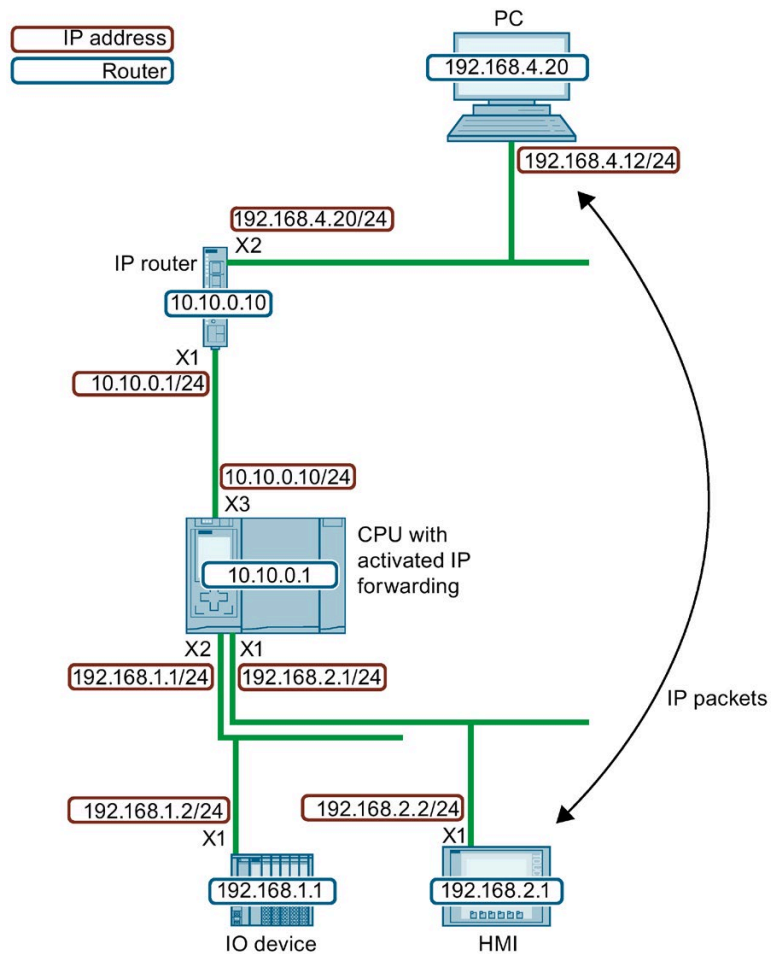


Figure 11-8 Sample configuration



This example configuration results in the following IP routing table for the CPU.

Table 11- 1 IP route table of the CPU

| Network destination | Interface   | Gateway   |
|---------------------|-------------|-----------|
| 0.0.0.0/0           | 10.10.0.10  | 10.10.0.1 |
| 192.168.1.0/24      | 192.168.1.1 | -         |
| 192.168.2.0/24      | 192.168.2.1 | -         |
| 10.10.0.0/24        | 10.10.0.10  | -         |

For IP communication between the PG/PC and the HMI device, you need to set up additional IP routes to the IP subnet of the HMI device both in the PC and in the IP router. In the HMI device, you configure the IP address of the CPU interface X1 as the standard gateway.

In a Windows computer, for example, you set up an additional IP route from the command prompt using the command "route add <destination IP subnet> mask <subnet mask> <gateway>". However, you need certain access rights for this. For this example, enter the following prompt:

- "route add 192.168.2.0 mask 255.255.255.0 192.168.4.20"

In an IP router, you set up additional routes, e.g. via a web interface. Set up the following route for this example:

- Destination IP subnet: 192.168.2.0
- Subnet mask: 255.255.255.0
- Gateway: 10.10.0.10

## Restrictions

You cannot configure any additional IP routes other than the router ("Standard Gateway") for an S7-1500 CPU. The network destination is either a connected IP subnet, or the network destination can be reached via exactly one configurable router. Because the S7-1500 CPU does not support additional IP routes, you cannot build bi-directional IP router cascades.

In the following configuration, you can configure either "Router 1" or "Router 2" in the CPU. "Router 1" is configured as an example. In this case, you cannot configure "Router 2". IP communication between the PC and the HMI device is not possible because the route is not continuous in both directions.

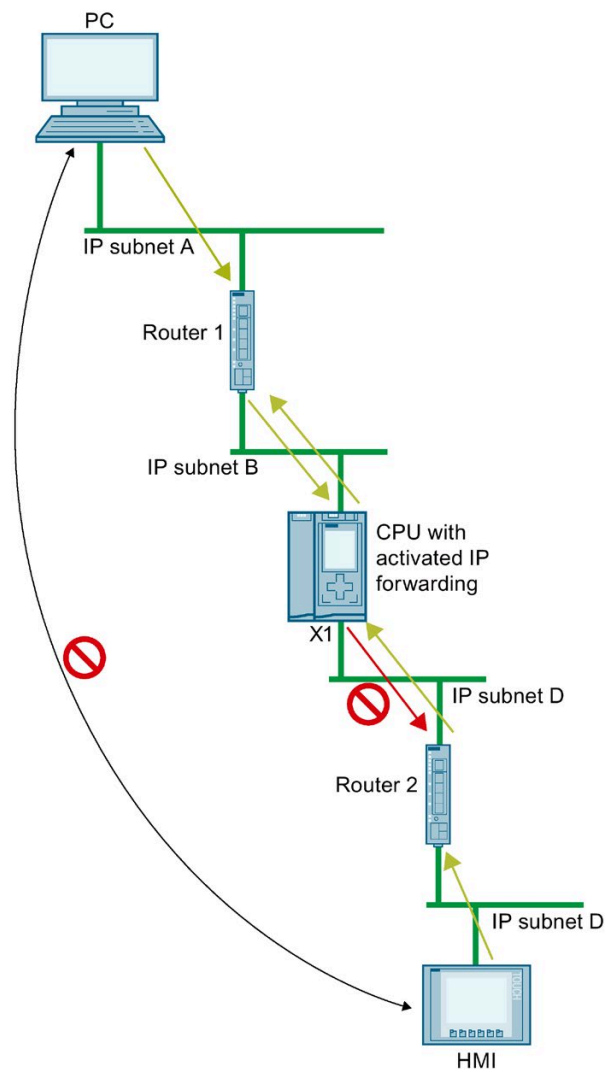


Figure 11-9 Unsupported IP router cascade

## IP forwarding via the interface of a CP

IP forwarding also works via the interface of a CP. For this you have to activate the "Access to PLC via communication module" function for this CP in the CPU.

How you enable the "Access to PLC via communication module" function is described in the online help of STEP 7.

## Reaching C/C++ Runtime of the CPU 1518 4 PN/DP MFP via interfaces X1 or X2

If you activate PN/DP MFP IP forwarding for the CPU 1518 4 PN/DP, you will not only reach devices in the IP subnet of interface X3 via interfaces X1 and X2, but also C/C++ Runtime. From the C/C++ Runtime of the CPU 1518 4 PN/DP MFP, you reach all devices in the IP subnets of the interfaces X1, X2 and X3.

Conditions:

- IP forwarding is enabled for the CPU 1518 4 PN/DP MFP.
- The IP address of C/C++ Runtime and the IP address of interface X3 are located in the same IP subnet.
- The routes to the IP subnets at X1 and X2 are entered in C/C++ Runtime.  
In C/C++ Runtime, enter a route with the following command: "Route add-net <destination IP subnet> mask <subnet mask> gw <gateway>"

The following figure shows a configuration in which a PC accesses the C/C++ Runtime of CPU 1518-4 PN/DP MFP via interface X2.

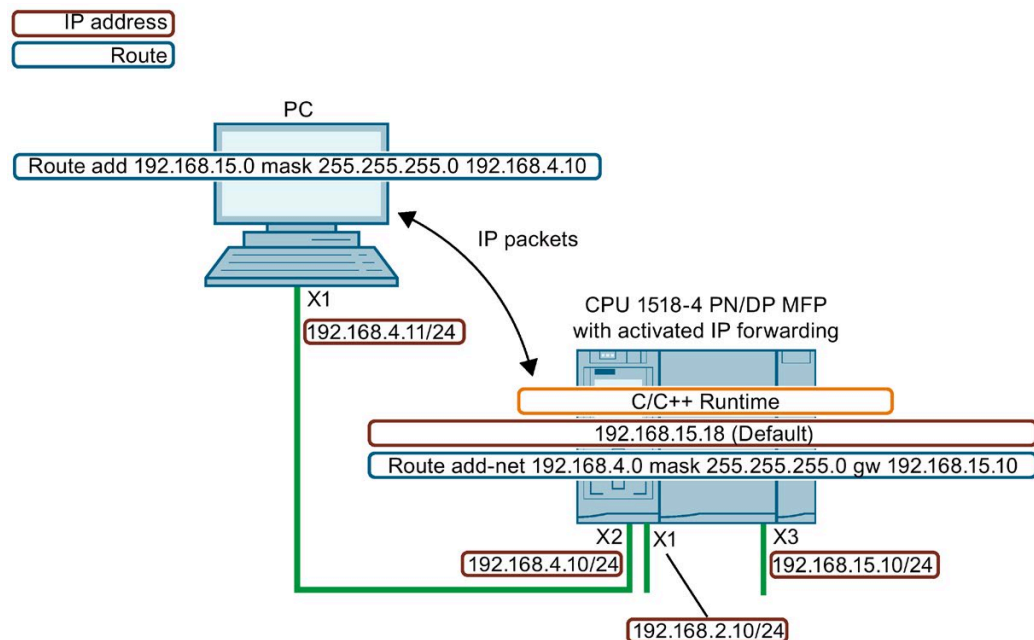


Figure 11-10 Access to C/C++ Runtime via interface X2

### Take network security into account for IP forwarding

If you activate IP forwarding for a CPU, you enable "external" access to devices that are actually only accessible and controlled by the CPU. These devices are therefore usually not protected against attacks.

The following figure shows how to protect your automation system against unauthorized access.

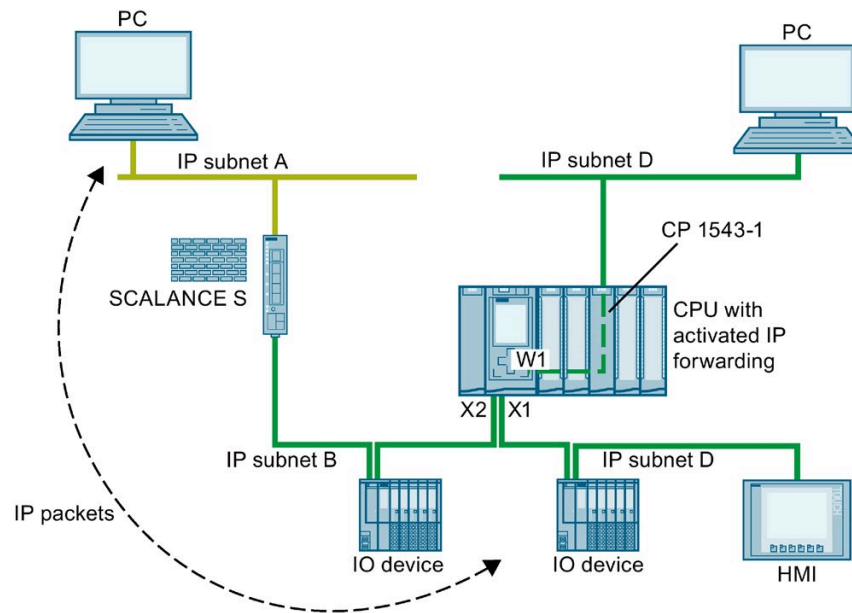


Figure 11-11 Network security for IP forwarding

- The CPU accesses all devices within the dark green IP subnets B and C close to the CPU via the interfaces X1 and X2.
- A SCALANCE S router is configured in the CPU. The CPU accesses the devices in the remote, light green IP subnet A via the router.
- The "Access to PLC via communication module" function is enabled for the CP 1543 in the CPU. The CPU reaches all devices within the IP subnet D via W1 interface.

If IP forwarding is enabled in the CPU, then a device from IP subnet A can access any device within IP subnets B, C and D close to the CPU.

Protect your automation system and connected devices against unauthorized access from outside.

Separate the CPU-related IP subnets from the remote IP subnets with a firewall. For example, use the SCALANCE S security modules with integrated firewall.

This application example (<https://support.industry.siemens.com/cs/ww/en/view/22376747>) describes how to protect an automation cell with a firewall using the SCALANCE S602 V3 and SCALANCE S623 security modules.

## Enabling/disabling IP forwarding

To enable IP forwarding, proceed as follows:

1. Select the CPU in the network view of STEP 7 (TIA Portal).
2. In the properties of the CPU of the Inspector window, navigate to "General" > "Advanced Configuration" > "IP forwarding".
3. In the "Configuration IPv4 Forwarding" area, select the check box "Activate IPv4 for interfaces of this PLC".

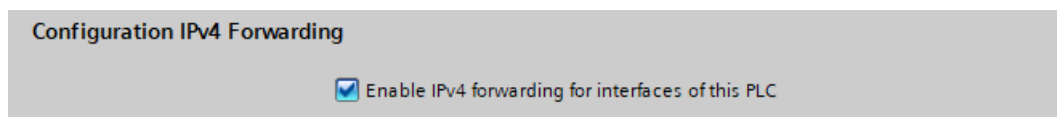


Figure 11-12 Enabling IP forwarding

Result: IP forwarding is enabled for all interfaces of the S7-1500 CPU.

You disable IP forwarding by clearing the check box "Enable IPv4 forwarding for interfaces of this PLC".

## 11.4 Data record routing

### Definition of data record routing

Data can be sent over PROFINET from an engineering station to field devices via multiple networks. Since the engineering station addresses the field devices using standardized records and these records are routed via S7 devices, the term "data record routing" is used to refer to this type of routing.

The data sent using data record routing include the parameter assignments for the participating field devices (slaves) and device-specific information (e.g. setpoint values, limit values).

Data record routing is used, for example, when field devices of different manufacturers are used. The field devices are addressed using standardized data records (PROFINET) for configuration and diagnostics.

### Data record routing with STEP 7

You can perform data routing with STEP 7 by calling a device tool (for example, PCT) via the TCI interface (Tool Calling Interface) and passing call parameters. The device tool uses the communication paths that STEP 7 also uses for communication with the field device.

No configuration is required for this type of routing except the installation of the TCI tools on the STEP 7 computer.

### Example: Data record routing with the Port Configuration Tool (PCT)

You can use the Port Configuration Tool (PCT) to configure the IO link master of the ET200 and assign parameters to connected IO link devices. The subnets are connected via data record routers. Data record routers are, for example, CPUs, CPs, IMs, IO link master.

You can learn about the constellations of data record routers supported by the PCT in this FAQ (<http://support.automation.siemens.com/WW/view/en/87611392>).

The figure below shows an example configuration with the data record routing with PCT.

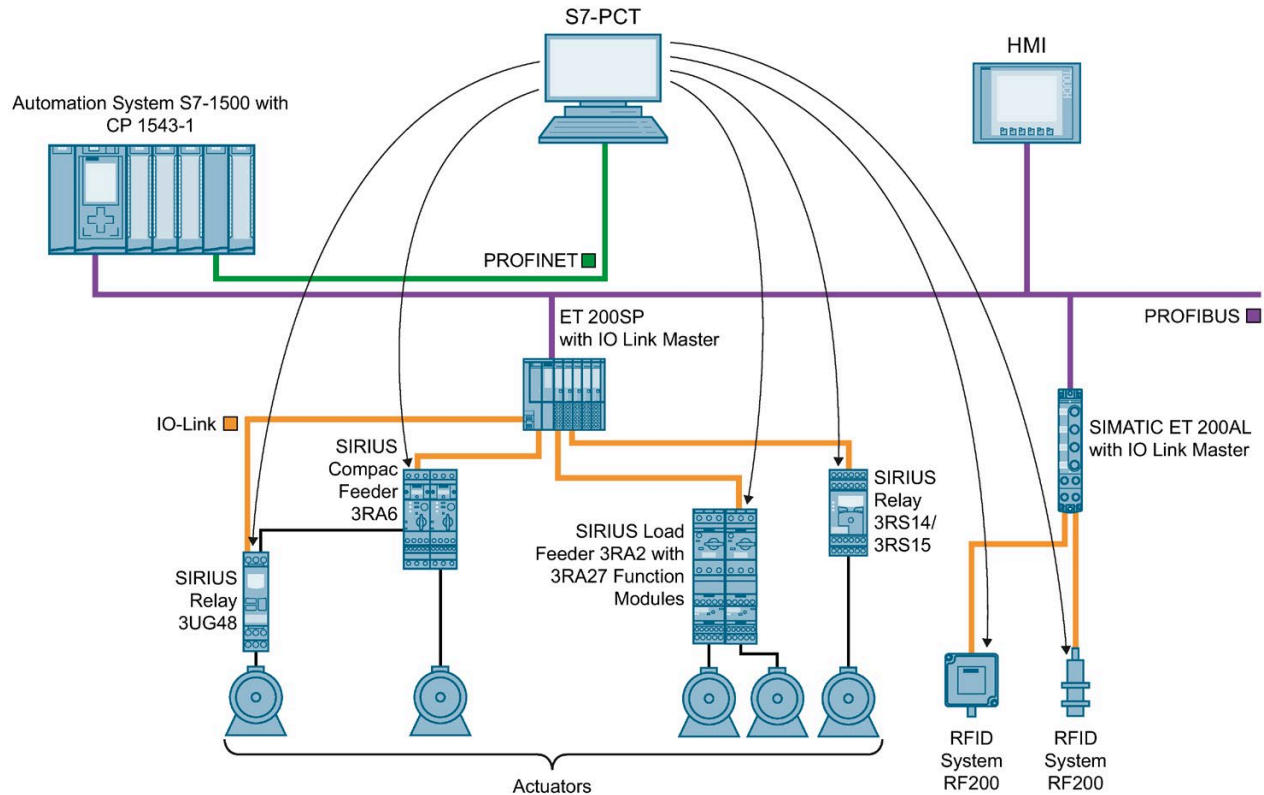


Figure 11-13 Example configuration for data record routing with PCT

### Additional information

- The differences that exist between "normal" routing and data record routing are described in this FAQ (<https://support.industry.siemens.com/cs/ww/en/view/7000978>).
- Whether or not the CPU, CP or CM you are using supports data record routing can be found in the relevant manuals.
- The allocation of connection resources with data record routing is described in the section Allocation of connection resources (Page 395).
- You can find additional information on configuration with STEP 7 in the STEP 7 online help.

## 11.5 Virtual interface for IP-based applications

As of firmware version 2.8, the S7-1500 CPU offers the option of reaching its IP-based applications, such as OPC UA, not only via its local (PN) interfaces, but also via the interfaces of communication processors in the same station. A communication partner reaches these IP-based applications via a virtual interface that can be configured in the TIA Portal as of version V16. The virtual interface is called W1 (according to IEC 81346-2).

### Features of the virtual interface

The virtual interface is not a fully diagnosable interface with the familiar properties of conventional interfaces. The virtual interface is not displayed in the graphical views, because the internal connection via the backplane bus does not represent an S7 subnet and does not have any ports. A physical connection by means of a network cable therefore cannot be established.

The IP address of the virtual interface is displayed (e.g. in the TIA Portal, in the display of the CPU) and can be configured.

The following IP-based services can be used e.g. via the virtual interface W1:

- OPC UA (client and server)
- Programmed OUC connections
- S7 communication (ES/HMI access and instructions for S7 communication such as PUT, GET)

The activated interface can be used in dialogs where IP-based connections are configured.

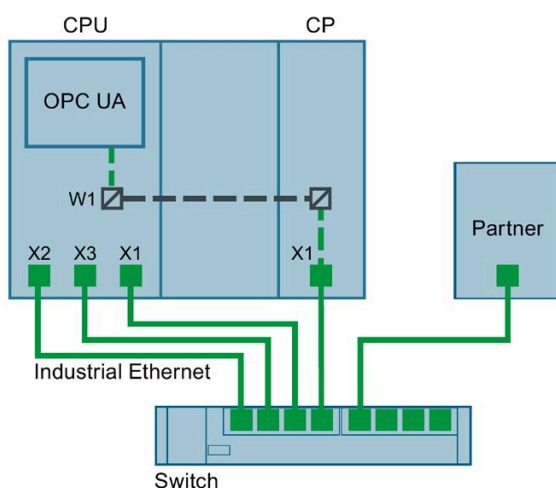


Figure 11-14 Principle of the virtual interface

Compared to conventional interfaces, the virtual interface has the following restrictions:

- No access to the web server over the virtual interface.
- Online backup is not possible via a connected programming device with the TIA Portal.
- If the CPU and communication partners are connected via the virtual interface, they cannot exchange data via LLDP (Link Layer Discovery Protocol).
- The S7 routing service does not use the virtual interface W1.

## Requirement

For a CPU service to be accessible via the Ethernet interface of a CP, the following requirements must be fulfilled:

- S7-1500 CPU firmware V2.8 or higher
- CP 1543-1 firmware V2.2 or higher

R/H CPUs do not support this function because R/H CPUs do not support CPs.

## Configuration of the virtual interface W1

In the properties of an S7-1500 CPU as of firmware V2.8, you can assign a plugged communication module to the virtual interface W1 under "Advanced Configuration > Access to PLC via communication module". You can then use this for external access to the CPU. If no CPs are plugged in or the plugged CPs do not support access to the CPU, the selection is empty.

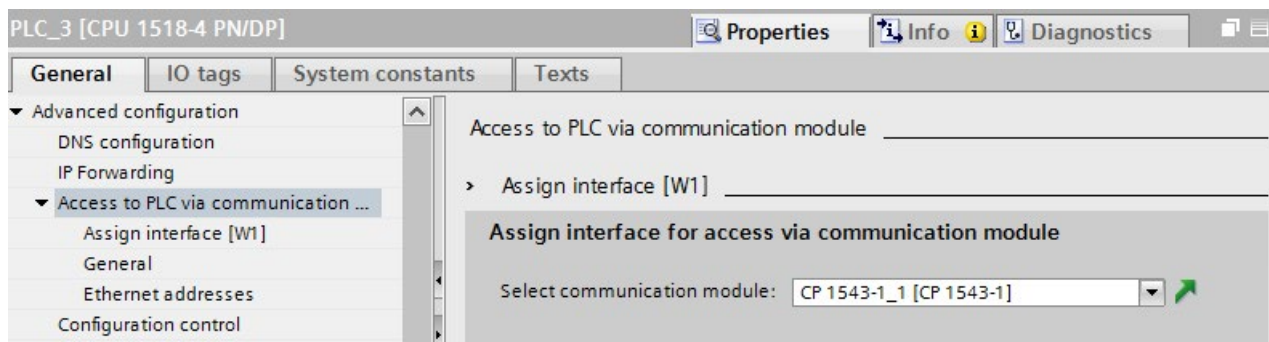


Figure 11-15 Selecting the CP in the CPU properties

After selecting the CP, the specifications and parameters for the virtual interface are displayed. Here, you can edit the settings for the IP protocol and the PROFINET parameters.

- The IP subnet is freely selectable, just like with the CP. The IP subnet is entered via the subnet mask and IP address of the virtual interface.
- When entering the IP subnet for the virtual interface, note that you are not using the same IP subnet as for the local interfaces of the CPU.



Once the IP address is entered, it is shown in the properties dialog of the OPC UA server in the list of server addresses. These settings provide the CPU with the new virtual interface W1 via which CPU services like the OPC UA server can be accessed via a communication module. The corresponding connections and S7 communication (e.g. HMI and BSEND, BRCV) are made via this interface. The OPC UA server does not allow selection of a specific interface (selection via an IP address), either all or none are possible.

---

**Note**

The IP address of the virtual interface is not listed as W1 in the device display under the currently displayed local interfaces (Xn) but is available under "Addresses" in the "Settings" section. The virtual interface is also visible when no CP is plugged or when the virtual interface is not activated. If no IP suite is available, the IP address and the subnet mask are 0.0.0.0.

---

If you change the configured and loaded IP address parameters of the virtual interface via display, T\_CONFIG instruction or online, the loaded configuration is active again after the CPU restarts.

### Configuration changes on the CP

A change of the assigned communication module may have an effect on the configuration of the virtual interface:

- In the properties of the CPU:
  - Assignment of a different CP: The configuration is used for the new CP.
  - Deselect the assigned CP: The virtual interface W1 is deactivated and the configuration is lost.  
When a CP is assigned again, the configuration must be performed again.
- On the device:
  - Moving the CP: If the CP is only moved to another slot of the device, the configuration continues to be valid.
  - Removing the CP: If the CP is deleted or moved to another device, the configuration is retained. In the drop-down list of the CPU, the CP is displayed as missing and compiling the configuration indicates an error. The missing CP can be deselected or assigned to another CP.

### Display in the diagnostics and the system constants

The virtual interface W1 is displayed in the diagnostics view under "Online & Diagnostics". The hardware ID of the virtual interface is displayed in the system constants of the CPU properties.

**Settings in the communication module**

The settings of the internal CP firewall do not have an effect on communication over the virtual interface. This means the security functions of the communication module cannot protect the data traffic via the virtual interface.

**NOTICE****Connecting to non-secure networks**

If you connect the CP to a non-secure network, it is absolutely necessary to connect an additional firewall between the CP and the non-secure network. For example, use the security modules SCALANCE S602 V3 and SCALANCE S623 with integrated firewall.

## Connection resources

### 12.1 Connection resources of a station

#### Introduction

Some communications services require connections. Connections occupy resources in the automation system (station). The connection resources are made available to the station by the CPUs, communications processors (CPs) and communications modules (CMs).

#### Connection resources of a station

The connection resources available depend on the CPUs, CPs and CMs being used and must not exceed a maximum number per station.

The maximum number of resources of a station is determined by the CPU.

##### Reserved connection resources

Each CPU has reserved connection resources for PG, HMI and Web server communication. This ensures, for example, that a PG can always establish at least one online connection with the CPU regardless of how many other communications services are already using connection resources.

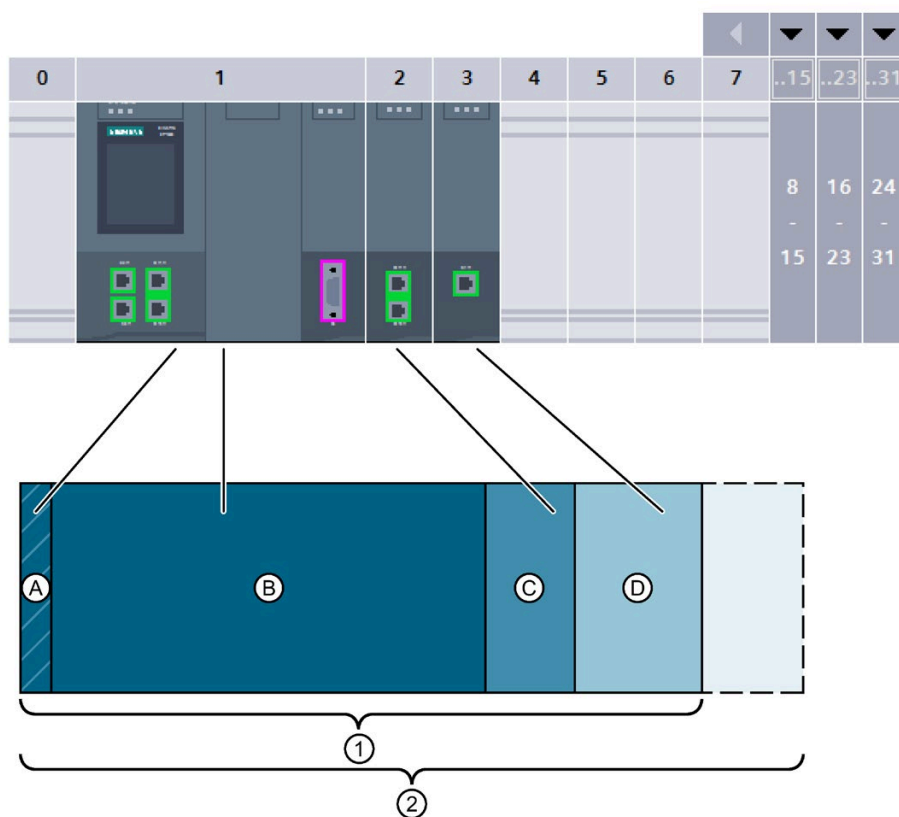
##### Dynamic connection resources

In addition, dynamic resources exist. The difference between the maximum number of connection resources and the number of reserved connection resources is the maximum number of dynamic connection resources.

The communication services PG Communication, HMI Communication, S7 Communication, Open User Communication, Web Communication, OPC UA Client/Server Communication and other communication from the pool of dynamic connection resources are used.

## 12.1 Connection resources of a station

The figure below shows an example of how individual components make connection resources available to an S7-1500 station.



- ① Available connection resources of the station, of which
  - A Reserved connection resources of the station
  - A + B Connection resources of CPU 1518
  - C Connection resources of communications module CM 1542-1
  - D Connection resources of communications processor CP 1543-1
- ② Maximum communications resources of the station using the example of a configuration from CPU 1518, CM 1542-1 and CP 1543-1

Figure 12-1 Connection resources of a station

## Number of connection resources of a station

Table 12- 1 Maximum number of connection resources supported for some CPU types

| Connection resources of a station                                    | 1511<br>1511C | 1512C<br>1513 | 1515 | 1516 | 1517 | 1518 |
|----------------------------------------------------------------------|---------------|---------------|------|------|------|------|
| Maximum connection resources of the station                          | 96            | 128           | 192  | 256  | 320  | 384  |
| of which reserved                                                    | 10            |               |      |      |      |      |
| of which dynamic                                                     | 86            | 118           | 182  | 246  | 310  | 374  |
| Connection resources of the CPU                                      | 64            | 88            | 108  | 128  | 288  | 320  |
| Max. additionally usable connection resources by plugging in CMs/CPs | 32            | 40            | 84   | 128  | 32   | 64   |
| Additional connection resources CM 1542-1                            | 64            |               |      |      |      |      |
| Additional connection resources CP 1543-1                            | 118           |               |      |      |      |      |
| Additional connection resources CM 1542-5                            | 40            |               |      |      |      |      |
| Additional connection resources CP 1542-5                            | 16            |               |      |      |      |      |

The number of connection resources that a CPU or a communication module supports is specified in the device manuals in the Technical Specifications.

### Example

You have configured a CPU 1516-3 PN/DP with a CM 1542-1 communication module and a CP 1542-5 communication processor.

- Maximum connection resources of the station: **256**
- Available connection resources:
  - CPU 1516-3 PN/DP: 128
  - CM 1542-1: 64
  - CP 1542-5: 16
  - Total: **208**

The setup provides 208 connection resources. By adding further communication modules, the station can support a maximum of 48 additional connection resources.

### Reserved connection resources

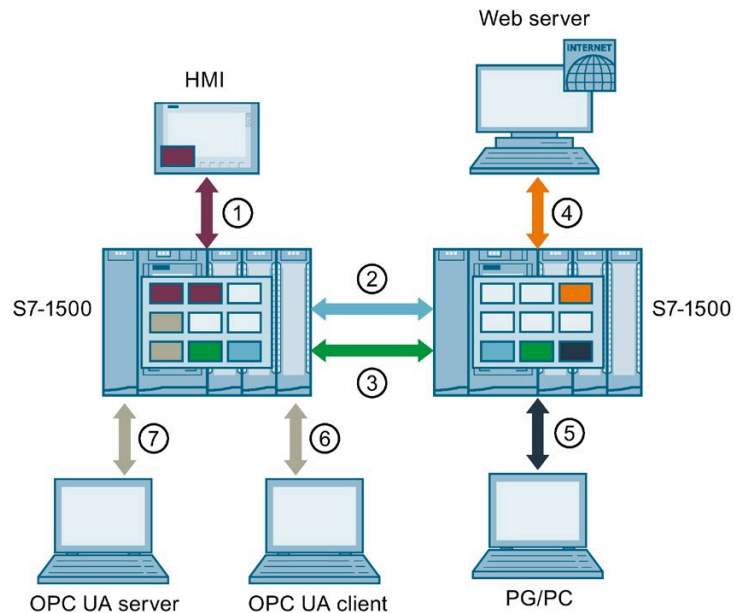
10 connection resources are reserved for stations with S7-1500 CPU, ET 200SP CPU and ET 200pro CPU based on S7-1500:

- 4 for PG communication required by STEP 7, for example, for test and diagnostics functions or downloading to the CPU
- 4 for HMI communication which are occupied by the first HMI connections configured in STEP 7
- 2 for communication with the Web server

## 12.2 Allocation of connection resources

### Overview - occupation of connection resources

The following figure shows how different connections occupy the resources of the S7-1500.



- ① HMI communication: See below.
- ② Open User Communication: Connections of Open User Communication occupy a connection resource in every end point.
- ③ S7 communication: Connections of S7 communication occupy a connection resource in every end point.
- ④ Web communication: The Web server connection occupies at least one connection resource in the station. The number of occupied connections depends on the browser.
- ⑤ PG communication: The PG connection occupies one connection resource in the station.
- ⑥ OPC UA client/server communication: Connection resource allocation for the server, see below
- ⑦ OPC UA client/server communication: Connection resource allocation for the client, see below

- Connection resource for HMI communication
- Connection resource for Open User Communication
- Connection resource for S7 communication
- Connection resource for Web communication
- Connection resource for PG communication
- Connection resources for OPC UA server communication

Figure 12-2 Allocation of connection resources

### Connection resources for HMI communication

With HMI communication, the occupation of connection resources in the station depends on the HMI device being used.

Table 12- 2 Maximum occupied connection resources for different HMI devices

| HMI device      | Maximum occupied connection resources of the station per HMI connection |
|-----------------|-------------------------------------------------------------------------|
| Basic Panel     | 1                                                                       |
| Comfort Panel   | 2 <sup>1</sup>                                                          |
| RT Advanced     | 2 <sup>1</sup>                                                          |
| RT Professional | 3                                                                       |

<sup>1</sup> If you do not use system diagnostics or alarm configuration, the station occupies only one connection resource per HMI connection.

**Example:** You have configured the following HMI connections for a CPU 1516-3 PN/DP:

- Two HMI connections to an HMI TP700 Comfort. (2 connection resources each)
- One HMI connection to an HMI KTP1000 Basic. (1 connection resource)

In total 5 connection resources are occupied for HMI communication in the CPU.

### Connection resources for OPC UA client communication

Each connection that the OPC UA client of the CPU has established to an OPC UA server occupies a connection resource in the station.

When establishing and closing an OPC UA connection, the OPC UA client temporarily occupies an additional connection resource. According to RFC 793, this connection resource is released again after a wait of approx. 60 seconds.

---

#### Note

##### Lack of resources due to temporary connection resources

A lack of connection resources occurs in the following situation:

- The OPC UA client of the CPU establishes or closes several connections simultaneously.
- The number of available connection resources of the station is insufficient for permanent and temporary connection resources of the OPC UA client communication.

Ensure that there are always enough available connection resources in the station to establish and end OPC UA connections.

Measures:

- Plan enough reserve for the OPC UA client connections.
  - If necessary, establish or close the OPC UA connections one after the other.
-



## Connection resources for routing

To transfer data beyond S7 subnets ("S7 routing"), an S7 connection is established between two CPUs. The S7 subnets are connected via gateways known as S7 routers. CPUs, CMs and CPs in S7-1500 are S7 routers.

The following applies for a routed S7 connection:

- A routed connection occupies one connection resource each in both end points. STEP 7 shows these connection resources in the "Connection resources" table.
- On the S7 router, two special connection resources are occupied for S7 routing. STEP 7 does not show the special connection resources for S7 routing in the "Connection resources" table. The number of resources for S7 routing depends on the CPU. You will find the resources for S7 routing in the technical specifications of the CPU in "Number of S7 routing connections".

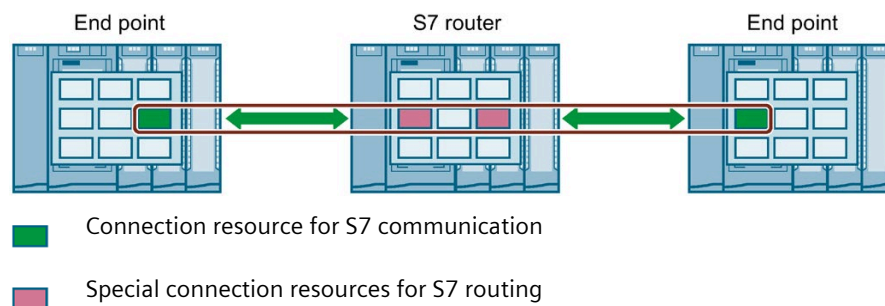


Figure 12-3 Connection resources with S7 routing

Data record routing also enables transfer of data beyond S7 subnets from an engineering station connected to PROFINET to various field devices via PROFIBUS.

With data record routing, as with S7 routing, two of the special connection resources for S7 routing are also occupied on every data record router.

### Note

#### Connection resources with data record routing

With data record routing, on the data record router, two special connection resources for S7 routing are occupied. Neither the data record connection nor the allocated connection resources are displayed in the table of connection resources.

### When are connection resources occupied?

The time for the occupation of connection resources depends on how the connection is set up (see section Setting up a connection (Page 33)).

- **Programmed setup of a connection:**

As soon as an instruction to establish a connection is called in the user program (TSEND\_C/TRCV\_C or TCON), a connection resource is occupied.

With suitable parameter assignment of the CONT parameter of the TSEND\_C/TRCV\_C instructions or by calling the TDISCON instruction, the connection can be terminated following data transfer and the connection resource is available again. When the connection is terminated, the connection resources on the CPU/CP/CM are available again.

- **Configured connections (e.g. S7 connection):**

If you have configured a connection in STEP 7, the connection resource is occupied as soon as the hardware configuration is downloaded to the CPU.

After using a configured connection for data transfer, the connection is not terminated. The connection resource is permanently occupied. To release the connection resource again, you need to delete the configured connection in STEP 7 and download the modified configuration to the CPU.

- **PG connection:**

As soon as you have connected the PG to a CPU online in STEP 7, connection resources are occupied.

- **Web server:**

As long as you have opened the Web server of the CPU in a browser, connection resources are occupied in the CPU.

- **OPC UA server**

Each connection to the OPC UA server of the CPU occupies a connection resource in the station. This connection resource is released immediately when the connection is terminated.

- **OPC UA client**

Each connection that the OPC UA client of the CPU has established to an OPC UA server occupies a connection resource in the station. When an OPC UA connection is established, the OPC UA client temporarily occupies an additional connection resource. When an OPC UA connection is terminated, the connection resource is not released again until after a wait time of approx. 60 seconds in accordance with RFC 793.

### Monitoring the maximum possible number of connection resources

#### Offline

During configuration of connections, STEP 7 monitors the occupation of the connection resources. If the maximum possible number of connection resources is exceeded, STEP 7 signals this with a suitable warning.

#### Online

The CPU monitors the use of connection resources in the automation system. If you establish more connections in the user program than those provided by the automation system, the CPU acknowledges the instruction to establish the connection with an error.

## S7-1500 and S7-300 comparison

You will find a comparison of how the communication resources of the S7-1500 and S7-300 are managed in this FAQ (<https://support.industry.siemens.com/cs/ww/en/view/109747092>).

## 12.3 Display of the connection resources

### Display of the connection resources in STEP 7 (offline view)

You can display the connection resources of an automation system in the hardware configuration. You will find the connection resources in the Inspector window in the properties of the CPU.

| Connection resources                |                     |            |                                                                                           |                    |                 |                  |
|-------------------------------------|---------------------|------------|-------------------------------------------------------------------------------------------|--------------------|-----------------|------------------|
|                                     | ① Station resources |            |                                                                                           | ② Module resources |                 |                  |
|                                     | Reserved            |            | Dynamic  | PLC_1 [CPU 15...   | CM 1542-1_1 [.. | CP 1543-1_1 [... |
| Maximum number of resources:        | 10                  |            | 246                                                                                       | 128                | 64              | 118              |
|                                     | Maximum             | Configured | Configured                                                                                | Configured         | Configured      | Configured       |
| PG communication:                   | 4                   | -          | -                                                                                         | -                  | -               | -                |
| HMI communication:                  | 4                   | 4          | 6                                                                                         | 6                  | 0               | 4                |
| S7 communication:                   | 0                   | -          | 7                                                                                         | 4                  | 3               | 0                |
| Open user communication:            | 0                   | -          | 13                                                                                        | 8                  | 5               | 0                |
| Web communication:                  | 2                   | -          | -                                                                                         | -                  | -               | -                |
| OPC UA client/server communication: | 0                   | -          | -                                                                                         | -                  | -               | -                |
| Other communication:                | -                   | -          | 0                                                                                         | 0                  | 0               | 0                |
| Total resources used:               | 4                   |            | 26                                                                                        | 18                 | 8               | 4                |
| Available resources:                | 6                   |            | 220                                                                                       | 110                | 56              | 114              |

Figure 12-4 Example: Reserved and available connection resources (offline view)

#### ① Station-specific connection resources

The columns of the station-specific connection resources provide information about the used and available connection resources of the station.

In the example, a maximum of 256 station-specific connection resources are available for the automation system.

- 10 reserved connection resources, of which 4 are already in use and a further 6 available.  
The used resources are divided up as follows:
  - 4 Resources for HMI communication
- 246 dynamic connection resources, of which 26 are already in use and a further 220 available.  
The used resources are divided up as follows:
  - 6 resources for HMI communication
  - 7 resources for S7 communication
  - 13 resources for Open User Communication

### 12.3 Display of the connection resources

The warning triangle in the column of the dynamic station resources is displayed because the sum of the maximum available connection resources of CPU, CP and CM (= 310 connection resources) exceeds the station limit of 256.

---

#### **Note**

##### **Available connection resources exceeded**

STEP 7 signals the exceeding of the station-specific connection resources with a warning. To make full use of the connection resources from the CPU, CP and CM, either use a CPU with a higher maximum number of available station-specific connection resources or reduce the number of communications connections.

---

#### **② Module-specific connection resources**

The columns of the module-specific connection resources provide information about the use of resources on the CPUs, CPs and CMs of an automation system:

The display is per module and not per interface.

In the example, the CPU makes a maximum of 128 connection resources available, of which 18 are already in use and 110 still available.

The used resources are divided up as follows:

- 6 resources for HMI communication
- 4 resources for S7 communication
- 8 resources for Open User Communication



## Display of the connection resources for HMI

For information regarding the availability and assignment of connection resources for HMI connections, refer to the "Connection resources" properties in the Inspector window of the offline view (in the context of the HMI device).

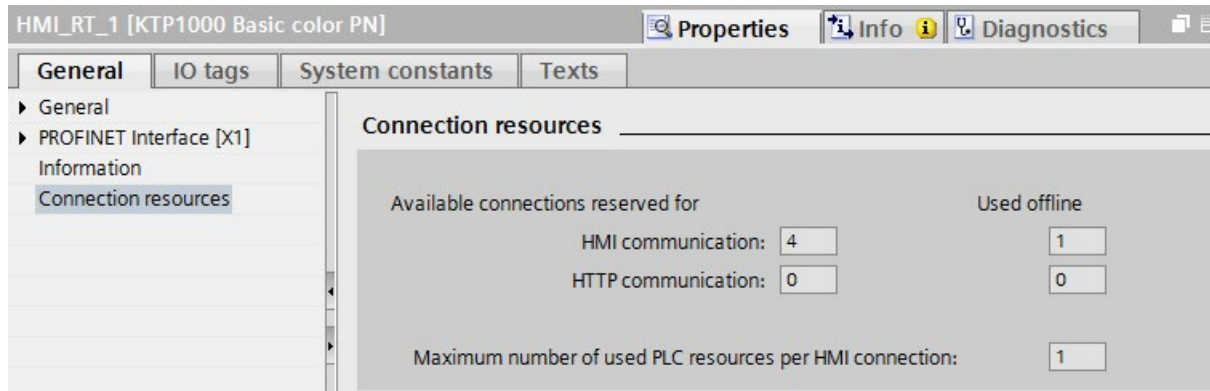


Figure 12-6 Connection resources - HMI communication

The following is displayed in the connection resources area:

- Number of available connections on the HMI reserved for HMI communication and HTTP communication
- Number of connection resources for HMI communication and HTTP communications used offline in the HMI

If the maximum number of available connection resources for an HMI device is exceeded, a corresponding message is output by STEP 7.

- "Maximum number of used PLC resources per HMI connection". This parameter is a factor that is to be multiplied by the number of HMI connections used offline. The product is the number of HMI resources occupied on the CPU.

## Displaying the connection resources in the Web server

You can display the connection resources not only in STEP 7, but also with a browser that displays the relevant page of the Web server.

You will find information on displaying connection resources in the Web server in the Web Server (<http://support.automation.siemens.com/WW/view/en/59193560>) function manual.

## Diagnostics and fault correction

### 13.1 Connection diagnostics

#### Connections table in the online view

After selecting a CPU in the Devices & networks editor of STEP 7, you will see the status of your connections displayed in the online view of the connections table.

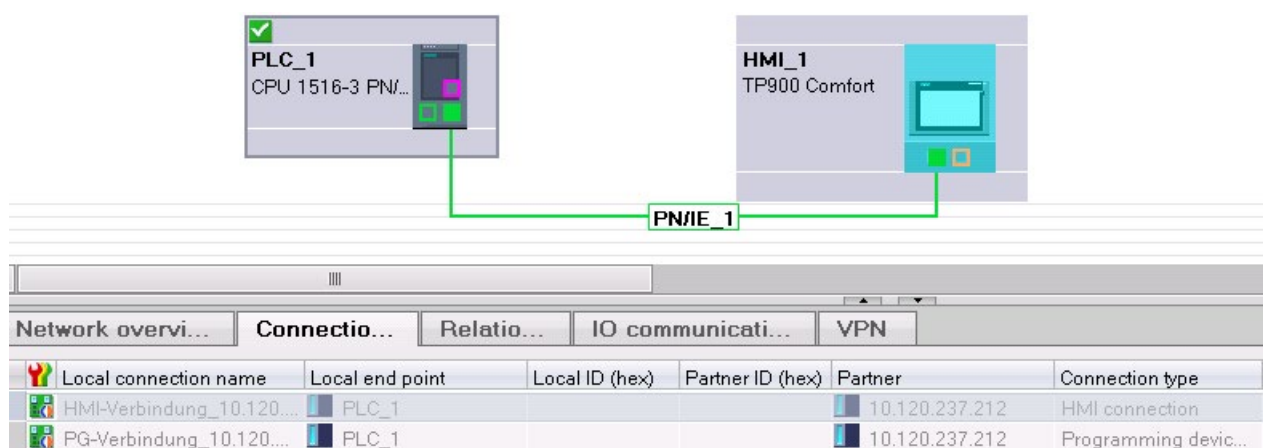


Figure 13-1 Online view of the connections table

After selecting the connection in the connections table, you obtain detailed diagnostic information in the "Connection information" tab.

**"Connection information" tab: Connection details**

The screenshot displays the 'Connection information' tab in a software interface. At the top, there is a table with columns: Local connection name, Local end point, Local ID (hex), Partner ID (hex), Partner, and Connection type. The table lists two connections: 'HMI-Verbindung\_10.120.237.212\_1' (HMI connection) and 'Established, exists online only.' (Programming device...). Below the table, the 'Connection details' section is expanded, showing fields for Connection name, Local ID (hex), Connection type, Protocol, Online status, and Details. The 'Online status' is 'Connected' with a green icon. The 'Details' field contains the text: 'Established: Connection exists only online. Connection is connected.'

| Local connection name            | Local end point | Local ID (hex) | Partner ID (hex) | Partner        | Connection type       |
|----------------------------------|-----------------|----------------|------------------|----------------|-----------------------|
| HMI-Verbindung_10.120.237.212_1  | PLC_1           |                |                  | 10.120.237.212 | HMI connection        |
| Established, exists online only. | PLC_1           |                |                  | 10.120.237.212 | Programming device... |

**Connection details**

Connection name: HMI-Verbindung\_10.120.237.212\_1 (ConnEnd\_187)

Local ID (hex):

Connection type: Connection from HMI+ client

Protocol: ISO-on-TCP

Online status: Connected

Details: Established: Connection exists only online.  
Connection is connected.

Figure 13-2 Diagnostics of connections - connection details



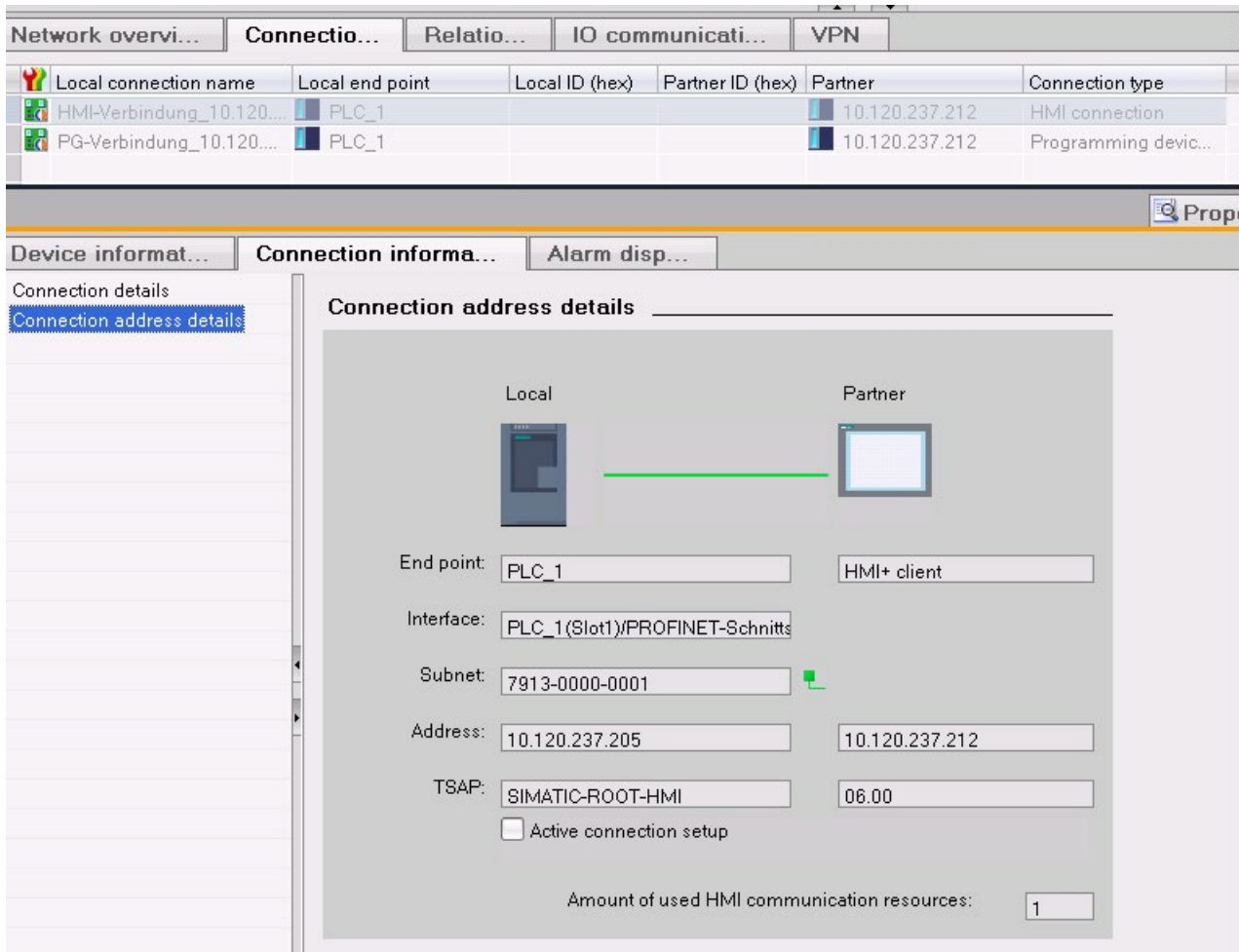
**"Connection information" tab: Address details**

Figure 13-3 Diagnostics of connections - address details

**Diagnostics via web server**

You can evaluate diagnostic information from the CPU using a web browser via the integrated web server of a CPU.

On the "Communication" Web page, you will find the following information about communication via PROFINET in various tabs:

- Information on the PROFINET interfaces of the CPU (for example addresses, subnets, physical properties).
- Information on the quality of the data transfer (for example number of data packets sent/received error-free).
- Information about the allocation/availability of connection resources.
- The "Connection status" page is similar to the online view in STEP 7 and also provides an overview of all connections with detail view.

## Diagnostics with the user program

When you program the T\_DIAG instruction, you can evaluate diagnostic information about the configured and programmed connections of the CPU using the user program.

## Additional information

You will find the description of the web server functionality in the function manual Web server (<http://support.automation.siemens.com/WW/view/en/59193560>).

## 13.2 Emergency address

If you cannot reach the CPU via the IP address, you can set a temporary emergency address (emergency IP) for the CPU. Via this emergency address, you can re-establish the connection with a CPU in order to load a device configuration with a valid IP address.

You can set an emergency address regardless of the protection level of the CPU

## When do you need an emergency address?

Your CPU cannot be reached in the following cases:

- The IP address of your PROFINET interface is assigned twice.
- The subnet mask is set incorrectly.

## Requirements

- You have selected "Set IP address in the project" for the IP protocol in the device configuration in STEP 7.
- The CPU is in STOP mode.

## Restoring a valid device configuration with an emergency address

1. Set the emergency address for the interface of the CPU with a DCP tool. For example, the SIMATIC Automation Tool has a DCP command "Define IP address".  
The maintenance LED of the CPU lights up. The diagnostic buffer also shows that an emergency address was activated for an Ethernet interface.
2. Load a STEP 7 project with a valid IP address into the CPU.
3. Switch the CPU off and on again.  
The emergency address is reset.

## Result

The CPU starts up with the valid IP address.

## Introduction

Communication with the S7-1500R/H redundant system basically functions as with the S7-1500 standard system.

This chapter describes the special features and restrictions for communication with the S7-1500R/H redundant system.

## Communication options for the S7-1500R/H redundant system

- Open User Communication via TCP/IP, UDP, ISO on-TCP and Modbus/TCP
- S7 communication as server
- HMI communication, PG communication
- Secure PG/HMI communication (see also Secure PG/HMI communication (Page 92))
- SNMP
- Time-of-day synchronization via NTP

## Restrictions for communication with the S7-1500R/H redundant system

- Open User Communication:
  - no configured connections
  - No support for Secure Open User Communication
  - Email: The S7-1500R/H CPUs support only the versions < V5.0 of the "TMAIL\_C" instruction. Versions from V5.0 are not supported.
  - No support of connection descriptions according to "TCON\_Param"
- no OPC UA
- no S7 communication as client
- no web server
- PG communication: It is not possible to access two CPUs online at the same time. You can either access the primary CPU or the backup CPU.
- The CPUs of the S7-1500R/H do not support centrally plugged communication modules.

## 14.1 System IP addresses

### The system IP address of the S7-1500R/H redundant system

In addition to the device IP addresses of the CPUs, the S7-1500R/H redundant system supports system IP addresses:

- System IP address for the PROFINET interfaces X1 of the two CPUs (system IP-address X1)
- System IP address for the PROFINET interfaces X2 of the two CPUs (system IP-address X2)

You use the system IP addresses for communication with other devices (for example, HMI devices, CPUs, PCs). The devices always communicate via the system IP address with the primary CPU of the redundant system. This ensures, for example, that the communication partner can communicate with the new primary CPU (previously backup CPU) in the RUN-Solo system state after failure of the original primary CPU in redundant operation.

There is a virtual MAC address for each system IP address.

You enable the system IP addresses in STEP 7.

### Advantages of the system IP addresses compared to device IP addresses

- The communication partner communicates specifically with the primary CPU.
- Communication of the S7-1500R/H redundant system via a system IP address still also works in the event of the failure of the primary CPU.

### Applications

You use the system IP addresses for the following applications:

- HMI communication with the S7-1500R/H redundant system: You can use an HMI device to control or monitor the process on the redundant S7 1500R/H system.
- Open User Communication with the S7-1500R/H redundant system:
  - Another CPU or an application on a PC accesses data of the S7-1500R/H redundant system.
  - The S7-1500R/H redundant system accesses a different device.TCP, UDP and ISO-on-TCP-connections are possible.
- IP forwarding: If you use the system IP addresses as the gateway/default route for IP routes through the S7-1500R/H redundant system, IP packets are forwarded even if one CPU fails.

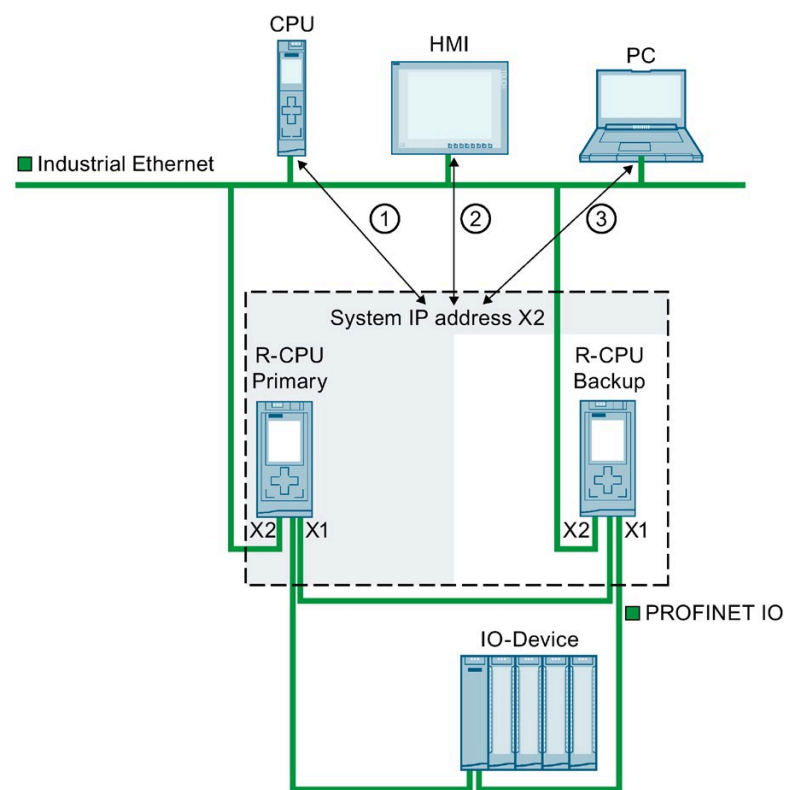
### Requirements

- The interface of the communication partner is connected to both CPUs, each via the same interface (e.g. X2).
- The system IP address for the interfaces of the S7-1500R/H system is enabled.

## Communication via the system IP address X2

If the CPUs of the S7-1500R/H redundant system have two PROFINET interfaces, preferably use the PROFINET interface X2 for communication with other devices.

The following figure shows a configuration in which the communication partners are connected via the respective PROFINET interfaces X2 with the CPUs of the redundant system S7-1500R/H.



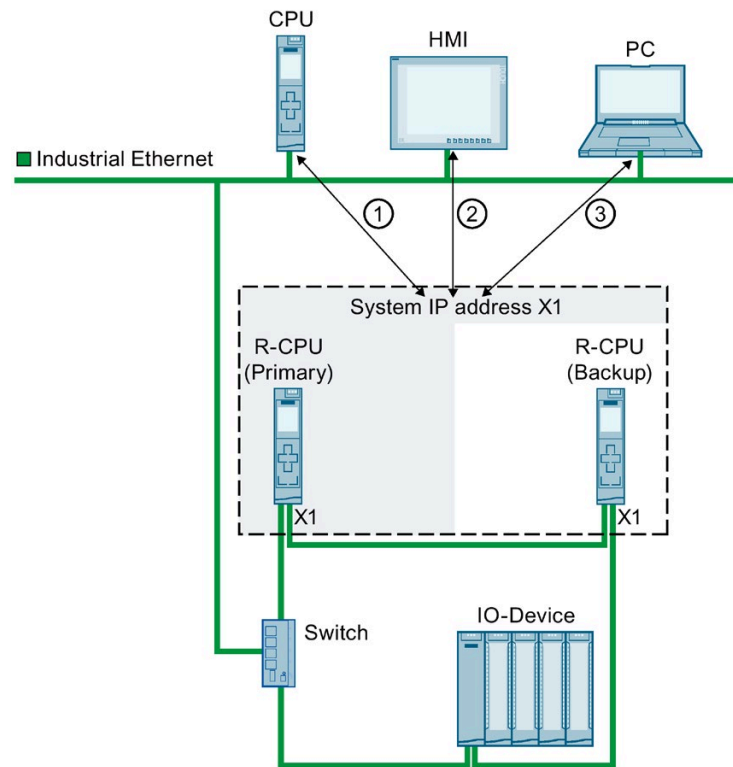
- ① Open User Communication between a different CPU and the S7-1500R/H redundant system
- ② HMI communication with the S7-1500R/H redundant system
- ③ Open User Communication between the S7-1500R/H redundant system and a PC

Figure 14-1 Example: Communication of the S7-1515R redundant system via the system IP address X2

### Communication via the system IP address X1

The following diagram shows a configuration where the communication partners are connected with a switch to the PROFINET ring of the S7-1500R/H redundant system. The PROFINET ring connects the communication partners with the respective PROFINET interfaces X1 of the two CPUs.

As the CPU 1513R only has one PROFINET interface, connection via the PROFINET ring is the only possibility of communicating via the system IP address X1.

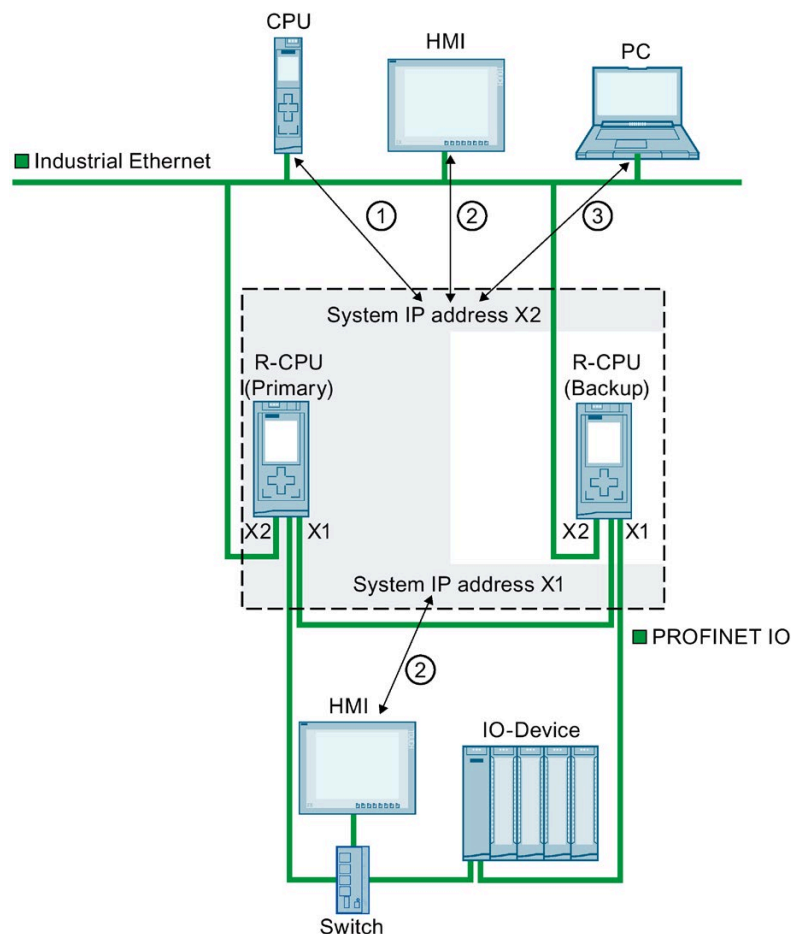


- ① Open User Communication between the S7-1500R/H redundant system and a different CPU
- ② HMI communication with the S7-1500R/H redundant system
- ③ Open User Communication between the S7-1500R/H redundant system and a PC

Figure 14-2 Example: Communication of the S7-1513R redundant system via the system IP address X1

### Communication via the system IP addresses X1 and X2

If the CPUs of the redundant system S7-1500R/H have two PROFINET interfaces (X1 and X2), you can use the a system IP address for each PROFINET interface. PROFINET devices which are connected to the interfaces X1 of the CPUs communicate via the system IP address X1. PROFINET devices which are connected to the interfaces X2 of the CPUs communicate via the system IP address X2.



- ① Open User Communication between the S7-1500R/H redundant system and a different CPU.
- ② HMI communication with the S7-1500R/H redundant system
- ③ Open User Communication between the S7-1500R/H redundant system and a PC

Figure 14-3 Example: Communication of the S7-1515R redundant system via the system IP addresses X1 and X2

### IP forwarding via the system IP address

If you use the system IP addresses as the gateway/default route for IP routes through the S7-1500R/H redundant system, IP packets are forwarded even if one CPU fails.

In the following figure, the PC is connected to the two X2 interfaces of the S7-1500R CPUs. Enter the system IP address X2 as gateway in the PC for the route to the HMI device. The HMI device is connected to the PROFINET ring of the redundant system S7-1500 via a switch. The system IP address X1 is configured as router in the HMI device.

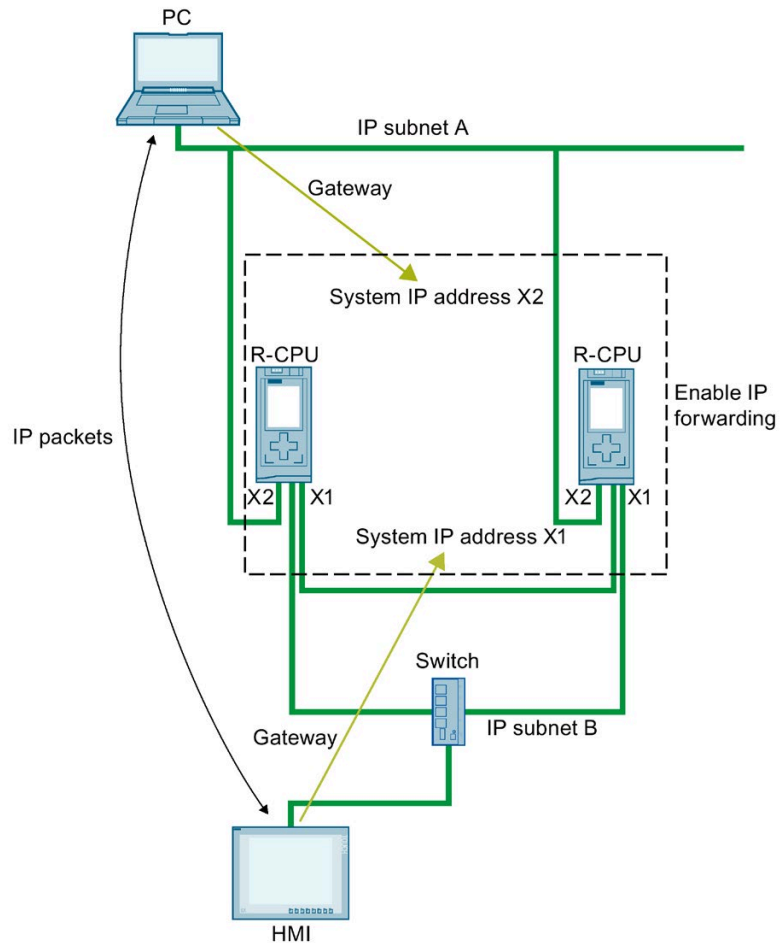


Figure 14-4 Example: IP forwarding via the system IP address



## Enable system IP addresses

Requirements:

- STEP 7 V15.1 or higher
- redundant system S7-1500R/H with two CPUs, e.g. two CPUs 1513R-1PN

If the CPUs of the S7-1500R/H redundant system have two PROFINET interfaces (X1 and X2), then you can use a system IP address for both PROFINET interfaces. The following section describes how to enable the system IP address for the interface X1.

Proceed as follows to enable the system IP address for your S7-1500R/H redundant system:

1. In the network view of STEP 7, select the interface X1 of one of the two CPUs.
2. In the Inspector window go to "Properties" > "General" > "Ethernet addresses" in the area "System IP address for switched communication".
3. Select the check box "Enable the system IP address for switched communication".

STEP 7 automatically creates a system IP address.

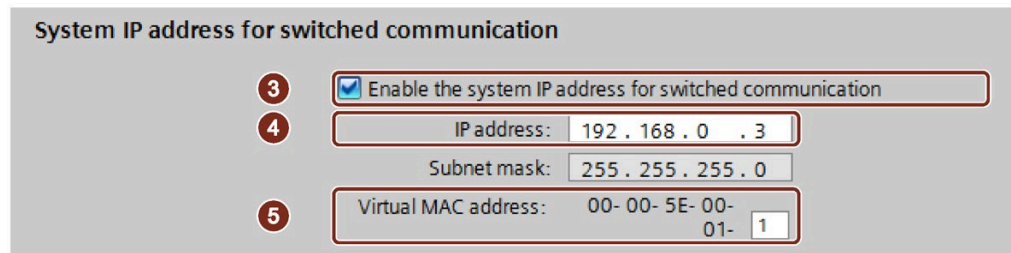


Figure 14-5 Configure IP address

4. Change the system IP address if necessary.
5. If required, change the virtual MAC address. To do this, in "Virtual MAC address", assign a project-wide unique value (value range 01<sub>H</sub> to FF<sub>H</sub>) for the last byte.

---

### Note

#### Uniqueness of the virtual MAC address

The redundant system S7-1500R/H uses a MAC address from the address range 00-00-5E-00-01-00 to 00-00-5E-00-01-00 for each system IP address. This address range is also used for VRRP (Virtual Redundancy Protocol).

If you use devices with VRRP, e.g. switches, ensure the uniqueness of the MAC addresses within an Ethernet broadcast domain.

---

Result: The system IP address X1 for the PROFINET interface X1 of the two CPUs is enabled.

## 14.2 Response to Ssyncup

### Response of communication connections via the system IP address in the system state SYNCUP

- HMI, PG- and S7-connections are temporarily closed. For a short time during the SYNCUP it is not possible to establish connections to the S7-1500R/H redundant system.
- All existing connections of Open User Communication are interrupted:
  - Connections set up by the CPUs of the redundant system as an active connection partner are set up again after the SYNCUP.
  - The S7-1500R/H redundant system sets up connection endpoints again for the passive connection establishment after the SYNCUP.
- The processing of running instances of the instructions TSEND and TRCV is stopped. The block parameter STATUS returns 80C4<sub>H</sub> (temporary communication error).

## 14.3 Response to primary-backup switchover

### Response of communication connections via the system IP address during a primary-backup switchover

- Running instances of the instructions TSEND and TRCV are stopped and return the status 80C4<sub>H</sub> (temporary communication error).
- Connections successfully established by the S7-1500R/H redundant system are established again by the new primary CPU.
- The new primary CPU sets up connection endpoints again for the passive connection establishment.

---

#### Note

##### Increased duration of connection interruption

If the remote system does not transmit actively after the primary-backup switchover, the connection monitoring (e.g. TCP-Keep-Alive or application) may have to be performed by the remote system until the connection can be re-established.

---

## 14.4 Connection resources of the redundant system S7-1500R/H

### Maximum number of connection resources of the S7-1500R/H redundant system

The S7-1500R/H redundant system supports a maximum number of connection resources.

The CPU used determines the maximum number of resources for the redundant system:

- CPU 1513R: max. 88 connection resources
- CPU 1515R: max. 108 connection resources
- CPU 1517H: max. 288 connection resources

### Allocation of connection resources

Communication connections occupy communication resources in the S7-1500R/H redundant system.

Each communication connection to the redundant system S7 1500R/H occupies connection resources in the S7 1500R/H station. The S7-1500R/H station comprises the hardware setup of both CPUs of the redundant S7-1500R/H system.

Depending on the IP address used, a communication connection also uses connection resources in one or both CPUs of the redundant S7-1500R/H system. The S7-1500R/H station can also be used to establish a communication connection.

The following table shows in which CPU a communication connection occupies connection resources depending on the IP address used.

| Connect via...                                      | Connection resources of the station | Connection resources CPU with redundancy ID 1 | Connection resources CPU with redundancy ID 2 |
|-----------------------------------------------------|-------------------------------------|-----------------------------------------------|-----------------------------------------------|
| a system IP address                                 | X                                   | X                                             | X                                             |
| a device IP address of the CPU with redundancy ID 1 | X                                   | X                                             | -                                             |
| a device IP address of the CPU with redundancy ID 2 | X                                   | -                                             | X                                             |

**Display of the occupied connection resources in STEP 7**

Requirements: Online connection to the redundant system S7-1500R/H

You will find the online display of the connection resources in the inspector window under "Diagnostics" > "Connection information". STEP 7 always displays the connection resources of the selected CPU and the S7-1500R/H-station.

| Connection resources         |   |                   |            |         |            |                        |            |      |
|------------------------------|---|-------------------|------------|---------|------------|------------------------|------------|------|
|                              |   | Station resources |            |         |            | Module resources       |            |      |
|                              |   | Reserved          |            | Dynamic |            | CPU 1517H-3 PN (R0/S1) |            |      |
| Maximum number of resources: |   | 10                | 10         | 150     | 150        | 160                    | 160        |      |
|                              |   | Maximum           | Configured | Used    | Configured | Used                   | Configured | Used |
| PG communication:            | 4 | -                 | 2          | -       | 0          | -                      | 2          |      |
| HMI communication:           | 4 | 0                 | 0          | 0       | 0          | 0                      | 0          |      |
| S7 communication:            | 0 | -                 | 0          | 0       | 0          | 0                      | 0          |      |
| Open user communication:     | 0 | -                 | 0          | 0       | 0          | 0                      | 0          |      |
| Web communication:           | 2 | -                 | 0          | -       | 0          | -                      | 0          |      |
| Other communication:         | - | -                 | 0          | 0       | 0          | 0                      | 0          |      |
| Total resources used:        |   | 0                 | 2          | 0       | 0          | 0                      | 2          |      |
| Available resources:         |   | 10                | 8          | 150     | 150        | 160                    | 158        |      |

Figure 14-6 Display of the connection resources of the S7-1500R/H redundant system in STEP 7

## 14.5 HMI communication with the redundant system S7-1500R/H

### 14.5.1 HMI connection via the system IP address

#### Requirements

- A redundant S7-1500R/H system, e.g. CPU 1513R-1PN
- System IP address is enabled
- HMI device with PROFINETI interface

## Procedure

To set up a HMI connection to an S7-1500R/H redundant system, follow these steps:

1. In the network view of STEP 7, select a PROFINET interface of the HMI device.
2. Using a drag&drop operation, draw a line between the PROFINET interface of the HMI device and a PROFINET interface of the S7-1500R/H redundant system.  
The HMI device and the S7-1500R/H redundant system are networked together.

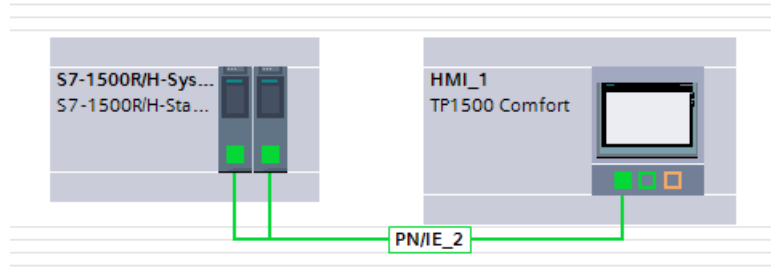


Figure 14-7 Networking an HMI device with the S7-1500R/H redundant system

3. In the list of functions, click the "Connections" icon. This activates connection mode.
4. Using a drag-and-drop operation, draw a line between the HMI device and a CPU of the S7-1500R/H redundant system.  
The list "Connection partners" opens.

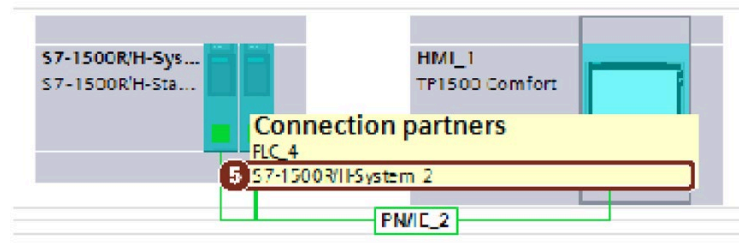


Figure 14-8 Setting up an HMI connection to the S7-1500R/H redundant system

5. Select the S7-1500R/H redundant system in the list "Connection partners".

Result: You have set up a HMI connection between the HMI device and the S7-1500R/H redundant system. The HMI connection uses the system IP address. The HMI device always connects to the primary CPU.

## Changing the HMI connection over to the device IP address

To permanently change the HMI connection over to the selected CPU, clear the check box "Use the system IP address for switched communication" in the properties of the HMI connection. The HMI connection then uses the device IP address of the PROFINET interface. In the event of the failure of this CPU, then the HMI connection to this CPU permanently fails.

**Connection**

Name:

**Connection path**

Local:  Partner: 

End point:

Interface:

Interface type:

Subnet:

Address:

☒ Use the system IP address for switched communication

Figure 14-9 Properties of the HMI connection

### Note

#### Automatic setup of HMI connection

When you drag-and-drop a tag from the S7-1500R/H redundant system into an HMI screen or into the HMI tag table, STEP 7 automatically sets up an HMI connection. This HMI connection exists by default between the PROFINET interface of the HMI device and the PROFINET interface X1 of the CPU with redundancy ID 1. The connection uses the device IP address of the PROFINET interface X1.

You can change the HMI connection to a system IP address in the properties of the HMI connection.

## 14.6 Open User Communication with the redundant system S7-1500R/H

The following table shows which protocols of the Open User Communication you can use for the S7-1500R/H redundant system and the matching system data types and instructions.

Table 14- 1 Protocols, system data types and usable instructions for Open User Communication with the redundant system S7-1500R/H

| Protocol   | System data type                                                                                                                | Instructions                                                                                                                                                                           |
|------------|---------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| TCP        | <ul style="list-style-type: none"> <li>TCON_QDN</li> <li>TCON_IP_v4</li> </ul>                                                  | Establish connection and send/receive data via:                                                                                                                                        |
| ISO-on-TCP | <ul style="list-style-type: none"> <li>TCON_IP_RFC</li> </ul>                                                                   | <ul style="list-style-type: none"> <li>TSEND_C/TRCV_C or</li> <li>TCON, TSEND/TRCV or</li> <li>TCON, TUSEND/TURCV (connection can be terminated via TDISCON)</li> </ul>                |
| UDP        | <ul style="list-style-type: none"> <li>TCON_IP_v4</li> <li>TADDR_Param</li> <li>TADDR_SEND_QDN</li> <li>TADDR_RCV_IP</li> </ul> | Establish connection and send/receive data via: <ul style="list-style-type: none"> <li>TSEND_C/TRCV_C</li> <li>TUSEND/TURCV/TRCV (connection can be terminated via TDISCON)</li> </ul> |
| Modbus TCP | <ul style="list-style-type: none"> <li>TCON_IP_v4</li> <li>TCON_QDN</li> </ul>                                                  | <ul style="list-style-type: none"> <li>MB_CLIENT</li> <li>MB_RED_CLIENT</li> <li>MB_SERVER</li> <li>MB_RED_SERVER</li> </ul>                                                           |

### 14.6.1 Setting up the connection of the Open User Communication with the redundant S7-1500R/H system

#### Introduction

The S7-1500R/H redundant system can communicate with other devices via Open User Communication.

You set up the connections in the user program, e.g. via the "TSEND\_C" instruction. The S7-1500R/H redundant system does not support configured connections.

You can either set up the connections either via the device IP addresses or via the system IP addresses of the PROFINET interfaces.

### Open User Communication via a system IP address of the redundant system S7 1500R/H

If you set up the connection via a system IP address, then communication always takes place via the primary CPU.

Recommendation: Always use a system IP address for Open User Communication.

### Open User Communication via a device IP address of the redundant system S7 1500R/H

In redundant mode, the redundant system can establish or terminate connections and send or receive data via every device IP address.

If you set up the connection via a device IP address, then communication takes place via the associated CPU. In the event of the failure of the CPU, then the entire communication via the device IP addresses of this CPU fails.

### Setting up a connection via a system IP address

The following describes how to establish a connection to another CPU via a system IP address of a PROFINET interface of the redundant S7 1500R/H system.

You set up the connection in the user program of the redundant system S7-1500R/H with a TSEND\_C instruction. You create a corresponding TRCV\_C instruction in the user program of the other CPU.

The procedure is described using the example of a TCP connection between the S7-1500R/H redundant system and a CPU 1516-3PN/DP.

### Requirements

- A redundant system S7 1500R/H, e.g. 2 CPUs 1513 1PN
- System IP address of the PROFINET interface X1 is enabled.
- CPU 1516-3PN/DP
- The PROFINET interfaces X1 of the CPUs 1513R and the PROFINET interface X2 of the CPU 1516-3PN/DP are located in the same subnet.

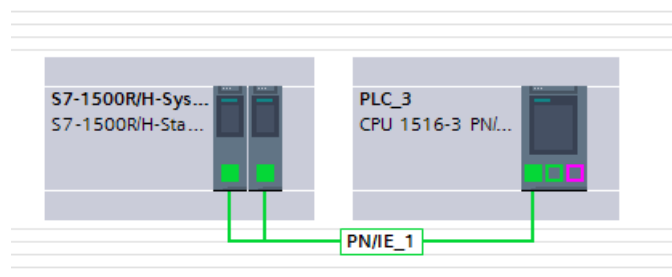


Figure 14-10 Example configuration for TCP-connection



## TSEND\_C instruction in the user program of the S7-1500R/H redundant system

To set up a TCP-connection to a different CPU, follow these steps:

1. Create a "TSEND\_C" instruction in the user program.

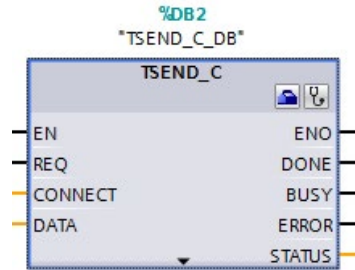


Figure 14-11 S7-1500R/H: "TSEND\_C" instruction

2. Select the "TSEND\_C" instruction.

3. In the Inspector window, go to "Properties" > "Configuration" > "Connection parameters". On the left-hand side you can see the S7-1500R/H redundant system as a local end point of the connection:
  - "Interface:": X1 is the preset interface.
  - "Subnet:": If the interface X1 is assigned to an S7-subnet, then STEP 7 displays the name of the S7-subnet.
  - The check box "Use address of the H-system" is selected. The system IP address of the S7-1500R/H redundant system is in "Address".

**General**

Local

End point: S7-1500R/H-System\_1

Interface: PLC\_1, PROFINET-Schnittstelle\_1[X1]

Subnet: PN/IE\_1

Address: 192.168.0.3

☒ Use system IP address

Connection type: TCP

Configuration mode: Use program blocks

Connection ID (dec): 1

Connection data: PLC\_1\_Send\_DB

☒ Active connection establishment

Partner

End point: PLC\_3 [CPU 1516-3 PN/DP]

Interface: PLC\_3, PROFINET-Schnittstelle\_2[X2]

Subnet: PN/IE\_1

Address: 192.168.0.10

Connection ID (dec): 1

Connection data: PLC\_3\_Receive\_DB

☐ Active connection establishment

**Address details**

Local Port

Port (decimal):

Partner Port

2000

Figure 14-12 S7-1500R/H: Assigning parameters to the TSEND\_C instruction in STEP 7

4. In "Partners" under "End point:" select the CPU 1516-3PN/DP as the communication partner.
5. In "Partners" under "Interface:" select the PROFINET interface X2 of the CPU 1516-3PN/DP.
6. In "Local" under "Connection data" select the setting "<new>".  
STEP 7 creates a data block for the connection data in the user program of the S7-1500R/H redundant system, for example "PLC\_1\_Send\_DB".  
"TCP" is set by default as the connection type.
7. In "Partners" under "Connection type" select the setting "NEW".  
STEP 7 creates a data block for the connection data in the user program of the other CPU, for example "PLC\_3\_Receive\_DB".

## TRCV\_C instruction in the user program of the CPU 1516 3PN/DP

Create a TRCV\_C instruction in the user program of the CPU 1516-3PN/DP and assign parameters as below:

| General                                               |                                                                  |
|-------------------------------------------------------|------------------------------------------------------------------|
| Local                                                 | Partner                                                          |
| End point: PLC_3 [CPU 1516-3 PN/DP]                   | S7-1500R/H-System_1 [S7-1500R/H-Station]                         |
| Interface: PLC_3, PROFINET-Schnittstelle_2[X2]        | PLC_1, PROFINET-Schnittstelle_1[X1]                              |
| Subnet: PN/IE_1                                       | PN/IE_1                                                          |
| Address: 192.168.0.10                                 | 192.168.0.3                                                      |
|                                                       | <input checked="" type="checkbox"/> Use system IP address        |
| Connection type: TCP                                  |                                                                  |
| Configuration mode: Use program blocks                |                                                                  |
| Connection ID (dec): 1                                | 1                                                                |
| Connection data: PLC_3_Receive_DB                     | PLC_1_Send_DB                                                    |
| <input type="radio"/> Active connection establishment | <input checked="" type="radio"/> Active connection establishment |
| Address details                                       |                                                                  |
| Local Port                                            | Partner Port                                                     |
| Port (decimal): 2000                                  |                                                                  |

Figure 14-13 S7-1500-3PN/DP: Assigning parameters to the TRCV\_C instruction in STEP 7

### Setting up a connection via a device IP address

To set up an OUC-connection via a device IP address of one of the two CPUs:

- Select a suitable PROFINET interface of the S7-1500R/H redundant system.
- Deselect the "Use address of H-system" check box.

**General**

**Local**

End point: S7-1500R/H-System\_1 [S7-1500R/H-Station]

Interface: PLC\_1, PROFINET-Schnittstelle\_1[X1]

Subnet: PN/IE\_1

Address: 192.168.0.1

☐ Use system IP address

**Partner**

End point: PLC\_3 [CPU 1516-3 PN/DP]

Interface: PLC\_3, PROFINET-Schnittstelle\_2[X2]

Subnet: PN/IE\_1

Address: 192.168.0.10

Figure 14-14 OUC-connection via a device IP address

### Reference

You can find additional information on system states in the S7-1500R/H (<https://support.industry.siemens.com/cs/ww/en/view/109754833>) system manual.

### See also

PROFINET FUNCTION MANUAL  
(<https://support.industry.siemens.com/cs/ww/en/view/49948856>)

# Industrial Ethernet Security with CP 1543-1

## All-round protection - the task of Industrial Ethernet Security

With Industrial Ethernet Security, individual devices, automation cells or network segments of an Ethernet network can be protected. Data transfer can also be protected by a combination of different security measures:

- Data espionage
- Data manipulation
- Unauthorized access

## Security measures

- Firewall
  - IP firewall with stateful packet inspection (layer 3 and 4)
  - Firewall also for Ethernet "non-IP" frames according to IEEE 802.3 (layer 2)
  - Bandwidth limitation
  - Global firewall rules

All network nodes located in the internal network segment of a CP 1543-1 are protected by its firewall. Exception: If you access the CPU via the interface of the CP with the "Access to PLC via communication module" function, the firewall does not protect this connection.

- Logging

To allow monitoring, events can be stored in log files that can be read out using the configuration tool or can be sent automatically to a Syslog server.
- HTTPS

For encrypted transfer of websites, for example during process control.
- FTPS (explicit mode)

For encrypted transfer of files.
- Secure NTP

For secure time-of-day synchronization and transmission.
- SNMPv3

For secure transmission of network analysis information safe from eavesdropping.

## 15.1 Firewall

- **VPN groups**  
You can combine the CP 1543-1 with other security modules into VPN groups through configuration. IPsec tunnels are established between all the security modules of a VPN group (VPN). All internal nodes of these security modules can communicate securely with each other through this tunnel.
- **Protection for devices and network segments**  
The firewall and VPN groups protective functions can be applied to the operation of single devices, multiple devices, or entire network segments.

### Additional information

An overview with links to the most important contributions on Industrial Security is available in this FAQ (<https://support.industry.siemens.com/cs/ww/en/view/92651441>).

## 15.1 Firewall

### Tasks of the firewall

The purpose of the firewall functionality is to protect networks and stations from outside influences and disturbances. This means that only certain previously specified communications relations are permitted.

To filter the data traffic, IPv4 addresses, IPv4 subnets, port numbers or MAC addresses among other things can be used.

The firewall functionality can be configured for the following protocol levels:

- IP firewall with stateful packet inspection (layer 3 and 4)
- Firewall also for Ethernet "non-IP" frames according to IEEE 802.3 (layer 2)

### Firewall rules

Firewall rules describe which packets are permitted or forbidden in which direction.

## 15.2 Logging

### Functionality

For test and monitoring purposes, the security module has diagnostics and logging functions.

- Diagnostics functions

These include various system and status functions that you can use in online mode.

- Logging functions

This involves the recording of system and security events. Depending on the event type, the recording is made in volatile or non-volatile local buffer areas of the CP 1543-1. As an alternative, it is also possible to record on a network server.

The parameter assignment and evaluation of these functions is only possible with a network connection.

### Recording events with logging functions

You specify which events should be recorded with the log settings. Here you can configure the following recording variants:

- Local logging

With this variant, you record the events in local buffers of the CP 1543-1. In the online dialog of the Security Configuration Tool, you can then access these recordings, visualize them and archive them on the service station.

- Network Syslog

With the network Syslog, you use a Syslog server in the network. This records the events according to the configuration in the log settings.

## 15.3 NTP client

### Functionality

To check the time validity of a certificate and the time stamp of log entries, the date and time are maintained on the CP 1543-1 as on the CPU. This time can be synchronized with NTP. The CP 1543-1 forwards the synchronized time to the CPU via the backplane bus of the automation system. This way the CPU also receives a synchronized time for the time events in program execution.

The automatic setting and periodic synchronization of the time takes place either via a secure or non-secure NTP server. You can assign a maximum of 4 NTP servers to the CP 1543-1. A mixed configuration of non-secure and secure NTP servers is not possible.

## 15.4 SNMP

### Functionality

Like the CPU, the CP 1543-1 supports the transfer of management information using the Simple Network Management Protocol (SNMP). To achieve this, an "SNMP agent" is installed on the CP/CPU that receives and responds to the SNMP queries. Information about the properties of devices capable of SNMP is contained in so-called MIB files (Management Information Base) for which the user needs to have the appropriate rights.

With SNMPv1, the "community string" is also sent. The "community string" is like a password that is sent along with the SNMP query. The requested information is sent when the "community string" is correct. The request is discarded when the string is incorrect.

With SNMPv3, data can be transferred encrypted. To do this, select either an authentication method or an authentication and encryption method.

Possible selection:

- Authentication algorithm: none, MD5, SHA-1
- Encryption algorithm: none, AES-128, DES

You can deactivate the use of SNMP for the CP/CPU. Deactivate SNMP if the security guidelines in your network do not permit SNMP or if you use your own SNMP solution.

To find out how to deactivate SNMP for the CPU, refer to section Disabling SNMP (Page 104).

## 15.5 VPN

### Functionality

For security modules that protect the internal network, VPN (Virtual Private Network) tunnels provide a secure data connection through the non-secure external network.

The module uses the IPsec protocol (tunnel mode of IPsec) for tunneling.

In STEP 7 you can assign VPN groups to security modules. VPN tunnels are automatically established between all modules of a VPN group. A module in one project can belong to several different VPN groups at the same time in the process.



# Glossary

## Automation system

Programmable logic controller for the open-loop and closed-loop control of process chains of the process engineering industry and manufacturing technology. The automation system consists of different components and integrated system functions according to the automation task.

## Backup CPU

If the R/H system is in RUN-Redundant system state, the primary CPU controls the process. The backup CPU processes the user program synchronously and can take over process control if the primary CPU fails.

## Bus

Transmission medium that connects several devices together. Data transmission can be performed electrically or via optical fibers, either in series or in parallel.

## Client

Device in a network that requests a service from another device in the network (server).

## CM

→ *Communications module*

## Communications module

Module for communications tasks used in an automation system as an interface expansion of the CPU (for example PROFIBUS) and providing additional communications options (PtP).

## Communications processor

Module for expanded communications tasks covering special applications, for example in the area of security.

## Consistent data

Data that belongs together in terms of content and must not be separated when transferred.

## CP

→ *Communications processor*

## CPU

**Central Processing Unit** - Central module of the S7 automation system with a control and arithmetic unit, memory, operating system and interface for programming device.

## Device

Generic term for:

- Automation systems (PLC, PC, for example)
- Distributed I/O systems
- Field devices (for example, PLC, PC, hydraulic devices, pneumatic devices) and
- Active network components (for example, switches, routers)
- Gateways to PROFIBUS, AS interface or other fieldbus systems

## Device certificates

Such certificates are signed by a certificate authority (CA).

The signature of an end-entity certificate is checked with the public key of the certificate authority certificate.

The "Subject" attribute must not be identical to the "Issuer" attribute.

The "Subject", for example, contains the name of a program as with the OPC UA application certificate.

"Issuer" is the certificate authority that signed the certificate.

The "CA" field must be set to "False".

## DP master

Within PROFIBUS DP, a master in the distributed I/O that behaves according to the EN 50170 standard, Part 3.

→ *See also DP slave*

## DP slave

Slave in the distributed I/O that is operated on PROFIBUS with the PROFIBUS DP protocol and behaves according to the EN 50170 standard, Part 3.

→ *See also DP master*

**Duplex**

Data transmission system; a distinction is made between full and half duplex.

Half duplex: One channel is available for alternate data exchange (sending or receiving alternately but not at the same time).

Full duplex: Two channels are available for simultaneous data exchange in both directions (simultaneous sending and receiving in both directions).

**End-entity certificate**

→ *See also device certificate*

**Ethernet**

International standard technology for local area networks (LAN) based on frames. It defines types of cables and signaling for the physical layer and packet formats and protocols for media access control.

**Ethernet network adapter**

Electronic circuitry for connecting a computer to an Ethernet network. It allows the exchange of data / communication within the network.

**FETCH/WRITE**

Server services using TCP/IP, ISO-on-TCP and ISO for access to system memory areas of S7 CPUs. Access (client function) is possible from a SIMATIC S5 or a third-party device/PC. FETCH: Read data directly; WRITE: Write data directly.

**Field device**

→ *Device*

**Freeport**

Freely programmable ASCII protocol; here for data transfer via a point-to-point connection.

**FTP**

**F**ile **T**ransfer **P**rotocol; a network protocol for transferring files via IP networks. FTP is used to download files from the server to the client or to upload files from the client to the server. FTP directories can also be created and read out and directories and files can be renamed or deleted.

**HMI**

**H**uman **M**achine **I**nterface, device for visualization and control of automation processes.

## IE

→ *Industrial Ethernet*

## IM

→ *Interface module*

## Industrial Ethernet

Guideline for setting up an Ethernet network in an industrial environment. The essential difference compared with standard Ethernet is the mechanical ruggedness and immunity to noise of the individual components.

## Instruction

The smallest self-contained unit of a user program characterized by its structure, function or purpose as a separate part of the user program. An instruction represents an operation procedure for the processor.

## Interface module

Module in the distributed I/O system. The interface module connects the distributed I/O system via a fieldbus to the CPU (IO controller/DP master) and prepares the data for the I/O modules.

## Intermediate CA certificate

This is a certificate authority certificate that is signed with the private key of a root certificate authority.

An intermediate certificate authority signs end-entity certificates with its private key.

The signature of these end-entity certificates is verified with the public key of the intermediate certificate authority.

The "Subject" and "Issuer" attributes of the intermediate CA certificate must not be identical. This certificate authority has after all not signed its certificate itself.

The "CA" field must be set to "True".

## IO controller, PROFINET IO controller

Central device in a PROFINET system, usually a classic programmable logic controller or PC. The IO controller sets up connections to the IO devices, exchanges data with them, thus controls and monitors the system.

**IO device, PROFINET IO device**

Device in the distributed I/O of a PROFINET system that is monitored and controlled by an IO controller (for example distributed inputs/outputs, valve islands, frequency converters, switches).

**IP address**

Binary number that is used as a unique address in computer networks in conjunction with the Internet Protocol (IP). It makes these devices uniquely addressable and individually accessible. An IPv4 address can be evaluated using a binary subnet mask that results in a network part or a host part as a structure. The textual representation of an IPv4 address consists, for example, of 4 decimal numbers with the value range 0 to 255. The decimal numbers are separated by periods.

**IPv4 subnet mask**

Binary mask, with which an IPv4 address (as a binary number) is divided into a "network part" and a "host part".

**ISO protocol**

Communications protocol for message or packet-oriented transfer of data in an Ethernet network. This protocol is hardware-oriented, very fast and allows dynamic data lengths. The ISO protocol is suitable for medium to large volumes of data.

**ISO-on-TCP protocol**

Communications protocol capable of S7 routing for packet-oriented transfer of data in an Ethernet network; provides network addressing. The ISO-on-TCP protocol is suitable for medium and large volumes of data and allows dynamic data lengths.

**Linear bus topology**

Network topology characterized by the arrangement of the devices in a line (bus).

**MAC address**

Worldwide unique device identification for all Ethernet devices. The MAC address is assigned by the manufacturer and has a 3-byte vendor ID and 3-byte device ID as a consecutive number.

**Master**

Higher-level, active participant in the communication on a PROFIBUS subnet. The master has rights to access the bus (token) and can request and send data.

→ See also *DP master*

## Modbus RTU

**Remote Terminal Unit**; Open communications protocol for serial interfaces based on a master/slave architecture.

## Modbus TCP

**Transmission Control Protocol**; Open communications protocol for Ethernet based on a master/slave architecture. The data are transmitted as TCP/IP packets.

## Network

A network consists of one or more interconnected subnets with any number of devices. Several networks can exist alongside each other.

## NTP

The **Network Time Protocol** (NTP) is a standard for synchronizing clocks in automation systems via Industrial Ethernet. NTP uses the connectionless UDP transport protocol for the Internet.

## OPC UA

**OPC Unified Automation** is a protocol for communication between machines, developed by the OPC Foundation.

## Operating states

Operating states describe the behavior of a single CPU at a specific time.

The CPUs of the SIMATIC standard systems have the STOP, STARTUP and RUN operating states.

The primary CPU of the redundant system S7-1500R/H has the operating states STOP, STARTUP, RUN, RUN-Syncup and RUN-Redundant. The backup CPU has the operating states STOP, SYNCUP and RUN-Redundant.

## Operating system

Software that allows the use and operation of a computer. The operating system manages resources such as memory, input and output devices and controls the execution of programs.

## PG

→ *Programming device*

## PNO

→ *PROFIBUS user organization*

**Point-to-point connection**

Bidirectional data exchange via communications modules with a serial interface between two communications partners (and two only).

**Port**

Physical connector to connect devices to PROFINET. PROFINET interfaces have one or more ports.

**Primary CPU**

If the R/H system is in RUN-Redundant system state, the primary CPU controls the process. The backup CPU processes the user program synchronously and can take over process control if the primary CPU fails.

**Process image (I/O)**

The CPU transfers the values from the input and output modules to this memory area. At the start of the cyclic program, the CPU transfers the process image output as a signal state to the output modules. The CPU then reads the signal states of the input modules into the process image input. The CPU then executes the user program.

**PROFIBUS**

**Process Field Bus** - European Fieldbus standard.

**PROFIBUS address**

Unique identifier of a device connected to PROFIBUS. The PROFIBUS address is sent in the frame to address a device.

**PROFIBUS device**

Device with at least one PROFIBUS interface either electrical (for example RS-485) or optical (for example Polymer Optical Fiber).

**PROFIBUS user organization**

Technical committee dedicated to the definition and development of the PROFIBUS and PROFINET standard.

**PROFIBUS DP**

A PROFIBUS with DP protocol that complies with EN 50170. DP stands for distributed I/O = fast, real-time capable, cyclic data exchange. From the perspective of the user program, the distributed I/O is addressed in exactly the same way as the centralized IO.

## **PROFINET**

Open component-based industrial communications system based on Ethernet for distributed automation systems. Communications technology promoted by the PROFIBUS user organization.

### **PROFINET device**

Device that always has a PROFINET interface (electrical, optical, wireless).

### **PROFINET interface**

Interface of a module capable of communication (for example CPU, CP) with one or more ports. A MAC address is assigned to the interface in the factory. Along with the IP address and the device name (from the individual configuration), this interface address ensures that the PROFINET device is identified uniquely in the network. The interface can be electrical, optical or wireless.

## **PROFINET IO**

IO stands for input/output; distributed I/O (fast, cyclic data exchange with real-time capability). From the perspective of the user program, the distributed I/O is addressed in exactly the same way as the centralized IO.

PROFINET IO as the Ethernet-based automation standard of PROFIBUS & PROFINET International defines a cross-vendor communication, automation, and engineering model.

With PROFINET IO, a switching technology is used that allows all devices to access the network at any time. In this way, the network can be used much more efficiently through the simultaneous data transfer of several devices. Simultaneous sending and receiving is enabled via the full-duplex operation of Switched Ethernet.

PROFINET IO is based on switched Ethernet with full-duplex operation and a bandwidth of 100 Mbps.

## **Programming device**

Programming devices are essentially compact and portable PCs which are suitable for industrial applications. They are identified by a special hardware and software configuration for programmable logic controllers.

## **Protocol**

Agreement on the rules by which the communication between two or more communication partners transpires.

## **PtP**

**Point-to-Point**, interface and/or transmission protocol for bidirectional data exchange between two (and only two) communications partners.



**Redundant systems**

Redundant systems have multiple (redundant) instances of key automation components. Process control is maintained if a redundant component fails.

**Ring topology**

All devices of a network are connected together in a ring.

**Root CA certificates**

→ See also *root certificate*

**Root certificate**

This is the certificate of a certificate authority: It signs end-entity certificates and intermediate CA certificates with its private key.

The "Subject" attribute and the "Issuer" of this certificate must be identical. This certificate authority has signed its certificate itself.

The "CA" field must be set to "True".

TIA Portal V14 has such a root CA certificate:

If you configure the OPC UA server of an S7-1500 in the TIA Portal, the TIA Portal generates an end-entity certificate for the OPC UA server and signs that certificate with its own private key.

The signature of this end-entity certificate can be verified with the public key of the TIA Portal. This key can be found in the root CA certificate of the TIA Portal.

**Router**

Network node with a unique identifier (name and address) that connects subnets together and allows transportation of data to uniquely identified communications nodes in the network.

**RS232, RS422 and RS485**

Standard for serial interfaces.

**RTU**

Modbus RTU (RTU: **R**emote **T**erminal **U**nit, transfers the data in binary form; allows a good data throughput. The data must be converted to a readable format before it can be evaluated.

**S7 routing**

Communication between S7 automation systems, S7 applications or PC stations in different S7 subnets via one or more network nodes functioning as S7 routers.

## SDA service

Send Data with Acknowledge. SDA is an elementary service with which an initiator (for example DP master) can send a message to other devices and then receives acknowledgment of receipt immediately afterwards.

## SDN service

Send Data with No Acknowledge. This service is used primarily to send data to multiple stations and the service therefore remains unacknowledged. Suitable for synchronization tasks and status messages.

## Security

Generic term for all the measures taken to protect against

- Loss of confidentiality due to unauthorized access to data
- Loss of integrity due to manipulation of data
- Loss of availability due to the destruction of data

## Self-signed certificates

These are certificates that you sign with your private key and use as end-entity certificates.

The signature of these end-entity certificates is verified with your public key.

The "Subject" and "Issuer" attributes of self-signed certificates must be identical: You have signed your certificate yourself.

The "CA" field must be set to "False".

You can, for example, use self-signed certificates as application certificates for an OPC UA client.

The procedure required to generate a self-signed certificate with the certificate generator of the OPC Foundation is described here (Page ).

## Server

A device or more generally an object that can provide certain services; the service is performed at the request of a client.

## Slave

Distributed device in a fieldbus system that can only exchange data with a master after the master has requested this.

→ See also DP slave

## SNMP

**Simple Network Management Protocol**, uses the wireless UDP transport protocol. SNMP works in much the same way as the client/server model. The SNMP manager monitors the network nodes. The SNMP agents collect the various network-specific information in the individual network nodes and makes this information available in a structured form in the MIB (**Management Information Base**). This information allows a network management system to run detailed network diagnostics.

## Subnet

Part of a network whose parameters must be matched up on the devices (for example in PROFINET). A subnet includes the bus components and all connected stations. Subnets can be linked together, for example using gateways or routers to form one network.

## Switch

Network components used to connect several terminal devices or network segments in a local network (LAN).

## Switched communication

In addition to the device IP addresses of the CPUs, the redundant system S7-1500R/H supports system IP addresses:

- System IP address for the X1 PROFINET interfaces of the two CPUs (system IP address X1)
- System IP address for the X2 PROFINET interfaces of the two CPUs (system IP address X2)

You use the system IP addresses for communication with other devices (for example, HMI devices, CPUs, PG/PC). The devices always communicate over the system IP address with the primary CPU of the redundant system. This ensures that the communication partner can communicate with the new primary CPU (previously backup CPU) in the RUN-Solo system state after failure of the original primary CPU in redundant operation.

## System states

The system states of the redundant system S7-1500R/H result from the operating states of the primary and backup CPUs. The term system state is used as a simplified expression that refers to the operating states that occur simultaneously on both CPUs. The redundant system S7-1500R/H has the system states STOP, STARTUP, RUN-Solo, SYNCUP and RUN-Redundant.

## TCP/IP

**Transmission Control Protocol / Internet Protocol**, connection-oriented network protocol, generally recognized standard for data exchange in heterogeneous networks.

## Time-of-day synchronization

Capability of transferring a standard system time from a single source to all devices in the system so that their clocks can be set according to the standard time.

### **Tree topology**

Network topology characterized by a branched structure: Two or more bus nodes are connected to each bus node.

### **Twisted-pair**

Fast Ethernet via twisted-pair cables is based on the IEEE 802.3u standard (100 Base-TX). The transmission medium is a shielded 2x2 twisted-pair cable with an impedance of 100 Ohms (22 AWG). The transmission characteristics of this cable must meet the requirements of category 5.

The maximum length of the connection between the terminal and the network component must not exceed 100 m. The connectors are designed according to the 100Base-TX standard with the RJ-45 connector system.

### **UDP**

**User Datagram Protocol**; communications protocol for fast and uncomplicated data transfer, without acknowledgment. There are no error checking mechanisms as found in TCP/IP.

### **User program**

In SIMATIC, a distinction is made between the CPU operating system and user programs. The user program contains all instructions, declarations and data by which a system or process can be controlled. The user program is assigned to a programmable module (for example, CPU, FM) and can be structured in smaller units.

### **USS**

Universal Serial Interface protocol (**Universelles Serielles Schnittstellen-Protokoll**); defines an access method according to the master-slave principle for communication via a serial bus.

### **Web server**

Software/communications service for data exchange via the Internet. The web server transfers the documents using standardized transmission protocols (HTTP, HTTPS) to a Web browser. Documents can be static or put together dynamically from different sources by the web server on request from the Web browser.

# Index

## A

- Advanced Encryption Algorithm, 43
- AES, 43
- Applicant, 46
- Asymmetric encryption, 44

## B

- BRCV, 139
- BSEND, 139

## C

- Certificate authorities, 46
- Certificate subject, 46
- CM, 20
- Communication
  - Data record routing, 385
  - HMI communication, 110
  - Open communication, 112
  - Open User Communication, 112
  - PG communication, 107
  - Point-to-point connection, 147
  - S7 communication, 138
  - S7 routing, 373
- Communication options
  - Overview, 25
- Communication via PUT/GET instruction
  - Creating and configuring a connection, 140
- Communications
  - Communication protocols, 113
  - Establishment and termination, 137
- Communications module, 20
- Communications processor, 20
- Communications services
  - Connection resources, 32
- Connection
  - Diagnostics, 403
  - Instructions for Open User Communication, 115
- Connection diagnostics, 403
- Connection resources
  - Data record routing, 397
  - HMI communication, 396
  - Module-specific, 400
  - occupying, 398

- Overview, 32, 391
- S7 routing, 397
- Station specific, 399
- Consistency of data, 37
- CP, 20

## D

- Data consistency, 37
- Data record routing, 385
- Digital certificates, 46

## E

- E-mail, 25, 114, 133
- End-entity certificate, 49
- Establishment and termination of communications, 137
- Export file for OPC UA, 217

## F

- FDL, 114
- Fetch, 25
- Firewall, 426
- Freeport protocol, 147
- FTP, 25, 114, 133, 134

## G

- GDS, 185, 189
- GET, 139
- Global Discovery Server (GDS), 185, 189

## H

- Handshake Protocol, 45
- HMI communication, 25, 110

## I

- IM, 24
- Industrial Ethernet Security, 425
- Interface module, 24
- Interfaces for communication, 21

## Interfaces of communications modules

- Point-to-point connection, 23

## Interfaces of communications processors, 22

- IP address, emergency address (temporary), 406

- IP forwarding, 378

- ISO, 25, 113

- ISO-on-TCP, 113, 122

**L**

- Logging, 427

**M**

- Man-in-the-middle attack, 46

- Modbus protocol (RTU), 147

- Modbus TCP, 114

**N**

- NTP, 25, 427

**O**

- Occupation of connection resources, 398

## OPC UA

- Certificate generator, 178

- DB tags, 208

- End points, 203

- GDS, 185, 189

- Identifier, 162

- Introduction, 157

- Layer model, 183

- Namespace, 161

- NodeId, 161

- OpenSSL, 179

- PLC tags, 208

- Secure channel, 182

- Secure connection, 182

- Security mechanisms, 172

- Security settings, 203

- Signing and encryption, 174

- X.509 certificates, 177

## OPC UA client

- Authentication, 347

- Basics, 165

- Certificate, 344

## OPC UA server

- Address space, 163

- Addressing, 220

- Application name, 219

- Authentication, 237

- Basics, 201

- Commissioning, 218

- Customizing the server certificate, 233

- Generating a server certificate, 227

- Performance, 216

- Performance increase, 216

- Publishing interval, 225

- Runtime licenses, 241, 242

- Sampling interval, 226

- Security settings, 231

- Subscription, 223

- TCP port, 222, 224

- Write and read rights, 208

- XML export file, 217

## Open communication

- Connection configuration, 122

- Setting up e-mail, 133

- Setting up FTP, 134

- Setting up TCP, ISO-on-TCP, UDP, 122

## Open User Communication

- Features, 112

- Instructions, 115

- Protocols, 113

## OpenSSL, 179

**P**

- PCT, 386

- PG communication, 25, 107

- Point-to-point connection, 25, 147

- Private Key, 41

- Procedure 3964(R), 147

- Protocols for Open User Communication, 113

- Public Key, 41

- PUT, 139

**R**

- Record Protocol, 45

- RFC 5280, 41

- Root certificate, 49

**S**

- S7 communication, 25, 138, 397

- S7 routing, 373

- Connection resources, 397

- Secure communication, 41

- Secure Socket Layer, 45

- Security, 425
- Security measures, 425
  - Firewall, 426
  - Logging, 427
  - NTP, 427
  - SNMP, 428
- Self-signed certificates, 46
- Server certificate, 233
- Setting up a connection, 33
  - By configuring, 126
  - ISO connection with CP 1543-1, 127
- Signature, 47
- SNMP, 25, 428
- SSL, 45
- Symmetric encryption, 43
- Syslog, 427
- System data type, 116

## T

- TCON, 115
- TCP, 25, 113, 122
- TDISCON, 115
- Time-of-day synchronization, 25
- TLS, 45
- Transport Layer Security, 45
- TRCV, 115
- TRCV\_C, 115
- TSEND, 115
- TSEND\_C, 115

## U

- UDP, 25, 113, 122
- URCV, 139
- USEND, 139
- USS protocol, 147

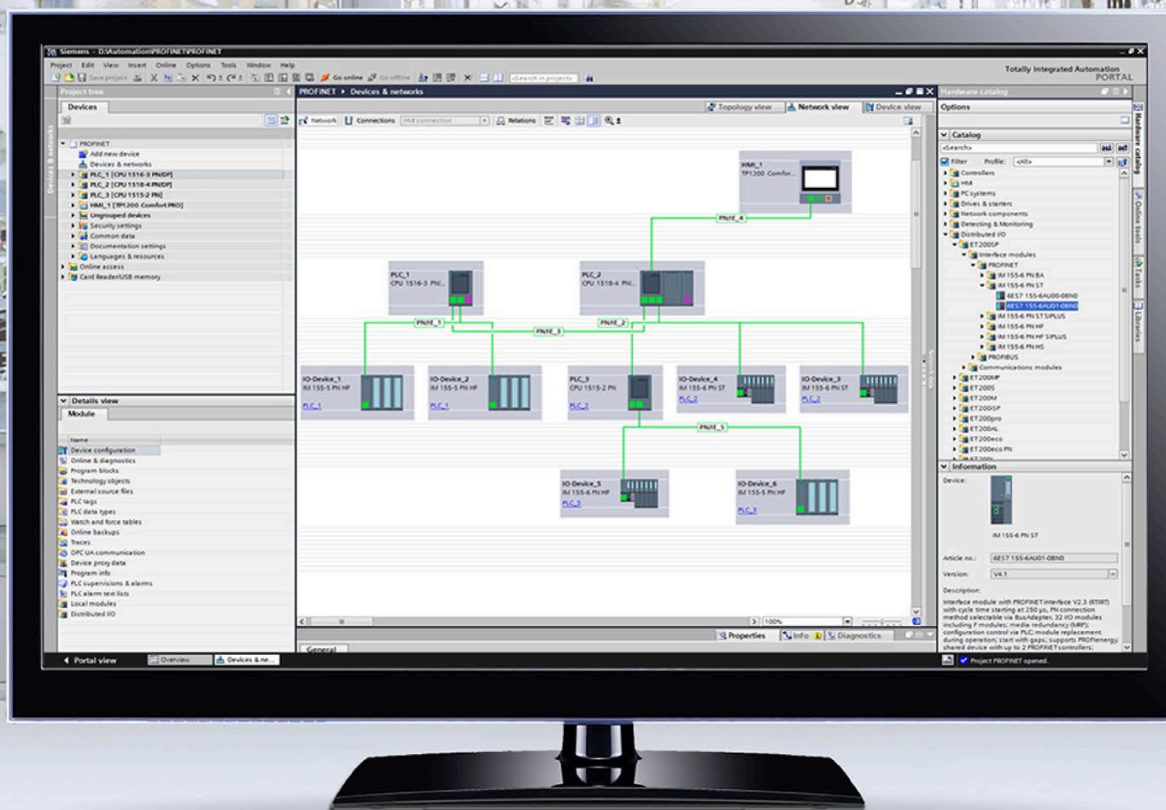
## W

- Web server, 25
- Write, 25

## X

- X.509, 41

# SIEMENS



Function manual

# SIMATIC

## PROFINET

PROFINET with STEP 7

Edition

05/2021

[support.industry.siemens.com](https://support.industry.siemens.com)



# SIEMENS

SIMATIC

PROFINET  
PROFINET with STEP 7

Function Manual

Preface

---

Function manuals  
Documentation Guide

---

1

Description

---

2

Parameter  
assignment/addressing

---

3

Diagnostics and  
maintenance

---

4

Functions

---

5

PROFINET with the  
redundant S7-1500R/H  
system

---

6

## Legal information

### Warning notice system

This manual contains notices you have to observe in order to ensure your personal safety, as well as to prevent damage to property. The notices referring to your personal safety are highlighted in the manual by a safety alert symbol, notices referring only to property damage have no safety alert symbol. These notices shown below are graded according to the degree of danger.

#### **DANGER**

indicates that death or severe personal injury **will** result if proper precautions are not taken.

#### **WARNING**

indicates that death or severe personal injury **may** result if proper precautions are not taken.

#### **CAUTION**

indicates that minor personal injury can result if proper precautions are not taken.

#### **NOTICE**

indicates that property damage can result if proper precautions are not taken.

If more than one degree of danger is present, the warning notice representing the highest degree of danger will be used. A notice warning of injury to persons with a safety alert symbol may also include a warning relating to property damage.

### Qualified Personnel

The product/system described in this documentation may be operated only by **personnel qualified** for the specific task in accordance with the relevant documentation, in particular its warning notices and safety instructions. Qualified personnel are those who, based on their training and experience, are capable of identifying risks and avoiding potential hazards when working with these products/systems.

### Proper use of Siemens products

Note the following:

#### **WARNING**

Siemens products may only be used for the applications described in the catalog and in the relevant technical documentation. If products and components from other manufacturers are used, these must be recommended or approved by Siemens. Proper transport, storage, installation, assembly, commissioning, operation and maintenance are required to ensure that the products operate safely and without any problems. The permissible ambient conditions must be complied with. The information in the relevant documentation must be observed.

### Trademarks

All names identified by ® are registered trademarks of Siemens AG. The remaining trademarks in this publication may be trademarks whose use by third parties for their own purposes could violate the rights of the owner.

### Disclaimer of Liability

We have reviewed the contents of this publication to ensure consistency with the hardware and software described. Since variance cannot be precluded entirely, we cannot guarantee full consistency. However, the information in this publication is reviewed regularly and any necessary corrections are included in subsequent editions.

# Preface

## Purpose of the documentation

This function manual provides an overview of the PROFINET communication system with SIMATIC STEP 7 V17.

STEP 7 V17 is integrated into the high-performance graphical Totally Integrated Automation Portal (TIA Portal), the integration platform for all automation software tools.

This function manual supports you in planning a PROFINET system. The manual is structured into the following subject areas:

- PROFINET basics
- PROFINET diagnostics
- PROFINET functions

## Basic knowledge required

The following knowledge is required in order to understand the manual:

- General knowledge of automation technology
- Knowledge of the industrial automation system SIMATIC
- Knowledge about the use of Windows-based computers
- Knowledge about how to use STEP 7 (TIA Portal)

## Scope

This documentation is the basic documentation for all SIMATIC products from the PROFINET environment. The product documentation is based on this documentation.

The examples are based on the functionality of the S7-1500 automation system.

## What's new in the PROFINET Function Manual, Edition 05/2021 compared to Edition 11/2018

| Function                    | What are the customer benefits?                                                                                                                                                                                                                                                                                                                                                             | Where can I find this information?                                                                                    |
|-----------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------|
| MRP interconnection         | The MRP interconnection procedure is an extension of MRP. MRP interconnection enables the redundant coupling of two or more rings with MRP in PROFINET networks. MRP interconnection offers you the following benefits: There is no limit to the maximum number of 50 devices in a ring when setting up redundant network topologies. Monitoring of larger topologies with ring redundancy. | Section MRP interconnection (Page 188)<br>Section MRP interconnection with the redundant system S7-1500R/H (Page 311) |
| Enable/disable the I-device | You can use the "D_ACT_DP" instruction to locally disable or enable the I-device function in the user program of the I-device CPU.                                                                                                                                                                                                                                                          | Section Enabling/disabling I-device in the user program of the I-device CPU (Page 144)                                |

## What's new in the PROFINET Function Manual, Edition 11/2019 compared to Edition 10/2018

| Function             | What are the customer benefits?                                                                                                                                                                                                                 | Where can I find this information?      |
|----------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------|
| Direct data exchange | In the case of direct data exchange, an S7-1500 CPU provides cyclic user data from the I/O area to one or more partners. The "Direct data exchange" function enables deterministic, isochronous IO communication between multiple S7-1500 CPUs. | Section Direct data exchange (Page 231) |
| Switched S1 device   | The "Switched S1 device" function of the CPU enables operation of standard IO devices in the S7-1500R/H redundant system.                                                                                                                       | Section Switched S1 device (Page 296)   |

## What's new in the PROFINET Function Manual, Edition 10/2018 compared to Edition 12/2017

This manual (version 10/2018) includes the following new functions compared to the previous version (version 12/2017):

| Function                                         | Applications                                                                                                          | Your benefits                                                                                                                                                                                                                                                  |
|--------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| PROFINET IO with the redundant S7-1500R/H system | In a PROFINET IO system with the redundant S7-1500R/H system, the IO communication continues even when one CPU fails. | The redundant S7-1500R/H system offers a high degree of reliability and system availability. A redundant configuration of the most important automation components reduces the probability of production downtimes and the consequences of component failures. |

## What's new in the PROFINET function manual, version 12/2017 compared to version 09/2016

This manual (version 12/2017) encompasses the following new functions compared to the previous version (version 09/2016):

| Function                                            | Applications                                                                                                                                                                                                                                                                                                                          | Your benefits                                                                                                                                                                                                                                                                                                                                                                                                                   |
|-----------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Specifying the router for a PROFINET IO device      | You can specify the IP address of a router for each IO device. You reach the IO device from outside the IP subnet through the router.                                                                                                                                                                                                 | In the past, it was only possible to specify a router for a PROFINET IO interface at the IO controller. The IO devices inherited the setting of the IO controller interface.<br><br>Now you can set the router address independently of the IO controller setting. This allows, for example, a router address at the IO device although you have not set a router address or have set a different address at the IO controller. |
| Configuring an IO device through hardware detection | You can detect an existing IO device and enter it in your project.                                                                                                                                                                                                                                                                    | STEP 7 inserts the IO device with all the modules and submodules into the project. Article numbers and firmware versions between real and configured IO devices match.<br><br>You reduce the project planning work required.                                                                                                                                                                                                    |
| Asset management                                    | You can centrally manage non-PROFINET components (assets) of a PROFINET device. The PROFINET device makes the identification data of the assets available for evaluation via a standardized data record.                                                                                                                              | The new standardized PROFINET service makes it possible to manage all the hardware and firmware components of PROFINET devices centrally. The possibilities available for filtering device data, for example, depend on the range of performance of the evaluating application.                                                                                                                                                 |
| Asset management data record for I-devices          | Special application of asset management: From the point of view of a higher-level IO controller, the modules plugged into the I-device represent assets. The user program in the I-device compiles the asset management data record. The IO controller can read identification data of the I-device modules through this data record. | See Asset management.                                                                                                                                                                                                                                                                                                                                                                                                           |

## What's new in the PROFINET function manual, Version 09/2016 compared to Version 12/2014

This manual (version 09/2016) encompasses the following new functions compared to the previous version (version 12/2014):

| Function                                                  | Applications                                                                                                                                      | Your benefits                                                                                                                                                                                                                                                      |
|-----------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| PROFINET IO on the 2nd PROFINET interface                 | You can operate another PROFINET IO system on the CPU or connect additional IO devices.                                                           | You use a fieldbus type in the plant.<br>The CPU can perform fast and deterministic data exchange as an I-device with a higher-level controller (PROFINET/Ethernet) through the second line.                                                                       |
| IRT with very short data cycle times down to 125 µs       | You realize high-end applications with IO communication which place very high performance demands on the IO processing.                           | You make PROFINET IO communication and standard communication possible via one cable even with a send clock of 125 µs.                                                                                                                                             |
| MRPD: Media Redundancy with Planned Duplication of frames | PROFINET IO IRT enables you to realize applications that place particularly high demands on the reliability and accuracy (isochronous mode).      | By sending the cyclic IO data in both directions in the ring, the communication to the IO devices is maintained even when the ring is interrupted and does not result in device failure even with fast update times. You achieve higher reliability than with MRP. |
| PROFINET performance upgrade                              | You can implement applications with high speed and send clock requirements. This is of interest to applications with high demands on performance. | Better utilization of the bandwidth results in short reaction times.                                                                                                                                                                                               |
| Limitation of the data infeed into the network            | You limit the network load for standard Ethernet communication to a maximum value.                                                                | You flatten peaks in the data feed.<br>You share the remaining bandwidth based on demand.                                                                                                                                                                          |

## Conventions

**STEP 7:** We refer to "STEP 7" in this documentation as a synonym for the configuration and programming software "STEP 7 as of V12 (TIA Portal)" and subsequent versions.

This documentation contains pictures of the devices described. The figures may differ slightly from the device supplied.

You should also pay particular attention to notes such as the one shown below:

---

### Note

A note contains important information on the product, on handling of the product and on the section of the documentation to which you should pay particular attention.

---

Siemens provides products and solutions with industrial security functions that support the secure operation of plants, systems, machines and networks.

## Security information

In order to protect plants, systems, machines and networks against cyber threats, it is necessary to implement – and continuously maintain – a holistic, state-of-the-art industrial security concept. Siemens' products and solutions constitute one element of such a concept.

Customers are responsible for preventing unauthorized access to their plants, systems, machines and networks. Such systems, machines and components should only be connected to an enterprise network or the internet if and to the extent such a connection is necessary and only when appropriate security measures (e.g. firewalls and/or network segmentation) are in place.

For additional information on industrial security measures that may be implemented, please visit (<https://www.siemens.com/industrialsecurity>).

Siemens' products and solutions undergo continuous development to make them more secure. Siemens strongly recommends that product updates are applied as soon as they are available and that the latest product versions are used. Use of product versions that are no longer supported, and failure to apply the latest updates may increase customers' exposure to cyber threats.

To stay informed about product updates, subscribe to the Siemens Industrial Security RSS Feed visit (<https://www.siemens.com/industrialsecurity>).

## Siemens Industry Online Support

You can find current information on the following topics quickly and easily here:

- **Product support**

All the information and extensive know-how on your product, technical specifications, FAQs, certificates, downloads, and manuals.

- **Application examples**

Tools and examples to solve your automation tasks – as well as function blocks, performance information and videos.

- **Services**

Information about Industry Services, Field Services, Technical Support, spare parts and training offers.

- **Forums**

For answers and solutions concerning automation technology.

- **mySupport**

Your personal working area in Industry Online Support for messages, support queries, and configurable documents.

This information is provided by the Siemens Industry Online Support in the Internet (<https://support.industry.siemens.com>).

## Industry Mall

The Industry Mall is the catalog and order system of Siemens AG for automation and drive solutions on the basis of Totally Integrated Automation (TIA) and Totally Integrated Power (TIP).

You can find catalogs for all automation and drive products on the Internet (<https://mall.industry.siemens.com>) and in the Information and Download Center.



# Table of contents

|          |                                                                                  |           |
|----------|----------------------------------------------------------------------------------|-----------|
|          | <b>Preface .....</b>                                                             | <b>3</b>  |
| <b>1</b> | <b>Function manuals Documentation Guide.....</b>                                 | <b>13</b> |
| <b>2</b> | <b>Description.....</b>                                                          | <b>18</b> |
| 2.1      | Introduction to PROFINET.....                                                    | 18        |
| 2.1.1    | PROFINET terms.....                                                              | 20        |
| 2.1.2    | Basic terminology of communication .....                                         | 23        |
| 2.1.3    | PROFINET interface .....                                                         | 26        |
| 2.1.4    | Implementation of the PROFINET device model in SIMATIC.....                      | 29        |
| 2.2      | Setting up PROFINET .....                                                        | 30        |
| 2.2.1    | Active Network Components.....                                                   | 31        |
| 2.2.2    | Cabling technology.....                                                          | 33        |
| 2.2.3    | Wireless design.....                                                             | 36        |
| 2.2.3.1  | Basics .....                                                                     | 36        |
| 2.2.3.2  | Tips on assembly .....                                                           | 38        |
| 2.2.4    | Network security.....                                                            | 39        |
| 2.2.4.1  | Basics .....                                                                     | 39        |
| 2.2.4.2  | Network components and software.....                                             | 41        |
| 2.2.4.3  | Application example .....                                                        | 42        |
| <b>3</b> | <b>Parameter assignment/addressing .....</b>                                     | <b>44</b> |
| 3.1      | Assigning an IO device to an IO controller .....                                 | 45        |
| 3.2      | Device name and IP address .....                                                 | 46        |
| 3.2.1    | Device name.....                                                                 | 48        |
| 3.2.2    | IP address .....                                                                 | 49        |
| 3.2.3    | Assigning a device name and IP address .....                                     | 52        |
| 3.2.4    | Assign device name via communication table.....                                  | 57        |
| 3.2.5    | Permitting changes to the device name and IP address directly on the device..... | 60        |
| 3.3      | Configuring an IO device through hardware detection.....                         | 62        |
| 3.4      | Specifying the router for a PROFINET IO device.....                              | 64        |
| 3.5      | Configuring topology.....                                                        | 68        |
| 3.5.1    | Topology view in STEP 7 .....                                                    | 70        |
| 3.5.2    | Interconnecting ports in the topology view .....                                 | 72        |
| 3.5.3    | Interconnecting ports - Inspector window .....                                   | 74        |
| 3.5.4    | Automatic assignment of devices by offline/online comparison .....               | 75        |
| 3.5.5    | Apply the port interconnections identified online manually to the project.....   | 76        |
| 3.5.6    | Include the devices identified online manually in the project .....              | 77        |
| 3.5.7    | Automatic assignment of devices by advanced offline/online comparison .....      | 77        |
| <b>4</b> | <b>Diagnostics and maintenance .....</b>                                         | <b>78</b> |
| 4.1      | Diagnostics mechanisms of PROFINET IO .....                                      | 78        |
| 4.1.1    | Diagnostics levels in PROFINET IO.....                                           | 80        |
| 4.2      | Diagnostics via LEDs.....                                                        | 82        |

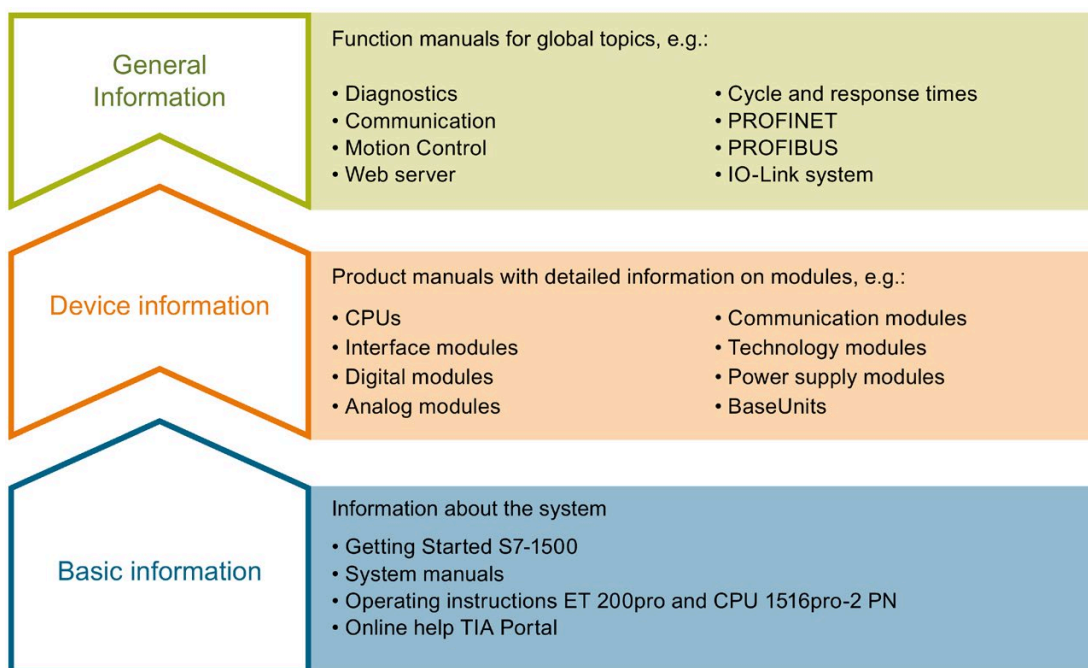
|          |                                                                                      |            |
|----------|--------------------------------------------------------------------------------------|------------|
| 4.3      | Diagnostics via the display of the S7-1500 CPUs .....                                | 83         |
| 4.4      | Diagnostics via Web server .....                                                     | 87         |
| 4.5      | Online diagnostics with STEP 7 .....                                                 | 91         |
| 4.6      | Extended maintenance concept .....                                                   | 94         |
| 4.7      | Diagnostics of the network topology .....                                            | 96         |
| 4.8      | Diagnostics in the user program .....                                                | 97         |
| 4.8.1    | Diagnostics and configuration data records .....                                     | 97         |
| 4.8.2    | Evaluate diagnostics in the user program .....                                       | 99         |
| 4.9      | Maintenance .....                                                                    | 102        |
| 4.9.1    | I&M data (identification and maintenance) .....                                      | 102        |
| 4.9.2    | Loading I&M data to PROFINET IO devices and your modules .....                       | 102        |
| 4.9.3    | Asset management .....                                                               | 103        |
| 4.9.3.1  | Further information about asset management at PROFINET .....                         | 103        |
| 4.9.3.2  | Content and structure of an asset management record .....                            | 105        |
| 4.9.3.3  | Asset management data record for I-devices .....                                     | 112        |
| <b>5</b> | <b>Functions .....</b>                                                               | <b>117</b> |
| 5.1      | Connecting other bus systems .....                                                   | 117        |
| 5.1.1    | Linking PROFINET and PROFIBUS .....                                                  | 119        |
| 5.1.2    | Connect the DP slave via the IE/PB Link to a PROFINET IO system .....                | 120        |
| 5.2      | Intelligent IO devices (I-devices) .....                                             | 122        |
| 5.2.1    | I-device functionality .....                                                         | 122        |
| 5.2.2    | Properties and Advantages of the I-Device .....                                      | 123        |
| 5.2.3    | Characteristics of an I-Device .....                                                 | 124        |
| 5.2.4    | Data Exchange between higher- and lower-level IO system .....                        | 128        |
| 5.2.5    | Configuring the I-device .....                                                       | 130        |
| 5.2.6    | Program examples .....                                                               | 133        |
| 5.2.7    | Diagnostics and interrupt characteristics .....                                      | 136        |
| 5.2.8    | Rules for the Topology of a PROFINET IO System with I-Device .....                   | 138        |
| 5.2.9    | Boundary conditions when using I-devices .....                                       | 141        |
| 5.2.10   | Configuring PROFINET with I-devices .....                                            | 142        |
| 5.2.11   | Enabling/disabling I-device in the user program of the I-device CPU .....            | 144        |
| 5.3      | Shared device .....                                                                  | 150        |
| 5.3.1    | Useful information on shared devices .....                                           | 150        |
| 5.3.2    | Configuring shared device .....                                                      | 153        |
| 5.3.3    | Configuring an I-device as a shared device .....                                     | 158        |
| 5.3.4    | Module-internal shared input/shared output (MSI/MSO) .....                           | 167        |
| 5.4      | Media redundancy (ring topologies) .....                                             | 174        |
| 5.4.1    | Media Redundancy Protocol (MRP) .....                                                | 175        |
| 5.4.2    | Configuring media redundancy .....                                                   | 178        |
| 5.4.3    | Media redundancy with planned duplication of frames (MRPD; not for S7-1500R/H) ..... | 181        |
| 5.4.4    | Multiple rings .....                                                                 | 184        |
| 5.4.5    | MRP interconnection .....                                                            | 188        |

|          |                                                                       |     |
|----------|-----------------------------------------------------------------------|-----|
| 5.5      | Real-time communication .....                                         | 192 |
| 5.5.1    | Introduction .....                                                    | 192 |
| 5.5.2    | RT.....                                                               | 193 |
| 5.5.3    | IRT.....                                                              | 194 |
| 5.5.4    | Comparison of RT and IRT .....                                        | 197 |
| 5.5.5    | Configuring PROFINET IO with IRT .....                                | 197 |
| 5.5.6    | Setting the bandwidth usage for the send clock .....                  | 200 |
| 5.5.7    | Setup recommendations for optimizing PROFINET .....                   | 202 |
| 5.5.8    | Limitation of the data infeed into the network.....                   | 206 |
| 5.6      | PROFINET with performance upgrade.....                                | 207 |
| 5.6.1    | Dynamic frame packing .....                                           | 208 |
| 5.6.2    | Fragmentation.....                                                    | 210 |
| 5.6.3    | Fast forwarding .....                                                 | 211 |
| 5.6.4    | Configuration of IRT with high performance .....                      | 212 |
| 5.6.5    | Sample configuration for IRT with high performance .....              | 216 |
| 5.7      | Isochronous mode .....                                                | 217 |
| 5.7.1    | What is isochronous mode?.....                                        | 217 |
| 5.7.2    | Use of isochronous mode.....                                          | 218 |
| 5.7.3    | Time sequence of synchronization on PROFINET IO.....                  | 220 |
| 5.7.4    | Configuring isochronous mode .....                                    | 221 |
| 5.7.4.1  | Introduction .....                                                    | 221 |
| 5.7.4.2  | Configuring isochronous mode on PROFINET IO .....                     | 223 |
| 5.7.4.3  | Setting the application cycle and delay time .....                    | 225 |
| 5.7.5    | Programming isochronous mode .....                                    | 226 |
| 5.7.5.1  | Basics of Programming.....                                            | 226 |
| 5.7.5.2  | Program execution according to the IPO model .....                    | 227 |
| 5.7.5.3  | Program execution according to the OIP model .....                    | 229 |
| 5.8      | Direct data exchange .....                                            | 231 |
| 5.8.1    | Introduction .....                                                    | 231 |
| 5.8.2    | Configuring direct data exchange between two S7-1500 CPUs .....       | 234 |
| 5.8.3    | Configuring direct data exchange between multiple IO controllers..... | 237 |
| 5.9      | Device replacement without exchangeable medium.....                   | 241 |
| 5.9.1    | Device replacement without exchangeable medium/PG function .....      | 242 |
| 5.9.2    | Replacing an IO device without exchangeable medium.....               | 244 |
| 5.9.3    | Permit overwriting of PROFINET device name .....                      | 245 |
| 5.10     | Standard machine projects.....                                        | 248 |
| 5.10.1   | Multiple use IO systems .....                                         | 249 |
| 5.10.1.1 | What you should know about multiple use IO systems.....               | 249 |
| 5.10.1.2 | Configuring multiple use IO systems .....                             | 253 |
| 5.10.1.3 | Adapt multiple use IO systems locally.....                            | 256 |
| 5.10.2   | Configuration control for IO systems .....                            | 258 |
| 5.10.2.1 | Information about configuration control of IO systems .....           | 258 |
| 5.10.2.2 | Configuring IO devices as optional .....                              | 261 |
| 5.10.2.3 | Enabling optional IO devices in the program.....                      | 263 |
| 5.10.2.4 | Configuring flexible order of IO devices.....                         | 270 |
| 5.10.2.5 | Customizing arrangement of IO devices in the program.....             | 272 |
| 5.10.2.6 | System behavior and rules .....                                       | 275 |
| 5.11     | Saving energy with PROFIenergy .....                                  | 277 |

|          |                                                                                                  |            |
|----------|--------------------------------------------------------------------------------------------------|------------|
| 5.12     | Docking systems .....                                                                            | 279        |
| 5.12.1   | Configuring docking systems .....                                                                | 282        |
| 5.13     | Accelerating startup.....                                                                        | 284        |
| 5.13.1   | Options for accelerating the startup of IO devices.....                                          | 284        |
| 5.13.2   | Prioritized startup .....                                                                        | 286        |
| 5.13.3   | Configuring prioritized startup .....                                                            | 287        |
| 5.13.4   | Optimize the port settings.....                                                                  | 288        |
| 5.13.5   | Optimize the cabling of the ports .....                                                          | 289        |
| 5.13.6   | Measures in the user program.....                                                                | 290        |
| <b>6</b> | <b>PROFINET with the redundant S7-1500R/H system .....</b>                                       | <b>292</b> |
| 6.1      | Media redundancy in the redundant S7-1500R/H system .....                                        | 293        |
| 6.2      | H-Sync Forwarding .....                                                                          | 293        |
| 6.3      | System redundancy S2.....                                                                        | 295        |
| 6.4      | Switched S1 device .....                                                                         | 296        |
| 6.5      | Main differences between IO device with S2 system redundancy and standard IO device .....        | 298        |
| 6.6      | Installation guidelines.....                                                                     | 299        |
| 6.7      | Configuring PROFINET IO on a redundant S7-1500R/H system .....                                   | 300        |
| 6.8      | Assigning IO device to the redundant S7-1500R/H system .....                                     | 306        |
| 6.9      | Configuring media redundancy (MRP) for a configuration with the redundant S7-1500R/H system..... | 309        |
| 6.10     | MRP interconnection with the redundant system S7-1500R/H.....                                    | 311        |
|          | <b>Glossary .....</b>                                                                            | <b>314</b> |
|          | <b>Index.....</b>                                                                                | <b>329</b> |

# Function manuals Documentation Guide

The documentation for the SIMATIC S7-1500 automation system, the CPUs 1513/1516pro-2 PN based on SIMATIC S7-1500, and the distributed I/O systems SIMATIC ET 200MP, ET 200SP and ET 200AL is divided into three areas. This division allows you easier access to the specific information you require.



## Basic information

System manuals and Getting Started manuals describe in detail the configuration, installation, wiring and commissioning of the SIMATIC S7-1500, ET 200MP, ET 200SP and ET 200AL systems. Use the corresponding operating instructions for the CPUs 1513/1516pro-2 PN. The STEP 7 online help supports you in the configuration and programming.

## Device information

Product manuals contain a compact description of the module-specific information, such as properties, terminal diagrams, characteristics and technical specifications.

### General information

The function manuals contain detailed descriptions on general topics such as diagnostics, communication, Motion Control, Web server, OPC UA.

You can download the documentation free of charge from the Internet (<https://support.industry.siemens.com/cs/ww/en/view/109742705>).

Changes and additions to the manuals are documented in product information sheets.

You will find the product information on the Internet:

- S7-1500/ET 200MP (<https://support.industry.siemens.com/cs/us/en/view/68052815>)
- ET 200SP (<https://support.industry.siemens.com/cs/us/en/view/73021864>)

### Manual Collections

The Manual Collections contain the complete documentation of the systems put together in one file.

You will find the Manual Collections on the Internet:

- S7-1500/ET 200MP (<https://support.industry.siemens.com/cs/ww/en/view/86140384>)
- ET 200SP (<https://support.industry.siemens.com/cs/ww/en/view/84133942>)
- ET 200AL (<https://support.industry.siemens.com/cs/ww/en/view/95242965>)

### "mySupport"

With "mySupport", your personal workspace, you make the best out of your Industry Online Support.

In "mySupport", you can save filters, favorites and tags, request CAx data and compile your personal library in the Documentation area. In addition, your data is already filled out in support requests and you can get an overview of your current requests at any time.

You must register once to use the full functionality of "mySupport".

You can find "mySupport" on the Internet (<https://support.industry.siemens.com/My/ww/en>).

### "mySupport" - Documentation

With "mySupport", your personal workspace, you make the best out of your Industry Online Support.

In "mySupport", you can save filters, favorites and tags, request CAx data and compile your personal library in the Documentation area. In addition, your data is already filled out in support requests and you can get an overview of your current requests at any time.

You must register once to use the full functionality of "mySupport".

You can find "mySupport" on the Internet (<https://support.industry.siemens.com/My/ww/en/documentation>).

## "mySupport" - CAx data

In the CAx data area of "mySupport", you can access the latest product data for your CAx or CAe system.

You configure your own download package with a few clicks.

In doing so you can select:

- Product images, 2D dimension drawings, 3D models, internal circuit diagrams, EPLAN macro files
- Manuals, characteristics, operating manuals, certificates
- Product master data

You can find "mySupport" - CAx data on the Internet  
(<https://support.industry.siemens.com/my/ww/en/CAxOnline>).

## Application examples

The application examples support you with various tools and examples for solving your automation tasks. Solutions are shown in interplay with multiple components in the system - separated from the focus on individual products.

You will find the application examples on the Internet  
(<https://support.industry.siemens.com/cs/ww/en/ps/ae>).

## TIA Selection Tool

With the TIA Selection Tool, you can select, configure and order devices for Totally Integrated Automation (TIA).

This tool is the successor of the SIMATIC Selection Tool and combines the known configurators for automation technology into one tool.

With the TIA Selection Tool, you can generate a complete order list from your product selection or product configuration.

You can find the TIA Selection Tool on the Internet  
(<https://support.industry.siemens.com/cs/ww/en/view/109767888>).

## SIMATIC Automation Tool

You can use the SIMATIC Automation Tool to perform commissioning and maintenance activities simultaneously on various SIMATIC S7 stations as a bulk operation independent of TIA Portal.

The SIMATIC Automation Tool provides a multitude of functions:

- Scanning of a PROFINET/Ethernet system network and identification of all connected CPUs
- Address assignment (IP, subnet, gateway) and station name (PROFINET device) to a CPU
- Transfer of the date and the programming device/PC time converted to UTC time to the module
- Program download to CPU
- RUN/STOP mode switchover
- CPU localization by means of LED flashing
- Reading out of CPU error information
- Reading of the CPU diagnostics buffer
- Reset to factory settings
- Firmware update of the CPU and connected modules

You can find the SIMATIC Automation Tool on the Internet

(<https://support.industry.siemens.com/cs/ww/en/view/98161300>).

## PRONETA

SIEMENS PRONETA (PROFINET network analysis) allows you to analyze the plant network during commissioning. PRONETA features two core functions:

- The topology overview automatically scans the PROFINET and all connected components.
- The IO check is a fast test of the wiring and the module configuration of a plant.

You can find SIEMENS PRONETA on the Internet

(<https://support.industry.siemens.com/cs/ww/en/view/67460624>).



## SINETPLAN

SINETPLAN, the Siemens Network Planner, supports you in planning automation systems and networks based on PROFINET. The tool facilitates professional and predictive dimensioning of your PROFINET installation as early as in the planning stage. In addition, SINETPLAN supports you during network optimization and helps you to exploit network resources optimally and to plan reserves. This helps to prevent problems in commissioning or failures during productive operation even in advance of a planned operation. This increases the availability of the production plant and helps improve operational safety.

The advantages at a glance

- Network optimization thanks to port-specific calculation of the network load
- Increased production availability thanks to online scan and verification of existing systems
- Transparency before commissioning through importing and simulation of existing STEP 7 projects
- Efficiency through securing existing investments in the long term and the optimal use of resources

You can find SINETPLAN on the Internet (<https://www.siemens.com/sinetplan>).

## Description

### 2.1 Introduction to PROFINET

#### What is PROFINET IO?

Within the framework of Totally Integrated Automation (TIA), PROFINET IO is the logical further development of:

- PROFIBUS DP, the established fieldbus and
- Industrial Ethernet

PROFINET IO is based on 20 years of experience with the successful PROFIBUS DP and combines the normal user operations with the simultaneous use of innovative concepts of Ethernet technology. This ensures the integration of PROFIBUS DP into the PROFINET world.

PROFINET IO as the Ethernet-based automation standard of PROFIBUS/PROFINET International defines a cross-vendor communication, automation, and engineering model.

#### Objectives of PROFINET

The objectives of PROFINET:

- Industrial networking, based on Industrial Ethernet (open Ethernet standard)
- Compatibility of Industrial Ethernet and standard Ethernet components
- High robustness due to Industrial Ethernet devices. Industrial Ethernet devices are suited to the industrial environment (temperature, noise immunity, etc.).
- Use of IT standards such as TCP/IP, http.
- Real-time capability
- Seamless integration of other fieldbus systems

## Implementation of PROFINET in SIMATIC

PROFINET is implemented in SIMATIC as follows:

- We have implemented communication between field devices in SIMATIC with **PROFINET IO**.
- Installation technology and network components are available as SIMATIC NET products.
- Ethernet standard protocol and procedures (e.g., SNMP = Simple Network Management Protocol for network parameter assignment and diagnostics) are used for remote maintenance and network diagnostics.

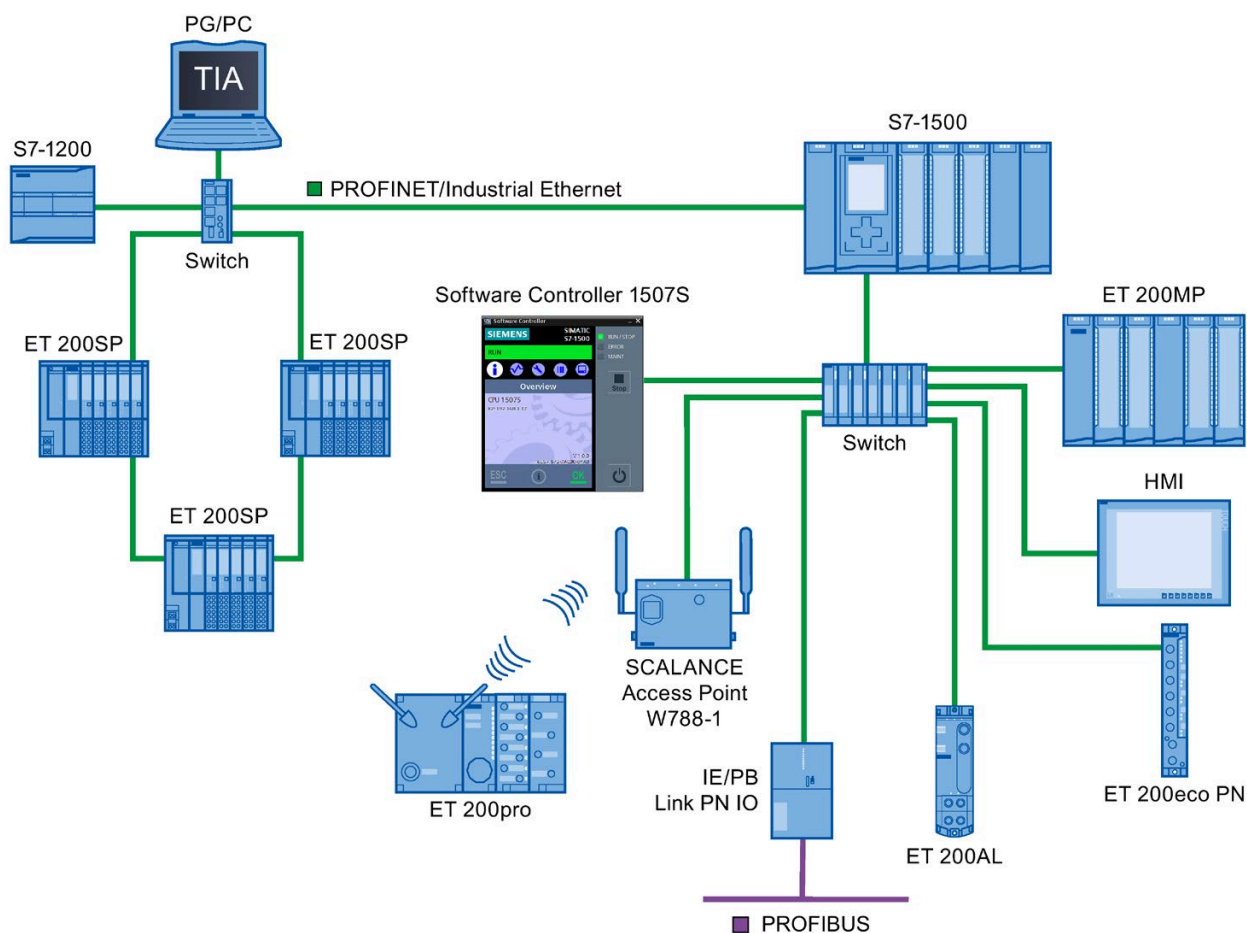


Figure 2-1 PROFINET overview configuration

## STEP 7

The STEP 7 engineering tool supports you in setting up and configuring an automation solution. STEP 7 provides a uniform application view over all bus systems.

## Documentation from PROFIBUS & PROFINET International on the Internet

You will find numerous documents on the topic of PROFINET at the Internet address (<http://www.profibus.com>) of the "PROFIBUS & PROFINET International" PROFIBUS user organization, which is also responsible for PROFINET.

Additional information can be found on the Internet (<http://www.siemens.com/profinet>).

## Overview of the most important documents and links

A compilation of the most important PROFINET application examples, FAQs and other contributions in the Industry Online Support is available in this FAQ (<https://support.industry.siemens.com/cs/ww/en/view/108165711>).

### 2.1.1 PROFINET terms

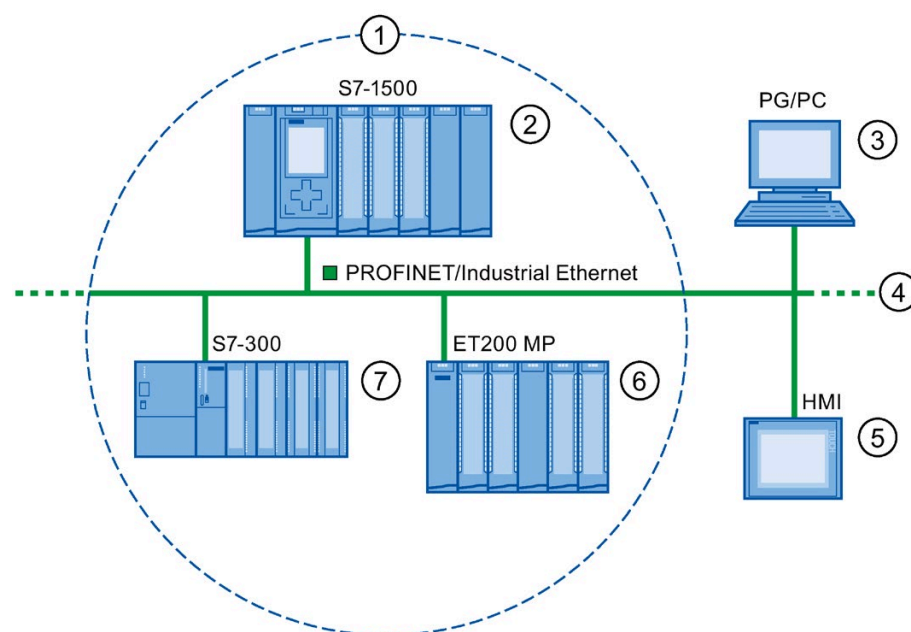
#### Definition: Devices in the PROFINET environment

In the PROFINET environment, "device" is the generic term for:

- Automation systems (PLC, PC, for example)
- Distributed I/O systems
- Field devices (for example, hydraulic devices, pneumatic devices)
- Active network components (for example, switches, routers)
- Gateways to PROFIBUS, AS interface or other fieldbus systems

## PROFINET IO devices

The following graphic shows the general names used for the most important devices in PROFINET. In the table below the graphic you can find the names of the individual components in the PROFINET IO context.

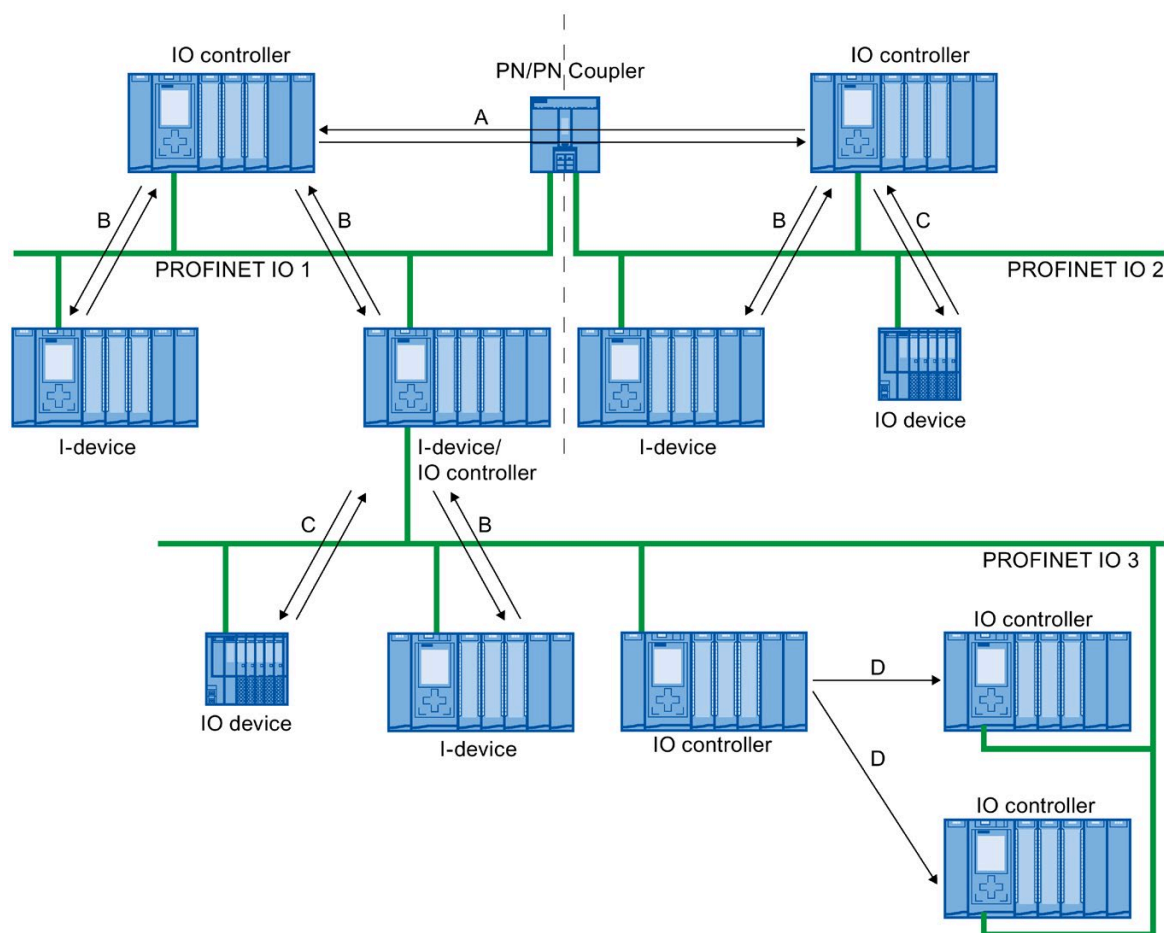


| Number | PROFINET                                         | Explanation                                                                                                                                                                                |
|--------|--------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| ①      | PROFINET IO System                               |                                                                                                                                                                                            |
| ②      | IO controller                                    | Device used to address the connected IO devices.<br>This means that: The IO controller exchanges input and output signals with field devices.                                              |
| ③      | Programming device / PC (PROFINET IO supervisor) | PG/PC/HMI device used for commissioning and for diagnostics                                                                                                                                |
| ④      | PROFINET/Industrial Ethernet                     | Network infrastructure                                                                                                                                                                     |
| ⑤      | HMI (Human Machine Interface)                    | Device for operating and monitoring functions.                                                                                                                                             |
| ⑥      | IO device                                        | A distributed field device that is assigned to one of the IO controllers (e.g., Distributed IO, valve terminals, frequency converters, switches with integrated PROFINET IO functionality) |
| ⑦      | I-device                                         | Intelligent IO device                                                                                                                                                                      |

Figure 2-2 PROFINET devices

## IO communication via PROFINET IO

The inputs and outputs of distributed I/O devices are read and written by means of PROFINET IO using what is referred to as IO communication. The following figure provides an overview of IO communication by means of PROFINET IO.



- A IO controller - IO controller communication via PN/PN coupler
- B IO controller - I-device communication
- C IO controller - IO-device communication
- D Direct data exchange between S7-1500-CPU's

Figure 2-3 IO communication via PROFINET IO

## IO communication via PROFINET IO

Table 2- 1 IO communication via PROFINET IO

| Communication between ...                          | Explanation                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |
|----------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| IO controllers and IO devices                      | The IO controller sends data cyclically to the IO devices of its PROFINET IO system and receives data from these devices.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |
| IO controller and I-device                         | <p>A fixed quantity of data is transferred cyclically between the user programs in CPUs of IO controllers and I-devices.</p> <p>The IO controller does not access the I/O module of the I-device, but instead accesses configured address ranges, i.e. transfer ranges, which may be located inside or outside the process image of the CPU of the I-device. If parts of the process image are used as transfer ranges, it is not permitted to use these for real I/O modules.</p> <p>Data transfer takes place using load- and transfer operations via the process image or via direct access.</p>                                                            |
| IO controller and IO controller (PN/PN coupler)    | <p>A fixed quantity of data is cyclically transferred between the user programs in CPUs of IO controllers. A PN/PN coupler is required as additional hardware.</p> <p>The IO controllers mutually access configured address ranges, i.e. transfer ranges, which may be located inside or outside the process image of the CPU. If parts of the process image are used as transfer ranges, it is not permitted to use these for real I/O modules.</p> <p>Data transfer takes place using load- and transfer operations via the process image or via direct access.</p> <p>I/O communication with PN/PN coupler is possible between two PROFINET IO systems.</p> |
| S7-1500-CPU and S7-1500-CPU (direct data exchange) | <p>In the case of direct data exchange, an S7-1500 CPU provides cyclic user data from the I/O area to one or more partners.</p> <p>The direct data exchange is based on PROFINET with IRT and isochronous mode.</p> <p>The data exchange takes place via transfer areas.</p>                                                                                                                                                                                                                                                                                                                                                                                   |

### See also

Communication (<http://support.automation.siemens.com/WW/view/en/59192925>)

Network security (Page 1)

Functions (Page 1)

## 2.1.2 Basic terminology of communication

### PROFINET communication

PROFINET communication takes place via Industrial Ethernet. The following transmission types are supported:

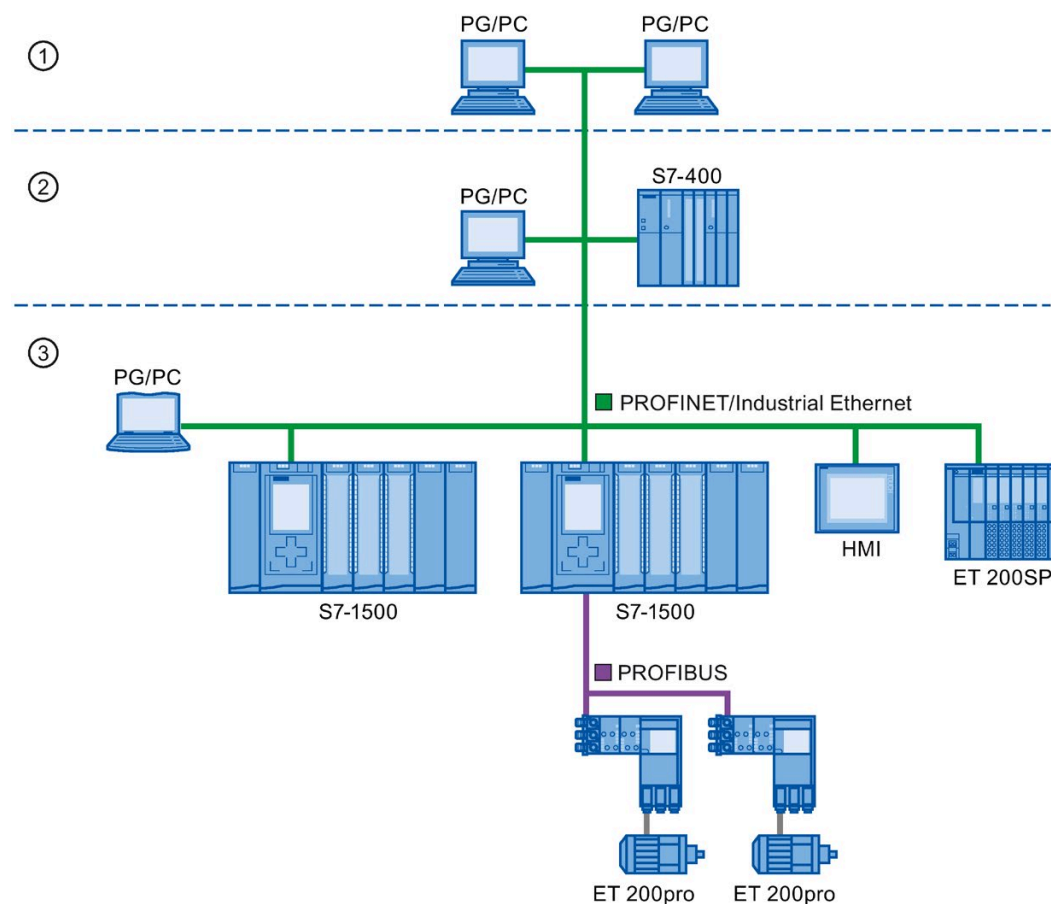
- Acyclic transmission of engineering and diagnostics data and interrupts
- Cyclic transmission of user data

The PROFINET-IO communication takes place in real-time.

For additional information on the real-time communication, refer to chapter Real-time communication (Page 1).

## Transparent data access

Access to process data from different levels of the factory is supported by PROFINET communication. By using Industrial Ethernet, standard mechanisms of communication and information technology such as OPC/XML can now be used along with standard protocols such as UDP/TCP/IP and HTTP in automation engineering. This allows transparent access from company management level directly to the data from the automation systems at the control level and production level.



- ① Management level
- ② Control level
- ③ Production level

Figure 2-4 Access to process data



## Update time

The update time is a time interval. IO controller and IO device/I-device exchange IO data cyclically in the IO system within this time interval. The update time can be configured separately for each IO device and determines the interval at which output data is sent from the IO controller to the IO device (output module/submodule) as well as input data from the IO device to the IO controller (input module/submodule).

STEP 7 calculates the update time automatically in the default setting for each IO device of the PROFINET IO system, taking into account the volume of data to be exchanged as well as the set send clock.

For additional information on the update time, refer to section Real-time communication (Page 1).

## Watchdog time

The watchdog time is the time interval that an IO controller or IO device permits, without receiving IO data. If the IO device is not supplied by the IO controller with data within the watchdog time, the IO device detects the missing frames and outputs substitute values. This is reported in the IO controller as a station failure.

In STEP 7, the watchdog time is made up from an integral multiple of the update time and can be set by the user.

## Send clock

The period of time between two consecutive communication cycles. The send clock is the shortest possible interval in data exchange and thus also the smallest value that can be set for the update time.

## Relationship between the update time and send clock

The calculated update times are reduction ratios (1, 2, 4, 8, ..., 512) of the send clock. The minimum possible update time thus depends on the minimum send clock of the IO controller that can be set and the efficiency of the IO controller and IO device. Depending on the send clock, it can be that only some of the reduction ratios are available (STEP 7 guarantees this through a pre-selection).

The following tables illustrate the dependency of the update time that can be set on the send clock, using an example of the CPU 1516-3 PN/DP. The update times satisfy the requirements of the PROFINET standard IEC 61158.

Table 2- 2 With real-time communication the following applies:

| Send clock  | Update time           | Reduction ratios |
|-------------|-----------------------|------------------|
| 250 $\mu$ s | 250 $\mu$ s to 128 ms | 1,2, ..., 512    |
| 500 $\mu$ s | 500 $\mu$ s to 256 ms | 1,2, ..., 512    |
| 1 ms        | 1 ms to 512 ms        | 1,2, ..., 512    |
| 2 ms        | 2 ms to 512 ms        | 1,2, ..., 256    |
| 4 ms        | 4 ms to 512 ms        | 1,2, ..., 128    |

## Additional information

For information on real-time communication, refer to the section Real-Time Communication (RT) (Page 1).

### 2.1.3 PROFINET interface

#### Overview

PROFINET devices of the SIMATIC product family have one or more PROFINET interfaces (Ethernet controller/interface). The PROFINET interfaces have one or more ports (physical connection options).

In the case of PROFINET interfaces with multiple ports, the devices have an integrated switch.

PROFINET devices with two ports on one interface allow you to configure the system in a line or ring topology. PROFINET devices with three or more ports on one interface are also ideal for setting up tree topologies.

Properties and rules for naming the PROFINET interface and its representation in STEP 7 are explained in the following.

#### Properties

Every PROFINET device on the network is uniquely identified via its PROFINET interface. For this purpose, each PROFINET interface has:

- A MAC address (factory default)
- An IP address
- A PROFINET device name

#### Identification and numbering of the interfaces and ports

Interfaces and ports for all modules and devices in the PROFINET system are identified with the following characters:

Table 2- 3 Identification for interfaces and ports of PROFINET devices

| Element   | Symbol | Interface number                                               |
|-----------|--------|----------------------------------------------------------------|
| Interface | X      | In ascending order starting from number 1                      |
| Port      | P      | In ascending order starting from number 1 (for each interface) |
| Ring port | R      |                                                                |

#### Examples of identification

Three examples illustrate the rules for identifying PROFINET interfaces:

Table 2- 4 Examples for identifying PROFINET interfaces

| Sample labeling | Interface number | Port number   |
|-----------------|------------------|---------------|
| X2 P1           | 2                | 1             |
| X1 P2           | 1                | 2             |
| X1 P1 R         | 1                | 1 (ring port) |

## Representation of PROFINET Interfaces in the Topology Overview in STEP 7

You can find the PROFINET interface in the topology overview in STEP 7. The PROFINET interface for an IO controller and an IO device is represented as follows in STEP 7:

| Topology overview                           |         |                 |                 |                       |              |                  |  |
|---------------------------------------------|---------|-----------------|-----------------|-----------------------|--------------|------------------|--|
| Port interconnection Compare offline/online |         |                 |                 |                       |              |                  |  |
| Device / port                               | Slot    | Partner station | Partner devi... | Partner interface     | Partner port | Cable data       |  |
| ▼ S7300/ET200M-Station_1                    |         |                 |                 |                       |              |                  |  |
| ▼ PLC_1                                     | 2       |                 |                 |                       |              |                  |  |
| PROFINET-Schnittstelle_1                    | 2 X2    |                 |                 |                       |              |                  |  |
| Port_1                                      | 2 X2 P1 | ET 200eco-St... | IO-Device_1     | PROFINET-Schnittst... | Port_1       | < 100 m (0,6 µs) |  |
| Port_2                                      | 2 X2 P2 |                 |                 |                       | Any pa...    |                  |  |
| ▼ ET 200eco-Station_1                       |         |                 |                 |                       |              |                  |  |
| ▼ IO-Device_1                               | 0       |                 |                 |                       |              |                  |  |
| PROFINET-Schnittstelle                      | 0 X1    |                 |                 |                       |              |                  |  |
| Port_1                                      | 0 X1 P1 | S7300/ET200...  | PLC_1           | PROFINET-Schnittst... | Port_1       | < 100 m (0,6 µs) |  |
| Port_2                                      | 0 X1 P2 |                 |                 |                       | Any partner  |                  |  |
| 8 DI DC24V 4xM12                            | 1       |                 |                 |                       |              |                  |  |

### Num-ber Description

- ① PROFINET interface of an IO controller in STEP 7
- ② PROFINET interface of an IO device in STEP 7
- ③ These lines represent the PROFINET interface.
- ④ These lines represent the "ports" of a PROFINET interface.

Figure 2-5 Representation of the PROFINET interfaces in STEP 7

## Schematic Representation of a PROFINET Interface with Integrated Switch

The following schematic diagram shows the PROFINET interface with integrated switch and its ports for all PROFINET devices.

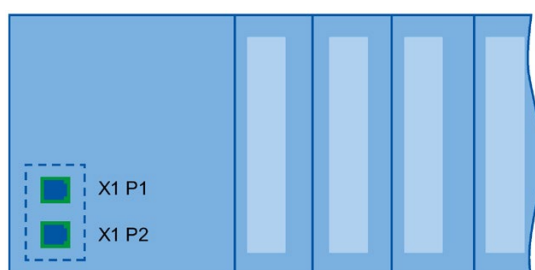


Figure 2-6 PROFINET interface with integrated switch

## Functional differences of the PROFINET interfaces

PROFINET interfaces can provide different functions. PROFINET interface functions include identification, configuration, diagnostics and communication services (e.g., open communication). PROFINET interfaces that provide PROFINET IO functions and network security functions are also available.

The following table illustrates the differences using the example of the CPU 1516-3 PN/DP (as of firmware version V2.0), which features two PROFINET interfaces with different functionality.

Table 2- 5 Differences between the PROFINET interfaces of the CPU 1516-3 PN/DP (as of firmware version V2.0)

| PROFINET interface (X1)                        | PROFINET interface (X2)                       |
|------------------------------------------------|-----------------------------------------------|
| <b>2 ports with PROFINET IO functionality:</b> | <b>1 port with PROFINET IO functionality:</b> |
| Identification, configuration and diagnostics  |                                               |
| PG communication                               |                                               |
| HMI communication                              |                                               |
| S7 communication                               |                                               |
| Time-of-day synchronization                    |                                               |
| Web server                                     |                                               |
| Open communication                             |                                               |
| OPC UA server                                  |                                               |
| IO controller                                  |                                               |
| I-device                                       |                                               |
| RT                                             |                                               |
| IRT                                            | -                                             |
| Isochronous mode                               | -                                             |
| Media redundancy                               | -                                             |
| Prioritized startup                            | -                                             |

## Additional Information on the Functionality of PROFINET interfaces

You can find information on the number and functionality of the interfaces of a PROFINET device in the documentation for the specific PROFINET device.

PROFINET communication services are described in the Communication function manual (<http://support.automation.siemens.com/WW/view/en/59192925>).

In the Network security (Page 1) section you can find components that are used to protect networks against hazards.

The Functions (Page 1) section describes the PROFINET IO functions.

## 2.1.4 Implementation of the PROFINET device model in SIMATIC

### Slots and modules

A PROFINET device can have a modular and compact structure. A modular PROFINET device consists of slots into which the modules are inserted. The modules have channels which are used to read and output process signals. A compact device has the same design and can include modules, however, it cannot be physically expanded, which means that no modules can be inserted.

This is illustrated by the following graphic.

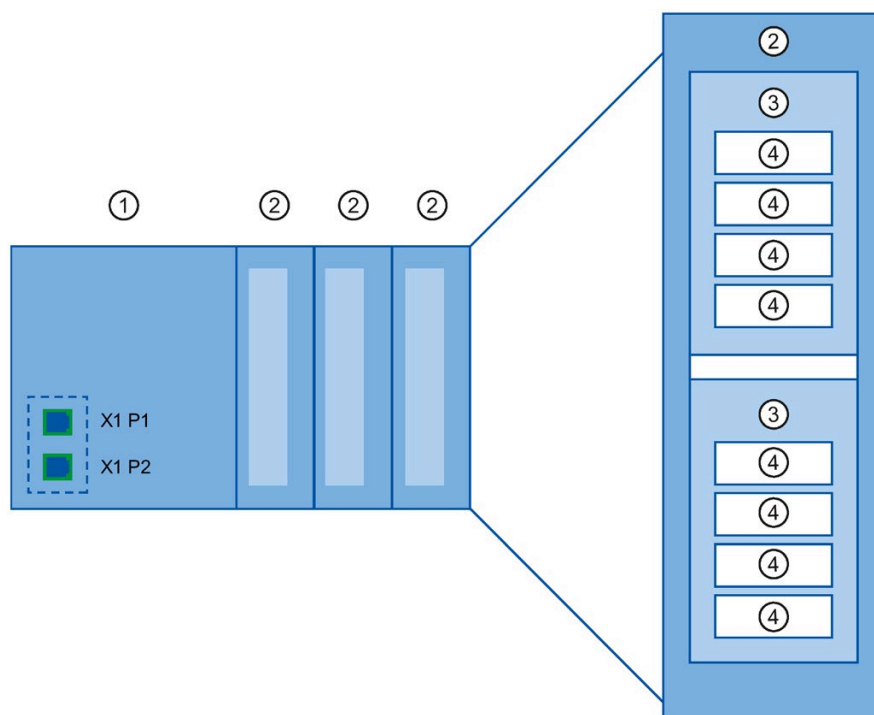


Figure 2-7 Configuration of a PROFINET device

| Number | Description             |
|--------|-------------------------|
| ①      | Slot with bus interface |
| ②      | Slot with module        |
| ③      | Subslot with submodule  |
| ④      | Channel                 |

A module can contain multiple submodules.

## Representation of PROFINET Device Model in the Device View of STEP 7

The following figure shows the representation of the PROFINET device model in the device view of STEP 7, based on the example of a distributed I/O system ET 200MP:

| Device overview                                                                   |                          |      |         |           |           |                        |
|-----------------------------------------------------------------------------------|--------------------------|------|---------|-----------|-----------|------------------------|
|  | Module                   | Rack | Slot    | I address | Q address | Type                   |
|                                                                                   | ▼ IO-Device_1            | 0    | 1       |           |           | IM 155-5 PN ST         |
|                                                                                   | ▼ PROFINET-Schnittstelle | 0    | 1 X1    |           |           | PROFINET interface     |
|                                                                                   | Port_1                   | 0    | 1 X1 P1 |           |           | Port                   |
|                                                                                   | Port_2                   | 0    | 1 X1 P2 |           |           | Port                   |
|                                                                                   | DI 32x24VDC HF_1         | 0    | 2       | 16...19   |           | DI32 x 24VDC HF        |
|                                                                                   | DQ 32x24VDC/0.5A ST_1    | 0    | 3       |           | 0...3     | DQ32 x 24VDC / 0.5A ST |

Figure 2-8 PROFINET device model in the device view of STEP 7

## 2.2 Setting up PROFINET

### Contents of this chapter

The following chapter provides background information on building your communication network.

- Overview of the most important passive network components: These are network components that forward a signal without the possibility of actively influencing it, for example, cables, connectors, etc.
- Overview of the most important active network components: These are network components that actively affect a signal, for example switches, routers, etc.
- Overview of the most common network structures (topologies).

## Physical connections of industrial networks

PROFINET devices can be networked in industrial systems in two different physical ways:

- Connected line
  - By means of electrical pulses via copper cables
  - By means of optical pulses via fiber-optic cables
- Wireless via wireless network using electromagnetic waves

PROFINET devices and cabling technology in SIMATIC are suited for industrial use, as they are based on Fast Ethernet and Industrial Ethernet.

- **Fast Ethernet**

You can use Fast Ethernet to transfer data at a speed of 100 Mbps. This transmission technology uses the 100 Base-T standard for this.

- **Industrial Ethernet**

Structure of Ethernet in industrial environment.

The biggest difference from standard Ethernet is the mechanical current carrying capacity and noise immunity of the individual components.

### 2.2.1 Active Network Components

#### Introduction

The following active network components are available for PROFINET:

- Switch
- Router

#### Switched Ethernet

PROFINET IO is based on switched Ethernet with full-duplex operation and a bandwidth of 100 Mbps. In this way, the network can be used much more efficiently through the simultaneous data transfer of several devices. The PROFINET IO frames are processed with high priority.

## Switches

Switches are network components used to connect several terminal devices or network segments in a local network (LAN).

For the communication of a device with several other devices on PROFINET, the device is connected to the port of a switch. Other communication devices (including switches) can then be connected to the other ports of the switch. The connection between a communication device and the switch is a point-to-point connection.

A switch has the task of receiving and distributing frames. The switch "learns" the Ethernet address(es) of a connected PROFINET device or additional switches and only forwards those frames that are intended for the connected PROFINET device or the connected switch.

## Switch variants

Switches are available in two models:

- Integrated into a PROFINET device

For PROFINET devices with multiple ports (two or more), we are dealing with devices with an integrated switch (for example, CPU 1516-3 PN/DP).

- As autonomous device (for example, switches of the SCALANCE product family)

## Selection Guide for Switches

To use PROFINET with the RT class "RT", you can use any switch of "PROFINET Conformance Class A" or higher. All switches of the SCALANCE product family meet these requirements.

If you want to use PROFINET functions that provide an additional value, such as topology recognition, diagnostics, device exchange without exchangeable medium/programming device, you have to use a switch of the "PROFINET Conformance Class B" or higher.

To use PROFINET with the RT class "IRT", you must use a switch of "PROFINET Conformance Class C". With switches of the SCALANCE product family, watch out for the catalog feature "IRT PROFINET IO switch".

To select appropriate switches, we recommend the SIMATIC NET Selection Tool on the Internet (<http://support.automation.siemens.com/WW/view/en/39134641>).

## Switches of the SCALANCE product family

Use the switches of the SCALANCE product family if you want to use the full scope of PROFINET. They are optimized for use in PROFINET IO.

In the SCALANCE X device family, you will find switches with electrical and optical ports and with a combination of both variants. SCALANCE X202-2IRT, for example, has two electrical ports and two optical ports and supports IRT communication.

Beginning with the SCALANCE X200, you can configure, diagnose and address switches of the SCALANCE X device series as PROFINET IO devices using STEP 7.



## Router

A router connects separated network segments with each other (e.g. management level and control level). The volume of data volume must be coordinated with the services of the respective network segment. A router also separates two networks and acts as a mediator between both networks. It thus reduces the network load. Routing functionality is provided in the SCALANCE X device family, with SCALANCE X300 or higher.

Communication devices on different sides of a router can only communicate with one another if you have explicitly enabled communication between them via the router.

If you want to access manufacturing data directly from SAP, for example, use a router to connect your Industrial Ethernet in the factory with the Ethernet in your office.

---

### Note

If devices need to communicate beyond the limits of a network, you must configure the router so that it allows this communication to take place.

---

Information on routing with STEP 7 is available in the function manual Communication (<http://support.automation.siemens.com/WW/view/en/59192925>).

## 2.2.2 Cabling technology

### Cables for PROFINET

Electrical and optical cables are available for PROFINET. The type of cable depends on the data transfer requirements and on the ambient conditions.

### Simple method for the prefabrication of twisted pair cables

When you set up your PROFINET system, you can cut the twisted-pair cable to the required length on site, strip it with the *stripping tool* (for Industrial Ethernet), and fit the *Industrial Ethernet Fast Connect RJ45 plugs* using the cut-and-clamp method. For more information on installation, refer to the installation instructions in the "SIMATIC NET Industrial Ethernet Network Manual" (<http://support.automation.siemens.com/WW/view/en/8763736>).

---

### Note

A maximum of four plug-in pairs are allowed between two switches per Ethernet path.

---

### Simple method for the prefabrication of fiber-optic cables

The FastConnect FO cabling system is available for the easy, fast and error-free prefabrication of fiber-optic cables. The glass-fiber optic cable consists of:

- FC FO Termination Kit for SC and BFOC plug (cleave tool, Kevlar scissors, buffer grip, fiber remains container)
- FC BFOC Plug
- FC SC Duplex plug
- FO FC Standard cable
- FO FC Trailing cable

### Simple method for the prefabrication of POF and PCF cables

The following special tools provide an easy and safe way to prefabricate POF / PCF cables and fit the SC RJ POF plugs:

- POF cable  
Prefabrication case IE Termination Kit SC RJ POF plug
- PCF cable  
Prefabrication case IE Termination Kit SC RJ PCF plug

## Overview of transmission media with PROFINET

The following table summarizes the technical specifications of a PROFINET interface with integrated switch or an external switch, and possible transmission media.

Table 2- 6 Transmission media with PROFINET

| Physical properties   | Connection methods                                                               | Cable type / transmission medium<br><br>standard                                                                                       | Transmission rate / mode                      | Max. segment length (between two devices) | Advantages                                                                                                                                                                       |
|-----------------------|----------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------|-------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Electrical            | RJ45 connector ISO 60603-7                                                       | 100Base-TX<br>2x2 twisted, symmetrical and shielded copper cable, CAT 5 transmission requirement<br>IEEE 802.3                         | 100 Mbps, full duplex                         | 100 m                                     | Simple and cheap cable connection                                                                                                                                                |
| Optical               | SCRJ 45 ISO/IEC 61754-24                                                         | 100Base-FX<br>POF fiber-optic cable (Polymer Optical Fiber, POF)<br>980/1000 µm (core diameter / external diameter)<br>ISO/IEC 60793-2 | 100 Mbps, full duplex                         | 50 m                                      | Use when there are large differences in potential<br>Insensitive towards electromagnetic radiation<br>Low line attenuation<br>Considerably longer segments possible <sup>1</sup> |
|                       |                                                                                  | Plastic-cladded glass fiber (Polymer Cladded Fiber, PCF)<br>200/230 µm (core diameter / external diameter)<br>ISO/IEC 60793-2          | 100 Mbps, full duplex                         | 100 m                                     |                                                                                                                                                                                  |
|                       | BFOC (Bayonet Fiber Optic Connector) and SC (Subscriber Connector) ISO/IEC 60874 | Monomode glass fiber optic cable<br>10/125 µm (core diameter / external diameter)<br>ISO/IEC 60793-2                                   | 100 Mbps, full duplex                         | 26 km                                     |                                                                                                                                                                                  |
|                       |                                                                                  | Multimode glass fiber optic cable<br>50/125 µm and 62.5/125 µm (core diameter / external diameter)<br>ISO/IEC 9314-4                   | 100 Mbps, full duplex                         | 3000 m                                    |                                                                                                                                                                                  |
| Electromagnetic waves | -                                                                                | IEEE 802.11 x                                                                                                                          | Depends on the extension used (a, g, h, etc.) | 100 m                                     | Greater mobility<br>Cost-effective networking to remote, difficult to access devices                                                                                             |

<sup>1</sup> Applies for fiber-optic cables only

## See also

PROFINET interface (Page 1)

Assembly Instructions for SIMATIC NET Industrial Ethernet

(<http://support.automation.siemens.com/WW/view/en/27069465>)

PROFINET Installation Guideline (<http://www.profibus.com/nc/download/installation-guide/downloads/profinet-installation-guide/display/>)

## 2.2.3 Wireless design

### 2.2.3.1 Basics

#### What is Industrial Wireless LAN?

In addition to data communication in accordance with the IEEE 802.11 standard, the SIMATIC NET Industrial Wireless LAN provides a number of enhancements which offer significant benefits for industrial customers. IWLAN is particularly suitable for demanding industrial applications that require reliable wireless communication. This is supported by the following properties:

- Automatic roaming when the connection to Industrial Ethernet is interrupted (Forced Roaming)
- Cost savings generated by using a single wireless network for reliable operation of a process with both process-critical data (alarm message, for example) and non-critical communication (service and diagnostics, for example)
- Cost-effective connection to devices in remote environments that are difficult to access
- Predictable data traffic (deterministic) and defined response times
- Cyclical monitoring of the wireless link (link check)

#### Objectives and advantages of Industrial Wireless LAN

Wireless data transmission achieves the following objectives:

- Seamless integration of PROFINET devices into the existing bus system via the wireless interface
- Mobile use of PROFINET devices for different production-linked tasks
- Flexible configuration of the system components for fast development in accordance with customer requirements
- Maintenance costs are minimized by savings in cables

## Application examples

- Communication with mobile subscribers (mobile controllers and devices, for example), conveyor lines, production belts, translation stages, and rotating machines
- Wireless coupling of communication segments for fast commissioning or cost-effective networking where routing of wires is extremely expensive (e.g. public streets, railroad lines)
- Stacker trucks, automated guided vehicle systems and suspended monorail systems

The following graphic illustrates the many possible applications and configurations for SIMATIC device family wireless networks.

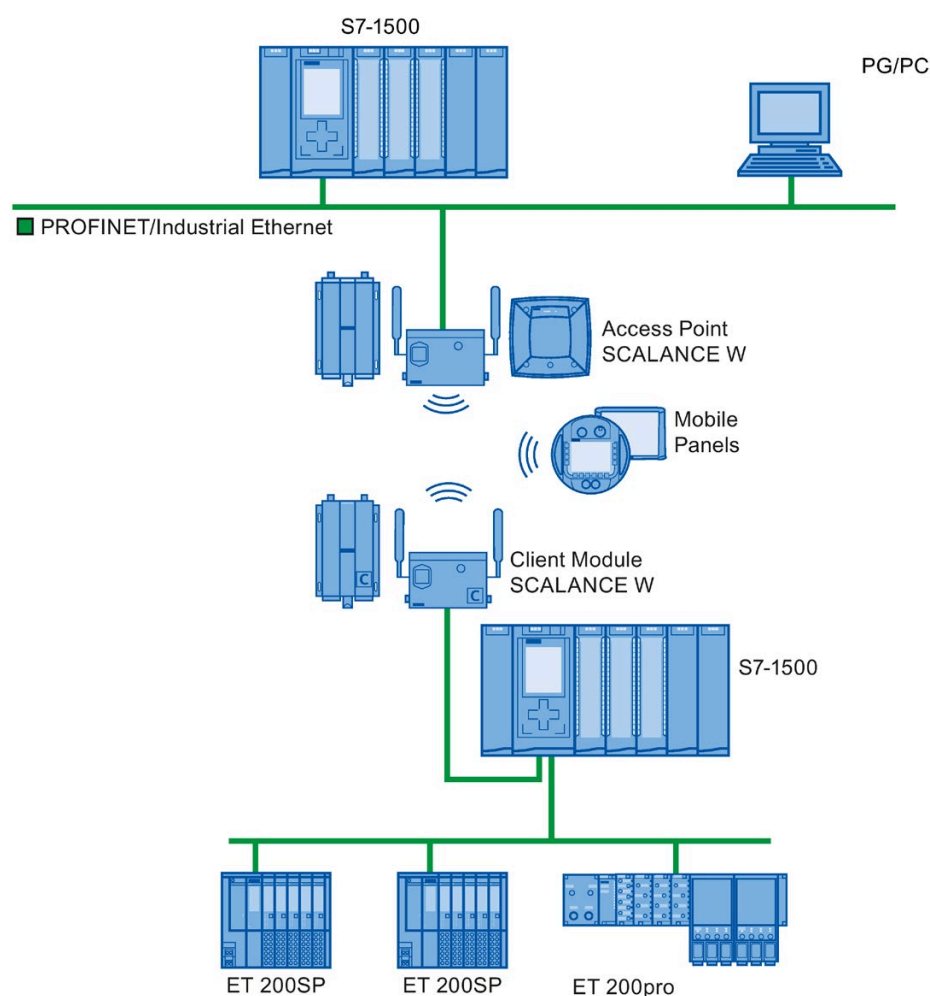


Figure 2-9 Application example for the use of Industrial Wireless LAN

## Data transmission rate

In Industrial Wireless LAN, gross data transmission rates of 11 Mbps or 54 Mbps without full duplex are permitted.

## Range

With SCALANCE W (access points), wireless networks can be set up indoors and outdoors. Multiple access points can be installed to create large wireless networks in which mobile subscribers are transferred seamlessly from one access point to another (roaming).

As an alternative to a wireless network, point-to-point connections of Industrial Ethernet segments can also be set up over large distances (several hundred meters). In this case, the range and characteristics of the RF field are determined by the antennas used.

### Note

#### Range

The range can be considerably less, depending on spatial factors, the wireless standard used, the data rate, and the antennas on the send and receive sides.

### 2.2.3.2 Tips on assembly

#### Wireless networks, SCALANCE device family

With PROFINET, you can also set up wireless networks with Industrial Wireless Local Area Network (IWLAN) technology. We recommend implementing the SCALANCE W device line for this.

#### Update time in STEP 7

If you set up PROFINET with Industrial Wireless LAN, you may have to increase the update time for the wireless devices. The IWLAN interface provides lower performance than the wired data network: Several communication stations have to share the limited transmission bandwidth. For wired solutions, 100 Mbps is available for each communication device.

The Update time parameter can be found in the "Realtime settings" section in the Inspector window of IO devices in STEP 7.

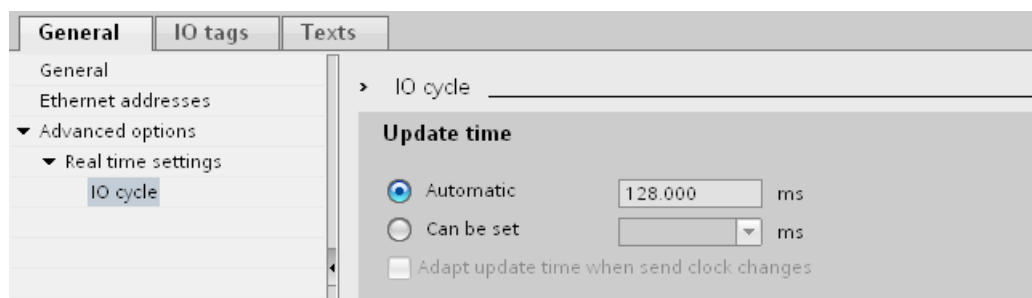


Figure 2-10 Update time in STEP 7

## Additional information

More information about SCALANCE W Industrial Wireless LAN components can be found in the manual SIMATIC NET SCALANCE W-700

(<http://support.automation.siemens.com/WW/view/en/42784493>).

More information about wired data transmission can be found in the manual SIMATIC NET Twisted Pair and Fiber Optic Networks

(<http://support.automation.siemens.com/WW/view/en/8763736>).

More information about wireless data transmission can be found in the manual Basics for configuring an industrial wireless LAN

(<http://support.automation.siemens.com/WW/view/en/9975764>).

You should also read the PROFINET installation guideline of the PROFIBUS User Organization on the Internet (<http://www.profibus.com/nc/download/installation-guide/downloads/profinet-installation-guide/display/>). Various documents that assist with the setting up of your PROFINET automation solution are available here:

- PROFINET planning guideline
- PROFINET installation guideline
- PROFINET commissioning guideline
- Additional documents for setup of PROFINET

## 2.2.4 Network security

### 2.2.4.1 Basics

#### Introduction

The topic of data security and access protection (Security) has become increasingly important in the industrial environment. The increased networking of entire industrial systems, vertical integration and networking of levels within a company and new techniques such as remote maintenance all result in higher requirements for protecting the industrial plant.

Data security solutions for office environments cannot simply be transferred one-to-one to industrial applications to protect against manipulation in sensitive systems and production networks.

#### Requirements

Additional security requirements arise from the specific communication requirements in the industrial environment (real-time communication, for example):

- Protection against interaction between automated cells
- Protection of network segments
- Protection against faulty and unauthorized access
- Scalability of network security
- Must not influence the network structure

### Definition of security

Generic term for all the measures taken to protect against:

- Loss of confidentiality due to unauthorized access to data
- Loss of integrity due to manipulation of data
- Loss of availability due to destruction of data, for example, through faulty configuration and denial-of-service attacks

### Threats

Threats can arise from external and internal manipulation. The loss of data security is not always caused by intentional actions.

Internal threats can arise due to:

- Technical errors
- Operator errors
- Defective programs

Added to these internal threats there are also external ones. The external threats are not really any different to the known threats in the office environment:

- Software viruses and worms
- Trojans
- Man-in-the-middle attacks
- Password Phishing
- Denial of Service



## Protective measures

The most important precautions to prevent manipulation and loss of data security in the industrial environment are:

- Physical access protection to the devices
- Filtering and control of data traffic by means of firewall
- A virtual private network (VPN) is used to exchange private data on a public network (Internet, for example).

The most common VPN technology is IPsec. IPsec (Internet Protocol Security) is a collection of security protocols that are used as the basis for the IP protocol at the mediation level and allow a secured communication via potentially unsecure IP networks.

- Segmenting in protected automation cells

This concept has the aim of protecting the lower-level network devices by means of security modules. A group of protected devices forms a protected automation cell.

- Authentication (identification) of the devices

The security modules identify each other over a safe (encrypted) channel using authentication procedures. It is therefore impossible for unauthorized parties to access a protected segment.

- Encrypting the data traffic

The confidentiality of data is ensured by encrypting the data traffic. Each security module is given a VPN certificate which includes the encryption key.

### 2.2.4.2 Network components and software

#### Protection against unauthorized access

The following solutions may be used to connect industrial networks to the intranet and Internet to protect against internal and external threats:

- Communication processors, such as the SIMATIC CP 1543-1
- SCALANCE X-300 and SCALANCE S - the data security components of the SIMATIC NET product family
- SOFTNET security client for use on PCs

#### Features

Both of these products have a wide variety of features, such as:

- Easy integration of existing networks without configuration, with integrated firewall.
- Segmenting in protected automation cells
- Authentication (identification) of the devices
- Encrypting the data traffic

## 2.2.4.3 Application example

## Data security at the office and production levels

The following graphic contains an application example with protected areas at different levels of the company created using SCALANCE S and the security client. The protected areas are highlighted in light gray.

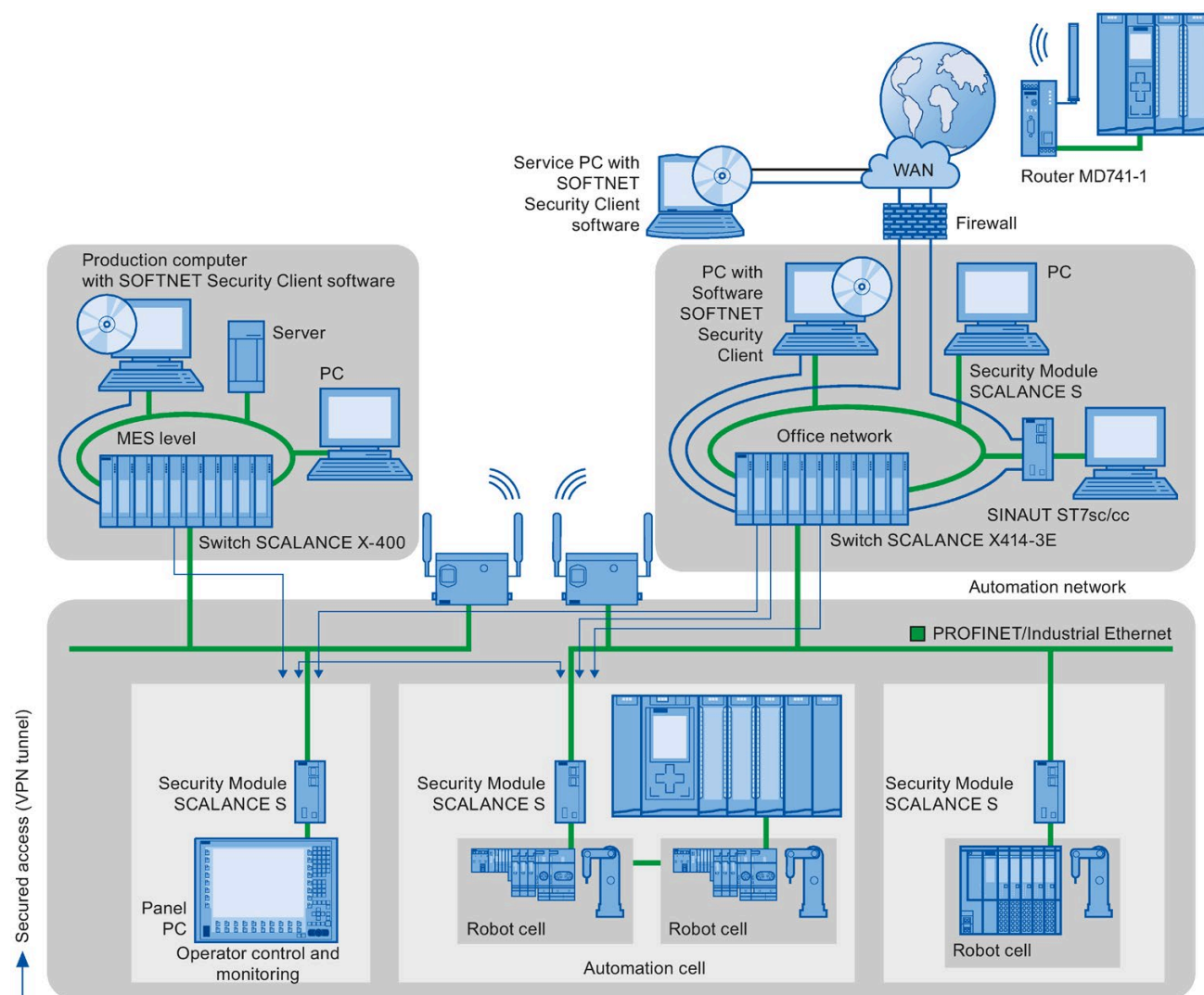


Figure 2-11 Network configuration with the SCALANCE S security module and the SOFTNET security client

### Additional information

Additional information on the configuration of a security standard in PROFINET, is available:

- In the PROFINET security guideline. These guidelines can be found on the homepage of the PROFIBUS user organization on the Internet (<http://www.profinet.com>).
- In the Industrial Ethernet Security (<http://support.automation.siemens.com/WW/view/en/56577508>) manual
- In the SCALANCE S and SOFTNET Security Client (<http://support.automation.siemens.com/WW/view/en/21718449>) manual

You can find general information on industrial security concepts, functions and news on the Industrial Security website (<http://www.siemens.com/industrialsecurity>).

## Parameter assignment/addressing

To set up an automation system, you will need to configure, assign parameters and interlink the individual hardware components. In STEP 7, the work needed for this is undertaken in the device, topology and network view.

### Configuring

"Configuring" is understood to mean arranging, setting and networking devices and modules within the device, topology or network view.

An I/O address is automatically assigned to each module. The I/O addresses can be subsequently modified.

The CPU compares the configuration preset in STEP 7 with the actual current configuration of the system. In this way, potential errors can be detected and reported straight away.

The exact procedure for configuring devices is described in detail in the STEP 7 online help.

### Assigning parameters

"Assigning parameters" is understood to mean setting the properties of the components used. The settings for the hardware components and for data communication are configured at the same time.

In STEP 7, you can "assign parameters" for the following settings PROFINET:

- Device names and IP address parameters
- Port interconnection and topology
- Module properties / parameters

The parameters are loaded into the CPU and transferred to the corresponding modules when the CPU starts up. Modules are easy to replace from spare parts, as the parameters assigned for the SIMATIC CPUs are automatically loaded into the new module at each startup.

### Adjusting the hardware to the project requirements

You need to configure hardware if you want to set up, expand or change an automation project. To do this, add hardware components to your structure, link these with existing components, and adapt the hardware properties to the tasks.

The properties of the automation systems and modules are preset such that in many cases they do not have to be assigned parameters again.

Parameter assignment is however needed in the following cases:

- You want to change the default parameter settings of a module.
- You want to use special functions.
- You want to configure communication connections.

## 3.1 Assigning an IO device to an IO controller

### PROFINET IO System

A PROFINET IO system is comprised of a PROFINET IO controller and its assigned PROFINET IO devices. After these devices have been placed in the network or topology view, STEP 7 assigns default values for them. Initially, you only have to worry about the assignment of IO devices to an IO controller.

### Requirement

- You are in the network view of STEP 7.
- A CPU has been placed (e.g., CPU 1516-3 PN/DP).
- An IO device has been placed (e.g., IM 155-6 PN ST).

### Procedure

To assign IO devices to an IO controller, proceed as follows:

1. Place the pointer of the mouse over the interface of the IO device.
2. Press and hold down the left mouse button.
3. Move the pointer.

The pointer now uses the networking symbol to indicate "Networking" mode. At the same time, you see the lock symbol on the pointer. The lock symbol disappears only when the pointer is over a valid target position.

4. Now move the pointer onto the interface of the IO controller. You can keep the left mouse button pressed or release it when performing this action.
5. Now release the left mouse button or press it again (depending on your previous action).

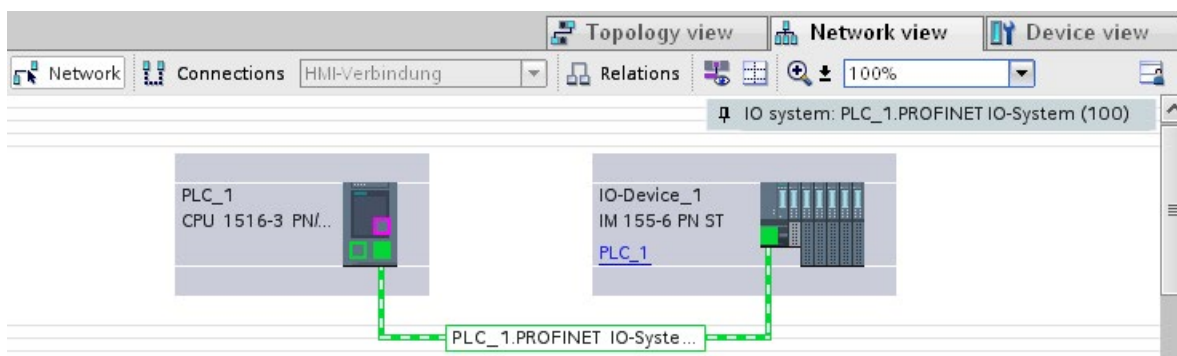


Figure 3-1 Assigning an IO device to an IO controller in the network view of STEP 7

### Result

You have assigned an IO device to an IO controller.

### Checking the assignment

You can find an overview of the communication relationships in the "IO communication" tab in the tabular area of the network view. This table is context-sensitive for selection in the graphic area:

- Selection of the interface shows the I/O communication of the respective interface.
- Selection of the CPU shows all I/O communication of the CPU (including PROFIBUS).
- Selection of the station (as in the above figure) interface shows the I/O communication of the complete station.

### Information on S7-1500R/H

You can find the procedure for assigning an IO device with system redundancy S2 to the redundant S7-1500R/H system in section Assigning IO device to the redundant S7-1500R/H system (Page 1).

## 3.2 Device name and IP address

### Introduction

In order that the PROFINET device can be addressed as node on PROFINET, the following are required:

- A unique PROFINET device name
- A unique IP address in the relevant IP subnet

STEP 7 assigns a device name during the arrangement of a PROFINET device in the hardware and network editor. The IP addresses are typically assigned automatically by STEP 7 and assigned to the devices based on the device name.

You can change the name and IP address manually.

**In STEP 7**

You can find the device name and the IP address under "Ethernet addresses" in the properties of the PROFINET interface in the Inspector window.

**General** | **IO tags** | **System constants** | **Texts**

General  
**Ethernet addresses**  
 Operating mode  
 ▶ Advanced options  
 Web server access

**Ethernet addresses**

**Interface networked with**

Subnet: PN/IE\_1  
 Add new subnet

**Internet protocol version 4 (IPv4)**

☒ Set IP address in the project  
 IP address: 192 . 168 . 0 . 1  
 Subnet mask: 255 . 255 . 255 . 0

☐ Use router  
 Router address: 0 . 0 . 0 . 0

☐ IP address from DHCP server  
 Mode: Use MAC address as client ID  
 Client ID:  
☒ Client ID can be changed during runtime

☐ IP address is set directly at the device

**PROFINET**

☐ PROFINET device name is set directly at the device  
☒ Generate PROFINET device name automatically

PROFINET device name: plc\_1.profinet-schnittstelle\_1  
 Converted name: plcxb1.profinet-schnittstellxb15ee1  
 Device number: 0

Figure 3-2 Device name and IP address in STEP 7

The function, the assignment and the changing of the device name and the IP address are described in the following sections.

### 3.2.1 Device name

#### Device names

Before an IO device can be addressed by an IO controller, it must have a device name. In PROFINET, this method was selected because it is simpler to work with names than with complex IP addresses.

The assignment of a device name for a specific IO device can be compared to setting the PROFIBUS address of a DP slave.

In delivery state, an IO device does not have a device name. A device name must first be assigned before an IO device can be addressed by an IO controller, for example, for transferring configuration data during startup or for exchanging user data in cyclic mode. You assign the device names to the IO device, for example, with the programming device / PC.

IO devices that have a slot for removable storage media provide the option of writing the device name directly to the removable storage medium in the programming device.

When a device is replaced by a device without removable medium, the IO controller assigns the device name based on topological configuration (see section Configuring topology (Page 1)).

#### Structured device names

The device name is automatically assigned by default for PROFINET devices S7-1200, S7-1500, ET 200MP, ET 200SP and ET 200AL when these are configured in STEP 7. The device names are formed from the name of the CPU or the name of the interface module. For devices with several PROFINET interfaces, the name of the interface is enhanced, for example, "plc\_1.profinet-interface\_2" or "io-device\_1".

You can structure the device names using DNS conventions.

These conventions are defined by "Internationalizing Domain Names in Applications (IDNA). According to this, device names are written in lower case.

The "Domain Name System" (DNS) is a distributed database (<http://iana.org>), which manages the name space on the Internet. To structure the names, you use the dot ("."). The hierarchy is shown in ascending order from left to right.

...<Subdomain name>.<Domain name>.<Top-level domain name>

If the name is not DNS-compliant, the name will be converted by STEP 7, for example, to "plcxb1.profinet-schnittstellexb2022c" or "io-devicexb15b32".



## Device number

In addition to the device name, STEP 7 also assigns a device number beginning with "1" when an IO device is allocated.

The device number is located in the Inspector window in the properties of the PROFINET interface, under "Ethernet addresses" in the area PROFINET.

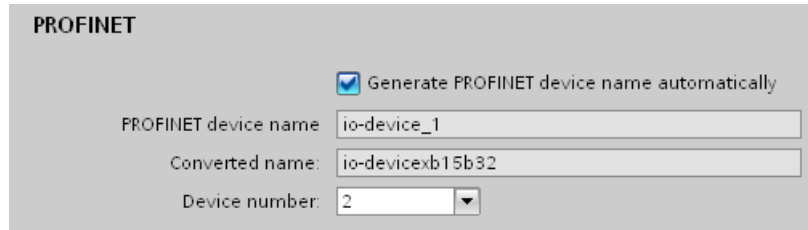


Figure 3-3 Device number

This device number can be used to identify an IO device in the user program (for example, with the instruction "LOG2GEO").

## 3.2.2 IP address

### IP address

To allow a PROFINET device to be addressed as a device on Industrial Ethernet, this device also requires an IP address that is unique within the network. The IP addresses are typically assigned automatically by STEP 7 and assigned to the devices based on the device name. If it is a standalone network, you can apply the IP address and subnet mask suggested by STEP 7. If the network is part of an existing Ethernet company network, obtain the information from your network administrator.

### Configuration of the IP address

In accordance with Internet Protocol version 4 (IPv4), the IP address is made up of four decimal numbers with a range of values from 0 through 255. The decimal numbers are separated by periods (for example, 192.162.0.0).

The IP address consists of the following:

- Address of the network
- Address of the device (PROFINET interface of the IO controller/IO device)

## Generating IP addresses

You assign the IP addresses of the IO devices in STEP 7. The IO devices receive their IP addresses during parameter assignment by the IO controller.

In addition, for some IO devices (e.g., SCALANCE X, S7-300 CPs), it is possible not to obtain the IP address during startup of the IO controller, but rather to set it beforehand on the device (see Permitting changes to the device name and IP address directly on the device (Page 1)).

The IP addresses of the IO devices always have the same subnet mask as the IO controller and are assigned from the IP address of the IO controller in ascending order. The IP address can be changed manually, if necessary.

For devices with several PROFINET interfaces (e.g., CPU 1516-3 PN/DP), the IP addresses must be located in different subnets.

---

### Note

#### Assignment of the IP address by a DHCP server

As of STEP 7 V17, you can select the option "IP address from DHCP server" for the PROFINET interface. With this option, the PROFINET interface is assigned an IP address by an DHCP server.

When you configure the option "IP address from DHCP server" for a PROFINET interface, this interface does no longer support the PROFINET IO functionality.

For more information on addressing by a DHCP server, please refer to the Communication (<http://support.automation.siemens.com/WW/view/en/59192925>) function manual.

---

## Default router

The default router is used when data has to be forwarded via TCP/IP or UDP to a partner located outside the local network.

In STEP 7, the default router is named Router. You can activate the use of a router in the Inspector window of a CPU with the "Use router" check box in the "IP protocol" section. STEP 7 assigns the local IP address to the default router by default.

The router address that is set on the PROFINET interface of the IO controller is automatically transferred for the configured IO devices.

## Subnet mask

The bits set in the subnet mask decide the part of the IP address that contains the address of the network.

In general, the following applies:

- The network address is obtained from the AND operation of the IP address and subnet mask.
- The device address is obtained from the AND NOT operation of the IP address and subnet mask.

### Example of the subnet mask

Subnet mask: 255.255.0.0 (decimal) = 11111111.11111111.00000000.00000000 (binary)

IP address: 192.168.0.2 (decimal) = 11000000.10101000.00000000.00000010 (binary)

Meaning: The first 2 bytes of the IP address determine the network - i.e., 192.168. The last two bytes address the device, i.e. 0.2.

### Relation between IP address and default subnet mask

An agreement exists relating to the assignment of IP address ranges and so-called "Default subnet masks". The first decimal number (from the left) in the IP address determines the structure of the default subnet mask with respect to the number of "1" values (binary) as follows:

| IP address (decimal) | IP address (binary)   | Address class | Default subnet mask |
|----------------------|-----------------------|---------------|---------------------|
| 0 to 126             | 0xxxxxxx.xxxxxxxx.... | A             | 255.0.0.0           |
| 128 to 191           | 10xxxxxx.xxxxxxxx...  | B             | 255.255.0.0         |
| 192 to 223           | 110xxxxx.xxxxxxxx...  | C             | 255.255.255.0       |

#### Note

##### Range of values for the first decimal point

A value between 224 and 255 is also possible for the first decimal number of the IP address (address class D etc.). However, this is not recommended because there is no address check for these values.

### Masking other subnets

You can use the subnet mask to add further structures and form "private" subnets for a subnet that is assigned one of the address classes A, B or C. This is done by setting other, less significant bits of the subnet mask to "1". For each bit set to "1", the number of "private" networks doubles and the number of devices they contain is halved. Externally, the network continues to function as an individual network.

Example:

You have a subnet of address class B (for example, IP address 129.80.xxx.xxx) and change the default subnet mask as follows:

| Masks               | Decimal       | Binary                              |
|---------------------|---------------|-------------------------------------|
| Default subnet mask | 255.255.0.0   | 11111111.11111111.00000000.00000000 |
| Subnet mask         | 255.255.128.0 | 11111111.11111111.10000000.00000000 |

Result:

All devices with addresses from 129.80.001.000 to 129.80.127.254 are located in a subnet, all devices with addresses from 129.80.128.000 to 129.80.255.254 in a different subnet.

### Reading out an IP address in the user program

You can read out the IP address of a PROFINET device in the user program of a S7-1500 CPU.

You can find information in this FAQ

(<https://support.industry.siemens.com/cs/ww/en/view/82947835>).

### 3.2.3 Assigning a device name and IP address

#### Assigning an IP address and subnet mask for an IO controller for the first time

You have the following options:

- **Using a programming device or PC:**

Connect your programming device/PC to the same network as the relevant PROFINET device. The interface of the programming device/PC must be set to TCP/IP mode. During the download, first of all display all available devices via the "Accessible devices" download dialog box. Select the target device via its MAC address and then assign its IP address before you download the hardware configuration including the configured IP address (IP address is saved retentively).

- **Using the display of a S7-1500 CPU:**

The S7-1500 CPUs have a front cover with a display and operating keys. You can use this display to assign or change the IP address. To set the IP address, navigate on the display via the menu items "Settings" > "Addresses" > "X1 (IE/PN)" > "Parameters".

- **Using a memory card:**

If your PROFINET device is equipped for a memory card (Micro Memory Card/SIMATIC memory card), plug this into your programming device/PC and save the hardware configuration together with the configured IP address on this memory card. Then plug the memory card into the PROFINET device. Once inserted, the PROFINET device automatically applies the IP address.

If you have saved a configuration to the memory card with the "IP address is set directly at the device" option, you must assign the IP address using a different method after inserting the memory card (see section Permitting changes to the device name and IP address directly on the device (Page 1)).

#### Assigning device names and IP address for "Device replacement without exchangeable medium/programming device"

For devices without exchangeable medium (e.g., ET 200MP, ET 200SP) and devices that support "Device replacement without exchangeable medium/PG" (e.g., ET 200S), the IO controller can identify the device without name from the neighbor relationships specified by the set topology and from actual neighbor relationships determined by the real PROFINET devices. The IO controller then assigns the PROFINET device the configured name and incorporates the PROFINET device in the user data traffic. (See also Device replacement without exchangeable medium (Page 1)).

## IP address assignment when replacing IO devices with exchangeable mediumPG

The following is contained on the memory card of the programmable logic controller:

- On the IO controller: Device name and IP address
- On the IO device: Device name

When you remove the memory card from a PROFINET device and insert it in another PROFINET device with exchangeable medium (e.g., ET 200S), device-specific information and the device name are loaded to the device.

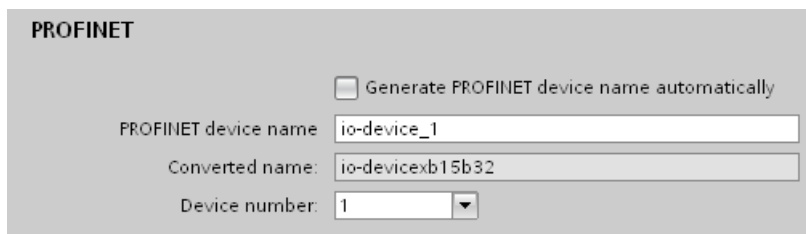
If an IO device has to be replaced in its entirety due to a device or module defect, the IO controller automatically assigns parameters and configures the replaced device or module. The cyclic exchange of user data is then restarted. In addition to this, before the power ON of the IO device, the memory card with the valid name must be removed from the faulty IO device and added to the replaced device.

In the event of an error in the PROFINET device, the memory card allows you to replace a module without a programming device/PC. You can also transfer the device data directly from the programming device/PC to the memory card.

## Procedure: Changing the device name using properties of the PROFINET interface

You can change the PROFINET name via the properties of the PROFINET interface. This is useful when the PROFINET device has not received its previous name from the automatic generation, for example, in the case of a migration.

1. In the network or device view of the STEP 7 hardware and network editor, select the PROFINET interface of a PROFINET device.
2. In the Inspector window, go to "Ethernet addresses" in the PROFINET area.
3. Clear the "Generate PROFINET device name automatically" check box.
4. Enter the new PROFINET device name in the relevant field.



**PROFINET**

☐ Generate PROFINET device name automatically

PROFINET device name:

Converted name:

Device number:

Figure 3-4 Changing the device name of a PROFINET device in the properties

**Alternative procedure: Changing the device name of a PROFINET device in the network view**

Requirement: The "Generate PROFINET device name automatically" check box is selected.

1. In STEP 7, select the "Network overview" tab in the tabular area of the network view.
2. In the "Device" column, overwrite the name in the row of the relevant PROFINET device.

The name is also changed accordingly in the graphic area of the network view.

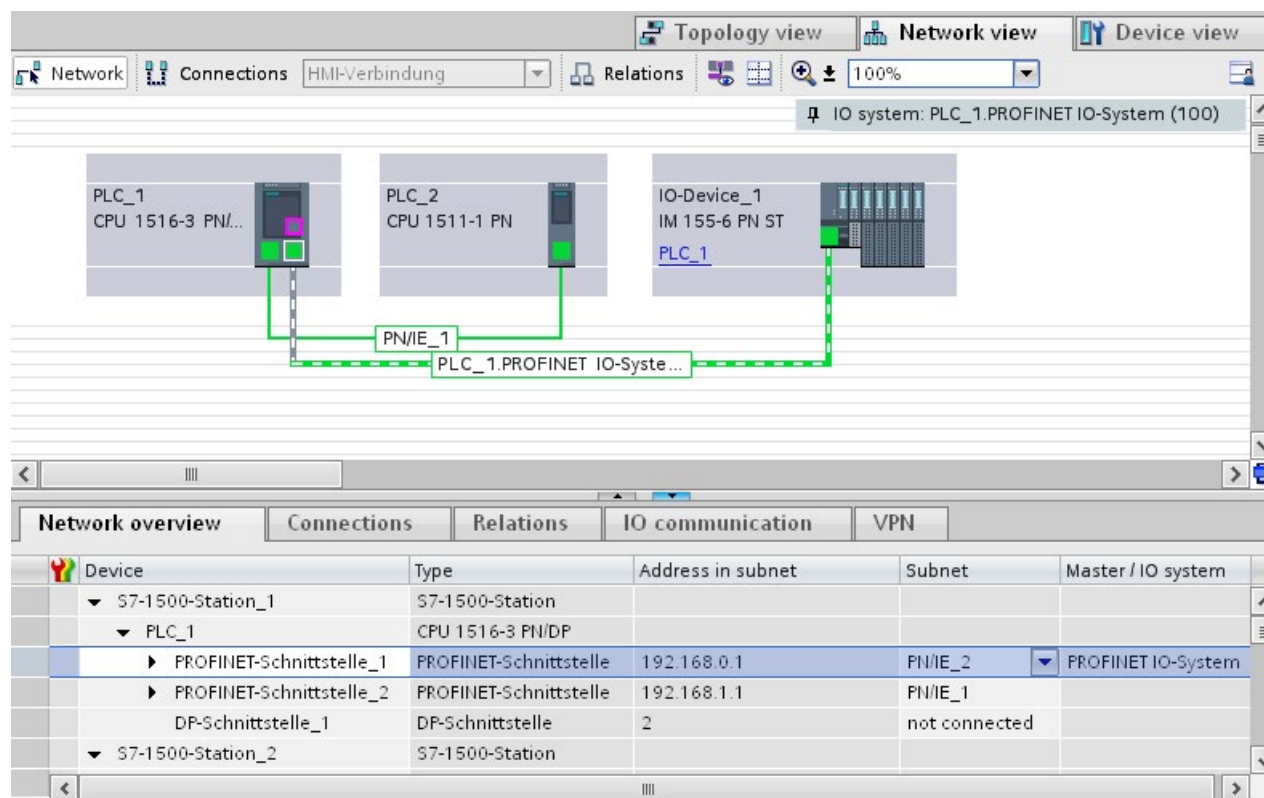


Figure 3-5 Changing the device name of a PROFINET device in STEP 7

**Procedure: Changing the IP address**

To change the IP address, follow these steps:

1. In the network or device view of the STEP 7 hardware and network editor, select the PROFINET interface of a PROFINET device.
2. In the Inspector window, go to "Ethernet addresses" in the "IP protocol" area.

3. Check that the option "Set IP address in the project" is selected.
4. Enter the new IP address in the relevant field.

Internet protocol version 4 (IPv4)

☒ Set IP address in the project

IP address: 192 . 168 . 0 . 1

Subnet mask: 255 . 255 . 255 . 0

☐ Use router

Router address: 0 . 0 . 0 . 0

☐ IP address from DHCP server

Mode: Use MAC address as client ID

Client ID:

☒ Client ID can be changed during runtime

☐ IP address is set directly at the device

Figure 3-6 Changing the IP address of a PROFINET device in STEP 7

### Downloading configured device name to IO device

To load the configured device names to the IO device, follow these steps:

1. Connect your programming device/PC to the same network as the relevant IO device. The interface of the programming device/PC must be set to TCP/IP mode.
2. In STEP 7, select the relevant IO device in the "Accessible devices" dialog based on the MAC address.
3. Click "Assign name" to download the configured device name to the IO device.

The IO controller recognizes the IO device automatically by its device name and automatically assigns the configured IP address to it.

## Identification of the PROFINET device

To clearly identify a device from several identical devices in a control cabinet, for example, you can flash the link LED of the PROFINET device.

To do this, select the menu command **Online > Accessible devices...** in STEP 7. In the "Accessible devices" dialog, set the "PG/PC" interface by means of which you are connected to the devices. STEP 7 now automatically searches for the accessible devices and displays them in the "Accessible devices in target subnet" table. Select the desired PROFINET device and click on the "Flash LED" button. The PROFINET device is identified based on its MAC address.

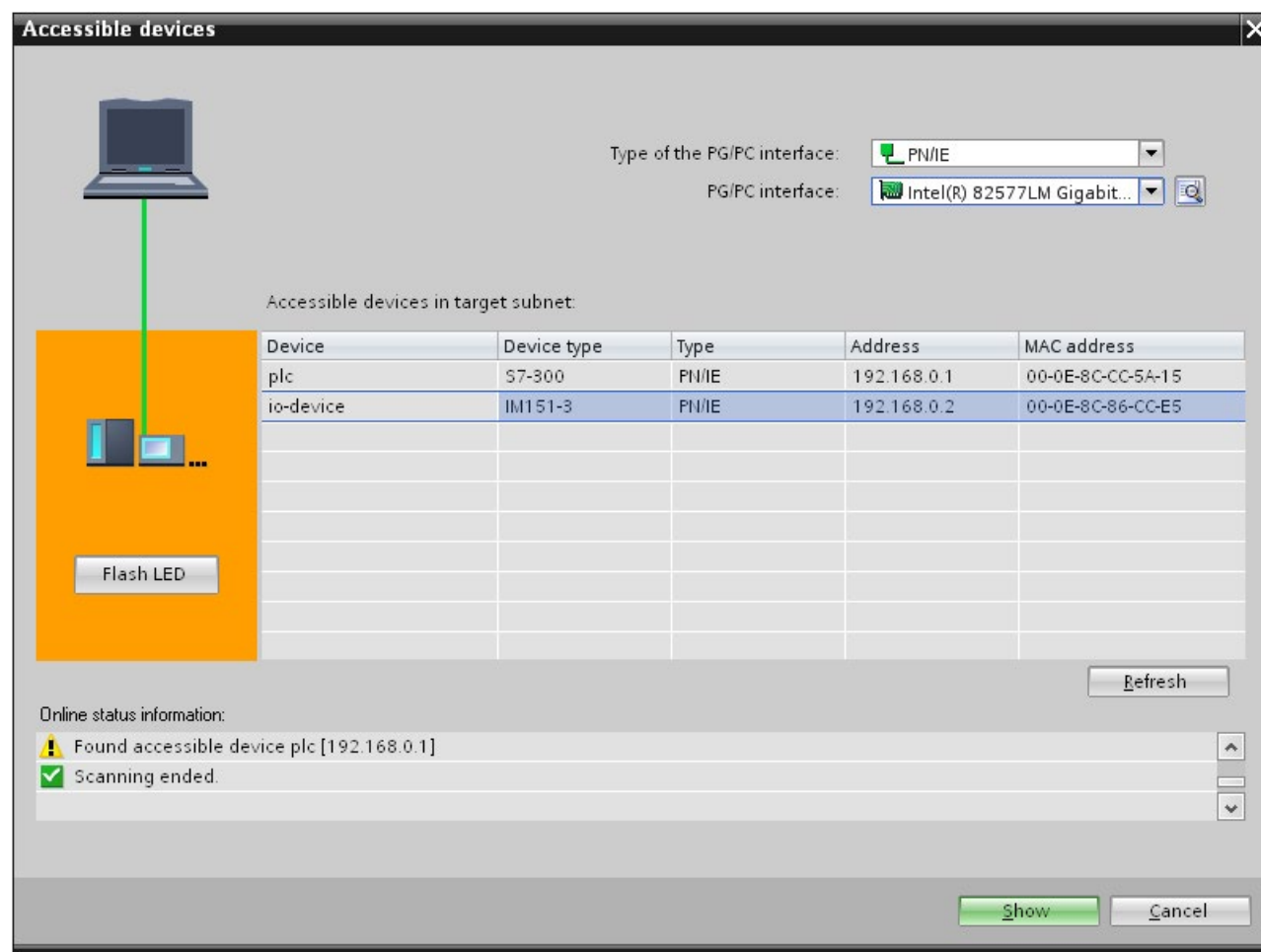


Figure 3-7 "Accessible devices" dialog

## Using an different way to assign IP addresses for IO devices

Various IO devices, for example, SCALANCE X, S7-300 CPs, support the option of not having the IP addresses assigned by the IO controller during startup. In this case, the IP address is assigned in a different way. For additional information, refer to the manual of the respective PROFINET device of the SIMATIC device family.



## Additional information

You can find a detailed description of the operation and functions of the display of the S7-1500 CPUs in the system manual S7-1500, ET 200MP (<http://support.automation.siemens.com/WW/view/en/59191792>).

### 3.2.4 Assign device name via communication table

#### Introduction

You can assign the device names of PROFINET IO devices configured offline to the devices online. You can do this in the table area of the network view in the table "I/O communication". You can also assign the device names to several devices at the same time.

#### "Online assignment" tab

In the I/O communication table, you will find the tabs "Offline configuration" and "Online assignment". In the "Online assignment" tab, you can assign the PROFINET device names that were assigned offline to the corresponding IO devices online. To do this, use the buttons "Check devices" and "Assign now".

Network overview

Connections

I/O communication

VPN

Offline configuration

Online assignment

→

←

Assign device name:

Check devices

Assign now

|   | Partner 1        | ↔ | Partner 2   | Device type     | Project address | PROFINET device name in project |
|---|------------------|---|-------------|-----------------|-----------------|---------------------------------|
| 1 | ▼ IO-Device_1    |   |             |                 |                 |                                 |
| 2 | ▼ PROFINET-IF-IO |   |             | IM 155-6 PN HF  | 192.168.0.2     | io-device_1                     |
| 3 | IE1              | ↔ | PLC_1       | CPU 1512SP-1 PN | 192.168.0.1     | plc_1                           |
| 4 | ▼ PLC_1          |   |             |                 |                 |                                 |
| 5 | ▼ PROFINET-IF-IO |   |             | CPU 1512SP-1 PN | 192.168.0.1     | plc_1                           |
| 6 | X1               | ↔ | IO-Device_1 | IM 155-6 PN HF  | 192.168.0.2     | io-device_1                     |

Figure 3-8 Assign device name via communication table

The objects displayed in the table of the "Online assignment" tab depend on the setting of the filter function. If only selected objects should be displayed, only objects of the corresponding context are displayed depending on the selection in the network view.

- PROFINET subnet: All connected devices and their PROFINET interfaces
- IO system All devices involved and their PROFINET interfaces
- Sync domain: All devices involved and their PROFINET interfaces
- Devices: The device and any existing PROFINET interfaces
- Other subnets or interfaces such as MPI or PROFIBUS are not displayed

If the display is set for all devices using the filter function, all devices are displayed that have a PROFINET interface, regardless of whether they are connected via a PROFINET subnet or are part of an IO system. Devices without a PROFINET interface, for example only with a DP or MPI interface, are not displayed.

## General procedure

To assign PROFINET device names, you must first detect the IO devices available online. With this procedure, it matters whether the MAC addresses are known or unknown. This results in a general procedure in two steps:

1. Detecting the IO devices available online
2. Assigning configured PROFINET device names to the IO devices available online

## Requirements

- You are in the network view.
- There is an online connection to the devices.

## Procedure (step 1)

To detect IO devices available online from the I/O communication table, follow these steps:

1. Optional: Entered known MAC addresses in the "MAC address" column. After every valid entry, the check box under "Assign device" is selected for the relevant row.

---

### Note

You can enter, insert or import the MAC address in different formats. The correct format is automatically entered in the cell. The following entries are supported and then converted to the required format:

- "08:00:06:BA:1F:20"
- "08 00 06 BA 1F 20"
- "080006BA1F20"

The formats used in the example are automatically converted to "08-00-06-BA-1F-20".

---

2. Click "Check devices" to start the check of the IO devices available online.
3. Set the PG/PC interface in the dialog window and click "Start".

## Intermediate result

After the check, the result is displayed for every device in the table. Online data found is automatically entered in the table and the check box "Assign device" is set to "checked" in the rows in which a MAC address was entered or found online. The result of the check is shown as an icon in the "Status" column.

| Status                                                                            | Meaning                                             |
|-----------------------------------------------------------------------------------|-----------------------------------------------------|
|  | Matching device and compatible type                 |
|  | Matching device and incompatible type               |
|  | Non-matching device                                 |
|  | Device cannot be reached (with a known MAC address) |
|  | Ready for assignment (with known MAC address)       |

### Note

The icon "Ready for assignment" appears when a MAC address exists and matching device data was found, but no PROFINET device name was found online.

You can update the data of the detected devices again via their MAC addresses at any time. To do this, you specify the MAC address and the status of the device is displayed immediately without having to re-detect the device.

## Procedure (step 2)

All PROFINET device names configured offline will be assigned to the devices available online in a bulk operation.

1. Click the "Assign now" button.

### Note

The bulk operation cannot be reversed. A message to this effect appears in a dialog window.

2. Click "Start" in the dialog window to start the assignment of the PROFINET device names.

## Result

The PROFINET device names configured offline will be assigned to the devices available online. This relates to devices in whose row the check box under "Assign device" is selected, that have a MAC address and have the status "Ready for assignment".

## Importing and exporting data

Using the import and export button, you can import or export the data of the I/O communication table for the online assignment:

- When you export, the currently displayed data of the table is exported to a CSV file. Using the filter function of the table, you can select which data will be exported.
- When you import, the data of the CSV file is written to the table. If there are conflicts with values already existing in the table, you can decide whether the data should be overwritten or whether the import needs to be stopped.

### 3.2.5 Permitting changes to the device name and IP address directly on the device

#### Introduction

Machines are frequently commissioned on site or integrated into the existing infrastructure without STEP 7. You can find typical applications in all areas of the series machine building. Alternative means for assigning the IP address are available for this.

#### Procedure

1. In the network or device view of the STEP 7 Hardware and Network editor, select the PROFINET interface of an IO controller.
2. Navigate in the Inspector window to "Ethernet addresses".

3. Select the "IP address is set directly at the device" option in the "IP protocol" area.
4. In the "PROFINET" area, select the "PROFINET device name is set directly at the device" check box.

**Internet protocol version 4 (IPv4)**

☐ Set IP address in the project

IP address: 192 . 168 . 0 . 1

Subnet mask: 255 . 255 . 255 . 0

☐ Use router

Router address: 0 . 0 . 0 . 0

☐ IP address from DHCP server

Mode: Use MAC address as client ID

Client ID:

☒ Client ID can be changed during runtime

☒ IP address is set directly at the device

---

**PROFINET**

☒ PROFINET device name is set directly at the device

☒ Generate PROFINET device name automatically

PROFINET device name: plc\_2.profinet-schnittstelle\_1

Converted name: plcxb2.profinet-schnittstellexb199e0

Device number: 0

Figure 3-9 Setting the device name and IP address on the device

## Note

### Gateway

When you operate a PROFINET device with the option "Allow adaption of the device name/IP address directly on device", you cannot use this PROFINET device as gateway for S7 routing.

## Options for assigning IP addresses and device names

Apart from the known address and device name assignment in the "Ethernet addresses" section of the Inspector window, there are other ways in which the IP address and name can be assigned:

- Assigning by means of the user program with the instruction "T\_CONFIG"
- Assignment when downloading the configuration to the target system via the "Extended download to device" dialog box.
- Assignment via the Primary Setup Tool (PST)
- Assignment via the PRONETA ("PROFINET network analysis") commissioning and diagnostics tool
- Assignment via the SIMATIC Automation Tool

### Additional information

For information on the "T\_CONFIG" instruction and on downloading to the target system, refer to the STEP 7 online help.

A free Download (<https://support.industry.siemens.com/cs/ww/en/view/109776941>) of the Primary Setup Tool (PST) can be found on the Internet. On this Internet page, you will also find a list of devices for which the PST is approved.

## 3.3 Configuring an IO device through hardware detection

### Introduction

As of STEP 7 V15, you have the possibility to detect a real existing IO device and to import it into your project.

You find the IO device in STEP 7 through the "Hardware detection" function. A detected device can be imported into your project. STEP 7 inserts the IO device with all the modules and submodules.

### Requirements

- STEP 7 (TIA Portal) as of V15
- It must be possible to technically access the IO device via IP

### Procedure

To detect one or more existing IO devices in STEP 7 and add them to the project, follow these steps:

1. In STEP 7, navigate to "Online" > "Hardware detection".
2. Click "PROFINET devices from network...".  
STEP 7 opens the "Hardware detection of PROFINET devices" window.
3. Select the interface of your programming device at "PG/PC interface:".
4. Click "Start search".  
STEP 7 begins with the hardware detection. When the hardware detection is completed, STEP 7 displays the detected IO devices.
5. Select the IO devices that you want to add to the project by clicking the corresponding check box before the IO device.
6. Click "Add devices".  
After a brief moment, a window is opens to report about the success or failure of the hardware detection.

**Result of the hardware detection**

If the hardware detection is successful, STEP 7 inserts the IO device with all the modules and submodules into the project.

An IO device configured via hardware detection responds as follows:

- Modules configured through the "Hardware detection" are configured as if they have been inserted from the catalog.
- MAC address: STEP 7 imports the MAC address of the detected IO device into the project.
- IP settings:
  - If the detected IO device already has an IP address, STEP 7 imports the IP address into the project.
  - If the detected IO device does not have an IP address, STEP 7 automatically assigns an IP address in the project.

PROFINET device name:

- If the detected IO device already has a PROFINET device name, STEP 7 imports the PROFINET device name into the project.
- If the detected IO device does not have a PROFINET device name, STEP 7 automatically assigns a PROFINET device name in the project.
- IO devices configured through "Hardware detection" have neither an IP subnet nor an IO controller assigned.

## 3.4 Specifying the router for a PROFINET IO device

### Introduction

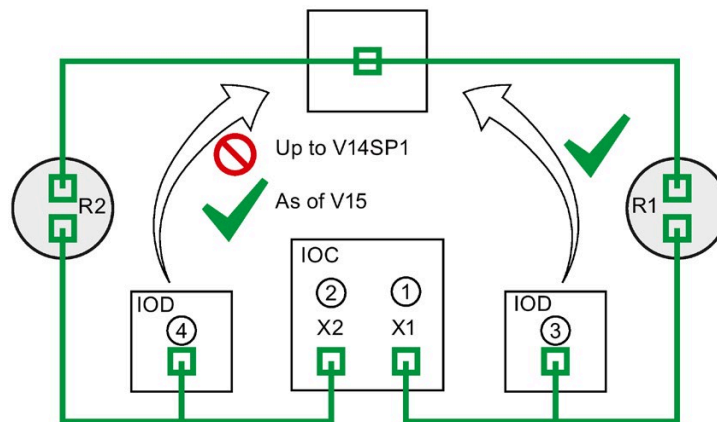
You always require a router (also referred to as a "Standard Gateway") when the PROFINET device has to communicate with a node whose IP addresses lie outside the own IP subnet. If the PROFINET device sends an IP packet to an IP address outside its own IP subnet, the IP packet first goes to the configured router. The router in turn checks the IP address. If this lies outside its own subnet, the router passes the IP packet on to the next router. The IP packet is routed to the next router until it has reached the target address.

Like all S7-1500 CPUs, S7-1500 CPUs with several PROFINET interfaces provide the possibility to configure the IP address of a router. However, there is the restriction that you can only enter the IP address of a router at a PROFINET interface.

You cannot configure an IP address of a router for the other PROFINET interfaces of the CPU. IO devices that are connected to this PROFINET interface adopt this setting. Up to and including STEP 7 V14 SP1, these IO devices did not have any possibility to reach devices in a different IP subnet.

As of STEP 7 V15, you have the possibility to assign the address of a router for an IO device independent of the setting of the IO controller. You can now, for example, set a router address at the IO device in the following cases as well:

- You have not set an IP address of a router for the interface of the associated IO controller.
- You have already set a router address for a different interface in the CPU.



- ① Router R1 configured at PROFINET X1
- ② If a router is configured at X1, you cannot configure a router at X2.
- ③ Because a router is configured at X1, the IO device adopts the IP address of the router R1. The IO device can be reached from a different IP subnet.
- ④ As of STEP 7 V15, you set the IP address of the router R2 at the IO device irrespective of the setting at the interface X2. The IO device can be reached from a different IP subnet.

Figure 3-10 Specifying the router for an IO device



### Further information about the "User router" setting

You have the possibility to configure the use of a router including IP address of the router in the "IP protocol" section of the settings for the PROFINET interface (Ethernet addresses).

#### Rules

Observe the following rules if you want to configure a router for the PROFINET interface of an IO controller:

- A PROFINET IO device supports exactly one router, irrespective of the number of interfaces.
- You can configure a router for exactly one PROFINET interface. All IO devices that are assigned to the PROFINET interface adopt the configured router from the IO controller.
- You cannot configure a router for the further PROFINET interfaces of the CPU. The further PROFINET interfaces take on the IP address "0.0.0.0" as the router and pass it on to their IO devices.

As of STEP 7 V15, you can configure the use of a router for an IO device. This allows the IO device to communicate with a node outside its own IP subnet, irrespective of the setting of the PROFINET interface of the IO controller.

**Configuration example: Configuring a router for an IO device**

The following example shows a configuration in which you configure a router at the IO device so that the IO device reaches IP addresses in the higher-level network.

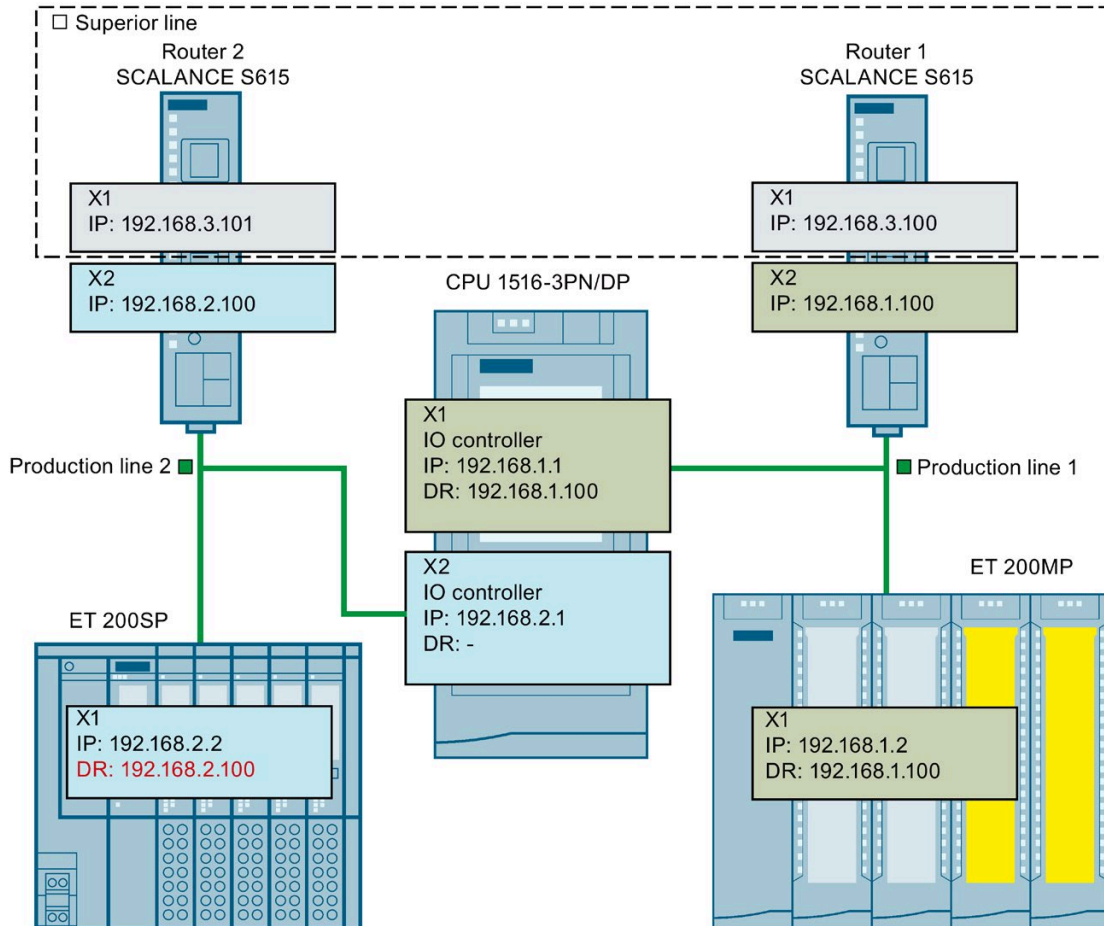


Figure 3-11 Configuration example: Configuring a router for an IO device

You have a CPU 1516-3PN/DP. The two PROFINET interfaces X1 and X2 of the CPU work in the "IO controller" operating mode. The PROFINET interface X1 is connected with the subnet "Production line 1". PROFINET interface X2 is connected with the subnet "Production line 2". The two subnets "Production line 1" and "Production line 2" are each connected via a router with the higher-level network "Superior line".

For PROFINET X1, you configure the router "Router 1" with the IP address 192.168.1.100.

The IO device (ET 200SP) in the "Production line 1" subnet adopts the router from the IO controller.

You cannot configure a router for the PROFINET interface X2 because you have already configured a router for the PROFINET interface X1 of the CPU.

No router is transferred by the PROFINET interface X2 to the IO device in the subnet "Production line 2".

In order for the IO device in the subnet "Production line 2" to reach nodes in the higher-level "Superior line", configure the router "Router 2" with the IP address 192.168.2.100 for the IO device.

### Configuring the router for the IO controller

Requirements: You use the "Set IP address in the project" option for the PROFINET interface.

Follow these steps to configure a router for the IO controller in STEP 7:

1. In the network view of STEP 7, select the PROFINET interface of the IO controller.
2. In the Inspector window, navigate to "Properties" > "General" > "Ethernet addresses".
3. Select the "Use router" check box in the "IP protocol" field.
4. Enter the IP address of the router at "Router address".

### Configuring a router for an IO device

Requirements:

- STEP 7 as of V15
- CPU 1500 as of firmware version V2.5
- IO device is assigned to the PROFINET interface of an IO controller. The PROFINET interface of the IO controller uses the "Set IP address in the project" option.

Follow these steps to configure a router for the IO device in STEP 7:

1. In the network view of STEP 7, select the PROFINET interface of the IO device.
2. In the Inspector window, navigate to "Properties" > "General" > "Ethernet addresses".
3. Clear the "Synchronize router settings with IO controller" check box.
4. Select the "Use router" check box.
5. Enter the IP address of the router at "Router address".

## 3.5 Configuring topology

### Introduction

If an IO device is assigned to an IO controller, this does not yet specify how the ports are connected to each other.

A port interconnection is not required to use RT, but it provides the following advantages:

- A set topology is assigned with the port interconnection. Based on an online-offline comparison, it is possible to conduct a set-actual comparison with all devices that support this function.
- The "Device replacement without exchangeable medium" function can be used.

A port interconnection is an essential requirement for using IRT.

An overview of various options for setting up a PROFINET network is given below.

### Line



All the communication devices are connected in a linear bus topology.

In PROFINET, the linear bus topology is implemented with switches that are already integrated into the PROFINET devices. Therefore, the linear bus topology at PROFINET is merely a special form of tree / star topology.

If a link element (switch, for example) fails, communication across the failed link element is no longer possible. The network is then divided into 2 subsegments.

Linear bus topology structures require the least cabling.

### Star



If you connect communication devices to a switch with more than two PROFINET ports, you automatically create a star network topology.

If an individual PROFINET device fails, this does not automatically lead to failure of the entire network, in contrast to other structures. It is only if a switch fails that part of the communication network will fail as well.

### Tree



If you interconnect several star structures, you obtain a tree network topology.

### Ring



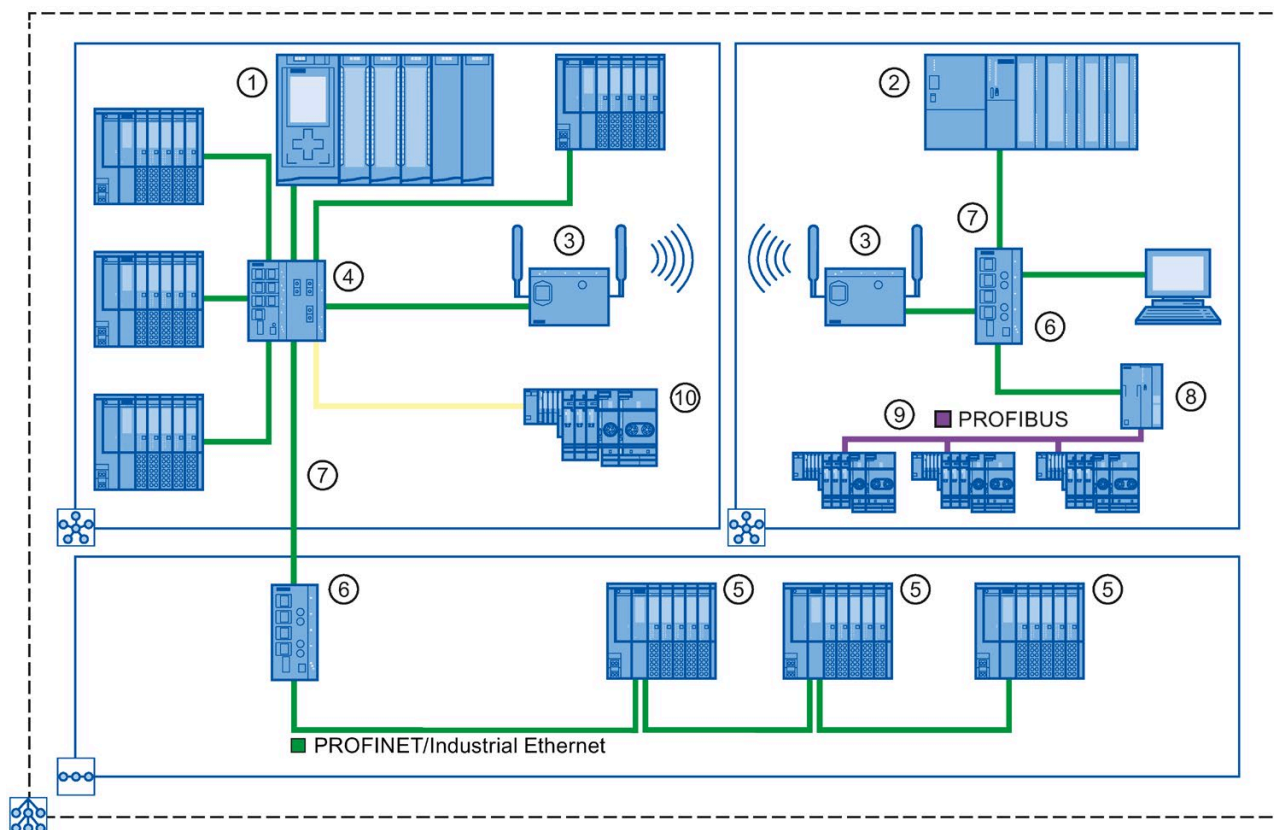
In order to increase the availability of a network, use ring structures. In principle, a linear bus topology is connected to a ring through a so-called redundancy manager.

The task of the redundancy manager is managed by an external switch SCALANCE X, a CPU that supports the Media Redundancy Protocol MRP (e.g., CPU 1516-3 PN/DP) or a CP (e.g., CP 343-1 Lean).

If there is a break in the network, the redundancy manager ensures that the data is redirected over an alternative network connection in the ring.

## Example for topology

The following example shows a combination of different topologies.



| Number                                                                              | Meaning                                                        |
|-------------------------------------------------------------------------------------|----------------------------------------------------------------|
| ①                                                                                   | S7-1500 as IO controller                                       |
| ②                                                                                   | S7-300 as IO controller                                        |
| ③                                                                                   | Industrial WLAN with SCALANCE W                                |
| ④                                                                                   | SCALANCE X 307-3 with seven electrical and three optical ports |
| ⑤                                                                                   | ET 200SP with integrated 2-port switch                         |
| ⑥                                                                                   | SCALANCE X 204 with four electrical ports                      |
| ⑦                                                                                   | PROFINET/Industrial Ethernet                                   |
| ⑧                                                                                   | IE/PB-Link PN IO                                               |
| ⑨                                                                                   | PROFIBUS DP                                                    |
| ⑩                                                                                   | ET 200S with two optical ports                                 |
|  | Star topology                                                  |
|  | Linear bus topology                                            |
|  | The combination of topology forms results in a tree topology.  |

Figure 3-12 Combined topology

### Additional information

Observe the PROFINET Installation Guideline (<http://www.profibus.com/nc/download/installation-guide/downloads/profinet-installation-guide/display/>) of the PROFIBUS User Organization when planning your PROFINET topology.

For more detailed information, see the SIMATIC NET Twisted Pair and Fiber Optic Networks (<http://support.automation.siemens.com/WW/view/en/8763736>) manual.

You can find basic information in the Communication with SIMATIC (<http://support.automation.siemens.com/WW/view/en/1254686>) manual.

## 3.5.1 Topology view in STEP 7

### Introduction

The topology view is one of three working areas of the hardware and network editor. You undertake the following tasks here:

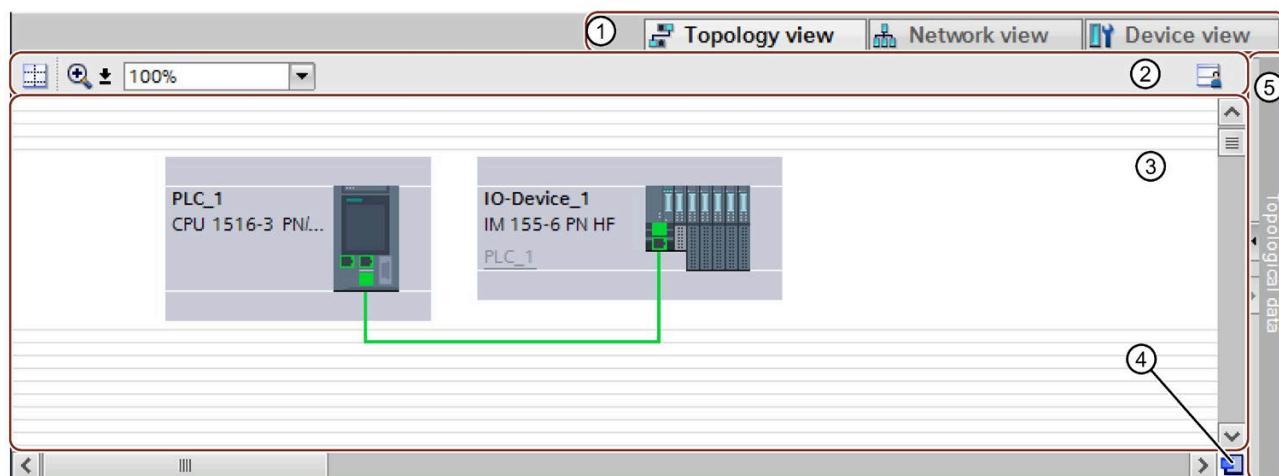
- Displaying the Ethernet topology
- Configuring the Ethernet topology
- Identify and minimize differences between the set and actual topology (online)

The topology view in STEP 7 consists of a graphic area and a table area.

## Graphic area

The graphic area of the topology view displays PROFINET devices with their appropriate ports and port connections. Here you can add more PROFINET devices.

The following figure shows the graphic area of the topology view.



- ① Selector: Device view/Network view/Topology view
- ② Toolbar
- ③ Graphic area of the topology view
- ④ Overview navigation
- ⑤ Selector for the table area of the topology view

Figure 3-13 Graphic area of the topology view

### Overview navigation

Click in the overview navigation to obtain an overview of the created objects in the graphic area. By holding down the mouse button, you can quickly navigate to the desired objects and display them in the graphic area.

## Table area

- Topology overview: This displays the Ethernet or PROFINET devices with their appropriate ports and port connections in a table. This table corresponds to the network overview table in the network view.
- Topology comparison: Here you can import devices and port interconnections automatically through offline/online comparison or extended Offline/Online comparison into STEP 7.

| Device / port              | Slot    | Partner station    | Partner device | Partner interface  | Partner port | Cable data       |
|----------------------------|---------|--------------------|----------------|--------------------|--------------|------------------|
| ▼ S71500/ET200MP station_1 |         |                    |                |                    |              |                  |
| ▼ PLC_1                    | 1       |                    |                |                    |              |                  |
| ▼ PROFINET interface_1     | 1 X1    |                    |                |                    |              |                  |
| Port_1                     | 1 X1 P1 |                    |                |                    | Any partner  | ---              |
| Port_2                     | 1 X1 P2 | ET 200SP statio... | IO device_1    | PROFINET interf... | Port_1       | < 100 m (0.6 µs) |
| ▼ PROFINET interface_2     | 1 X2    |                    |                |                    |              |                  |
| Port_1                     | 1 X2 P1 |                    |                |                    | Any partner  | ---              |
| ▼ ET 200SP station_1       |         |                    |                |                    |              |                  |
| ▼ IO device_1              | 0       |                    |                |                    |              |                  |
| ▼ PROFINET interface       | 0 X1    |                    |                |                    |              |                  |
| Port_1                     | 0 X1 P1 | S71500/ET200...    | PLC_1          | PROFINET interf... | Port_2       | < 100 m (0.6 µs) |

- ① Selector for the graphic area of the topology view
- ② Selector: Device view/Network view/Topology view
- ③ Selector: Topology overview/Topology comparison
- ④ Table area of the topology view

Figure 3-14 Table area of the topology view

### 3.5.2 Interconnecting ports in the topology view

#### Requirement

You are in the graphic view of the topology view.

#### Procedure

To interconnect ports in the topology view, follow these steps:

1. Place the pointer of the mouse on the port you want to interconnect.
2. Press and hold down the left mouse button.



3. Move the pointer.

The pointer now uses the networking symbol to indicate "Interconnecting" mode. At the same time, you see the lock symbol on the pointer. The lock symbol disappears only when the pointer is over a valid target position.

4. Now drag the pointer to the target port. You can keep the left mouse button pressed or release it when performing this action.

5. Now release the left mouse button or press it again (depending on your previous action).

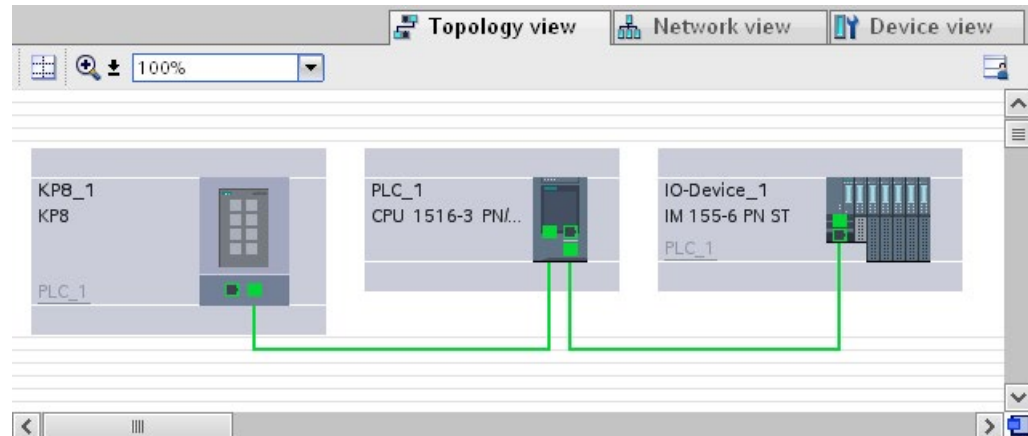


Figure 3-15 Interconnecting ports in the topology view

## Result

You have created a port interconnection.

### 3.5.3 Interconnecting ports - Inspector window

#### Interconnecting ports in the Inspector window

To interconnect ports, follow these steps:

1. In the device or network view, select the PROFINET device or PROFINET interface.
2. In the Inspector window, navigate to the port property "Port interconnection".

When the PROFINET interface is selected, you can find this setting in the Inspector window as follows: "Properties > General > Advanced Options > Port [...] > Port Interconnection."

3. In the "Local port" section, you can find the settings at the local port. In the case of fiber-optic cable you can, for example, set the cable names here.

In the "Partner port" area, select the drop-down list for "Partner port" in order to display the available partner ports and make a selection.

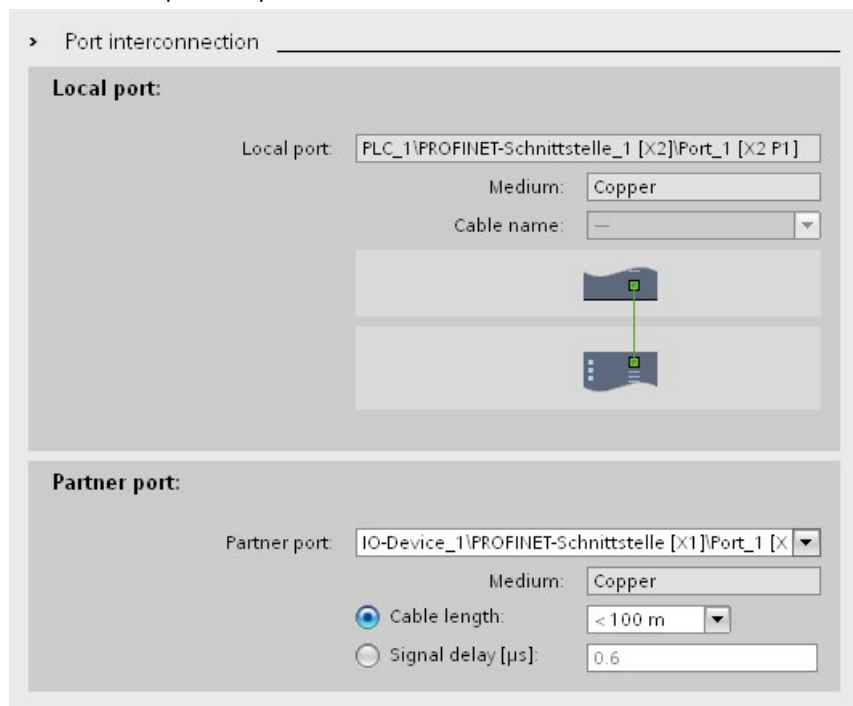


Figure 3-16 Interconnecting ports in the Inspector window in STEP 7

If the PROFINET interface was disconnected, it is automatically connected by this action. In the properties of the subnet you can set whether this subnet should or should not be used for the networking.

### 3.5.4 Automatic assignment of devices by offline/online comparison

#### Overview

During the offline/online comparison, the configured topology is compared with the actual existing topology. Devices identified online are automatically assigned to configured devices as far as this is possible.

#### Start of availability detection

You start the availability detection the first time by clicking the "Compare offline/online" button in the toolbar of the "Topology comparison" tab.

You restart availability detection by clicking the "Update" button.

---

#### Note

The availability detection can take several seconds. During this time, no user input is possible.

---

#### Automatic assignment of a PNIO device

A PNIO device identified online is automatically assigned to a configured device if the following properties of the two devices match up:

- Article no.
- Type
- PROFINET device name

#### No automatic assignment

In the following situations, no automatic assignment is possible:

- No device can be identified online to match a configured device. (This means that the corresponding columns in the "Online topology" area of the topology comparison table are empty.)

In this case, you should add the already configured device to your system or delete the configured device from the configuration.

- A device identified online can be assigned to a configured device, but there are differences in the port interconnections.

In this case, you can Apply the port interconnections identified online manually to the project (Page 1).

- A device identified online cannot be assigned to a configured device. (In this case, the corresponding columns in the "Offline topology" area of the topology comparison table are empty.)

In this case, you can Include the devices identified online manually in the project (Page 1).

### 3.5.5 Apply the port interconnections identified online manually to the project

#### Requirements

You have run an offline/online comparison in the topology view. The result of this is that at least one device identified online was automatically assigned to a configured device, but that there are differences relating to the interconnection.

#### Procedure

To adopt one more port interconnections identified online in the project manually, follow these steps:

1. Select the row belonging to the port interconnection.
2. If applicable, select further roles using multi-selection.
3. Select "Apply" > "Use selected" in the shortcut menu.

The content of the corresponding table cells in the "Action" column changes to "Apply".

4. If you have mistakenly prepared too many port interconnections to be included in the project:

Select the rows belonging to the port interconnections you have mistakenly prepared for inclusion in the project using multi-selection.

Select "Reset" > "Reset selected" in the shortcut menu.

The content of the corresponding table cells in the "Action" column change to "No action".

5. Click the "Synchronize" button.

#### Result

The port interconnections identified online for the corresponding devices are included in the project. Successful adoption is indicated by the diagnostics icon "Identical topology information" for each port.

---

#### Note

If other port interconnections are recognized for a device identified online and these differ from those that exist in the project, adopting these in the project means that the port interconnections that were previously in the project are replaced by those identified online. If no port interconnections are detected for a device identified online, adopting in the project means that all the port interconnections of this device are deleted in the project.

---

### 3.5.6 Include the devices identified online manually in the project

#### Requirements

You have run an offline/online comparison in the topology view. The result of this is that at least one device identified online could not be assigned to any configured device.

#### Procedure

To adopt one more devices identified online in the project manually, follow these steps:

1. For a configured device without an online partner, move the mouse pointer to the "Device/port" column of the online topology.
2. Select the device you want to assign to the configured device from the drop-down list of this box.
3. Repeat the previous steps if necessary for other configured devices without an online partner.

#### Result

The selected device that was identified online is moved up from the end of the table. Following this, it is in the row of the configured device to which you have just assigned it.

### 3.5.7 Automatic assignment of devices by advanced offline/online comparison

#### Overview

With the advanced offline/online comparison, ICMP is also used alongside DCP to be able to detect devices that do not support DCP.

#### Automatic assignment of devices detected by ICMP

With devices detected by ICMP, no type is available.

With passive devices, no article number is available. For this reason, passive devices can only be assigned automatically if you have not assigned an article number in the configured data and the offline and online IP addresses match.

With switches, automatic assignment is possible if the offline and online article number, IP address and PROFINET device name match.

## Diagnostics and maintenance

### 4.1 Diagnostics mechanisms of PROFINET IO

#### Totally Integrated Diagnostics Concept

All SIMATIC products have integrated diagnostics functions that they can use to detect and remedy faults. The components automatically flag a potential fault in the operation and provide detailed information.

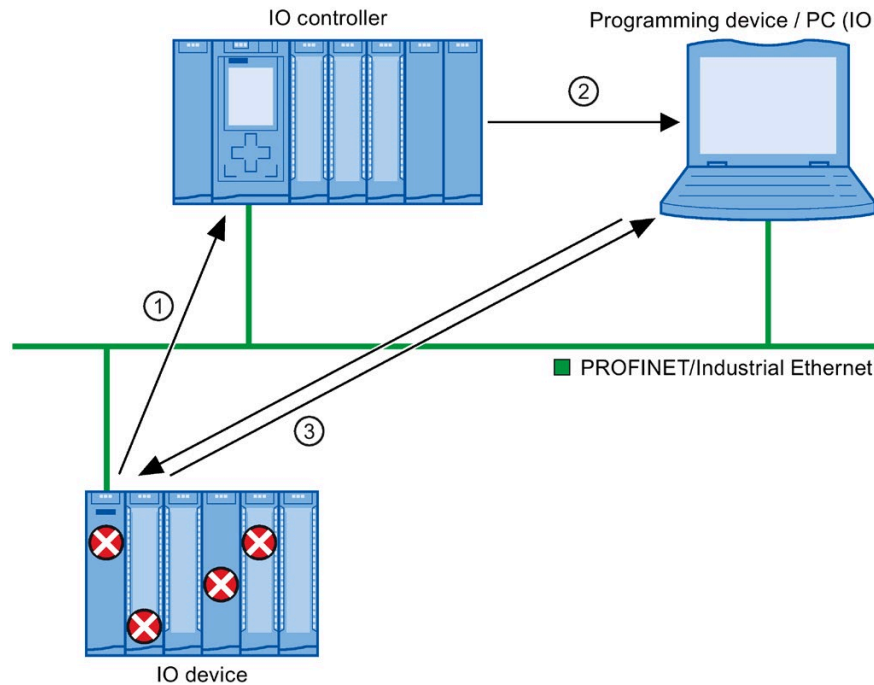
Each individual error or several errors occurring concurrently are transferred from the IO device to the IO controller. If you require the full status of the IO device including any pending errors, you can also read the status directly from the IO device.

The following sections provide basic information on using diagnostics via PROFINET IO. You can find a detailed description of the system diagnostics for S7-1500, ET 200MP, ET 200SP and ET 200AL in the Diagnostics

(<http://support.automation.siemens.com/WW/view/en/59192926>) function manual.

### Accessing the status of an IO device with a PG/PC or an HMI device

If you are connected to the Industrial Ethernet via a PG/PC with STEP 7 or an HMI device, you can also call up diagnostics information online. This is illustrated by the following graphic.



| Number | Description                                                                                                                                                                                                                                                                                                                                                                   |
|--------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| ①      | The IO device detects an error and sends diagnostics data to the IO controller.                                                                                                                                                                                                                                                                                               |
| ②      | The IO controller notifies the programming/HMI device. The display of the system diagnostics is updated.                                                                                                                                                                                                                                                                      |
| ③      | In STEP 7, you can read the station status for "Accessible devices" directly from the IO device regardless of the IO controller. This is only possible if the programming device is connected to Industrial Ethernet.<br>This means that you can access diagnostics information during the commissioning phase or for servicing even if the IO controller is not operational. |

Figure 4-1 PROFINET IO diagnostics with PG/PC or HMI device

### 4.1.1 Diagnostics levels in PROFINET IO

#### Concept

The IO device sends all error messages that occur to the IO controller. The scope and volume of diagnostics information varies according to the level of diagnostics data evaluation and the PROFINET devices you are using.

#### Diagnostics levels

You can evaluate diagnostics data at different levels. The number and type of channels is selected, for example, at the diagnostics level 4.

The following figure shows the diagnostics levels with PROFINET IO.

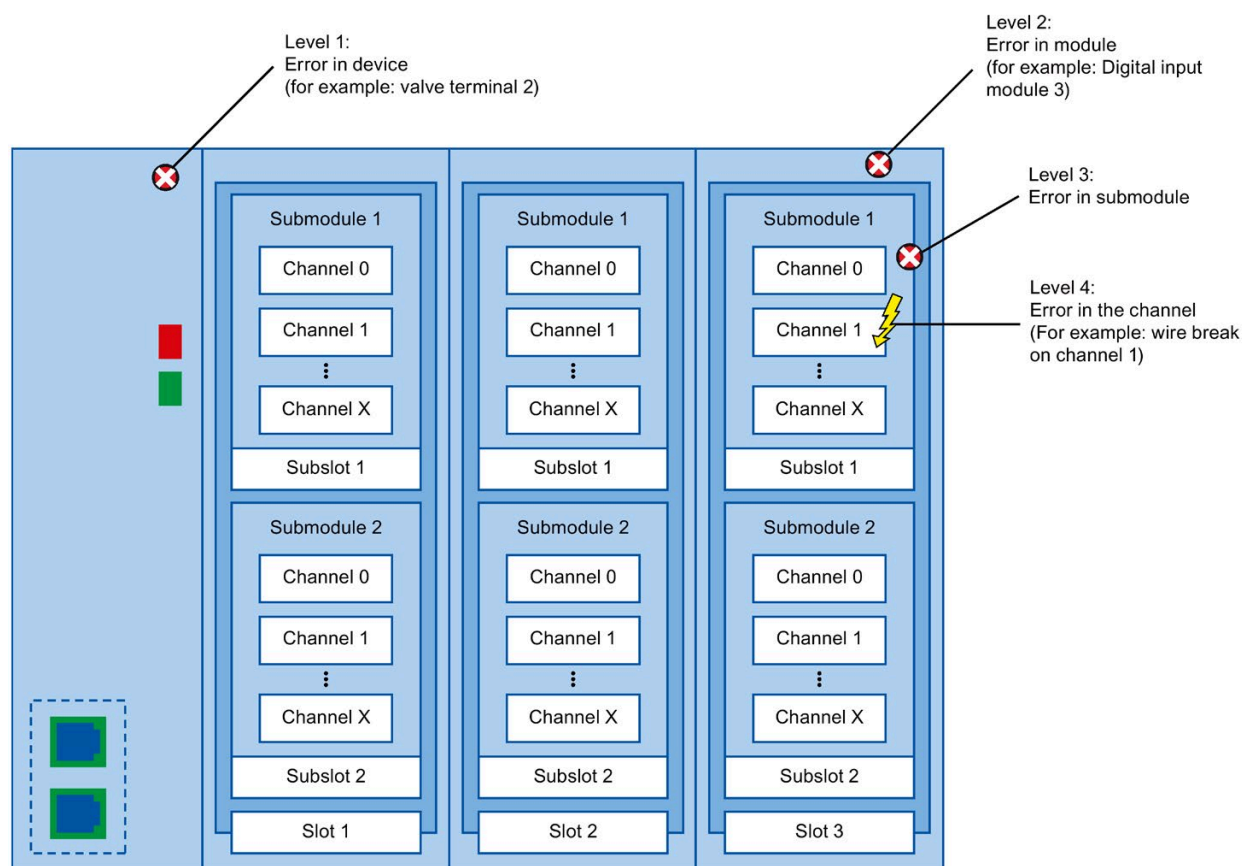
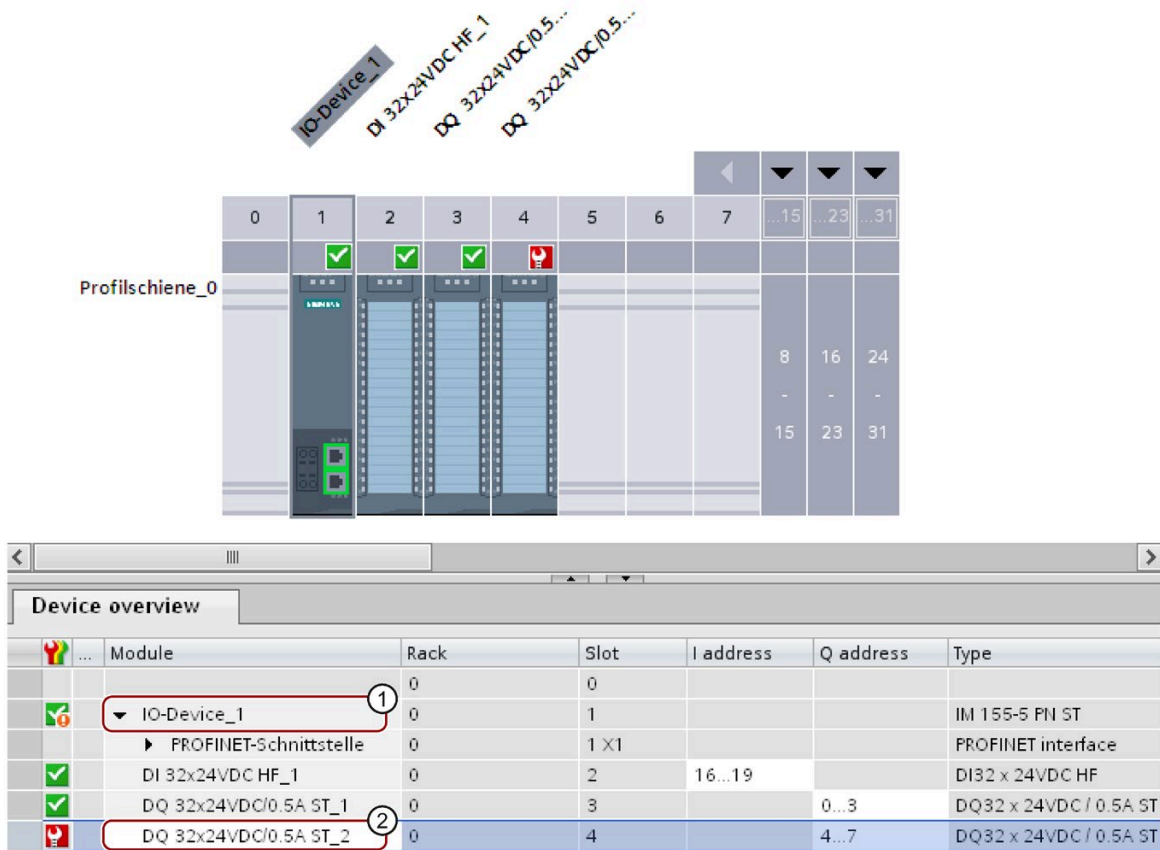


Figure 4-2 Diagnostics levels with PROFINET IO



## Representation of diagnostics levels in the device view in STEP 7

The following figure shows the representation of the PROFINET device model in the device view of STEP 7, based on the example of a distributed I/O system ET 200MP:



### Number Description

- ① Level 1: Error(s) in the device
- ② Level 2: Error(s) in the module

Figure 4-3 Diagnostics levels in the device view of STEP 7

## Which PROFINET nodes support the extended PROFINET diagnostics?

An overview of the PROFINET nodes that support extended PROFINET diagnostics and of what you have to configure is provided in this FAQ

(<https://support.industry.siemens.com/cs/ww/en/view/23678970>).

## 4.2 Diagnostics via LEDs

### LEDs for diagnostics on PROFINET

Each port of a PROFINET interface of a SIMATIC device has one LED.

The following table shows a summary of the meaning of these LEDs in the S7-1500, ET 200MP, ET 200SP and ET 200AL systems.

Table 4- 1 S7-1500, ET 200MP, ET 200SP, ET 200AL: LEDs for diagnostics on PROFINET

| LED image                                                                                               | Meaning                                                                                                                                                                                      | S7-1500        | ET 200MP | ET 200SP | ET 200AL                   |
|---------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------|----------|----------|----------------------------|
|                                                                                                         |                                                                                                                                                                                              | LINK/TX/RX LED |          | LK LED   | P1 Link LED<br>P2 Link LED |
|  LED off               | There is no Ethernet connection between the PROFINET interface of the PROFINET device and the communication partner.<br>No data is currently being sent/received via the PROFINET interface. | X              | X        | X        | X                          |
|  LED green             | There is an Ethernet connection between the PROFINET interface of your PROFINET device and a communication partner.                                                                          | X              | X        | X        | X                          |
|  LED flashes green   | The "LED flashing test" is being performed.                                                                                                                                                  | X              | X        | X        | X                          |
|  LED flickers yellow | Data is currently being received from or sent to a communications partner on Ethernet via the PROFINET interface of the PROFINET device.                                                     | X              | X        | -        | -                          |

### Additional information

You can find a detailed description of all LEDs of the module with cause of the error and remedies in the relevant documentation for the module.

## 4.3 Diagnostics via the display of the S7-1500 CPUs

### Display

The S7-1500 CPU has a display and operating keys. The display of the CPU shows you the control and status information in different menus. You use operating keys to navigate through the menus and make a variety of settings in the process.

### Diagnostics via the display

The following indicators can be evaluated for diagnostics purposes on the display:

- Error and alarm texts (system diagnostics, alarm messages)
- Module status for central and distributed modules

In the following example of a display of the CPU 1516-3 PN/DP, you can see a warning on the diagnostics icon and an exclamation mark on the icon for module.

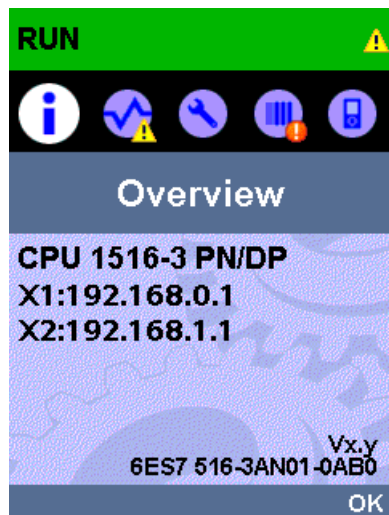


Figure 4-4 Display of overview

## Module status

To show the module status, navigate on the display through the menu items "Module" > "PROFINET I/O (X1)" > "Station" > "Slot" > "Status" > "Module status".

The module status indicates that a fault has occurred in the module. The "lower-level status" is the status of the module in the diagnostics level below this. In the example, the status is "good", i.e., the fault is not in the lower diagnostics level submodule or channel, but instead in the module.

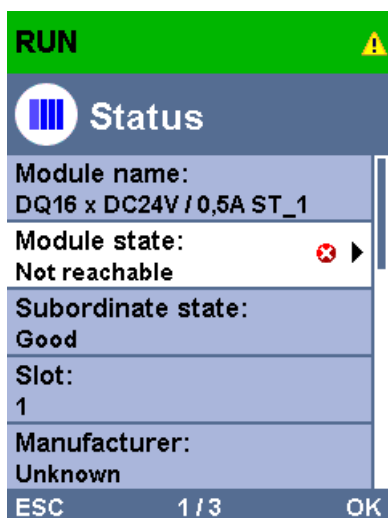


Figure 4-5 Display of module status

## Error and alarm texts

You can show diagnostics buffer entries and alarm messages for the relevant automation system on the display.

To show the diagnostics buffer entries of the CPU, navigate on the display via the menu items "Diagnostics" > "Diagnostics buffer".

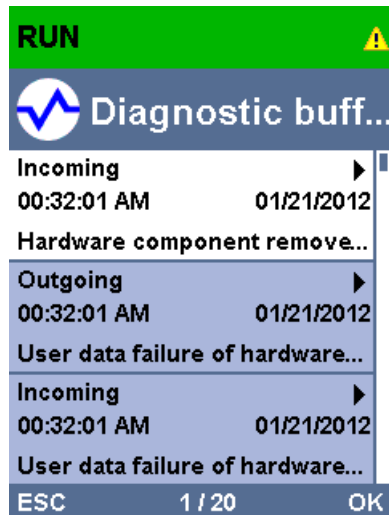


Figure 4-6 Display of diagnostics buffer

To show the alarm messages of the automation system, navigate through the menu items "Diagnostics" > "Alarms" > "Alarm text" on the display.

---

### Note

#### Updating the alarm display

The display shows the currently read status of the CPU in static form, the display is not automatically updated. The alarm display is updated after it has been exited and opened again.

You set the automatic updating of the diagnostics information under: "Display" > "DiagnosticRefresh".

---



Figure 4-7 Display of alarms

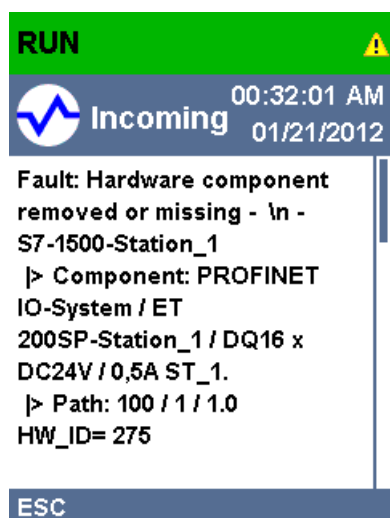


Figure 4-8 Display of alarm message

### Additional information

You can find the description of the operation and functions of the display in the SIMATIC S7-1500 Display Simulator ([http://www.automation.siemens.com/salesmaterial-as/interactive-manuals/getting-started\\_simatic-s7-1500/disp\\_tool/start\\_de.html](http://www.automation.siemens.com/salesmaterial-as/interactive-manuals/getting-started_simatic-s7-1500/disp_tool/start_de.html)).

## **4.4 Diagnostics via Web server**

The CPUs belonging to the S7 family have their own integrated Web server with a wide range of functions.

The following diagnostics options are available to you:

- Start page with general CPU information
- Information on diagnostics
- Contents of the diagnostics buffer
- Module information
- Alarms
- Information about communication
- PROFINET topology
- Motion Control diagnostics
- Trace
- Contents of the diagnostic buffer
- Module status
- Actual topology of the PROFINET system
- Set topology of the PROFINET system (from the configuration)

## Set topology and actual topology - graphic view

Requirements for displaying the set and actual topology:

- You have configured the PROFINET ports in the topology editor of the hardware and network editor of STEP 7.
- You have loaded the entire project with STEP 7 in the CPU.

The following shows an example of the graphic view.

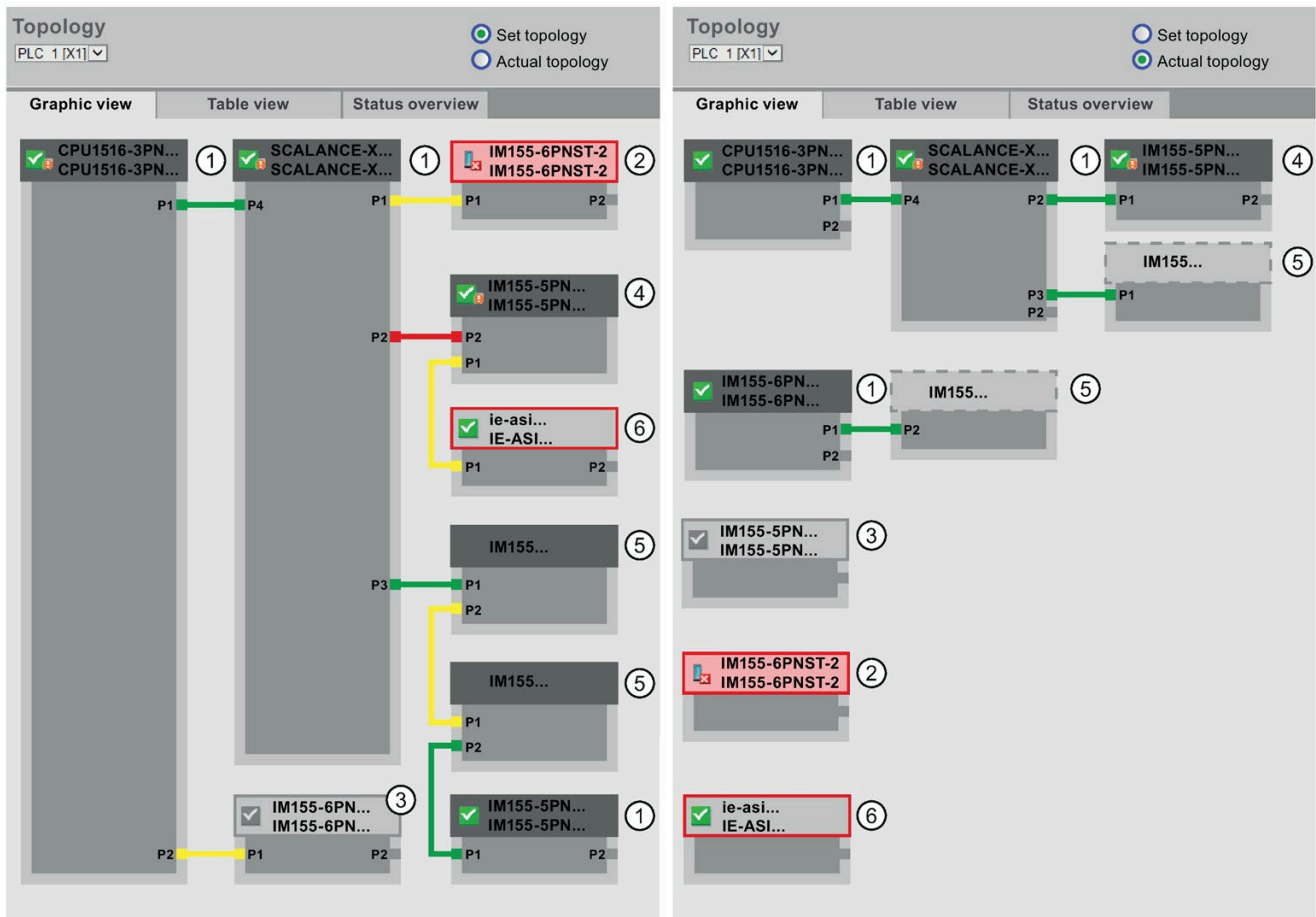


Figure 4-9 Topology - graphic view via the Web server



Meaning of the colored connections in the set/actual topology:

Table 4- 2 Meaning of the colored connections in the set/actual topology:

| Connection | Meaning                                                                                                                                                                                                                                                                                                       |                      |
|------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------|
|            | Set topology                                                                                                                                                                                                                                                                                                  | Actual topology      |
| green      | The current actual connection matches the configured set connection.                                                                                                                                                                                                                                          | detected connections |
| red        | The current actual connection does not match the configured set connection (e.g., port interchanged).                                                                                                                                                                                                         | -                    |
| yellow     | The connection cannot be diagnosed. Causes: <ul style="list-style-type: none"> <li>• The communication to an IO device has been disrupted (e.g., cable removed)</li> <li>• Connection to a passive component</li> <li>• Connection to PROFINET devices of another IO controller or PROFINET system</li> </ul> | -                    |

#### ① Configured and accessible PROFINET devices

Configured and accessible PROFINET devices are displayed dark-gray. Connections show the ports through which the PROFINET devices of a station are connected.

#### ① Configured but not accessible PROFINET devices

The configured but not accessible PROFINET devices are displayed in pink with red border (e.g., device has failed, cable disconnected).

#### ③ Disabled devices

All disabled, configured PROFINET devices are displayed light-gray.

#### ④ Interchanged ports

Interchanged ports are marked red in the set topology view. The currently connected ports are displayed in the actual topology, the configured set connection in the set topology.

### ⑤ PROFINET devices of another PROFINET IO system

- In the set topology:

A PROFINET device of another PROFINET IO system is displayed with a green connection (or red connected if the ports have been interchanged), when it is directly adjoining a configured and accessible PROFINET device ① and it is also accessible. When the PROFINET device of another PROFINET IO system is not accessible, a yellow connection line is displayed.

The connection between two PROFINET devices that both belong to a different PROFINET IO system, cannot be determined and is always displayed in yellow.

- In the actual topology:

A PROFINET device of another PROFINET IO system is only displayed if the PROFINET device is in direct proximity to a configured PROFINET device. The PROFINET device is displayed light-gray and with dashed line.

For PROFINET devices of a different PROFINET IO system, **no** status display is shown on the device head.

### ⑥ Representation of faulty neighbor relations

The devices whose neighbor relations cannot be read out completely or correctly are displayed light-gray with red border.

### Additional information

The tabular view of the actual topology and the status overview of the PROFINET devices in the project are possible.

You can find these views, additional topology examples, and detailed information on the operation and the functions of the Web server in the Web server (<http://support.automation.siemens.com/WW/view/en/59193560>) manual.

## 4.5 Online diagnostics with STEP 7

For PROFINET, you have the following options to evaluate diagnostics in STEP 7:

- Online & diagnostics - Devices & networks
- Online & diagnostics - diagnostics of PROFINET ports

### Online & diagnostics network view

In the hardware and network editor (launched from the "Project tree" by double-clicking "Devices & networks"), you can get an overview of the current state of your system by clicking on the "Go online" button. It also shows the configuration information (for example, non-configured modules). This option is also available in the topology view in similar form.

Schematic drawing of the network view (online):

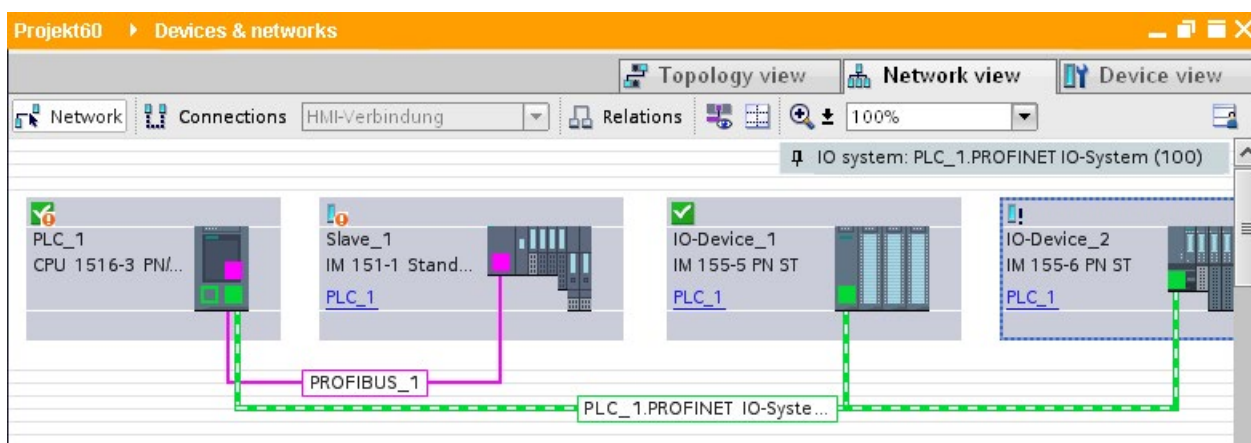


Figure 4-10 Online & diagnostics network view

## Online & diagnostics device view

In STEP 7, you can display an overview of the modules in which faults have occurred. To do this, select the menu command "Online > Online & diagnostics". Once you are connected, you can see the status of the accessible devices in the project tree.

Double-click the device which displays an alarm message to access the faulty module directly. The device view is opened in the work area. In the device view of the device that reports the fault you can see directly in which module the fault occurs.

Open the "Diagnostics" tab and the subordinate "Device information" tab in the Inspector window for a more detailed error description.

Schematic drawing of the device view (online):

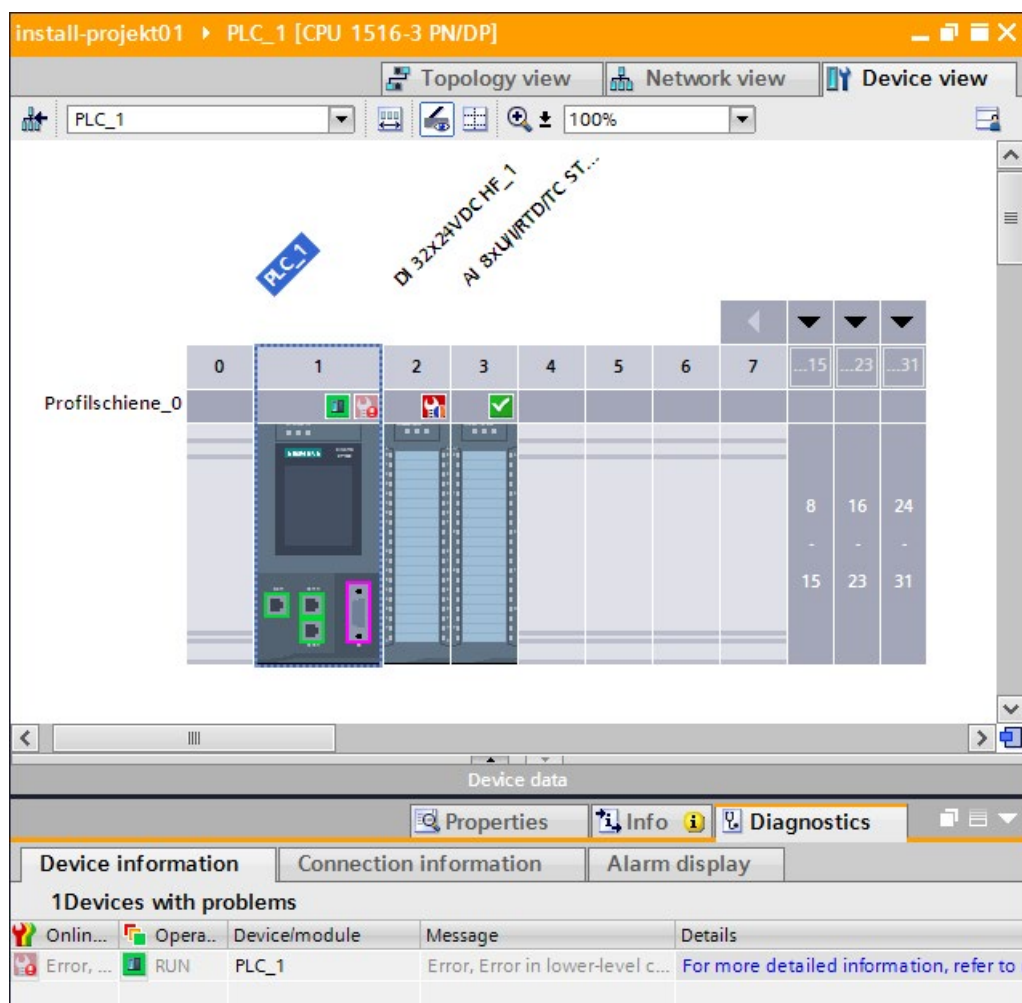


Figure 4-11 Online & diagnostics device view

## Diagnostics of PROFINET ports

If you select "PROFINET interface > Ports" in the Diagnostics area in the online & diagnostics device view of a PROFINET device, the ports of the PROFINET interface are listed in a table.

The table provides you with the following information about the ports of the PROFINET interface.

- Name
- Status
- Settings
- Operating mode

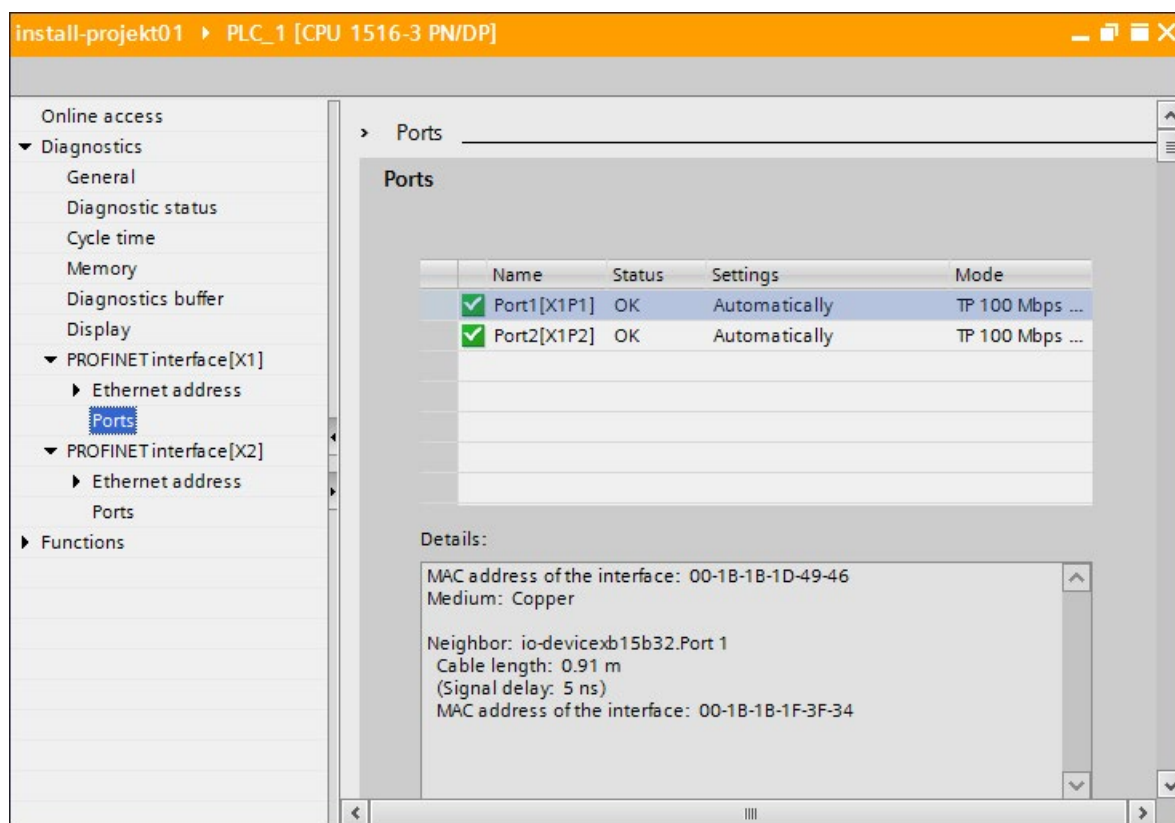


Figure 4-12 Diagnostics of PROFINET ports in STEP 7

## Additional information

You can find information on the system diagnostics for S7-1500, ET 200MP, ET 200SP and ET 200AL in the Diagnostics

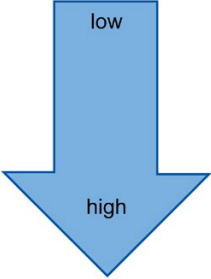
(<http://support.automation.siemens.com/WW/view/en/59192926>) function manual and online help for STEP 7.

## 4.6 Extended maintenance concept

### Extended maintenance concept

The PROFINET interfaces with integrated switch of the SIMATIC devices support the four-level diagnostics concept in accordance with PROFINET specification Version V2.3 or higher with the following status:

Table 4- 3 Classification of the diagnostic status

| Diagnostic status    | Symbol          |                                                                                     | Severity of the error                                                               |
|----------------------|-----------------|-------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------|
| Good                 | Green checkmark |  |  |
| Maintenance required | Green wrench    |  |                                                                                     |
| Maintenance demanded | Yellow wrench   |  |                                                                                     |
| Bad                  | Red wrench      |  |                                                                                     |

The aim of the diagnostics concept is the early detection and elimination of potential faults - before they cause a production outage.

Other status information is defined in addition to the Good (no fault) and Bad (fault) status information for a PROFINET device.

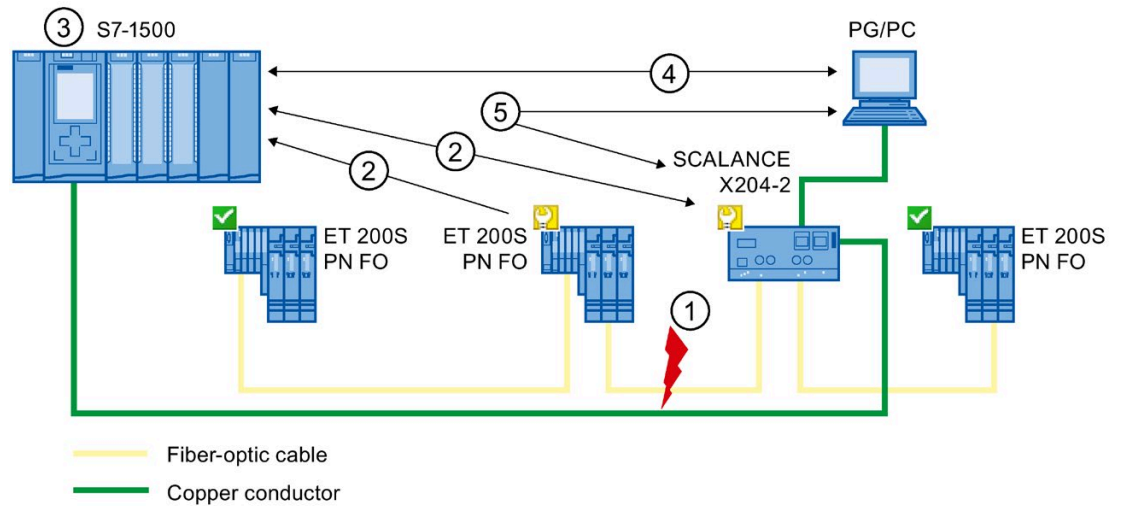
The maintenance information is generated with the following system alarms:

- Maintenance required (symbolized by a green wrench) and
- Maintenance demanded (symbolized by a yellow wrench)

The times at which the two system alarms are generated can be customized for most wear parameters.

### Example: Maintenance demanded for a PROFINET cable

The following graphic illustrates how diagnostics information is exchanged when the transmission quality on the optical cable decreases due to ageing, for example. In this example, the scenario is considered after a maintenance required has already been diagnosed.



- | Num-<br>ber | Description                                                                                                                                                                                                                                                                                                                                                                                                             |
|-------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| ①           | The system reserve of the fiber-optic cable drops below 0 dB.                                                                                                                                                                                                                                                                                                                                                           |
| ②           | Both the ET 200S PN FO and the switch send the maintenance demanded alarm to the IO controller.                                                                                                                                                                                                                                                                                                                         |
| ③           | Based on the interrupts, the IO controller detects the maintenance demanded from the switch and from the IO device. The module information data is updated in the IO controller and the corresponding error OBs are called. Note: To be able to start the error OBs in the IO controller, the "Call the user program if communication errors occur" property must be selected in STEP 7 for the relevant IO controller. |
| ④           | In STEP 7 (on the programming device/PC), the maintenance demanded message is indicated on the IO device and at the switch by a yellow wrench symbol.                                                                                                                                                                                                                                                                   |
| ⑤           | STEP 7 can also read out detailed information directly from the switch.                                                                                                                                                                                                                                                                                                                                                 |

Figure 4-13 Maintenance demanded for a PROFINET cable

## 4.7 Diagnostics of the network topology

### Availability

As an open standard, you can use any SNMP based systems or software solutions for diagnostics in PROFINET.

### Network diagnostics

The network management protocol SNMP (Simple Network Management Protocol) uses the wireless UDP transport protocol. It consists of two network components, similar to the client/server model. The SNMP manager monitors the network nodes and the SNMP clients collect the various network-specific information in the individual network nodes and store it in a structured form in the **MIB** (Management Information Base). This information allows a network management system to run detailed network diagnostics.

### MIB

The MIB (Management Information Base) is the database of a device. SNMP clients access this database in the device. The S7 device family supports the following standard MIBs:

- MIB II, standardized in the RFC 1213
- LLDP-MIB, standardized in the international standard IEC 802.1AB
- LLDP-PNIO-MIB, standardized in the international standard IEC 61158-6-10

You will find the MIBs for ET 200 interface modules and couplers with PROFINET interface in this product note (<https://support.industry.siemens.com/cs/ww/en/view/109770525>).

### Detecting the network topology

LLDP (Link Layer Discovery Protocol) is a protocol that is used to detect the closest neighbor. LLDP enables a device to send information about itself and to receive information from its neighbor devices. This information is then saved in the LLDP MIB, for example, and can be queried using SNMP. This information allows a network management system to determine the network topology.

### Use of SNMP (Simple Network Management Protocol)

SNMP can be used as follows:

- By users to integrate network diagnostics into a central HMI/SCADA system using the SIMATIC NET OPC server
- By the IT administration of machine and plant operators to monitor their Industrial Ethernet network using standard network management systems.
- By the IT administration, to monitor the automation network, alongside the office network, using standard network management systems.

### Use of SNMP in the SIMATIC NET environment

SNMP-compliant devices from the SIMATIC NET family can be monitored and operated via a conventional standard Internet browser. The management system known as web-based management offers a wide range of device-specific information (network statistics, status of redundant supply, for example).



## **4.8 Diagnostics in the user program**

### **4.8.1 Diagnostics and configuration data records**

#### **Diagnostics mechanism**

The IO device outputs a diagnostics interrupt to the IO controller when it detects faults such as wire break on an IO module. This interrupt calls a corresponding organization block in the user program (diagnostics interrupt OB82), in order to generate a defined (programmed) response to the fault and passes a diagnostics data record.

#### **Diagnostics data records in PROFINET IO**

There are two different types of diagnostics data record:

1. Channel diagnostics data records

Channel diagnostics data records are generated if a channel is in an error state and / or has triggered an interrupt.

A diagnostics data record of length 0 is returned if there is no fault.

2. Vendor-specific diagnostics data records

The structure and size of vendor-specific diagnostics data records depend on the vendor's settings.

For information about vendor-specific diagnostics data records, refer to the appropriate device manual.

## Addressing levels of diagnostics data records

Diagnostics and configuration data is evaluated at the following addressing levels:

- Device level
- AR (Application Relation)
- API (Application Process Identifier)
- Slot
- Subslot

A group of diagnostics and configuration data records are available for each address level (exception: device level always 0xF80c). In HEX representation, the individual groups of data records are distinguished by the first letter of the data record number.

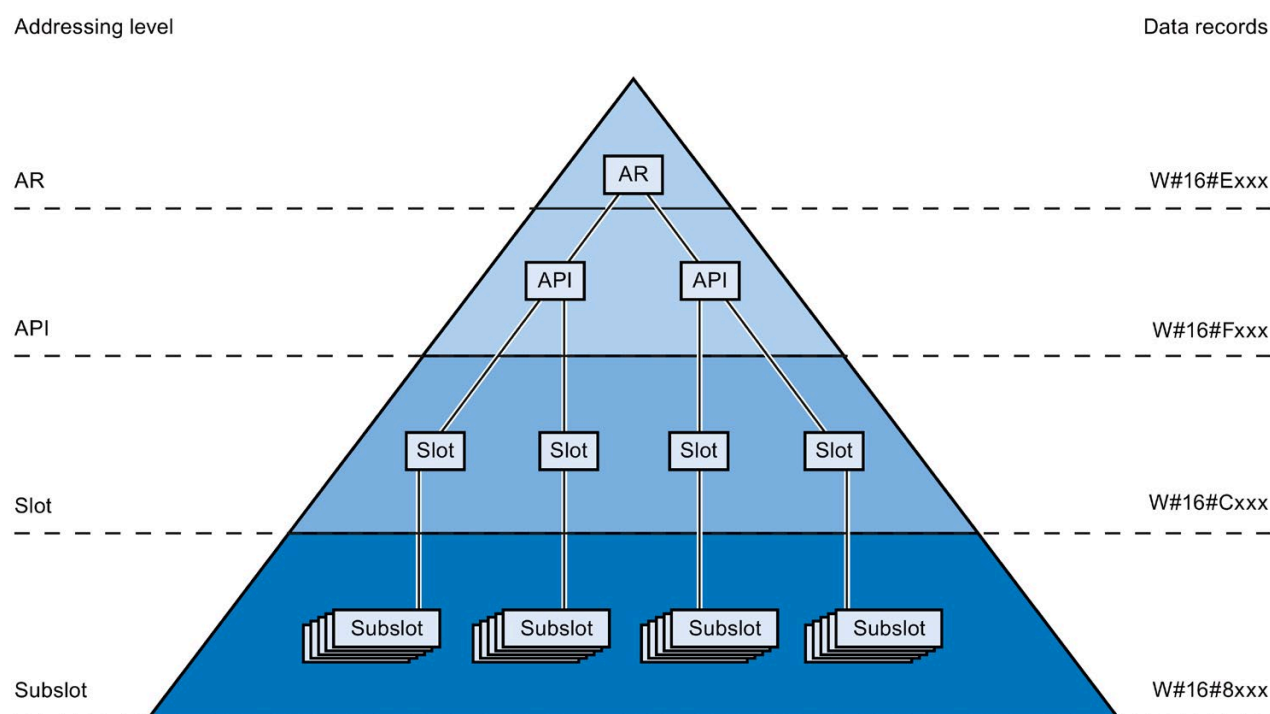


Figure 4-14 Addressing levels of diagnostics data records

The information for each IO device (addressing level AR), module (addressing level slot) or submodule (addressing level subslot) is always transferred in separate diagnostics or configuration data records. The data record returns diagnostics data or configuration data for one or more subslots, slots and APIs, depending on the addressing level.

### Note

The diagnostics information is only generated for configured modules / submodules / channels.

### **Library for PROFINET data records**

The "LPNDR" block library contains various function blocks. You can use these blocks to read out various device and status information from a PROFINET device and write parameters.

You can execute the following functions using the library blocks:

- Read device information:
  - Information about the interface, e.g. IP and MAC address
  - Information about the device interface, e.g. status, medium, name
  - Information about the link status of the interfaces, e.g. link down, link up
  - Information about the role of the device for MRP, e.g. client, manager
  - Information about the port statistics, e.g. number of received bytes
- Read the MRP status
- Modification of the parameters of analog input module of the ET 200SP in runtime, e.g. in order to disable/enable the channel diagnostics.

The finished functions are freely adaptable and can therefore be used universally.

The "LPNDR" block library with an example project can be found on the Internet (<https://support.industry.siemens.com/cs/ww/en/view/109753067>).

## **4.8.2 Evaluate diagnostics in the user program**

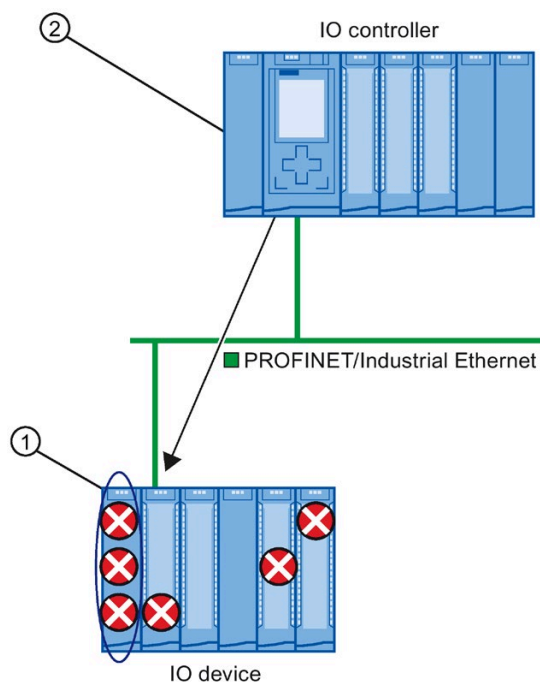
### **Diagnostics in the user program**

For PROFINET IO, a cross-vendor structure of data records with diagnostics information applies. Diagnostics information is created only for channels on which a fault has occurred. With PROFINET, there are two basic ways to obtain diagnostics information.

## 1. Evaluating the diagnostics status

Read out the diagnostics of your PROFINET IO system using the instructions "DeviceStates" and "ModuleStates" to localize faulty stations / modules or station / modules with maintenance demanded or maintenance required within a PROFINET IO system.

The instruction RDREC (read data record) is then used to read various diagnostics data records directly from the module concerned and thus obtain detailed information about the error.

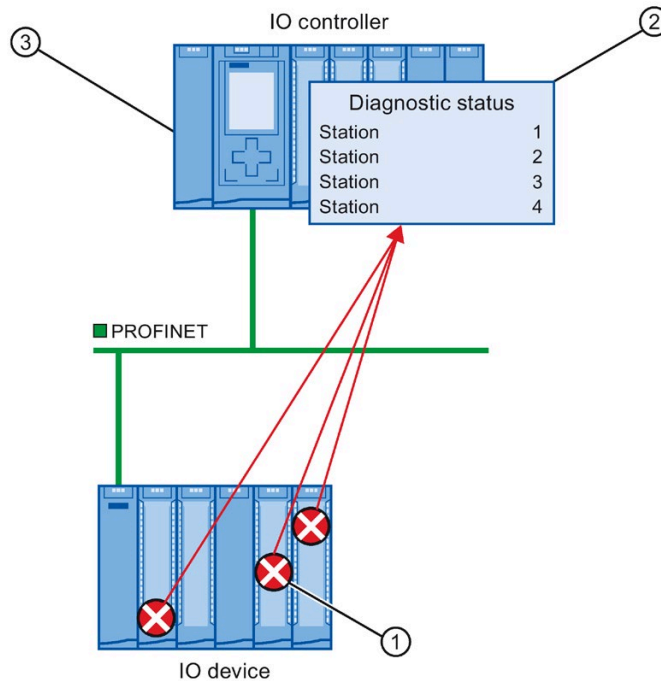


| Num-ber | Description                                                                                                               |
|---------|---------------------------------------------------------------------------------------------------------------------------|
| ①       | All individual errors are collected in a single data record on the interface module.                                      |
| ②       | In your user program, the instruction "RDREC" reads the entire station status asynchronously directly from the IO device. |

Figure 4-15 Example: Evaluating diagnostics data records with the instruction "RDREC"

## 2. Evaluation of interrupts

When the error OB (OB 82) is called, the OB's start information provides you with information on the cause and location of the error. Detailed information on the error event can be obtained in the error OB using the instruction "RALRM" (read additional interrupt information).



| Number | Description                                                                                                                                                  |
|--------|--------------------------------------------------------------------------------------------------------------------------------------------------------------|
| ①      | Every error is sent to the IO controller individually as channel diagnostics information in the form of an interrupt.                                        |
| ②      | In the IO controller, the module status data is updated automatically and the error OB (OB 82) is started.                                                   |
| ③      | In your user program in the error OB (OB 82), the instruction "RALRM" reads the error synchronously from the IO controller without addressing the IO device. |

Figure 4-16 Diagnostics with OB 82 and the instruction "RALRM"

## Instructions and OBs

You will find information on the instructions and OBs in the STEP 7 online help.

## 4.9 Maintenance

### 4.9.1 I&M data (identification and maintenance)

#### Definition and properties

Identification and maintenance data (I&M) is information saved to module memory in order to provide support when:

- Checking the plant configuration
- Locating hardware changes in a plant

Identification data (I data) is module information (some of which may be printed on the module housing) such as the order and serial number. I data is read-only vendor-specific module data.

Maintenance data (M data) is plant-specific information such as the location identifier and installation date. M data is created during configuration.

The modules can be uniquely identified in online mode by means of the I&M data.

#### Further information

To find out whether and to what extent a PROFINET device supports I&M data, refer to the documentation of the relevant device.

### 4.9.2 Loading I&M data to PROFINET IO devices and your modules

#### Which I&M data can be loaded to PROFINET IO devices and your modules?

You can load I&M 1 data (plant designation and location identifier) and/or I&M 2 data (installation date) and/or I&M 3 data (additional information) to the actual hardware.

#### Requirements

- In the project settings (Options > Settings, Hardware configuration > Compiling and downloading), the option "Download I&M data" must be enabled.
- There is an online connection to the PROFINET IO devices and the modules to which you want to load I&M data.
- You have entered the I&M data you want to download in the properties of the respective PROFINET IO devices and your modules (Inspector window: "Properties" tab > "General" tab, Settings > Identification & Maintenance).

**Where do I specify which I&M data is downloaded to which PROFINET IO devices?**

You specify which I&M data you want to download to which PROFINET IO devices in the "Load preview" dialog. You will find the following alternatives in the drop-down list of the "Identification and maintenance data (I&M)" row:

- Load nothing

The check boxes for all PROFINET IO devices as well as the check boxes for the loadable I&M data are cleared.

No I&M data is transferred to the actual hardware during loading with this setting.

- Load data

The check boxes for all PROFINET IO devices as well as the check boxes for the loadable I&M data are selected.

The respective I&M 1, I&M 2 and I&M 3 data is transferred to all PROFINET IO devices during loading with this setting.

- Load selected

You select the check boxes of those PROFINET IO devices to which you want to load I&M data. You also select the check boxes of the identification data you want to load.

With this setting, you transfer the selected I&M data to the selected PROFINET IO devices during loading.

---

**Note****Language dependency of the I&M data to be loaded**

The I&M data are loaded to the real hardware in the form that you specified in the properties of the relevant PROFINET IO devices and your modules. There is no language dependency.

---

## **4.9.3 Asset management**

### **4.9.3.1 Further information about asset management at PROFINET**

Operation of machines and plants without a detailed knowledge of devices and assets is difficult to imagine.

Maintenance requires data for this – data that is extensive and up-to-date as far as possible.

The requirement of greater transparency with regard to the data made available by plant components has been fulfilled by PROFIBUS & PROFINET International (PI): The identification and maintenance data familiar since PROFIBUS times have been extended.

The current PROFINET fulfills this requirement through the definition of a special data record: the Asset Management Record (AMR).

The aim of this definition is to enable you to acquire **all** the components to be maintained online - and not only those components that can be addressed and accessed through the PROFINET device model (Device / Module / Submodule). PROFINET now also reaches non-PROFINET components!

## Assets general and asset management data records

**Assets** are components (hardware and software / firmware) of a machine, for example a laser welding machine, or a plant.

A large number of these device components can already be identified through tried-and-tested I&M functions or corresponding data records (I&M0 to I&M5) in the PROFINET context: The device itself as well as its modules and submodules. Meaning all components that can be addressed through the PROFINET device model.

Components that **cannot** be addressed via the PROFINET device model, but whose data it should be possible to acquire online for operation and maintenance, can be identified through **asset management** functions. This asset management data (short: AM data) is stored in a defined structure in a special data record, the **asset management record** (AMR) mentioned above.

The PROFINET Guideline "Identification & Maintenance Functions" differentiates here between I&M functions (I&M data) and asset management functions (AM data): The following sections only deal with the AM data.

The components that can be read additionally online through asset management data records include both hardware components, such as backplane bus modules of a device as well as firmware components such as a drive control unit with own versioning.

## Application examples

Importing asset management records enables you to read the following information during installation or operation, for example:

- Are only approved devices being used (whitelist check)?
- A firmware update is due. Obtain a fast overview: Which devices or components are affected and have to be upgraded?

## Making asset management data available

The concept for the asset management of PROFINET devices stipulates that the manufacturers of PROFINET devices have to ensure that non-PROFINET automation components are made available through an asset management record. This data record is assigned to the PROFINET device.

In contrast to a "standard" IO device, with an I-device the project engineer has to make the asset management record available. In this case, the central modules of the I-device are assets. From the perspective of PROFINET, these central modules are not visible from the point of view of the higher-level IO controller. The higher-level IO controller only "sees" the transfer areas through which it exchanges IO data with the I-device.

The principle of this provision is explained in the section.



## Reading asset management data

The asset management record has the index 0xF880 and is read with standard PROFINET mechanisms by the user of the records, for example a tool or program for evaluating these data.

A user program in the S7-1500 IO controller, for example, can read out the AMR of an IO device with the RDREC instruction (Index 0xF880).

It is not possible to write to this data record.

## Further information

Whether and to which extent a PROFINET device supports asset management data, meaning whether it makes an AMR available, is specified in the documentation of the respective device.

### 4.9.3.2 Content and structure of an asset management record

#### Basic structure of the asset management record

You are first provided with an overview of the general structure of the record. The following table describes the framework within which the asset management data blocks are embedded. Each data block represents an asset, a terminal block for example.

| Element of the data structure                    | Designation according to IEC 61158-6-10 | Code                                                                     | Data type / length in bytes |
|--------------------------------------------------|-----------------------------------------|--------------------------------------------------------------------------|-----------------------------|
| Header AssetManagement-Data                      | BlockType                               | 0x0035                                                                   | UINT / 2                    |
|                                                  | BlockLength                             | Number of bytes without counting the bytes for BlockType and BlockLength | UINT / 2                    |
|                                                  | BlockVersion                            | 0x0100                                                                   | UINT / 2                    |
| AssetManagementInfo<br>AssetManagementBlocks (n) | NumbersOfEntries                        | Number of AssetManagementBlocks                                          | UINT / 2                    |
|                                                  | AssetManagementBlock 1                  | See the table below                                                      |                             |
|                                                  | AssetManagementBlock 2                  |                                                                          |                             |
|                                                  | ...                                     |                                                                          |                             |
|                                                  | AssetManagementBlock n                  |                                                                          |                             |

## Structure of asset management blocks

Each AssetManagementBlock contains identification data and localization information for an asset. An AssetManagementBlock has a substructure with basic characteristics described below.

The header of an AssetManagementBlock contains the coded information about which of the three possible AM data compilations the data record contains. Devices make a suitable BlockType available in accordance with the various device types:

- Complex devices with information about the hardware and firmware (BlockType "AM\_FullInformation")
- Complex devices with information about the hardware (BlockType "AM\_HardwareOnlyInformation")
- Devices with information about the firmware (BlockType "AM\_FirmwareOnlyInformation")

The differentiation provides an efficient data structure below the header. Nevertheless, the data record can have a considerable size (maximum of 64 KB, depending on the number of assets that the IO device supplies).

Table 4- 4 Structure of AssetManagementBlock

| Element of the data structure                                                                                         | Designation according to IEC 61158-6-10 | Code                                                                                                                                                                                              | Data type / length in bytes |
|-----------------------------------------------------------------------------------------------------------------------|-----------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------|
| Header AssetManagementBlock                                                                                           | BlockType                               | 0x0036 (AM_FullInformation)<br>0x0037 (AM_HardwareOnlyInformation)<br>0x0038 (AM_FirmwareOnlyInformation)                                                                                         | UINT / 2                    |
|                                                                                                                       | BlockLength                             | Number of bytes without counting the bytes for BlockType and BlockLength                                                                                                                          | UINT / 2                    |
|                                                                                                                       | BlockVersion                            | 0x0100                                                                                                                                                                                            | UINT / 2                    |
|                                                                                                                       | Padding                                 | 0x0000 (padding byte)                                                                                                                                                                             | USINT / 1                   |
|                                                                                                                       | Padding                                 | 0x0000 (padding byte)                                                                                                                                                                             | USINT / 1                   |
| AssetManagementBlock<br>(Structure depends on the BlockType. Here it is shown using AM_FullInformation as an example) | IM_UniqueIdentifier                     | Manufacturer-generated Universal Unique Identifier (UUID) conforming to ISO/IEC 9834-8. Used as a reference key to uniquely identify this asset.<br>Example: 550c5300-d34a-22b4-11d3-5533991111b3 | Array of Byte / 16          |
|                                                                                                                       | AM_Location                             | Description of the location of the asset:<br>Either slot-oriented ("Slot and Sub-slotNumber format") or hierarchical ("Twelve level tree format").<br>See following description                   | Array of Byte / 16          |
|                                                                                                                       | IM_Annotation                           | Manufacturer-specific notation<br>Example: "Terminal block, Type xyz123".<br>64 bytes are always used. Spaces are used for padding if the string is shorter.                                      | Array of Char / 64          |

| Element of the data structure | Designation according to IEC 61158-6-10                        | Code                                                                                                                                                                                                                                                                                                                                                                     | Data type / length in bytes                                                                  |
|-------------------------------|----------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------|
|                               | IM_OrderID                                                     | Manufacturer-specific article number<br>Example: "6ES7 131-6BF00-0BA0 ".<br>64 bytes are always used. Spaces are used for padding if the string is shorter.                                                                                                                                                                                                              | Array of Char / 64                                                                           |
|                               | AM_SoftwareRevision<br>(not at<br>AM_HardwareOnlyInformation)  | Manufacturer-specific SW version<br>Example: "V6.3.8 ".<br>64 bytes are always used. Spaces are used for padding if the string is shorter.<br>If the asset supports IM_Software_Revision, the AM_SoftwareRevision is padded with spaces.                                                                                                                                 | Array of Char / 64                                                                           |
|                               | AM_HardwareRevision<br>(not at<br>AM_FirmwareOnlyInformation)  | Manufacturer-specific hardware version<br>Example: "A4 ".<br>64 bytes are always used. Spaces are used for padding if the string is shorter.<br>If the asset supports IM_Hardware_Revision, the AM_HardwareRevision is padded with spaces.                                                                                                                               | Array of Char / 64                                                                           |
|                               | IM_Serial_Number                                               | Manufacturer-specific unique production-related number.<br>The characters come from the visible range (0x20 ... 0x7E), no control characters.<br>Example: "A78C-1C82 ".<br>16 bytes are always used. Spaces are used for padding if the string is shorter.                                                                                                               | Array of Char / 16                                                                           |
|                               | IM_Software_Revision<br>(not at<br>AM_HardwareOnlyInformation) | Software version, follows a strict structure (SW version prefix, for example "V", digits for functional extension, digits for BugFix, digits for internal change).<br>Example: 'V' 0x01 0x2 0x3<br>If AM_SoftwareRevision is padded with spaces, you should evaluate IM_Software_Revision.<br>If the asset does not support any hardware, the coding 'V' 0x00 0x00 0x00. | Array of Byte / 4<br>Prefix (character "V", "R", "P", "U", or "T"), then 3 digits "0" to "9" |

| Element of the data structure | Designation according to IEC 61158-6-10                        | Code                                                                                                                                                                                                                                                                                                                                                                            | Data type / length in bytes |
|-------------------------------|----------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------|
|                               | AM_DeviceIdentification                                        | Identification of the device. The structure is as follows:<br>AM_DeviceIdentification.DeviceSubID (for SIEMENS e.g. 0x0000)<br>AM_DeviceIdentification.DeviceID (Device ID from manufacturer, 0x0000 to 0xFFFF)<br>AM_DeviceIdentification.VendorID (Example for Siemens assets: 0x002A)<br>AM_DeviceIdentification.Organization: Example for Siemens assets: 0x0000 (PROFINET) | Array of Byte / 8           |
|                               | AM_TypeIdentification                                          | Manufacturer-allocated type identification:<br>0x0000: Unspecified<br>0x0001: Controller (PLC)<br>0x0002: PC-based<br>0x0003: IO module, IO submodule<br>0x0004: Communications module / submodule<br>0x0005: Interface module / submodule<br>0x0006: Active network component<br>0x0007: Media attached unit (bus adapter)<br>0x0100 to 0x7FF: Manufacturer-specific           | UINT / 2                    |
|                               | IM_Hardware_Revision<br>(not at<br>AM_FirmwareOnlyInformation) | Version of the hardware (0x0000 to 0xFFFF)<br>Example: 0x0003<br>If AM_HardwareRevision is padded with spaces, you should evaluate IM_Hardware_Revision.                                                                                                                                                                                                                        | UINT / 2                    |

## AM\_Location

Asset management at PROFINET supports two formats for coding the location of an asset:

- Slot-oriented format ("Slot and SubslotNumber format")
- Hierarchical format ("Twelve Level Tree format" abbreviated **LT** format)

Assets that are part of the PROFINET device use the slot-oriented format. These assets are bound completely to the PROFINET modules and submodules.

Assets that are located outside the PROFINET device use the hierarchical format (LT format) for coding the location of an asset.

These assets are localized by their tree level. The tree level begins with Level 0. The value of Level 0 provides information about the proximity to the PROFINET device:

- If the asset is connected to a module that can be addressed through the PROFINET device model, Level 0 has the value 0. The subsequent levels (Level 1 to Level 3) then have the meaning of slot address, subslot address and channel number. If further assets are connected to this asset, the next Level 4 is used. The limit is reached at Level 11.
- If the asset belongs to a PROFINET device but is not connected to a module that can be addressed through the PROFINET device model, Level 0 has a value between 1 and 0x1FF. An example of such an asset is a power supply unit in the PROFINET device. If a further asset is connected to this power supply unit, for example a sensor, the next tree level is used to localize this sensor (Level 1).
- If the asset is located outside the PROFINET device, but, for example, belongs to a machine into which the PROFINET device is installed, Level 0 has a value between 0x200 and 0x3FE.

The value 0x3FF for a tree level shows that this tree level is not used. This means that no further asset is connected. In this case, all the lower tree levels down to Level 11 must also have this value.

### Example AM\_Location slot-oriented

A rack and the terminal blocks located on it each supply AM data. The slot assignments are shown in the figure.

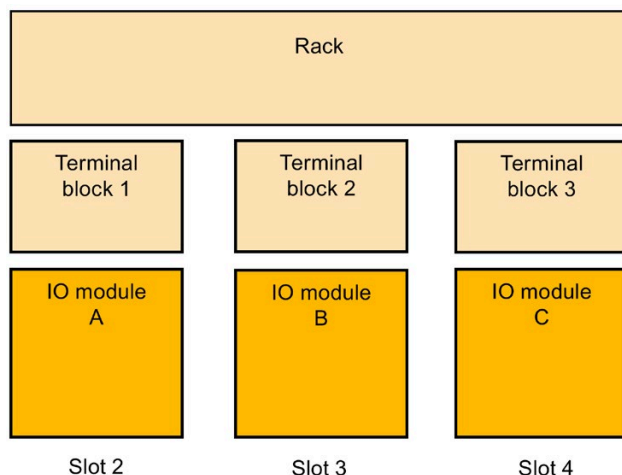


Figure 4-17 Example of assets with slot-oriented AM\_Location coding.

Code the AM\_Location as an asset for each module as follows:

Bit 0 – 7: AM\_Location.Structure = 0x02 (coding "Slot and SubslotNumber format")

Bit 8 – 15: AM\_Location.Reserved1 = 0x00 (padding byte)

Bit 16 – 31: AM\_Location.BeginSlotNumber = 2 (the "Rack" asset begins from Slot 2 on)

Bit 32 – 47: AM\_Location.BeginSubslotNumber = 0xFFFF (the asset encompasses all the subslots of Slot 2. Otherwise you specify the no. of the subslot at which the asset begins)

Bit 48 – 63: AM\_Location.EndSlotNumber = 4 (the asset ends at Slot 4)

Bit 64 – 79: AM\_Location.EndSubslotNumber = 0xFFFF (the asset encompasses all the subslots of Slot 4. Otherwise you specify the no. of the subslot at which the asset ends)

Bit 80 – 95: AM\_Location.Reserved2 = 0x0000 (padding byte)

Bit 96 – 111: AM\_Location.Reserved3 = 0x0000

Bit 112 – 127: AM\_Location.Reserved4 = 0x0000

### Example AM\_Location level-oriented

A complex sensor is connected to an IO module (Slot 5, Subslot 1, Channel 1). Two simple sensors, in turn, are connected to the complex sensor. The module can be addressed within the PROFINET device model. Level 0 therefore has the value 0x0000. The next level (Level 1) is specified by the assigned slot. This is followed by the further levels for the subslot and channel and, if appropriate, further subordinate layers.

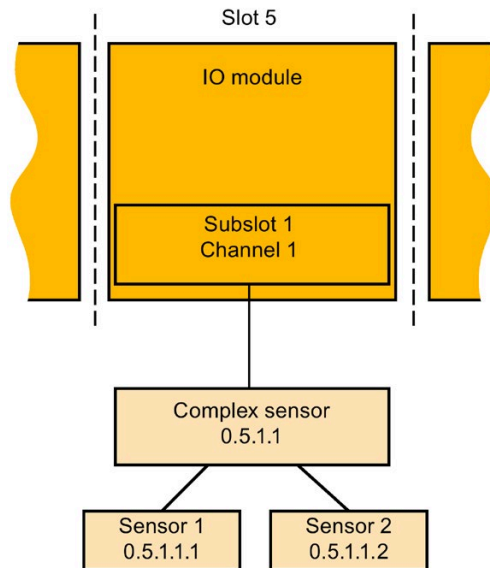


Figure 4-18 Example of assets with hierarchical AM\_Location coding.

Detailed coding for the example:

Bit 0 – 7: AM\_Location.Structure = 0x01 (LT format)

Bit 8 – 17: AM\_Location.Level0 = 0x000 (assets that are assigned to modules always have the Level 0 value 0x000)

Bit 18 – 27: AM\_Location.Level1 = 0x005 (Slot 5)

Bit 28 – 37: AM\_Location.Level2 = 0x001 (Subslot 1)

Bit 38 – 47: AM\_Location.Level3 = 0x001 (Channel 1)

Bit 48 – 57: AM\_Location.Level4 = 0x3FF (coding for "Level not used")

Bit 58 – 67: AM\_Location.Level5 = 0x3FF (coding for "Level not used")

...

Bit 118 – 127: AM\_Location.Level11 = 0x3FF (coding for "Level not used")

Notation used in the screen for the LT coding of complex sensors: 0.5.1.1

The following correspondingly applies for the remaining sensors:

LT coding for simple Sensor 1 at complex sensor: 0.5.1.1.1

LT coding for second simple Sensor 2 at complex sensor: 0.5.1.1.2

### 4.9.3.3 Asset management data record for I-devices

With STEP 7 (TIA Portal) as of V15 and with S7-1500 CPUs as of firmware V2.5.2, you can compile an asset management data record via a user program. Configured as an I-device, these CPUs then supply the data from centrally plugged modules to a requesting IO controller as assets.

"S7-1500 CPUs" also refers to the CPU variants S7-1500F, S7-1500T, S7-1500C, S7-1500 SW Controller, S7-1500pro CPUs and ET 200SP CPUs.

#### Asset management records for I-devices

I-devices often represent machines. The PROFINET IO controller to which the I-device is assigned only sees the PROFINET interface (also configured as an IO device) and the transfer areas of the I-device configured by the machine manufacturer. The local modules of the I-device are not visible or cannot be accessed.

The assigned IO controller can read the central modules as assets of the I-device by means of an asset management record that the user program of the I-device compiles.

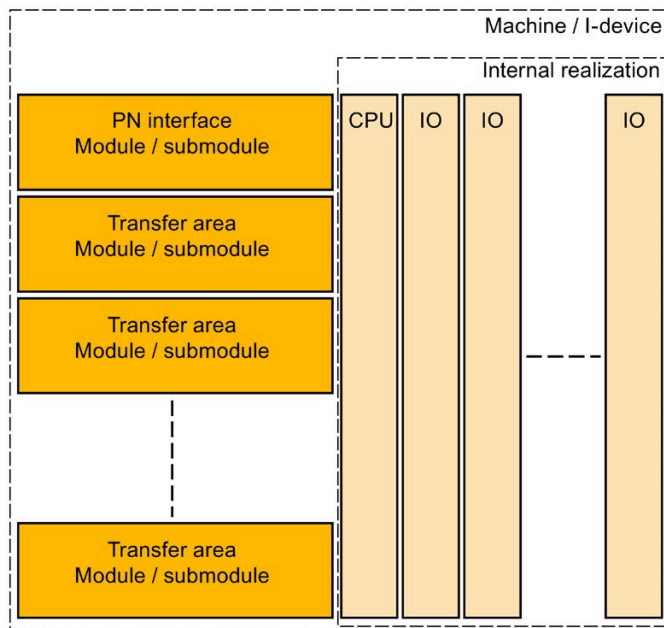


Figure 4-19 Assets of an I-device

#### Requirement

- S7-1500 CPU as of firmware V2.5.2, configured as I-device
- STEP 7 (TIA Portal) as of V15
- If an IO controller is to read the asset management record:

The PROFINET IO controller is programmed correspondingly to read an asset management record.

For a SIMATIC IO controller, for example, you call a read instruction (RDREC) with record index 0xF880. The instruction addresses any submodule of the I-device, for example the first configured transfer area submodule.



## Basic procedure

The following steps are fundamentally required to create the requirements so that an I-device can make its local modules available as an asset management record to a requesting IO controller:

1. Make the settings in the properties of the PROFINET interface of the CPU.

- Activate "IO device" operating mode
- Activate the "Activate asset management using user program" option

PROFINET interface forwards a request of an IO controller to the user program of the I-device for reading the asset management record only if the option is selected.

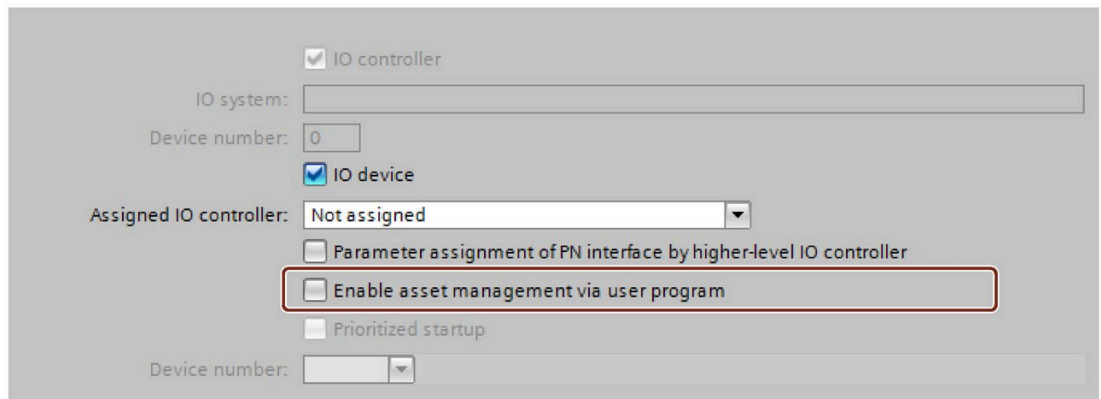


Figure 4-20 Activating asset management using a data record

2. Configure the program routine for compiling the asset management record. The program part collects the required I&M0 data of the plugged central modules and stores them in the corresponding fields of the data record structure of the asset management record.
3. Configure the program part for coordinating the data record provision:  
For this, call the instruction PRVREC (Provide Record) in accordance with the following templates in the corresponding modes:

- Cyclic calling (for example in the cycle OB) of the PRVREC instruction with Mode 0, in order to recognize the AMR request.
- When the AM record request is recognized, the PRVREC program has to acknowledge within one second that the request has been recognized. This means that PRVREC must be called with the Mode 2, and with the required AM record. If the I-device does not adhere to the time frame, the I-device acknowledges the record request of the IO controller as negative.

Particular aspect for configuration of the PRVREC call: PRVREC has to be called with **F\_ID = 0**. This codes that this is an IO-device-specific data record. The SLOT and SUBSLOT output parameters therefore also return the value 0.

- Within 10 seconds the AM record now has to be completed and PRVREC be called with Mode 3 (positive response to the IO controller with provision of the AM record). If the I-device does not adhere to the time frame, the I-device acknowledges the record request of the IO controller as negative.

A detailed description of the PRVREC instruction and possible error codes for evaluating the function can be found in the online help of STEP 7 (TIA Portal).

## Compilation of the asset management record

You have various possibilities for compiling the asset management record for an I-device:

- Recommendation: The Siemens Industry Online Support makes an application available to you that helps you to compile the asset management record.

The data area of the asset management record is divided in two. The first part consists of an automatically determined area that packages the IM0 data of the slots of the I-device into an asset management block. The second part consists of the user-specific asset management blocks. You configure the user-specific asset management blocks based on pre-configured asset management record structures, fill them with information and make them available to the application.

The application performs the following:

- The application determines the required size of all the asset management blocks.
- The application fills the data block in accordance with the specifications of an asset management record with the automatically determined asset management blocks and your user-specific asset management blocks.
- The application makes this asset management record available to the higher-level IO controller.

The application is described in this application example

(<https://support.industry.siemens.com/cs/ww/en/view/109748894>)

- You create the asset management record yourself.

The following section describes how you can compile an asset management record for an I-device yourself.

The concept assumes you yourself determine the I&M data for each centrally plugged module and fill the asset management record with this information. The I&M0 data of a module contains basic information about the module such as the manufacturer's code, article number, serial number, hardware and firmware version. These are the data that are also required in the AM record for an asset.

## Determine the I&M data of centrally plugged modules

The central structure consists of an optionally plugged power supply unit (Slot 0), followed by the I-device CPU (Slot 1), and then followed by the further modules, such as digital modules, analog modules, etc. (as of Slot 2).

You determine the I&M data with the "Get\_IM\_Data" instruction for the plugged modules with exception of the CPU:

To assign parameters for the "Get\_IM\_Data" instruction, you require the hardware identifier (LADDR input parameter). You determine the hardware identifier for each occupied slot with the "GEO2LOG" instruction (Determine hardware identifier from slot).

Summary of the theoretical steps:

1. In a loop, determine the hardware identifiers of the plugged modules with the "GEO2LOG" instruction.
2. For each hardware identifier found, determine the I&M data by using the "Get\_IM\_Data" instruction and store these data in a data block that you address with the input parameter DATA. Use ARRAY of BYTE for the data storage. This corresponds to the description of the AM record contents in the preceding section.

## Forming an AM record with the determined I&M data

The following sections are based on the description of the fundamental structure of the AM record, see the preceding section.

Since each module of an S7-1500 contains hardware and firmware information, select the coding for "AM\_FullInformation" for the assigned BlockType.

For the data types used:

- IM\_Annotation, IM\_OrderID, AM\_SoftwareRevision and AM\_HardwareRevision: Characters (UTF-8)
- IM\_Serial\_Number: Characters ("ASCII characters") with the exception of the characters for DEL (0x7F)
- Do not use String data types. They require additional bytes and therefore do not conform to the conventions of the PROFINET standard 61158-6-10 "Application layer protocol specification".

Form the AM\_FullInformationBlock for each module as follows:

Table 4- 5 AM\_FullInformationBlock for modules

| Data record element  | Description                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |
|----------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| IM_UniqueIdentifier  | <p>Generate a (pseudo) random UUID (hash value) in accordance with ISO 9834-8 as follows:</p> <ul style="list-style-type: none"> <li>• Generate an 8-byte hash value across the I&amp;M0 data of the module (as of Slot 2). Use the algorithm Fowler-Noll-Vo (in short: FNV); an algorithm for generating variance coefficients (hash values) across data field, see corresponding example code in the Internet or online support.</li> <li>• Generate an 8-byte hash value across the I&amp;M0 data of the CPU. (Use the algorithm Fowler-Noll-Vo (in short: FNV) as described above)</li> <li>• IM_UniqueIdentifier<br/>           Byte 0 to 7: Hash value of module I&amp;M0 data<br/>           Bytes 8 to 15: Hash value for CPU-I&amp;M0 data<br/>           Required customizations to ISO 9834-8:<br/>           Byte 8, Bit 7 has to be set to 1, and Byte 8, Bit 6 to 0 (result of the AND operator with <b>0011 1111</b>, subsequent OR operator with <b>1000 0000</b>)<br/>           Byte 6, Bit 4 to 7 have to be set to 0100 (result of the AND operation with 0000 1111, then OR operation with 0001 0000)</li> </ul> <p>Since this algorithm is based on the I&amp;M0 data of the CPU as well as of the modules, it generates a constant IM_UniqueIdentifier for an individual module. When the configuration changes the IM_UniqueIdentifier also changes.</p> |
| AM_Location          | Byte 0 = 0x02 (slot-oriented coding), see description in the preceding section.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |
| IM_Annotation        | Example: "S7-1500 module" and pad the remaining bytes of IM_Annotation with spaces (0x20).                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |
| IM_OrderID           | Copy 20 bytes of the I&M0 data of the module (beginning with offset 2 of the I&M0 data). Pad the remaining 44 bytes with spaces (0x20)                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |
| AM_SoftwareRevision  | Pad the field with 64 spaces (0x20)                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |
| AM_HardwareRevision  | Pad the field with 64 spaces (0x20)                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |
| IM_Serial_Number     | Copy 16 bytes of the I&M0 data of the module (beginning with offset 22 of the I&M0 data)                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |
| IM_Software_Revision | Copy 4 bytes of the I&M0 data of the module (beginning with offset 40 of the I&M0 data)                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |

| Data record element     | Description                                                                                                            |
|-------------------------|------------------------------------------------------------------------------------------------------------------------|
| AM_DeviceIdentification | Byte 0, 1, 2, 6, 7 = 0x00<br>Byte 3 = 0x2A (Vendor = Siemens)<br>Byte 4 = 01, Byte 5 = DeviceID (e.g. CPU 15xx = 0x0E) |
| AM_TypeIdentification   | Copy 2 bytes of the I&M0 data of the module (beginning with offset 48 of the I&M0 data)                                |
| IM_Hardware_Revision    | Copy 2 bytes of the I&M0 data of the module (beginning with offset 38 of the I&M0 data)                                |

# Functions

## Introduction

The following section describes the PROFINET IO functions for field of application, properties and configuration in STEP 7.

Refer to the documentation for the respective device to see to what extent the PROFINET devices support the described functions.

You can find a tabular overview of the PROFINET devices and the functions these support on the Internet (<https://support.industry.siemens.com/cs/ww/en/view/102325771>).

## 5.1 Connecting other bus systems

### Fieldbus integration

PROFINET allows you to use a proxy-capable PROFINET device to integrate existing fieldbus systems (for example, PROFIBUS, AS interface). The devices of these fieldbus systems are mapped on proxy PROFINET devices. In this way, you can set up any hybrid systems consisting of fieldbus and Ethernet-based subsystems. This allows a continuous exchange of information.

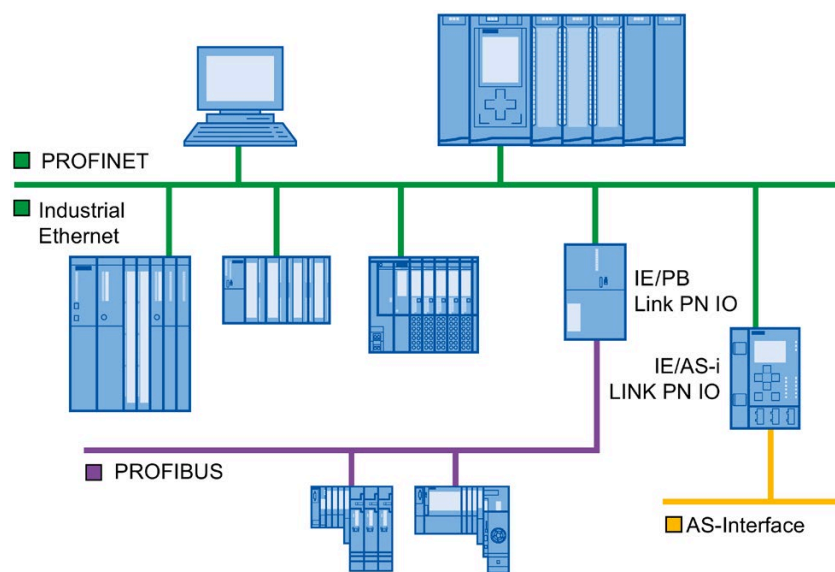


Figure 5-1 Gateways on PROFINET IO

### Gateways of an S7-1500 CPU

An overview of the gateways at an S7-1500 CPU is provided in this FAQ (<https://support.industry.siemens.com/cs/ww/en/view/88778900>).

### Connecting to building busses

- BACnet: You can find the procedure for configuring communication between a SIMATIC PLC and a BACnet network with a gateway in this application example (<https://support.industry.siemens.com/cs/ww/en/view/109476182>).
- M-bus: You can find the procedure for configuring communication between a SIMATIC PLC and an M-bus network with a gateway in this application example (<https://support.industry.siemens.com/cs/ww/en/view/109478527>).
- DALI: You can find the procedure for configuring communication between a SIMATIC PLC and a DALI network with a gateway in this application example (<https://support.industry.siemens.com/cs/ww/en/view/109740160>).
- KNX: You can find the procedure for configuring communication between a SIMATIC PLC and a KNX network with a gateway in this application example (<https://support.industry.siemens.com/cs/ww/en/view/109739689>).

### 5.1.1 Linking PROFINET and PROFIBUS

#### Linking PROFINET and PROFIBUS

With a proxy-capable PROFINET device which is equipped with a PROFINET interface in addition to a PROFIBUS interface (for example, IE/PB Link PN IO), you can integrate existing PROFIBUS configurations into the PROFINET configuration.

The following figures shows how a PROFIBUS system is connected via IE/PB Link to a CPU S7-1500 (as of firmware version 1.7).

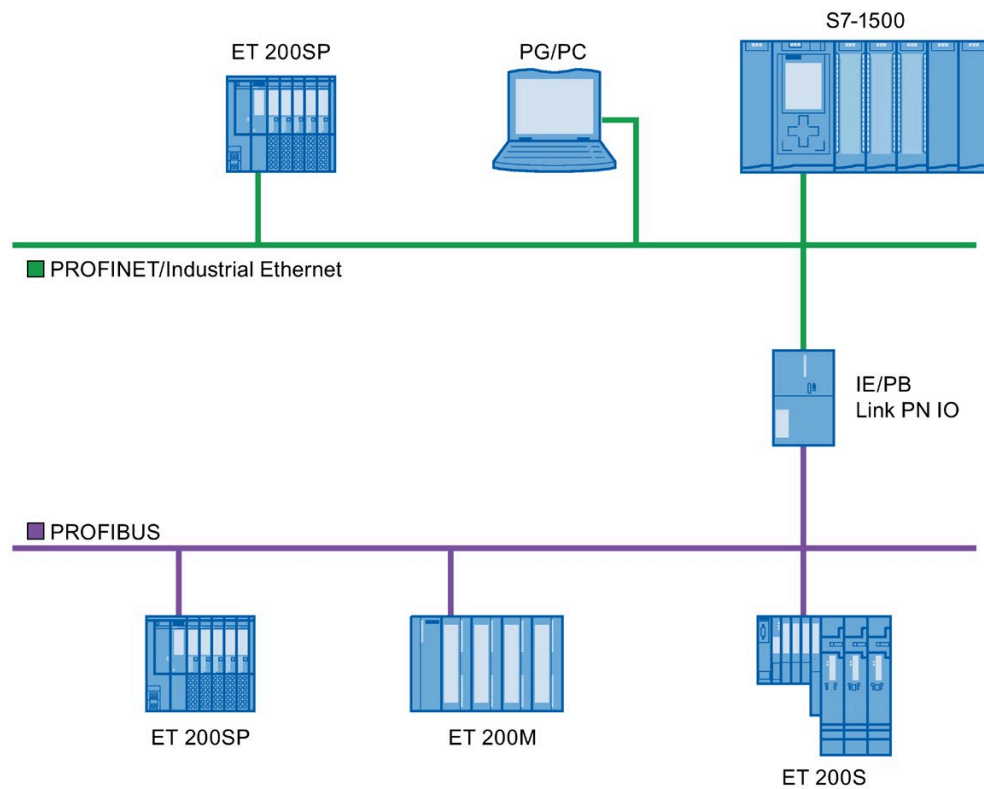


Figure 5-2 Gateway from PROFINET and PROFIBUS via IE/PB link

**PROFINET device with proxy functionality**

The PROFINET device with proxy functionality is the substitute for a PROFIBUS device on Ethernet. The proxy functionality allows a PROFIBUS device to communicate not only with its master but also with all devices on PROFINET.

With PROFINET you can connect an existing PROFIBUS system to an IO controller, for example with the help of an IE/PB Link PN IO.

From the IO controller perspective, the PROFIBUS DP slaves are connected to the same network as the IE/PB Link PN IO. These slaves have the same device name and IP address as the IE/PB Link PN IO, but different device numbers. Furthermore, each also has a specific PROFIBUS address.

In this way, you can link both DPV0 and DPV1 slaves to PROFINET.

For information on how to connect a DP slave to a PROFINET IO system, refer to section Connect the DP slave via the IE/PB Link to a PROFINET IO system (Page 1).

**Diagnostic options with a CPU S7-1500 as IO controller**

The CPU S7-1500 (as of firmware version 1.7) as IO controller detects disrupted DP slaves behind the IP/PB link.

**5.1.2 Connect the DP slave via the IE/PB Link to a PROFINET IO system****Requirements**

- STEP 7 as of V13 SP1
- CPU supports IE/PB link, e.g.:
  - S7-1500 CPU as of firmware version 1.7
  - S7-1500 Software Controller as of firmware version 1.7
  - S7-300/400 CPU

**Procedure for connecting a DP slave via an IE/PB Link**

To connect a DP slave to a PROFINET IO system via an IE/PB Link in STEP 7, follow these steps:

1. Drag-and-drop a PROFINET CPU, for example CPU 1513-1 PN, from the hardware catalog into the network view of STEP 7.
2. Drag-and-drop an IE/PB Link PN IO from the hardware catalog into the network view of STEP 7. The IE/PB Link PN IO is located under Network components > Gateways > IE/PB Link PN IO.
3. Assign the IE/PB Link PN IO to the CPU.
4. Drag a PROFIBUS interface module e.g. IM155-6 DP HF, from the hardware catalog to the network view.



- Assign the interface module to the IE/PB Link.

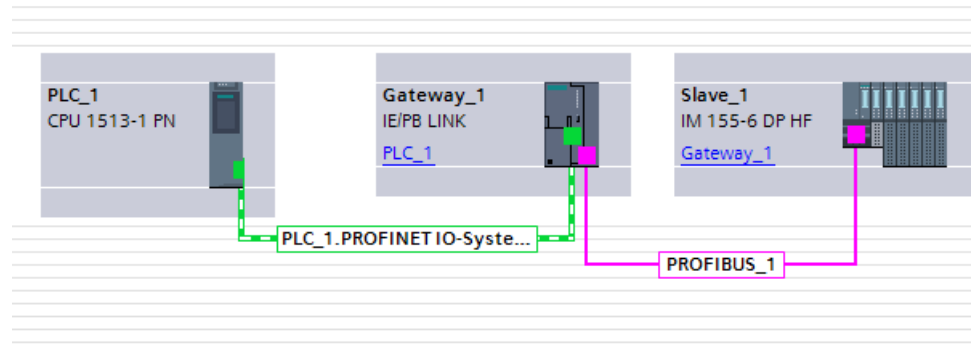


Figure 5-3 Configuring an IE/PB link

- Select the IE/PB Link PN IO in the network view of STEP 7.
- In the Inspector window, go to the "Gateway" area and select the "Network gateway as PROFINET IO proxy" option.

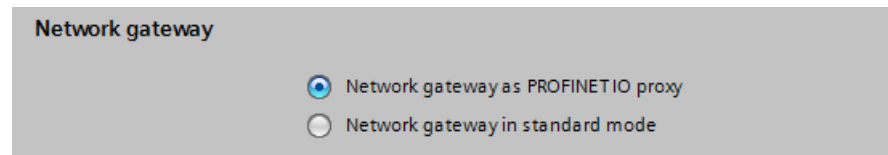


Figure 5-4 Setting a gateway

- In the PROFINET device number area, you can assign a PROFINET device number for the DP slave.  
If you have selected the "Device number = PB address" check box (default), STEP 7 automatically assigns the device number according to the PROFIBUS address of the slave. In addition, you no longer need to update the device number if the PROFIBUS address changes.

| PROFINET device number |         |          |                                     |                          |  |
|------------------------|---------|----------|-------------------------------------|--------------------------|--|
| PB address             | Name    | PROFI... | Device number = PB address          | PSU                      |  |
| 3                      | Slave_1 | 3        | <input checked="" type="checkbox"/> | <input type="checkbox"/> |  |
|                        |         |          |                                     |                          |  |

Figure 5-5 Assigning PN device numbers for IE/PB link

## Result

You have connected the DP slave to the PROFINET IO system.

## Reference

Additional information on the IE/PB link is available in the manual Gateway IE/PB Link PN IO (<http://support.automation.siemens.com/WW/view/en/19299692>).

## 5.2 Intelligent IO devices (I-devices)

### 5.2.1 I-device functionality

#### I-device functionality

The "I-device" (intelligent IO device) functionality of a CPU facilitates data exchange with an IO controller and operation of the CPU as intelligent preprocessing unit of sub processes, for example. The I-device is linked as an IO device to a "higher-level" IO controller.

The preprocessing is handled by the user program in the I-device. The process values acquired in the centralized or distributed (PROFINET IO or PROFIBUS DP) I/O are preprocessed by the user program and made available to the IO controller.

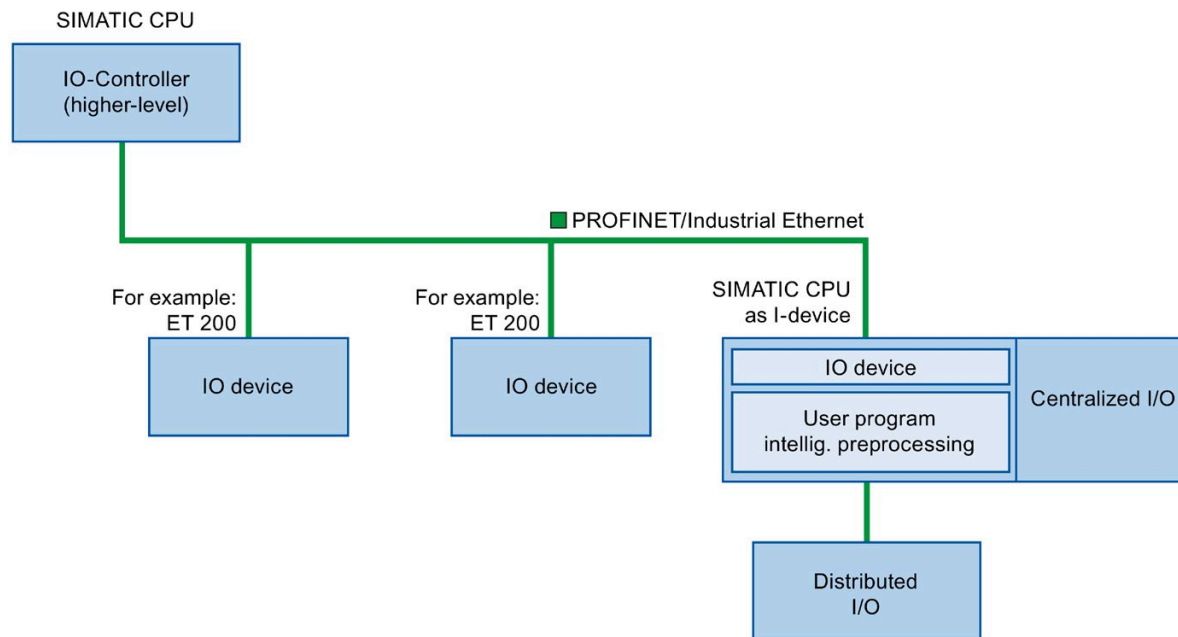


Figure 5-6 I-device

#### "I-device" naming conventions

In the remainder of this description, a CPU or a CP with I-device functionality is simply called an "I-device".

#### Application example: Configuration and application of the PROFINET I-device function

A detailed application example is available here  
<https://support.industry.siemens.com/cs/ww/en/view/109478798>.

## 5.2.2 Properties and Advantages of the I-Device

### Fields of application

Fields of application of the I-device:

- Distributed processing

A complex automation task can be divided into smaller units/subprocesses. This results in manageable processes which lead to simplified subtasks.

- Separating subprocesses

Complicated, widely distributed and extensive processes can be subdivided into several subprocesses with manageable interfaces by using I-devices. These subprocesses can be stored in individual STEP 7 projects if necessary, which can later be merged to form one master project.

- Know-how protection

Components can only be delivered with a GSD file for the I-device interface description instead of with a STEP 7 project. The know-how of the user program may no longer be published.

### Properties

Properties of the I-device:

- Unlinking STEP 7 projects

Creators and users of an I-device can have completely separated STEP 7 automation projects. The GSD file forms the interface between the STEP 7 projects. This allows a link to standard IO controllers via a standardized interface.

- Real-time communication

The I-device is provided with a deterministic PROFINET IO system via a PROFINET IO interface and therefore supports RT (real-time communication) and IRT (isochronous real time).

### Advantages

The I-device has the following advantages:

- Simple linking of IO controllers
- Real-time communication between IO controllers
- Relieving the IO controller by distributing the computing capacity to I-devices.
- Lower communication load by processing process data locally.
- Manageable, due to processing of subtasks in separate STEP 7 projects

### 5.2.3 Characteristics of an I-Device

#### Principle

An I-device is included in an IO system like a standard IO device.

#### I-device without lower-level PROFINET IO system

The I-device does not have its own distributed I/O. The configuration and parameter assignment of the I-devices in the role of an IO device is the same as for a distributed I/O system (for example ET 200).

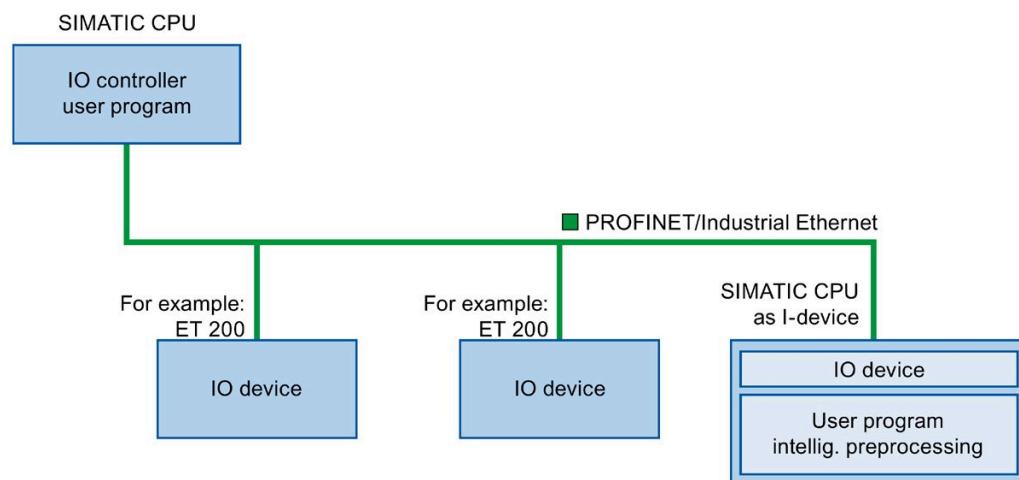


Figure 5-7 I-device without lower-level PROFINET IO system

### I-device with lower-level PROFINET IO system

Depending on the configuration, an I-device can also be an IO controller on a PROFINET interface in addition to having the role of an IO device.

This means that the I-device can be part of a higher-level IO system via its PROFINET interface and as an IO controller can support its own lower-level IO system.

The lower-level IO system can, in turn, contain I-devices (see figure below). This makes hierarchically structured IO systems possible.

In addition to its role as IO controller, an I-device can also be used via a PROFIBUS interface as DP master for a lower-level PROFIBUS system.

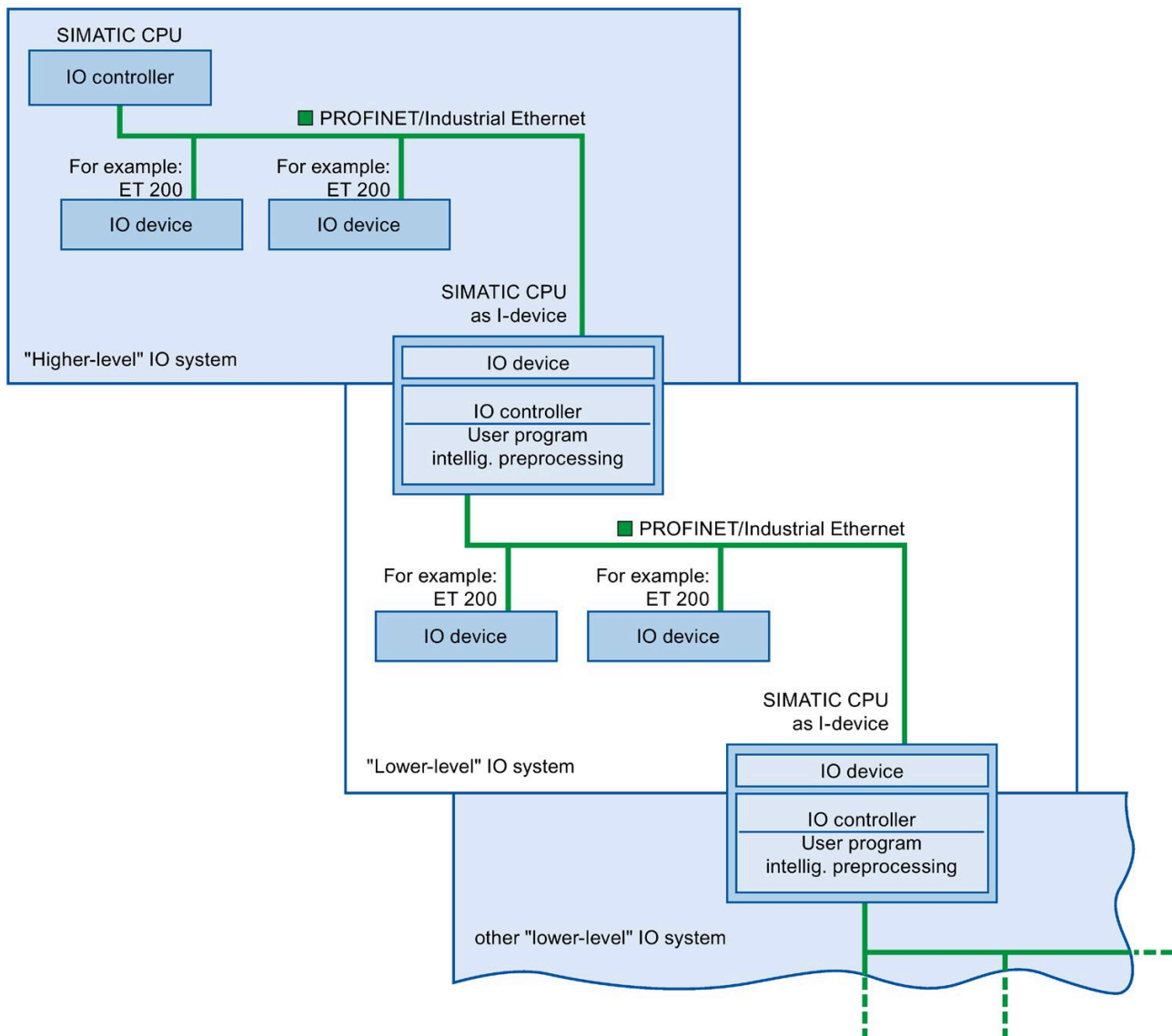


Figure 5-8 I-device with lower-level IO system

**Example - the I-device as IO device and IO controller**

The I-device as IO device and IO controller is explained based on the example of a print process. The I-device controls a unit (a subprocess). One unit is used, for example, to insert additional sheets such as flyers or brochures in a package of printed material.

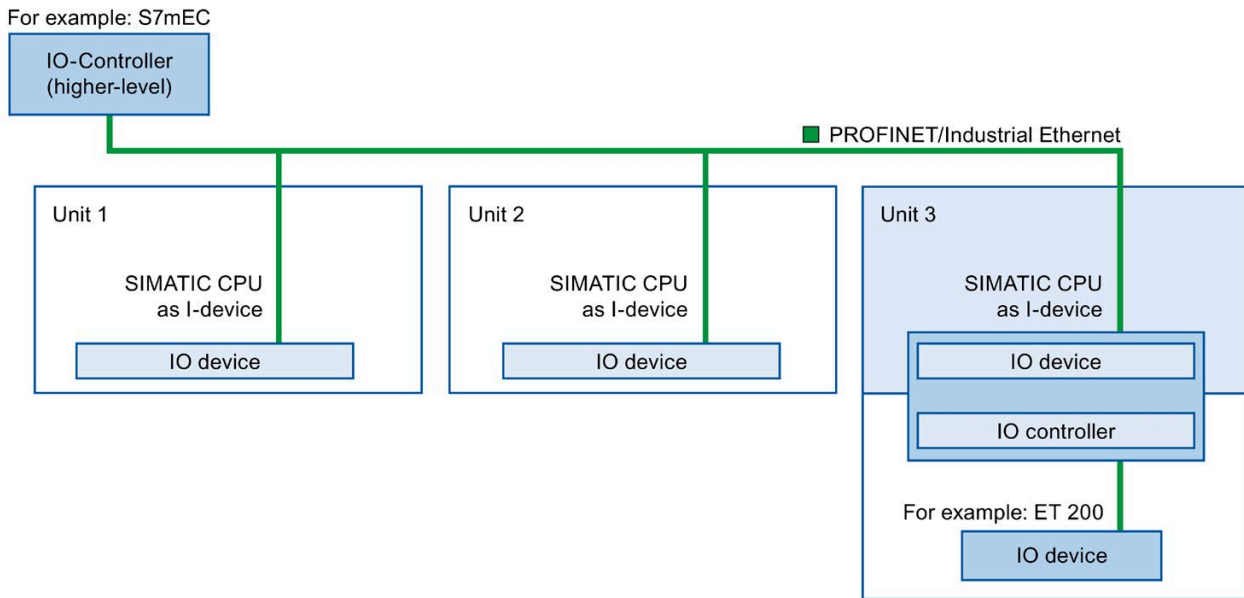


Figure 5-9 Example - the I-device as IO device and IO controller

Unit 1 and unit 2 each consist of an I-device with centralized I/O. The I-device along with the distributed I/O system (for example ET 200) forms unit 3.

The user program on the I-device is responsible for preprocessing the process data. For this task, the user program of the I-device requires default settings (for example control data) from the higher-level IO controller. The I-device provides the higher-level IO controller with the results (for example status of its subtask).

### I-device as a shared device

An I-device can also be used simultaneously by multiple IO controllers as a shared device.

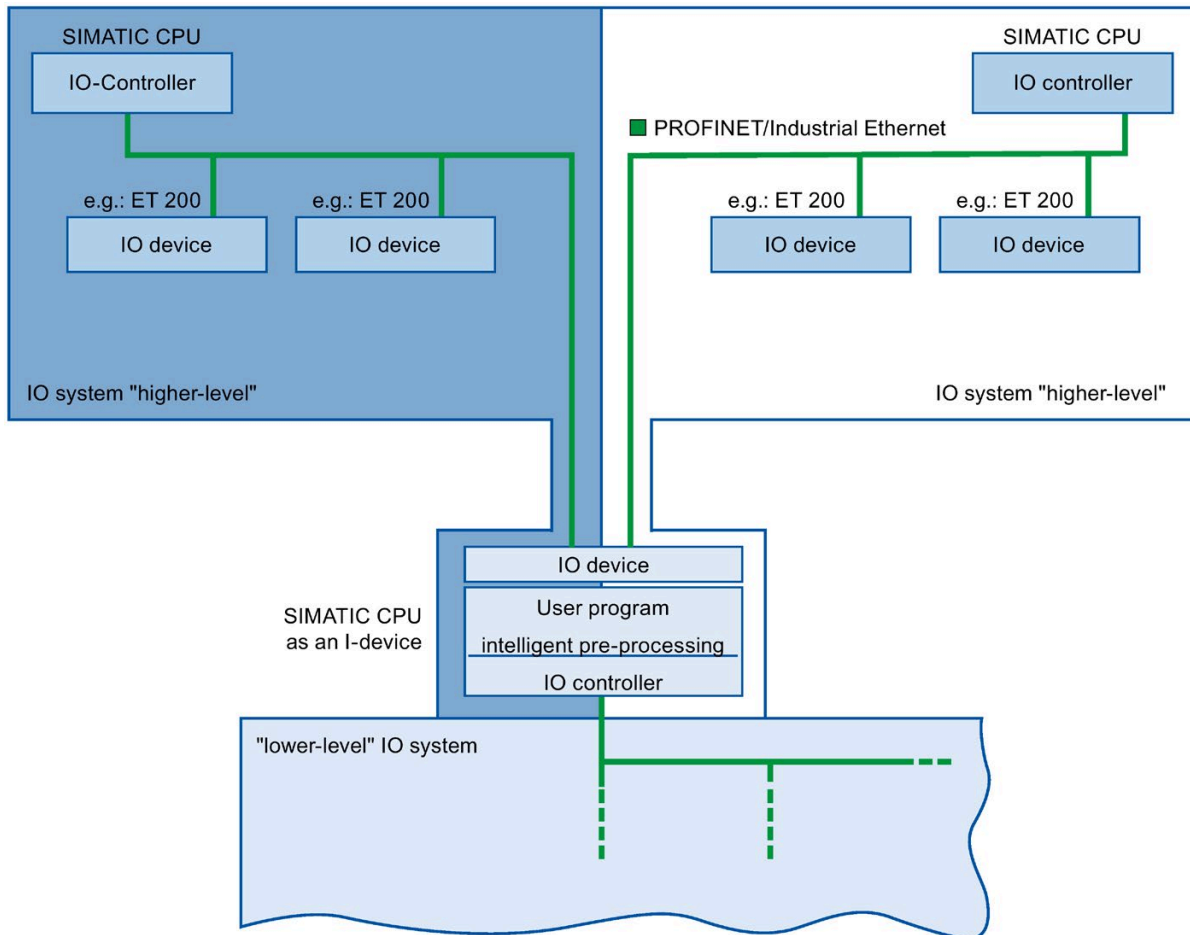


Figure 5-10 I-device as a shared device

Information about configuring an I-device as a shared device is available in the section [Configuring an I-device as a shared device \(Page 1\)](#).

## 5.2.4 Data Exchange between higher- and lower-level IO system

### Introduction

The next chapter shows the data exchange between the higher- and lower-level IO system.

### Transfer areas

Transfer areas are an interface to the user program of the I-device CPU. Inputs are processed in the user program and outputs are the result of the processing in the user program.

The data for communication between IO controller and I-device is made available in the transfer areas. A transfer area contains an information unit that is exchanged consistently between IO controller and I-device. You can find more information on configuration and use of transfer areas in the section Configuring the I-device (Page 1).



The next figure shows the data exchange between the higher- and lower-level IO system. The individual communication relations are explained below based on the numbers.

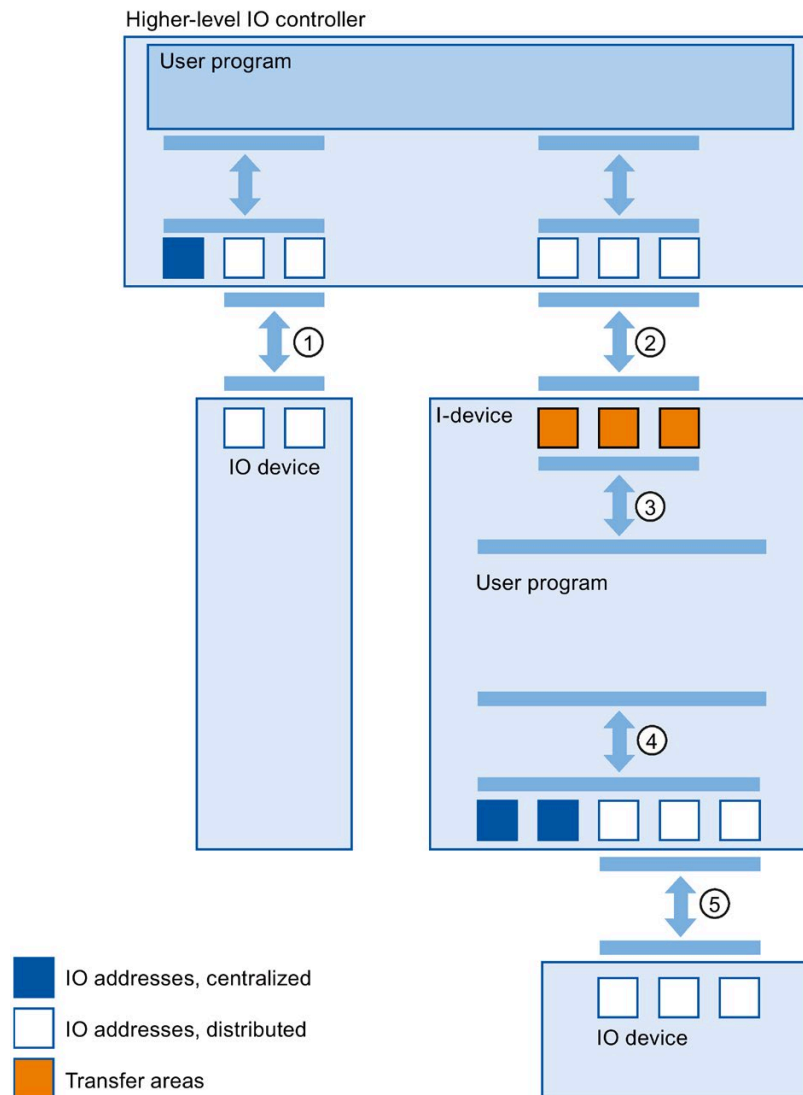


Figure 5-11 Data exchange between higher- and lower-level IO system

**① Data exchange between higher-level IO controller and normal IO-device**

In this way, the IO controller and IO devices exchange data through PROFINET.

**② Data exchange between higher-level IO controller and I-device**

In this way, the IO controller and the I-device exchange data through PROFINET.

The data exchange between a higher-level IO controller and an I-device is based on the conventional IO controller / IO device relationship.

For the higher-level IO controller, the transfer areas of the I-devices represent submodules of a preconfigured station.

The output data of the IO controller is the input data of the I-device. Analogously, the input data of the IO controller is the output data of the I-device.

**③ Transfer relationship between the user program and the transfer area**

In this way, the user program and the transfer area exchange input and output data.

**④ Data exchange between the user program and the I/O of the I-device**

In this way, the user program and the centralized / distributed I/O exchange input and output data.

**⑤ Data exchange between the I-device and a lower-level IO device**

In this way, the I-device and its IO devices exchange data. The data transfer is via PROFINET.

## 5.2.5 Configuring the I-device

### Introduction

There are basically two possibilities for configuration:

- Configuration of an I-device within a project
- Configuration of an I-device that is used in another project or in another engineering system.

STEP 7 allows you to configure an I-device for another project or for another engineering system by exporting a configured I-device to a GSD file. You import the GSD file in other projects or engineering systems as with other GSD files. The transfer areas for the data exchange, among other data, are stored in this GSD file.

### Configuration of an I-device within a project

1. Drag-and-drop a PROFINET CPU from the hardware catalog into the network view.
2. Drag-and-drop a PROFINET CPU, which can also be configured as an IO device, from the hardware catalog into the network view. This device is configured as I-device (e.g., CPU 1516-3 PN/DP).
3. Select the PROFINET interface for the I-device.
4. In the Inspector window in the area navigation choose "Operating mode" and select the check box "IO device".

5. Now you have the option of choosing the IO controller in the "Assigned IO controller" drop-down list.

Once you have chosen the IO controller, the networking and the IO system between both devices are displayed in the network view.

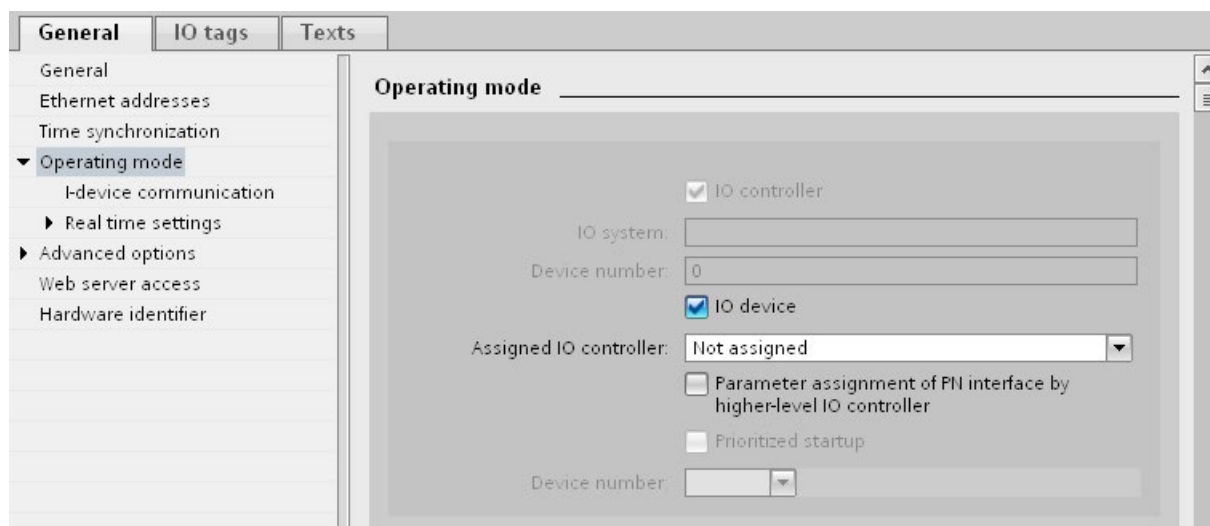


Figure 5-12 Configuring the I-device

6. With the "Parameter assignment of PN interface by higher-level IO controller" check box, you specify whether the interface parameters will be assigned by the I-device itself or by a higher-level IO controller.

If you operate the I-device with a lower-level IO system, then the parameters of the I-device PROFINET interface (for example, port parameter) cannot be assigned with the higher-level IO controller.

7. Configure the transfer areas. The transfer areas are found in the area navigation section "I-device communication".
  - Click in the first field of the "Transfer area" column. STEP 7 assigns a default name which you can change.
  - Select the type of communication relation: you can currently only select CD or F-CD for "Controller-device communication relation".
  - Addresses are automatically preset; you can correct addresses if necessary, and determine the length of the transfer area which is to be consistently transferred.

| Transfer areas |     |                 |      |                          |                       |
|----------------|-----|-----------------|------|--------------------------|-----------------------|
|                | ... | Transfer area   | Type | Address in IO controller | ↔ Address in I-device |
| 1              |     | Transfer area_1 | CD   | Q 4                      | → I 0                 |
| 2              |     | Transfer area_2 | CD   | Q 5                      | → I 1                 |
| 3              |     | <Add new>       |      |                          |                       |

Figure 5-13 Configuring the transfer areas

8. A separate entry is created in the area navigation for each transfer area. If you select one of these entries, you can adjust the details of the transfer area, or correct them and comment on them.

### Configuring an I-device with a GSD file

If you use an I-device in another project, or if the I-device is used in another engineering system, then configure the higher-level IO controller and the I-device as described above.

However, click on the "Export" button after configuring the transfer areas so a new GSD file is created from the I-device. This GSD file represents the configured I-device in other projects.

The "Export" button is found in the "I-device communication" section of the Inspector window.

The hardware configuration is compiled and the export dialog opened.

Assign a name for the I-device proxy as well as a description in the fields provided. Click the "Export" button to complete your process.

Finally, import the GSD file, for example, in another project.

## 5.2.6 Program examples

### Introduction

This simple program example shows how you use the transfer areas of an I-device.

### Requirements

You have configured an I-device.

### Task

The result of an "AND logic operation" of two inputs (preprocessing) in the I-device is to be provided to the higher-level IO controller. This result is to be assigned to a local output in the IO master (further processing).

Use a transfer area with the following addresses for this purpose:

- Address in the I-device: Q568
- Address in the IO controller: I68

### Required steps

The following steps to solve the task:

1. Configuring the transfer area
2. Programming I-device
3. Programming IO controller

## Configuring the transfer area

Configure a transfer area with the following properties in the I-device:

**Details of the transfer area**

Transfer area: Transferbereich\_1

Type of transfer area: CD

Partner: Local:

Data exchange between: PLC\_1 and PLC\_2

Subslot: 1000

Address type: I (Partner) / Q (Local)

Start address: 68 (Partner) / 568 (Local)

Organization block: --- (Automatic update)

Process image: Automatische Aktualisierung

Length: 1 Bytes

Comment:

☐ Enable PROFINET communication

Figure 5-14 I-device transfer area, sample program

## Programming I-device

To program the sample program for the I-device, follow these steps:

1. Using the SCL programming language, create a new function with the name "preprocessing" in the project tree in "Program blocks" > "Add new block". Open the function.
2. In the interface of the function "preprocessing", create the following tags:

| Name    | Data type | Input / output type |
|---------|-----------|---------------------|
| input 1 | bool      | Input               |
| input 2 | bool      | Input               |
| result  | bool      | Output              |

3. In the instruction window of the function "preprocessing", write the following program code:  

```
#result:=#input 1&#input 2;
```

4. Call the function "preprocessing" in a program cycle OB, for example, in OB1.
5. Wire the function "preprocessing" in the program cycle OB as follows:

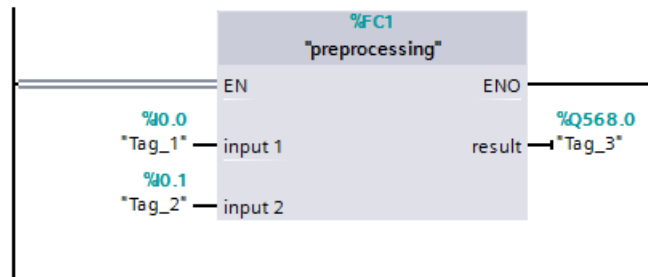


Figure 5-15 I-device sample program

## Programming IO controller

To program the sample program for the IO controller, follow these steps:

1. Using the SCL programming language, create a new function with the name "further processing" in the project tree in "Program blocks" > "Add new block". Open the function.
2. In the interface of the function "further processing", create the following tags:

| Name   | Data type | Input / output type |
|--------|-----------|---------------------|
| result | bool      | Input               |
| output | bool      | Output              |

3. In the instruction window of the function "further processing", write the following program code:  
#output:=#result;
4. Call the function "further processing" in a program cycle OB, for example, in OB1.
5. Wire the function "further processing" in the program cycle OB as follows:

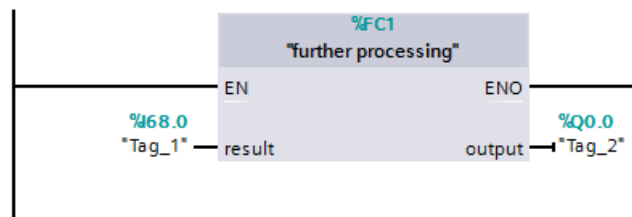


Figure 5-16 IO controller sample program

## Result

The IO controller and the I-device can exchange data with each other through the input/output transfer areas.

### 5.2.7 Diagnostics and interrupt characteristics

#### Diagnostics and interrupt characteristics

S7 CPUs have numerous diagnostics and interrupt functions that can, for example, report errors or failures of lower-level IO systems. These diagnostics messages reduce down times and simplify localization and elimination of problems.

#### Diagnostics options in the higher-level IO controller and in the I-device

The following diagnostics functions are available to the higher-level IO controller and the I-device CPU:

- OB 83 (pull/plug)
- OB 86 (rack failure)
- OB 122 (I/O access error)

---

#### Note

The diagnostics messages of the I/O can be processed in the user program of the I-device CPU and passed on from there to the higher-level IO controller via transfer areas.

---

#### Operating state changes and station failure / station return

In the following table, you can see which consequences an operating state change or the failure of an IO controller / I-device of the SIMATIC family has on the respective other(s):

Table 5- 1 Operating state changes and station failure / station return

| Initial status                                               | Event                            | I-device response                                                                                                                                                                                                                                                                                                          | Higher-level IO controller                                                                                                                                                                                                                                                                          |
|--------------------------------------------------------------|----------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| I-device CPU is in RUN, higher-level IO controller is in RUN | The I-device CPU changes to STOP | -                                                                                                                                                                                                                                                                                                                          | During the updating of the process image with the instructions "UPDAT_PI" and "UPDAT_PO" an error report is returned at the parameter RET_VAL.<br><br>With direct IO access to all transfer areas to the I-device: depending on the type of error handling, e.g., call of OB 122 (IO access error). |
| I-device CPU is in STOP higher-level IO controller is in RUN | The I-device CPU is starting up  | Call of OB 100 (startup).<br>Call of OB 83 (pull/plug) for input transfer areas to the higher-level IO controller.<br><br>Until call of OB 83 in the case of direct access to the input transfer areas to the higher-level IO controller: depending on the type of error handling, e.g., call of OB 122 (IO access error). | Call of OB 83 (pull/plug) for all transfer areas to the I-device.<br><br>Until call of OB 83 in the case of direct access to the transfer areas to the I-device: depending on the type of error handling, e.g., call of OB 122 (IO access error).                                                   |



| Initial status                                                                                                                                               | Event                                                                                                                                         | I-device response                                                                                                                                                                                                                                                                                                                                                                                                    | Higher-level IO controller                                                                                                                                                                                                                                                                                                               |
|--------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| I-device CPU is in RUN, higher-level IO controller is in RUN                                                                                                 | The higher-level IO controller changes to STOP                                                                                                | During the updating of the process image with the instructions "UPDAT_PI" and "UPDAT_PO" an error report is returned at the parameter RET_VAL.<br><br>With direct IO access to the input transfer areas to the higher-level IO controller: depending on the type of error handling, e.g., call of OB 122 (IO access error).<br><br>Note: Output transfer areas can still be accessed.                                | -                                                                                                                                                                                                                                                                                                                                        |
| Higher-level IO controller is in STOP, I-device CPU in RUN                                                                                                   | The higher-level IO controller starts up                                                                                                      | Call of OB 83 (pull/plug) for input transfer areas to the higher-level IO controller.<br><br>Until call of OB 83 in the case of direct access to the input transfer areas to the higher-level IO controller: depending on the type of error handling, e.g., call of OB 122 (IO access error).                                                                                                                        | Call of OB 100 (startup).                                                                                                                                                                                                                                                                                                                |
| I-device CPU is in RUN, higher-level IO controller is in RUN                                                                                                 | Station failure I-device, for example, through bus interruption                                                                               | If the I-device continues to run without a bus connection:<br>Call of OB 86 (rack failure).<br>During the updating of the process image with the instructions "UPDAT_PI" and "UPDAT_PO" an error report is returned at the parameter RET_VAL.<br><br>With direct IO access to all transfer areas to the higher-level IO controller: depending on the type of error handling, e.g., call of OB 122 (IO access error). | Call of OB 86 (rack failure).<br><br>During the updating of the process image with the instructions "UPDAT_PI" and "UPDAT_PO" an error report is returned at the parameter RET_VAL.<br><br>With direct IO access to all transfer areas to the I-device: depending on the type of error handling, e.g., call of OB 122 (IO access error). |
| I-device CPU is in RUN, higher-level IO controller is in RUN, communication connection between IO controller and I-device is interrupted (bus interruption). | The bus connection between the IO controller and I-device has been reestablished and the I-device is again included in the user data traffic. | Call of OB 86 (rack failure).<br>Call of OB 83 (pull/plug) for input transfer areas to the higher-level IO controller.<br><br>Until call of OB 83 in the case of direct access to the input transfer areas to the higher-level IO controller: depending on the type of error handling, e.g., call of OB 122 (IO access error).                                                                                       | Call of OB 86 (rack failure).<br><br>Until reporting of station re-integration by OB 86 with direct IO access to all transfer areas to the I-device: depending on the type of error handling, e.g., call of OB 122 (IO access error)                                                                                                     |

**Note****Special characteristic during startup of the higher-level IO controller**

In contrast to the station return message from IO devices in the IO controller, which are covered completely by the call of the OB 86, the station return message of a higher-level IO controller in the I-device is separated into 2 parts:

1. Call of the OB 86: The initial values for the outputs of the I-device are set. However, the input values are not yet valid. These values will first be valid with the opening of OB 86 in the higher-level IO controller.
  2. Call of OB 83 for each input transfer area; with this call, the validity of an input transfer area is displayed. The starting up of the I device is first complete when the OB 83 has been called for the input transfer areas. This step can be delayed or not occur at all in the following situations:
    - Higher-level IO controller is in STOP: OB 83 is first called at the STOP-RUN transition of the higher-level IO controller.
    - The IRT communication has been disrupted (sync-master failure, topology error, ...). OB 83 is opened only after the IRT communication has taken place.
- 

**Reference**

For more information on error handling in the case of direct I/O access, refer to "Error handling" in the STEP 7 online help.

## 5.2.8 Rules for the Topology of a PROFINET IO System with I-Device

**Introduction**

The following recommendations for the structure and configuration of an IO system when using I-devices will help you to keep the bandwidths required for keeping communication small.

The following communication paths should not overlap:

- Communication paths between the IO controller and the IO device of its IO system.
- Communication paths of the I-device CPU and the IO devices of your IO system.

### I-device with one port

Connect an I-device with only one port to a PROFINET switch that is uncoupled from the higher-level IO system. Connect the lower-level IO system to another port of the switch as shown in the following figure.

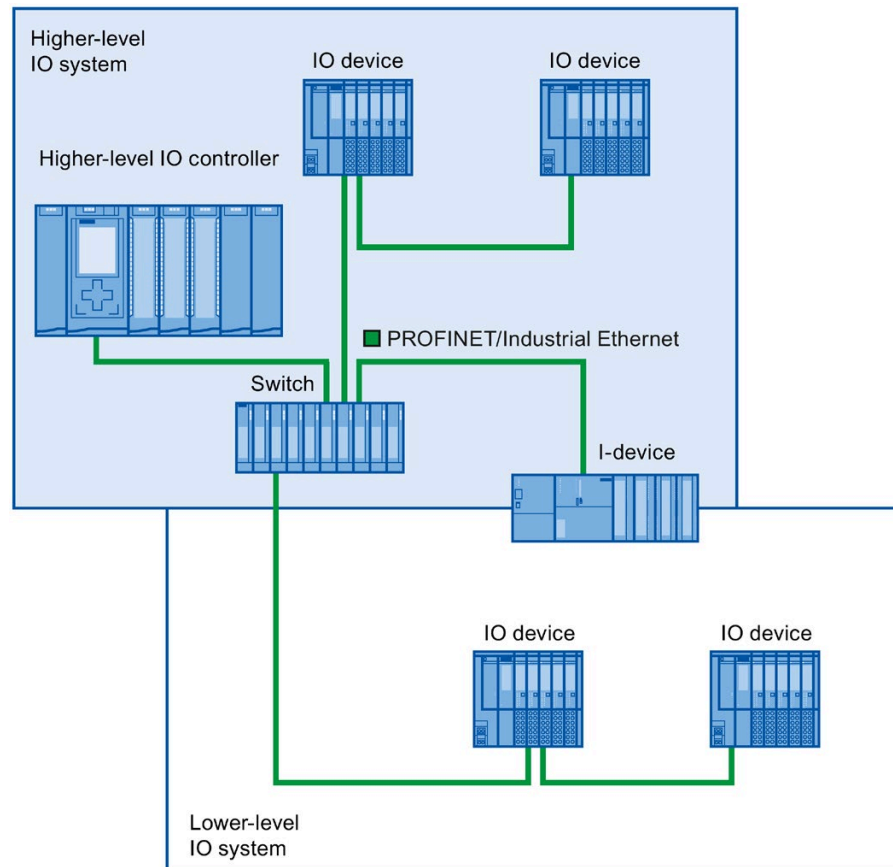


Figure 5-17 I-device with one port

### I-device with two ports

With an I-device with two ports, connect one port, uncoupled from the higher-level IO system, to the port of the PROFINET switch. Use the second port for the lower-level IO system as shown in the following figure.

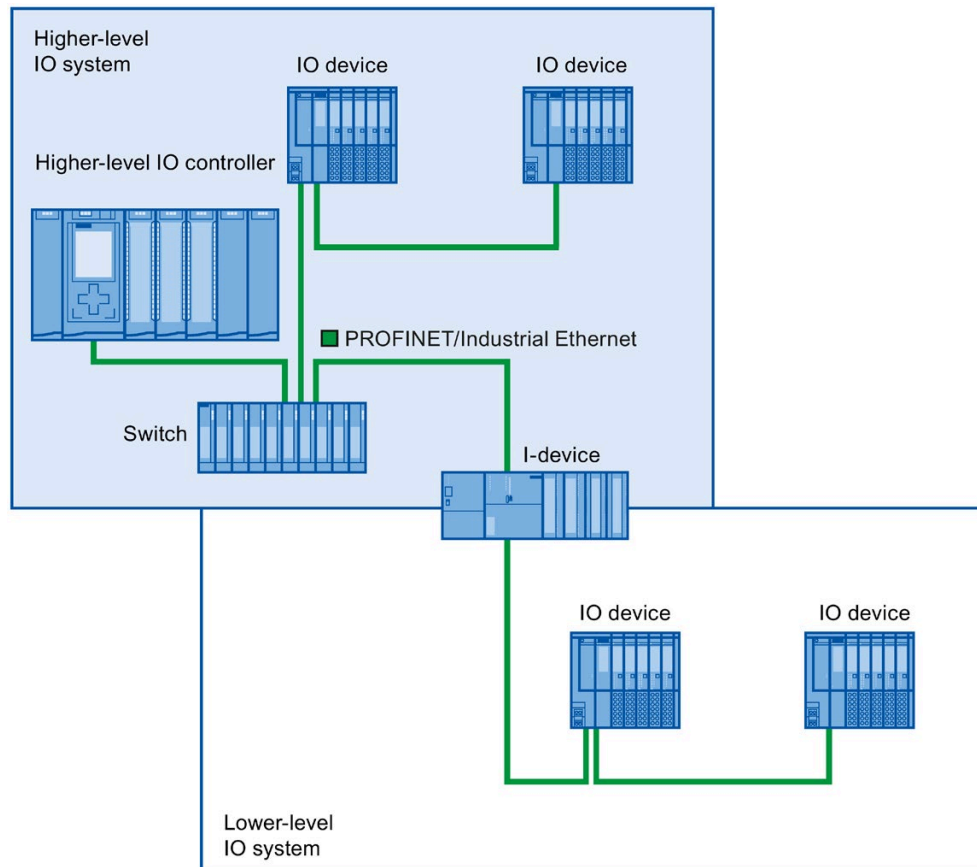


Figure 5-18 I-device with two ports

### I-device with three or more ports

If you have an I-device with three or more ports, connect the I-device to one or both ports to the higher-level IO system in a linear bus topology. Connect the third port to the lower-level IO system uncoupled from the linear bus topology as shown in the following figure.

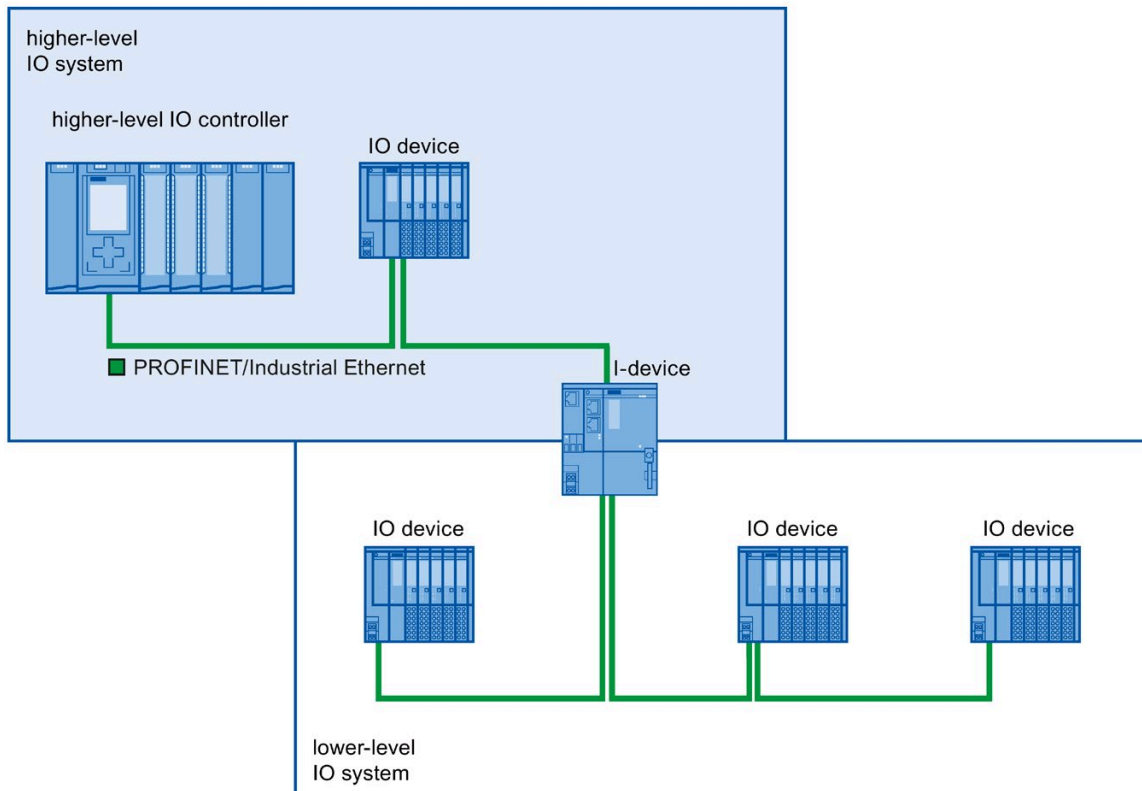


Figure 5-19 I-device with three or more ports

### 5.2.9 Boundary conditions when using I-devices

Note the following boundary conditions when using I-devices:

#### Bandwidth

The number of addresses of the configured transfer areas affects the usable bandwidth of the I-device:

- Bandwidth of the transfer areas + bandwidth of the lower-level IO system = total bandwidth used on the I-device

If the address space of the transfer areas is too large, this indicates a larger bandwidth requirement and can thus lead to longer update times.

**Tip:** Keep the address space of the transfer area as small as possible.

**Rules for RT and IRT communication.**

IO systems with I-devices are also suitable for setting up real-time applications with RT and IRT communication. The following rules must be followed for this:

- Both the higher-level and the lower-level IO system support RT communication. You can use RT communication for both IO systems at the same time.
- IRT communication can be combined with RT communication. You can use IRT communication in one of the two IO systems. Use IRT either in a higher-level or in a lower-level IO system.

**5.2.10 Configuring PROFlenergy with I-devices**

The requirement for program-controlled pauses for saving energy with PROFINET devices is that the PROFINET devices support the PROFlenergy protocol.

Only if a PROFINET device (I/O device) supports the PROFlenergy protocol does an I/O controller actually send PE commands to this I/O device, for example to start or stop pauses.

If an I/O device supports the PROFlenergy protocol, this property is saved in its PROFINET GSD file and is available for configuration in an engineering system.

For S7-1500 CPUs as intelligent I/O devices (I-devices), you have the option with STEP 7 V13 service pack 1 or later to set PROFlenergy support for each transfer area.

If you have selected the "Enable PROFlenergy communication" option for a transfer area and import the generated PROFINET GSD file into another project, you can handle an I-device as a PE entity there.

**Requirements**

- STEP 7 as of V13 service pack 1
- CPU supports PROFlenergy with I-devices, for example CPU 1215C DC/DC/DC as of firmware version 4.2
- You use the PROFINET IO interface as an I-device and have created transfer areas.
- The user program in the I-device handles PROFlenergy commands

Background: You need to program PROFlenergy functions with I-devices in the user program using the "PE\_I\_DEV" instruction and corresponding auxiliary blocks; this is different compared with IO devices for which this functionality is made available by the firmware. You may therefore only activate the PROFlenergy support for transfer areas if the user program in the I-device is configured correspondingly as well.

## Enabling PROFlenergy for transfer areas of I-devices

Proceed as follows to assign parameters for the support of PROFlenergy:

1. Select the PROFINET interface (X1) of the CPU.
2. Select the required transfer area in the area navigation, for example:  
Operating mode > I-device communication > Transfer\_area\_1.
3. Select the check box "Enable PROFlenergy communication".

**Details of the transfer area**

Transfer area:

Type of transfer area:

| Partner                                                                 | Local                                               |
|-------------------------------------------------------------------------|-----------------------------------------------------|
|                                                                         |                                                     |
| Data exchange between: <input type="text" value="PLC_4"/>               | and: <input type="text" value="PLC_5"/>             |
| Subslot: <input type="text" value="1000"/>                              | <input type="text" value="1000"/>                   |
| Address type: <input type="text" value="Q"/>                            | <input type="text" value="I"/>                      |
| Start address: <input type="text" value="0"/>                           | <input type="text" value="2"/>                      |
| Organization block: <input type="text" value="--- (Automatic update)"/> | <input type="text" value="--- (Automatic update)"/> |
| Process image: <input type="text" value="Automatic update"/>            | <input type="text" value="Automatic update"/>       |
| Length: <input type="text" value="1"/> Bytes                            |                                                     |
| Comment: <input type="text"/>                                           |                                                     |
| <input checked="" type="checkbox"/> Enable PROFlenergy communication    |                                                     |

Figure 5-20 Configuring PROFlenergy with I-devices

Once the I-device is fully configured, generate the GSD file for the I-device and import this file in the project for the I/O controller. The GSD file generated contains an entry that specifies that the I-device supports the PROFlenergy profile.

To address the I-device, for example for the PE command "PE\_START\_END", use the hardware identifier of the "PROFlenergy supporting" transfer area in the I-device.

To address the IO controller for the PE command "PE\_I\_DEV", use the hardware identifier of the transfer area that is supplied with the data for PROFlenergy on the IO controller.

You can find more information on PROFlenergy in the section Saving energy with PROFlenergy (Page 1).

### 5.2.11 Enabling/disabling I-device in the user program of the I-device CPU

When a PROFINET interface of a CPU was configured as an I-device in STEP 7, the I-device function is active after a status transition of the CPU from STOP > RUN. If no higher-level IO controller can be reached in this case, the I-device CPU signals an error using its ERROR LED.

As of firmware version 2.9 of an S7-1500/ET 200SP/ET 200pro CPU, you can locally disable or enable the I-device function in the user program of the I-device CPU. You use the "D\_ACT\_DP" instruction for this. After disabling the function, the I-device CPU no longer signals an error using its ERROR LED.

You can enable/disable the function with the user program at the CPU-internal PROFINET interfaces and for S7-1500 CM 1542-1 as of firmware version V3.0.



## Application examples

From a machine OEM's point of view, there are numerous device options possible in **series production of machines**. However, each delivered machine includes only one combination of selected options. All possible machine options can be configured as I-devices by the manufacturer to create and maintain a common user program having all possible options.

A higher-level IO controller used for line control, for example, is not necessary in every machine. In this case, the user program can disable the I-device function in the I-device CPU with the instruction "D\_ACT\_DP", for example, during startup.

Two production lines are shown schematically in the figure below. The same user program runs in both CPUs with I-device configuration. The I-device in line 1 is controlled by a higher-level IO controller.

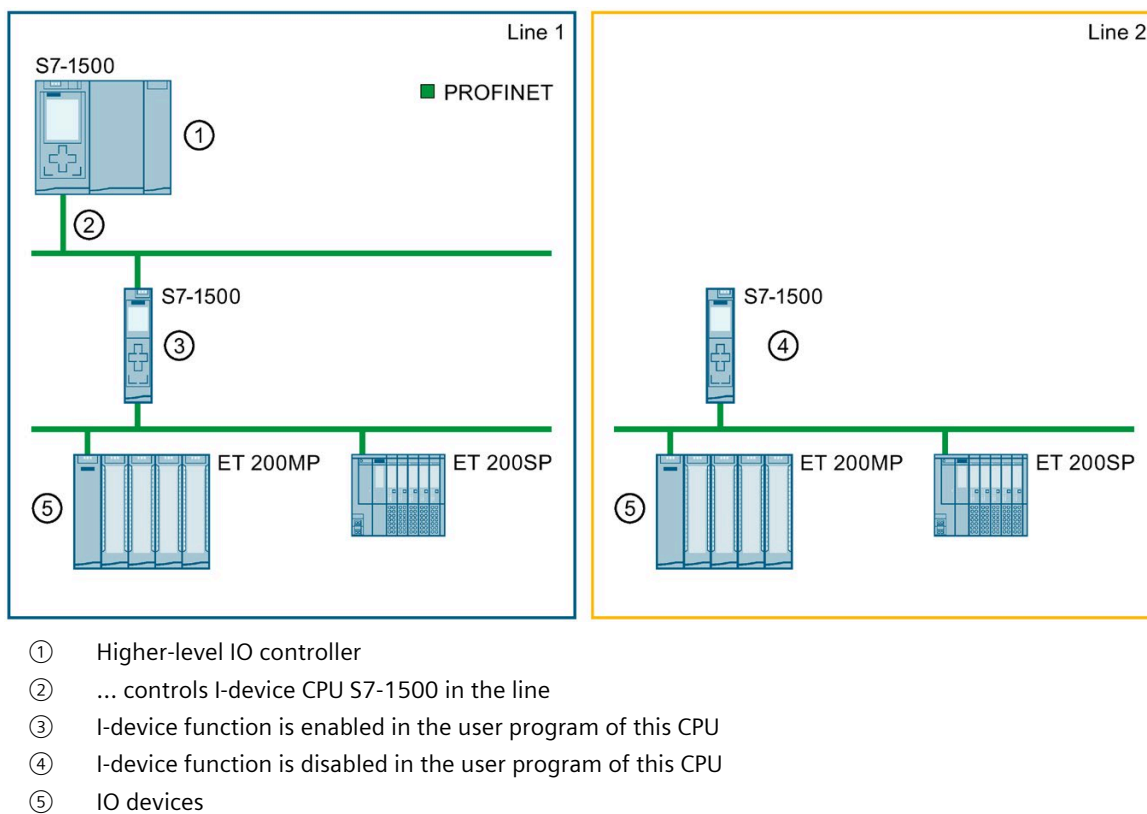


Figure 5-21 Enable/disable the I-device function in the I-device CPU

### **Automation task control of vehicles in a ride**

In a ride (ghost train), the vehicles are connected as I-devices to a higher-level controller via PROFINET.

#### **Feature**

The higher-level IO controller takes over the entire coordination and monitoring of the vehicles in the station. Among other things, the higher-level IO controller registers the following states:

- When the vehicles are available in the station
- When the vehicles exit the station

As soon as passengers are seated in the vehicle and the vehicle is closed, the higher-level IO controller issues the start signal.

Along the entire track, the vehicles are traveling independently and do not have a connection to the higher-level IO controller. Because this state does not represent an error, no errors should be signaled via the ERROR LEDs of the CPUs.

#### **Solution**

Depending on the position of the vehicle, inside or outside the station, the user program enables or disables the I-device function in the I-device CPU of the vehicle. No diagnostics were signaled via LED on the I-device CPU for enabling and disabling.

## Requirements

You operate the CPU as an I-device on one or multiple IO controllers or you have configured the CPU as I-device ("IO device" check box is selected). In the following figure, the right CPU 1518-4 PN/DP is the I-device at the higher-level IO controller CPU 1518-4 PN/DP (PLC\_2).

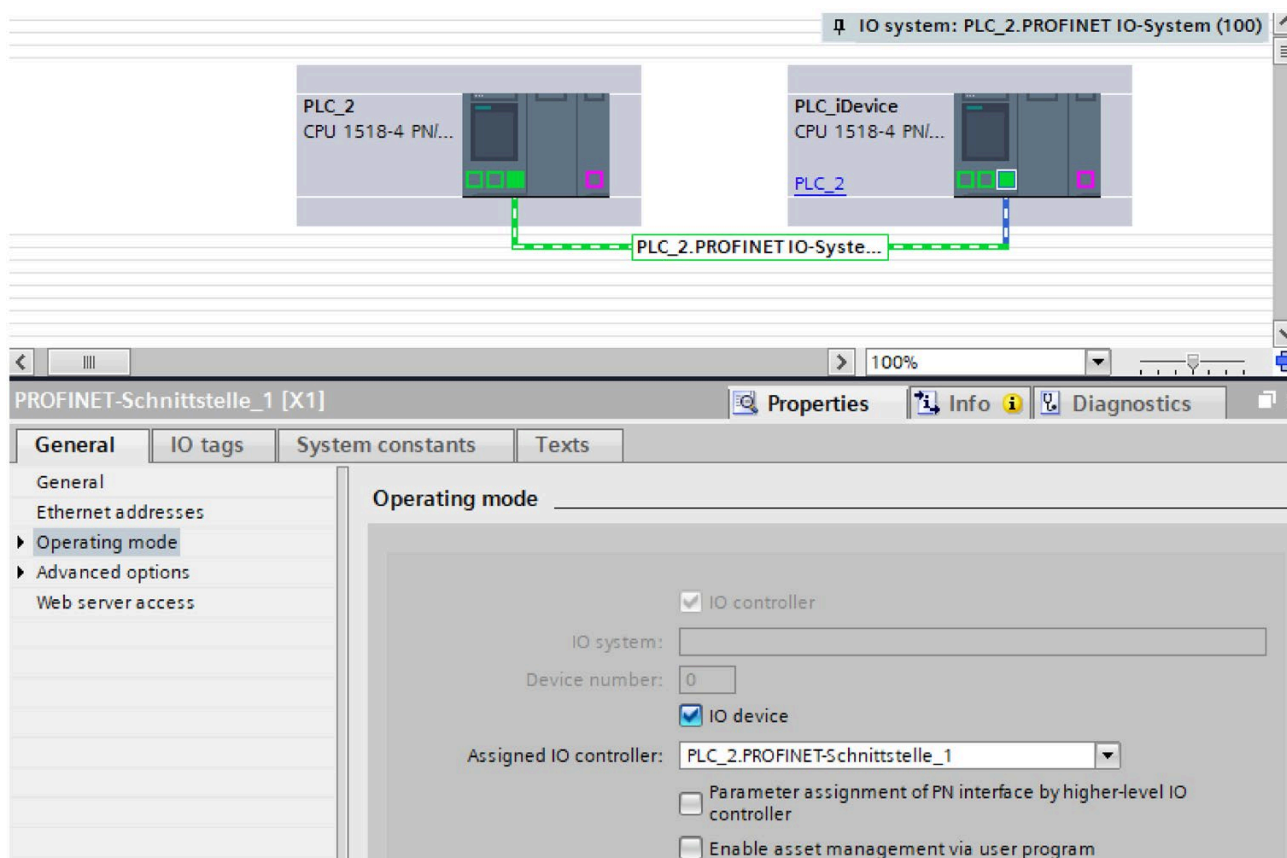


Figure 5-22 Example: Enable I-device

"D\_ACT\_DP" is an asynchronous instruction. Processing extends over multiple calls. You have started the job by calling "D\_ACT\_DP" with REQ = 1 in the startup OB of the I-device CPU.

You can find additional information on the "D\_ACT\_DP" instruction in the STEP 7 online help.

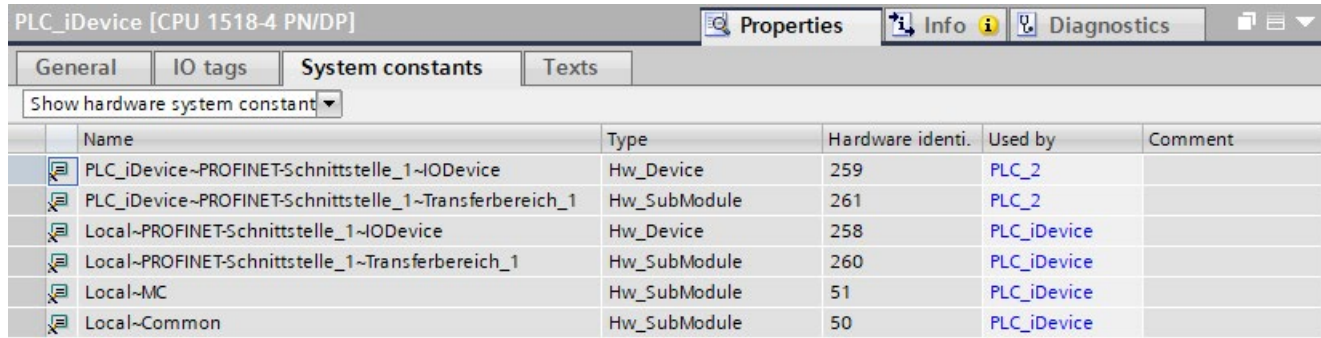
## Disabling the I-device function at a PROFINET interface

### Note

Only disable the I-device function in the I-device CPU when the I-device is not operated on a higher-level IO controller.

You disable the I-device function with the instruction "D\_ACT\_DP":

- Via the symbolic name or the hardware identification of the I-device of the respective PROFINET interface as LADDR parameter, in the example, HW identification 260
- Via the MODE parameter = 2



| Name                                                   | Type         | Hardware identi. | Used by     | Comment |
|--------------------------------------------------------|--------------|------------------|-------------|---------|
| PLC_iDevice~PROFINET-Schnittstelle_1~IODevice          | Hw_Device    | 259              | PLC_2       |         |
| PLC_iDevice~PROFINET-Schnittstelle_1~Transferbereich_1 | Hw_SubModule | 261              | PLC_2       |         |
| Local~PROFINET-Schnittstelle_1~IODevice                | Hw_Device    | 258              | PLC_iDevice |         |
| Local~PROFINET-Schnittstelle_1~Transferbereich_1       | Hw_SubModule | 260              | PLC_iDevice |         |
| Local~MC                                               | Hw_SubModule | 51               | PLC_iDevice |         |
| Local~Common                                           | Hw_SubModule | 50               | PLC_iDevice |         |

Figure 5-23 Example: I-device system constants

**Result:** The goal has been accomplished: The CPU with disabled I-device function is no longer available for the data exchange with a higher-level IO controller. The higher-level IO controller can be reached again when the I-device function was enabled in the user program of the I-device CPU.

When an I-device that has been active on an IO controller disables itself, all application relations (ARs) that were set up between the I-device and the IO controller in the network are terminated. An IO device failure is signaled at the IO controller end. In the diagnostic buffer of the I-device CPU, "IO device user disable" is displayed with information on the associated PROFINET interface or the name of the IO controller.

### Enabling the I-device function at a PROFINET interface

You use the instruction "D\_ACT\_DP" to enable an inactive I-device function:

- Via the symbolic name or the hardware identification of the I-device of the respective PROFINET interface as LADDR parameter, in the example, HW identification 260
- Via the MODE parameter = 1

**Result:** After enabling, the I-device can exchange data with a higher-level IO controller.

If at least one IO controller is missing or the connection does not exist, "Hardware component removed or missing" is entered in the diagnostic buffer of the I-device CPU.

---

#### Note

##### Temporary access errors

Enabling the I-device function in the user program can result in temporary access errors "I/O data failure in hardware component", for example, because access to the I/O data of the I-device is already possible even though the data has not been declared as valid by the IO controller yet.

These messages are incoming and outgoing error events that can be neglected.

The behavior of IO controller and I-device in case of a station failure and station return still applies as described in the section Diagnostics and alarm response (Page 1).

---

### Calling up the status information of an I-device with the instruction "D\_ACT\_DP"

You are requesting the status information of an I-device:

- Via the hardware identification of the I-device of the respective PROFINET interface as LADDR parameter, in the example, HW identification 260
- Via the MODE parameter = 0

The status is returned in the RET\_VAL parameter:

- RET\_VAL = 0x0000: "D\_ACT\_DP" was completed without errors (disabling an inactive I-device/enabling an active I-device)
- RET\_VAL = 0x0001: I-device is enabled
- RET\_VAL = 0x0002: I-device is disabled

## 5.3 Shared device

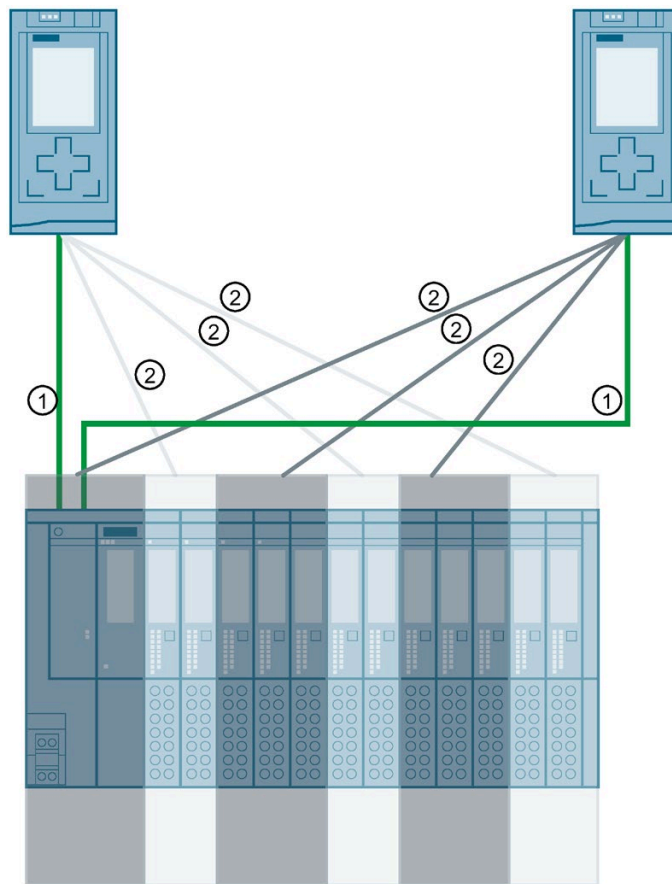
### 5.3.1 Useful information on shared devices

#### Shared device functionality

Numerous IO controllers are often used in larger or widely distributed systems.

Without the "Shared Device" function, each I/O module of an IO device is assigned to the same IO controller. If sensors that are physically close to each other must provide data to different IO controllers, several IO devices are required.

The "Shared Device" function allows the modules or submodules of an IO device to be divided up among different IO controllers. Thus allowing flexible automation concepts. You have, for example, the possibility of combining I/O modules lying near other into an IO device.



- ① PROFINET
- ② Logical assignment

Figure 5-24 Example: Shared device with 2 IO controllers

## Principle

Access to the submodules of the shared device is then divided up among the individual IO controllers. Each submodule of the shared device is assigned exclusively to one IO controller.

## Requirement

- STEP 7 V12 Service Pack 1 or higher
- IO device supports the shared device function, e.g. interface module IM 155-5 PN ST
- IO controller supports the shared device function, for example CPU 1516-3 PN/DP as of firmware version 1.1 or CPU 1215 DC/DC/DC as of firmware version 4.1

Explanatory notes:

- A CPU that is configured as an I-device can be used as a shared device. For this purpose, you create a GSD file for the I-device in STEP 7 via "GSD export". You then import the GSD file into a different project and assign the I-device to the IO controller there. The CPU has to support the GSD export, for example CPU 1215C DC/DC/DC as of firmware version 4.1. The maximum number of IO controllers that you can assign to a CPU configured as a shared I-device is given in the technical specifications in the CPU manuals.

## Configuring the access

The IO device must be present in several projects so that the modules or submodules of an IO device can be assigned to different IO controllers. A separate project is required for each IO controller.

You use the "Shared device" parameter of the interface module to determine the modules or submodules to which the IO controller has access:

- If the local IO controller has access to the configured module, select the name of the IO controller from the list.
- If the IO controller from a different project and not the local IO controller is to have access to the configured module, select the entry "---".

The configuration is consistent regarding access if each module or submodule in exactly one project is assigned to an IO controller.

## Module or submodule is assigned to another IO controller

The paragraph below describes the consequences of the "---" setting of the "Shared device" parameter from the point of view of the local IO controller.

In this case, the local IO controller does not have access to the module configured in this way. Specifically, this means:

- No data exchange with the module or submodule
- No reception of alarms or diagnostics, which means no display of the diagnostics status in the online view
- No parameter assignment of the module or submodule

### Setting of the real-time properties

STEP 7 calculates the communication load and thus the resulting update times. You must enter the number of project-external IO controllers in the project in which the PROFINET interface of the shared device is assigned to the IO controller so that a calculation is possible with shared device configurations.

The maximum possible number of IO controllers for the shared device depends on the device. This number is stored in the GSD file of the shared device.

You can set a very short send clock with a CPU as IO controller. The send clock can be shorter than the shortest send clock supported by the shared device. In this case, the shared device is operated by the IO controller with a send clock that it supports (send clock adaptation).

Example:

A CPU supports send clocks starting from 0.25 ms. A configured IO device also supports send clocks starting at 0.25 ms; another IO device supports send clocks starting at 1 ms. In this case, you have the option of setting the short send clock of 0.25 ms for the CPU. The CPU operates the "slow" IO device with the send clock of 1 ms, for example.

### Rules for the configuration

- IO controllers that use the shared device are created in different projects. In each project, care must be taken that the shared device is configured identically in each station. Only one IO controller may ever have full access to a submodule. Inconsistencies in the configuration result in a failure of the shared device.
- If you have selected the "Use router" option for the IO controllers involved, you must have set the same router address in all these IO controllers.
- I/O addresses of a module or submodule can only be edited if a module or submodule is assigned to the IO controller in the same project.
- The shared device must have the same IP parameters and the same device name in each project.
- The send clock must be identical for all IO controllers that have access to the shared device.
- The S7 subnet ID of the subnet to which the shared device is connected must be identical in all projects.
- The following functions are only available if the PROFINET interface of the shared device is assigned to the local IO controller:
  - IRT operation
  - Prioritized startup
  - Parameter assignment of the port properties



## Boundary conditions

The following boundary conditions result because a shared device configuration is distributed across several projects:

- The addresses of modules or submodules that are not assigned to this IO controller are missing in the address overview of each IO controller that has access to a shared device.
- The modules or submodules that are not assigned are not taken into consideration in the configuration limit calculation for the shared device during the consistency check. For this reason, you must verify for yourself that the maximum number of submodules or the maximum amount of cyclic IO data for the shared device will not be exceeded. For information on the maximum quantities, refer to the documentation for the devices you are using.
- Configuration errors such as the assignment of a module or submodule to several IO controllers are not detected in STEP 7.
- CPUs that are loaded with a shared device configuration do not have any information on whether the IO device is a shared device. Modules or submodules that are assigned to other IO controllers and therefore other CPUs are missing in the loaded configuration. These modules or submodules are therefore displayed neither in the CPU web server nor in the CPU display.

## Response in the event of fault

Information about how PROFINET IO controllers behave in the event of a fault when accessing the data of a shared device is available in this FAQ (<https://support.industry.siemens.com/cs/ww/en/view/109572804>).

### 5.3.2 Configuring shared device

Below, you will find a description of how to configure a distributed I/O system as a shared device with STEP 7 V12, Service Pack 1 or higher.

A "distributed" configuration with different engineering tools for different IO controller families is always possible. However, the description of the procedure is based solely on STEP 7 as of V12, service pack 1. The description is limited to two IO controllers of the S7-1500 family that share a shared device.

Two projects are created (Shared-Device-1 and Shared-Device-2), each with one IO controller (PLC1 and PLC2). You must create the shared device in both projects, even though it is physically one and the same IO device.

## Requirements

- STEP 7 V12 Service Pack 1 or higher
- The IO controller supports the shared device function, for example CPU 1513-1 PN as of firmware version 1.1.
- IO device supports shared device functionality, for example interface module IM 155-5 PN ST as of firmware version 2.0.

### Procedure - Creating project 1

To create the first project with a shared device, follow these steps:

1. Start STEP 7.
2. Create a new project with the name "Shared-Device-1".
3. Insert, for example, a CPU 1513-1 PN from the hardware catalog in the network view. Name it "PLC1".
4. Insert an IO device with the "Shared device" function from the hardware catalog.
5. Assign the IO controller "PLC1" to the IO device.
6. Double-click the IO device and insert all required modules and submodules from the hardware catalog in the device overview table.
7. Assign the module parameters.
8. Save the project.

### Procedure - Creating project 2

To create the second project with a shared device, follow these steps:

1. Start STEP 7 once again.  
A new instance of STEP 7 opens.
2. In the new instance, create a new project with the name "Shared-Device-2".
3. Insert, for example, a CPU 1513-1 PN in the network view. Name it "PLC2".
4. Copy the IO device from the project "Shared-Device-1" and insert it in the network view of project "Shared-Device-2".
5. Assign the IO controller "PLC2" to the IO device.
6. Save the project.

Both projects now have an identically structured IO device that must be configured in the next step for the different types of IO controller access.

## Procedure - Configuring access to the shared device

The modules and submodules you insert in the shared device are automatically assigned to the local CPU. To change the assignment, follow these steps:

1. Select the interface module in the network view or device view of project "Shared-Device-1".
2. Select the "Shared Device" area in the Inspector window.

A table shows which CPU has access to the respective module or submodule for all configured modules. The default setting is that the local CPU has access to all modules and submodules.

3. Keep the "PLC1" setting for all modules and submodules that are to remain in the address range of the local CPU.

Select the setting "---" for all modules and submodules that are to be located in the address range of the CPU from the "Shared-Device-2" project (PLC2). This means that an IO controller outside the project is to have access to the module or submodule.

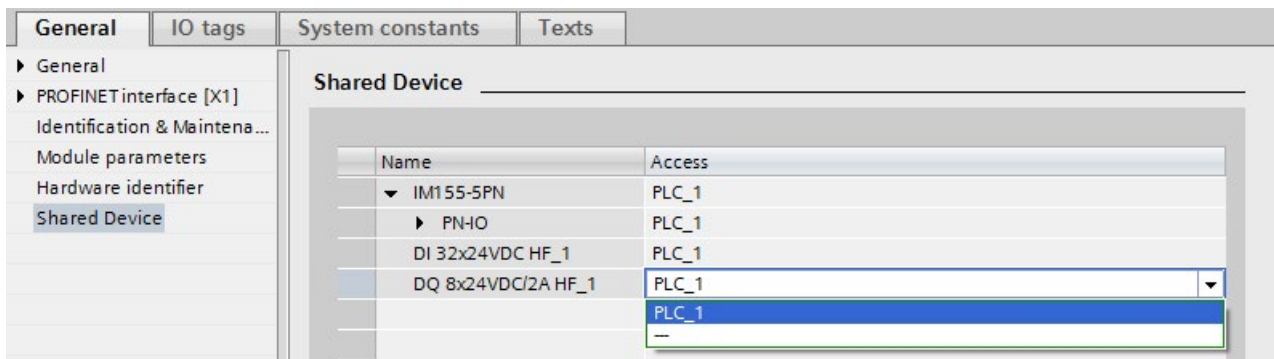


Figure 5-25 Configuring shared device

4. Select the interface module in the network view or device view of project "Shared-Device-2".
5. Select the "Shared Device" area in the Inspector window.

A table shows which CPU has access to the respective module or submodule for all configured modules.

6. Select the setting "---" for all modules and submodules that are to be located in the address range of the CPU from the "Shared-Device-1" project (PLC1).

7. Finally, check whether the settings for access are "complementary" for each module or submodule in both projects. This means that if the local CPU has access in one project, the option "---" must be set in the other project and vice versa.

Special consideration: The option "---" for the PROFINET interface and therefore for the ports makes the associated parameters read-only and not changeable. Parameters of the PROFINET interface and port parameters can only be edited in the project in which the PROFINET interface is assigned to the local CPU. The ports can be interconnected in both projects regardless of this.

8. Check whether the same IP address parameters and device name are set for the shared device in all projects.

Check whether the same S7 subnet ID is set in all projects for the subnet to which the shared device is connected (subnet properties, "General" area in the Inspector window).

---

**Note**

If you make changes to the shared device: Make the same changes in each project on the shared device. Make sure that only one IO controller has access to a module or submodule.

---

### Procedure - Adjusting the real-time settings

To ensure that all IO controllers and shared devices are operated with the appropriate send clock and that the update times are calculated correctly based on the communication load, you must adjust and check the following settings:

1. Select the project whose IO controllers have access to the PROFINET interface and the ports of the shared device.
2. Select the interface module of the shared device in the network view.
3. In the Inspector window, navigate to the "PROFINET interface > Advanced options > Real time settings > IO cycle" area.

4. In the "Shared Device" area, set the number of project-external IO controllers. The maximum number depends on the IO device (specification in GSD file).
5. You must set the same send clock for each IO controller that has access to modules and submodules of the shared device:
  - If you configure the IO controller with STEP 7 (TIA Portal):  
Open the corresponding project.  
Select the PROFINET interface of the IO controller.  
Select the "Advanced options > Real time settings > IO communication" area in the Inspector window and set the shared send clock.
  - If you configure the IO controller with a different engineering tool:  
Select the PROFINET interface of the shared device in STEP 7 (TIA Portal) and read out the send clock on the shared device ("Advanced options > Real time settings" area)  
Enter the read send clock in the engineering tool.
  - Special consideration: If you configure **all** IO controllers that have access to the shared device in STEP 7 (TIA Portal or V5.5), you can set shorter send clocks on the IO controller than supported by the shared device (send clock adaptation).

## Compiling and loading

You must compile the configurations for the different IO controllers and load them to the CPUs one after the other.

Due to the distributed configuration with separate projects, STEP 7 does not output consistency errors in the case of incorrect access parameter assignment. Example for incorrect access parameter assignment:

- Several IO controllers have access to the same module
- IP address parameters or send clocks are not identical

These errors do not show up until operation and are output as configuration errors, for example.

---

### Note

After a configuration has been loaded in the IO controller, non-assigned modules or submodules retain their current parameterization state to ensure the independence from the parameterizations of other IO controllers.

---

### 5.3.3 Configuring an I-device as a shared device

Below, you will find a description of how you configure an S7-1500 as an I-device with STEP 7 Version 13 or higher and then use it in two projects as a shared device.

A "distributed" configuration with different engineering tools for different IO controller families is generally also possible here. The procedure described below is based on STEP 7 V13 and is limited to a configuration with two IO controllers of the S7-1500 family that share the transfer areas of an I-device as a shared device. The I-device itself is also an S7-1500 CPU.

Three projects are created with one IO controller each (PLC-I-Device, PLC\_1, and PLC\_2).

PLC-I-Device is used to configure the I-device. The PROFINET GSD variant of PLC-I-Device is used in the PLC\_1 and PLC\_2 projects in order to assign the transfer areas in the respective higher-level IO controller.

#### Shared I-device concept

For the introduction of the shared I-device concept, two roles are distinguished:

- The role of manufacturer (e.g., machine manufacturer): The manufacturer configures and programs an I-device that performs a particular automation task. Transfer areas are defined as the I/O interface to the operator of the machine. These transfer areas can be assigned to different IO controllers. For the connection to higher-level IO controllers, the manufacturer provides a PROFINET GSD file and discloses the transfer areas via which the I-device can be accessed.
- The role of the operator: The operator uses the I-device as a PROFINET GSD variant during configuration of the PROFINET IO system and, in this process, specifies the I/O addresses under which the IO controllers access the transfer areas.

## Manufacturer view

You assign the following parameters for an S7-1500 CPU as an I-device: centralized and distributed I/O, the desired transfer areas, and the number of IO controllers having access to this I-device (always greater than 1 for a shared device!).

Special consideration: The I-device is configured without a higher-level IO controller. As a result, only the local I/O addresses of the transfer area are available (= "Address in the I-device") in order to create the user program for editing the addresses from the transfer area. The I-device that has been completely configured except for the connection to the higher-level IO controller is loaded to the S7-1500 CPU.

You export a PROFINET GSD file from the I-device configuration.

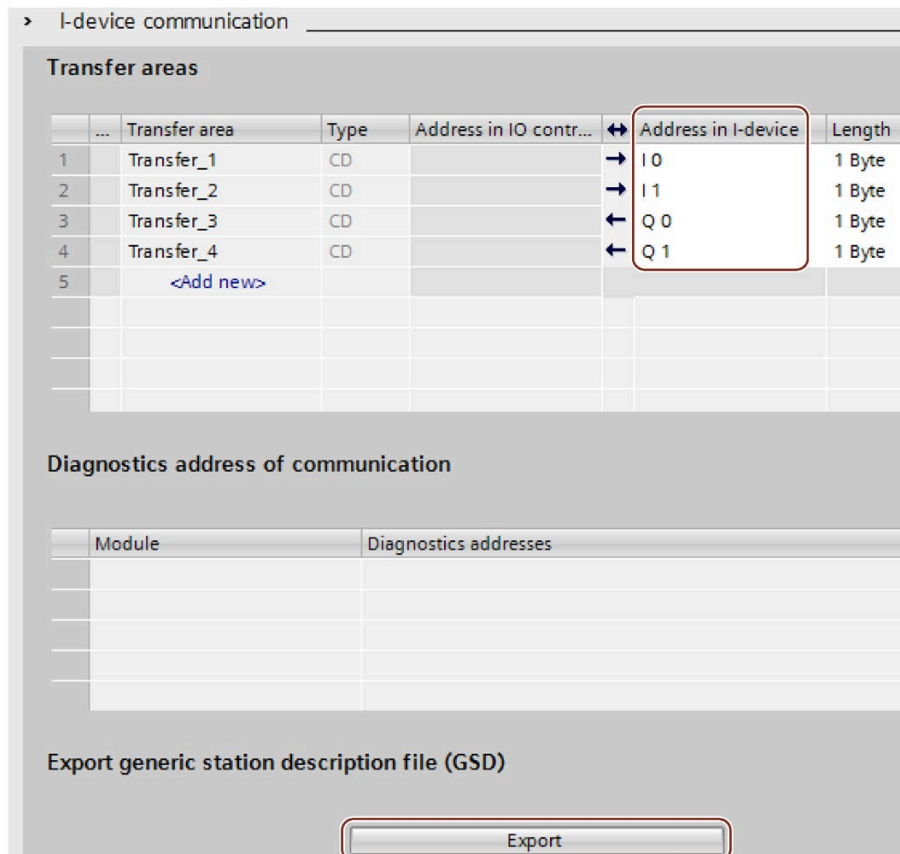


Figure 5-26 Exporting an I-device as a GSD file

## Operator view

You must install the PROFINET GSD file created from the I-device configuration in all engineering systems that are involved in configuring a PROFINET IO system with this shared I-device. If all uses of this I-device will be configured with STEP 7 V13, it is sufficient to install the GSD file in STEP 7.

You configure the I-device as a GSD variant on the PROFINET IO system in the projects involved. In STEP 7 V13, this I-device can be found under "Other field devices > PROFINET IO > PLCs & CPs" following installation.

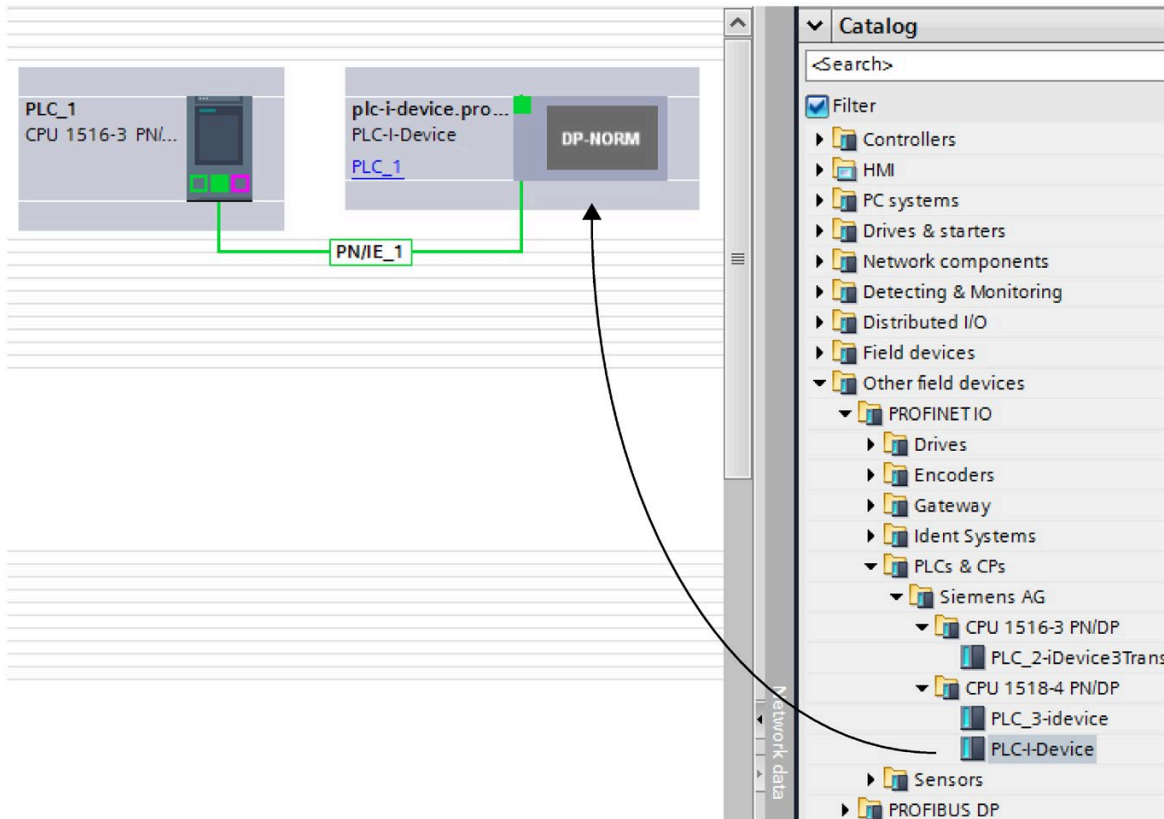


Figure 5-27 Configuring an I-device as a GSD file



In each of the projects involved, you define which transfer areas are assigned exclusively to the higher-level IO controller (default setting: all). You set the other transfer areas to "---" (not assigned). As a result of this setting, the local IO controller has no access to this transfer area and it can therefore be assigned to another IO controller in another project.

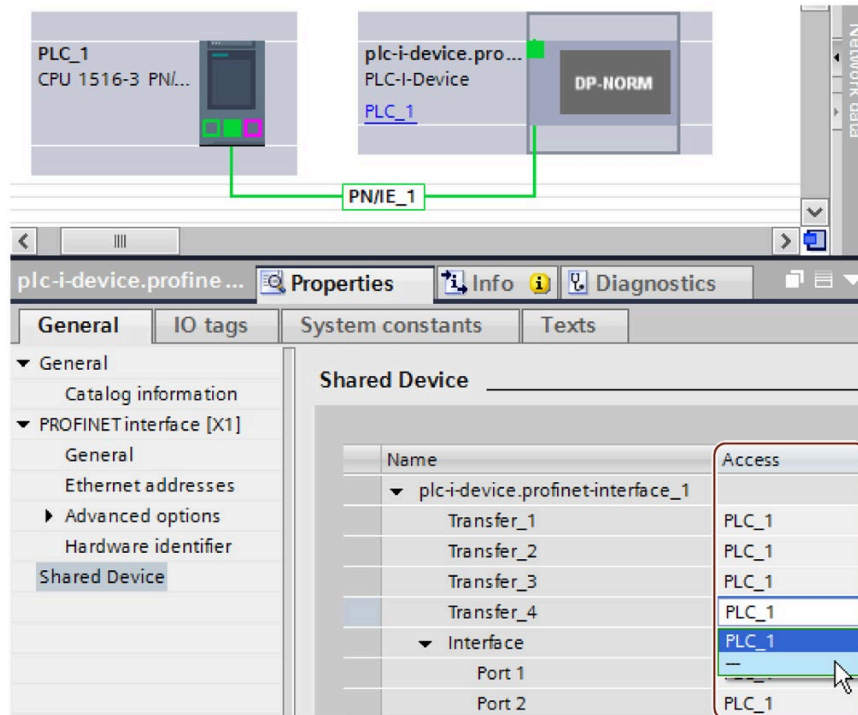


Figure 5-28 Setting the access to the shared I-device.

You adapt the addresses from the view of the IO controller in the device overview. To open the device overview, double-click the I-device.

| Device overview                   |     |      |        |           |           |                         |      |        |        |
|-----------------------------------|-----|------|--------|-----------|-----------|-------------------------|------|--------|--------|
| Module                            | ... | Rack | Slot   | I address | Q address | Type                    | O... | Fir... | Access |
| plc-i-device.profinet-interfac... |     | 0    | 1      |           | 256       | PLC-I-Device            | 6... | V1.5   |        |
| Transfer_1                        |     | 0    | 1 1000 |           | 256       | Transfer_1              |      |        | PLC_1  |
| Transfer_2                        |     | 0    | 1 1001 |           | 100       | Transfer_2              |      |        | PLC_1  |
| Transfer_3                        |     | 0    | 1 1002 | 256       |           | Transfer_3              |      |        | PLC_1  |
| Transfer_4                        |     | 0    | 1 1003 |           |           | Transfer_4              |      |        | ---    |
| Interface                         |     | 0    | 1 X1   |           |           | plc-i-device.profine... |      |        | PLC_1  |

Figure 5-29 I/O addresses of the transfer areas in the device overview

## Requirements

- STEP 7 as of V13

## Procedure - Creating the PLC-I-device project

To create the project with a shared I-device, follow these steps:

1. Start STEP 7.
2. Create a new project with the name "PLC-I-device".
3. Insert, for example, a CPU 1518-4 PN/DP from the hardware catalog in the network view.  
Assign the name "PLC-I-device".
4. Double-click the IO device and configure all required modules and submodules.

### 5. Assign the module parameters.

In particular, the following settings for the CPU are necessary in the area of the PROFINET interface [X1]:

- Enable the "IO device" option in the "Operating mode" area.
- Configure the transfer areas in the "Operating mode" > "I-device configuration" area. The "Address in IO controller" column remains empty because no IO controller is assigned.

Note: To change an input area to an output area, and vice versa, you must navigate to the area of the corresponding transfer area.

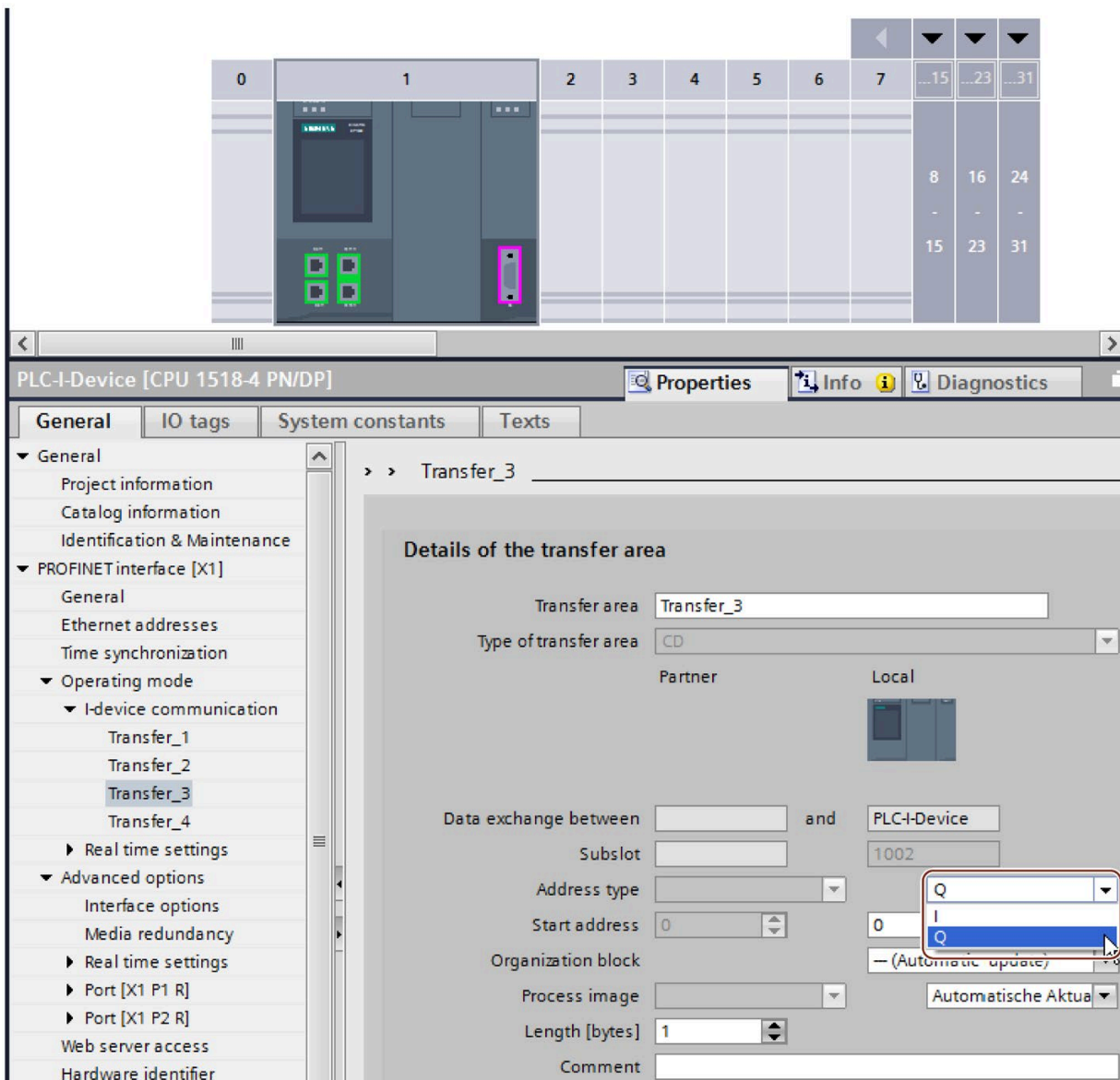


Figure 5-30 Changing the address type for the transfer area

- Select the number of IO controllers (at least two) that will access the shared I-device during operation ("Operating mode" > "Real time settings" area, "Shared Device" area).
- 6. Save the project.
- 7. Click the "Export" button ("Mode" > "I-device configuration" area, "Export general station description file (GSD)" section).

If you do not change the name in the Export dialog, the GSD file has a name in the form "GSDML-V2.31-#Siemens-PreConf\_PLC-I-Device-20130925-123456", for example.

### Procedure - Creating the PLC\_1 project

To create the first project with a shared I-device, follow these steps:

1. Start STEP 7.
2. Install the PROFINET GSD file from the export of the I-device CPU (PLC-I-Device).
3. Create a new project with the name "PLC\_1".
4. Insert, for example, a CPU 1516-3 PN/DP in the network view. The name of the CPU should be "PLC\_1".
5. Insert the I-device from the hardware catalog (Hardware catalog: Other field devices > PROFINET IO > PLCs & CPs).
6. Assign the IO controller "PLC\_1" to the I-device.
7. Select the "Shared Device" area in the properties of the I-device.  
In the table, all transfer areas and the PROFINET interface are assigned to the local IO controller (PLC\_1).
8. Define the transfer areas to which the PLC\_1 CPU should **not** have access. Select the "---" entry for these areas. These transfer areas are provided for PLC\_2.
9. Save the project.

### Procedure - Creating the PLC\_2 project

To create the second project with a shared I-device, follow these steps:

1. Start STEP 7 once again.  
A new instance of STEP 7 opens.
2. In the new instance, create a new project with the name "PLC\_2".
3. Insert, for example, a CPU 1516-3 PN/DP in the network view. Assign the name "PLC\_2".
4. Insert the I-device from the hardware catalog (Hardware catalog: Other field devices > PROFINET IO > PLCs & CPs).
5. Assign the IO controller "PLC\_2" to the I-device.
6. Adapt the access to the transfer areas as in the PLC\_1 project. Ensure that no duplicate assignments result.

7. Adapt the parameters of the subnet and PROFINET interface. Because the shared I-device involves the same device in different projects, these data must match.
8. Save the project.

Both projects now have an identically configured shared I-device. The IO controller access and the parameters of the PROFINET interface should still be checked in the different projects during the next step.

### Summary - Assigning parameters for access to the shared device

The transfer areas are automatically assigned to the local IO controller. To change the assignment, follow these steps:

1. Click the "PLC\_I-Device" device in the network view of the "PLC\_1" project, and select the "Shared Device" area.
2. A table shows which CPU has access to each of the configured transfer areas. The default setting is that the local CPU has access to all modules and submodules.
3. Keep the setting "PLC\_1" for all transfer areas that are to remain in the address range of the local CPU

Select the setting "---" for all transfer areas that are to be located in the address range of the "PLC\_2" CPU from the "PLC\_2" project. This means that an IO controller outside the project is to have access to the transfer area.

4. Follow the same procedure for the remaining projects.
5. Finally, check whether the settings for access are "complementary" for each module or submodule in both projects. This means that if the local CPU has access in one project, the option "---" must be set in the other project and vice versa.

Special consideration: The option "---" for the PROFINET interface and therefore for the ports makes the associated parameters read-only and not changeable. Parameters of the PROFINET interface and port parameters can only be edited in the project in which the PROFINET interface is assigned to the local CPU. The ports can be interconnected in both projects regardless of this.

6. Check whether the same IP address parameters and device name are set for the shared device in all projects.

Check whether the same S7 subnet ID is set in all projects for the subnet to which the shared device is connected (subnet properties, "General" area in the Inspector window).

---

#### Note

If you make changes to the I-device (e.g., change the number or length of the transfer areas):

Export the I-device as a GSD file again. Re-install the GSD file in each project that uses the I-device as a shared device. Make sure that only one IO controller has access to a transfer area.

---

### Procedure - Adjusting the real-time settings

To ensure that all IO controllers and shared devices are operated with the appropriate send clock and that the update times are calculated correctly based on the communication load, you must adjust and check the following settings:

1. You must set the same send clock for each IO controller that has access to modules and submodules of the shared device:
  - If you configure the IO controller with STEP 7 (TIA Portal):  
Open the corresponding project.  
Select the PROFINET interface of the IO controller.  
Select the "Advanced options > Real time settings > IO communication" area in the Inspector window and set the shared send clock.
  - If you configure the IO controller with a different engineering tool:  
Select the PROFINET interface of the shared device in STEP 7 (TIA Portal) and read out the send clock on the shared device ("Advanced options > Real time settings" area)  
Enter the read send clock in the engineering tool.
  - Special consideration: If you configure **all** IO controllers that have access to the shared I-device in STEP 7 (TIA Portal or V5.5), you can set shorter send clocks on the IO controller than supported by the shared device (send clock adaptation).

### Compiling and loading

You must compile the configurations for the different IO controllers and load them to the CPUs one after the other.

Due to the distributed configuration with separate projects, STEP 7 does not output consistency errors in the case of incorrect access parameter assignment. Example for incorrect access parameter assignment:

- Several IO controllers have access to the same module
- IP address parameters or send clocks are not identical

These errors do not show up until operation and are output as configuration errors, for example.

---

#### Note

After a configuration has been loaded in the IO controller, non-assigned modules or submodules retain their current parameterization state to ensure the independence from the parameterizations of other IO controllers.

---

### 5.3.4 Module-internal shared input/shared output (MSI/MSO)

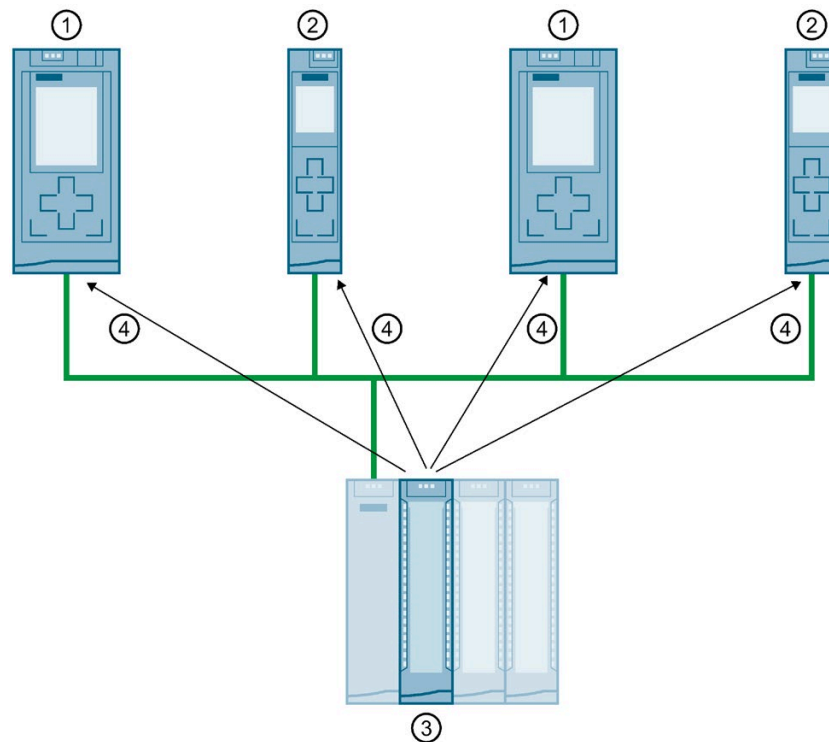
#### Introduction

This section describes the module-internal shared input/shared output (MSI/MSO) functionality for I/O modules that are operated on PROFINET.

#### Module-internal shared input/shared output functionality

The module-internal shared input (MSI) function allows an input module to make its input data available to up to four IO controllers. Each controller has read access to the same channels.

The following figure shows the MSI functionality.

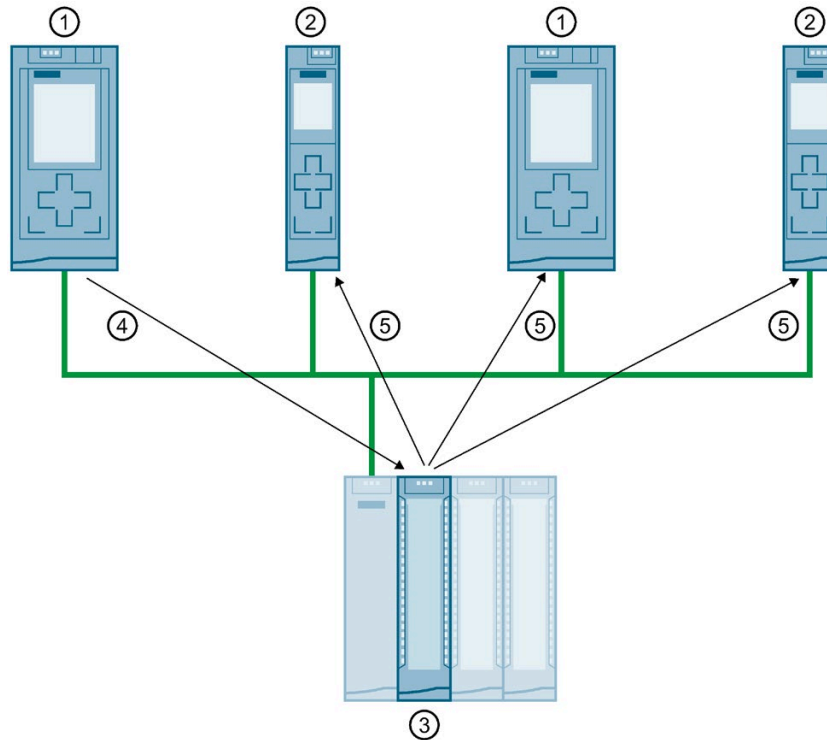


- ① CPU 1516-3 PN/DP as IO controller
- ② CPU 1511-1 PN as IO controller
- ③ Input module with MSI
- ④ Read access to the input channels of the input module
- ⑤ Write access to the channels of the I/O module (only with MSO)

Figure 5-31 Example configuration with MSI

The module-internal shared output (MSO) function allows an output module to make its output data available to up to four IO controllers. An IO controller has write access to the channels of the output module. Up to three IO controllers can additionally have read-access to the channels.

The following figure shows the MSO functionality.



- ① CPU 1516-3 PN/DP as IO controller
- ② CPU 1511-1 PN as IO controller
- ③ Output module with MSO
- ④ Write access to the output channels of the output module
- ⑤ Read access to the output channels of the output module

Figure 5-32 Example configuration with MSO

## Advantages of MSI/MSO

Module-internal shared input/shared output (MSI/MSO) offers the following advantages:

- Real-time acquisition in multiple CPUs
- Lower costs due to saving on additional IO devices and modules
- Lower space requirements due to saving on additional IO devices and modules
- Reduced communication load because no CPU-CPU communication is needed
- No additional programming effort is needed for CPU-CPU communication



**Requirements for the use of MSI/MSO**

Observe the following requirements:

- MSI/MSO can only be used with PROFINET IO
- Configuration software: STEP 7 (TIA Portal) as of V12 SP1 with GSD file; the modules are integrated in the hardware catalog as of V13.
- The IM 155-5 PN ST interface module and the modules support MSI/MSO as of firmware version V2.0.0.

**Boundary conditions for the use of MSI/MSO**

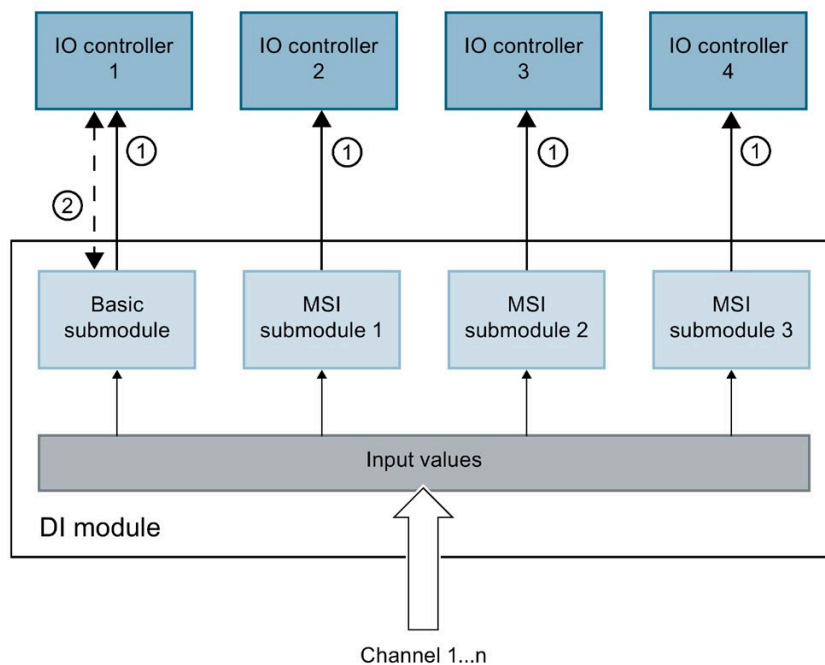
Note the following boundary conditions:

- The use of MSI/MSO is not possible in the case of module grouping.
- Modules with MSI/MSO cannot be operated in isochronous mode.
- The maximum number of IO controllers is dependent on the interface module. To find out how many IO controllers the interface module supports, refer to the manual for the respective interface module.

## MSI submodules

The input values of all channels are copied to a basic submodule and up to three other MSI submodules during MSI configuration of an input module. The channels of the module are then available with identical input values in the basic submodule and the MSI submodules. The MSI submodules can be assigned to up to three IO controllers when the module is used in a shared device. Each IO controller has read access to the same channels.

The following figure shows a digital input module with the basic submodule and three MSI submodules. Each submodule is assigned to an IO controller. Diagnostics and parameter assignment of the digital input module can be performed from the IO controller 1 via the basic submodule.



- ① Read access
- ② Parameter assignment and system diagnostics

Figure 5-33 DI module with MSI submodules

### Value status (Quality Information, QI)

The meaning of the value status depends on the submodule to which it pertains.

With basic submodule (= 1st submodule), the "0" value status indicates that the value is incorrect.

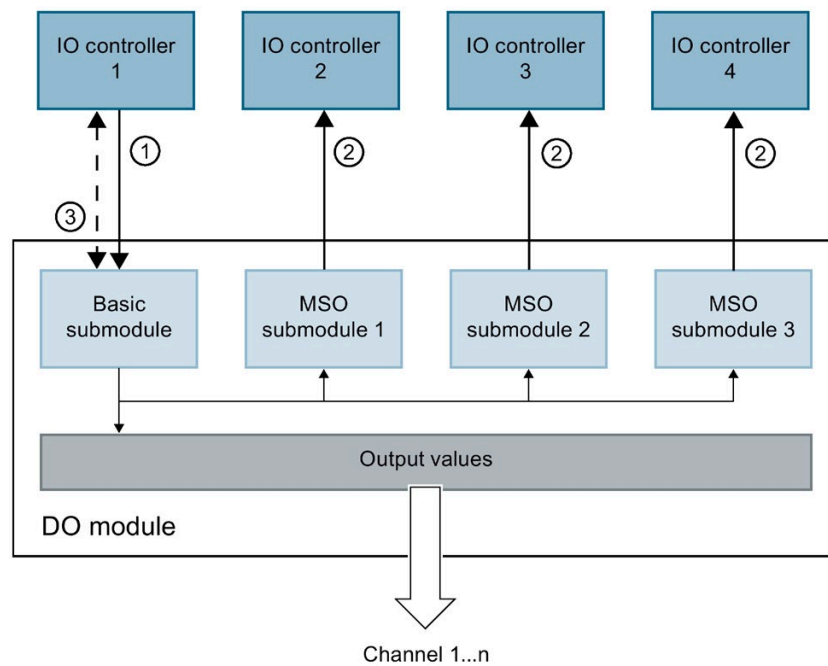
With an MSI submodule (2nd to 4th submodule), the "0" value status indicates that the value is incorrect or the basic submodule has not yet been configured (not ready).

## MSO submodules

During MSO configuration of an output module, the output values of all channels of the module are copied from a basic submodule to up to three other MSO submodules. The channels of the module are then available with identical values in the basic submodule and the MSO submodules. The MSO submodules can be assigned to up to three IO controllers when the module is used in a shared device.

- The IO controller to which the basic submodule is assigned has write access to the outputs of the module. The basic submodule therefore occupies output addresses in the process image of the IO controller.
- The IO controllers to which the MSO submodules are assigned have read access to the outputs of the module. MSO submodules therefore occupy input addresses in the process image of the IO controller.

The following figure shows a digital output module with the basic submodule and three MSO submodules. Each submodule is assigned to an IO controller. Diagnostics and parameter assignment of the digital output module can be performed from IO controller 1 via the basic submodule.



- ① Write access
- ② Read access
- ③ Parameter assignment and system diagnostics

Figure 5-34 DQ module with MSO submodule

**Value status (Quality Information, QI)**

The meaning of the value status depends on the submodule to which it pertains.

With basic submodule (= 1st submodule), the "0" value status indicates that the value is incorrect.

With MSO submodule (= 2nd to 4th submodule) the "0" value status indicates that the value is incorrect or one of the following errors has occurred:

- The basic submodule parameters have not yet been assigned (not ready for operation).
- The connection between the IO controller and the basic submodule has been interrupted.
- The IO controller of the basic submodule is in STOP or POWER OFF state.

**Configuring I/O modules with MSI/MSO submodules****Requirements**

- Configuration software STEP 7 as of V13
- IO device supports MSI/MSO (for example IM 155-5 PN ST as of firmware version 2.0.0)

**Procedure**

1. In the network view of STEP 7, insert an IM 155-5 PN ST interface module as of V2.0.
2. Double-click the IO device.

You are now in the device view.

3. Place the I/O modules from the hardware catalog in a suitable slot.
4. Add MSI/MSO submodules to the I/O modules:
  - Input modules: Select the number of MSI submodules under "Module parameters" > "DI configuration" or "AI configuration" in the area "Copy of module for Shared Device (MSI)".
  - Output modules: Select the number of MSO submodules under "Module parameters" > "DQ configuration" or "AW configuration" in the area "Copy of module for shared device (MSO)".

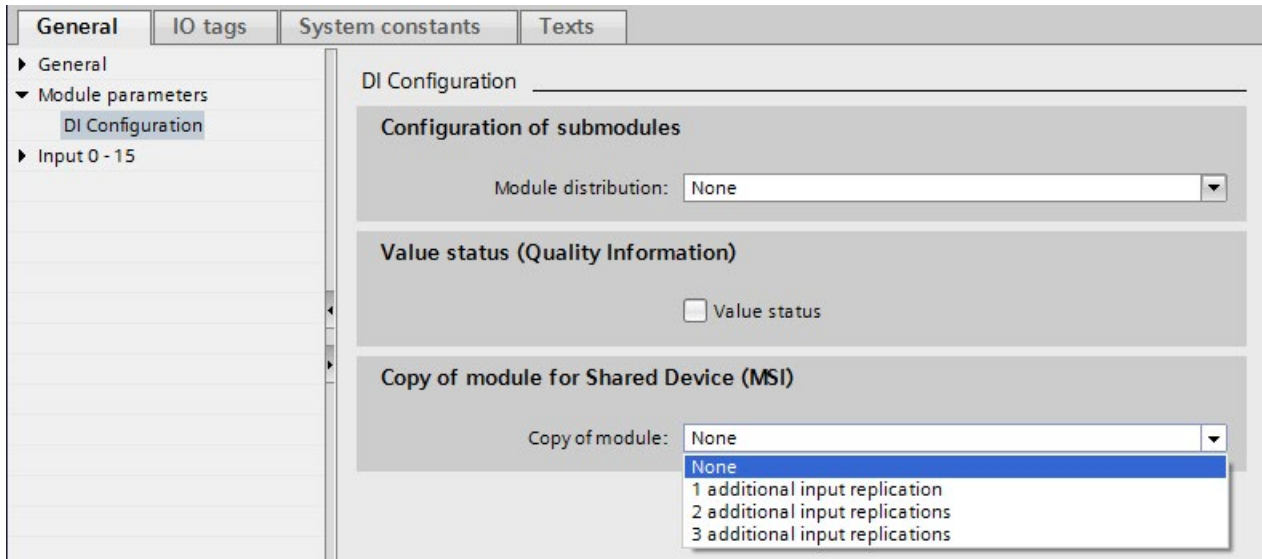


Figure 5-35 Configuring I/O modules with MSI/MSO

### Assigning MSI/MSO submodules to an IO controller

You can assign the submodules in a shared device to an IO controller.

For more information, refer to Configuring shared device (Page 1).

### Configuring access to a shared device and the module-internal shared input / shared output (MSI /MSO) function

You can learn how to access a shared device and the MSI /MSO function in STEP 7 with this FAQ (<https://support.industry.siemens.com/cs/ww/en/view/109736536>).

## 5.4 Media redundancy (ring topologies)

In order to increase the network availability of an Industrial Ethernet network with optical or electrical linear bus topologies, you can convert a linear bus topology to a ring topology by joining the ends together.

### Media redundancy in ring topologies

Devices in a ring topology can be IO devices, IO controllers, external switches and/or the integrated switches of communication modules.

To set up a ring topology with media redundancy, you need to bring together the two free ends of a linear bus topology in one device. Closing the linear bus topology to form a ring is achieved with two ports (ring ports) of a device in the ring. One device of the resulting ring then takes over the role of the redundancy manager. All other devices in the ring are redundancy clients.

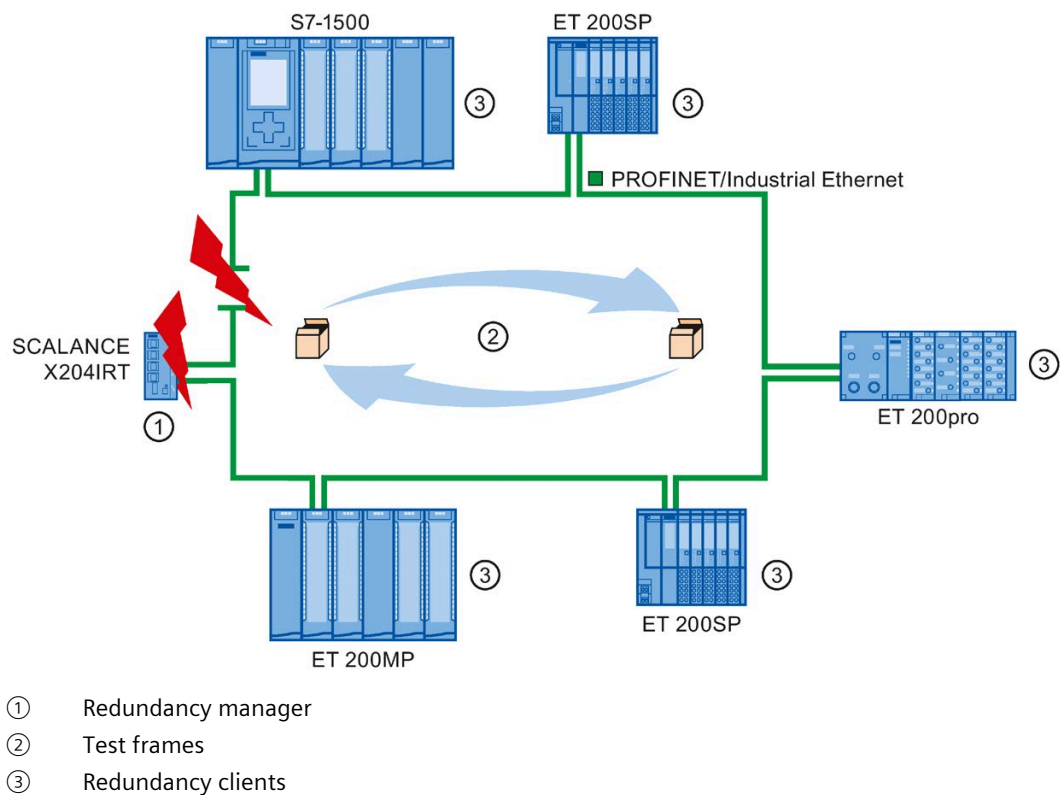


Figure 5-36 Media redundancy in ring topology

The ring ports of a device are the ports that establish the connection to the two neighboring devices in the ring topology. The ring ports are selected and set in the configuration of the relevant device (is also preset, if applicable).

### How media redundancy works in a ring topology

The data paths between the individual devices are automatically reconfigured if the ring is interrupted at any point. The devices are available again after reconfiguration.

In the redundancy manager, one of the two ring ports is blocked in uninterrupted network operation for normal communication so that no data frames are circulated. In terms of data transmission, the ring topology is a linear bus topology. The redundancy manager monitors the ring for interruptions. For this purpose, it sends test frames not only from ring port 1 but also from ring port 2. The test frames pass through the ring in both directions until they arrive at the other ring port of the redundancy manager.

An interruption of the ring can be caused by loss of the connection between two devices or by failure of a device in the ring.

If the test frames of the redundancy manager no longer arrive at the other ring port during an interruption of the ring, the redundancy manager connects its two ring ports. This substitute path once again restores a functioning connection between all remaining devices in the form of a linear bus topology.

The time between the ring interruption and restoration of a functional linear topology is known as the reconfiguration time.

As soon as the interruption has been eliminated, one of the two ring ports is blocked again in the redundancy manager. The redundancy clients are informed about the change and use the original paths to the other devices again.

### Media redundancy method

The standard method of media redundancy in SIMATIC is MRP (Media Redundancy Protocol) with a typical reconfiguration time of 200 ms. Up to 50 devices can participate per ring.

In addition, the real-time capable media redundancy process MRPD (Media Redundancy with Planned Duplication of frames) is also available.

## 5.4.1 Media Redundancy Protocol (MRP)

### Media Redundancy Protocol (MRP)

The "MRP" process works in conformity with the Media Redundancy Protocol (MRP) that is specified in the standard IEC 62439-2.

### Requirements

- All devices in the ring support MRP.
- You have complied with the rules for topology set out below. STEP 7 monitors compliance with the rules during compilation and outputs corresponding alarms.

## Topology

The following schematic shows a possible topology for devices in a ring with MRP. The devices inside the shaded oval are in the redundancy domain.

Example of a ring topology with the MRP media redundancy protocol:

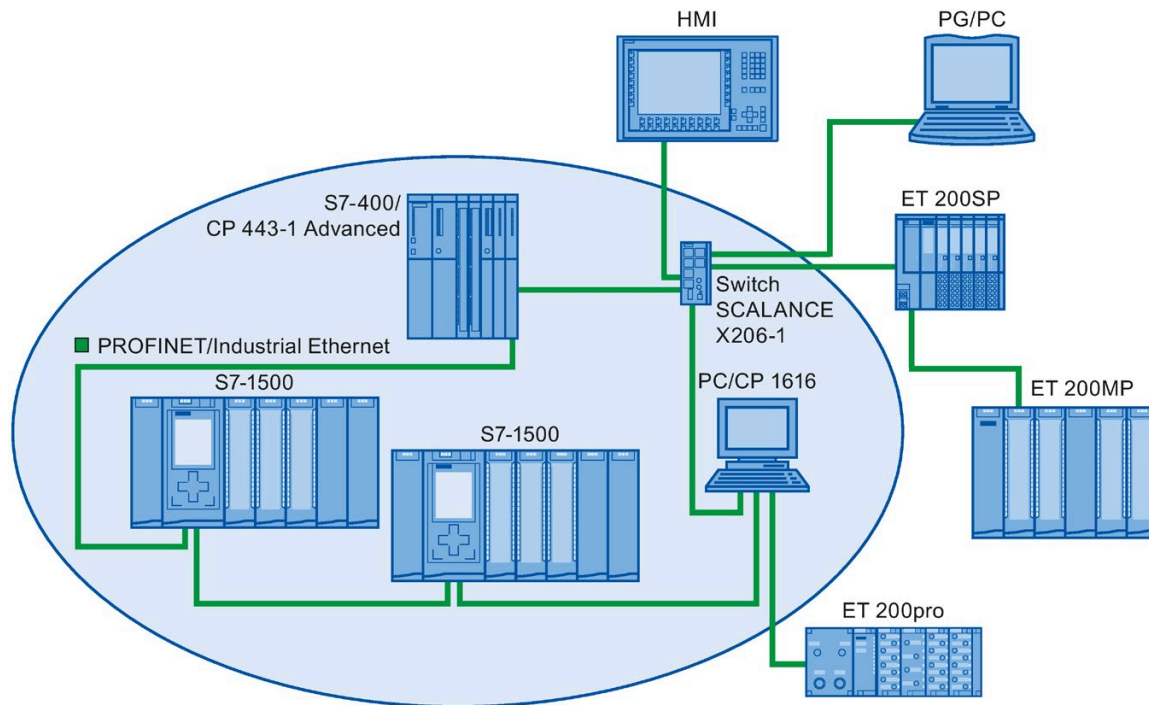


Figure 5-37 Example of a ring topology with the MRP media redundancy protocol:

The following rules apply to a ring topology with media redundancy using MRP:

- All devices must be connected to one other via their ring ports.
- All devices in the ring belong to the same redundancy domain.
- A device in the ring takes on the task of a redundancy manager.
  - One device only has the role of "Manager". No other device may have the role of "Manager". Or
  - One device or multiple devices in the ring have the role of "Manager (auto)". The devices with the role of "Manager (auto)" then negotiate between themselves which device is to take on the role of redundancy manager. In this case, no device is permitted to have the role of "Manager".
- All other devices in the ring are redundancy clients.
- You can connect up to 50 devices in a ring.

Non MRP-compliant devices can, for example, be connected to the ring via a SCALANCE X switch or via a PC with a CP 1616.



## Rules for loading the devices of an MRP domain

When loading devices of an MRP domain, frame loops can occur and result in network failure if there is an invalid MRP configuration.

Example: You change the MRP roles of several devices and consecutively load the configuration into the devices involved. Configurations can arise that contradict the roles mentioned above, for example, there may be devices that simultaneously have the "Manager" and "Manager (auto)" roles in the ring.

To ensure that an invalid MRP configuration does not result in the failure of the network, open the ring before loading.

Follow these steps:

1. Open the ring.
2. Load the error-free and consistent MRP configuration from your project onto all the devices involved and ensure that the devices are in data exchange mode (i.e. the application relations (ARs) are set up).
3. Close the ring.

## Boundary conditions

### MRP and RT

RT operation is possible with the use of MRP.

---

### Note

The RT communication is disrupted (station failure) if the reconfiguration time of the ring is greater than the selected response monitoring time of the IO device. This is why you should select a response monitoring time of the IO devices that is sufficiently large.

---

### MRP and IRT

IRT mode is not possible together with MRP.

If you want to use media redundancy together with IRT in a ring, only use devices that support MRPD.

### MRP and TCP/IP (TSEND, HTTP, ...)

The TCP/IP communication with MRP is possible, because lost data packages are resent, if applicable.

### MRP and prioritized startup

If you configure MRP in a ring, you cannot use the "prioritized startup" function in PROFINET applications on the devices involved.

If you want to use the "prioritized startup" function, then you must disable MRP in the configuration (the device may also not be part of the ring).

### Information on S7-1500R/H

You can find information on the media redundancy method MRP of the redundant S7-1500R/H system in section Configuring PROFINET IO on a redundant S7-1500R/H system (Page 1).

### Application example: Reading the MRP status in the user program

The "LPNDR\_ReadMRPState" function block from the "LPNDR" block library helps you to determine the status of the MRP ring per program. The block reads the MRP information from the PROFINET device (MRP Manager) and outputs the status.

The "LPNDR" block library and the corresponding documentation can be found in this application example (<https://support.industry.siemens.com/cs/ww/de/view/109753067>).

## 5.4.2 Configuring media redundancy

### Configuring MRP

Proceed as follows to create a PROFINET IO configuration with MRP in STEP 7:

1. Generate a ring via the port interconnections in the topology view. First interconnect the devices to a line topology. Connect the unassigned port of the last device in the line with the unassigned port of the first device.  
The following example shows one CPU 1516-3 PN/DP and two interface modules IM 155-6 PN HF that are interconnected in a ring in the topology view of STEP 7.

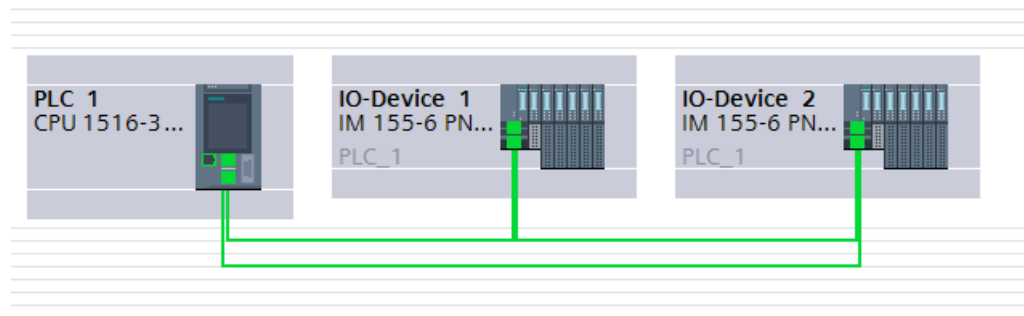


Figure 5-38 Configuring media redundancy

2. Select the PROFINET IO system in the network view.
3. In the Inspector window, navigate to "Properties" > "General" > "PROFINET" > "MRP domains" in the "Ring interconnections" field.  
This field shows you all the topological rings in the IO system with the associated MRP domains.

4. Select the ring generated above in the "Ring interconnections" field.  
The table below it shows all the PROFINET devices in the ring.
5. Set the media redundancy role for the PROFINET devices in the MRP role column.

**Ring interconnection**

|   | Ring  | MRP domain  |
|---|-------|-------------|
| 1 | Ring1 | mrpdomain-1 |
|   |       |             |
|   |       |             |
|   |       |             |
|   |       |             |
|   |       |             |

|   | PROFINET device name    | MRP domain  | MRP role          | Ring port 1      | Ring port 2      |
|---|-------------------------|-------------|-------------------|------------------|------------------|
| 1 | IO-Device_1.PROFINET-IF | mrpdomain-1 | Not device in ... | Port_1 [X1 P1 R] | Port_2 [X1 P2 R] |
| 2 | IO-Device_2.PROFINET-IF | mrpdomain-1 | Not device in ... | Port_1 [X1 P1 R] | Port_2 [X1 P2 R] |
| 3 | PLC_1.PROFINET-IF_1     | mrpdoma...  | Not device in ... | Port_1 [X1 P1 R] | Port_2 [X1 P...  |
|   |                         |             |                   |                  |                  |
|   |                         |             |                   |                  |                  |
|   |                         |             |                   |                  |                  |

Not device in the ring  
 Manager  
 Client  
 Manager (auto)

Figure 5-39 MRP domain

### Automatic MRP configuration

You can also have the media redundancy roles assigned automatically for your PROFINET devices in the ring.

To have the media redundancy roles assigned automatically, click the "Configure MRP automatically" button. STEP 7 automatically assigns the media redundancy role for each device in the ring. After the automatic MRP configuration, you can make modifications to the media redundancy roles in the "MRP role" column.

## "Media redundancy" setting options

### Media redundancy role

Depending on the device used, the roles "Manager", "Manager (auto)", "Client" and "Not device in the ring" are available.

Rules:

- A ring must have precisely one device with the role "Manager". No additional devices with the role "Manager" or "Manager (auto)" are permissible. All the other devices may only have the "Client" role.
- If a ring has no device with the "Manager" role, the ring must at least have a device with the role "Manager (auto)". Any number of devices with the "Client" role may exist.
- Managers and clients of an MRP domain can be configured in different projects. In the project without a manager, you need to select the "Redundancy manager outside the project" option so that the configuration can be compiled. For multiple ring configurations, you need to set the option identically for each MRP domain.

### Ring port 1 / Ring port 2

Select one at a time those ports you want to configure as ring port 1 or ring port 2. The drop-down list box shows the selection of possible ports for each device type. If the ports are set at the factory, then the fields are unavailable.

If you use single-stage commissioning, use the preset ring ports in STEP 7.

## Diagnostic interrupts

If diagnostic interrupts to the MRP state are to be output in the local CPU, select the "Diagnostic interrupts" check box. The following diagnostic interrupts can be configured:

- Wiring or port error  
Diagnostic interrupts will be generated for the following errors in the ring ports:
  - A neighbor of the ring port does not support MRP.
  - A ring port is connected to a non-ring port
  - A ring port is connected to the ring port of another MRP domain.
- Interruption / return (redundancy manager only)
  - In case the ring is interrupted, a diagnostic interrupt "Ring open (incoming)" is generated.
  - When the ring is closed, the diagnostics "Ring open (outgoing)" is generated.

You can respond to these events in the user program by programming the appropriate response in the diagnostic error interrupt OB (OB 82).

## Reference

You can find the procedure for configuring a common MRP ring and the topology with two projects in this FAQ (<https://support.industry.siemens.com/cs/ww/en/view/109741671>).

### 5.4.3 Media redundancy with planned duplication of frames (MRPD; not for S7-1500R/H)

#### MRP extension "Media Redundancy with Planned Duplication of frames" (MRPD)

The MRP extension "Media Redundancy with Planned Duplication of frames" (MRPD) provides the advantage that, in the case of a failure of a device or a line in the ring, all other devices continue to be supplied with IO data without interruption and with short update times.

MRPD is based on IRT and MRP. To realize media redundancy with short update times, the PROFINET devices participating in the ring send their data in both directions. The devices receive this data at both ring ports so that there is no reconfiguration time.

#### Requirements for media redundancy with MRPD

- All the devices of the ring must support MRPD, for example interface module IM 155-6 PN HS as of firmware version 4.0.
- You have configured MRP for all the devices of the ring. You have assigned the MRP role "Not device in the ring" to devices that are not located in the ring.
- You have configured IRT for all the involved components.

#### Configuring MRPD

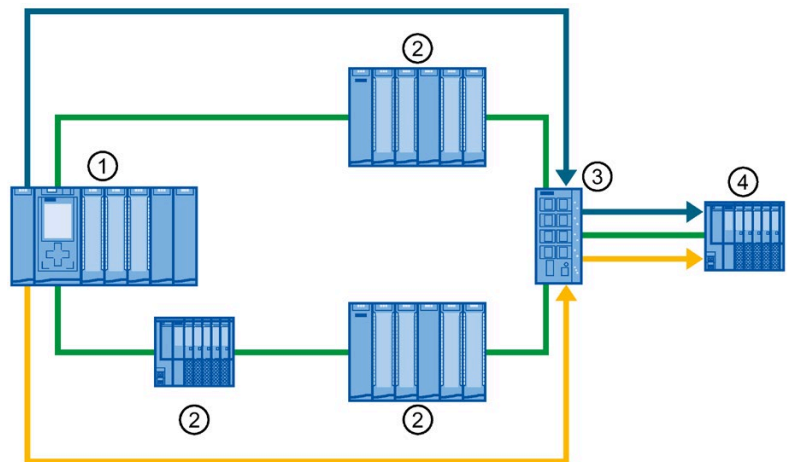
You do not have to explicitly activate MRPD in STEP 7. The function is available automatically as soon as all the requirements for MRPD are fulfilled.

### Redundancy levels of IO devices with MRPD

The redundancy level of an IO device specifies how strongly the real-time communication is influenced in the case of a power interruption between an IO device and its IO controller.

- Full redundancy: No influence, because the IO controller and IO device are located in the same ring.
- Partial redundancy:
  - If the interruption takes place on a non-redundant part (line) between the IO device and IO controller, real-time communication is influenced.
  - If the interruption takes place on a redundant part (ring), real-time communication is not influenced.
- No redundancy: No redundant path between the IO device and its IO controller, communication is always influenced.

The figure below shows the redundancy levels of the IO devices for an example configuration with MRPD. The three devices in the ring and the switch have the redundancy level "Full redundancy". Device 4 has the redundancy level "Partial redundancy", because the connection between the switch and the device is not redundant.



- ① IO controller in the ring
- ② IO device in the ring with redundancy level "Full redundancy"
- ③ Switch in the ring with redundancy level "Full redundancy"
- ④ IO device in the spur with the redundancy level "Partial redundancy"

Figure 5-40 Example configuration with MRPD

The figure below shows the display of the redundancy levels in STEP 7 for the example configuration.

| IO devices                 |          |                      |                    |           |
|----------------------------|----------|----------------------|--------------------|-----------|
| PROFINET device name       | RT class | Synchronization role | Redundancy level   | DFP group |
| plc_1.profinet interface_1 | RT,IRT   | Sync master          |                    |           |
| io-device_1                | IRT      | Sync slave           | Full redundancy    |           |
| io-device_2                | IRT      | Sync slave           | Full redundancy    |           |
| io-device_3                | IRT      | Sync slave           | Full redundancy    |           |
| io-device_4                | IRT      | Sync slave           | Partial redundancy |           |
| switch_1                   | IRT      | Sync slave           | Full redundancy    |           |

Figure 5-41 Display of the redundancy levels in STEP 7

### 5.4.4 Multiple rings

#### Multiple rings

Use multiple rings to achieve higher availability for PROFINET IO networks with star topology.

In a multiple ring configuration, several PROFINET lines lead from a switch (star topology). The individual PROFINET lines lead from IO device to IO device. Redundant PROFINET cables run back to the switch from the last IO device on each individual line.

The switch operates as a manager. The manager must have two ring ports for each ring. Multiple rings are possible. The SCALANCE X414 as of firmware version 3.10, for example, supports up to 4 rings.

The manager monitors all the rings individually: It checks for each particular ring (an MRP domain) whether the transmission path is intact. To do this, it uses an MRP instance in each case. An MRP instance is required for each connected ring (set up automatically by STEP 7).

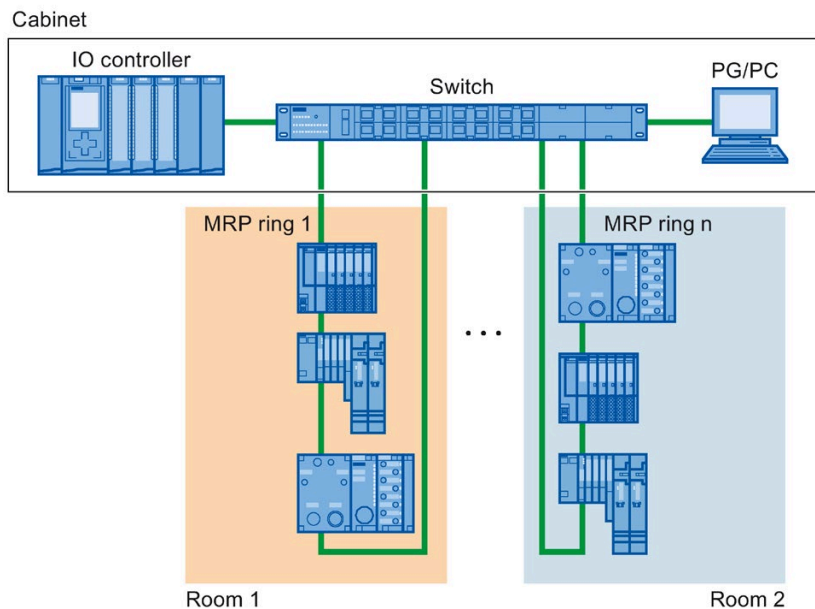


Figure 5-42 Configuration with several rings

#### Requirements

- SCALANCE X414 as of version 3.10
- SCALANCE X300 as of version 4.0 (configured via GSD file)



## Rules for the configuration of multiple rings

- MRP role at multiple rings:
  - The device that belongs to all the rings must have the MRP role in every instance that is entered in the GSD file in the "SupportedMultipleRole" attribute.
  - The switches from the series SCALANCE X300 as of version 4.0 and the switch X414 as of version 4.10 support the MRP role "Manager" for multiple rings.
- If the device that belongs to all rings has the "Manager" role in one ring, no devices with the "Manager (Auto)" role may exist in this ring.

## Configuring multiple rings

To configure an MRP configuration with multiple rings, follow these steps:

1. In the topology view, interconnect the ring ports of the devices that are intended to belong to an MRP domain to form a ring.
2. Select the PROFINET IO system in the network view.
3. In the Inspector window, navigate to "Properties" > "General" > "PROFINET" > "MRP domains" in the "Ring interconnections" field.  
This field shows you all the topological rings in the IO system with the associated MRP domains.
4. Select one of the rings generated above in the "Ring interconnections" field.  
The table below it shows all the PROFINET devices in the ring.
5. Set the media redundancy role for the PROFINET devices in the MRP role column.

## Example of multiple rings

The following figure shows an example configuration for multiple rings.

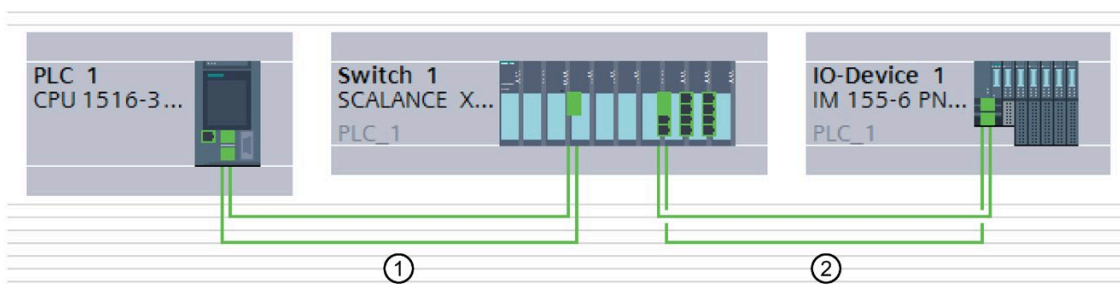


Figure 5-43 Example configuration with two rings ① and ②

## 5.4 Media redundancy (ring topologies)

In the example, Switch 1 belongs to two MRP rings. Ring 1 is formed by Switch 1 and PLC 1, Ring 2 by Switch 1 and IO device 1.

STEP 7 automatically assigns the "Manager" role to the switch. The other devices receive the "Client" role.

The manager is located at the point of intersection of the two rings 1 and 2. The manager monitors the two rings separately. To do this, it uses two MRP instances.

One MRP instance checks whether all devices in ring 1 are reachable, another instance monitors whether all devices in ring 2 are reachable (only one device in each case in the example).

You can configure each MRP instance separately.

The following figure shows the two MRP instances in the manager (PROFINET interface of the switch). Here in the example, MRP instance 1 checks whether the devices in the MRP domain "mrpdomain-1" can be reached. The MRP instance 2 is responsible for monitoring the devices of the MRP domain "mrpdomain-2".

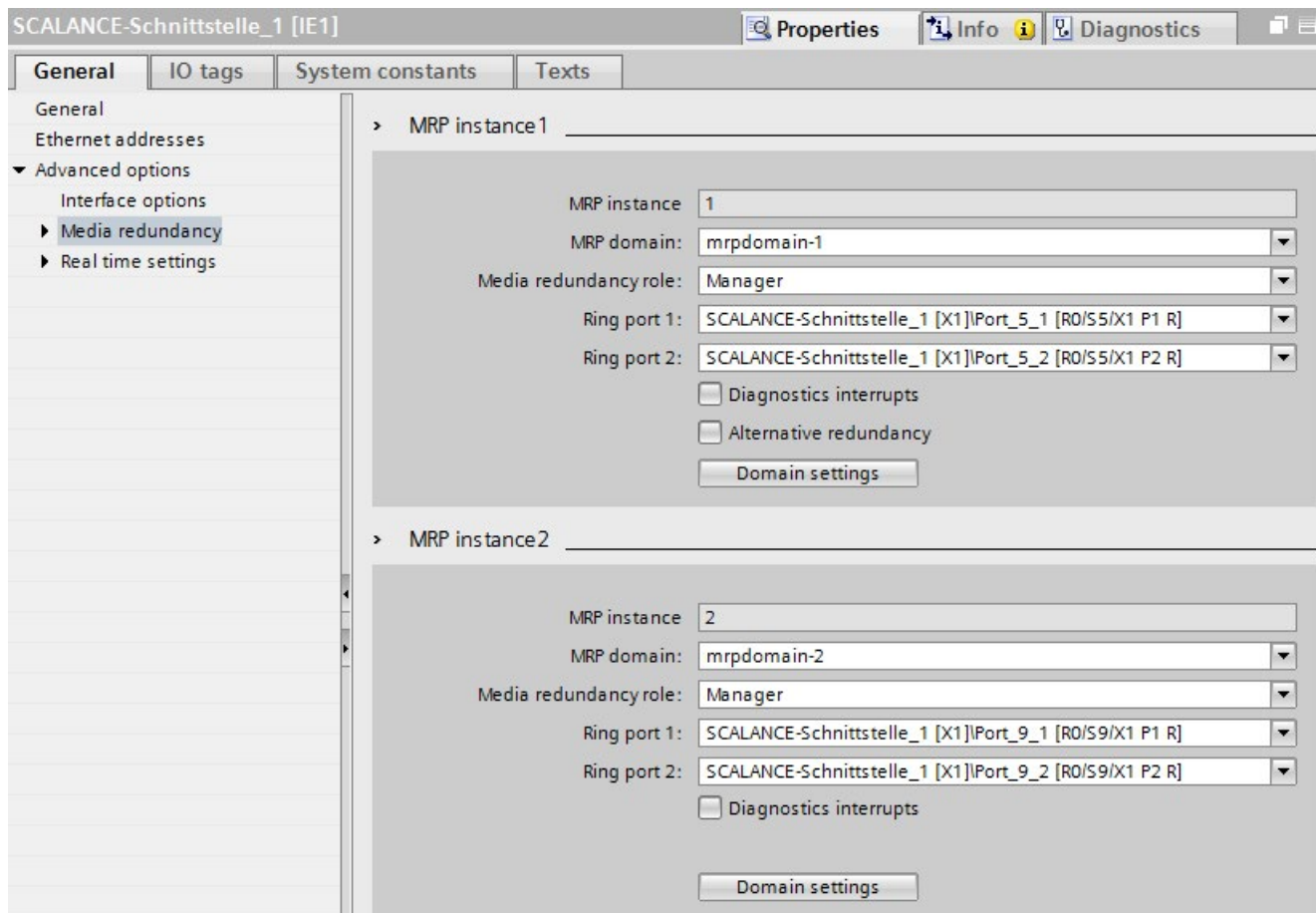


Figure 5-44 Setting media redundancy for multiple rings

### Ring interconnection

|   | Ring  | MRP domain  |
|---|-------|-------------|
| 1 | Ring1 | mrpdomain-1 |
| 2 | Ring2 | mrpdomain-2 |
|   |       |             |
|   |       |             |
|   |       |             |
|   |       |             |

|   | PROFINET device name   | MRP instance | MRP domain  | MRP role | Ring port 1            | Ring port 2            |
|---|------------------------|--------------|-------------|----------|------------------------|------------------------|
| 1 | PLC_1.PROFINET-IF_1    |              | mrpdomain-1 | Client   | Port_1 [X1 P1 R]       | Port_2 [X1 P2 R]       |
| 2 | Switch_1.SCALANCE-IF_1 | 1            | mrpdomain-1 | Manager  | Port_1 [R0/S5/X1 P1 R] | Port_2 [R0/S5/X1 P2 R] |

The following figure shows Ring 2 (mrpdomain-2). The participants of the mrpdomain-2 are the PROFINET interface of the IO device as the "Client" and the MRP instance 2 of the PROFINET interface of the switch as the "Manager".

### Ring interconnection

|   | Ring  | MRP domain  |
|---|-------|-------------|
| 1 | Ring1 | mrpdomain-1 |
| 2 | Ring2 | mrpdomain-2 |
|   |       |             |
|   |       |             |
|   |       |             |
|   |       |             |

|   | PROFINET device name    | MRP instance | MRP domain  | MRP role | Ring port 1            | Ring port 2            |
|---|-------------------------|--------------|-------------|----------|------------------------|------------------------|
| 1 | IO-Device_1.PROFINET-IF |              | mrpdomain-2 | Client   | Port_1 [X1 P1 R]       | Port_2 [X1 P2 R]       |
| 2 | Switch_1.SCALANCE-IF_1  | 2            | mrpdomain-2 | Manager  | Port_5 [R0/S9/X1 P1 R] | Port_6 [R0/S9/X1 P2 R] |

PROFINET with STEP 7  
Function Manual, 05/2021, A5E03444486-AL

### 5.4.5 MRP interconnection

#### Definition

The process MRP interconnection is an enhancement of MRP and allows the redundant coupling of two or more rings with MRP in PROFINET networks. MRP interconnection is - like MRP - specified in the standard IEC 62439-2 (Edition 3).

#### Advantages

MRP interconnection allows the monitoring of larger topologies with ring redundancy. With MRP interconnection, you are not limited to the maximum number of 50 devices in a ring when setting up redundant network topologies. For information on the quantity structure of MRP Interconnection, refer to the SCALANCE XM-400/XR-500 Web Based Management (WBM) (<https://support.industry.siemens.com/cs/ww/en/view/109760840>) configuration manual.

#### Requirements

- The media redundancy procedure MRP is used in the participating rings.
- Each ring has its own MRP domain with an MRP manager and MRP clients.
- As MRP managers in the rings, the PROFINET devices support MRP interconnection (see technical specifications of the devices).  
S7-1500 CPUs as of firmware version V2.9 support MRP interconnection.
- If you use PROFINET devices with more than 2 ports as MRP clients in the ring, then MRP interconnection is binding for these devices. For a device without MRP interconnection, telegrams leave the ring. This results in an additional load on the network.
- If you use PROFINET devices with only 2 ports in the ring as MRP clients, then MRP interconnection is recommended for all devices in the ring.

#### 4 devices for MRP interconnection connections

2 MRP-interconnection connections provide redundant coupling between 2 MRP rings. Four devices are required for the 2 connections:

- A Media Redundancy Interconnection Manager (MIM)
- 3 media-redundancy interconnection clients (MIC):
  - Primary MIC
  - Primary Coupled MIC
  - Secondary Coupled MIC

Since each of the four devices is part of an MRP ring, each device also assumes a media redundancy role.

Each of the 4 devices can take over the MRP manager role or MRP client role.

## Topology

The following screen shows the redundant coupling of 2 MRP rings.

Redundancy: If the primary connection (primary link) between the two rings is interrupted, the secondary connection (secondary link) takes over the data exchange between the rings after a short reconfiguration time.

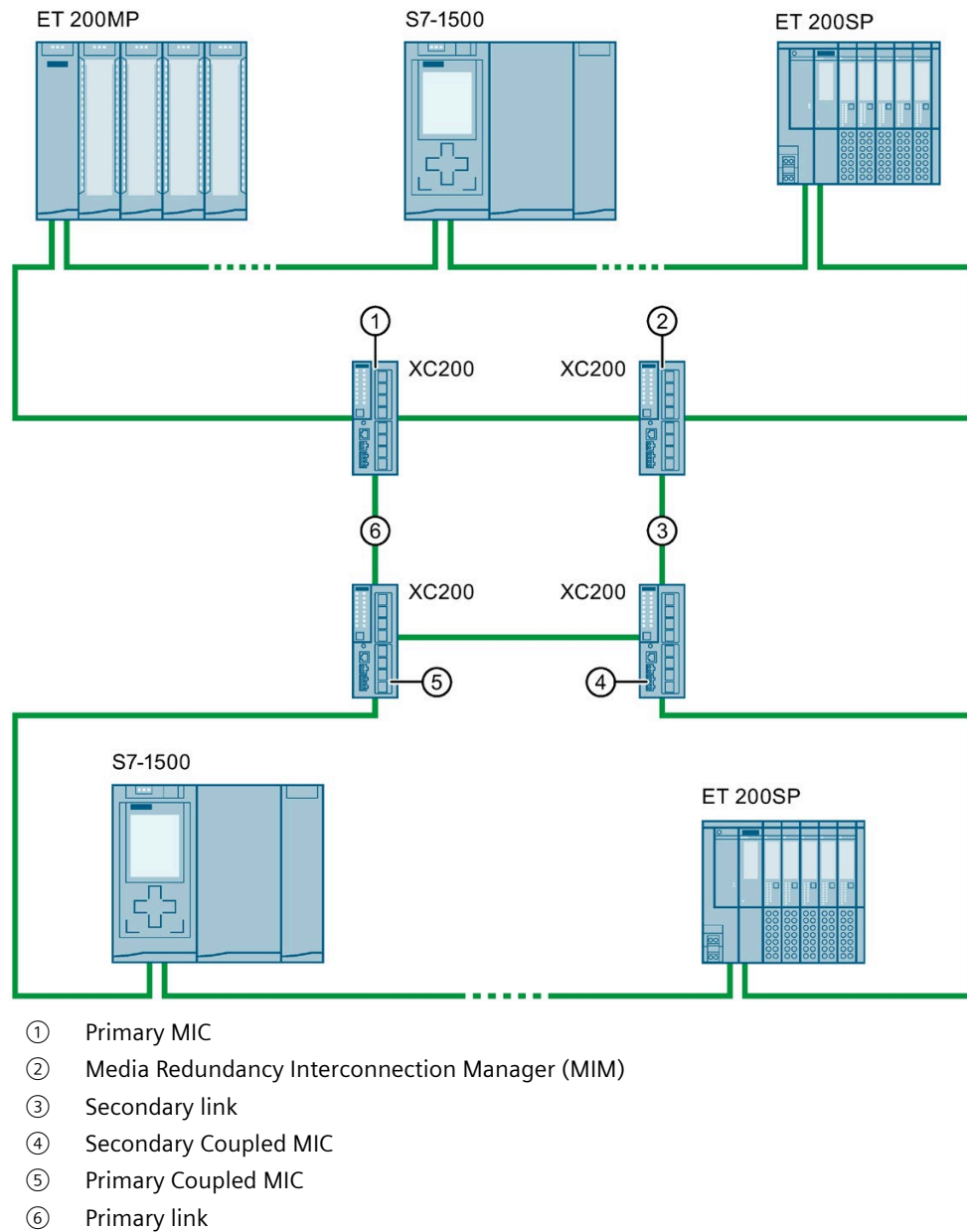


Figure 5-47 Example: Redundant connection of 2 rings with MRP interconnection

### Function of the interconnection ports

Interconnection ports are appropriately configured PROFINET ports of the 4 devices for MRP interconnection. The primary or secondary connection of the rings exists between the interconnection ports.

Via the interconnection ports; the MIM is always informed about the connection status between the Primary MIC and the Primary Coupled MIC ("primary connection") as well as its own connection to the Secondary Coupled MIC ("secondary connection").

Depending on the connection status of the interconnection ports, each MIC sends a message to the MIM when its status changes (Link-Up or Link-Down).

In regular operation the data between the two rings is exchanged over the primary connection (primary link) and the MIM blocks its interconnection port.

### Link-Down of the primary connection

In the figure below, the primary connection was interrupted (Link-Down).

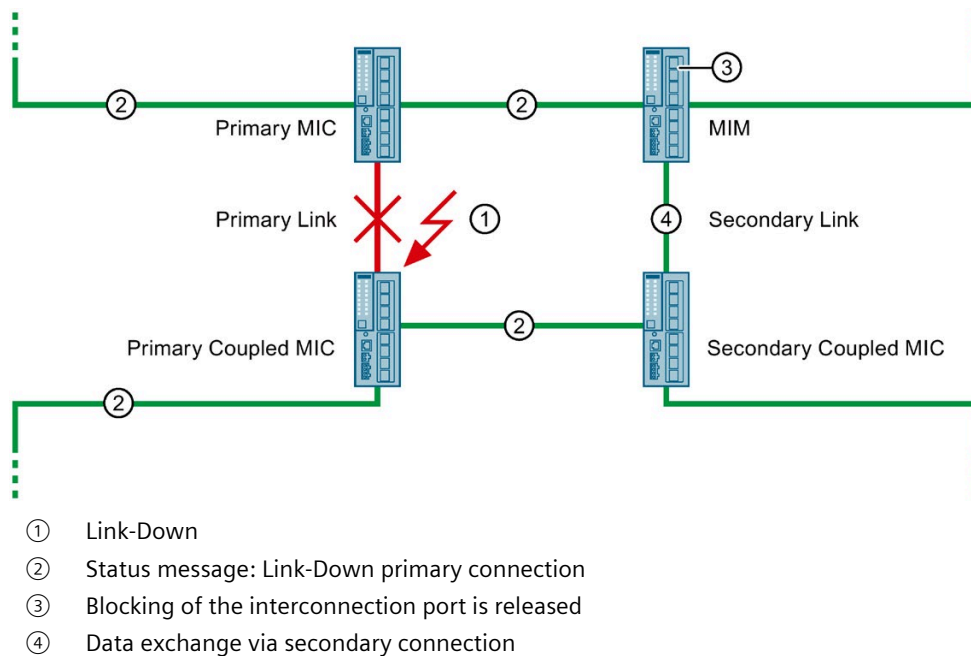


Figure 5-48 Link-Down of the primary connection

With a Link-Down of the primary connection ①, Primary MIC and Primary Coupled MIC send the status message "Link-Down" via all lines ②.

The MIM then unblocks its interconnection port at ③ and informs the MRP managers in both rings to trigger the reconfiguration of the rings.

After the reconfiguration, the data exchange between the two rings takes place via the secondary connection ④.

As soon as Primary MIC and Primary Coupled "Link-Up" for the primary connection, the MIM blocks its interconnection port and informs the MRP managers in both rings to trigger the reconfiguration of the rings.

After the reconfiguration, the data exchange is again carried out via the primary connection.

## Configuring and assigning MRP interconnection parameters

---

### Note

MRP interconnection is not integrated into the TIA Portal. This means you cannot configure, parameterize and diagnose MRP interconnection in STEP 7.

---

You configure and assign MRP interconnection parameters via the integrated web pages (Web Based Management) of the SCALANCE switches used as MIM and MIC (e.g. SCALANCE XC200, XM-400, XR-500).

For the configuration, follow the step-by-step instruction in the configuration manual SCALANCE XM-400/XR-500 Web Based Management (WBM) (<https://support.industry.siemens.com/cs/ww/en/view/109760840>).

## Reconfiguration and watchdog timer

The reconfiguration time of the rings is typically less than 200 milliseconds.

In order for the data exchange to work after a reconfiguration, the watchdog timers of the IO devices must be set sufficiently large. Therefore, when using MRP interconnection, set the watchdog timer of the IO devices to 256 milliseconds or more.

## 5.5 Real-time communication

### 5.5.1 Introduction

#### Properties

PROFINET IO is a scalable real-time communication system based on the Layer 2 protocol for Fast Ethernet. With the RT transmission method, two real-time-support performance levels are available for time-critical process data and IRT for high-accuracy and also isochronous processes .

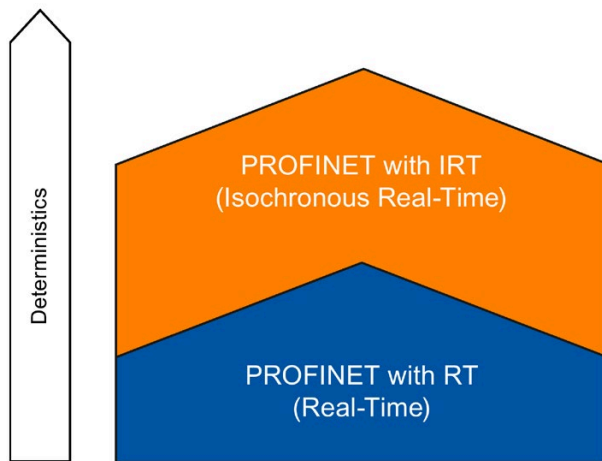


Figure 5-49 Real-time communication performance

#### Real-time communication and IT communication

Industrial communication, especially in the factory automation and process automation, requires a punctual and deterministic data transmission. This is why, for the cyclic exchange of time-critical IO user data, PROFINET IO does not use TCP/IP, it uses real-time communication (RT) or isochronous real-time communication (IRT) for the synchronized data exchange in reserved time intervals.

#### Fields of application of PROFINET with RT

PROFINET with RT is suited for:

- Time-critical applications in factory automation
- The implementation of large quantity structures in line process plants



## Fields of application of PROFINET with IRT

PROFINET with IRT is particularly suitable for:

- Considerable deterministics with large quantity structures concerning the I/O user data communication (productive data)
- Considerable performance also with many devices concerning the I/O user data communication (productive data)
- Parallel transfer of productive and TCP/IP data via a cable, even with considerable data traffic whilst ensuring the forwarding of productive data by reserving the transmission bandwidth.

## International standard IEC 61158

The communication procedures RT and IRT are standardized in the international standard IEC 61158.

### 5.5.2 RT

PROFINET IO with real-time communication (RT) is the ideal solution for integrating IO systems. This is a solution that also uses standard Ethernet in the devices and commercially available industrial switches as infrastructure components. A special hardware support is not required.

If you want to use PROFINET functions that provide an additional value, such as topology detection, diagnostics, device exchange without exchangeable medium/PG, you have to use switches that support the PROFINET standard according to the IEC 61158 standard. In the integrated switches of PROFINET devices and PROFINET switches (e.g., the SCALANCE product family), PROFINET functions in accordance with the PROFINET standard are implemented and can be used without restriction for integration in the PROFINET IO system (see also section Active network components (Page 1)).

## Real-time communication (RT)

PROFINET IO frames have priority over standard frames in accordance with IEEE802.1Q. This ensures the required determinism in the automation technology. The data is transferred via prioritized Ethernet frames. With RT, you can achieve update times  $\geq 250 \mu\text{s}$  with RT.

## Switching mechanisms

Switches in SIMATIC meet the real-time requirements with two mechanisms on PROFINET: "Store and forward" and "Cut through".

### Store and forward

In the Store and forward method, the switch stores the frames completely and places them in a queue. If the switch supports the international standard IEEE 802.1Q, then the data is sorted according to its priority in the queue. The frames are then forwarded selectively to the specific port that can access the addressed node (Store and forward).

## Cut through

In the Cut through process the entire data package is not stored temporarily in a buffer, it is passed directly onto the target port as soon as the target address and the target port have been determined.

The times required by the data package to pass through the switch are then minimal and independent of the frame length. The data are only stored temporarily in accordance with the Store and forward process as per priority when the section between the target segment and the port of the next switch is occupied.

### 5.5.3 IRT

#### Isochronous real-time communication (IRT)

IRT is a synchronized communication protocol for cyclic exchange of IRT data between PROFINET devices. A reserved bandwidth is available in the send cycle for IRT data. The reserved bandwidth ensures that the IRT data can be transferred at reserved synchronized intervals, without being influenced also by higher other network loads (such as TCP/IP communication, or additional real-time communication).

#### Advantages

PROFINET with IRT is synchronized communication in reserved time intervals. With IRT you have the option to be able to control time-critical applications such as motion control via PROFINET. With IRT you use further advantages:

- High-precision deterministics allow highest control quality and thus, for example, exact positioning of axes
- Simple and flexible integration of PROFINET devices for real-time applications in existing company networks
- Shortest response times and highest deterministics by means of bandwidth reservation and thus also for applications that have to satisfy highest performance requirements (e.g., printing control/position control for presses, print-mark recognition with packaging machines)
- Secured standard communication parallel to real-time communication via the same transmission medium
- You can continue to use standard components for your PROFINET IO system outside of the sync domain

## Properties of isochronous real-time

Topology configuration is a prerequisite for IRT.

In addition to the reserved bandwidth, the frames from defined transmission paths are exchanged for the further optimization of data transfers. For this, the topological information from the configuration is used for planning the communication. Transmission and reception points of every individual data frame at every communication node are thus guaranteed. This allows you to achieve optimal usage of the bandwidth and reach the best possible performance in the PROFINET IO system.

Use of IRT allows you to achieve update times with very high deterministics  $\geq 125 \mu\text{s}$  and a jitter accuracy of the send clock  $< 1 \mu\text{s}$ . Isochronous applications are possible with IRT (see section Isochronous mode (Page 1)).

\* The minimum update time depends on the CPU used. The update times supported by a CPU are listed in the technical specifications of the CPU manual.

---

### Note

#### IWLAN and IRT

PROFINET devices that are connected to PROFINET IO via access points, do not support IRT.

---

## Synchronization

The prerequisite for the IRTcommunication is a synchronization cycle for all PROFINET devices in a sync domain for distributing a mutual time basis. A synchronism of the transmission cycle of the PROFINET devices within a sync domain is achieved with this basic synchronization.

A sync master specifies the clock to which sync slaves are synchronized. An IO controller or an IO device can have the role of sync master. If the sync master fails, all IO devices with IRT will fail.

Sync master and sync slaves are always devices in a sync domain. Bandwidth is reserved within the sync domain for IRT communication. Real-time and non-real-time communication (TCP/IP communication) is possible outside of the reserved bandwidth.

## Default sync domain

If you have created a PROFINET subnet, a special sync domain is automatically created, the default sync domain. All PROFINET devices configured for the PROFINET subnet automatically belong to this sync domain.

For additional information on creating sync domains, refer to the STEP 7 online help.

### Time ranges of the communication cycle

The communication cycle is divided into three time ranges, which are shown in the following chart:

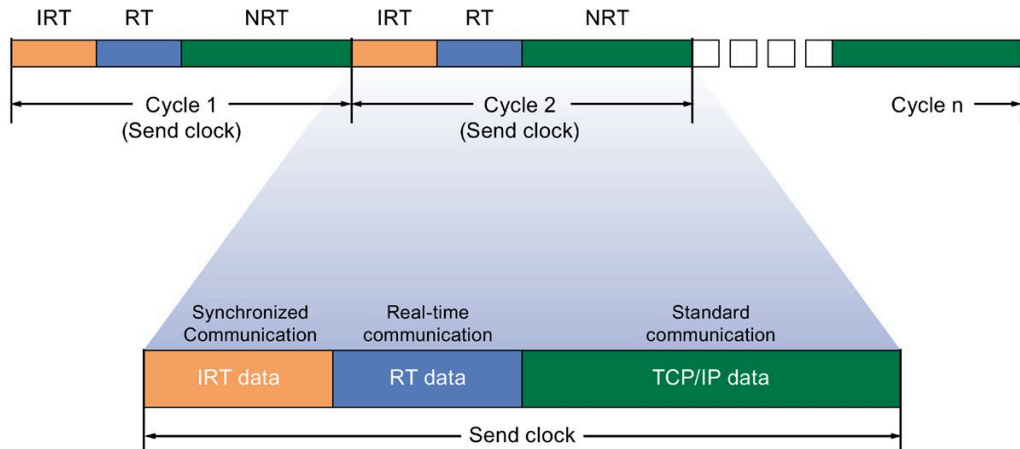


Figure 5-50 Reserving bandwidth

- IRT data (synchronized communication)  
This time range can be reserved in specific steps, depending on the send clock. Only IRT data is transmitted during this time range.
- RT data (real-time communication)  
The cyclic RT data is transferred in this time range. RT data is prioritized over "normal" TCP/IP data. TCP/IP data or Ethernet frames can have a priority of between 1 and 7. RT data have the Priority 6.
- TCP/IP data (standard communication)  
Standard communication (e.g., TCP/IP) is transmitted in the remaining interval of the communication cycle.

In STEP 7, you can set the ratio of the bandwidth usage of cyclic IO data to standard communication. For information on how to set the bandwidth usage, refer to the section [Setting the bandwidth usage for the send clock \(Page 1\)](#)

## 5.5.4 Comparison of RT and IRT

### The most important differences between RT and IRT

Table 5- 2 Comparison between RT and IRT

| Property                                                          | RT                                                                                                                           | IRT                                                                                                                                        |
|-------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------|
| Transmission method                                               | Prioritizing the RT frames through Ethernet priority (VLAN tag)                                                              | Path-based switching on the basis of a communication path plan; no transmission of TCP/IP frames in the time range with IRT communication. |
| Determinism                                                       | Variance of the duration of transmission by the shared use of the transmission bandwidth with other protocols (e.g., TCP/IP) | Exact, planned transmission, transmission and reception times are guaranteed for all topologies.                                           |
| Hardware support through special Ethernet controllers is required | Not required                                                                                                                 | Required                                                                                                                                   |
| Isochronous application                                           | -                                                                                                                            | Yes                                                                                                                                        |
| Starting time of the isochronous application                      | -                                                                                                                            | The point in time for the reception of the data is planned exactly. Application can be started synchronized to the cycle.                  |

## 5.5.5 Configuring PROFINET IO with IRT

### Introduction

If you want to configure a PROFINET IO system with IRT, you have to configure the PROFINET IO devices. These PROFINET devices must support IRT. Set which device acts as the sync master and synchronizes the other devices. This is done by configuring a sync domain with a sync master and at least one sync slave.

### Requirement

- There is an IO system with an IO controller and at least one IO device.
- You have configured the topology for the IO system.
- The devices support IRT.

## Procedure

Proceed as follows to enable an existing IO system for the use of IRT:

1. Select the PROFINET interface of the IO controller.
2. In the Inspector window, navigate to "Advanced options > Real time settings > Synchronization".

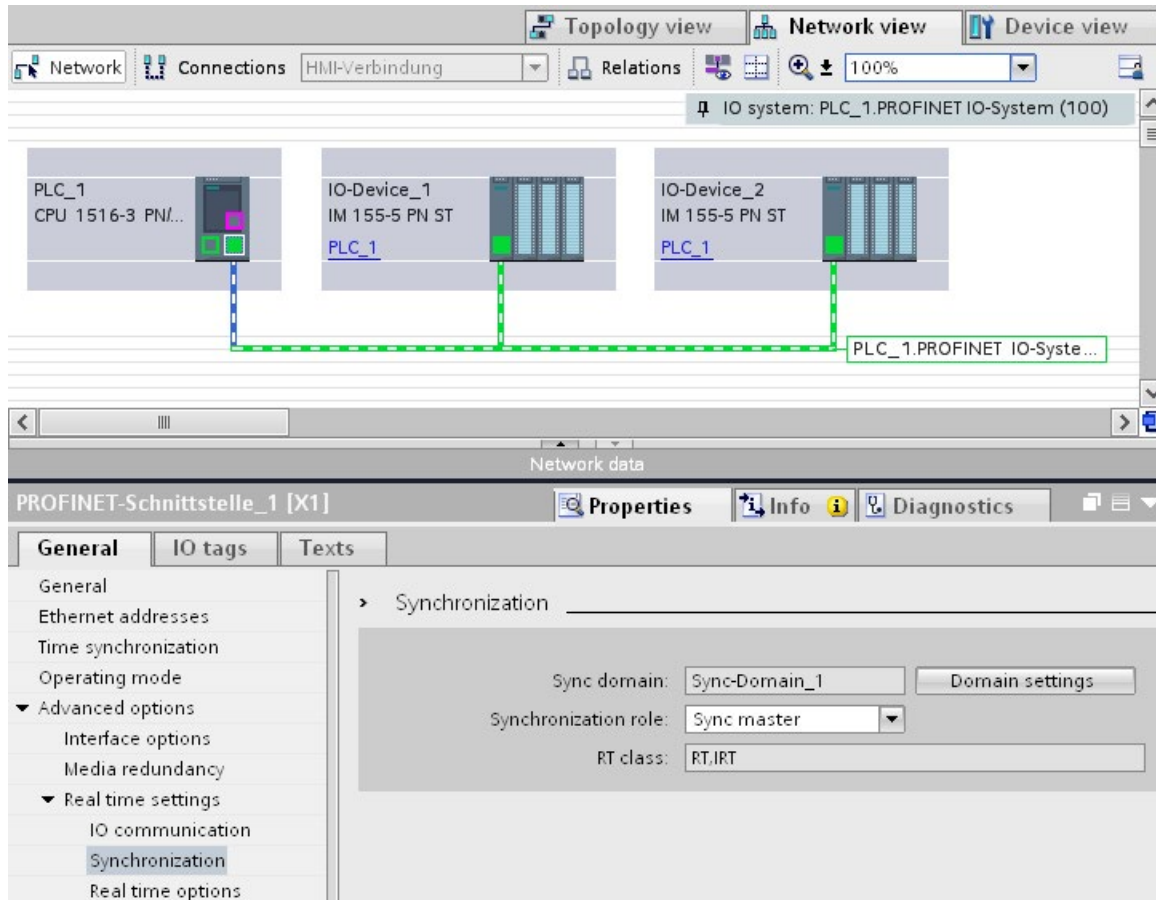


Figure 5-51 IRT configuring sync master

3. Assign the IO controller the role of sync master under "Synchronization role".
4. Select the PROFINET interfaces of an associated IO device.

5. In the Inspector window, navigate to "Advanced options > Real time settings > Synchronization".

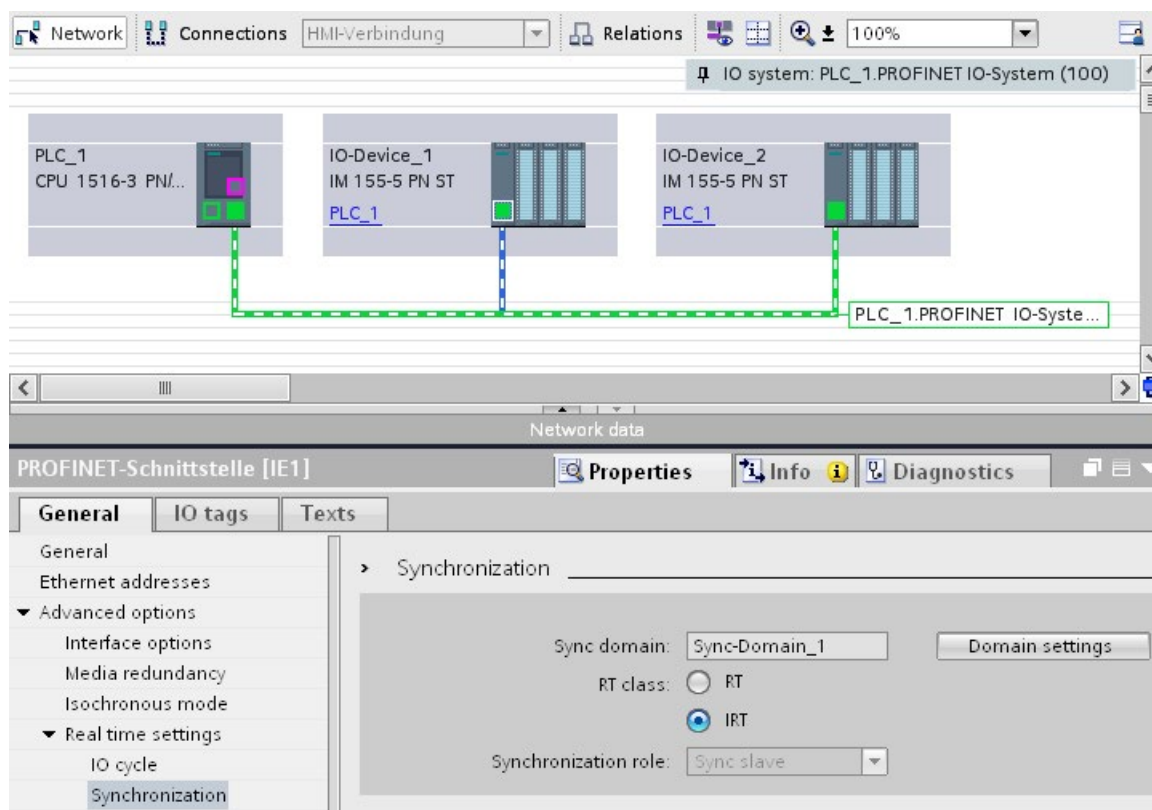


Figure 5-52 IRT configuring sync slave

6. Activate the RT class "IRT". The IO device will then automatically be assigned the synchronization role "sync slave".
  7. You can check and correct your settings at any time using the "Domain settings" button.
- Or
1. Highlight the PROFINET IO system in the network view.
  2. Click on the PROFINET IO system.

3. Navigate to the device of the required sync domain in the Inspector window.

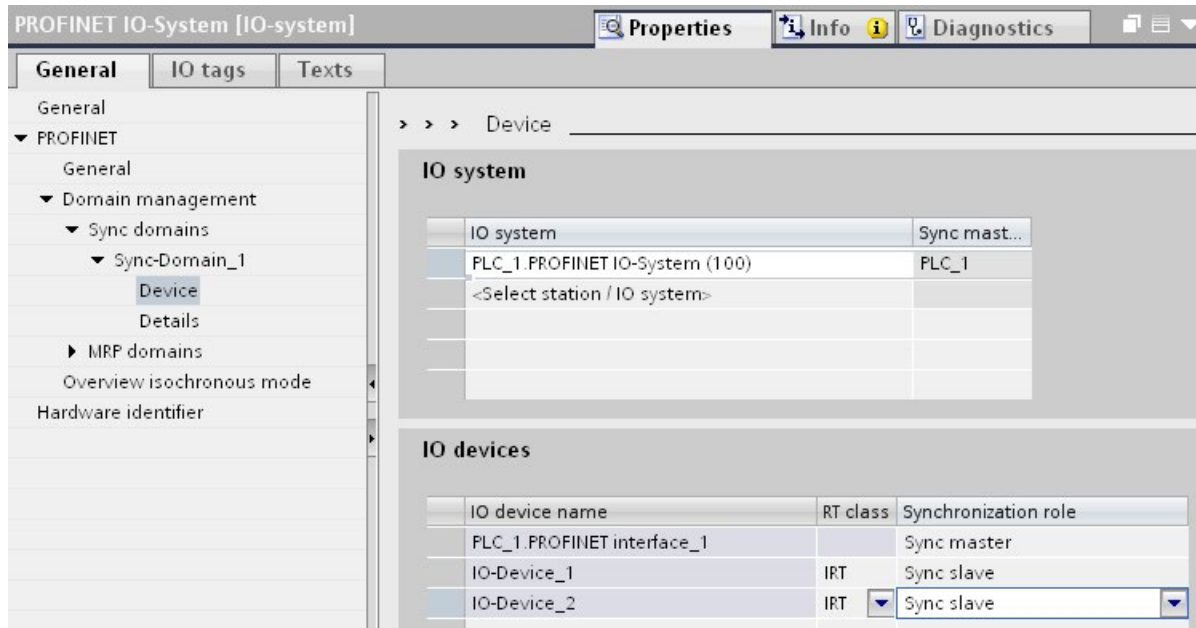


Figure 5-53 IRT configuring sync domain

4. Enter all necessary settings in the tables:
  - Select an IO system.
  - Set the synchronization role "sync master" for the IO controller.
  - Set the RT class for the IO devices to "IRT". The IO devices will then automatically be assigned the synchronization role "sync slave".

You can now load the configuration to the relevant devices with PROFINET IRT.

## 5.5.6 Setting the bandwidth usage for the send clock

### Bandwidth level

For PROFINET IO with IRT, you can specify the maximum portion of the send cycle that you want to use for cyclic IO communication.

You have the following setting options for the bandwidth usage in STEP 7.

- Maximum 25% cyclic IO data. Focus on non-cyclic data.
- Maximum 37.5% cyclic IO data. Focus on non-cyclic data.
- Maximum 50% cyclic IO data. Balanced proportion.
- Maximum 90% cyclic IO data. Focus on cyclic IO data. (Requirement: The "Make 'high performance' possible" option is activated)



## Setting the bandwidth usage

To set the bandwidth usage for a PROFINET IO system in STEP 7, follow these steps:

1. Select your IO system in the network view of STEP 7.
2. In the Inspector window, go to "Properties" > "General" > "PROFINET" > "Domain management" > "Sync domains" > "Name of the sync domain" > "Details".
3. Select the desired level of bandwidth usage from the "Bandwidth use" drop-down list box.

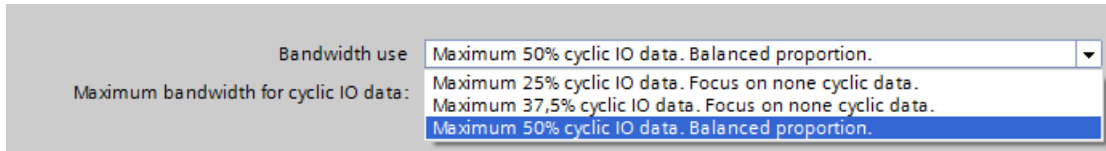


Figure 5-54 Setting the bandwidth usage

For information on how to set the bandwidth usage for IRT with maximum performance, refer to the section Configuration of IRT with high performance (Page 1)

### 5.5.7 Setup recommendations for optimizing PROFINET

#### Optimizing PROFINET with RT

PROFINET provides you with high-performance communication on all levels.

The following figures shows an example of an optimized PROFINET topology.

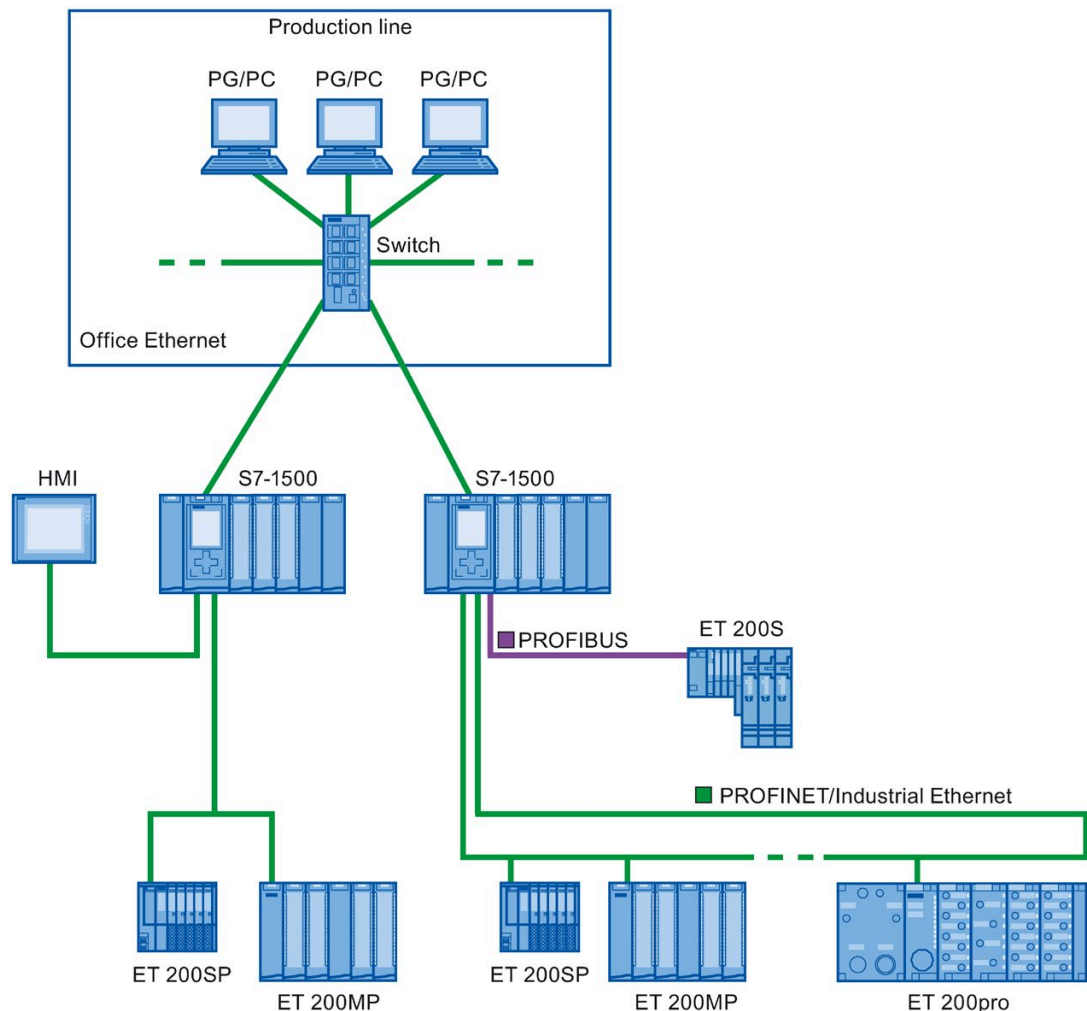


Figure 5-55 Optimized PROFINET topology

When setting up your PN network topology, take care that the various automation applications are distributed among separate network branches so that a sufficient bandwidth reserve will be available for future expansions.

- If you integrate standard Ethernet devices into the network topology or use standard Ethernet communication, take into account the network load caused by standard Ethernet and adapt the network topology as appropriate (max. bandwidth 100 Mbps).
- For communication with higher-level networks with a high data volume, use the most direct paths possible to the higher-level network infrastructure.

Also observe the Installation Guideline (<http://www.profibus.com/nc/download/installation-guide/downloads/profinet-installation-guide/display/>) of the PROFIBUS User Organization.

## Setting up PROFINET with IRT

Keep in mind the following rules for setting up and operating a PROFINET IO system in IRT mode. These rules will ensure best possible operation of your PROFINET IO system.

- When using IRT, you must configure the topology. This will enable exact calculation of the update time, bandwidth, and other parameters.
- If you would like to use multiple sync domains, configure a sync boundary for the port which is currently connected to the PROFINET device of another sync domain.
- In a sync domain, you can only configure one sync master at a time.
- A PROFINET IO system may only be part of a single sync domain.
- If you configure PROFINET devices in a sync domain and want to synchronize with IRT, the PROFINET devices concerned must support IRT communication.
- If possible, use the same PROFINET device as the PROFINET IO controller and sync master.
- If only some of the PROFINET devices in a PROFINET IO system are synchronized, please keep in mind the following: Assign PROFINET devices that are not participating in the IRT communication to the RT class "RT" and the synchronization role "unsynchronized" in the sync domain.

### Applications for CPU with multiple PROFINET IO interfaces

- Connecting machines: Your configuration contains machines located on separate IO lines. You can perform real-time communication between the CPUs over PROFINET IO interface X2. Use the I-device or shared I-device function for this purpose. The figure below shows an example configuration for two machines connected over the X2 interface with an I-device relationship.

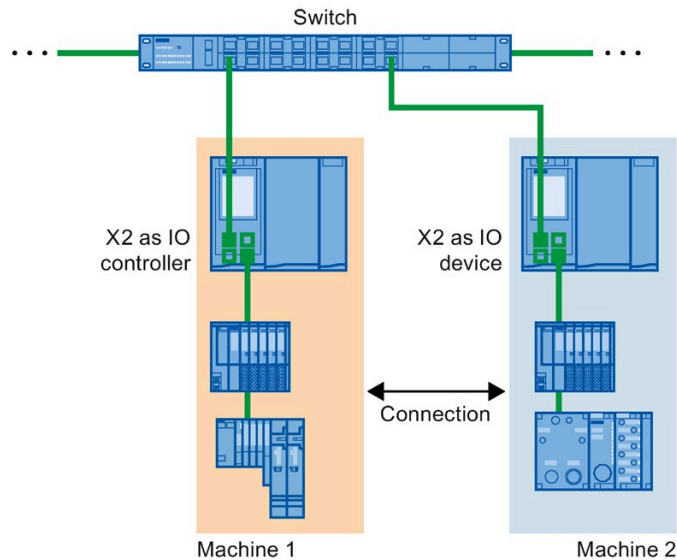


Figure 5-56 I-device connection over 2nd PNIO interface

- Distribution by automation tasks:
  - For automation tasks with high performance and deterministic requirements, use PROFINET with IRT over the X1 interface.
  - For other tasks that you can implement with RT, use the X2 interface.

If you use interface X2 as the PROFINET IO interface for one of the following CPUs, this can affect performance:

- CPU 1515(F)-2 PN
- CPU 1515T(F)-2 PN
- CPU 1516(F)-3 PN/DP
- CPU 1516T(F)-3 PN/DP
- CPU 1516(F)pro-2 PN

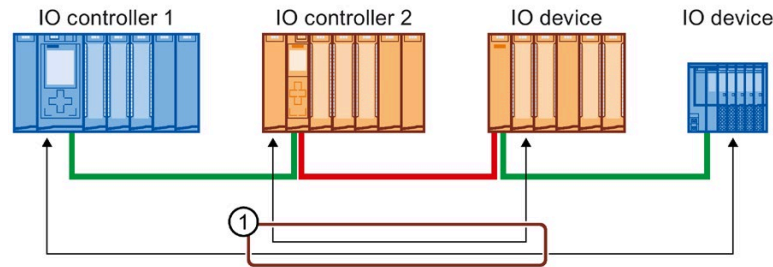
You can find additional information in the section PROFINET interface (Page 1) and in the Cycle and Response Times (<https://support.industry.siemens.com/cs/ww/en/view/59193558>) function manual.

## Topological overlap of IO systems in multi-controller applications

In a configuration with multiple IO controllers, shared paths are subject to the combined network loads of all connected PROFINET IO systems.

To avoid high communication loads in multi-controller applications, observe the following recommendations:

- Avoid paths that are shared by multiple IO systems.  
The figure below shows a configuration with two PROFINET IO systems that use the same paths.



① Shared path

Figure 5-57 Multi-controller application with shared path

In the figure below, the two PROFINET IO systems do not use shared paths.

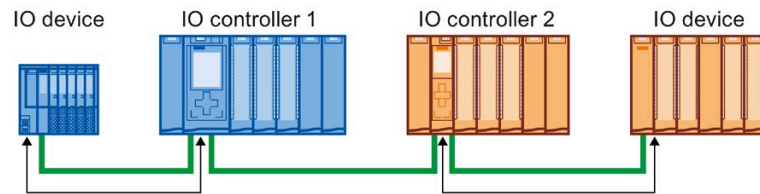


Figure 5-58 Multi-controller application with separate paths

- If separation is not possible: Increase the update time for the affected IO devices.

## Installation guidelines of the PROFIBUS user organization

The installation guidelines can be found on the Internet

(<http://www.profibus.com/nc/download/installation-guide/downloads/profinet-installation-guide/display/>).

### 5.5.8 Limitation of the data infeed into the network

#### Limiting the data infeed into the network on PROFINET interfaces

The "Limit data infeed into the network" function limits the network load of standard Ethernet communication which is fed into the network by the interface to a maximum value. This does not apply to cyclic real-time communication (RT/IRT).

In a PROFINET IO system, critical network loads can occur quickly with standard Ethernet communication, especially in line topologies. Devices which feed a lot of standard Ethernet communication into the PROFINET IO system, should support the function "Limit data infeed into the network". If necessary, you should optimize your topology by avoiding e.g. standard Ethernet devices in line topologies. You can find additional information on this in section Setup recommendations for optimizing PROFINET (Page 1).

Depending on the interface, you can activate or deactivate the "Limit data infeed into the network" function. If you use the X1 interface of an S7-1500 CPU as the IO controller or I-device, the "Limit data infeed into the network" function is always enabled. Example: If you are not using the X1 interface of an S7-1500 CPU as IO controller or I-device, you can enable or disable the function.

#### Uses of the limitation of the data infeed to the network

- Division of the bandwidth for standard Ethernet communication between devices:  
In PROFINET networks cyclic real-time communication and standard Ethernet communication share the same network. This means that only a limited bandwidth remains for standard Ethernet communication. The limitation of the data infeed ensures that the remaining bandwidth for standard Ethernet communication is not used just by one device, but is divided between several devices.
- Smoothing peaks in the data infeed:  
The limitation of the data infeed smooths peak loads of standard Ethernet communication (for example, from Open User Communication, access by the Web server).
- Limiting problems in the data infeed:  
If applications in a device generate too much data, this data is not forwarded to the PROFINET network. Negative effects (for example data loss, communication breakdown) remain limited to the device and its communications partner. Other nodes are not disturbed.

### Setting limitation of the data infeed into the network for a CPU

To set the limitation of the data infeed into the network, follow these steps:

1. In the network view of STEP 7, select the interface of the CPU.
2. In the Inspector window, go to "Properties" > "General" > "Advanced options" > "Interface options".
3. Select or clear the "Limit data infeed into the network" check box.

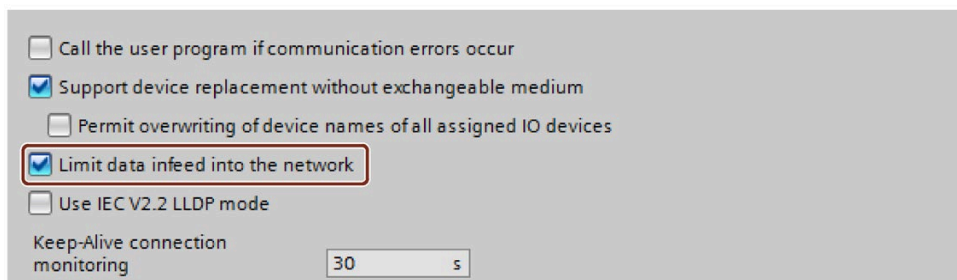


Figure 5-59 Limit data infeed into the network

## 5.6 PROFINET with performance upgrade

### Performance upgrade

The performance upgrade implements the application class "High Performance" of the PROFINET specification V2.3.

The performance upgrade provides a series of measures that lead to the following improvements for PROFINET with IRT:

- Reduction of runtime delays in the IO devices
- Increase in the bandwidth for cyclic IO data
- Reduction of the bandwidth used for PROFINET frames
- Reduction of the send clocks

The improvements achieved with the performance upgrade mean that you can operate your PROFINET IO system with more devices with the same send clock or the same number of devices with a shorter send clock.

With PROFINET, it was previously possible to reach a send clock of 250  $\mu$ s.

With the performance upgrade, it is now possible to achieve isochronous send clocks of up to 125  $\mu$ s with the fast forwarding, dynamic frame packing and fragmentation procedures, depending on the performance capability of the CPU (see Technical Specifications in the device manuals). With short send clocks, standard communication remains possible.

The performance upgrade will help you to implement applications with high speed and send clock requirements.

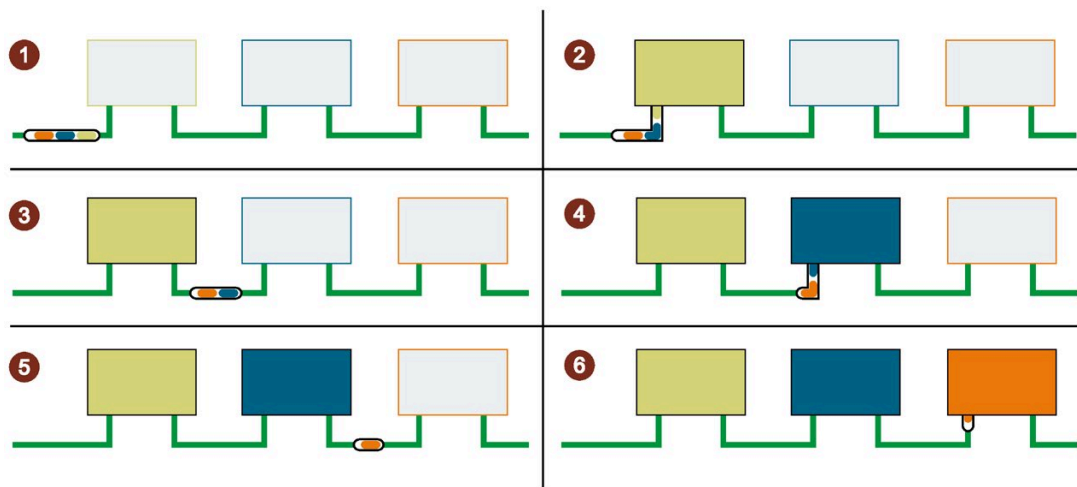
### 5.6.1 Dynamic frame packing

#### Dynamic frame packing

Previously, individual PROFINET IO frames were sent for every PROFINET IO device.

The performance upgrade uses the dynamic frame packing procedure that is based on the summation frame method. With the summation frame method, a frame contains the user data for neighboring devices on a line. With Dynamic Frame Packing, every IO device takes its data from the frame and forwards the rest. The frame is shortened from IO device to IO device. Dynamic frame packing improves the use of the bandwidth in a line topology.

The following figure shows how Dynamic Frame Packing works based on the example of a frame containing the user data for 3 IO devices.



- ① The PROFINET IO frame contains the user data for all 3 IO devices (green, blue and orange).
- ② The PROFINET IO frame reaches the first IO device. The IO device takes its user data (green) from the frame and forwards the remaining frame.
- ③ The PROFINET IO frame contains the user data for two IO devices (blue and orange).
- ④ The PROFINET IO frame reaches the second IO device. The IO device takes its user data (blue) from the frame and forwards the remaining frame.
- ⑤ The PROFINET IO frame contains the user data for one IO device (orange).
- ⑥ The PROFINET IO frame reaches the last IO device. The IO device saves the entire frame including user data (orange).

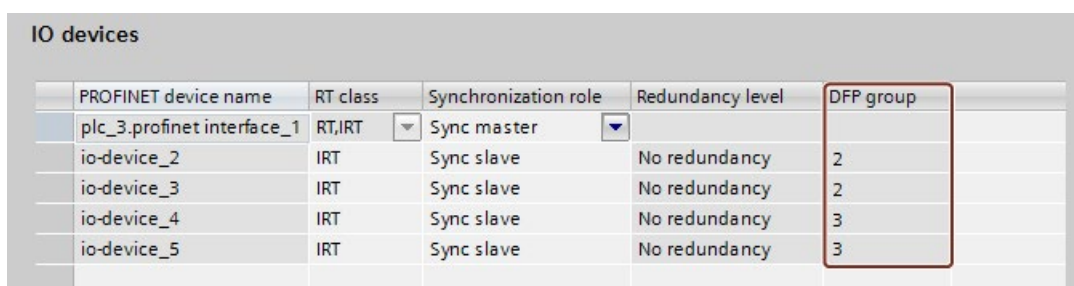
Figure 5-60 Dynamic Frame Packing (DFP)



## DFP groups

Dynamic frame packing automatically groups IO devices that support the performance upgrade into DFP groups. To be grouped together in a DFP group, the IO devices must be located one after the other in a line and must have the same update time and watchdog time. As soon as a maximum frame size for the DFP group is exceeded or a maximum number of members for a DFP group is reached, Dynamic Frame Packing automatically opens a new DFP group.

STEP 7 shows the DFP groups in "Domain management" > "Sync domains" > "Name of the sync domain" > "Device" in the "IO devices" box.



| PROFINET device name       | RT class | Synchronization role | Redundancy level | DFP group |
|----------------------------|----------|----------------------|------------------|-----------|
| plc_3.profinet interface_1 | RT,IRT   | Sync master          |                  |           |
| io-device_2                | IRT      | Sync slave           | No redundancy    | 2         |
| io-device_3                | IRT      | Sync slave           | No redundancy    | 2         |
| io-device_4                | IRT      | Sync slave           | No redundancy    | 3         |
| io-device_5                | IRT      | Sync slave           | No redundancy    | 3         |

Figure 5-61 Display of the DFP groups in STEP 7

### Note

#### Dynamic frame packing with high watchdog times

If you set the "Accepted update cycles without IO data" parameter higher than 31 for an IO device, Dynamic Frame Packing does not place this IO device in a DFP group.

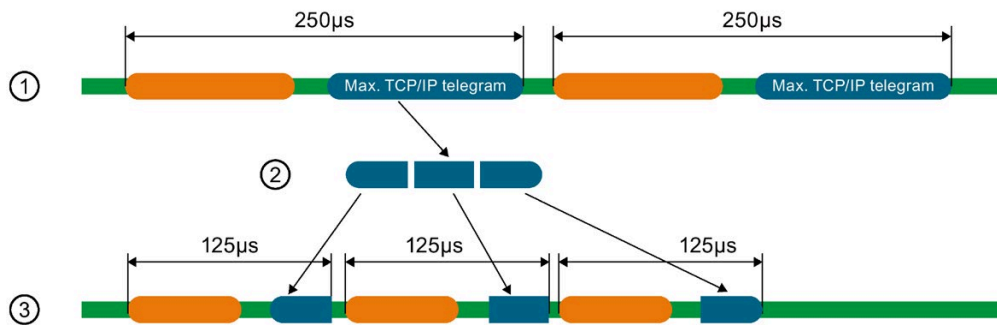
### 5.6.2 Fragmentation

The transfer of a complete standard Ethernet frame with TCP/IP data takes up to 125  $\mu$ s. This means that the cycle time for PROFINET IO data cannot be reduced by any desired amount.

The performance upgrade uses the fragmentation procedure, which breaks down TCP/IP frames into sub-frames. These frame segments are transferred to the target device over multiple send clocks; there they are reassembled to the original TCP/IP frame.

Fragmentation is a requirement for cycle times lower than 250  $\mu$ s. In these short send clocks, you can use more bandwidth for cyclic IO data, since the fragments of the standard Ethernet frame use significantly less bandwidth than a complete standard Ethernet frame.

The following figure shows how fragmentation works.



- ① A standard Ethernet frame with TCP/IP data is up to 125  $\mu$ s.
- ② During fragmentation, the standard Ethernet frame is divided into frame segments.
- ③ The frame segments are divided into multiple short send clocks.

Figure 5-62 Fragmentation

#### Note

The PROFINET IO interface of the IO controller supports fragmentation if all the ports except one are deactivated.

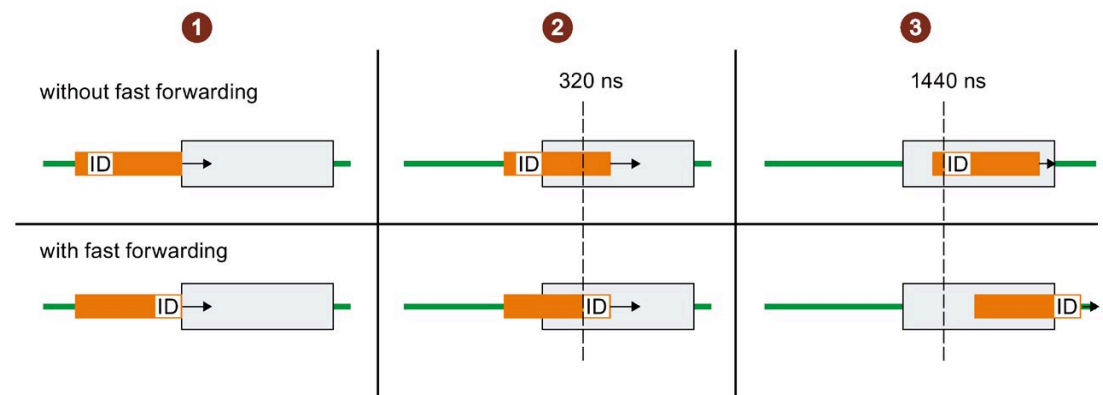
### 5.6.3 Fast forwarding

To be able to decide whether a frame should be forwarded or used, a PROFINET IO device requires the frame ID. It previously took 1440 ns until the frame ID was present in the IO device.

The performance upgrade uses the fast forwarding procedure in which the frame ID is located nearer the front of the frame. The throughput time in the device is reduced to 320 ns.

With fast forwarding, the throughput time of the frame is reduced in your PROFINET IO system. This results in decisive performance advantages, particularly in line, ring and tree topologies.

The figure below compares the throughput of a PROFINET IO frame in an IO device with and without fast forwarding.



- ① Start:
  - Both PROFINET frames reach the IO device.
  - The IO devices start to check the frames for the frame ID
- ② After 320 ns:
  - Without fast forwarding: The IO device is still checking the PROFINET frame for the frame ID.
  - With fast forwarding: The IO device receives the frame ID from the PROFINET frame and forwards the frame.
- ③ After 1440 ns:
  - Without fast forwarding: The IO device receives the frame ID from the PROFINET frame and forwards the frame.
  - The PROFINET frame with fast forwarding is "ahead" of the PROFINET frame without fast forwarding.

Figure 5-63 Fast forwarding

### 5.6.4 Configuration of IRT with high performance

High-end applications with IO communication require excellent performance in IO processing, for example in the control of wind turbines (converter control).

To use IRT communication with the highest performance in your PROFINET IO system, enable the option "Make 'high performance' possible".

When you enable the "Make 'high performance' possible" option, this has the following effects:

- You can set send clocks of 187.5  $\mu$ s and 125  $\mu$ s (for example CPU 1518-4 PN/DP) or 187.5  $\mu$ s (for example CPU 1517-3 PN/DP), see Technical specifications in the CPU device manuals.
- You can set more bandwidth use for cyclic IO data.
- You can use the option "Allows the use of 'fast forwarding'".

#### Requirements

- S7-1500 CPU as of firmware version V2.0

#### Enable the "Make 'high performance' possible" option.

Follow these steps to activate the "Make 'high performance' possible" option:

1. Select the PROFINET IO system in the network view of STEP 7.
2. In the Inspector window, go to "Properties" > "General" > "PROFINET" > "Domain management" > "Sync domains" > "Name of the sync domain".
3. Enable the "Make 'high performance' possible" option.

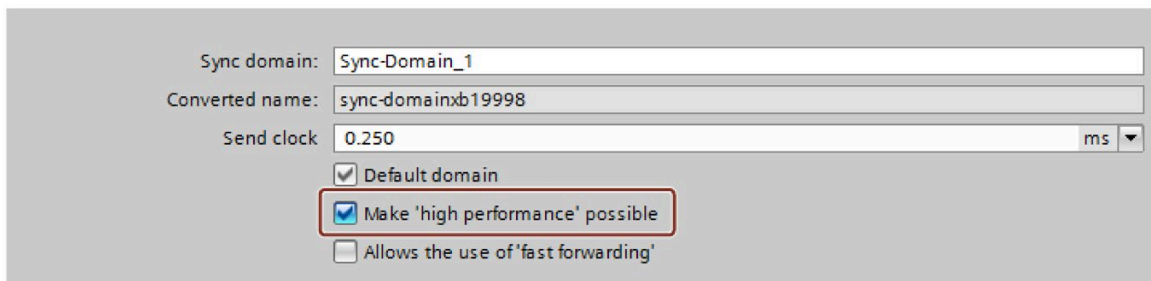


Figure 5-64 Activating high performance

## Using more bandwidth for cyclic IO data

Requirement: The "Make 'high performance' possible" option is enabled.

To set more bandwidth for cyclic IO data for your PROFINET IO system, follow these steps:

1. Select your IO system in the network view of STEP 7.
2. In the Inspector window, go to "Properties" > "General" > "PROFINET" > "Domain management" > "Sync domains" > "Name of the sync domain" > "Details".
3. In the drop-down list, select "Maximum 90% cyclic IO data. Focus on cyclic IO data".

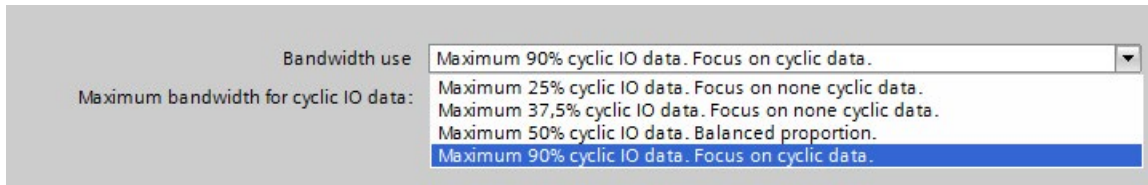


Figure 5-65 Using more bandwidth for cyclic IO data

### Note

#### Bandwidth usage in isochronous mode

If you operate your PROFINET IO system in isochronous mode, avoid using the setting for the bandwidth usage "Maximum 90% cyclic IO data. Focus on cyclic IO data."

## Setting low send clocks (example CPU 1518-4 PN/DP)

Requirement: The "Make 'high performance' possible" option is enabled.

1. Select the PROFINET IO system in the network view of STEP 7.
2. In the Inspector window, go to "Properties" > "General" > "PROFINET" > "Domain management" > "Sync domains" > "Name of the sync domain".
3. Select the send clock for "Send clock" in the drop-down list.

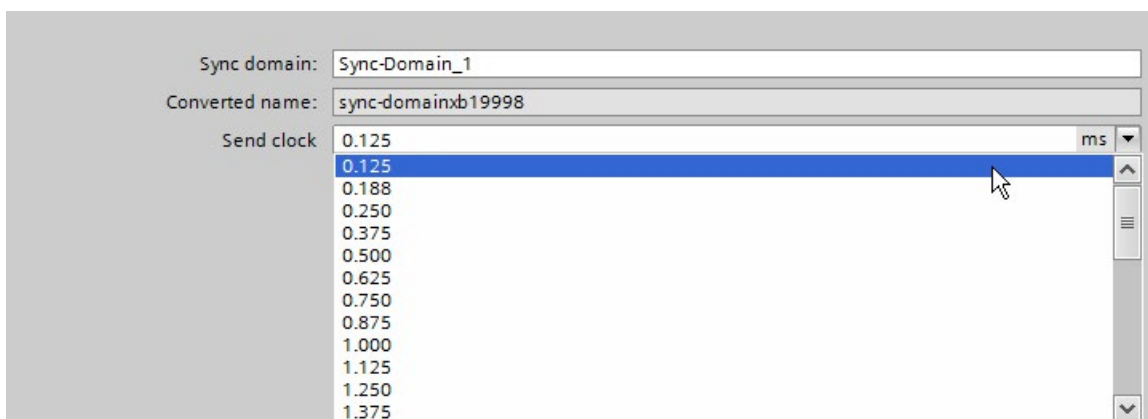


Figure 5-66 Setting low send clocks

### Requirements for the fragmentation process (example CPU 1518-4 PN/DP)

If you use the following combinations for send clock and bandwidth settings, the devices in the IO system use the fragmentation process.

- Send clock cycle 125 µs: Always fragmentation irrespective of the bandwidth setting.
- Send clock cycle 187.5 µs: Fragmentation with the bandwidth settings "Maximum 50% cyclic IO data. Balanced proportion." and "Maximum 90% cyclic IO data. Focus on cyclic IO data."

The PROFINET IO interface of the controller supports fragmentation if all the ports except one are deactivated.

### Optimizing port settings for low send clocks

You can further optimize the bandwidth use in your PROFINET IO system by using cables with a short cable length (< 20 m) or a short signal delay (max. 0.12 µs) between the devices.

To configure cables with a shorter length or signal delay in STEP 7, follow these steps:

1. Select the port in the topology view of STEP 7.
2. Navigate in the Inspector window to "Port interconnection" in the "Partner port" box.
3. Select the option "Cable length" or "Signal delay:".
4. Select the cable length or enter the signal delay.

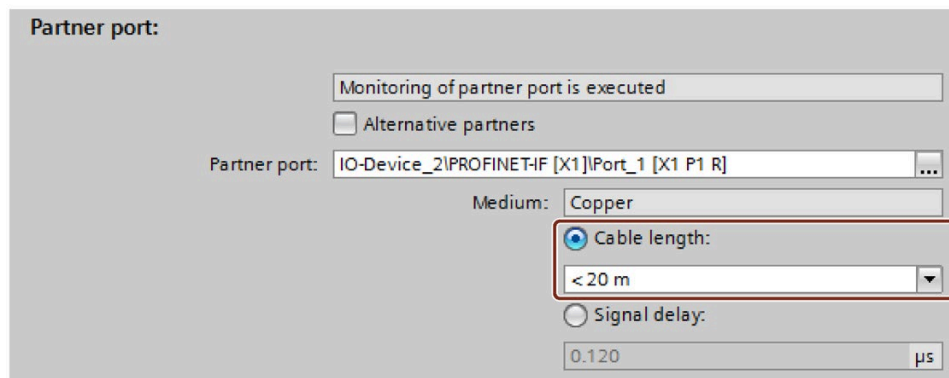


Figure 5-67 Optimizing port settings for low send clocks

## Allowing fast forwarding

Requirements:

- The PROFINET IO device has to support the fast forwarding process so that the process can be used by the device.
- The "Make 'high performance' possible" option is enabled.
- The PROFINET IO interface supports fast forwarding if all the ports except one are deactivated.

Follow these steps to allow fast forwarding:

1. Select the PROFINET IO system in the network view of STEP 7.
2. In the Inspector window, go to "Properties" > "General" > "PROFINET" > "Domain management" > "Sync domains" > "Name of the sync domain".
3. Enable the "Allows the use of 'fast forwarding'" option.

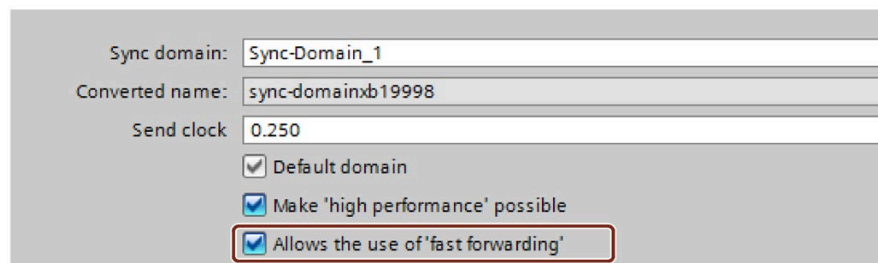


Figure 5-68 Allowing fast forwarding

---

### Note

#### Fast forwarding and IPv6

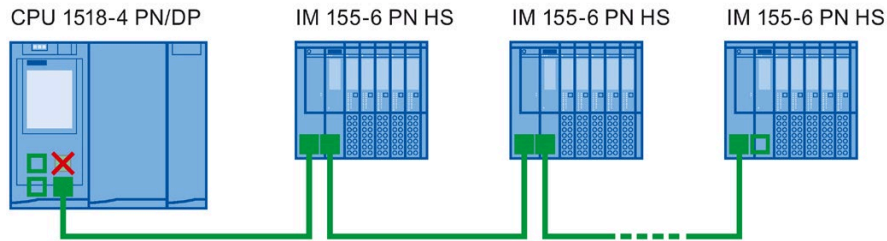
The operation of fast forwarding in combination with IPv6 is not supported.

As soon as an IO device in the subnet uses an IPv6 address, you must not activate "fast forwarding".

---

### 5.6.5 Sample configuration for IRT with high performance

The figure below shows an example configuration with which you can achieve maximum performance.



- ✗ Port 1 of the X1 interface of the CPU is deactivated.
- Port 2 of the X1 interface and the ports of the interface modules on the bus use the following setting: Medium copper, cable length < 20 m or signal delay max. 0.12µs
- A programming device connection to the CPU can be established via the interfaces X2 and X3 of the CPU or via the free port at the end of the line.

Figure 5-69 Example configuration for IRT with high performance

Use the following settings for the Sync domain:

- Enable the "Make 'high performance' possible" option.
- Set the send clock to 125 µs.
- Enable the "Allows the use of 'fast forwarding'" option.

### Standard Ethernet communication for IRT with high performance

Standard Ethernet communication is still possible even in a PROFINET IO system with high performance. Keep in mind that you first arrange the IRT nodes, as seen from the IO controller, and arrange the standard Ethernet nodes at the end of the line.

With a large volume of data through standard Ethernet communication, it makes sense to reduce the load on your network by separating standard Ethernet communication and cyclic real-time communication. Example: Use the interface X1 for the PROFINET IO communication and a different interface for the standard Ethernet communication.



## 5.7 Isochronous mode

### 5.7.1 What is isochronous mode?

#### Objectives of isochronous operation

The advantages of the isochronous mode function in automation engineering can be seen in an example from everyday life.

The transmission of data corresponds to the transport of people on public transport. Assuming public transport were to operate at maximum speed while reducing stop times at the passenger terminals to absolute minimum, the last thing many potential passengers would notice of the departing contraption are its red tail lights. The overall travel time is, however, decided by the train, bus or underground-railway clock, because well adjusted timing is essential to a good service. This also applies in automation engineering. Not only fast cycles but also the adaptation and synchronization of the individual cycles result in optimum throughput.

#### Just-In-Time

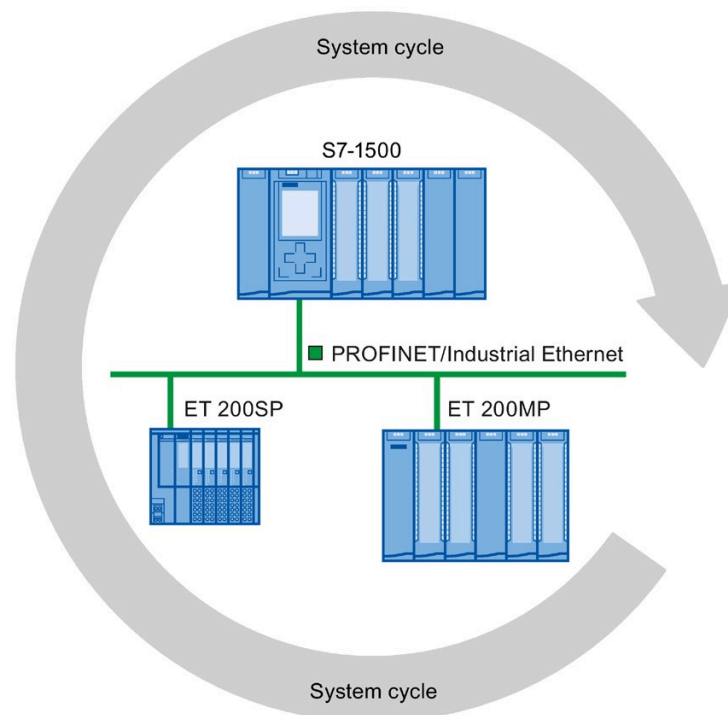


Figure 5-70 System cycle

The fast and reliable response time of a system operating in isochronous mode is due to the fact that all data is provided just-in-time. The basis for this is an equidistant cycle.

The isochronous mode function guarantees synchronization of the following at constant time intervals:

- Signal acquisition and output by the distributed I/O
- Signal transmission via PROFINET IO
- Program execution in the CPU in time with the equidistant PROFINET IO

The result is a system that acquires its input signals, processes them and outputs the output signals at constant time intervals. Isochronous mode guarantees precisely reproducible and defined process response times as well as equidistant and synchronous signal processing for distributed I/O.

### Advantages of isochronous mode

The use of isochronous mode allows high-precision control.

- Optimized control loops through constant, calculable dead times
- Determinism, reliable reproducibility of response times
- Consistent (simultaneous) reading in of input data
- Consistent (simultaneous) output of output data

#### 5.7.2 Use of isochronous mode

An isochronous system acquires measured values and process data within a fixed system cycle, processes the signals and outputs them synchronously to the process. Isochronous mode contributes to a high control quality and increased production accuracy. With isochronous mode, the possible fluctuations of process response times are drastically reduced. You make use of the time-assured processing to improve machine cycle times. Even fast processes can be reliably controlled thanks to the precise time reproducibility of all sequences. Shorter cycle times increase the processing speed and help to lower production costs.

In principle, isochronous mode is worthwhile whenever measured values must be acquired synchronously, movements must be coordinated, and process responses must be defined and simultaneously executed, as in the following example. Isochronous mode can thus be used in a wide variety of applications.

### Example: Measuring at multiple measurement points with isochronous mode

#### Automation task

A camshaft production process requires precise measurement of the camshafts for quality assurance purposes.

#### Feature

For this purpose, a component is needed that can synchronously measure the positions and displacements of the cam during a rotation of the camshaft.

#### Solution

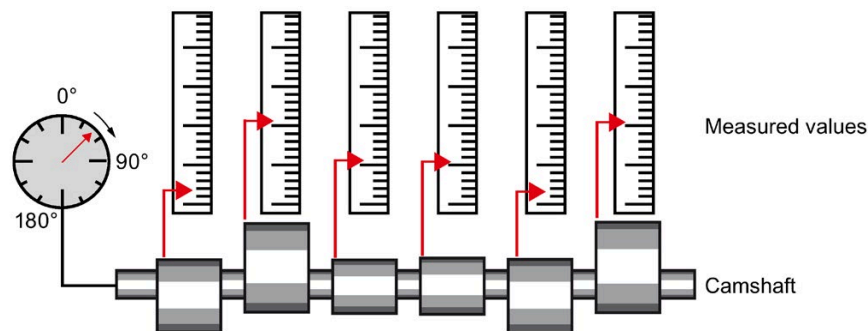


Figure 5-71 Measuring of camshafts

With use of isochronous mode, the measured values are simultaneously acquired at the various measuring points at fixed times. This results in the following workflow:

- Continuously rotate the camshaft
- During continuous rotation, synchronously measure the positions and cam displacements
- Process the next cam shaft

Thus, during a single rotation of the camshaft, all the positions of the camshaft and the associated measured values (red) are measured synchronously. The machine cycle time improves with the same or better measuring accuracy.

#### Advantage and benefits

The time required for measurement is reduced.

### 5.7.3 Time sequence of synchronization on PROFINET IO

#### Introduction

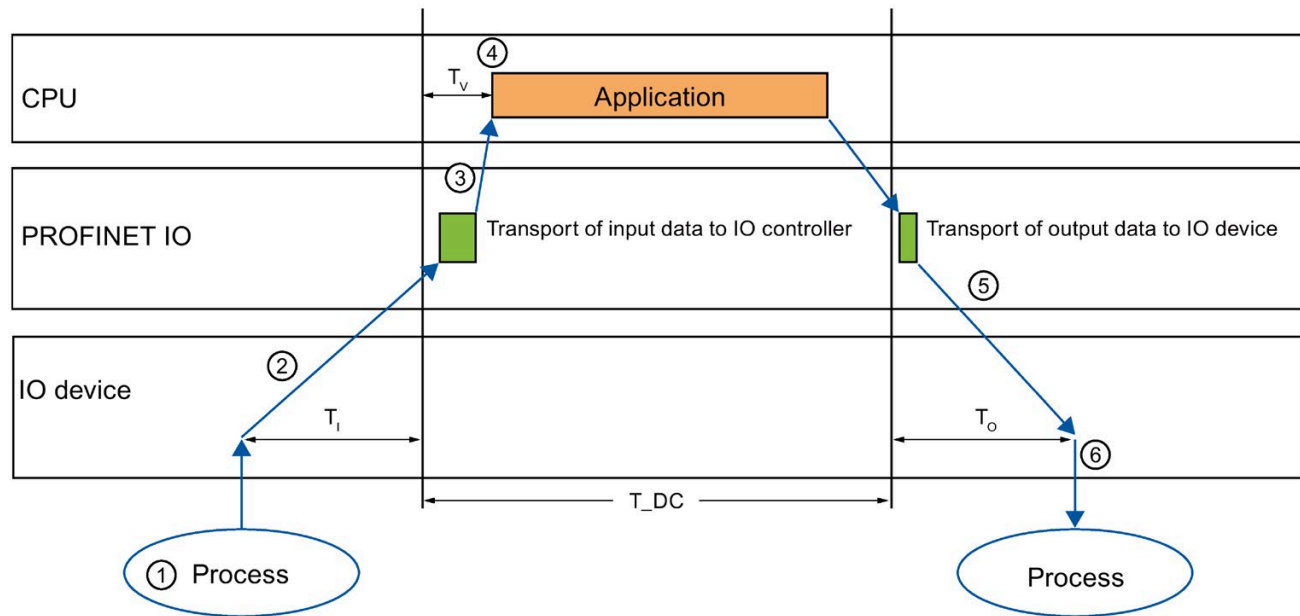
On PROFINET IO, you can isochronously operate I/O modules in distributed I/O systems on a CPU, e.g. in distributed I/O systems ET 200SP, ET 200MP.

Like the I/O modules, the interface modules of the I/O systems must support isochronous mode.

#### From reading in input data to outputting output data

The basic time sequence of all components involved in synchronization is explained below:

- ① Measured value acquisition in the process
- ② Isochronous read-in of input data
- ③ Transport of input data to the IO controller (CPU) via the subnet
- ④ Further processing in the isochronous application of the CPU
- ⑤ Transport of output data to the outputting IO device via the subnet
- ⑥ Isochronous output of output data



$T_{DC}$  Data cycle (Time\_DataCycle)  
 $T_i$  Time for reading in the input data  
 $T_o$  Time for outputting the output data  
 $T_v$  Configured delay time

Figure 5-72 Time sequence of synchronization on PROFINET IO

To ensure that all input data is ready for transport via the subnet at the next start of the PROFINET IO cycle, the start of the I/O read-in cycle is advanced by the amount of lead time  $T_i$ .  $T_i$  is the "flashbulb" for the inputs; at this instant, all synchronized inputs are read in.  $T_i$  is necessary in order to compensate for analog-to-digital conversion, backplane bus times, and the like. The lead time  $T_i$  can be configured by STEP 7 or by you. Let the lead time  $T_i$  be assigned automatically by STEP 7. With the default setting, STEP 7 ensures that a common, minimum  $T_i$  is set.

The subnet transports the input data to the IO controller/DP master. The application is started synchronized to the cycle. That is, the isochronous mode interrupt OB is called after a configurable delay time  $T_v$ . The user program in the isochronous mode interrupt OB defines the process response and provides the output data in time for the start of the next data cycle. The length of the data cycle (send clock/DP cycle time) is always configured by you.

$T_o$  is the time for the compensation arising from the backplane bus and the digital-to-analog conversion within the IO device/DP slave.  $T_o$  is the "flashbulb" for the outputs. The synchronized outputs are output at this time. Time  $T_o$  can be configured by STEP 7 or by you. Let time  $T_o$  be assigned automatically by STEP 7. STEP 7 automatically calculates a common, minimum  $T_o$ .

## 5.7.4 Configuring isochronous mode

### 5.7.4.1 Introduction

#### Configuring at a glance

##### Setting parameters for isochronous operation of the I/O module

You use the properties of the I/O addresses of the corresponding I/O module to:

- Set isochronous mode for the module.
- Assign the inputs and outputs of the module to a process image partition and an isochronous mode interrupt OB.

The data of the process image partition is updated synchronously to the assigned OB. Isochronous mode interrupts give you the option of starting programs isochronously with the PROFINET send clock. Isochronous mode interrupts are processed with high priority.

##### Setting the send clock

The send clock is the shortest possible transmission interval for the data exchange. In isochronous mode, the send clock corresponds to data cycle  $T_{DC}$ .

You set the send clock in the properties of the PROFINET interface of the CPU or in the sync domain.

**Setting the application cycle**

The application cycle is a multiple of data cycle T<sub>DC</sub>. If the runtime of the isochronous mode interrupt OB is short, the application cycle can be identical to the data cycle (= send clock).

You can reduce the application cycle of the isochronous mode interrupt OB relative to the send clock of an isochronous PROFINET IO system. Set an integer multiple of the send clock as the reducing factor.

You use the factor to reduce the CPU utilization by executing the isochronous mode interrupt OB less frequently. You set the application cycle in the properties of the isochronous mode interrupt OB.

**Setting the delay time**

The delay time is the time between the start of the send clock and the start of the isochronous mode interrupt OB. During this time, the IO controller performs cyclic data exchange with the IO devices.

STEP 7 sets the default delay time in such a way that the isochronous update of the process image partition automatically falls within the execution window of the application cycle.

You set the delay time in the properties of the isochronous mode interrupt OB. A shorter delay time enables you to increase the processing time for your user program in the isochronous mode interrupt OB.

**Additional configurations for isochronous mode on PROFINET IO:**

- **Setting IRT as the RT class for the interconnected PROFINET interfaces**

A precondition for isochronous operation on PROFINET IO is IRT communication (Isochronous Real Time Communication). IRT means synchronized data exchange at reserved time intervals.

- **Configuring the topology of the configuration**

A precondition for IRT communication is the topology configuration. In addition to the reserved bandwidth, the exchange of frames on defined transmission paths is used for further optimization of data communication. For this, the topological information of the configuration is used for planning the communication.

- **Using a sync domain**, you assign the IO devices (sync slaves) to an IO controller (sync master) for the isochronous data exchange.

A precondition for IRT communication is a synchronization cycle for all PROFINET devices in a sync domain, for distribution of a common time base. With this basic synchronization, synchronous operation of the transmission cycle of the PROFINET devices within a sync domain is achieved.

### 5.7.4.2 Configuring isochronous mode on PROFINET IO

#### Introduction

The configuring of isochronous mode for a module is described as IO device in the following based on the ET 200MP distributed I/O system. The procedure described also applies to other distributed I/O systems (e.g., ET 200S or ET 200SP).

The IO controller is an S7-1500 CPU.

#### Requirements

- The STEP 7 network view is open.
- A S7-1500 CPU has been placed (e.g., CPU 1516-3 PN/DP).
- An IM 155-5 PN HF interface module (ET 200MP) has been placed and networked with the CPU via PROFINET IO.
- All requirements for an IRT configuration are met:
  - The ports of the networked PROFINET interfaces of the CPU and interface module are interconnected (topology configuration).
  - The RT class of the PROFINET interface of the interface module is set to "IRT" (area "Advanced options > Real time settings > Synchronization").
  - The "sync master" and "sync slave" roles are assigned for the PROFINET interfaces of the CPU and interface module (in the properties of a PROFINET interface: area "Advanced options" > "Media redundancy" > "Domain settings").

## Procedure

To create an isochronous connection between the I/O and user program, follow these steps:

1. Select the IM 155-5 PN HF in the network view of STEP 7. Change to the device view.
2. Insert an I/O module that can be operated isochronously (e.g. DI 16 x 24VDC HF).
3. Go to the "I/O addresses" area in the Inspector window of the selected I/O module.

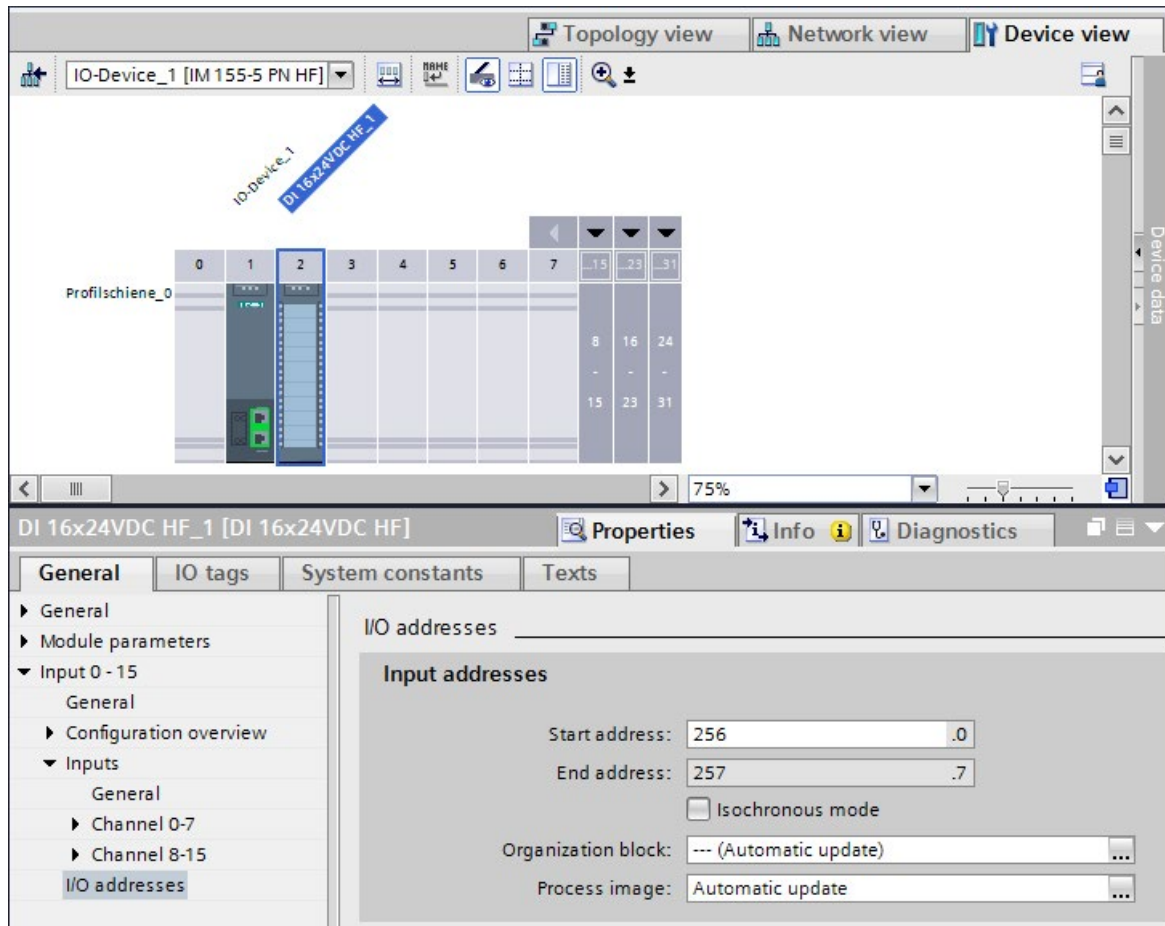


Figure 5-73 Configuring isochronous mode on PROFINET IO

4. Make the following settings in the I/O addresses area:
  - Select the "Isochronous mode" option.
  - Select a process image partition, e.g., process image partition 1.
  - Click the "Organization block" drop-down list. Click the "Add" button or select an existing OB. A dialog box for selecting organization blocks opens.
  - Select the "Synchronous Cycle" OB. Confirm the selection with "OK".

In the case of automatic number assignment, OB 61 will be generated and opened.

In the Inspector window, you can continue directly with the setting of the application cycle and delay time (Page 1) in the "Isochronous mode" area and start the programming of the OB in the instruction section.



5. If required, insert additional IO devices in the network view. Adapt the configuration and the settings for the isochronous mode.
6. You want to retrieve information about calculated bandwidths or on adapting the send clock. Select the sync domain in the network view and navigate to the corresponding area of the domain management in the Inspector window.

## Reference

You can find examples of parameter assignment and possible settings of isochronous mode for distributed I/O and drives in STEP 7 in this FAQ on the Internet (<https://support.industry.siemens.com/cs/ww/en/view/109480489>).

### 5.7.4.3 Setting the application cycle and delay time

#### Requirements

- You have created an isochronous mode configuration in STEP 7.
- You have created an isochronous mode interrupt OB Synchronous Cycle (OB 6x).
- The isochronous mode interrupt OB is open.

#### Setting the application cycle

The application cycle is a multiple of data cycle T\_DC (send clock). You use the application cycle setting to reduce the CPU utilization caused by execution of the isochronous mode interrupt OB. In the following example, the OB is called only after every 2nd data cycle T\_DC in the CPU.

To set the application cycle for your isochronous mode application, follow these steps:

1. Open the "Properties" dialog of the isochronous mode interrupt OB under consideration.
2. In the area navigation, click the "Isochronous mode" group .
3. Set the application cycle in "Application cycle (ms)". Open the drop-down list box and select the application cycle. The drop-down list offers multiples of data cycle T\_DC as possible values for the application cycle. Data cycle T\_DC is set to 2 ms in the following figure.

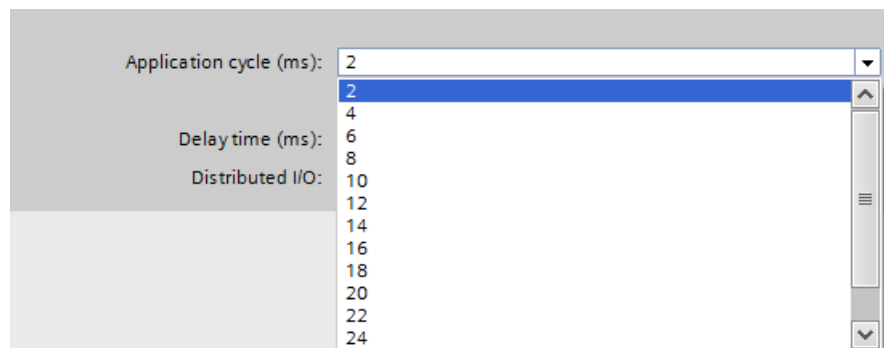


Figure 5-74 Setting the application cycle

## Setting the delay time

The delay time is the time between the start of the send clock and the start of the isochronous mode interrupt OB. STEP 7 sets the delay time automatically to the start of the execution window by default. As a result, the isochronous mode update of the process image partition automatically falls within the execution window of the application cycle.

You can also set the delay time manually. A shorter delay time enables you to increase the processing time for your user program in the isochronous mode interrupt OB. If a manual setting is made, note that you must call the "SYNC\_PI" and "SYNC\_PO" instructions in the execution window of the application cycle.

To set the delay time for your isochronous mode application, follow these steps:

1. Open the "Properties" dialog of the isochronous mode interrupt OB under consideration.
2. In the area navigation, click the "Isochronous mode" group .
3. Clear the "Automatic setting" check box.
4. Enter your desired delay time in "Delay time (ms)".

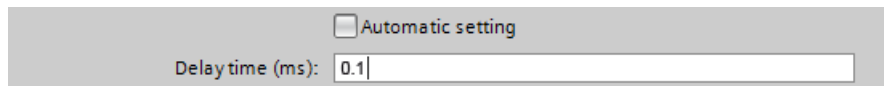


Figure 5-75 Setting the delay time

## 5.7.5 Programming isochronous mode

### 5.7.5.1 Basics of Programming

#### Programming in the isochronous mode interrupt OBs

You program the isochronous section of the program exclusively in the isochronous mode interrupt OBs Synchronous Cycle (OB 6x).

Because the isochronous mode interrupts are processed with high priority, only the time-critical sections of the program should be processed in the isochronous mode interrupt OB. The isochronous mode interrupt OB is called with a configured delay time.

### Access to isochronous I/O through call of instructions

You access the isochronous I/O via a process image partition. That is, the addresses of the isochronous modules must be within one process image partition.

You program access to the isochronous IO in isochronous mode interrupt OB Synchronous Cycle (OB 6x) with the SYNC\_PI and SYNC\_PO instructions.

The isochronous I/O is updated by the call of the "SYNC\_PI" and "SYNC\_PO" instructions and therefore in the corresponding process image partition.

---

**Note**

Recommendation: To prevent inconsistent data from being returned to OB 6x, do not use the "DPRD\_DAT" and "DPWR\_DAT" instructions (direct data access) in the isochronous mode interrupt OB.

---

The "SYNC\_PI" and "SYNC\_PO" instructions update the process image partition only within the permitted execution window. The execution window stretches from the end of the cyclic data exchange to the point in time before the end of T\_DC at which the outputs can still be copied in time. The data exchange must be started within this time window. If the execution window is violated by the processing of the "SYNC\_PI" and "SYNC\_PO" instructions, the instructions indicate a corresponding error message.

### Program execution models

Depending on the order of the "SYNC\_PI" and "SYNC\_PO" instruction calls in OB 6x, there are two basic models for the program execution:

- **IPO** model (read Inputs - Processing - write Outputs)
- **OIP** model (write Outputs - read Inputs - Processing)

#### 5.7.5.2 Program execution according to the IPO model

If the execution time of the isochronous mode interrupt OB is significantly shorter than one data cycle T\_DC, use the IPO model. In the IPO model, you do not reduce the data cycle. That is, the application cycle of the isochronous mode interrupt OB is equal to data cycle T\_DC.

The IPO model enables the shortest response times.

### Programming according to the IPO model in the isochronous mode interrupt OB

For programming according to the IPO model:

1. Call the SYNC\_PI instruction at the start of the isochronous mode interrupt OB.
2. Then call the actual user program.
3. Call the SYNC\_PO instruction at the end of the isochronous mode interrupt OB.

Table 5- 3 Programming according to the IPO model

| Step | Action      | Explanation                                                                                                                        |
|------|-------------|------------------------------------------------------------------------------------------------------------------------------------|
| 1    | Read in (I) | The SYNC_PI instruction reads in the inputs of the process image partition and provides them to the isochronous mode interrupt OB. |
| 2    | Process (P) | You program the actual user program of the isochronous mode interrupt OB.                                                          |
| 3    | Output (O)  | The SYNC_PO instruction outputs the data changed by the user program via the process image partition.                              |

### Signal sequence in the IPO model

The following figure shows the signal sequence in the IPO model from the acquisition and the processing in the CPU to the output of the process values:

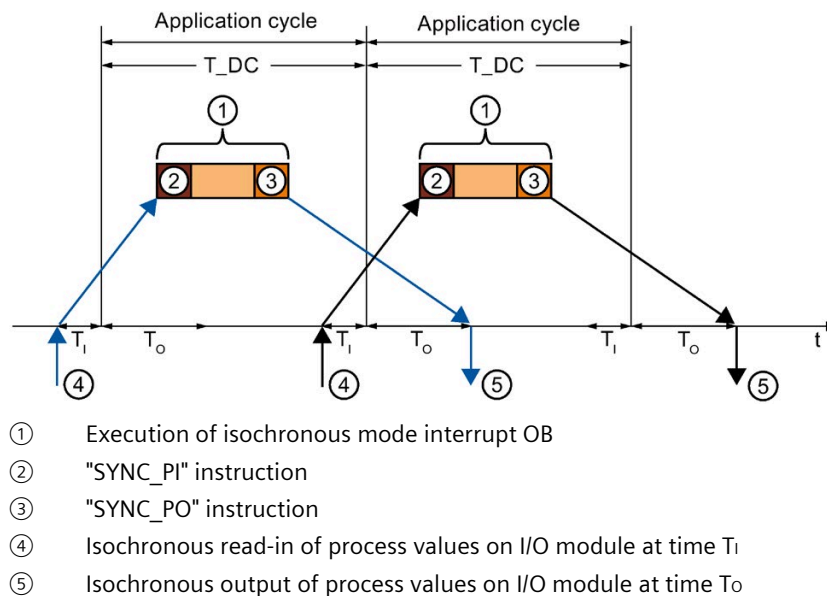


Figure 5-76 Signal sequence in the IPO model

At time  $T_I$  the process values are read in isochronously on the I/O. The processing of the data in the IPO model is completed within one data cycle  $T_{DC}$ . The output data is always available on the I/O in the next data cycle  $T_{DC}$  at time  $T_O$ .

With the IPO model, there is a constant execution time from the "input terminal" to the "output terminal" of  $T_I + T_{DC} + T_O$ .

$T_I + 2 \times T_{DC} + T_O$  can be guaranteed for the process response time.

### 5.7.5.3 Program execution according to the OIP model

Use the OIP model in the case of execution cycles of the isochronous mode interrupt OB of different lengths, if the application cycle is greater than data cycle  $T_{DC}$ .

The data exchange with the process is always deterministic in the OIP model, i.e. takes place at a precisely specified time.

### Programming according to the OIP model in the isochronous mode interrupt OB

For programming according to the OIP model:

1. Call the SYNC\_PO instruction at the start of the isochronous mode interrupt OB.
2. Then call the SYNC\_PI instruction.
3. Then call the actual user program.

Table 5- 4 Programming according to the OIP model

| Step | Action      | Explanation                                                                                                                                                   |
|------|-------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 1    | Output (O)  | The SYNC_PO instruction outputs the data that was changed by the user program in the previous cycle via the outputs of the process image partition.           |
| 2    | Read in (I) | The SYNC_PI instruction reads in the inputs of the process image partition of the current cycle and provides the inputs to the isochronous mode interrupt OB. |
| 3    | Process (P) | You program the actual user program of the isochronous mode interrupt OB.                                                                                     |

### Signal sequence in the OIP model

The following figure shows the signal sequence in the OIP model from the acquisition of process values and the processing in the CPU to the output of the process values. The application cycle is twice as long as data cycle  $T_{DC}$  in this example.

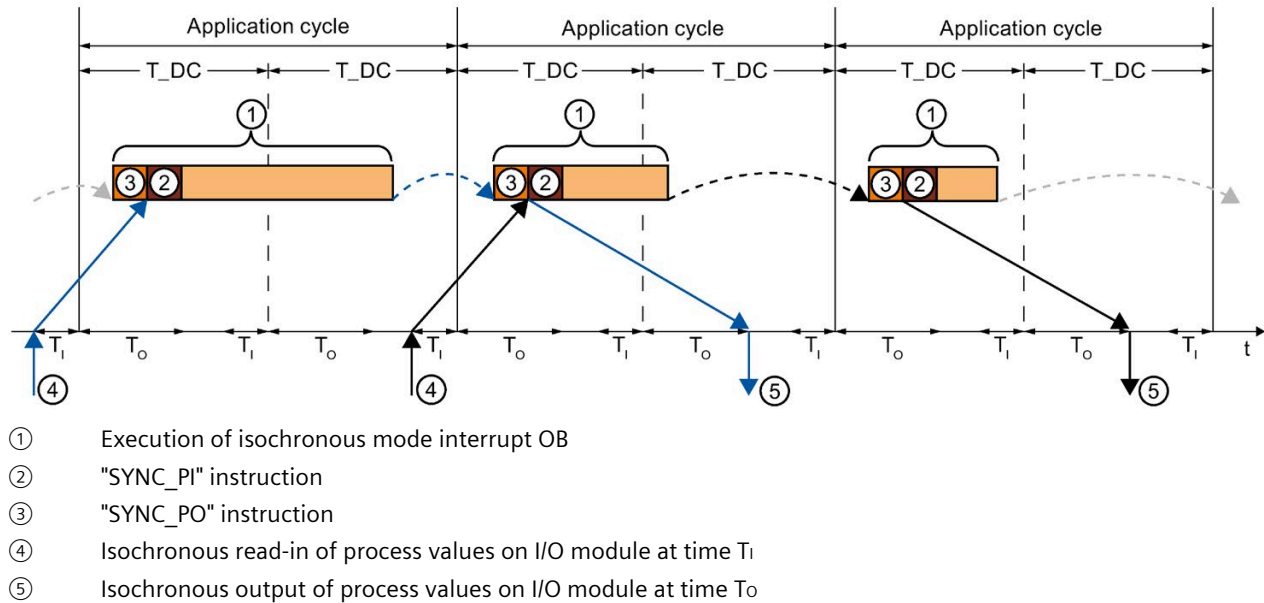


Figure 5-77 Signal sequence in the OIP model

At time  $T_i$  the process values are read in isochronously on the I/O. The data is processed over 2 application cycles in the OIP model. The output data is always available on the I/O in the following application cycle at time  $T_{DC} + T_o$ .

With the IPO model, there is a constant execution time from the "input terminal" to the "output terminal" of  $T_i + \text{application cycle} + T_{DC} + T_o$ .

$T_i + 2 \times \text{application cycle} + T_{DC} + T_o$  can be ensured as the process response time.

## 5.8 Direct data exchange

### 5.8.1 Introduction

This section describes the direct data exchange function.

#### Principle of operation

Starting with firmware version V2.8, the S7-1500 CPU supports direct data exchange (cross data traffic) with other S7-1500 CPUs.

In the case of direct data exchange, an S7-1500 CPU provides cyclic user data from the I/O area to one or more partners. The direct data exchange is based on PROFINET with IRT and isochronous mode.

The data exchange takes place via transfer areas.

#### Direct data exchange between two S7-1500 CPUs (1:1)

The figure below shows the direct data exchange between two S7-1500 CPUs. The output transfer areas of the sending S7-1500 CPU correspond to the input transfer areas of the receiving S7-1500 CPU.

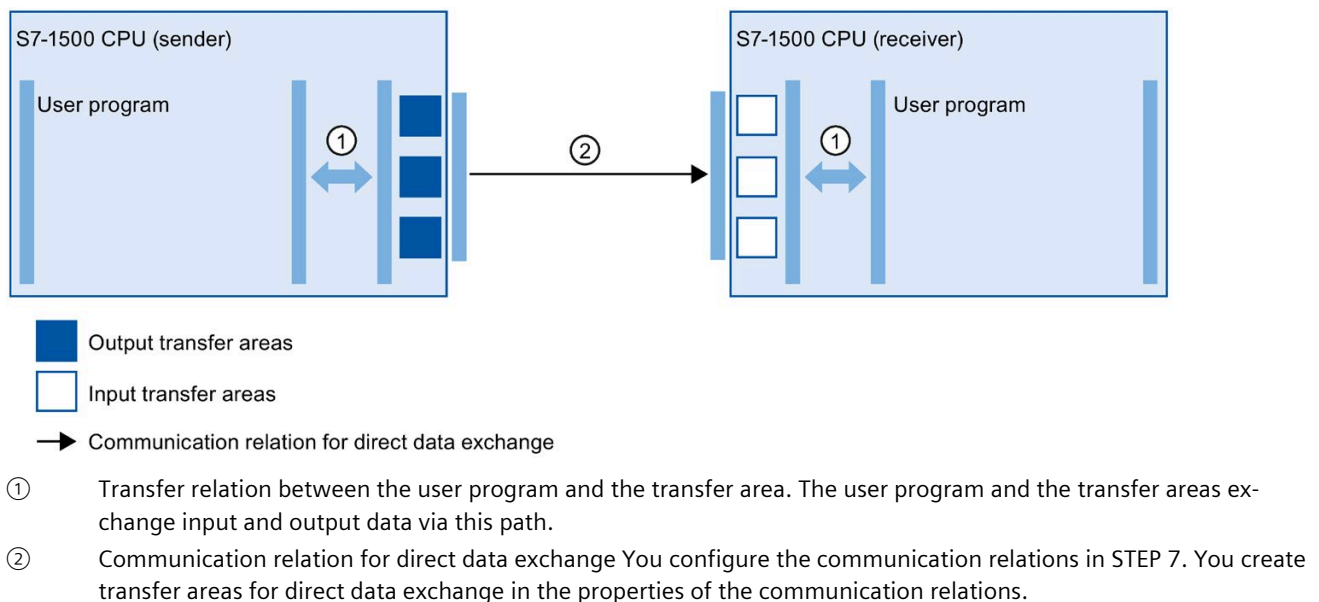


Figure 5-78 Direct data exchange between two S7-1500 CPUs (1:1)

### Direct data exchange with multiple receivers (1:n)

The following figure shows the direct data exchange with multiple S7-1500 CPUs. In this case, the sending S7-1500 CPU provides the data of its output transfer areas to multiple S7-1500 CPUs. Each receiving S7-1500 CPU has its own input transfer areas.

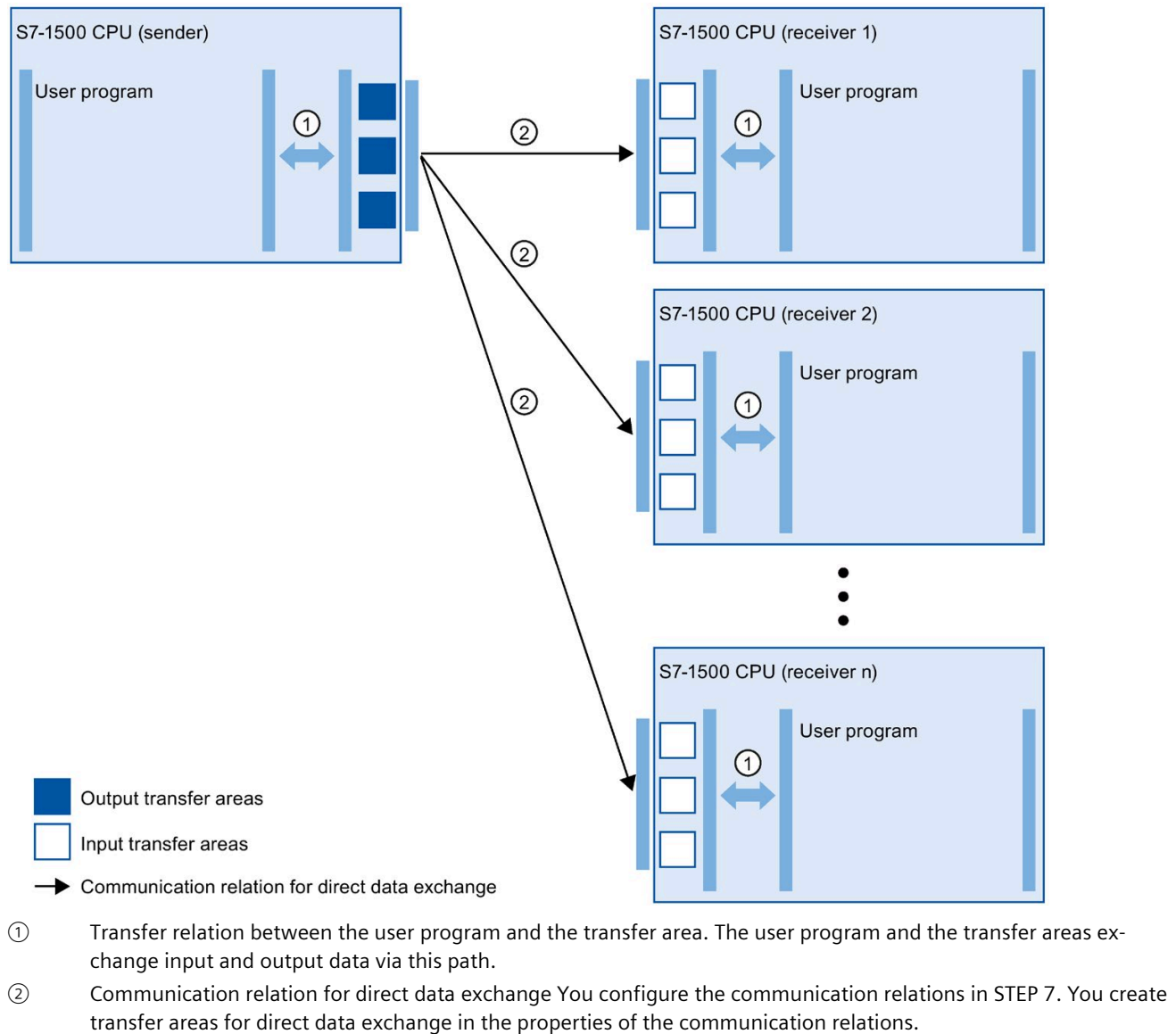


Figure 5-79 Direct data exchange with multiple receivers (1:n)

### Applications

- Deterministic, isochronous I/O communication between multiple S7-1500 CPUs



### Properties of direct data exchange

- Always isochronous
- Support of MRPD for MRP configuration
- No acyclic data exchange via PROFINET data record mechanisms
- No PROFINET alarms
- Configuration limits:
  - Maximum data length for direct data exchange 3075 bytes including user data qualifier
  - Maximum data length for a transfer area: 1024 bytes without user data qualifier
  - Maximum number of transfer areas of sender: 128
  - Maximum number of transfer areas of receiver: 512, distributed among a maximum of 64 receivable PROFINET frames and thus up to 64 sender CPUs

### Diagnostics options of the receiver

Operating state change of sender:

- When the sender goes from RUN to STOP, the receiver behaves as follows:
  - The "SYNC\_PI" and "SYNC\_PO" instructions return an error message in parameter RET\_VAL during synchronization of the process image.
  - With direct I/O access to the input transfer areas of the direct data exchange, OB 122 "I/O access error" is called, if present.
  - Incoming diagnostic message "I/O data failure in hardware component"
- When the sender goes from STOP to RUN, the receiver behaves as follows:
  - Call of OB 83 "Pull/plug interrupt" for input transfer areas of the direct data exchange
  - Up until the call of OB 83, OB 122 is called if present.
  - Outgoing diagnostic message "User data failure of hardware component"

Station failure/station recovery of the sender:

- When the sender fails, e.g. due to a bus interruption, the receiver behaves as follows:
  - Call of OB86 "Rack failure"
  - The "SYNC\_PI" and "SYNC\_PO" instructions return an error message in parameter RET\_VAL during synchronization of the process image.
  - With direct I/O access to the input transfer areas of the direct data exchange, OB 122 "I/O access error" is called, if present.
- When the sender recovers after a station failure, e.g. because the bus connection is re-established, the receiver behaves as follows:
  - Call of OB86 "Rack failure"

### 5.8.2 Configuring direct data exchange between two S7-1500 CPUs

The procedure for configuring direct data exchange between two IO controllers is described below.

First, you create the communication relation for direct data exchange. You then configure transfer areas for the connection.

#### Requirements

- STEP 7 V16 or higher
- Two S7-1500 CPUs firmware version V2.8 or higher
- IRT is configured:
  - Both CPUs are in one sync domain.
  - One CPU is the sync master, and the other CPU is the sync slave.
  - Ports are interconnected.

#### Setting up the communication relation for direct data exchange

To set up the communication relation for direct data exchange between two S7-1500 CPUs, follow these steps:

1. Select the PROFINET interface X1 of the sending S7-1500 CPU.
2. Change to the table view of the network view, tab "I/O communication".  
The PROFINET interface X1 of the CPU is shown in the "Partner 1" column.
3. In the "Partner 2" column at "<Drop or select the device here>", select the PROFINET interface of the communication partner from the drop-down list as the connection partner.  
Note the communication direction:
  - ←: Communication partner is sender
  - →: Communication partner is receiver

The communication relation for direct data exchange between the two S7-1500 CPUs is set up.

|   | Partner 1                  | Partner 2                         | Interface partner 2      | Mode                 |
|---|----------------------------|-----------------------------------|--------------------------|----------------------|
| 1 | ▼ PLC_1                    |                                   |                          |                      |
| 2 | ▼ PROFINET-Schnittstelle_1 |                                   |                          |                      |
| 3 | X1                         | → PLC_2                           | PROFINET-Schnittstelle_1 | Direct data exchange |
| 4 |                            | Drop or select the device here -> |                          |                      |
| 5 |                            |                                   |                          |                      |

Figure 5-80 Communication relation for direct data exchange

## Configuring transfer areas for direct data exchange

To configure a transfer area for direct data exchange, follow these steps:

1. Select the communication relation for direct data exchange.

|   | Partner 1                  | ↔ | Partner 2                         | Interface partner 2      | Mode                 |
|---|----------------------------|---|-----------------------------------|--------------------------|----------------------|
| 1 | ▼ PLC_1                    |   |                                   |                          |                      |
| 2 | ▼ PROFINET-Schnittstelle_1 |   |                                   |                          |                      |
| 3 | X1                         | → | PLC_2                             | PROFINET-Schnittstelle_1 | Direct data exchange |
| 4 |                            |   | Drop or select the device here -> |                          |                      |
| 5 |                            |   |                                   |                          |                      |

Figure 5-81 Communication relation for direct data exchange

2. Navigate to the properties of the communication relation to "General" > "Direct data exchange" > "Transfer areas".
3. Create a new transfer area by double-clicking on "<Add new>". Assign a meaningful name for the transfer area.

A transfer area for direct data exchange is created.

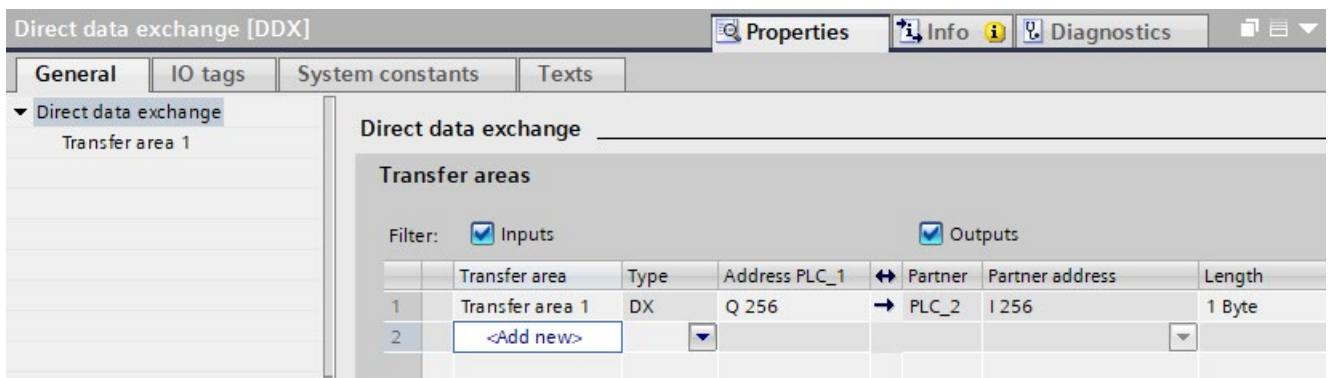


Figure 5-82 Transfer area for direct data exchange

The communication direction of the transfer area is specified by the communication relation. You cannot change the communication direction of the transfer area.

## Editing the transfer area

Set the properties of the transfer area under "General" > "Direct data exchange" > "Name of transfer area" > "Detail of the transfer area".

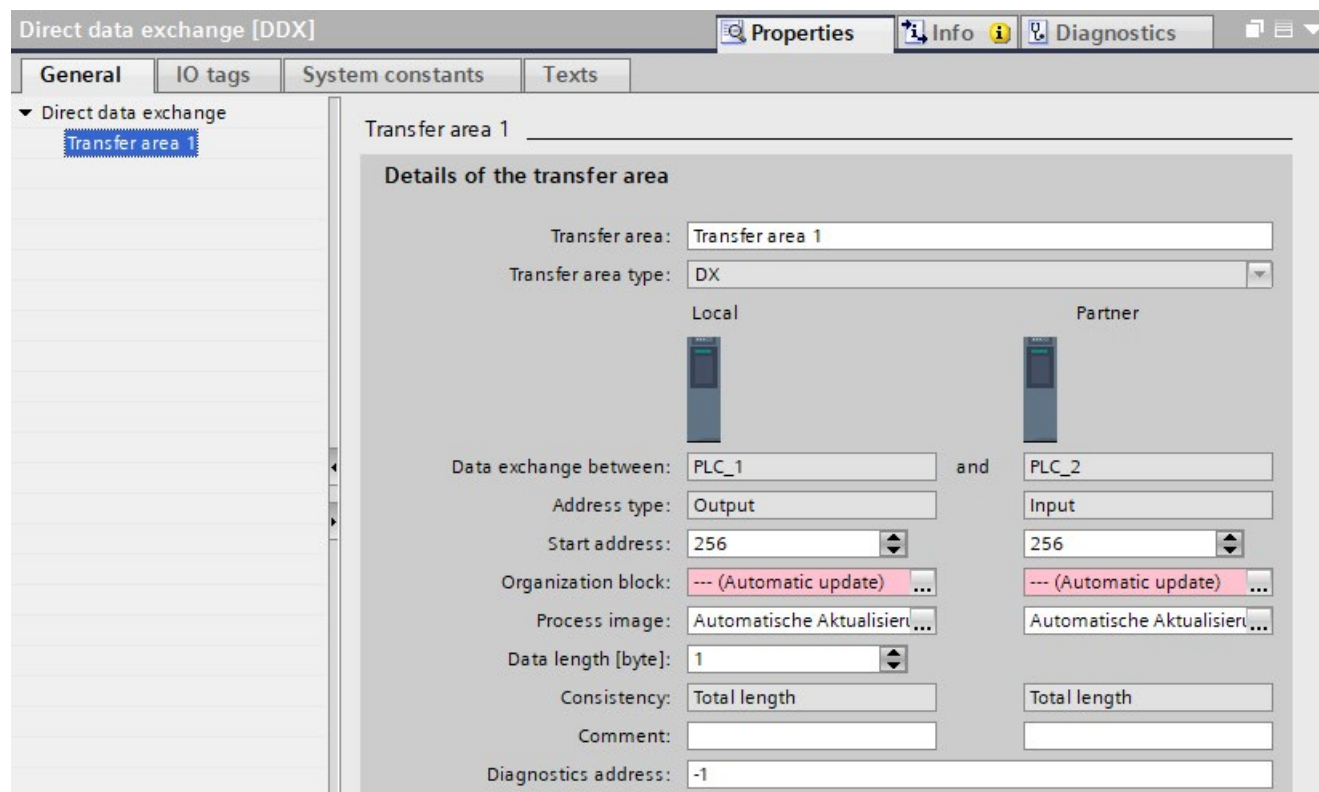


Figure 5-83 Properties of the transfer area

Table 5- 5 Overview of the settings of the transfer area

| Parameter           | Local                                                                                                                                                                   | Partner                                                                                                                                                                 |
|---------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Start address       | Set the start address of the input or output transfer areas in the local CPU.                                                                                           | Set the start address of the input or output transfer areas in the partner CPU.                                                                                         |
| Organization block  | Assign the transfer area to an isochronous mode interrupt OB or the "MC-Servo" OB.                                                                                      | Assign the transfer area to an isochronous mode interrupt OB or the "MC-Servo" OB.                                                                                      |
| Process image       | Select a process image partition, e.g. PIP 1. If you have assigned "MC-Servo" as the organization block, STEP 7 automatically sets "PIP OB Servo" as the process image. | Select a process image partition, e.g. PIP 1. If you have assigned "MC-Servo" as the organization block, STEP 7 automatically sets "PIP OB Servo" as the process image. |
| Data length [bytes] | Set the size of the transfer area.                                                                                                                                      | -                                                                                                                                                                       |

## Downloading the configuration to devices

Rules:

- Download the configuration to all CPUs involved.
- If you make changes to the configuration of the direct data exchange, download these changes to all CPUs involved.

### 5.8.3 Configuring direct data exchange between multiple IO controllers

The procedure for configuring direct data exchange between multiple S7-1500 CPUs is described below.

First, you set up the communication relations for direct data exchange. You then configure transfer areas for the communication relations.

#### Requirements

- STEP 7 V16 or higher
- S7-1500 CPUs firmware version V2.8 or higher
- IRT is configured:
  - All CPUs are in one sync domain.
  - One CPU is the sync master, and the other CPUs are sync slaves.
  - Ports are interconnected.

#### Setting up the communication relations for direct data exchange

To set up the connection for direct data exchange between multiple S7-1500 CPUs, follow these steps:

1. Select the PROFINET interface X1 of the sending CPU.
2. Change to the table view of the network view, "I/O communication" tab.  
The PROFINET interface X1 of the CPU is shown in the "Partner 1" column.
3. In the "Partner 2" column at "<Drop or select the device here>", select the PROFINET interface of the communication partner from the drop-down list as the connection partner.  
Note the transfer direction:
  - ←: Connection partner is sender
  - →: Connection partner is receiverThe connection for direct data exchange between the two S7-1500 CPUs is set up.
4. Repeat step 3 for every other receiving IO controller.

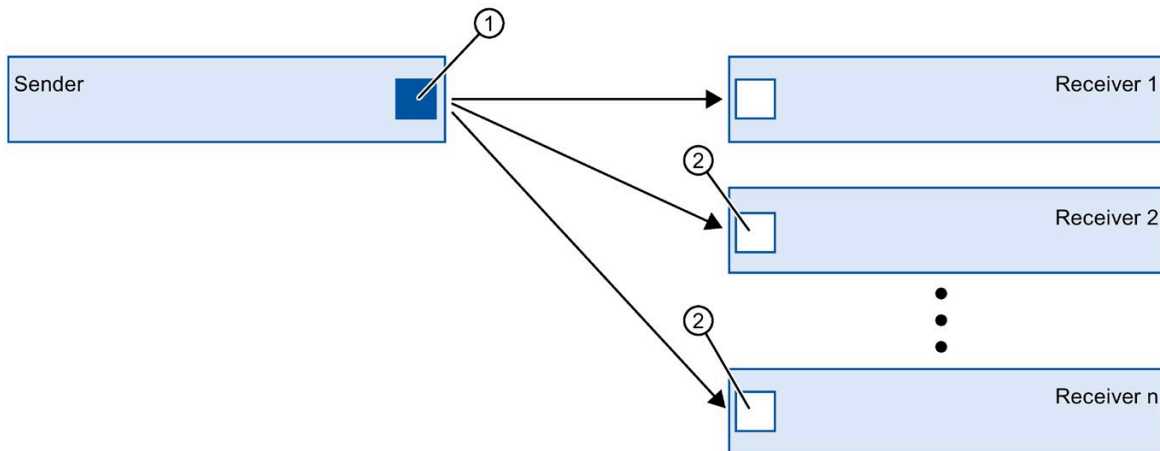
The connections for direct data exchange between the sending CPU and the receiving CPUs are set up.

| Topology view   <b>Network view</b>   Device view                                         |   |                                   |                          |                      |
|-------------------------------------------------------------------------------------------|---|-----------------------------------|--------------------------|----------------------|
| Network overview   <b>Connections</b>   Relations   I/O communication   VPN   TeleControl |   |                                   |                          |                      |
| Offline configuration   <b>Online assignment</b>   ↗ ↖                                    |   |                                   |                          |                      |
| Partner 1                                                                                 | ↔ | Partner 2                         | Interface partner 2      | Mode                 |
| 1 ▾ PLC_1                                                                                 |   |                                   |                          |                      |
| 2 ▾ PROFINET-Schnittstelle_1                                                              |   |                                   |                          |                      |
| 3 X1                                                                                      | → | PLC_2                             | PROFINET-Schnittstelle_1 | Direct data exchange |
| 4 X1                                                                                      | → | PLC_3                             | PROFINET-Schnittstelle_1 | Direct data exchange |
| 5                                                                                         |   | Drop or select the device here -> |                          |                      |

Figure 5-84 Connection for direct data exchange with multiple S7-1500 CPUs

### Configuring transfer areas for direct data exchange

The following graphic shows the order for configuration of the transfer areas.



- ① First, you configure the transfer area between the sender and one receiver. You configure this transfer area at the PROFINET interface of the sender.
- ② You then configure the transfer areas between the sender and the other receivers. You configure these transfer areas at the PROFINET interfaces of the receivers.

Figure 5-85 Order of configuration of transfer areas in the case of multiple receivers

To configure a transfer area for direct data exchange, follow these steps:

1. Select the PROFINET interface X1 of the sending CPU and change to the table view, "I/O communication" tab.
2. In the table view of the network view, select a communication relation for direct data exchange between the sender and receiver 1.
3. Navigate to the properties of the I/O connection to "General" > "Direct data exchange" > "Transfer areas".

4. Create a new transfer area by double-clicking on "<Add new>". Assign a meaningful name for the transfer area.

A transfer area for direct data exchange between the sender and receiver 1 is configured.

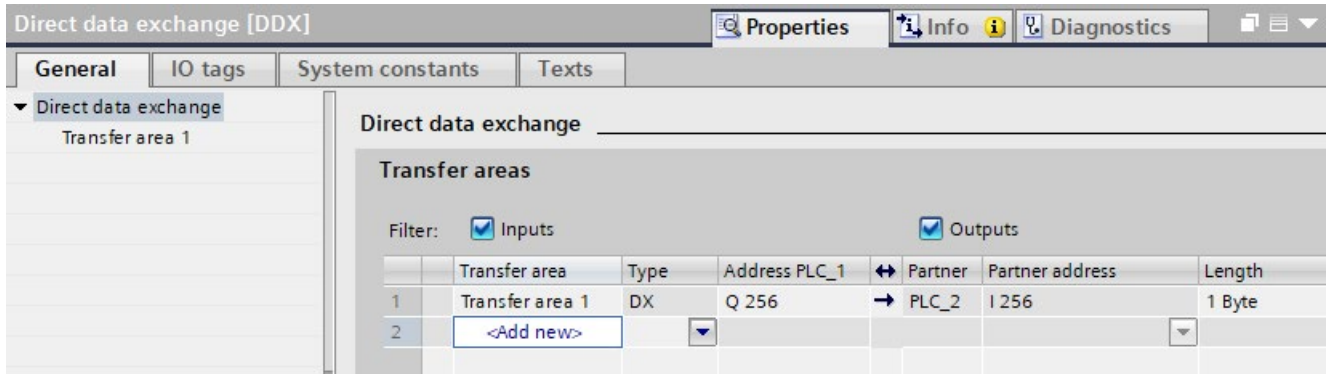


Figure 5-86 Transfer area for direct data exchange

5. Now, select the PROFINET interface of a receiver for which a transfer area is not yet set up, e.g. receiver 2.
6. Change to the table view of the network view to "I/O communication"  
The communication relation for direct data exchange with the sender is displayed.

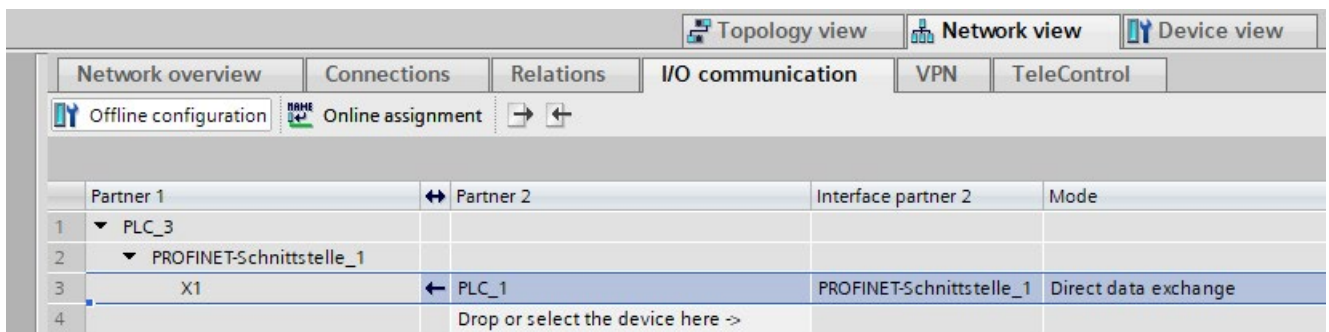


Figure 5-87 Connection for direct data exchange in receiver 2

7. Select the communication relation.
8. Navigate to the properties to "General" > "Direct data exchange" > "Transfer areas".
9. Create a new transfer area by double-clicking on "<Add new>". Assign a meaningful name for the transfer area.

A transfer area for direct data exchange is configured.

10. Select the transfer area.

11. For "Partner address", select the existing address area in the sender as the output transfer area.

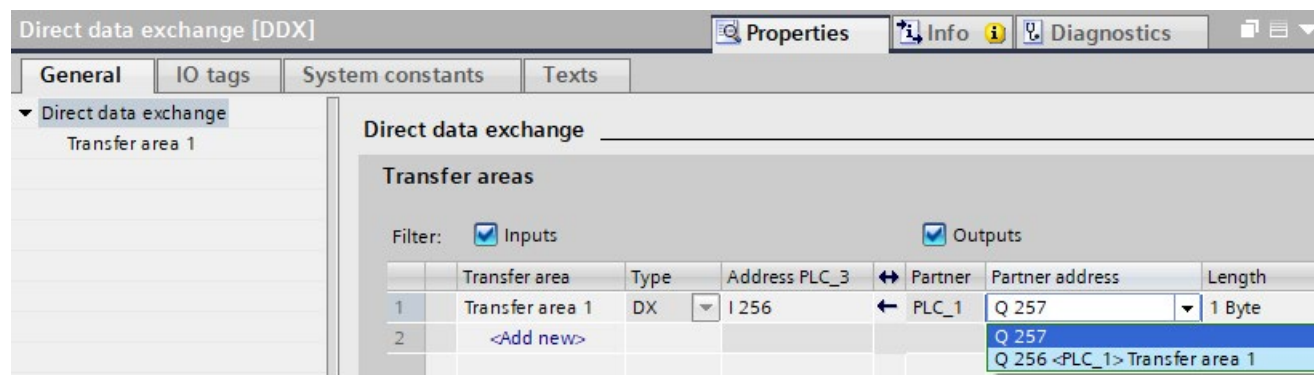


Figure 5-88 Transfer area for direct data exchange of multiple IO controllers

A transfer area for direct data exchange between receiver 2 and the sender is configured.

## Editing the transfer area

Set the properties of the transfer area under "General" > "Direct data exchange" > "Name of transfer area" > "Detail of the transfer area".

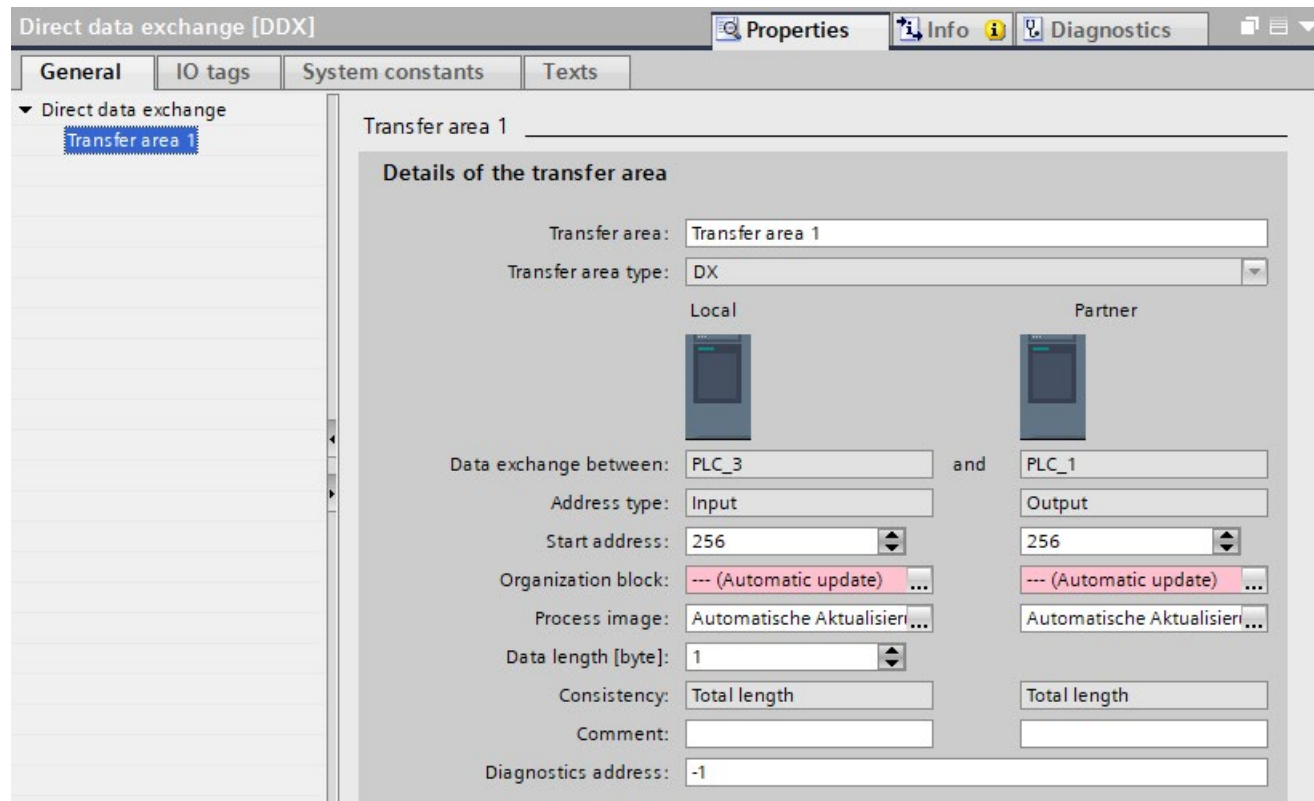


Figure 5-89 Properties of the transfer area



Table 5- 6 Overview of the settings of the transfer area

| Parameter           | Local                                                                                                                                                                   | Partner                                                                                                                                                                 |
|---------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Start address       | Set the start address of the input or output transfer areas in the local CPU.                                                                                           | Set the start address of the input or output transfer areas in the partner CPU.                                                                                         |
| Organization block  | Assign the transfer area to an isochronous mode interrupt OB or the "MC-Servo" OB.                                                                                      | Assign the transfer area to an isochronous mode interrupt OB or the "MC-Servo" OB.                                                                                      |
| Process image       | Select a process image partition, e.g. PIP 1. If you have assigned "MC-Servo" as the organization block, STEP 7 automatically sets "PIP OB Servo" as the process image. | Select a process image partition, e.g. PIP 1. If you have assigned "MC-Servo" as the organization block, STEP 7 automatically sets "PIP OB Servo" as the process image. |
| Data length [bytes] | Set the size of the transfer area.                                                                                                                                      | -                                                                                                                                                                       |

## Downloading the configuration to the device

Rules:

- Download the configuration to all CPUs involved.
- If you make changes to the configuration of the direct data exchange, download these changes to all CPUs involved.

## 5.9 Device replacement without exchangeable medium

### Definition

IO devices which have no slot for exchangeable medium (e.g. ET 200SP, ET 200MP) or IO devices which support the PROFINET functionality "Device replacement without exchangeable medium/PG" can be replaced without having an exchangeable medium with saved device names inserted and without having to assign the device name with the PG. The new IO device is given a device name by the IO controller and not by the exchangeable medium or the PG.

To assign the device name, the IO controller uses the configured topology and the neighborhood relations established from the IO devices.

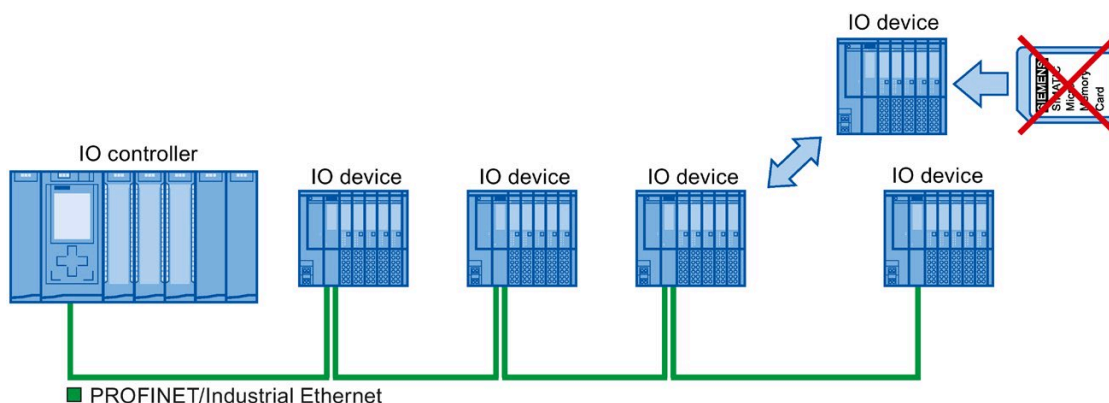


Figure 5-90 Device replacement without exchangeable medium

---

**Note**

When you exchange a device, make sure that the PROFINET cable is again inserted into the correct port, as it is configured in STEP 7.

Otherwise, the device names can be assigned incorrectly.

---

**Advantages**

With the Device replacement without exchangeable medium/PG PROFINET functionality, you can profit from the following advantages:

- After the replacement of the IO device, it automatically obtains its device name from the IO controller. You no longer have to assign device names with the PG or exchangeable medium.
- You can save on the storage medium for the IO device that replaces the removed one.
- Simple device name allocation with series machines that have the same configuration and set topology. It is no longer necessary to assign device names via exchangeable medium/PG.

**Which devices support device replacement without exchangeable medium?**

An overview of the devices that support the "Device replacement without exchangeable medium" function is provided in this FAQ

(<https://support.industry.siemens.com/cs/ww/en/view/36752540>).

**5.9.1 Device replacement without exchangeable medium/PG function**

**Neighborhood**

Neighborhood is the physical relationship between two ports of adjacent PROFINET devices. A PROFINET device is connected in this case through one of its ports over a physical Ethernet line to a specific port of the second PROFINET device in close proximity (neighbors).

Both terminal devices, for example, IO controllers and IO devices with a port, and network components, for example, switches, IO controllers and IO devices with multiple ports, are considered PROFINET devices.

## Failure and replacement of an IO device

The following example describes device replacement without exchangeable medium in the case of failure of an IO device.

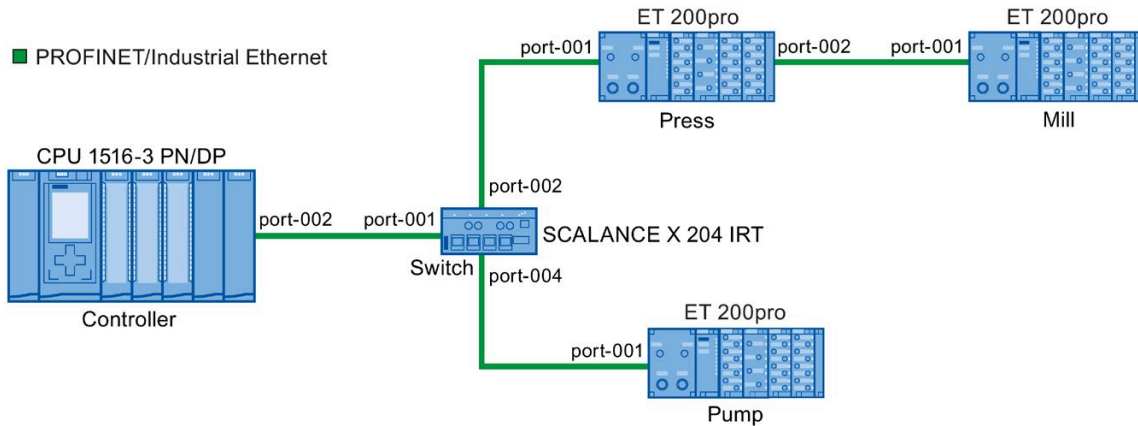


Figure 5-91 Example configuration of device replacement without exchangeable medium

For the device replacement, the following information is available to the IO controller:

| PROFINET device | Device alias                                             |
|-----------------|----------------------------------------------------------|
| Controller      | "port-001.Switch"                                        |
| Switch          | "port-002.Controller", "port-001.Press", "port-001.Pump" |
| Press           | "port-002.Switch", "port-001.Mill"                       |
| Mill            | "port-002.Press"                                         |
| Pump            | "port-004.Switch"                                        |

The IO device with the device name "Mill" fails in this example:

## Requirement

The PROFINET device replacing the removed one has no device name.

### Principles of name assignment

The failure of the "Mill" IO device is considered here.

1. The IO controller queries the device name of the replaced IO device.
2. The IO controller detects that the IO device with the device alias "port-002.Press" does not have a device name.
3. The IO controller assigns the device name "Mill" to the replaced IO device via the device alias "port-002.Press" of the failed IO devices.

---

**Note**

If you insert a device with the Device replacement without exchangeable medium/PG PROFINET functionality at a different location than the configuration, a different device name is then assigned to the device.

Reset a wrongly inserted device to delivery state before you use it again.

---

## 5.9.2 Replacing an IO device without exchangeable medium

### Introduction

Replacement of IO devices is sometimes frequently required in automation systems. The IO devices are generally assigned a device name by either inserting an exchangeable medium or via the programming device. The CPU identifies the IO device by using these device names.

Under certain circumstances, replacing an IO device can be done without inserting an exchangeable medium or without the PG.

### Requirements

- The topology of the PROFINET IO system with the respective IO devices must be configured.

By configuring the topology, the neighbor relationships of all the PROFINET devices located in the PROFINET IO system are announced to the PROFINET IO system or the IO controller. From the neighbor relationships specified by the set topology and the actual neighbor relationships established by the real PROFINET devices, the IO controller can identify the replaced IO device without a name and assign to it the configured name and the IP address and then again list it in the user data traffic.

- The affected IO devices in the automation system must support device replacement without exchangeable medium.

If the individual IO devices in the automation system do not support device replacement without exchangeable medium, a corresponding alarm is output for the IO device.

---

**Note**

Use only new IO devices as replacements or restore configured IO devices to their delivery state.

---

### Activating/deactivating device replacement without exchangeable medium

The "Device replacement without exchangeable medium" function is activated in the IO controller by default.

To deactivate device replacement without exchangeable medium, follow these steps:

1. In the device or network view of the STEP 7, select the PROFINET interface in the corresponding IO controller.
2. In the interface properties under "Advanced options > Interface options", clear the "Support device replacement without exchangeable medium" check box.

To reactivate device replacement without exchangeable medium, you must select the "Support device replacement without exchangeable medium" check box again.

### 5.9.3 Permit overwriting of PROFINET device name

With the option "Permit overwriting of PROFINET device names of all assigned IO devices", you can overwrite PROFINET device names of IO devices. This option reduces the effort during automatic commissioning, for example, when replacing a device.

#### Requirements

- IO controller supports the "Permit overwriting of device names of all assigned IO devices" option, for example CPU 1215C DC/DC/DC as of firmware version 4.0

#### How the "Permit overwriting of PROFINET device names of all assigned IO devices" option works

The IO controller (CPU) can overwrite the PROFINET device names of IO devices in the IO system when the "Permit overwriting of PROFINET device names of all assigned IO devices" option is enabled.

Multiple use IO systems can only be operated when this option is enabled. The IO controller checks prior to overwriting if the type of the IO device matches the configured type.

If the option is not selected, the IO controller cannot overwrite the device names of the IO devices. In this case, you must manually assign the PROFINET device name on the IO device if the PROFINET device name changes in the configuration or when a device is replaced, or delete the device names of the IO devices prior to an automatic commissioning.

## Response during commissioning

Select the option "Permit overwriting of PROFINET device names of all assigned IO devices" only if the following requirements are fulfilled:

- All the configured IO devices are available.
- All IO devices are wired correctly in accordance with the topology configuration.
- No IO device is jumpered.

If configured IO devices are missing or are jumpered (partial commissioning), do not use the option.

You can also use the option for standard machine projects in which you adjust the configuration later via ReconfigIOSystem. Always keep in mind that it is always the configuration that was transferred to the IO controller in the control data record via the instruction ReconfigIOSystem Mode:=2 that is valid. As soon as you enable the reconfiguration with ReconfigIOSystem Mode:=3, the PROFINET device names are overwritten as defined in the data record.



### CAUTION

#### Error at partial commissioning

If device names are assigned incorrectly during partial commissioning or incorrect wiring, these have to be deleted manually after a correction of the wiring in order to attain correct assignment of the device names.

## Behavior during operation

As soon as you replace a device, the new device is overwritten with the configured PROFINET device name.

The PROFINET device name is not overwritten when the MAC address of the IO device is already actively being used in the project.



### WARNING

#### Wrong PROFINET device name

When the "Permit overwriting of PROFINET device names of all assigned IO devices" option is enabled, incorrectly connected devices can be assigned an incorrect PROFINET device name from the configuration.

Depending on the connected I/O, there is risk of death, severe injuries or damage caused by malfunctions.

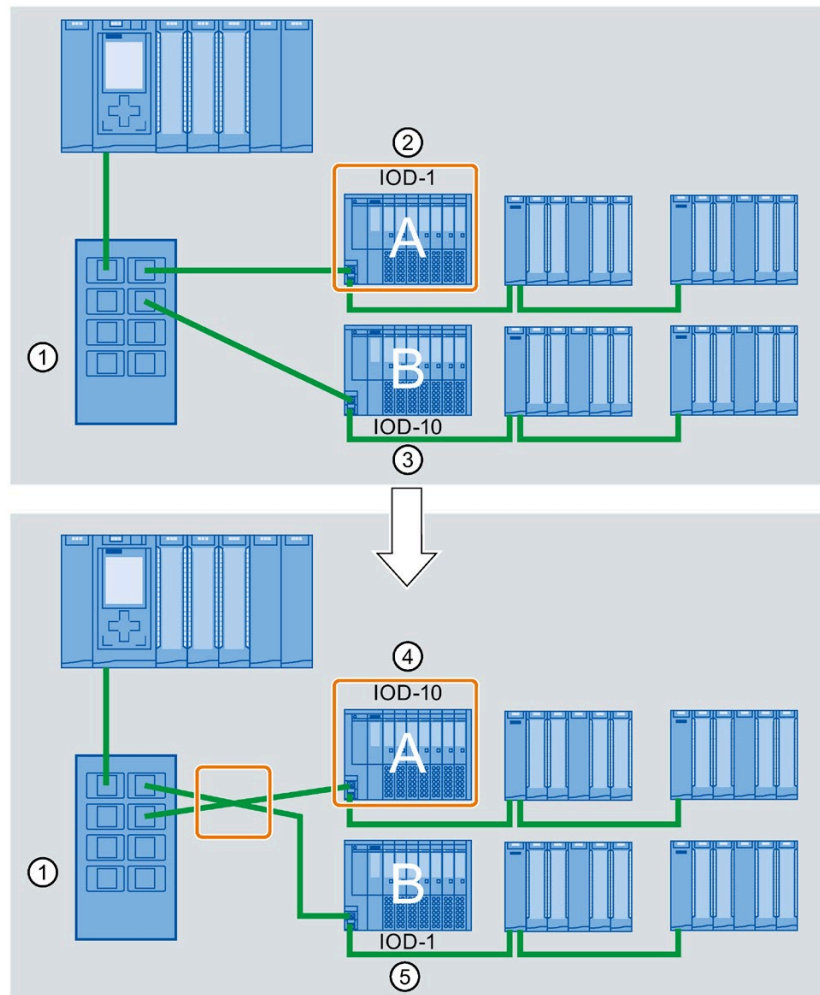
To rule out any danger, check whether the suitable replacement device has been connected in case of a device replacement and whether the port interconnection matches the configured preset topology.

## Typical source of danger

When replacing an IO device ("standard case"), it is almost guaranteed that the replaced device will be connected according to the configured port interconnection.

The figure below shows a scenario whereby the connections of two identical PROFINET cables are swapped at two switch ports. Because the IO controller assigns the device names according to the preset topology, the incorrect connection of the devices has serious effects on the naming.

Due to the control of different actuators, the plant could become hazardous in this case.



- ① Switch with connected PROFINET cables
- ② Device A, device name "IOD-1": controls motor 1
- ③ Device B, device name "IOD-10": controls motor 10
- ④ Device A controls motor 10!
- ⑤ Device B controls motor 1!

## Procedure

Proceed as follows to change the "Permit overwriting of PROFINET device names of all assigned IO devices" option:

1. Select the PROFINET interface of the CPU for which you want to change the option in the network view or in the device view.
2. Select the area "Advanced options", section "Interface options".
3. Change the option.

## 5.10 Standard machine projects

### Introduction

Standard machine projects are STEP 7 projects that use a set of innovative functions allowing simple configuration and commissioning of flexible automation solutions for standard machines or for machines with a modular structure.

A hardware configuration consisting of an IO controller and any number of connected IO devices represents a "PROFINET IO system master". This master is configured with a maximum configuration based on a template from which various options can be derived for different standard machines, for example with different configuration variants of the IO system.

### Greater flexibility at all levels

Standard machine projects have the following central characteristics:

- Different variants of a standard machine can be loaded from precisely one project with an engineered maximum configuration (IO system options). The standard machine project covers all variants (options) of the IO system.
- An IO system option can be integrated in an existing network locally using simple tools.

Flexibility is provided in more ways than one:

- With suitable configuration, adaptation of the IP address parameters of the IO controller is possible locally using simple tools. This allows a standard machine to be integrated in different plants with little effort or to be included in a network several times.  
IO systems with this property are known as **multiple use IO systems**.
- With suitable configuration and programming, different setups of IO system options can be operated locally that differ in terms of the selection of IO devices used or in terms of the arrangement of the IO devices.  
Since the specific configuration of the IO system is controlled by the user program, this is known as **configuration control for IO systems**.
- Independently of the functions described above, with suitable configuration and programming, you can use different station options of central devices or distributed I/O devices in one project. The devices can be different in terms of the selection and arrangement of the modules.  
Since the concrete configuration of the station is controlled by the user program, this is also known as **configuration control at the device layer**.



## Application examples

You can find application examples for configuration control at the device layer, configuration control for IO systems and multiple-use IO systems on the Internet (<https://support.industry.siemens.com/cs/ww/en/view/29430270>).

## Additional information

For more information on multiple use IO systems, refer to section Multiple use IO systems (Page 1).

For more information on the configuration control for IO systems, refer to section Configuration control for IO systems (Page 1).

For more information on configuration control, refer to the system manual S7-1500, ET 200MP (<http://support.automation.siemens.com/WW/view/en/59191792>).

### 5.10.1 Multiple use IO systems

#### 5.10.1.1 What you should know about multiple use IO systems

#### Multiple use automation solutions

For a flexible reusable automation solution as is the case with series machines, the following use cases are typical:

- The machine (and therefore also the PROFINET IO system) is used more than once by the customers.
- The machine is used in different plants by various customers.

For this to be possible, the automation solution must meet the following requirements:

- A project (configuration and program) can be loaded on various machines of the same type without changes.
- Only a few easy adaptations need to be performed locally to integrate the machine into an existing network infrastructure.

The following figure shows how an automation solution with a multiple use IO system is loaded on different automation systems and then one automation system is adapted to the existing network infrastructure locally.

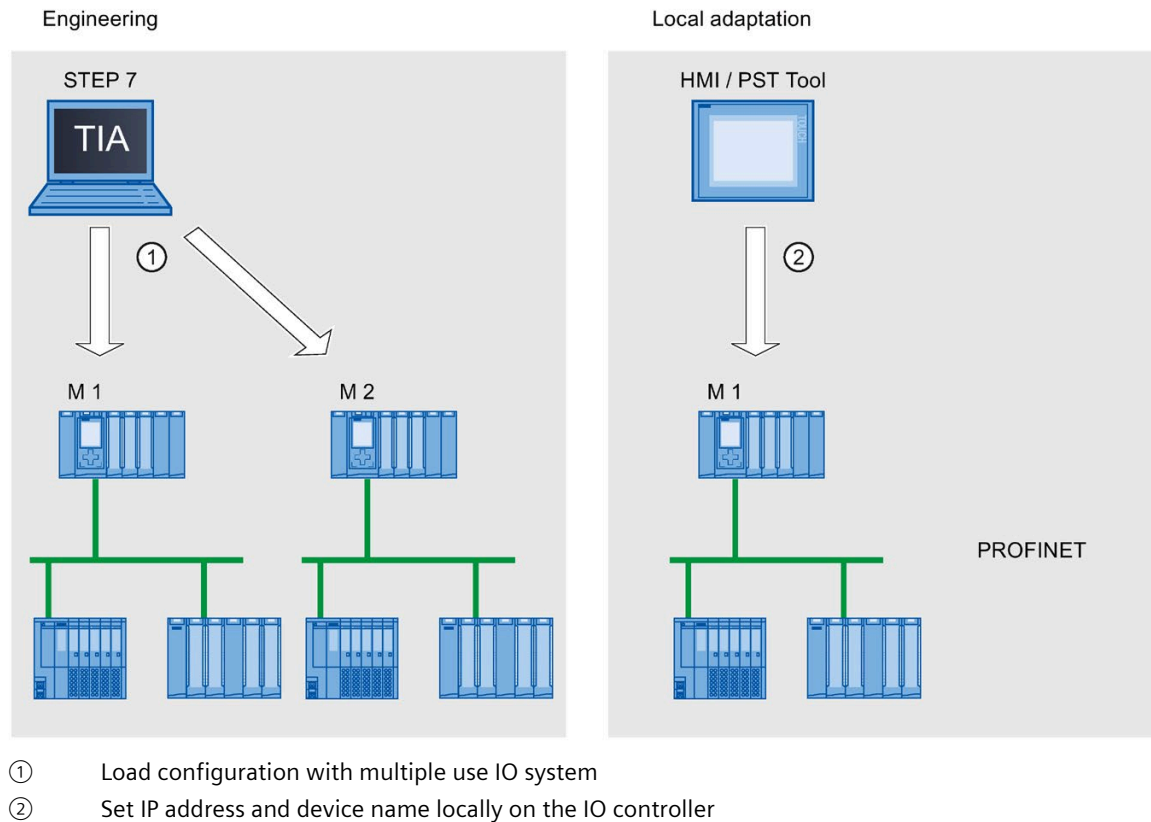


Figure 5-92 "Multiple use IO system" principle

## Principle

The automation components for a machine include a PROFINET IO system, consisting of an IO controller (PROFINET interface of a CPU) and the IO devices assigned to it.

With the "Multiple use IO system" setting for the IO system, you turn a STEP 7 project into a "Standard machine project".

The "Multiple use IO system" setting triggers various settings and checks of the configuration by STEP 7. The settings ensure that the IO system is self-contained and there are no dependencies on components outside the IO system.

## Requirements

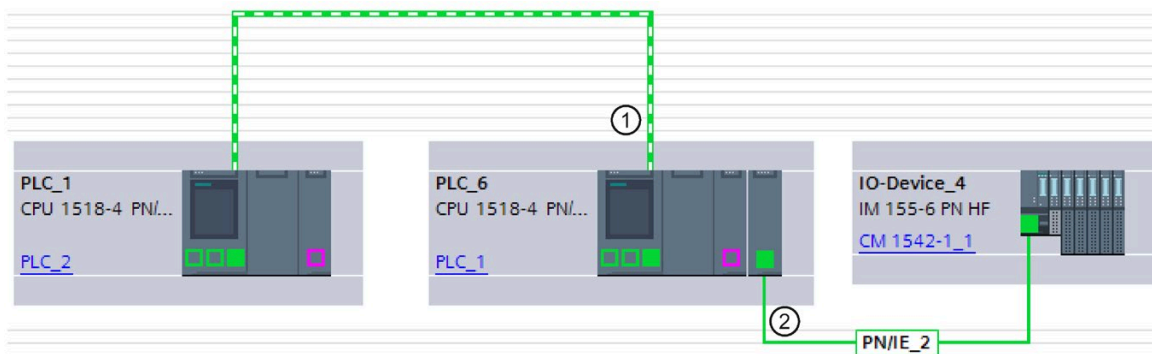
- STEP 7 as of V13
- The IO controller supports the "Multiple use IO system" function, for example a CPU 1512SP-1 PN as of firmware version 1.6.

## Rules

The following rules apply to a multiple use IO system:

- No IO device can be configured as shared device.
- The ports of the devices must be interconnected.  
Devices for which no port interconnection is configured, for example, interface module IM 154-6 IWLAN (ET 200pro PN), cannot be operated with STEP 7 V13 as IO devices on a multiple use IO system.
- If an IO device in a multiple use IO system is an I-device (CPU as an "intelligent" IO device):
  - If the I-device has a lower-level IO system, this I-device cannot be connected to the same PROFINET interface as the higher-level IO controller.

Note: If the I-device is configured using a PROFINET GSD, STEP 7 cannot check for compliance with this rule. In this case, you are responsible for ensuring compliance with the rule.



- ① I-device in multiple use IO system. The PROFINET interface is operated as IO device. No other IO system is connected here.
- ② A lower-level IO system on the I-device is connected to another PROFINET interface.

Figure 5-93 Example configuration for "Multiple use IO system" with I-device

- The PROFINET interface of the I-device must be set to "Parameter assignment of PN interface by higher-level controller".
- If MRP (Media Redundancy Protocol) is configured:
  - All IO devices on the multiple use IO system must belong to the same MRP domain.
- If IRT (Isochronous Real Time) is configured:
  - All IO devices in multiple use IO systems must belong to the same sync domain.
  - The sync domain must not include any other IO devices.
- IE/PB Links cannot be operated as an IO device in a multiple use IO system with STEP 7 V13.

## Configuration

You specify whether or not a configuration can be used multiple times in the properties of the IO system.

All other parameter settings for the configured devices are then set automatically by STEP 7 and checked during compilation.

## Boundary conditions

To prevent a standard machine project from having dependencies on other devices outside of the machine, observe the following:

- A standard machine project consists of an IO controller and the corresponding IO devices. You should therefore configure only one CPU as IO controller and the corresponding IO devices in the standard machine project.
- Do not use connection configured at both ends for the communication. Instead, use only a connection configured at one end or unspecified connections if necessary.

Background: To configure the communication in a STEP 7 project, it is always possible to set the IP address parameters in the project. For multiple use IO systems, however, this strategy is not possible since the IP address parameters of the IO controller and the assigned IO devices are assigned locally. At the time of the configuration, the IP address parameters are therefore unknown.

If you nevertheless want to configure communication with devices on PROFINET, for example with a central coordinator, you can only use communications mechanisms that allow dynamic assignment of the IP address parameters in the user program.

Example: Open User Communication

If, for example, the device is configured as an active end point (initiator of the connection), the IP address parameters can be stored, for example, in a data block. You then supply the data block with the currently valid IP address parameters during commissioning. For this dynamic type of IP address parameter assignment, there is no system support; in other words, if you change the configuration of the system, the IP address parameters are not automatically adapted.

You will find a description of handling instructions for Open User Communication under this keyword in the STEP 7 online help.

### 5.10.1.2 Configuring multiple use IO systems

#### Requirements

- STEP 7 as of V13
- The IO controller supports the "Multiple use IO system" function, for example a CPU 1512SP-1 PN as of firmware version 1.6.

#### Procedure

The configuration of a series machine using an S7-1500-CPU as an example is described below.

To create a standard machine project, follow these steps:

1. Create a project.
2. Configure a CPU as the IO controller, for example a CPU 1518-4 PN/DP as of firmware version 1.5.
3. Configure the required IO devices and assign the IO devices to the IO controller.
4. Configure the port interconnection between the devices.
5. Select the IO system so that you can edit the properties in the inspector window.
6. Select the "Multiple use IO system" check box in the "General" area of the inspector window.

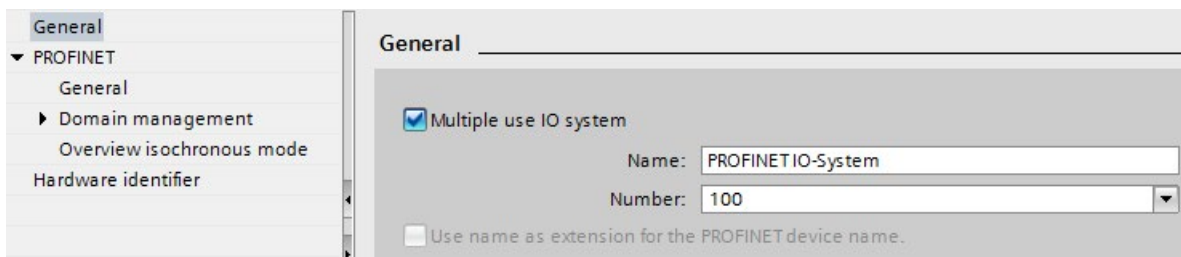


Figure 5-94 Activate "Multiple use IO system"

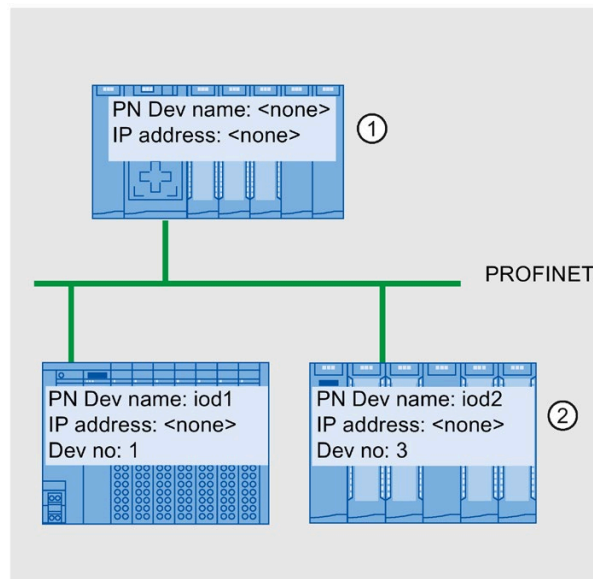
**Result:** The following settings are made by STEP 7:

- The device name of the IO controller (CPU) in the standard machine project is set to "PROFINET device name is set directly at the device". The IO controller (CPU) has no PROFINET device name initially.
- The IP protocol of the IO controller (CPU) is set to "IP address is set directly at the device". The CPU has no IP address initially.
- The "Support device replacement without exchangeable medium" option is selected automatically. This option enables automatic commissioning. A commissioning engineer does not have to assign device names to the IO devices locally. The IO controller assigns the device name and IP address to the IO devices based on the preset topology and other settings during startup.
- The device name of the IO devices is set to "Generate PROFINET device name automatically" (from the configured name of the IO device).
- The IP protocol of the IO devices is set to "IP address is set by the IO controller during runtime". The IO devices have no IP address initially. If an IO device is not a typical distributed I/O system (e.g., ET 200 systems), but rather another device such as an HMI device, change the option to "IP address is set directly at the device"; see below.
- The device number for the IO devices is automatically assigned and is used locally for making the IP address unique.

The option "Permit overwriting of PROFINET device name" must be selected (CPU parameters, properties of the PROFINET interface, Ethernet addresses area) so that the IO controller can adapt the device name later at the operator.

This option is disabled by default.

The following figure shows the above-described settings for the IP address and PROFINET device name.



- ① After the configuration is loaded from the standard machine project, the IO controller has no device name and no IP address.
- ② Following loading, the IO devices have a device name and a device number but no IP address.

Figure 5-95 Settings for the IP address and the PROFINET device name

### How an IO device obtains an IP address locally

Below, you will find an explanation of the "IP address is set by the IO controller during runtime" and "IP address is set directly at the device" options, which can generally be configured for a multiple use IO system.

If you have set the "Multiple use IO system" option for the IO system, STEP 7 automatically sets the "IP address is set by the IO controller during runtime" option for the IO devices.

In this case, the IO controller assigns the IO device an IP address that results from the locally assigned IP address of the IO controller (see next section). This option is appropriate if the IO device is a field device, e.g., ET 200MP, ET 200SP, ET 200AL, or another distributed I/O system.

If the IO device is not a "standard" field device, for example, an HMI device for a Windows operating system, the "IP address is set by the IO controller during runtime" option described above does not work. In this case, choose the "IP address is set directly at the device" option. You must then assign the IP address to the device locally and take steps to ensure that this address is suitable for the IP addresses of the other IO devices and the IP address of the IO controller.

### 5.10.1.3 Adapt multiple use IO systems locally

A few steps are needed to adapt the machine that was loaded with the standard machine project.

Only the device name and IP address of the IO controller must be adapted locally. The device names and IP addresses of the IO devices result from these adaptations. In this example, the effects of local settings are described for two specific machine modules.

The local settings are possible, for example, with the CPU display and commissioning tools such as Primary Setup Tool (PST) or PRONETA. You do not need a programming device with STEP 7 to make these settings, even though it is possible to do so.

#### Requirements

- The machine was loaded with a standard machine project (see Configuring multiple use IO systems (Page 1)).
- The display is ready for operation and the desired tool for assigning the IP address and device name is available (e.g., PST Tool, STEP 7).
- The ports of the IO controller and IO devices are interconnected according to the configuration.

#### Procedure

Observe the boundary conditions and instructions for commissioning an S7-1500. For more information on commissioning an S7-1500 CPU, refer to the system manual S7-1500, ET 200MP (<http://support.automation.siemens.com/WW/view/en/59191792>).

To adapt a standard machine locally, follow these steps:

1. Integrate the machine into the network.
2. Connect the device for assigning the IP address and device name to the CPU, for example a PG/PC with the appropriate software.
3. Assign the desired device name and IP address to the IO controller.
4. Start up the CPU.

The IO controller then assigns the adapted PROFINET device name and a unique IP address to the IO devices.

The following rules apply to the assignment:

- The device names of the IO devices are formed by chaining together the following name components, separated by a period:  
<configured name of the IO device from the standard machine project>.<name of the associated IO controller set on the device>
- The IP addresses of the IO devices result from the locally configured IP address of the associated IO controller and the device number (sum).



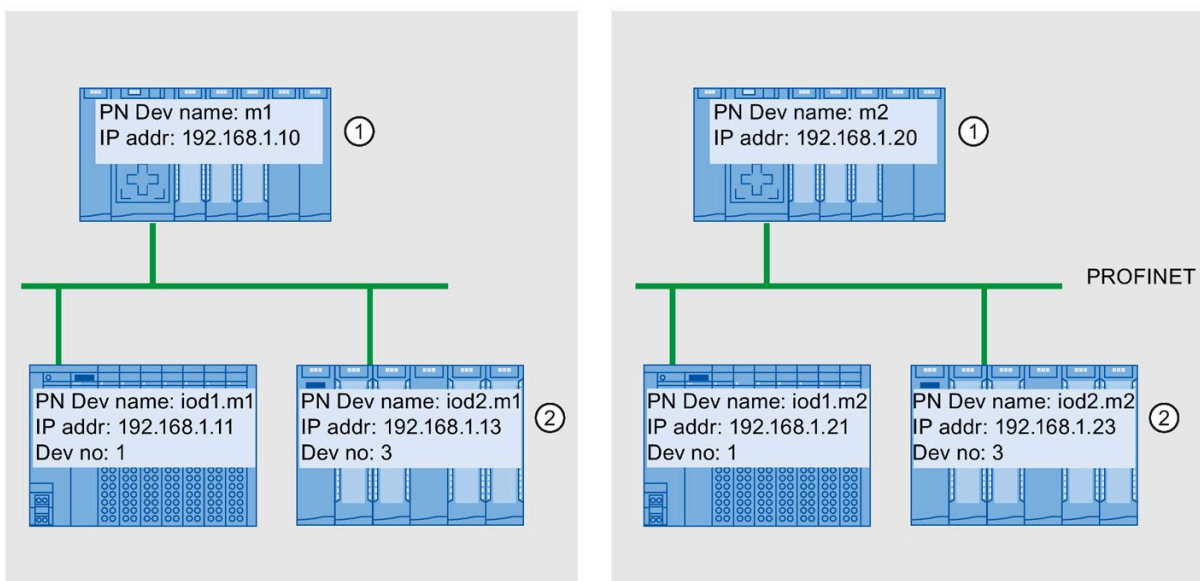
**Note**

Make sure that duplicate IP addresses cannot be created on the subnet during the assignment. The IO controller does not assign a new IP address in this case.

In the following figure, the device name "m1" and the IP address 192.168.1.10 have been assigned to the IO controller of the first machine.

The device name "m2" and the IP address 192.168.1.20 has been assigned for the second machine.

Refer to the figure for the resulting device names and IP addresses.



- ① Set device name and IP address on the IO controller
- ② After startup, the IO devices have an updated device name (<configured device name>.<device name of IO controller>) and an adapted IP address (= <IP address of IO controller> + <device number>)

Figure 5-96 Example of the assignment of IP addresses and device names at "Multiple use IO system"

**See also**

Configuring multiple use IO systems (Page 1)

## 5.10.2 Configuration control for IO systems

### 5.10.2.1 Information about configuration control of IO systems

Configuration control of IO systems makes it possible to generate several concrete versions of a standard machine from a standard machine project.

You are given the flexibility to vary the configuration of an IO system for a specific application as long as the real configuration can be derived from the set configuration. The configured configuration therefore represents the superset of all real configurations that can be derived from it.

The following figure shows an example of how two IO systems with a different number of IO devices arise from one standard machine project.

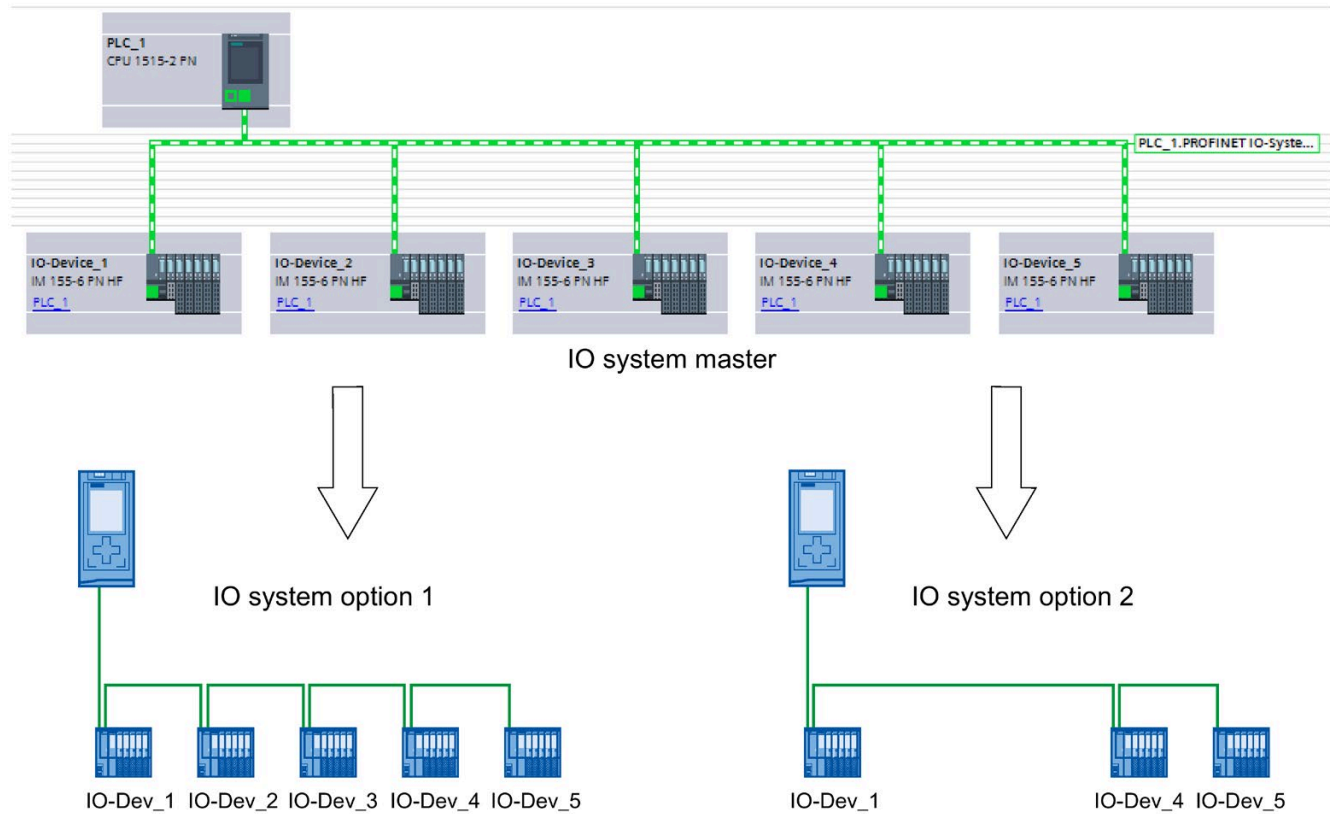


Figure 5-97 Example of configuration control for PROFINET IO systems

In the following sections, you find a description of how to configure and program a PROFINET IO system to commission, for example, a standard machine on-site without using configuration software.

## Concept

The principle of configuration control is already known at the device level for the flexible use of submodules/modules ("option handling"). Different configurations can be derived from one engineering project both for central as well as for distributed I/O.

With S7-1500 CPUs as of firmware version V1.7, this principle can also be applied at the IO system level. You have the option of omitting, adding or changing the order of stations (IO devices) of a PROFINET IO system in a specific plant.

Configuration control for devices and configuration control for IO systems can be combined; the functions are independent of each other.

It is possible to operate variants deviating from a maximum configuration of an IO system. In a standard machine project, you can prepare a kit of IO devices which can be flexibly customized for various configurations using configuration control.

The following variations are available:

- Variation of the number of IO devices involved  
You include optional IO devices for the configuration control in the configuration by transferring a suitable data record with the required configuration in the user program.
- Variation of the order of IO devices involved  
You adapt the port interconnection of the IO devices to the topology being used by transferring a suitable data record with the required topology in the user program.

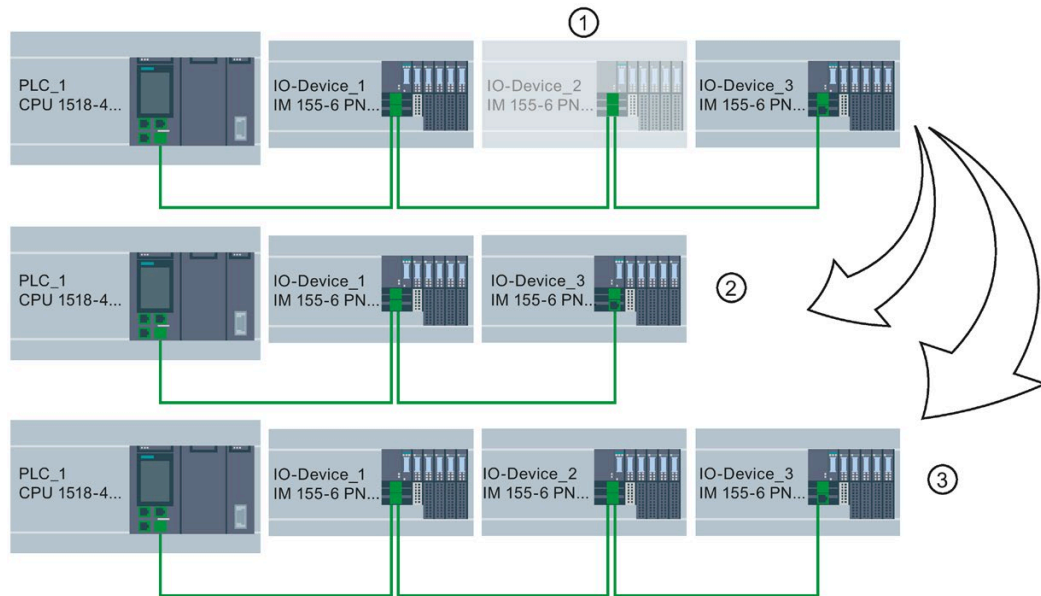
The following figure shows how you serve two different configurations with an IO device marked as optional in the network view of STEP 7.

- Configuration without the optional IO device:

In this case, you use the instruction "ReconfigIOSystem" to transfer a data record to the PROFINET interface containing the information that no optional IO device is to be included in the configuration.

- Configuration with the optional IO device:

In this case, you use the instruction "ReconfigIOSystem" to transfer a data record to the PROFINET interface adding the optional IO device to the configuration.



- ① Determined through parameter assignment: IO Device\_2 is optional IO device
- ② Configuration without the optional IO device
- ③ Configuration with the optional IO device

Figure 5-98 Example configuration with "Optional IO device" and the associated configuration options

### Summary: The procedure in principle

The following phases are distinguished when it comes to the implementation of a standard machine concept:

1. Engineering phase: Creating a standard machine project and loading into specific machine or plant:
  - Completely configuring all IO devices (options) ever required in a specific machine or plant
  - Configuring as optional those IO devices that will be omitted in specific machines or plants
  - Preparing user program (see Configuring flexible order of IO devices (Page 1)) with the possibility of selecting on-site the actually existing configuration via switch or HMI device
2. Commissioning phase: Preparing specific machine or plant for operation:
  - Integrating machine or plant in the on-site network (see Adapt multiple use IO systems locally (Page 1))
  - Selecting the currently existing configuration of the IO system via configured option

#### 5.10.2.2 Configuring IO devices as optional

##### Requirements

- IO controller supports configuration control for IO systems, for example CPU 1516-3 PN/DP as of firmware version 1.7
- STEP 7 V13 SP1 or higher
- The rules (Page 1) for the establishment and operation of a standard machine project have been considered.

##### Port interconnection

As of STEP 7 V15.1, port interconnection is not necessary for optional IO devices.

A port interconnection between the devices of the IO system that you want to customize with the user program is mandatory in the following cases.

- You have configured IRT.
- You have configured MRP.
- You are using STEP 7 <= V15.

## Procedure

To configure an IO device as optional IO device, proceed as follows:

1. Create a project.
2. Configure an S7-1500 CPU firmware version V1.7 or higher as IO controller.
3. Configure the required IO devices and assign the IO devices to the IO controller.
4. Select the IO device you want to mark as optional.
5. Select the area "PROFINET interface [X1]" > Advanced options".
6. Enable the "Optional IO device" option.

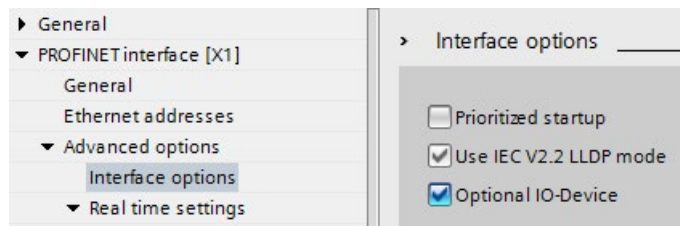


Figure 5-99 Configure the IO device as an optional IO device

7. Repeat steps 4 to 6 for all IO devices to be configured as optional.
8. Load the configuration onto the CPU.

**Result:** Once this configuration is loaded, the system behavior is as follows:

- The CPU is prepared for the configuration control of the IO system.
- All IO devices are disabled.
- Irrespective of whether you customize the configuration with the user program (adding optional IO devices) or make no changes to the loaded configuration: You must call the instruction "ReconfigIOSystem" in the user program and notify the current configuration to the system!

The system will not be operational without calling the instruction "ReconfigIOSystem".

For further information on the proceeding see Enabling optional IO devices in the program (Page 1).

## Fast parameter assignment in the "IO communication" table

You can also specify whether or not an IO device is optional in the "IO communication" tab.

In an additional "Optional IO device" column, a selectable check box is available for each IO device that indicates whether or not an IO device is optional. Here, you can adjust the setting centrally.

### 5.10.2.3 Enabling optional IO devices in the program

#### Requirements

- IO controller supports configuration control for IO systems, for example CPU 1516-3 PN/DP as of firmware version 1.7
- STEP 7 V13 SP1 or higher
- At least one IO device was configured as optional IO device.
- The rules (Page 1) for the establishment and operation of a standard machine project have been considered.

#### Procedure

Observe the information on and rules for commissioning in the documentation for SIMATIC S7-1500, for the ET 200SP CPUs and for the CPU 1516pro-2 PN.

The following description of the proceeding only includes steps required to understand the program-controlled activation of an optional IO device.

To activate or deactivate IO devices, follow these steps:

1. Create a data record "CTRLREC" for the instruction "ReconfigIOSystem". You can find information on the structure of the data record in the STEP 7 online help.
2. Call the instruction "ReconfigIOSystem" and select MODE 1 to deactivate all IO devices.

If you set the CPU to STOP or POWER OFF state in order to modify the plant in this status (for example to add an optional IO device), explicit deactivation using "ReconfigIOSystem" with mode 1 is not necessary. In this case, i.e. following a STOP-RUN transition and following a POWER-OFF > POWER-ON transition, all IO devices are deactivated automatically.

3. When you have brought the plant to a safe status that allows restructuring without any danger:

Put the plant together according to your intended application. Add the required optional IO devices at the points at which you planned this in the configuration (observe the order!) or remove optional IO devices that you no longer require.

4. Network the IO devices.

### 5.10 Standard machine projects

5. Startup the S7-1500 system and call again the instruction "ReconfigIOSystem". Select MODE 2 to transfer the data record CTRLREC.
6. Following successful transfer of the data record, call again the instruction "ReconfigIOSystem". Select MODE 3 to activate all IO devices forming part of the current configuration.

**Result:** The CPU **activates** the following IO devices:

- All IO devices that you have not set as optional IO devices.
- All optional IO devices listed in the control data record (CTRLREC).

The following IO devices remain **disabled**:

- Docking units (IO devices changing during operation).
- Optional IO devices that are not listed in the control data record.

---

#### Note

Call the instruction "ReconfigIOSystem" for all values of the parameter MODE with the same control data record (CTRLREC)!

If you use different data records for the values of the MODE parameter, this results in an inconsistent customization of the configuration and thus to rather incomprehensible error messages.

---



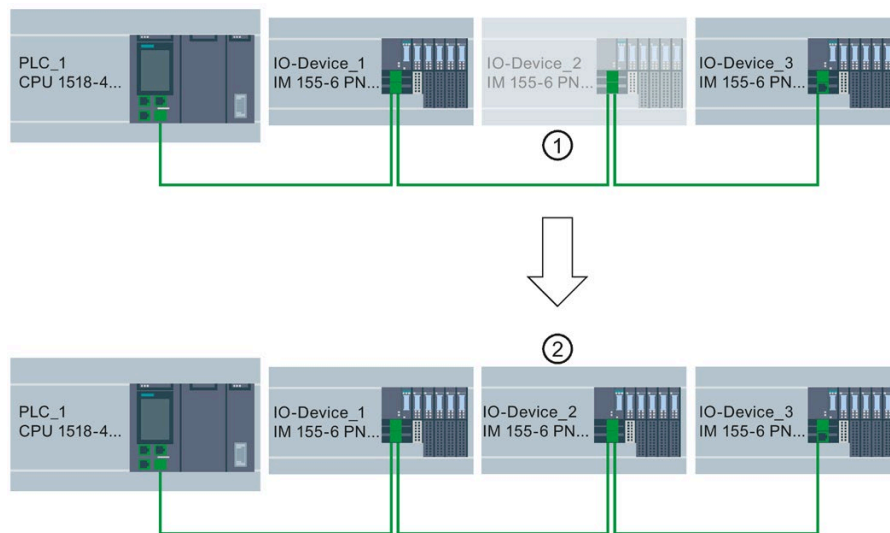
### Example: Data record structure for the activation of an IO device

The IO device "IO-Device\_2" is to be activated as the only IO device in the user program.

To do this, you only require the hardware identifier of "IO-Device\_2".

Recommendation: Use the system constants of the hardware identifiers instead of the absolute values as shown in this example. With this procedure, the content of the DB is not influenced by changes to the hardware identifiers as the result of changes to the configuration.

The data record is to be stored in a data block and to be transmitted to the PROFINET interface of the IO controller in the user program using the instruction "ReconfigIOSystem".



- ① IO device\_2 is configured as optional IO device.
- ② Once the data record is transmitted and the configuration is activated using the instruction "ReconfigIOSystem" IO device\_2 is included in the configuration and participates in the data exchange with the IO controller.

Figure 5-100 Example: Activating an optional IO device

## Creating data block

In this example, the control data record is created in a data block. The data block is structured as follows:

Line 2: Array definition: Array of type Word with 4 elements. Array of Word is permitted as the data type.

Line 3: Version of the data record (currently: V1.0).

Line 4: Number of optional IO devices to be activated (here: 1).

Line 5: List of the hardware identifiers of the IO devices, inserted here as system constants.

Line 6: Number of port interconnections that are set in the user program (here: 0).

Line 7: Additional data records (optional)

| myCTRLREC |                      |                     |                        |                                  |
|-----------|----------------------|---------------------|------------------------|----------------------------------|
|           | Name                 | Data type           | Start value            | Comment                          |
| 1         | Static               |                     |                        |                                  |
| 2         | ArrMachineConfig0    | Array[0..3] of Word |                        | Array for one optional IO device |
| 3         | ArrMachineConfig0[0] | Word                | 16#0100                |                                  |
| 4         | ArrMachineConfig0[1] | Word                | 16#0001                |                                  |
| 5         | ArrMachineConfig0[2] | Word                | "IO-Device_2~IODevice" |                                  |
| 6         | ArrMachineConfig0[3] | Word                | 16#0000                |                                  |
| 7         | ArrMachineConfig1    | Array[0..8] of Word |                        |                                  |

Figure 5-101 Data block with control records

## Parameter MODE of instruction "ReconfigIOSystem"

You control how the "ReconfigIOSystem" instruction works with the MODE parameter.

The following values are possible for the MODE input parameter:

| MODE | Description                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |
|------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 1    | <p>All IO devices of the IO system can be disabled by calling the instruction with MODE 1. The "ReconfigIOSystem" instruction uses the "D_ACT_DP" instruction internally. "ReconfigIOSystem" returns errors that are detected by D_ACT_DP in the following output parameters:</p> <ul style="list-style-type: none"> <li>• STATUS (error code)</li> <li>• ERR_INFO (hardware identifier of the IO device causing the error).</li> </ul> <p>In STATUS and ERR_INFO, the CPU enters the last determined error/HW identifier and in so doing overwrites an existing error code. For this reason, additional errors can be present besides the entered error.</p>                                                                                                                                                                                                                              |
| 2    | <p>For controlling the actual configuration of the IO system, the instruction transfers the data record to the PROFINET interface, which is addressed with LADDR block parameter (HW identifier of the PROFINET interface).</p>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |
| 3    | <p>All non-optional IO devices in the IO system and optional IO devices that are listed in the control data record CTRLREC are enabled.</p> <p>The optional IO devices that are <b>not</b> listed in the CTRLREC data record remain disabled.</p> <p>If IO devices that are part of docking units (alternating IO devices in operation) are listed in the CTRLREC control data record, the PN IO system reacts as follows:</p> <ul style="list-style-type: none"> <li>• IO devices of the docking units remain disabled when ReconfigIOSystem is called with MODE 3.</li> </ul> <p>This reaction corresponds to the reaction of a configuration without configuration-controlled IO devices. IO devices of docking units are disabled by default and must be enabled in the user program.</p> <p>For more information on docking units, refer to the section Docking systems (Page 1).</p> |

**Rules for the call sequence of "ReconfigIOSystem"**

- Always supply the instruction "ReconfigIOSystem" with the same control data record (CTRLREC input parameter)!
- Call sequence following POWER OFF -> POWER ON transition:
  - ReconfigIOSystem call with MODE 1 (optional).
  - ReconfigIOSystem call with MODE 2 (mandatory, even without previous reconfiguration!).
  - ReconfigIOSystem call with MODE 3 (mandatory).
- Call sequence following STOP > RUN transition:
  - ReconfigIOSystem call with MODE 1 (optional).
  - ReconfigIOSystem call with MODE 2 (mandatory, even when configuration was modified in STOP state). Otherwise not required).
  - ReconfigIOSystem call with MODE 3 (mandatory).
- Call sequence for reconfiguration in RUN state:
  - ReconfigIOSystem call with MODE 1 (mandatory).
  - ReconfigIOSystem call with MODE 2 (mandatory).
  - ReconfigIOSystem call with MODE 3 (mandatory).

**Explanations and recommendations concerning the rules**

- If you do not list an IO device to be configured as optional IO device in the control data record or data block resp. this IO device does not form part of the configuration and does not take part in data exchange with the CPU.
- If you do not activate any optional IO device at all and work with the loaded configuration without reconfiguration, you still have to follow the proceeding described in the above section and transmit the control data record to the CPU.

The control data record has the simple structure with the following tags:

- Version (High Byte = 1, Low Byte = 0)
- Number of optional devices to be activated = 0
- Number of port interconnections that are set in the user program = 0
- Following a STOP > RUN transition and following a POWER-OFF > POWER-ON transition, all IO devices are deactivated automatically. For this reason, no ReconfigIOSystem call with MODE 1 is required for configuration control to function properly.

If you use your project as a universally valid sample for programming the configuration control, we still recommend to perform the ReconfigIOSystem call with MODE 1 prior to any reconfiguration. This way, the sample can also be used for reconfigurations in RUN mode.

- Commissioning extensive I/O systems (more than 8 optional IO devices) while using IRT at the same time:

To keep the startup times short when activating the optional IO devices (ReconfigIOSystem, mode 3), note the following tip: Check the device numbers of the IO devices. The device numbers should follow the topological interconnection starting at the IO controller in ascending order. The further an IO device is from the IO controller topologically, in other words the more IO devices there are between the IO controller and the IO device in question, the higher the device number should be.

You set the device numbers in the "Ethernet addresses - PROFINET" area in the Inspector window with the PROFINET interface selected.

Example of the assignment of device numbers with a linear topology:

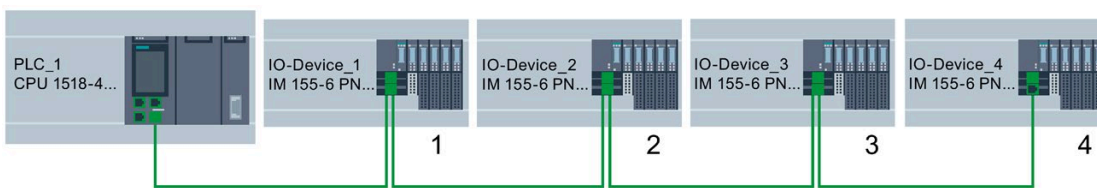


Figure 5-102 Example: Device numbers in a line topology

- The CPU processes the instruction "ReconfigIOSystem" to transfer the control data record asynchronously.

For this reason, you must call "ReconfigIOSystem" in a loop repeatedly when calling the instruction in the startup program until the output parameter "BUSY" or "DONE" indicate that the data record has been transferred.

Tip: To program the loop, use the SCL programming language with the instruction REPEAT ... UNTIL.

```

REPEAT
    "ReconfigIOSystem"(REQ := "start_config_ctrl",
        MODE := 1,
        LADDR := 64,
        CTRLREC := "myCTRLREC".ArrMachineConfig0,
        DONE => "conf_DONE",
        BUSY => "conf_BUSY",
        ERROR => "conf_ERROR",
        STATUS => "conf_STATUS");
UNTIL NOT "conf_BUSY"
END_REPEAT;
```

## Additional information

For information on the basic structure of the data record and on using the instruction "ReconfigIOSystem" see the STEP 7 online help.

## See also

Configuring IO devices as optional (Page 1)

### 5.10.2.4 Configuring flexible order of IO devices

The following section shows how you can create the conditions required to change the order of IO devices in a PROFINET IO system.

This function is also supported with optional IO devices. For simplicity, a maximum configuration without optional IO devices is shown below.

## Concept

A typical application for a standard machine project consists of composing an entire plant from a set of various plant units which only differ with respect to the different arrangement of the units, e.g. in the case of transport systems. Each plant unit consists of a functional unit of mechanics (rails or conveyor belts) and electrics (power supply, IO device with IO modules, sensors, actuators, motors, PROFINET port for data exchange with central control ...).

The following figure shows how, simply by exchanging two rail segments, a new transport system is created that is adapted with an upstream points to the local conditions.

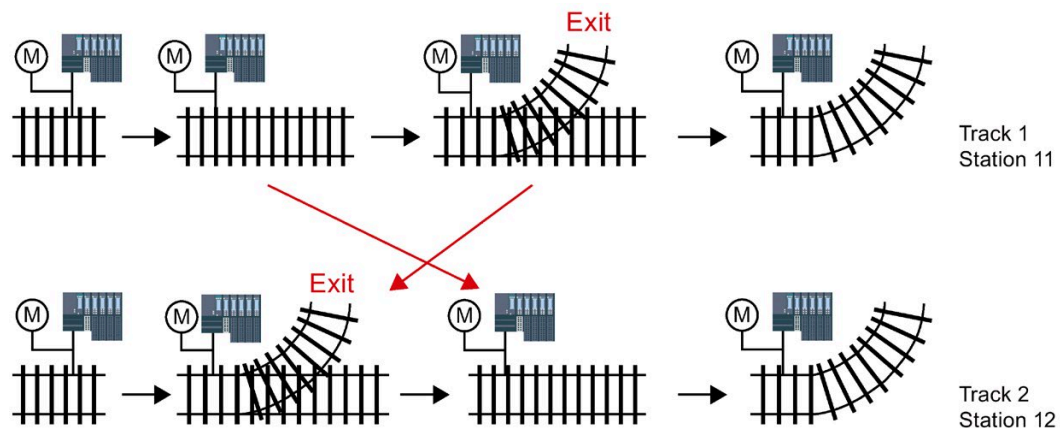


Figure 5-103 Example: Changing the arrangement of IO devices

From the automation viewpoint, no change in the project is required for the flexible adjustment of the PROFINET configuration.

The order of the IO devices is determined by the port interconnection. For each IO device, you define in the port properties the partner port and thus the neighboring device connected at the respective local port. If the partner port is to be defined by the user program, the option "Partner set by user program" is to be selected as partner port.

The figure below shows the initial configuration of the transport system shown above, which is to permit the order of the connected IO devices to be changed via the user program. In the example, the order of IO-Device\_2 and IO-Device\_3 is to be controlled via the user program.

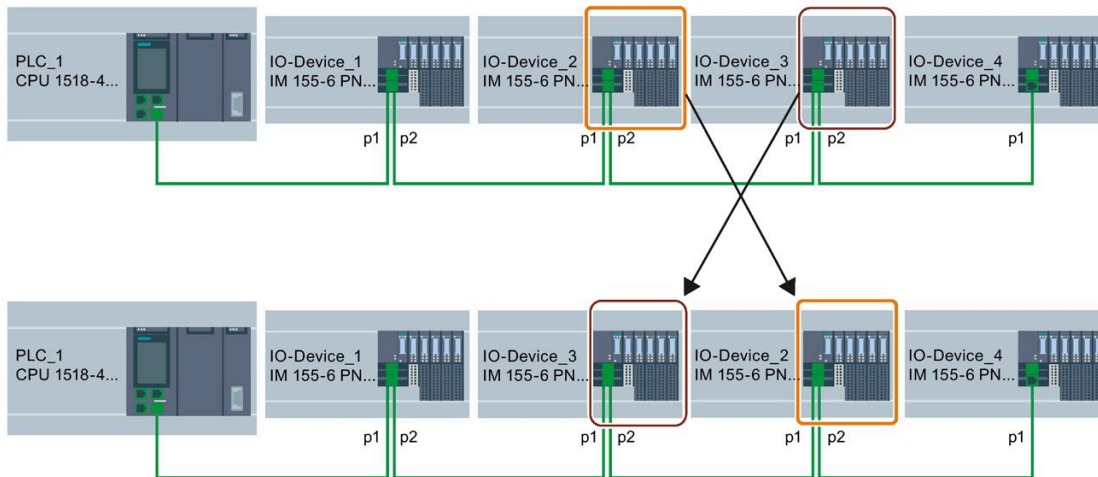


Figure 5-104 Example configuration: Configuring flexible order of IO devices

To determine how the partner port settings are to be selected, you must note for each device and each port of a device which partner can be interconnected.

- If the partner is always the same in the different configurations provided, you select the partner port for this partner.
- If the partners vary in the different configurations, you select "Setting partner by user program".

For the example in the figure above, the following port settings result:

| Device      | Local port | Partner port setting           | Explanation                                                                                              |
|-------------|------------|--------------------------------|----------------------------------------------------------------------------------------------------------|
| PLC_1       | p1         | p1 (IO device_1)               | Partner of PLC_1 at port 1 is IO device_1 (always)                                                       |
| IO device_1 | p1         | p1 (PLC_1)                     | Partner of IO device_1 at port 1 is PLC_1 (always)                                                       |
| IO device_1 | p2         | Partner is set by user program | Partner of IO device_1 at port 2 is either IO device_2 or IO device_3 => Setting partner by user program |
| IO device_2 | p1         | Partner is set by user program | Partner of IO device_2 at port 1 is either IO device_1 or IO device_3 => Setting partner by user program |
| IO device_2 | p2         | Partner is set by user program | Partner of IO device_2 at port 2 is either IO device_3 or IO device_4 => Setting partner by user program |
| IO device_3 | p1         | Partner is set by user program | Partner of IO device_3 at port 1 is either IO device_2 or IO device_1 => Setting partner by user program |

| Device      | Local port | Partner port setting           | Explanation                                                                                                 |
|-------------|------------|--------------------------------|-------------------------------------------------------------------------------------------------------------|
| IO device_3 | p2         | Partner is set by user program | Partner of IO device_3 at port 2 is either IO device_4 or IO device_2<br>=> Setting partner by user program |
| IO device_4 | p1         | Partner is set by user program | Partner of IO device_4 at port 1 is either IO device_3 or IO device_2<br>=> Setting partner by user program |
| IO device_4 | p2         | Any partner                    | No partner planned at port 2                                                                                |

## Requirement

- IO controller supports configuration control for IO systems, for example CPU 1515-2 PN as of firmware version 1.7
- STEP 7 V13 SP1 or higher
- The rules (Page 1) for the establishment and operation of a standard machine project have been considered.

## Procedure

To set the partner port for a program controlled interconnection, proceed as follows:

1. Select the PROFINET interface of the device (IO controller or IO device) whose port you want to set.
2. In the properties of the PROFINET interface, select the area "Port interconnection" (Extended options > Port [...] > Port interconnection).
3. From the drop-down list, select "Setting partner by user program" as partner port.
4. Repeat steps 1 to 3 for each port to be interconnected via the user program.

## See also

Customizing arrangement of IO devices in the program (Page 1)

### 5.10.2.5 Customizing arrangement of IO devices in the program

## Requirements

- IO controller supports configuration control for IO systems, for example CPU 1516pro-2 PN as of firmware version 1.7 as an IO controller
- STEP 7 V13 SP1
- At least one partner port was configured as "Partner set by user program".
- The rules (Page 1) for the establishment and operation of a standard machine project have been considered.



## Procedure

The proceedings corresponds to the proceeding for activating optional IO devices.

Only the structure of the data record must be extended for the program-controlled assignment of the ports. The extension is described in the following sections.

### Example: Data record structure for the assignment of partner ports

For the data record structure, you need the HW identifications of the ports.

The data record is to be stored in a data block and to be transmitted to the PROFINET interface of the IO controller in the user program using the instruction "ReconfigIOSystem".

As the input parameter RECORD of the instruction "ReconfigIOSystem" is of the VARIANT data type, you first have to create a data type for the data block.

In the following sections, you find a description of the structure of the PLC data type as well as of the structure of the data block based on this type.

### Selecting derived configuration

For the following selected configuration it is shown below what the data record must look like so that the IO devices are interconnected in the planned order by the user program.

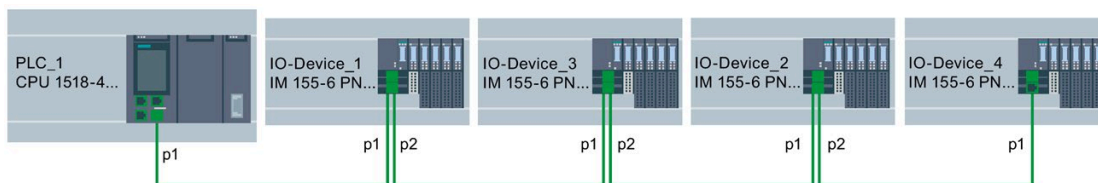


Figure 5-105 Example configuration: Customizing arrangement of IO devices in the user program

This example is based on the flexible configuration from the previous section (Page 1) with the settings for the respective partner ports described there.

The partner ports in the specific derived configuration have been defined so that it is possible to name the HW identifications of the ports involved.

The following table only contains those devices whose ports can be defined by the user program. Only these devices are relevant for the data record structure.

| Device      | Local port                           | Partner port setting           | Partner port of the selected configuration  |
|-------------|--------------------------------------|--------------------------------|---------------------------------------------|
| IO device_1 | p2 = Port 2<br>HW identifier:<br>251 | Partner is set by user program | Port 1 of IO device_3<br>HW identifier: 261 |
| IO device_2 | p1 = Port 1<br>HW identifier:<br>281 | Partner is set by user program | Port 2 of IO device_3<br>HW identifier: 291 |
| IO device_2 | p2 = Port 2<br>HW identifier:<br>311 | Partner is set by user program | Port 1 of IO device_4<br>HW identifier: 321 |

## Creating data block

For the derived configuration, the structure of the data block "DB-IO-SYSTEM-Port-Interconnections" is explained as an example.

This data block is used when calling the instruction "ReconfigIOSystem" at input parameter "CTRLREC".

Instead of the absolute values for the hardware identifiers of the ports, the system constants of the hardware identifiers are used here.

The data block is structured as follows:

Line 2: Declaration of an Array of Word (only this data type is possible).

Line 3: Version of the control data record: V1.0.

Line 4: Number of optional IO devices: 0.

Line 5: Number of specified port interconnections: 3.

Line 6: Port interconnection 1, local port.

Line 7: Port interconnection 1, partner port.

Line 8: Port interconnection 2, local port.

Line 9: Port interconnection 2, partner port

Line 10: Port interconnection 3, local port.

Line 11: Port interconnection 3, partner port.

| IO-SYSTEM-Port-Interconnections |                     |                     |                                         |                                         |
|---------------------------------|---------------------|---------------------|-----------------------------------------|-----------------------------------------|
|                                 | Name                | Datentyp            | Startwert                               | Kommentar                               |
| 1                               | Static              |                     |                                         |                                         |
| 2                               | ArrMachineConfig    | Array[0..8] of Word |                                         | data record for port interconn settings |
| 3                               | ArrMachineConfig[0] | Word                | 16#0100                                 |                                         |
| 4                               | ArrMachineConfig[1] | Word                | 16#0000                                 |                                         |
| 5                               | ArrMachineConfig[2] | Word                | 16#0003                                 |                                         |
| 6                               | ArrMachineConfig[3] | Word                | "IO_device_1~PROFINET_interface~Port_2" |                                         |
| 7                               | ArrMachineConfig[4] | Word                | "IO_device_3~PROFINET_interface~Port_1" |                                         |
| 8                               | ArrMachineConfig[5] | Word                | "IO_device_2~PROFINET_interface~Port_1" |                                         |
| 9                               | ArrMachineConfig[6] | Word                | "IO_device_3~PROFINET_interface~Port_2" |                                         |
| 10                              | ArrMachineConfig[7] | Word                | "IO_device_2~PROFINET_interface~Port_2" |                                         |
| 11                              | ArrMachineConfig[8] | Word                | "IO_device_4~PROFINET_interface~Port_1" |                                         |

Figure 5-106 Data block with data record for port interconnections

## Interconnection not listed in data block

If the partner port was configured as "Setting partner by user program" in the port properties and this port is not listed in the data record or data block resp., then the CPU sets this port to the setting "any partner". If no data record is transmitted at all, the CPU sets this "any partner" setting for all program-controlled assignments.

## Additional information

For information on the basic structure of the data record and on using the instruction "ReconfigIOSystem" see the STEP 7 online help.

### 5.10.2.6 System behavior and rules

Below, you find a description of how an IO system whose configuration is controlled by the user program behaves in operation.

In addition, rules and restrictions are listed here which must be considered when configuring the maximum structure of the configuration in a standard machine project.

#### System behavior

- System diagnostics:

If an optional IO device is deactivated, the IO device is displayed as "deactivated" from the system diagnostics viewpoint (online view or Online & Diagnostics).

- Topology view:

Offline view: As configured. No interconnection is shown for ports with partner ports configured as "Setting partner by user program".

Online view: Ports and interconnections with deactivated IO devices are shown in a different shade of green as error-free ports and interconnections of activated IO devices.

- Representation in the Web server:

The names of devices are shown as configured (Properties > General > Project information).

The assigned PROFINET device name for the CPU is shown on the "Communication" website, at the "Parameter" tab.

IP address parameters: Currently assigned IP address parameters are shown on the site "Module state".

Topology: The current topology resulting from any customizations via user program is shown in the Web server. IO devices configured as optional are shown as "deactivated" IO devices in the Web server.

## Rules

The rules for standard machine projects as described here (Page 1) apply.

For configuration-controlled IO systems, the following additional rules apply:

- When configuring MRP (Media Redundancy Protocol):

The ports configured as ring ports must not be interlinked via user program.

However, devices with ring ports (devices of an MRP domain) can be optional IO devices.

- When configuring docking stations (= IO devices changing during operation):

Neither the docking station nor the first IO device of a docking unit may be optional IO devices.

The ports of the docking units must not be interlinked via user program.

- When configuring IRT:

The order of synchronized IO devices ("IRT devices") must be defined by the configuration and must not be changed in the different variants of a standard machine. For this reason, the ports of the IRT devices must not be interlinked via user program.

However, you have the possibility to configure IRT devices primarily as optional IO devices.

You also have the option to interconnect, by user program, RT devices that are, for example, separated from this line by a switchport (see figure).

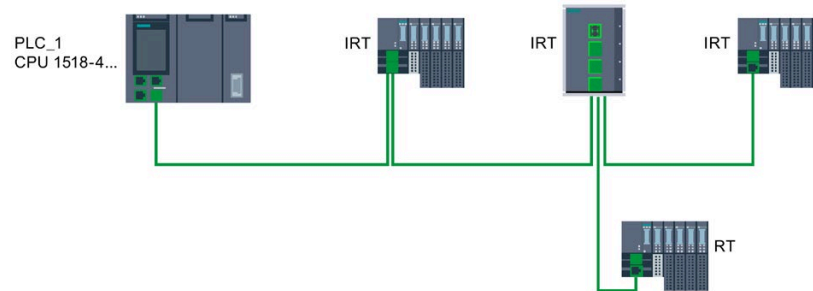


Figure 5-107 Example: Configuration control for IO systems with separated RT device

## 5.11 Saving energy with PROFlenergy

### Saving energy with PROFlenergy

PROFlenergy is a PROFINET-based data interface for switching off consumers centrally and with full coordination during pause times regardless of the manufacturer or device type. Through this, the process should only be provided with the energy that is absolutely required. The majority of the energy is saved by the process; the PROFINET device itself only contributes a few watts of savings potential.

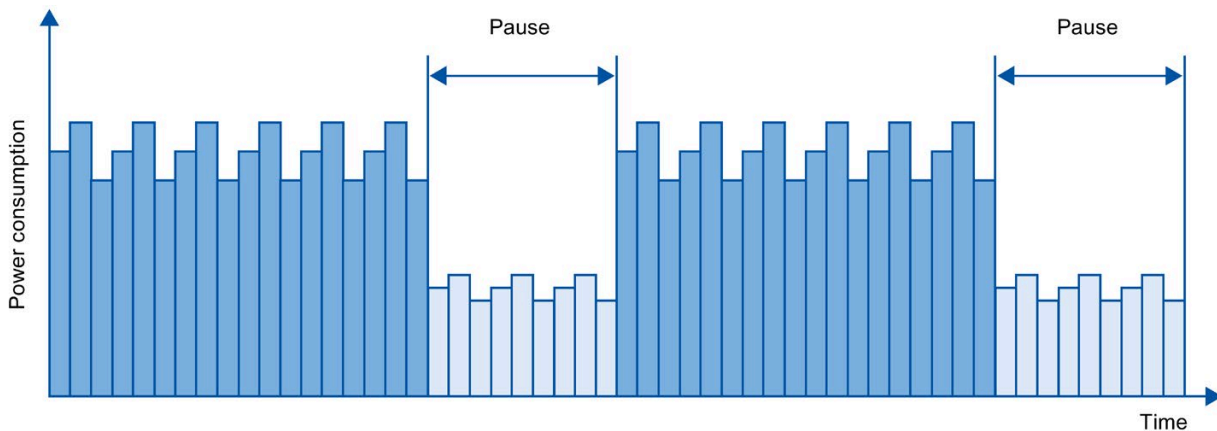


Figure 5-108 Energy savings during pauses with PROFlenergy

### Basic information

In order to use the PROFlenergy functionality, the existing IO controller has to be "upgraded" to a so-called "PROFlenergy controller" by means of a function block in the PROFINET IO system and at least one PROFlenergy-capable IO device ("PROFlenergy device") has to exist. The PROFlenergy commands (for example to start or end a pause) are sent by the "PROFlenergy controller" to the individual "PROFlenergy devices". Each "PROFlenergy device" decides individually how it responds to the PROFlenergy command (response is device- and manufacturer-specific).

No additional hardware is needed; the PROFlenergy commands are directly interpreted by the PROFINET devices.

### Principle of operation

At the beginning and end of pauses, the system manager enables or disables the pause function of the system; then the IO controller sends the PROFlenergy command "Start\_Pause"/"End\_Pause" to the PROFINET devices. The device interprets the contents of the PROFlenergy command and switches off or back on.

Through other PROFlenergy functions, device information can be accessed during pauses. The user can use this information in order to optimally time the transfer of the "Start\_Pause"/"End\_Pause" command.

### PROFlenergy instructions for IO controllers

Two instructions are needed for controlling and monitoring the PROFlenergy functions.

The instruction PE\_START\_END allows you to easily activate and deactivate the idle state of PROFINET devices. This occurs by means of an incoming edge or outgoing edge. The instruction PE\_START\_END provides a simple interface for implementing the PROFlenergy commands Start\_Pause and End\_Pause.

The instruction PE\_CMD allows you to transmit all PROFlenergy commands, including Start\_Pause and End\_Pause. The other commands can be used, for example, to query the current status of the PROFINET device or the behavior during the pauses. The instruction PE\_CMD is a convenient means for handling all PROFlenergy functions.

### PROFlenergy instruction for I-devices

The instruction PE\_I\_DEV allows you to also implement PROFlenergy on I-devices. The instruction receives PROFlenergy commands on the I-device and forwards these to the user program for execution. After executing the command, the user program calls the PE\_I\_DEV instruction again in order to send the acknowledgment to the IO controller. For these replies, each command offers you a helper instruction that supplies the reply data to the instruction.

The instructions can be found in the "Instructions" task card of the STEP 7 program editor.

### Configuration and programming

The functions can be comfortably integrated into existing systems. No configuration is required for the use of PROFlenergy. However, amendments to the user program are required:

- Before the "Start\_Pause" command, you must ensure that your system is brought into a condition that is suitable for a pause.
- A sequential control system for the beginning of the pause of the devices and for the punctual restarting of the device on break must be programmed (depending on the required startup times that the respective PROFINET device demands).
- The error messages of the PE\_CMD instruction must be evaluated, and the required reaction must be programmed (for example, cancellation or continuation of further commands on lower-level PROFINET devices).

---

#### Note

In the case of the ET 200S distributed I/O system, you have to configure the application of PROFlenergy in STEP 7. You configure PROFlenergy by selecting the "Use energy saving for this potential group" check box in the PM-E DC24V/8A RO power module.

If you want to use PROFlenergy for an I-device, you have to configure this in STEP 7. Information about configuring PROFlenergy for an I-device is available in the section Configuring PROFlenergy with I-devices (Page 1).

---

## Application examples

- SIMATIC S7 library for simple configuration of PROFinergy.  
The application example is available here  
(<https://support.industry.siemens.com/cs/ww/en/view/109478388>).
- Application guide for implementation of shutdown concepts with PROFinergy.  
The application example is available here  
(<https://support.industry.siemens.com/cs/ww/en/view/96837137>).
- Saving energy with SIMATIC S7 PROFinergy with I-device  
The application example is available here  
(<https://support.industry.siemens.com/cs/ww/en/view/41986454>).

## 5.12 Docking systems

### Using alternating IO devices ("alternating partners") during operation in a docking station

The following figure shows an automation cell with a docking station and several docking units.

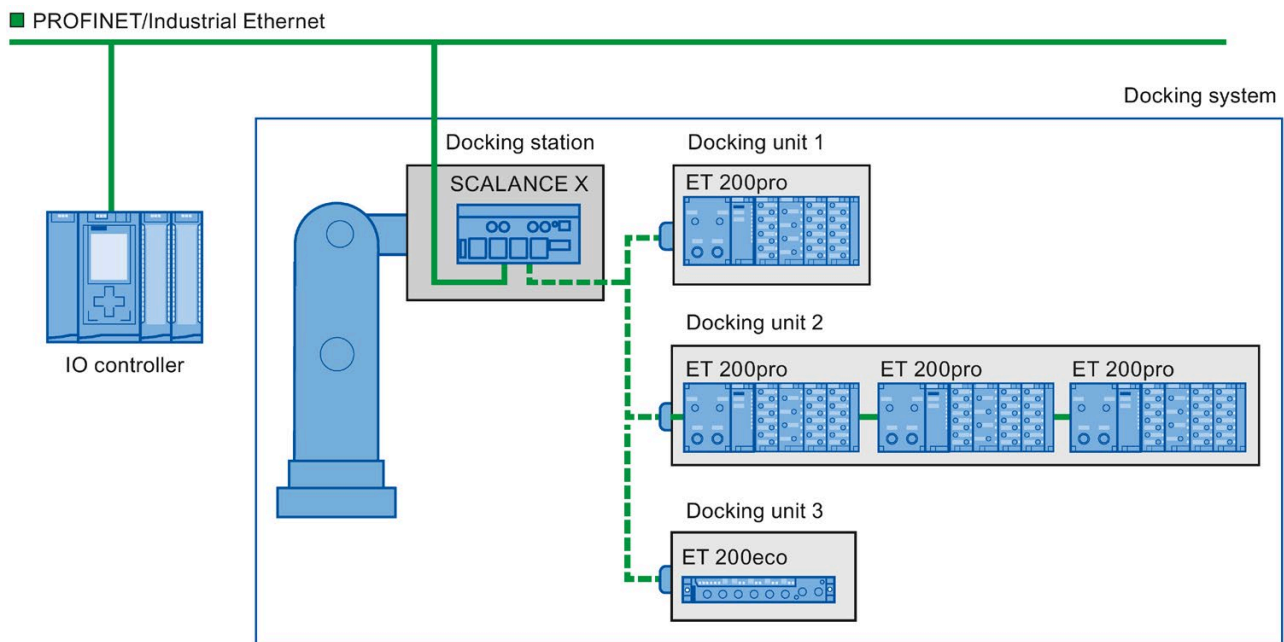


Figure 5-109 Alternating IO devices (partner ports) in a docking system

### Area of application for alternating IO devices during operation

You can use the PROFINET function "Alternating IO devices during operation" ("alternating partners"), for the tool changeover for robots, for example. Typical tools include:

- Welding guns
- Positioning tools for manufacturing parts

**Requirements for interconnecting alternating partner ports during operation**

You can interconnect IO devices with alternating partner ports during operation in the following situations:

- The alternating IO device (docking unit) has no IRT communication configured.
- The PROFINET interface is connected to the Ethernet subnet.
- The PROFINET devices support topology configuration.
- The IO controller, the alternating IO devices (docking unit) and the switch (docking station) on which the alternating IO devices are to be operated support this feature.

---

**Note****Unique IP address**

Each docking unit of a docking system must be configured with a unique IP address in a shared project and operated on the same IO controller as all other docking units of the system.

---

**Applicative conditions**

The following points should be observed when implementing a docking system with alternating IO devices during operation:

- The IO devices of all docking units must be deactivated by default in the configuration.
- At any time, only one docking unit can be active, i.e., only the IO devices of one docking unit can be activated. All IO devices of other docking units must be deactivated or become deactivated before the IO devices of a docking unit can be activated. You activate an IO device with the "D\_ACT\_DP" instruction.
- A physical connection to this docking unit and its IO devices must be created in order to activate a docking unit. The IO devices are then switched on (power on). At the same time, all the IO devices of this docking unit must be activated in the user program with the "D\_ACT\_DP" instruction.

---

**Note****Automatic deactivation in "Startup" mode of the CPU**

If the CPU is in "Startup" mode, IO devices of a docking system that alternate during operation are deactivated automatically.

---



- After the feedback "IO device activated", you can access the IO device by means of direct I/O access.
- Call the "D\_ACT\_DP" instruction to activate and deactivate the IO device as close as possible to the start of the OB 1 cycle.

---

**Note****Number of alternating IO devices during operation ("alternating partner port") - number of docking units**

If you wish to achieve the shortest possible tool changeover times, you must observe the following points that are dependent on the CPU or the CP that is being used:

- Only those IO devices that have been configured with the PROFINET function "Prioritized startup" can start up in an optimized fashion. The number of IO devices with configuration for this PROFINET function is restricted.
- Only a limited number of IO devices can be activated at the same time. This number depends on the available "D\_ACT\_DP" resources. A docking unit should not contain more than the corresponding number of IO devices. If more IO devices are operated in a docking unit, the IO devices must be activated one after the other, which takes correspondingly longer.

Example: An S7-CPU 1516-3 PN/DP can operate a maximum of 32 IO devices with prioritized startup and can simultaneously activate 8 IO devices by means of "D\_ACT\_DP".

Therefore, for a scheduled optimum use, a docking unit should include no more than 8 IO devices and no more than 32 IO devices should be used in all the alternating docking units.

---

## 5.12.1 Configuring docking systems

### Configuring docking systems

The possible connections to the individual IO devices must be configured in STEP 7.

#### Procedure in STEP 7

1. Configure your system as usual, but do not yet configure the topological interconnections of the individual PROFINET devices.
2. Navigate to the "Topology view" tab.
3. Select the port which you want to operate with alternating partners during operation.
4. Navigate to the "Properties" tab of the inspector window and select "Port interconnection" in the area navigation.
5. Under "Partner port", select the "Alternative partners" option.
6. Select the desired partner ports: To do this, click "<Add alternative partners..." and choose a partner port. Repeat this process until all required partner ports are connected.

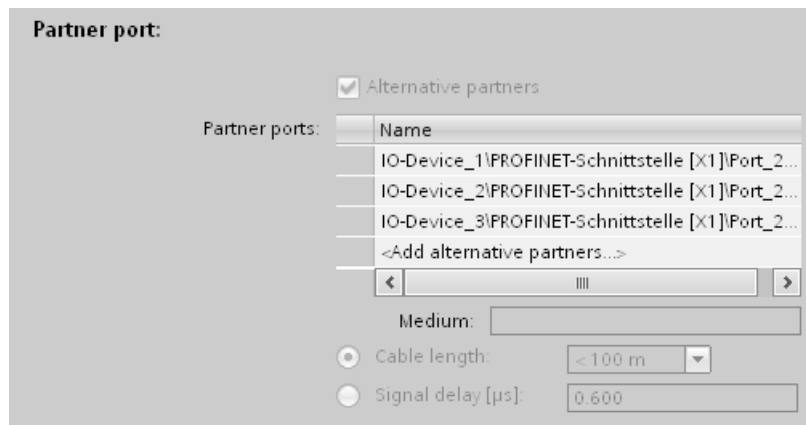


Figure 5-110 Configuring docking systems in STEP 7

**Tip:** You can also use drag-and-drop operation to connect alternative partner ports in the topology view.

### Result

You have interconnected the respective port with one or more alternating IO devices. The connections with the individual alternating partner ports during operation are shown in the topology view by a green, dashed line.

### Multiple IO devices as a docking unit ("Alternating partner port")

A docking unit may also consist of several IO devices connected in series. If you use IO devices connected in series as a docking unit, ensure that the topology of the IO devices is configured. A docking unit consisting of two IO devices connected in series (Tool\_3\_1 and Tool\_3\_2) is shown at the bottom right in the figure below.

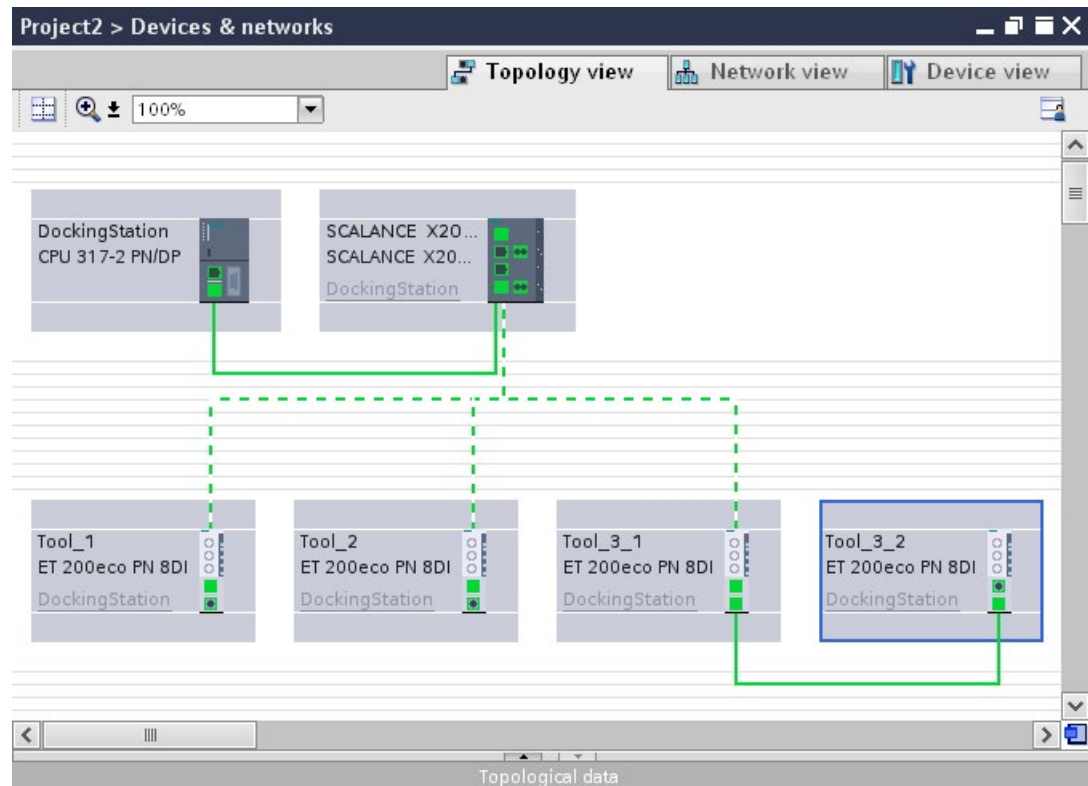


Figure 5-111 Docking system in the topology view of STEP 7

### Restriction in the interconnection

The interconnection with a partner port is not possible in the following cases:

- The partner port does not have a suitable type of cable. In this case, a media convertor from the catalog must be inserted.
- The partner port is blocked (deactivated).
- The two ports that are to be interconnected belong to the same interface (it is only possible to interconnect the ports from different interfaces in a station).
- The two ports that are to be interconnected belong to different Ethernet subnets.

### Deleting interconnections

Select the port of the alternating partner and remove the interconnection with the "Remove" button.

## 5.13 Accelerating startup

### 5.13.1 Options for accelerating the startup of IO devices

#### Reducing the startup time of IO devices

The time needed for the startup of IO devices depends on various factors and can be reduced in different ways.

You can achieve a significant reduction in the startup time using the "Prioritized startup" PROFINET function.

To further reduce the startup times, use the following measures in addition to the "Prioritized startup":

- Optimize the port settings
- Optimize the cabling of the ports
- Perform measures in the user program (for docking systems only)

These measures will accelerate the startup of IO devices even without "Prioritized startup". However, you can only achieve the fastest startup times of about 500 ms by combining all the measures with "Prioritized startup".

---

#### Note

##### Startup time up to 8 s

In the following situation, despite prioritized startup, a startup time of up to 8 s may occur:

On a docking point, multiple physical IO devices dock as an IO device with identical device names and identical IP configurations (for example, docking point for automatic transport system).

---

## Dependencies

The length of the startup time for an IO device (distributed I/O) with the "Prioritized startup" PROFINET function depends on the following factors:

- IO devices (distributed I/O)
- IO structure of the IO device (distributed I/O)
- Modules of the IO device (distributed I/O)
- IO controller
- Switch
- Port setting
- Cabling
- Configured RT class of the IO device

---

### Note

#### Startup time and RT class of the IO device

An IO device with IRT communication requires longer than an IO device with RT communication for the accelerated startup.

The longer startup for IRT is due to the necessity of synchronizing the IO device before the communication can be set up.

---

### Note

#### IWLAN and prioritized startup

PROFINET devices which are connected via access points to PROFINET IO do not support the "Prioritized startup" PROFINET function.

---

## 5.13.2 Prioritized startup

### Definition

Prioritized startup refers to the PROFINET function for accelerating the startup of IO devices in a PROFINET IO system with RT communication. It shortens the time that the respective configured IO devices require in order to reach the cyclic user data exchange in the following cases:

- After the power supply has returned
- After a station has returned
- After activation of IO devices



#### **WARNING**

##### **Data exchange despite multiple use IP addresses/device names in PROFINET IO system**

To achieve higher ramp-up times, the IO controller checks the uniqueness of device name of IP address parallel to the device ramp-up. In the case of incorrect or double assignment of device name or IP address, a short-time data exchange is possible until the IO controller reacts to the error. In this time the IO controller can exchange IO data with the false device.

During commissioning, ensure that no IP addresses / device names are assigned multiple times in the PROFINET IO system.

### Advantages

The PROFINET functionality "prioritized startup" enables PROFINET IO applications in which machine parts or tools and their IO devices have been permanently replaced. Waiting times of several seconds between the scheduled processes of the restart are reduced to a minimum by this optimization. This accelerates the production process with alternating IO devices (PROFINET functionality "docking systems"), e.g. in tool changer applications, and enables a greater throughput in production.

The PROFINET functionality "prioritized startup" also offers a considerable increase in performance for applications where a quick startup time of the IO devices after "power on" or after station failure / station return is required, or when activating IO devices.

## Area of application

You can use prioritized startup, for example, for changing tools for robots in the automotive industry. Typical tools are, for example:

- Welding guns
- Positioning tools for the manufacture of car body parts

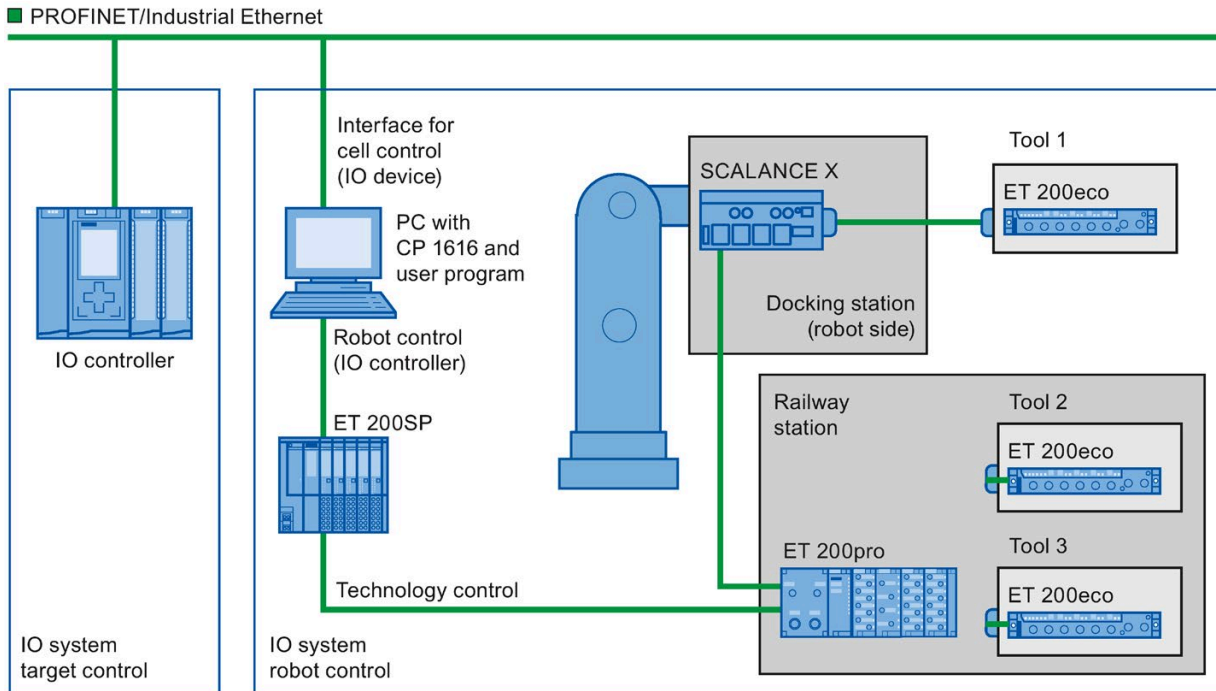


Figure 5-112 Example configuration of a tool changer: Tools 1-3 configured with "Prioritized startup".

### 5.13.3 Configuring prioritized startup

#### Requirements

You can enable the "Prioritized startup" PROFINET function for the IO devices (distributed I/O) only in the following cases:

- The IO controller used can prioritize selected IO devices during startup.
- The IO device used supports prioritization.

#### Procedure

1. Select the IO device in the network view or device view for which you wish to accelerate startup.
2. Open the IO device properties in the Inspector window.
3. Select "PROFINET interface > Advanced options > Interface options".

4. Select the "Prioritized startup" check box.

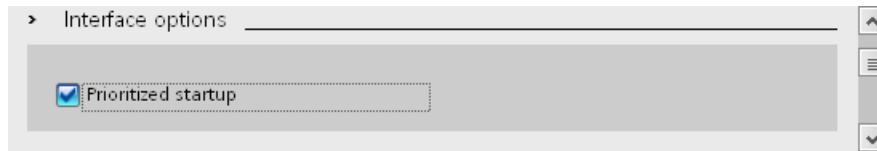


Figure 5-113 Configuring prioritized startup in STEP 7

5. Download the configuration to the IO controller.

---

**Note****Prioritized startup after a startup for the first time**

A prioritized startup of the IO device is always available to you after the first configuration of this IO device in the very first startup of the PROFINET IO system. Even in the case of spare parts or a reset to factory settings, the first startup is a standard startup for the respective configured IO devices.

---

**Note****Number of IO devices (distributed I/O) with prioritized startup**

You can only start up a maximum number of IO devices with the "Prioritized startup" PROFINET functionality within one PROFINET IO system. This maximum number depends on the IO controller used.

---

## 5.13.4 Optimize the port settings

### Optimizing port settings on the IO device and IO controller

The transfer medium and the duplex option are checked during startup of the IO device in the case of copper cabling.

These checks require time, but with specific presets of these options you can save the time the check requires. Make certain that the settings made correspond to the actual conditions (using the correct cables).



### Optimizing port settings for accelerated startup

To optimize port settings for accelerated startup, follow these steps:

1. Select the ports of the IO controller or the partner port of the corresponding IO device.
2. Navigate to "Port options > Connection" in the Inspector window. Select the setting "TP 100 Mbps full duplex" under "Transmission rate/duplex"
3. Clear the "Enable autonegotiation" check box.

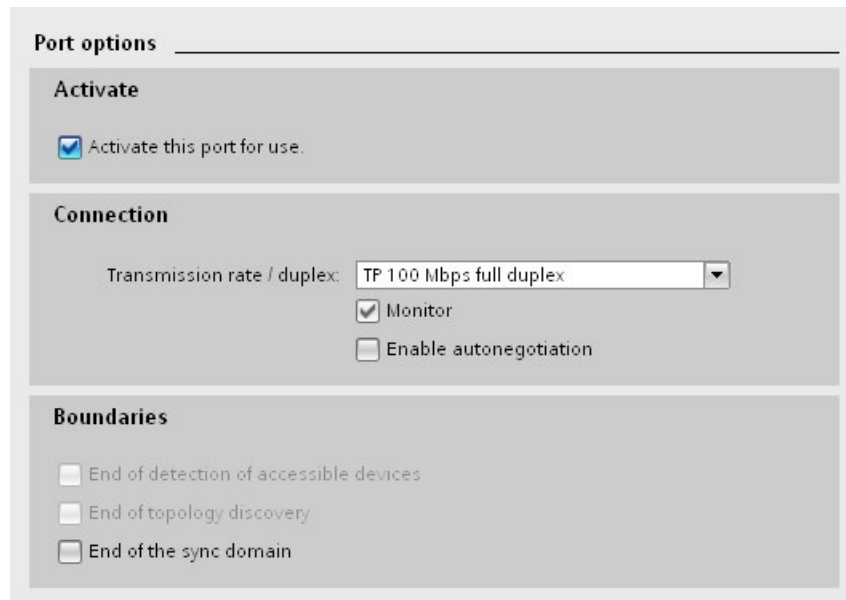


Figure 5-114 Optimizing port settings for accelerated startup in STEP 7

These settings are automatically applied during topology configuration for the partner port.

### 5.13.5 Optimize the cabling of the ports

#### Requirements

You have made the following settings for the port in question to reduce the startup time of the IO device:

- Fixed transmission rate
- Autonegotiation deactivated

The time for negotiating the transmission rate during startup is saved.

If you have disabled autonegotiation, you must observe the cabling rules.

## Properties of ports

PROFINET devices have the following two types of ports:

| Type of port                                    | PROFINET devices                                                   |
|-------------------------------------------------|--------------------------------------------------------------------|
| Switch port with crossed pin assignment         | For IO devices: Port 2<br>For S7-CPU with two ports: Ports 1 and 2 |
| Terminal device port with normal pin assignment | For IO devices: Port 1<br>For S7-CPU with one port: Port 1         |

Crossed pin assignment means that the pin assignment for the ports for sending and receiving between the respective PROFINET devices is inverted internally.

## Validity of the cabling rules

The cabling rules described in the following paragraph apply exclusively for the situation in which you have specified a fixed port setting in STEP 7.

## Rules for cabling

You can connect several IO devices in series using patch cables. To do this, connect port 2 of the IO device (distributed I/O) with port 1 of the next IO device. The following graphic provides an example with two IO devices.

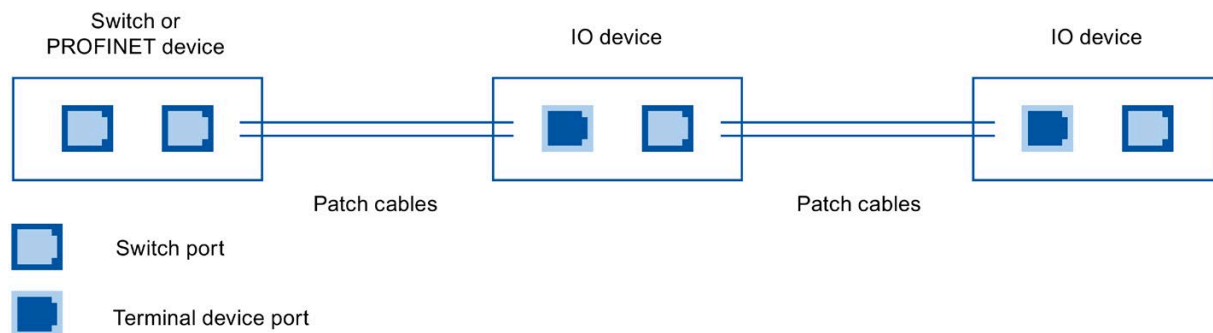


Figure 5-115 Optimized cabling for accelerated startup

## 5.13.6 Measures in the user program

### Introduction

You can make certain changes in the user program to accelerate the startup for IO devices of docking systems that alternate during operation.

**Making the required changes to the user program**

To accelerate the startup by making changes to the user program, follow these steps:

1. Call the "D\_ACT\_DP" instruction to activate and deactivate the IO device at the start of the OB 1 cycle.

If the IO device is replaced, the device that is no longer required must be deactivated and the new device must be activated.

2. If you control the "Power ON" command of the IO devices via the application, then start the activation of the IO devices via the corresponding call of the "D\_ACT\_DP" instruction as near to the same time as possible. The IO device has to be physically connected for this.
3. You access the IO device using direct access commands after the "D\_ACT\_DP" instruction has provided the feedback "IO device activated".

# PROFINET with the redundant S7-1500R/H system

## Introduction

The same basic rules apply to PROFINET IO communication with the redundant S7-1500R/H as with the S7-1500 automation system. The redundant S7-1500R/H system exchanges IO data cyclically with the IO devices.

The redundant S7-1500R/H system supports a limited scope of PROFINET functions.

The redundant S7-1500R/H system uses media redundancy (MRP) in the PROFINET ring.

You can use the following IO devices on the redundant S7-1500R/H system:

- IO devices with S2 system redundancy
- Standard IO devices over the "Switched S1 device" function of the CPU

When configuring PROFINET with the redundant S7-1500R/H system, you must observe a few specifics, e.g. special configuration requirements.

## Limitations

- Real-time communication:
  - RT with a fixed send clock of 1 ms
  - No IRT
  - No MRPD redundancy procedure
  - No PROFINET with performance upgrade
- No isochronous mode
- No direct data exchange
- No operation as I-device
- No access to shared devices
- No support of docking systems
- No support of series machine projects
- Port options (only for PROFINET interface X1):
  - No port disabling possible
  - No configuring of boundaries possible
- Functionality as IO controller:
  - No prioritized startup
  - No enabling/disabling of IO devices
  - No support of series machine projects, e.g. IO systems that can be used multiple times
- PROFINET interface X2 does not support IO functionality (CPU 1515R/CPU 1517H)
- No diagnostics using the web server
- No IP address assignment by the DHCP server

## 6.1 Media redundancy in the redundant S7-1500R/H system

The two CPUs of the redundant system must be located in a PROFINET ring that uses the media redundancy method MRP. All PROFINET devices in the PROFINET ring are connected to the S7-1500R/H in a media-redundant manner. If the PROFINET ring is interrupted, reconfiguration may occur. After a short reconfiguration time, the PROFINET devices can be accessed again via an alternative path.

## 6.2 H-Sync Forwarding

### Introduction

H-Sync Forwarding enables a PROFINET device with MRP to forward synchronization data (synchronization frames) of a S7-1500R redundant system only within the PROFINET ring.

In addition, H-Sync Forwarding forwards the synchronization data even during reconfiguration of the PROFINET ring. H-Sync Forwarding avoids a cycle time increase if the PROFINET ring is interrupted.

---

#### Note

##### Support of H-Sync Forwarding

The technical specifications typically state whether a PROFINET device supports H-Sync Forwarding.

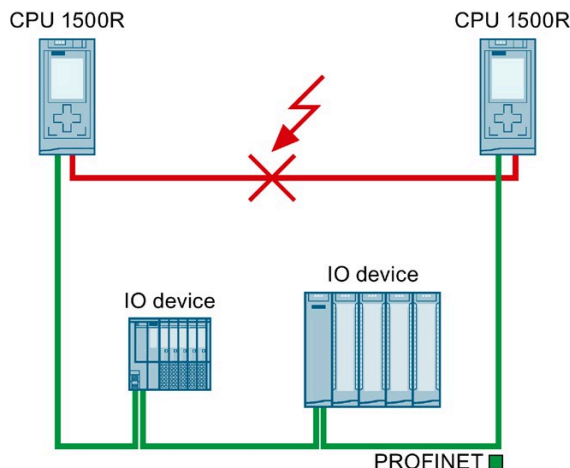
The GSD file will also indicate whether the device supports H-Sync Forwarding. The device supports H-Sync Forwarding when the "AdditionalForwardingRulesSupported" attribute in the "MediaRedundancy" element is set to "true".

---

## Conditions

- H-Sync Forwarding is not relevant for redundant S7-1500H systems. With the redundant S7-1500H system, the H-Sync frames are transmitted exclusively via the fiber-optic cables.
- **When you use PROFINET devices with more than two ports (e.g. switch) in the PROFINET ring of an R-system, these devices must support H-Sync Forwarding.**  
H-Sync frames leave the PROFINET ring with a switch without H-Sync Forwarding. This results in an additional load on the network. Another serious result is that the redundancy of other R-systems in the network can fail or startup can be prevented.
- **H-Sync Forwarding is recommended if you are using PROFINET devices with only 2 ports in the PROFINET ring of an R-system.**

When you operate PROFINET devices without H-Sync Forwarding in the PROFINET ring of the redundant S7-1500R/H system, the following scenario will result in an additional cycle time increase:



1. The redundant S7-1500R system is in the RUN-Redundant system state.
2. The PROFINET cable which directly connects the two CPUs fails.
3. The PROFINET ring is interrupted.
4. The PROFINET ring is being reconfigured.
5. PROFINET devices without H-Sync Forwarding do not forward any H-Sync frames during the reconfiguration time of the PROFINET ring.
6. The cycle time increases by the reconfiguration time of the PROFINET ring.

Figure 6-1 Failure of the PROFINET cable between the CPUs

If the cyclic program exceeds the cycle monitoring time, the timeout OB (OB 80) can be started. Redundancy is lost if the time error OB (OB 80) is not present or the cycle time was exceeded twice with OB 80.

### Note

If failure of the PROFINET cable that directly connects the two CPUs of the redundant S7-1500R system is unlikely, you can use PROFINET devices without H-Sync Forwarding in the PROFINET ring of the redundant S7-1500R system.

Example: Both CPUs of the redundant S7-1500R/H system are located next to each other in the control cabinet. In this case, it is unlikely that the PROFINET cable will fail.

## 6.3 System redundancy S2

### Introduction

IO devices with S2 system redundancy enable uninterrupted process data exchange with the S7-1500R/H redundant system in the event of a CPU failure.

An IO device with system redundancy S2 supports system redundancy ARs. The system redundancy ARs can be present in duplicate (redundantly). Thus, an IO device supports ARs of 2 IO controllers simultaneously (with respect to the same modules).

A system redundancy AR can be either a primary AR or a backup AR. An IO device activates the data of the primary AR at the outputs. The data of the backup AR is only saved.

In STEP 7, you configure system redundancy S2 for an IO device by assigning the IO device to both CPUs of the S7-1500R/H redundant system.

### Behavior in system state RUN-Redundant

Both CPUs are IO controllers. The PROFINET communication runs simultaneously on both system redundancy ARs, in each case between one of the CPUs (IO controllers) and the IO device. If the primary CPU now fails, the backup CPU becomes the primary CPU and, at the same time, the backup AR changes over to primary AR. The data of this AR becomes active at the outputs.

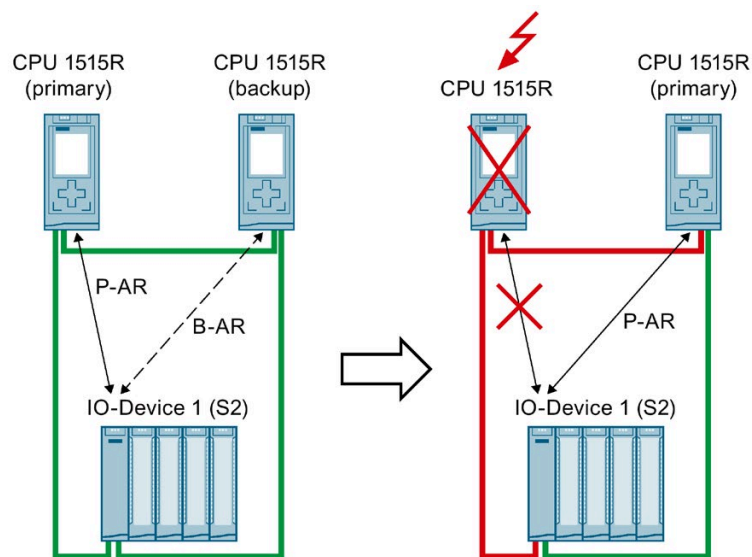


Figure 6-2 Primary backup AR

### Behavior in system state RUN-Solo

Only the primary CPU is an IO controller. The PROFINET communication runs on the primary AR between the primary CPU (IO controller) and the IO device. There is no AR between the backup CPU and the IO device.

## 6.4 Switched S1 device

### Introduction

As of FW version V2.8, the S7-1500R/H redundant system supports the "Switched S1 device" function.

The "Switched S1 device" function of the CPU enables operation of standard IO devices on the S7-1500R/H redundant system.

Standard IO devices, too, are always assigned to both CPUs of the S7-1500R/H redundant system. In contrast to an IO device with S2 system redundancy, a standard IO device supports only one AR. The AR always exists only to the primary CPU of the S7-1500R/H redundant system.

In STEP 7 you configure an IO device connected via the "Switched S1 device" function by assigning a standard IO device to both CPUs of the redundant S7-1500R/H system.

---

#### **Note**

##### **Standard IO devices in the redundant system S7-1500R**

Standard IO devices usually do not support H-Sync Forwarding (Page 1).

To avoid a cycle time increase when the PROFINET ring is interrupted, integrate the standard IO devices behind a switch and not in the PROFINET ring.

---



### Behavior in system state RUN-Redundant

PROFINET communication runs on the AR between the primary CPU (IO controller) and the standard IO device. There is no AR between the backup CPU and the standard IO device. If the primary CPU fails or is switched to STOP, the S7-1500R/H redundant system responds as follows:

- The AR between the primary CPU and the standard IO device is disconnected.
- The previous backup CPU becomes the new primary CPU.
- The S7-1500R/H redundant system temporarily has no access to the inputs and no control over the outputs of the standard IO device. During this time, the configured substitute value behavior applies to the standard IO device.
- The new primary CPU builds an AR to the standard IO device.
- As soon as the new primary CPU has set up the AR, the S7-1500R/H redundant system has access to the inputs again and control over the outputs of the standard IO device.

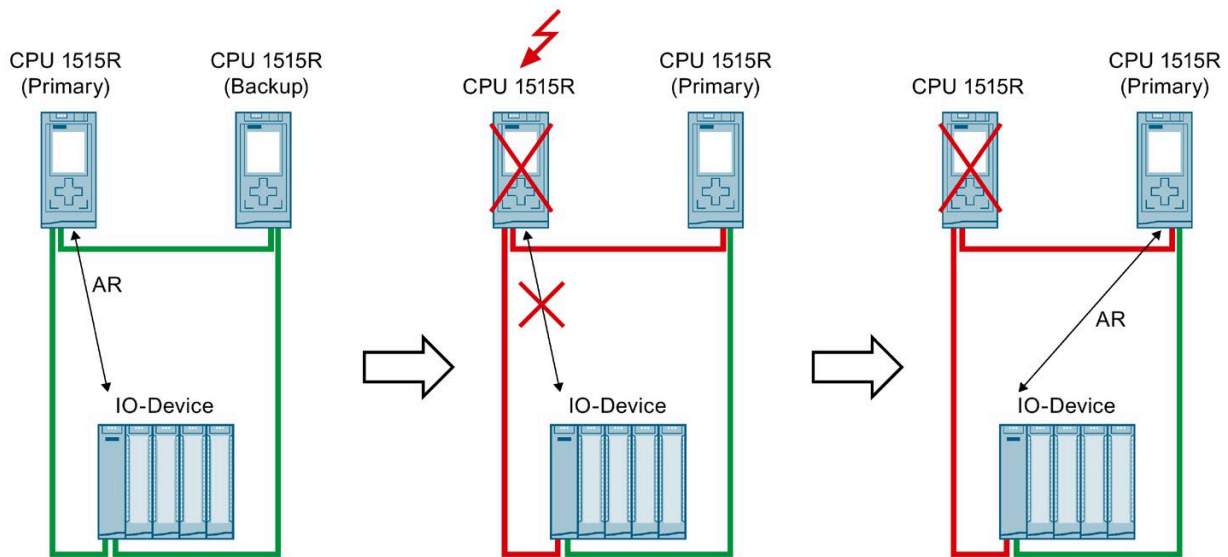


Figure 6-3 Behavior of standard IO devices in case of failure of the primary CPU

### Behavior in system state RUN-Solo

Only the primary CPU is an IO controller. PROFINET communication runs on the AR between the primary CPU and the standard IO device. There is no AR between the backup CPU and the IO device.

### OB behavior for standard IO devices with primary backup switching

If the primary CPU fails or goes to STOP, the standard IO devices temporarily fail. OB 72 "Redundancy error" is called, additional OB 86 "Module rack failure" for the failed IO devices are not called. To detect the failed IO devices, call the DeviceStates instruction in OB 72.

With the "Switched S1 device" function, the new primary CPU establishes the ARs to the standard IO devices again. OB 86 is called for each return of an IO device.

### Influence changeover time of switched S1 devices

As of FW version V2.9, you can influence the changeover time between disconnection and return of switched S1 devices after a failure/STOP of the primary CPU.

Advantages:

- Optimization of the changeover time between disconnection and return of switched S1 devices
- Prioritization of the return of S1 devices in the PROFINET ring by setting a lower changeover time for S1 devices with important process functions.

The changeover time depends on the watchdog timer of the switched S1 device. The watchdog timer is the product of the update time multiplied by the accepted update cycles without IO data. With the parameters, you influence the time as of which the new primary CPU starts returning the S1 device. The return also depends on the amount of time that is required for the parameter assignment of the S1 device.

You set the parameters in STEP 7 in the properties of the interface of each S1 device:

- Update time: Advanced options > Real time settings > IO cycle > Update time
- Watchdog timer: Advanced options > Real time settings > IO cycle > Watchdog timer > Accepted update cycles without IO data

Setting a shorter changeover time of an S1 device: Reduce the values of the parameters/of a parameter.

Setting a longer changeover time of an S1 device: Increase the values of the parameters/of a parameter.

## 6.5 Main differences between IO device with S2 system redundancy and standard IO device

Table 6- 1 Main differences between IO device with S2 system redundancy and standard IO device

| Property                                                             | IO device with S2 system redundancy                                                            | Standard IO device                                                                                                                                                                                                                          |
|----------------------------------------------------------------------|------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Requirement for IO device                                            | Device supports S2 system redundancy                                                           | -                                                                                                                                                                                                                                           |
| Maximum simultaneously supported ARs with regard to the same modules | 2                                                                                              | 1                                                                                                                                                                                                                                           |
| Behavior when replacing the primary CPU                              | Continuous connection with S7-1500R/H redundant system<br>Process data is transferred further. | Temporary disconnection from S7-1500R/H redundant system.<br>No process data is transferred until the standard IO device is available again. The status of the outputs depends on the substitute value behavior of the respective channels. |

## 6.6 Installation guidelines

### Configuration requirements for a ring topology with the redundant S7-1500R system

- The two CPUs have the media redundancy role "Manager (auto)".
- All other devices in the PROFINET ring have the media redundancy role "Client".
- No other redundant S7-1500R/H system is present in the PROFINET ring.
- Port interconnection:
  - The two CPUs are directly interconnected via one of the two ports of PROFINET interface X1. No other devices of the ring are located in between.
  - The two CPUs can be indirectly interconnected via the other two ports. The other devices of the ring are located in between. See the examples below.
- Max. number of IO devices: 64

---

**Note****Standard IO devices in the redundant system S7-1500R**

Standard IO devices usually do not support H-Sync Forwarding.

To avoid a cycle time increase when the PROFINET ring is interrupted, integrate the standard IO devices behind a switch and not in the PROFINET ring.

---

- Number of PROFINET devices (IO devices, switches, S7-1500R CPUs, S7-1500 CPUs (V2.5 or later) and HMI devices) in the PROFINET ring:
  - Max. 50 (recommended: max. 16)

---

**Note**

Recommendation: The number of devices in the PROFINET ring influences the availability of the S7-1500R system. The number of PROFINET devices including R-CPU in the PROFINET ring should not exceed 16. If you operate significantly more devices in the PROFINET ring, the availability of the IO devices and R-CPU is reduced. The technical specifications in the documentation are based on the recommended maximum of 16 PROFINET devices in the ring in S7-1500R.

---

### Configuration requirements for a ring topology with the redundant S7-1500H system

- The two CPUs have the media redundancy role "Manager (auto)".
- All other devices in the PROFINET ring have the media redundancy role "Client".
- No other redundant S7-1500R/H system is present in the PROFINET ring.

## 6.7 Configuring PROFINET IO on a redundant S7-1500R/H system

### PROFINET IO configurations with the redundant S7-1500R/H system

The following figures show you examples of PROFINET IO configurations with the redundant S7-1500R/H system.

All the figures use the following abbreviations for AR:

- SR-AR: System redundancy AR between an IO device (S2) and one of the CPUs of the redundant S7-1500R/H system
- AR: "normal" AR between a standard IO device and the associated IO controller

All configurations use the CPU 1515R as an example. The PROFINET configurations shown also work with the CPU 1513R and CPU 1517H.

### IO devices in the PROFINET ring

The redundant S7-1500R system consists of the two CPUs 1515R and two IO devices in the PROFINET ring. The IO devices support system redundancy S2, media redundancy and H-Sync Forwarding.

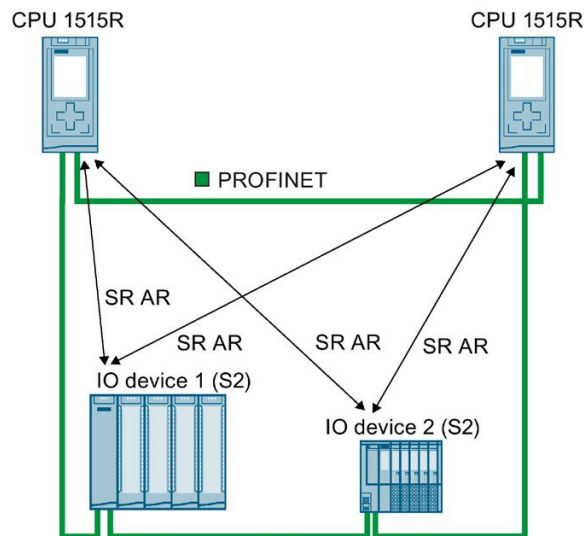


Figure 6-4 Example of a S7-1500R redundant system with two IO devices in the PROFINET ring

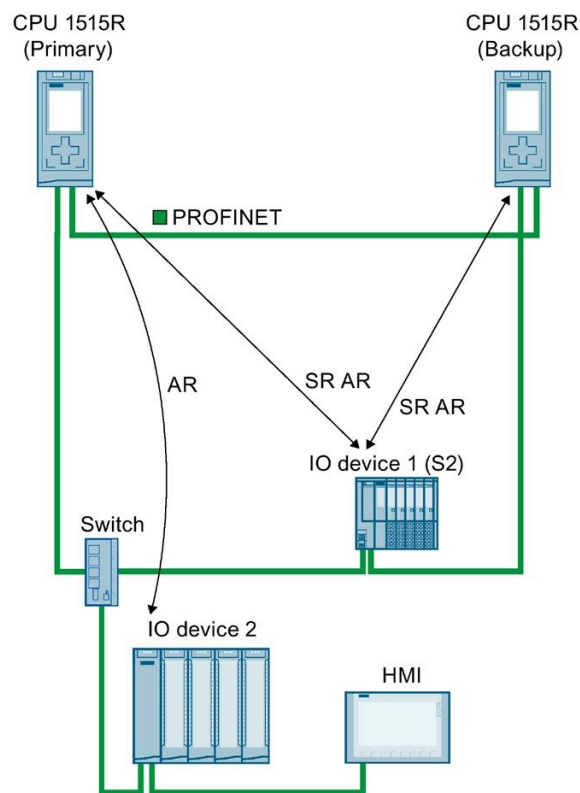
## PROFINET devices downstream of a switch

To connect additional PROFINET devices to the PROFINET ring, use a switch. For the redundant S7-1500R system, ensure that a switch in the PROFINET ring supports H-SYNC Forwarding in addition to MRP.

You connect the following devices to the PROFINET ring with a switch.

- PROFINET devices with one port
- Non MRP-capable PROFINET devices
- PROFINET devices that do not support H-Sync Forwarding, such as standard IO devices.

The following figure shows a redundant S7-1500R system with connected PROFINET devices downstream of a switch.



- |                  |                                                                                                                                                                                                |
|------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| IO device 1 (S2) | IO device 1 is located in the PROFINET ring.<br>The IO device 1 supports system redundancy S2, MRP and H-Sync Forwarding.                                                                      |
| Switch           | The switch is located in the PROFINET ring. The switch supports MRP and H-SYNC Forwarding.                                                                                                     |
| IO device 2      | IO device 2 is connected to the PROFINET ring via the switch.<br>IO device 2 is a standard IO device that is connected to the redundant S7-1500R system via the "Switched S1 device" function. |
| HMI device       | The HMI device is connected to the PROFINET ring via the switch.                                                                                                                               |

Figure 6-5 PROFINET devices downstream of a switch

### Additional PROFINET IO system in the configuration

The configuration can also contain additional IO controllers with their own IO devices. To ensure that enough bandwidth is available in the PROFINET ring for the redundant S7-1500R/H system, place additional IO controllers with their I/O downstream of a switch.

When determining the maximum number of IO devices inside and outside the PROFINET ring, the redundant system does not detect the S7-1500 CPUs and their IO devices. If you use S7-1500 CPUs, you must check the maximum number yourself.

The following figure shows a redundant S7-1515R system. An additional PROFINET IO system with a CPU 1516 as IO controller is located downstream of the switch. A separate standard IO device has been assigned to the IO controller.

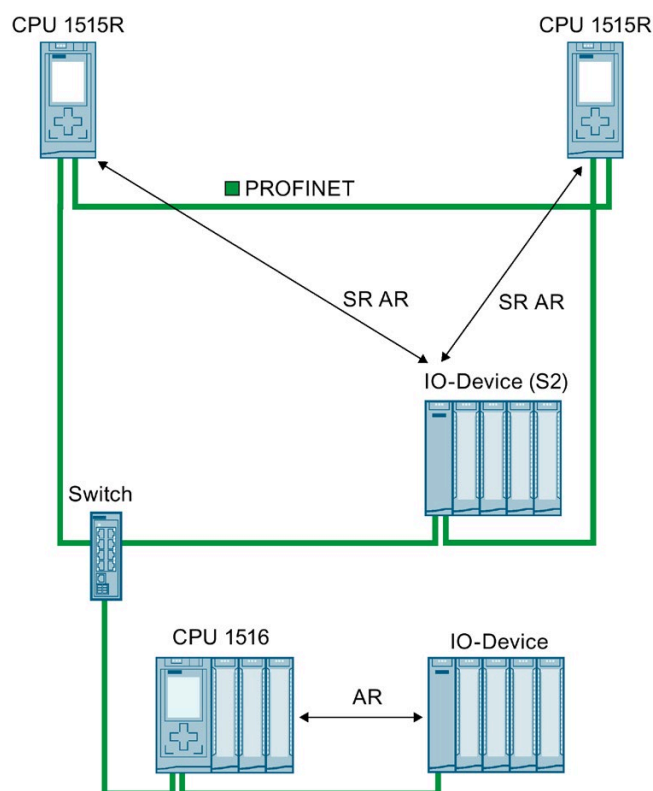


Figure 6-6 Example of a redundant S7-1500R system with an additional PROFINET IO system

Additional IO controllers can also be connected as I-device to the redundant S7-1500R/H system. An I-device is connected like a standard IO device to the redundant S7-1500R/H system.

The redundant S7-1500R/H system supports the use of I-devices only via GSD file and as standard IO device.

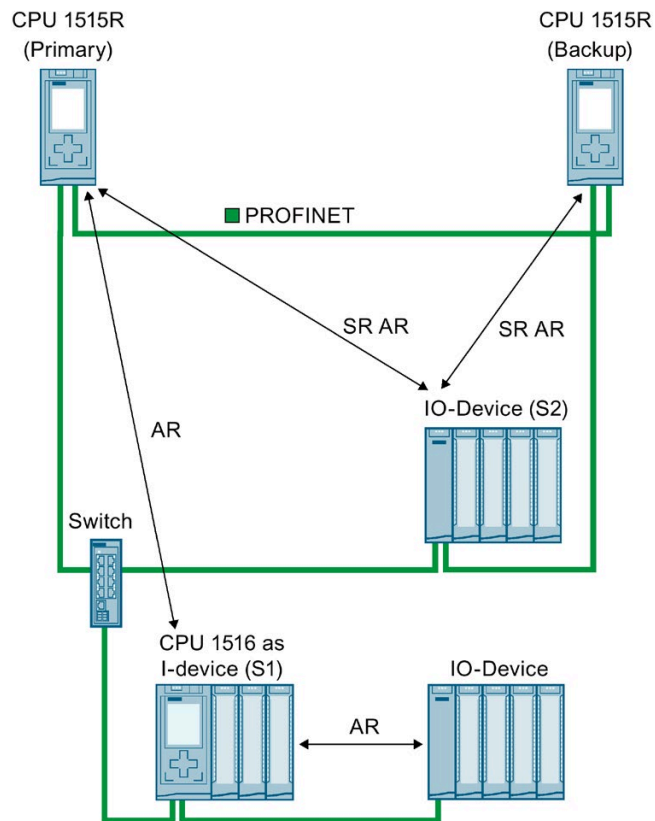


Figure 6-7 I-device downstream of a switch

### Connection to another PROFINET IO system via the PN/PN coupler

The redundant S7-1500R/H system cyclically exchanges IO data with another PROFINET IO system via a PN/PN coupler.

In the following figure, the PN/PN coupler connects a redundant S7-1515R system to another PROFINET IO system. The left side of the PN/PN coupler is assigned to the redundant S7-1515R system. The assignment is system-redundant and media-redundant. The right side of the PN/PN coupler is assigned to the CPU 1516 (IO controller). The PROFINET IO system of the CPU 1516 has no redundancy in this example.

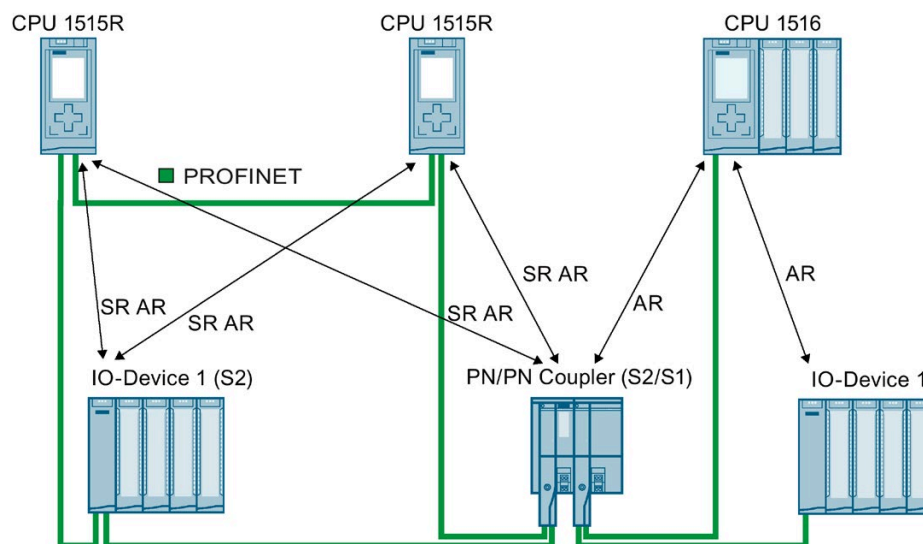


Figure 6-8 Configuration with the PN/PN coupler with one-sided system redundancy (S2/S1)



### Connection to an additional redundant S7-1500R/H system via the PN/PN coupler

Two redundant S7-1500R/H systems cyclically exchange IO data via the PN/PN coupler.

In the following figure, the PN/PN coupler connects two redundant S7-1515R systems to each other. Each of the two PN/PN coupler sides are assigned to a redundant S7-1515R system. Each of the two sides of the PN/PN coupler are connected to the respective redundant S7-1515R system in a system-redundant and media-redundant manner.

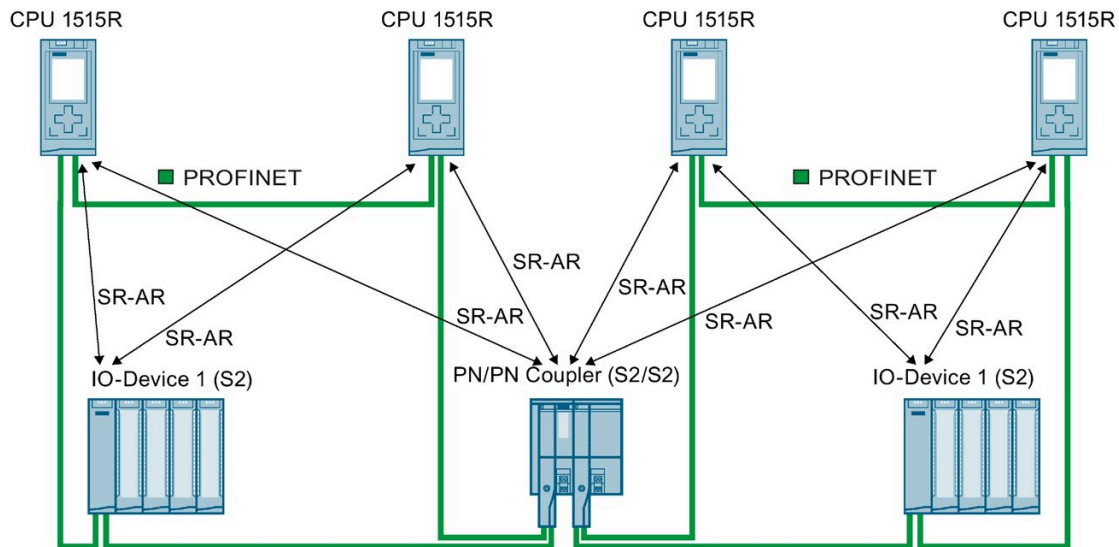


Figure 6-9 Configuration with the PN/PN coupler with two-sided system redundancy (S2/S2)

### Reference

You can find more information on the PN/PN coupler in the PN/PN Coupler (<https://support.industry.siemens.com/cs/ww/en/view/44319532>) manual.

## 6.8 Assigning IO device to the redundant S7-1500R/H system

### Requirements

- Redundant S7-1500R/H system
- IO device:
  - As of firmware version V2.8, the redundant S7-1500R/H system supports IO devices with system redundancy S2 and standard IO devices.
  - The redundant S7-1500R/H system with firmware version before V2.8 only supports IO devices with system redundancy S2, e.g. IM 155-6 PN HF as of firmware version V4.2.

### Procedure

To assign an IO device to the redundant S7-1500R/H system, follow these steps:

1. In the network view of STEP 7, select the PROFINET interface of the IO device.
2. Using drag-and-drop, draw a line between the PROFINET interface of the IO device and the PROFINET interface X1 of the left CPU.

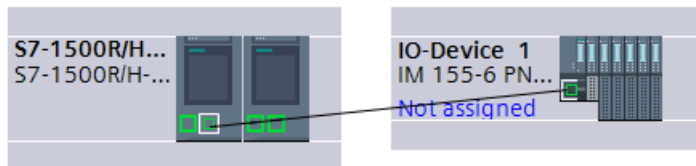


Figure 6-10 Assigning IO device to the left CPU

The IO device is assigned to the left CPU.

3. Using drag-and-drop, draw a line between the PROFINET interface of the IO device and the PROFINET interface X1 of the right CPU.

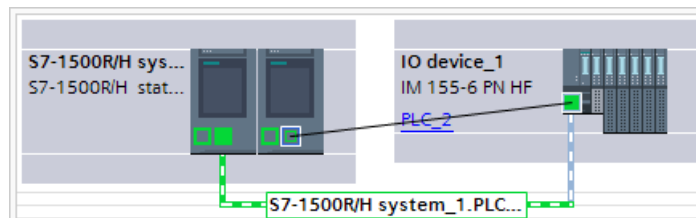


Figure 6-11 Assigning IO device to the right CPU

Result: The IO device is connected to the redundant S7-1500R/H system.

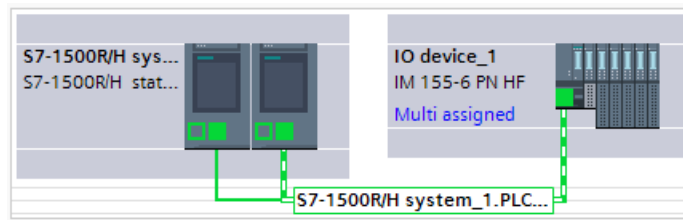


Figure 6-12 Assigned IO device

**Note****I-device as standard IO device**

You cannot assign a device that you configured in STEP 7 as an I-device to the S7-1500R/H redundant system.

In order to operate an I-device as a standard IO device on the S7-1500R/H redundant system, always configure the I-device via **GSD file**.

- SIMATIC CPU as I-device
  - First, configure the SIMATIC CPU in STEP 7 as an I-device with all transfer areas.
  - Export the I-device as a GSD file. The GSD export can be found in the properties of the PROFINET interface under "Operating mode" > "I-device communication" > "Export Generic System Description file (GSD)".
  - Install the GSD file in STEP 7.
- HMI device as I-device ("Direct key" function)
  - The GSD files for SIMATIC Comfort Panel and SIMATIC Mobile Panel can be found in this application example (<https://support.industry.siemens.com/cs/ww/en/view/73502293>).

Assign the device configured via GSD file to the S7-1500R/H redundant system.

**Display of the IO device assignments in STEP 7**

Regardless of whether an IO device is connected as system redundant or as standard IO device to the redundant S7-1500R/H system, the network view always shows "Multi assigned".

To determine which IO devices are connected system redundant and which ones are connected as standard IO devices, follow these steps:

1. In the network view of STEP 7, select the redundant S7-1500R/H system.
2. In the tabular view of the network view switch to "I/O communication".

## 6.8 Assigning IO device to the redundant S7-1500R/H system

The table contains all assignments of IO devices to the PROFINET interfaces of the redundant S7-1500R/H system.

The "Operating mode" column shows how the IO device is connected to the redundant S7-1500R/H system:

- IO device (S2): IO device is connected system redundant.
- IO device (S1): IO device is connected over the "Switched S1 device" function.

| Topology view Network view Device view |                            |                   |                        |                                   |
|----------------------------------------|----------------------------|-------------------|------------------------|-----------------------------------|
| Network overview                       |                            | Connections       | Relations              | I/O communication VPN TeleControl |
| Offline configuration                  |                            | Online assignment |                        |                                   |
| Partner 1                              |                            | Partner 2         | Interface partner 2    | Mode                              |
| 1                                      | ▼ PLC_1                    |                   |                        |                                   |
| 2                                      | ▼ PROFINET-Schnittstelle_1 |                   |                        |                                   |
| 3                                      | X1                         | ↔ IO-Device_1     | PROFINET-Schnittstelle | IO-Device(S2)                     |
| 4                                      | X1                         | ↔ IO-Device_2     | PROFINET-Schnittstelle | IO-Device(S1)                     |
| 5                                      | ▼ PLC_2                    |                   |                        |                                   |
| 6                                      | ▼ PROFINET-Schnittstelle_1 |                   |                        |                                   |
| 7                                      | X1                         | ↔ IO-Device_1     | PROFINET-Schnittstelle | IO-Device(S2)                     |
| 8                                      | X1                         | ↔ IO-Device_2     | PROFINET-Schnittstelle | IO-Device(S1)                     |
| 9                                      |                            |                   |                        |                                   |

Figure 6-13 Display of the IO device assignments in STEP 7

## 6.9 Configuring media redundancy (MRP) for a configuration with the redundant S7-1500R/H system

### Requirements

- Redundant S7-1500R/H system
- All devices in the ring support the media redundancy protocol MRP.
- IO devices are assigned to the redundant S7-1500R/H system.

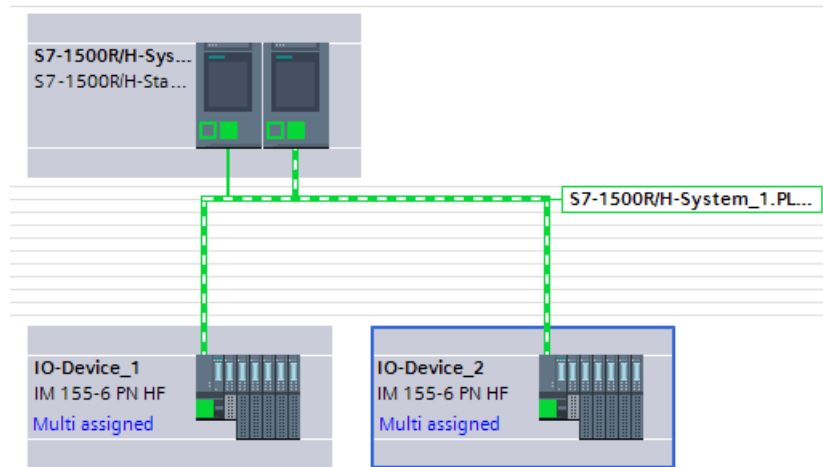


Figure 6-14 Example configuration: Configuring MRP for S7-1500R/H

### MRP role of the CPUs of the redundant S7-1500R/H system

As soon as you create a redundant S7-1500R/H system in STEP 7, STEP 7 automatically assigns the MRP role "Manager (auto)" to the PROFINET interfaces X1 of both CPUs.

### Defining the MRP role for additional devices of the ring in STEP 7

To specify the media redundancy for additional devices in the ring, follow these steps:

1. In the network view of STEP 7, select the PROFINET interface X1 of one of the two CPUs of the redundant S7-1500R/H system.
2. In the Inspector window navigate to "Properties" > "General" > "Advanced options" > "Media redundancy".

- Click the "Domain settings" button.

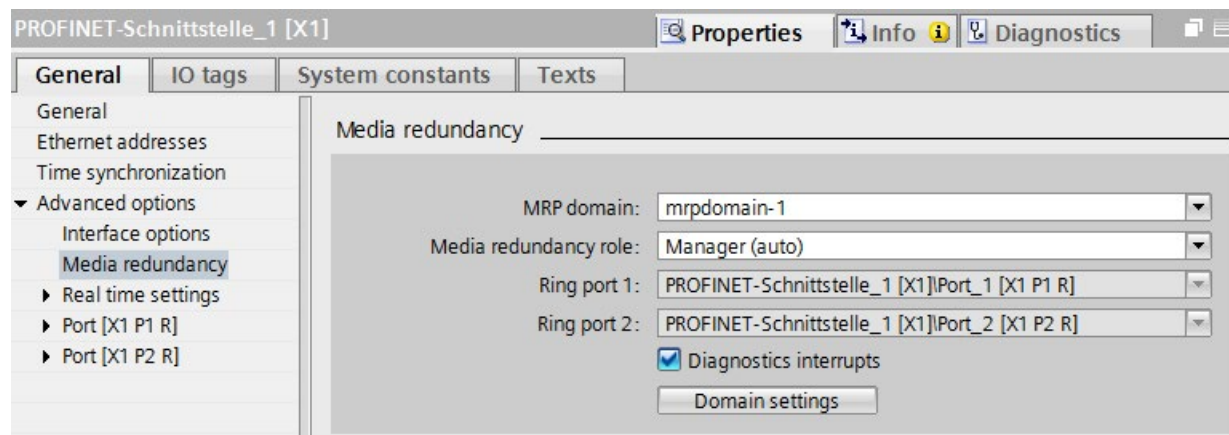


Figure 6-15 S7-1500R/H: MRP role "Manager (auto)"

In the Inspector window, STEP 7 displays the properties of the MRP domain in which the PROFINET interface X1 of the CPU is located.

- In the "MRP role" column of the "Devices" table, assign the MRP role "Client" to all the other devices of the ring.

| Devices |                              |             |                |                  |                  |
|---------|------------------------------|-------------|----------------|------------------|------------------|
|         | PROFINET device name         | MRP domain: | MRP role       | Ring port 1      | Ring port 2      |
| 1       | io-device_1                  | mrpdomain-1 | Client         | Port_1 [X1 P1 R] | Port_2 [X1 P2 R] |
| 2       | io-device_2                  | mrpdomain-1 | Client         | Port_1 [X1 P1 R] | Port_2 [X1 P2 R] |
| 3       | plc_1.profinet-schnittstel.. | mrpdomain-1 | Manager (auto) | Port_1 [X1 P1 R] | Port_2 [X1 P2 R] |
|         |                              |             |                |                  |                  |
|         |                              |             |                |                  |                  |

Figure 6-16 S7-1500R/H: Assigning MRP roles for ring devices

### Parameter assignment for devices outside the STEP 7 project

- Set the MRP role "Client" for the devices of the ring that are not located in STEP 7.  
Example: For a switch in the PROFINET ring, set the MRP role "Client" via the Web interface of the switch.
- For PROFINET devices outside of the ring, set the MRP role to "Not device in the ring".  
Example: For a router outside of the PROFINET ring, set the MRP role "Not device in the ring" via the Web interface of the router.

## 6.10 MRP interconnection with the redundant system S7-1500R/H

The S7-1500R/H CPUs support MRP interconnection as of firmware version V2.9.

MRP interconnection enables the redundant data exchange via S7-1500R/H across two or more MRP rings.

### Requirements for S7-1500R/H

In addition to the requirements for S7-1500, the following requirements are in effect for S7-1500R/H:

- The two CPUs of the redundant S7-1500R/H system are located in the same ring.
- You have configured the media redundancy role of the two CPUs as "Manager (auto)" in the ring with the two R/H CPUs.

You have configured the following in the other rings:

- For one or more PROFINET devices the media redundancy role "Manager (auto)" or
- For exactly one PROFINET device the media redundancy role "Manager"

You have assigned the MRP client role to the other devices in all rings.

## Topology

### Topology with 2 rings

The following figure shows the redundant coupling based on the example of S7-1500R in 2 rings.

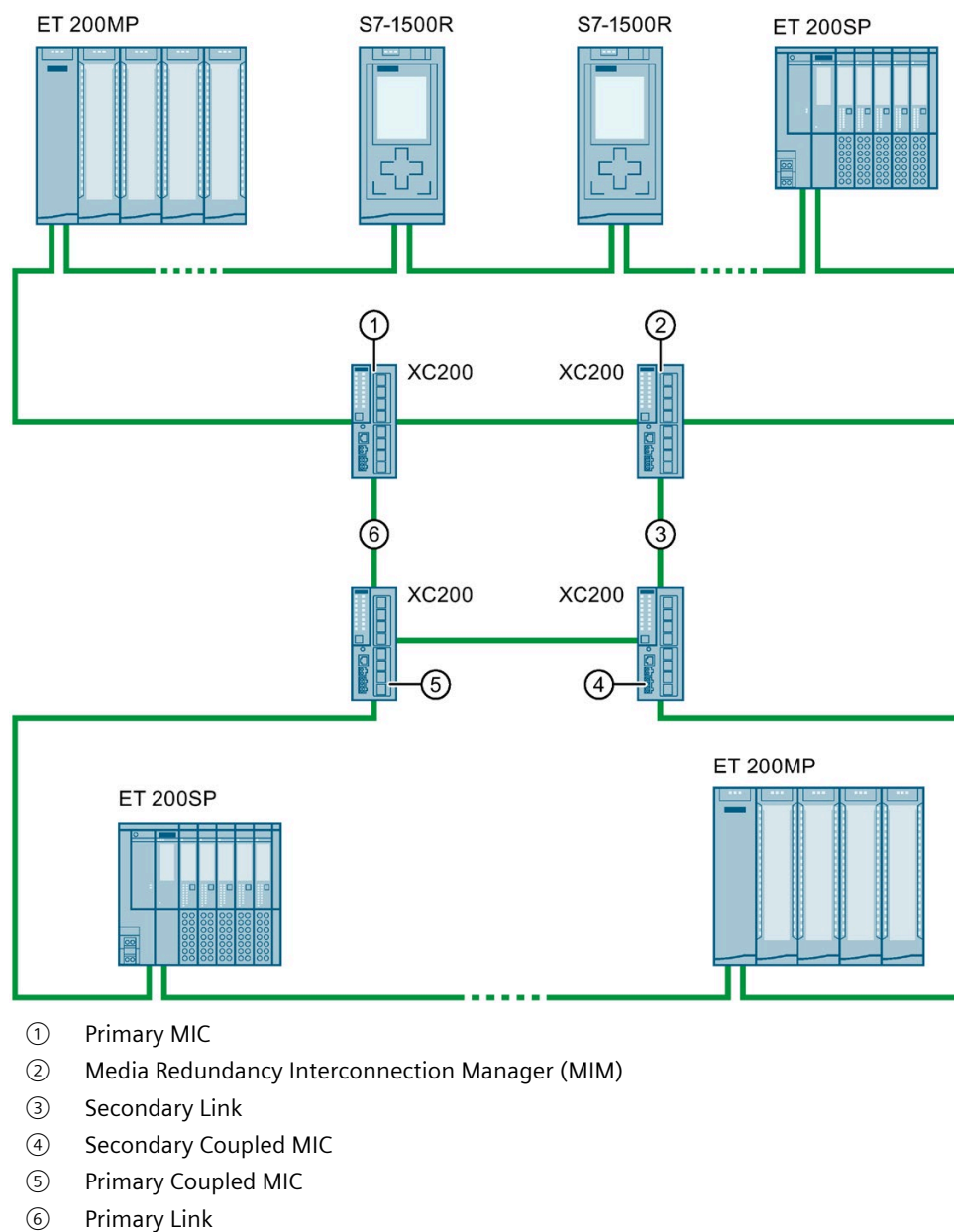
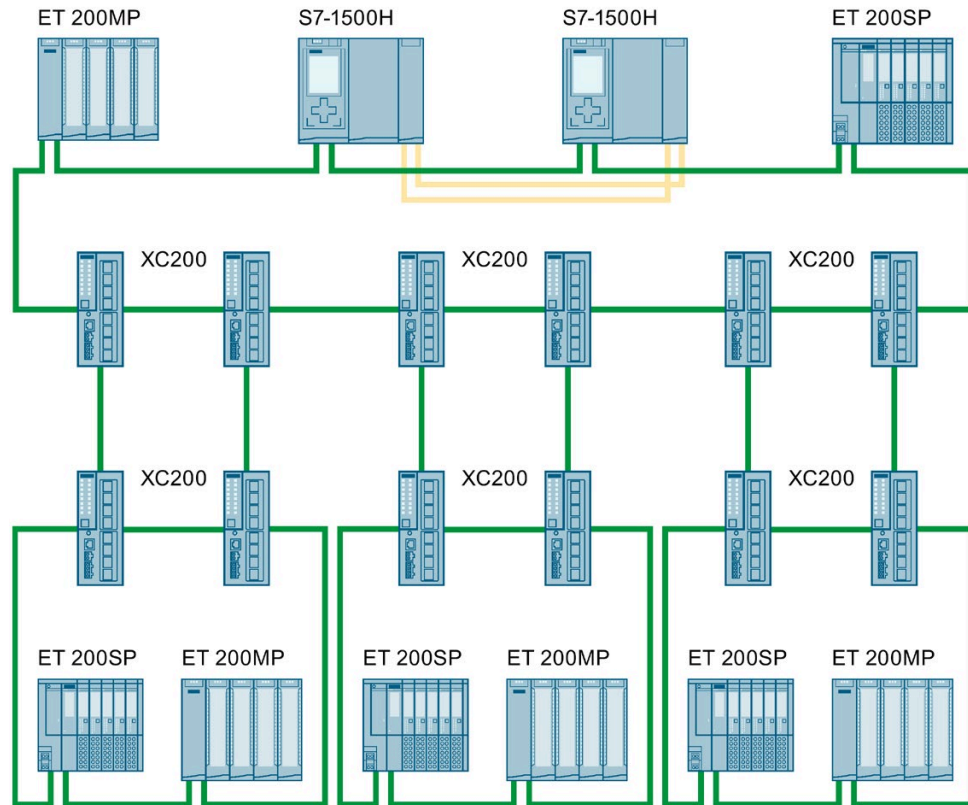


Figure 6-17 Example: Redundant connection of S7-1500R in 2 rings with MRP interconnection



### Topology with several rings

The following figure shows the redundant coupling based on the example of S7-1500H in 4 rings:



### Additional information

You can find all information that generally applies to MRP interconnection and thus also to redundant S7-1500R/H systems with MRP interconnection, in the section MRP interconnection (Page 1), for example, constraints, principle of operation, configuration and times.

### Tool for setting the watchdog timer

For the correct setting of the watchdog timer, you can use the "S7-1500R/H AddIn (<https://support.industry.siemens.com/cs/de/en/view/109769093>)" which is available on the Internet and can also be used for MRP interconnections.

# Glossary

## API

API (**A**pplication **P**rocess **I**dentifier) is a parameter, the value of which specifies the IO data processing process (application).

The PROFINET standard IEC 61158 assigns profiles to specific APIs (PROFIdrive, PROFIsave), which are defined by the PROFINET user organization.

The standard API is 0.

## Application

An application is a program that runs directly on the MS-DOS/Windows operating system. An application on the PG is STEP 7, for example.

## AR

The AR (**A**pplication **R**elation) comprises all the communication relationships between IO controller and IO device (e.g. IO data, data records, interrupts).

AR is also an addressing level for diagnostic data records.

## Asset

An asset is a component of a machine or plant This can be either hardware or software/firmware.

## Automation system

Programmable logic controller for the open-loop and closed-loop control of process chains of the process engineering industry and manufacturing technology. The automation system consists of different components and integrated system functions according to the automation task.

## Backplane bus

The backplane bus is a serial data bus for module intercommunication and the distribution of the necessary power to the modules. Bus connectors interconnect the modules.

## Backup AR

The backup AR is the system redundancy AR between an IO device with system redundancy S2 and the backup CPU of the redundant S7-1500R/H system.

**Backup CPU**

If the R/H system is in RUN-Redundant system state, the primary CPU controls the process. The backup CPU synchronously executes the user program and can take over the process control on failure of the primary CPU.

**Bus**

A bus is a transfer medium that interconnects several devices. Data transmission can be performed electrically or via optical fibers, either in series or in parallel.

**Communications Cycle and Reservation of Transmission Bandwidth**

PROFINET IO is a scalable real-time communication system based on the Layer 2 protocol for Fast Ethernet. With the RT transmission method, two real-time-support performance levels are available for time-critical process data and IRT for high-accuracy and also isochronous processes .

**Communications processor**

Communication processors are modules used for point-to-point and bus connections.

**Configuring**

Selecting and putting together individual components of an automation system or installing necessary software and adapting it for a specific application (for example, by configuring the modules).

**Consistent data**

Data which belongs together in terms of content and must not be separated is known as consistent data.

For example, the values of analog modules must always be handled as a whole, that is, the value of an analog module must not be corrupted as a result of reading out at two different points in time.

**CP**

→ *Communications processor*

**CPU**

**Central Processing Unit** - Central module of the S7 automation system with a control and arithmetic unit, memory, operating system and interface for programming device.

## DCP

DCP (**D**iscovery and **B**asic **C**onfiguration **P**rotocol). Enables the assignment of device parameters (for example, the IP address) using manufacturer-specific configuration/programming tools.

## Default router

The default router is used when data has to be forwarded via TCP/IP to a partner located outside the local network.

## Determinism

Determinism means that a system responds in a predictable (deterministic) manner.

## Device

In the PROFINET environment, "device" is the generic term for:

- Automation systems (for example, PLC, PC)
- Distributed I/O systems
- Field devices (for example, PLC, PC, hydraulic devices, pneumatic devices)
- Active network components (for example, switches, routers)
- Gateways to PROFIBUS, AS interface or other fieldbus systems

## Device name (PROFINET device name)

In the PROFINET IO environment, the device name is a unique identifier for the PROFINET IO interface of a device.

## DHCP

DHCP (**D**ynamic **H**ost **C**onfiguration **P**rotocol). Protocol that can be used to assign IP addresses (and other important startup parameters in the Internet environment).

## Diagnostics

→ *System diagnostics*

## Diagnostics buffer

The diagnostics buffer represents a backup memory in the CPU, used to store diagnostics events in their order of occurrence.

**Diagnostics error interrupt**

Modules capable of diagnostics operations report detected system errors to the CPU by means of diagnostics interrupts.

→ *See also CPU*

**Direct data exchange**

In the case of direct data exchange, an S7-1500 CPU provides cyclic user data from the I/O area to one or more partners.

The direct data exchange function enables deterministic, isochronous I/O communication between multiple S7-1500 CPUs.

**DP master**

A master which behaves in accordance with EN 50170, Part 3, is known as a DP master.

→ *See also Master*

**DP slave**

A slave operated on PROFIBUS with PROFIBUS DP protocol and in accordance with EN 50170, Part 3 is referred to as DP slave.

→ *See also Slave*

**DPV1**

The designation DPV1 refers to the functional extension of acyclic services (to include new interrupts, for example) provided by the DP protocol. The DPV1 functionality is integrated in IEC 61158/EN 50170, Volume 2, PROFIBUS.

**Duplex**

Half duplex: One channel is available for alternating exchange of information.

Full duplex: Two channels are available for simultaneous exchange of information in both directions.

**Ethernet**

Ethernet is an international standard technology for local area networks (LAN) based on frames. It defines types of cables and signaling for the physical layer and packet formats and protocols for media access control.

**GSD file**

As a Generic Station Description, this file contains all properties of a PROFINET device that are necessary for its configuration in XML format.

## H-Sync Forwarding

H-Sync Forwarding enables a PROFINET device with MRP to forward synchronization data (synchronization frames) of a S7-1500R redundant system only within the PROFINET ring.

In addition, H-Sync Forwarding forwards the synchronization data even during reconfiguration of the PROFINET ring. H-Sync Forwarding avoids a cycle time increase if the PROFINET ring is interrupted.

S7-1500R: H-Sync Forwarding is recommended for all PROFINET devices with only two ports in the PROFINET ring. All PROFINET devices with more than two ports (e.g. switch) in the PROFINET ring must support H-Sync forwarding.

S7-1500H: H-Sync Forwarding is not relevant for redundant S7-1500H systems.

## I-device

The "I-device" (intelligent IO device) functionality of a CPU facilitates data exchange with an IO controller, for example, as intelligent preprocessing unit of sub-processes. In its role as an IO device, the I-device is accordingly integrated into a "higher-level" IO controller.

## Industrial Ethernet

Industrial Ethernet is a guideline for installing an Ethernet in an industrial environment. The biggest difference from standard Ethernet is the mechanical current carrying capacity and noise immunity of the individual components.

## Interrupt

An interrupt is an event that causes the operating system of an S7-CPU to automatically call an assigned organization block (interrupt OB) in which the user can program the desired reaction.

## Interrupt, diagnostics

→ *Diagnostics error interrupt*

## IP address

To allow a PROFINET device to be addressed as a device on Industrial Ethernet, this device also requires an IP address that is unique within the network. Example: An IPv4 address consists of 4 decimal numbers with the value range 0 to 255. The decimal numbers are separated by periods.

The IP address is made up of the following components:

- Address of the network
- Address of the device (generally called the host or network node).

**IRT**

IRT is a synchronized communication protocol for cyclic exchange of IRT data between PROFINET devices. A reserved bandwidth is available in the send cycle for IRT data. The reserved bandwidth ensures that the IRT data can be transferred at reserved synchronized intervals, without being influenced also by higher other network loads (such as TCP/IP communication, or additional real-time communication).

**LAN**

**Local Area Network** - a local network to which multiple computers within a company are connected. The LAN therefore has a limited geographical span and is only available to the company or institution.

**Line depth**

Designates the number of external switches or integrated switches interconnected in series.

**MAC address**

Worldwide unique device identification for all Ethernet devices. It is assigned by the manufacturer and has a 3-byte vendor ID and 3-byte device ID as a consecutive number.

Every PROFINET device is assigned a worldwide unique device identifier at the factory. This 6-byte long device identifier is the MAC address.

**Maintenance Required / Maintenance Demanded**

A "Maintenance required" system message can be defined for different wear parameters and an inspection of a component can be recommended, for example, when a certain number of operating hours has elapsed.

The "Maintenance demanded" alarm is sent when the part involved needs to be replaced within a foreseeable period.

(Example printer: The maintenance demanded alarm is sent when the ink/printer cartridges have to be replaced immediately.)

**Master**

Higher-level, active participant in the communication/on a PROFIBUS subnet. It has rights to access the bus (token), sends data and requests it.

**Media redundancy**

The so-called **Media Redundancy Protocol (MRP)** enables the configuration of redundant networks. Redundant transmission links (ring topology) ensure that an alternating communication path is made available if a transmission link fails. The PROFINET devices that are a part of this redundant network form an MRP domain.

## Micro Memory Card (MMC)

Micro Memory Cards are memory media for CPUs and CPs. Their only difference to the SIMATIC memory card is the smaller size. S7-1500 and ET 200SP-CPU use SIMATIC memory cards.

## MPI

The multipoint interface (**M**ulti **P**oint Interface, MPI) represents the programming device interface of SIMATIC S7. It enables multiple devices (programming devices, text-based displays, OPs) to be operated simultaneously by one or more CPUs. Each device is identified by its unique (MPI) address.

## MRP

MRP (**M**edia **R**edundancy **P**rotocol) describes the ring redundancy according to IEC 61158 and IEC 62439.

## MRP interconnection

The MRP interconnection procedure is an extension of MRP. MRP interconnection enables the redundant coupling of two or more rings with MRP in PROFINET networks.

## MRPD

MRPD (**M**edia **R**edundancy with **P**lanned **D**uplication of Frames) based on IRT and MRP. To realize media redundancy with short update times, the PROFINET devices participating in the ring send their data in both directions. The devices receive this data at both ring ports so that there is no reconfiguration time.

## Network

A network consists of one or more interconnected subnets with any number of devices. Several networks can exist alongside each other.

## OB

→ *Organization block*

## OPC

OPC (OLE for Process Control) refers to a standard interface for communication in automation technology.



## Operating states

Operating states describe the behavior of a single CPU at a specific time.

The CPUs of the SIMATIC standard systems feature the STOP, STARTUP and RUN operating states.

The primary CPU of the S7-1500R/H redundant system has the operating states STOP, STARTUP, RUN, RUN-Syncup and RUN-Redundant. The backup CPU has the operating states STOP, SYNCUP and RUN-Redundant.

## Organization block

Organization blocks (OBs) form the interface between the CPU operating system and the user program. The order in which the user program is executed is defined in the organization blocks.

## Parameter

1. Tag of a STEP 7 code block:
2. Tag used to set one or several characteristics of a module

In delivery state, every module has practical basic settings, which can be modified by configuration in STEP 7.

There are static and dynamic parameters

## PG

→ *Programming device*

## PLC

→ *Programmable logic controller*

## Primary AR

The primary AR is the system redundancy AR between an IO device with system redundancy S2 and the primary CPU of the redundant S7-1500R/H system.

## Primary CPU

If at least one R/H CPU is in RUN state, the primary CPU is the controlling CPU. The primary CPU controls the process (productive data).

The user program is executed identically in the primary CPU and the backup CPU.

### **Prioritized startup**

Prioritized startup denotes the PROFINET functionality for accelerating the startup of IO devices operated on a PROFINET IO system with RT and IRT communication. It reduces the time that the correspondingly configured IO devices require in order to return to cyclic user data exchange in the following cases:

- After the power supply has returned
- After a station has returned
- After activation of IO devices

### **Process image (I/O)**

The CPU transfers the values from the input and output modules to this memory area. At the start of the cyclic program, the CPU transfers the process image output as a signal state to the output modules. The CPU then transfers the signal states of the input modules to the process image of the inputs. Then the CPU executes the user program.

### **PROFIBUS**

**Process Field Bus** - European Fieldbus standard.

### **PROFIBUS device**

A PROFIBUS device has at least one PROFIBUS interface with an electrical (RS485) or optical (polymer optical fiber, POF) interface.

### **PROFIBUS DP**

A PROFIBUS with DP protocol that complies with EN 50170. DP stands for distributed I/O (fast, real-time capable, cyclic data exchange). From the perspective of the user program, the distributed I/Os are addressed in exactly the same way as the centralized I/Os.

### **PROFIBUS Users Organization**

Technical committee dedicated to the definition and development of the PROFIBUS and PROFINET standard. Additional information can be found on the Internet (Page ).

### **PROFenergy**

Function for energy saving in the process, for example, during pause times by briefly switching off the entire system via standardized PROFenergy commands.

### **PROFINET**

Open component-based industrial communication system based on Ethernet for distributed automation systems. Communication technology promoted by the PROFIBUS Users Organization.

**PROFINET device**

A PROFINET device always has a PROFINET interface (electrical, optical, wireless). A lot of devices also have a PROFIBUS DP interface to connect PROFIBUS devices.

**PROFINET IO**

Communication concept for the realization of modular, distributed applications within the scope of PROFINET.

PROFINET IO is based on switched Ethernet with full-duplex operation and a bandwidth of 100 Mbps.

**PROFINET IO Controller**

Device used to address the connected IO devices. This means that the IO controller exchanges input and output signals with assigned field devices. The IO controller is often the controller on which the automation program runs.

**PROFINET IO Device**

A distributed field device that is assigned to one of the IO controllers (e.g. remote IO, valve terminals, frequency converters, switches)

**PROFINET IO System**

PROFINET IO controller with assigned PROFINET IO devices.

**PROFINET ring**

Structure of a network. Common structures include:

- Linear bus topology
- Ring topology
- Star topology
- Tree topology

**Programmable logic controller**

Programmable logic controllers (PLCs) are electronic controllers whose function is stored as a program in the control unit. The structure and wiring of the device does not therefore depend on the controller's function. A programmable logic controller is structured like a computer. It consists of a CPU with memory, input/output modules and an internal bus system. The IOs and the programming language are oriented to the requirements of the control technology.

## Programming device

Programming devices are essentially compact and portable PCs which are suitable for industrial applications. They are identified by a special hardware and software configuration for programmable logic controllers.

## Proxy

The PROFINET device with proxy functionality is the substitute for a PROFIBUS device on Ethernet. The proxy functionality allows a PROFIBUS device to communicate not only with its master but also with all devices on PROFINET.

With PROFINET, existing PROFIBUS systems can be integrated into the PROFINET communication with the aid of an IE/PB link, for example. The IE/PB Link PN IO then handles communication via PROFINET on behalf of the PROFIBUS components.

In this way, you can link both DPV0 and DPV1 slaves to PROFINET.

## Real-time

Real-time means that a system processes external events within a defined time.

## Real-time communication

Group error for RT and IRT.

PROFINET uses its own real-time channel (RT) rather than TCP/IP for communication of time-critical IO user data.

## Redundant systems

Redundant systems are characterized by the fact that important automation components are present multiple times (redundantly). Process control is maintained if a redundant component fails.

## Router

A router interconnects two subnets. A router works in a similar way to a switch. With a router, however, you can also specify which communication devices may communicate via the router and which may not. The communication devices on various sides of a router can only communicate with one another if you have explicitly enabled communication between these devices via the router. Real-time data cannot be exchanged beyond subnet boundaries.

## RT

PROFINET IO with Real Time communication (RT) is the optimal transmission method for time-critical applications in factory automation. PROFINET IO frames are prioritized over standard frames in accordance with IEEE802.1Q. This ensures the required determinism in the automation technology.

**Security**

Generic term for all the measures taken to protect against

- Loss of confidentiality due to unauthorized access to data
- Loss of integrity due to manipulation of data
- Loss of availability due to the destruction of data

**Send clock**

Period between two consecutive intervals for IRT or RT communication. The send clock is the shortest possible transmit interval for exchanging data.

**SIMATIC**

The term denotes Siemens AG products and systems for industrial automation.

**SIMATIC NET**

Siemens Industrial Communication division for Networks and Network Components.

**SIMATIC PC Station**

A "PC station" is a PC with communication modules and software components within a SIMATIC automation solution.

**SIMATIC Memory Card (SMC)**

→ *Micro Memory Card (MMC)*

**Slave**

A slave can only exchange data after being requested to do so by the master.

→ *See also DP slave*

**SNMP**

The network management protocol SNMP (**S**imple **N**etwork **M**anagement **P**rotocol) uses the wireless UDP transport protocol. It consists of two network components, similar to the client/server model. The SNMP manager monitors the network nodes and the SNMP agents collect the various network-specific information in the individual network nodes and stores it in a structured form in the MIB (**M**anagement **I**nformation **B**ase). This information allows a network management system to run detailed network diagnostics.

**STEP 7**

STEP 7 is an engineering system and contains programming software for the creation of user programs for SIMATIC S7 controllers.

## Subnet

All the devices interconnected by switches are nodes of the same network or subnet. All the devices in a subnet can communicate directly with each other.

All devices in the same subnet have the same subnet mask.

A subnet is physically restricted by a router.

## Subnet mask

The bits set in the subnet mask decide the part of the IP address that contains the address of the network.

In general, the following applies:

- The network address is obtained from the AND operation of the IP address and subnet mask.
- The device address is obtained from the AND NOT operation of the IP address and subnet mask.

## Switch

Network components used to connect several terminal devices or network segments in a local network (LAN).

## Switched S1 device

The "Switched S1 device" function of the CPU enables operation of standard IO devices on the S7-1500R/H redundant system.

PROFINET communication runs on an AR between the primary CPU and the standard IO device. When replacing the primary CPU, the standard IO device is briefly disconnected from the S7-1500R/H redundant system until the new primary CPU has set up an AR to the standard IO device.

## Sync domain

All PROFINET devices to be synchronized with IRT via PROFINET IO must belong to a sync domain.

The sync domain consists of exactly one sync master and at least one sync slave. An IO controller or switch generally handles the role of the sync master.

Non-synchronized PROFINET devices are not part of a sync domain.

## System diagnostics

System diagnostics refers to the detection, evaluation, and signaling of errors that occur within the automation system, for example, programming errors or module failures. System errors can be indicated by LEDs or in STEP 7.

## System redundancy AR

In a redundant system, an IO device with system redundancy S2 has a system redundancy AR with each of the two CPUs (IO controllers).

## System states

The system states of the redundant S7-1500R/H system result from the operating states of the primary and backup CPUs. The concept of the system state is used to obtain a simplified expression that characterizes the simultaneously occurring operating states of the two CPUs. The following system states are available for the redundant S7-1500R/H system: STOP, STARTUP, RUN-Solo, SYNCUP and RUN-Redundant.

## TCP/IP

The Ethernet itself is only a transport system for data - similar to a highway, which is a transport system for people and goods. The actual data transport is performed by so-called protocols - similar to cars and trucks, which transport people and goods on the highway.

The two basic protocols TCP (Transmission Control Protocol) and IP (Internet Protocol) - TCP/IP for short - perform the following tasks:

1. The data is broken down into packets at the sender.
2. The packets are transported over the Ethernet to the correct recipient.
3. At the recipient, the packets are reassembled in the correct order.
4. Corrupt packets continue to be sent until they are received correctly.

Most higher-level protocols use TCP/IP to perform their duties. Hyper Text Transfer Protocol (HTTP), for example transfers documents written in Hyper Text Markup Language (HTML) in the World Wide Web (WWW). This technique is what enables you to view web pages in your Internet browser in the first place.

## Topology configuration

All the interconnected ports of the PROFINET devices in the STEP 7 project and their relationships to each other.

## Twisted-pair

Fast Ethernet via twisted-pair cables is based on the IEEE 802.3u standard (100 Base-TX). The transmission medium is a shielded 2x2 twisted-pair cable with an impedance of 100  $\Omega$  (AWG 22). The transmission characteristics of this cable must meet the requirements of category 5.

The maximum length of the connection between the terminal and the network component must not exceed 100 m. The connectors are designed according to the 100Base-TX standard with the RJ45 connector system.

## **Update time**

An IO device / IO controller in the PROFINET IO system is supplied cyclically with new data from the IO controller / IO device within this time interval. The update time can be configured separately for each IO device and determines the interval at which data is sent from the IO controller to the IO device (outputs) as well as from the IO device to the IO controller (inputs).

## **User program**

In SIMATIC, we distinguish between the CPU operating system and user programs. The user program contains all instructions, declarations and data by which a plant or process can be controlled. The user program is assigned to a programmable module (for example, CPU, CM) and can be structured in smaller units.

## **WAN**

A network that extends beyond LAN boundaries and enables, for example, intercontinental network communication. Legal rights do not belong to the user but to the provider of the communication network.

## **XML**

XML (Extensible Markup Language) is a flexible, easy to understand and easy to learn data description language. Information is exchanged using readable XML documents. These include continuous text supplemented by structure information.



# Index

## A

- Accelerating startup, 286, 286
  - Adapting the user program, 291
  - Optimize the port settings, 288
  - Optimizing cabling, 290
- Advanced offline/online comparison
  - Automatic device assignment, 77
- Alarm texts, 85
- Alternating IO devices during operation, 282
- Alternating partner ports during operation, 279
- Application cycle, 224
  - Setting, 225
- Asset management, 104
- Assigning parameters, 45
- Assignment IO device - controller, 45

## B

- Bandwidth, 143

## C

- Cables, 33
- Calling status from IO device, 79
- Channel, 29
- Communication, 23
- Compare offline/online
  - Automatic device assignment, 75
- Configuration control, 248
- Configuration control for IO systems, 248, 259, 275
- Configuring, 45
- Configuring docking system, 282
- Configuring hardware and assigning parameters for hardware, 45
- CPU display
  - Diagnostics, 83
  - IP address, 52
- Cut through, 195

## D

- D\_ACT\_DP, 145, 282
- Data access, 24
- Data cycle, 220

- Data exchange between IO systems, 128
- Data security
  - Basics, 42
  - Example, 42
  - SCALANCE, 42
  - Security, 42
- Default router, 51
- Delay time, 224
  - Setting, 225
- Device name, 48, 248
  - Automatically assign, 47
  - Changing, 54
  - Exchanging without removable storage medium, 52
  - Permitting changes directly on the device, 60
  - Structured, 48
- Device number, 49
- Device replacement
  - Assign device name, 244
  - Configuring, 244
  - Failure and replacement of an IO device, 243
  - Neighborhood detection, 243
  - Without exchangeable medium/programming device, 241
- Device replacement without exchangeable medium/programming device, 52, 241
- Devices & networks, 91
- DHCP, 61
- Diagnostics, 78
  - Diagnostics status, 100
  - Evaluation of interrupts, 101
  - I-device, 136
  - PROFINET ports, 93
  - STEP 7, 91
  - User program, 100
    - via CPU display, 83
    - via LEDs, 82
    - via Web server, 88
- Diagnostics buffer, 85
- Diagnostics data record, 98
  - Channel-specific, 98
  - Vendor-specific, 98
- Diagnostics levels, 80
- Diagnostics status, 100
- Display
  - Diagnostics, 83
  - IP address, 52
- DNS conventions, 49
- Docking station, 279

Docking unit, 279  
DP cycle time, 224

## E

Evaluation of interrupts, 101  
Exchangeable medium, 241  
Execution window, 228

## F

Fast Ethernet, 32  
Fiber-optic cable (FOC), 35  
Fieldbus integration, 117  
Full-duplex mode, 32  
Functionality  
    I-device, 122  
    PROFINET IO, 28

## G

Gateway, 61  
Go online, 91  
GSD file, 132

## H

Hardware and network editor  
    Assign device name, 47  
    Assign IP address, 47  
    Topology view, 70

## I

I&M data, 104  
    downloading to PROFINET IO devices, 104  
I/O addresses, 224  
I/O communication, 46, 57  
Identification data, 104  
Identification of the PROFINET device, 56  
I-device, 143  
    Configuring with GSD file, 132  
I-device (intelligent IO device)  
    Alarm response, 136  
    Configuring, 130  
    Diagnostics, 136  
    Functionality, 122  
    Lower-level PN IO system, 124  
    Properties, 124  
    Topology rules, 138

IE/PB link, 119  
Industrial Ethernet, 19, 32  
Industrial Wireless LAN, 37  
    Application examples, 37  
    Range, 38  
Instruction  
    T\_CONFIG, 61  
Interconnecting ports  
    In the Inspector window, 74  
    In topology view, 72  
IO controller, 45  
IO device, 224  
    Activating and deactivating during change, 282  
    Assigning, 45  
    Calling status, 79  
    Configuring alternating partners, 282  
IO system, 249, 253, 256, 259, 262, 263, 272, 273  
    Checking the assignment, 46  
    Data exchange, 128  
IP address, 49  
    Assigning for the first time, 52  
    assigning using an different way, 56  
    Changing, 54  
    Permitting changes directly on the device, 60  
IPO model, 228, 228  
IRT, 224  
    Area of application, 193  
    Communication, 195  
    Communication cycle, 196  
    Configuring, 198  
    Definition, 195  
    Differences of RT, 197  
    Properties, 195  
    Rules, 143  
    Setup recommendations, 203  
    Synchronization, 196  
Isochronous mode  
    Configuring, 224  
    Definition, 217  
    Example, 219  
    Time synchronization, 220  
Isochronous mode interrupt OB, 220, 224  
    OB 6x, 228  
Isochronous real-time, (see IRT)

## L

Lead time, 220  
LEDs for diagnostics, 82  
Linking PROFINET and PROFIBUS, 119  
LLDP, 96

**M**

Machine tailoring, (see Configuration control for IO systems)  
 Maintenance concept, 94  
 Maintenance data, 104  
 Maintenance demanded, 94  
 Maintenance required, 94  
 Media redundancy  
   Configuring, 178  
   Functions in ring topology, 176  
 Media Redundancy Protocol (MRP), 176  
 MIB, 96  
 Module, 29  
 Module status, 84  
 Module-internal shared input (MSI), 167  
 Module-internal shared output (MSO), 167  
 MRP, 176  
 MRPD, 181  
 MSI/MSO, 167  
 Multiple use IO system, 248, 249, 253, 256  
 Multiple use IO systems, 248

**N**

Neighborhood detection, 243  
 Network limits, 33  
 Network view  
   I/O communication, 57

**O**

OB 82, 101  
 OB MC Servo, 228  
 OIP model, 228, 229  
 Online & diagnostics network view, 91  
 Online assignment (PROFINET device names), 57  
 Option handling in the network  
   see Configuration control for IO systems, 259  
 Optional IO device, 262  
 Overwriting the PROFINET device name, 248

**P**

Port  
   Alternating partners, 279  
   Diagnostics, 93  
   Switchport, 290  
   Terminal port, 290  
 Prefabricating PCF cables, 35  
 Prefabricating POF cables, 35

Primary Setup Tool (PST), 61  
 Prioritized startup, 282  
   Configuring, 287  
   Definition, 286  
 PROFIBUS, 19  
 PROFIBUS & PROFINET International, 20  
 PROFlenergy, 143, 277  
 PROFINET, 19  
   Assigning a device name, 57  
   Communication, 23  
   Device model, 29  
   Devices, 21  
   Equipment designations, 21  
   Implementation, 19  
   Interface, 21, 26  
   Objectives, 19  
   Optimizing with IRT, 203  
   Optimizing with RT, 202  
   Send clock, 25  
   Topology rules with I-device, 138  
   Transmission media, 35  
   Update time, 25  
   Watchdog time, 25  
 PROFINET device name, 248  
 PROFINET interface  
   Properties, 26  
   Topology overview, 27  
 PROFINET IO, 19  
   Diagnostics levels, 80  
   Functionality, 28, 117  
   System, 45  
 Proxy functionality, 120  
 PST, 61

**R**

Real-time class, 32  
 Real-time communication, 192, 195  
 Redundancy, 174  
   Redundancy clients, 174  
   Redundancy domains, 176  
   Redundancy manager, 174  
 Redundancy manager, 174  
 Ring port, 174, 180  
 Ring topology, 174  
 Router, 33, 51, 65  
 RT  
   Area of application, 193  
   Communication cycle, 196  
   Definition, 195  
   Differences of IRT, 197  
   Rules, 143

RT class, 224

## S

Saving energy, 277

SCALANCE, 33, 38, 42

Security

Definition, 42

Example of data security, 42

Protective measures, 42

Send clock, 25, 220, 224

Set/actual topology, 88

Shared device, 150, 167

SNMP, 98

MIB, 96

Network diagnostics, 96

Standard machine

project, 248, 248, 249, 253, 256, 262, 263, 272, 273

Startup of IO devices, 282, 286

Store and forward, 195

Submodule, 29, 167

Subnet, 46

Subnet mask, 51

Assigning for the first time, 52

Example, 51

Switch, 32

Integrated, 27

Selection guide, 32

Switched Ethernet, 32

Switchport, 290

Sync domain, 196, 224

SYNC\_PI, 228, 228, 229

SYNC\_PO, 228, 228, 229

Synchronous Cycle, 228

System diagnostics, 78

## T

T\_CONFIG, 61

T\_DC, 220, 224, 228, 230

TCP/IP in the communication cycle, 196

Terminal port, 290

Ti, 220

To, 220

Tool changer, 279

Topology

Example, 69

Line, 69

Ring, 69, 174, 176

Rules about the IO-system with I-device, 138

Set/actual, 88

Star, 69

Tree, 69

Topology configuration, 224

Topology overview, 27

Topology view

Adopt devices identified online, 77

Adopt port interconnections identified online, 77

Hardware and network editor, 70

Interconnecting ports, 72

Transfer area, 143

Transmission bandwidth, 32

Transmission media with PROFINET, 35

Twisted-pair, 33

## U

Update time, 25, 38

## V

Value status, 167

## W

Watchdog time, 25

Wire break, 95

Wireless networks, 38

## SIMATIC

## PROFIBUS PROFIBUS with STEP 7 V13

### Function Manual

#### Preface

#### Documentation guide

1

#### Description

2

#### Parameter assignment/addressing

3

#### Diagnostics

4

#### Functions

5

#### Service & Support

A

## Legal information

### Warning notice system

This manual contains notices you have to observe in order to ensure your personal safety, as well as to prevent damage to property. The notices referring to your personal safety are highlighted in the manual by a safety alert symbol, notices referring only to property damage have no safety alert symbol. These notices shown below are graded according to the degree of danger.

#### **DANGER**

indicates that death or severe personal injury **will** result if proper precautions are not taken.

#### **WARNING**

indicates that death or severe personal injury **may** result if proper precautions are not taken.

#### **CAUTION**

indicates that minor personal injury can result if proper precautions are not taken.

#### **NOTICE**

indicates that property damage can result if proper precautions are not taken.

If more than one degree of danger is present, the warning notice representing the highest degree of danger will be used. A notice warning of injury to persons with a safety alert symbol may also include a warning relating to property damage.

### Qualified Personnel

The product/system described in this documentation may be operated only by **personnel qualified** for the specific task in accordance with the relevant documentation, in particular its warning notices and safety instructions. Qualified personnel are those who, based on their training and experience, are capable of identifying risks and avoiding potential hazards when working with these products/systems.

### Proper use of Siemens products

Note the following:

#### **WARNING**

Siemens products may only be used for the applications described in the catalog and in the relevant technical documentation. If products and components from other manufacturers are used, these must be recommended or approved by Siemens. Proper transport, storage, installation, assembly, commissioning, operation and maintenance are required to ensure that the products operate safely and without any problems. The permissible ambient conditions must be complied with. The information in the relevant documentation must be observed.

### Trademarks

All names identified by ® are registered trademarks of Siemens AG. The remaining trademarks in this publication may be trademarks whose use by third parties for their own purposes could violate the rights of the owner.

### Disclaimer of Liability

We have reviewed the contents of this publication to ensure consistency with the hardware and software described. Since variance cannot be precluded entirely, we cannot guarantee full consistency. However, the information in this publication is reviewed regularly and any necessary corrections are included in subsequent editions.

# Preface

## Purpose of the manual

This function manual provides an overview of the PROFIBUS communication system with SIMATIC STEP 7 V13.

STEP 7 V13 is integrated into the powerful graphic Totally Integrated Automation Portal (TIA Portal), the new integration platform for all automation software tools.

This function manual supports you in planning a PROFIBUS system. The manual is structured into the following subject areas:

- PROFIBUS basics
- PROFIBUS diagnostics
- PROFIBUS functions

## Basic knowledge required

The following knowledge is required in order to understand the manual:

- General knowledge of automation technology
- Knowledge of the industrial automation system SIMATIC
- Knowledge about the use of Windows-based computers
- Proficiency with STEP 7

## Scope

This function manual is the basic documentation for all SIMATIC products from the PROFIBUS environment. The product documentation is based on this documentation.

The examples are based on the functionality of the S7-1500 automation system.

## Changes compared to previous version

As compared to the previous version (version 07/2014), this manual contains the following amendments/changes:

- Extension of the documentation to STEP 7 (TIA Portal) V13 SP1
- Addition of the function Intelligent DP slaves (I-slaves)
- New guide

## Conventions

**STEP 7:** We refer to "STEP 7" in this documentation as a synonym for the configuration and programming software "STEP 7 as of V12 (TIA Portal)" and subsequent versions.

This documentation contains figures of the devices described. The figures may differ slightly from the device supplied.

You should also pay particular attention to notes such as the one shown below:

---

### Note

A note contains important information on the product described in the documentation, on the handling of the product or on the section of the documentation to which particular attention should be paid.

---

## Additional support

You will find information about available technical support in the appendix Service & Support (Page 91).

The technical documentation for the individual SIMATIC products and systems is available on the Internet (<http://www.siemens.com/simatic-tech-doku-portal>).

The online catalog and the ordering system are available on the Internet (<http://mall.industry.siemens.com>).

## Security information

Siemens provides products and solutions with industrial security functions that support the secure operation of plants, solutions, machines, equipment and/or networks. They are important components in a holistic industrial security concept. With this in mind, Siemens' products and solutions undergo continuous development. Siemens recommends strongly that you regularly check for product updates.

For the secure operation of Siemens products and solutions, it is necessary to take suitable preventive action (e.g. cell protection concept) and integrate each component into a holistic, state-of-the-art industrial security concept. Third-party products that may be in use should also be considered. You can find more information about industrial security on the Internet (<http://www.siemens.com/industrialsecurity>).

To stay informed about product updates as they occur, sign up for a product-specific newsletter. You can find more information on the Internet (<http://support.automation.siemens.com>).



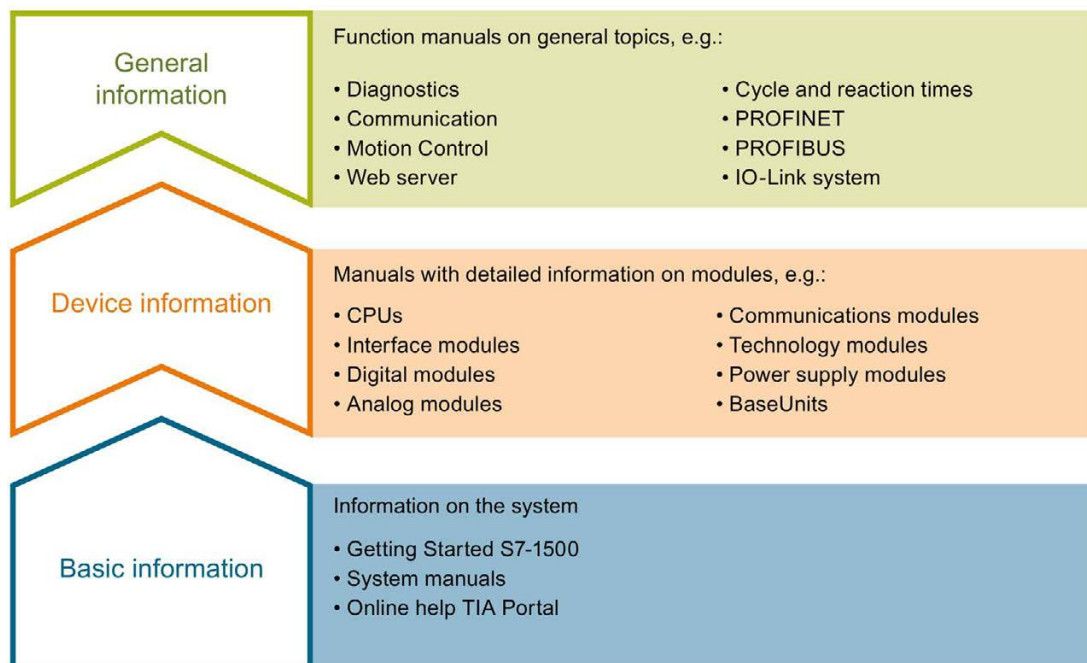
# Table of contents

|          |                                                      |           |
|----------|------------------------------------------------------|-----------|
|          | <b>Preface .....</b>                                 | <b>3</b>  |
| <b>1</b> | <b>Documentation guide .....</b>                     | <b>7</b>  |
| <b>2</b> | <b>Description.....</b>                              | <b>10</b> |
| 2.1      | Introduction to PROFIBUS.....                        | 10        |
| 2.1.1    | Applications of PROFIBUS DP .....                    | 11        |
| 2.1.2    | PROFIBUS terminology .....                           | 12        |
| 2.1.3    | PROFIBUS DP interface.....                           | 16        |
| 2.2      | Structure of PROFIBUS networks .....                 | 17        |
| 2.2.1    | Passive network components for RS 485 networks ..... | 19        |
| 2.2.1.1  | RS 485 cables.....                                   | 19        |
| 2.2.1.2  | PROFIBUS FastConnect system.....                     | 20        |
| 2.2.1.3  | PROFIBUS bus connector .....                         | 22        |
| 2.2.1.4  | M12 bus connector .....                              | 24        |
| 2.2.1.5  | Bus terminals for RS 485 networks .....              | 24        |
| 2.2.1.6  | M12 bus terminating resistor .....                   | 24        |
| 2.2.2    | Passive components for optical networks.....         | 25        |
| 2.2.2.1  | Fiber-optic cables.....                              | 25        |
| 2.2.2.2  | Plastic and PCF fiber-optic cables .....             | 26        |
| 2.2.2.3  | Glass fiber-optic cables.....                        | 27        |
| 2.2.3    | Active network components .....                      | 29        |
| 2.2.3.1  | Network components in electrical networks.....       | 29        |
| 2.2.3.2  | Network components in optical networks .....         | 33        |
| 2.2.4    | Examples for topology .....                          | 35        |
| 2.2.4.1  | Topology with RS485 repeater .....                   | 35        |
| 2.2.4.2  | Topology with diagnostic repeater .....              | 37        |
| 2.2.4.3  | OLM topology.....                                    | 40        |
| 2.2.4.4  | WLAN topology .....                                  | 40        |
| 2.2.4.5  | Connecting PROFIBUS to PROFINET .....                | 41        |
| <b>3</b> | <b>Parameter assignment/addressing .....</b>         | <b>42</b> |
| 3.1      | Assigning the DP slave to a DP master.....           | 43        |
| 3.2      | PROFIBUS address.....                                | 45        |
| 3.3      | Network settings .....                               | 46        |
| 3.4      | Cable configuration .....                            | 49        |
| 3.5      | Additional network stations .....                    | 51        |
| 3.6      | Bus parameters.....                                  | 52        |
| 3.7      | Constant bus cycle time.....                         | 55        |

|          |                                                    |           |
|----------|----------------------------------------------------|-----------|
| <b>4</b> | <b>Diagnostics .....</b>                           | <b>57</b> |
| 4.1      | Overview .....                                     | 57        |
| 4.2      | Diagnostics using the display of the S7-1500 ..... | 58        |
| 4.3      | Diagnostics with the diagnostic repeater .....     | 60        |
| 4.4      | I&M data (Identification and Maintenance) .....    | 61        |
| <b>5</b> | <b>Functions .....</b>                             | <b>62</b> |
| 5.1      | Isochronous mode .....                             | 62        |
| 5.1.1    | What is isochronous mode? .....                    | 62        |
| 5.1.2    | Use of isochronous mode .....                      | 63        |
| 5.1.3    | Isochronous applications .....                     | 64        |
| 5.1.4    | Sequence of synchronization .....                  | 65        |
| 5.1.5    | Requirements for configuration .....               | 66        |
| 5.1.6    | Configuring isochronous mode .....                 | 67        |
| 5.1.7    | Diagnostics and interrupt functions .....          | 70        |
| 5.1.8    | Parameter settings for isochronous mode .....      | 71        |
| 5.1.8.1  | Viewing isochronous mode parameters .....          | 71        |
| 5.1.8.2  | Change parameters .....                            | 72        |
| 5.2      | Acyclical data exchange .....                      | 74        |
| 5.3      | SYNC/FREEZE groups .....                           | 75        |
| 5.4      | Interrupts .....                                   | 77        |
| 5.5      | Intelligent DP slaves (I-slaves) .....             | 78        |
| 5.5.1    | I-slave functionality .....                        | 78        |
| 5.5.2    | Data exchange with higher-level DP master .....    | 81        |
| 5.5.3    | Configuring an I-slave .....                       | 82        |
| 5.5.4    | Configuring transfer areas .....                   | 84        |
| 5.5.5    | Sample program .....                               | 85        |
| 5.5.6    | Diagnostics and interrupt behavior .....           | 89        |
| <b>A</b> | <b>Service &amp; Support .....</b>                 | <b>91</b> |
|          | Glossary .....                                     | 94        |
|          | Index .....                                        | 99        |

# Documentation guide

The documentation for the SIMATIC S7-1500 automation system and the SIMATIC ET 200MP, ET 200SP and ET 200AL distributed I/O systems is divided into three areas. This division allows you easier access to the specific information you require.



## Basic information

System manuals and Getting Started describe in detail the configuration, installation, wiring and commissioning of the SIMATIC S7-1500, ET 200MP, ET 200SP and ET 200AL systems. The STEP 7 online help supports you in the configuration and programming.

## Device information

Product manuals contain a compact description of the module-specific information, such as properties, terminal diagrams, characteristics and technical specifications.

## General information

The function manuals contain detailed descriptions on general topics such as diagnostics, communication, Motion Control, Web server.

You can download the documentation free of charge from the Internet (<http://w3.siemens.com/mcims/industrial-automation-systems-simatic/en/manual-overview/Pages/Default.aspx>).

Changes and additions to the manuals are documented in product information sheets.

## Manual Collections

The Manual Collections contain the complete documentation of the systems put together in one file.

You will find the Manual Collections on the Internet:

- S7-1500/ET 200MP (<http://support.automation.siemens.com/WW/view/en/86140384>)
- ET 200SP (<http://support.automation.siemens.com/WW/view/en/84133942>)
- ET 200AL (<http://support.automation.siemens.com/WW/view/en/95242965>)

## My Documentation Manager

The My Documentation Manager is used to combine entire manuals or only parts of these to your own manual.

You can export the manual as PDF file or in a format that can be edited later.

You can find the My Documentation Manager on the Internet (<http://support.automation.siemens.com/WW/view/en/38715968>).

## Applications & Tools

Applications & Tools supports you with various tools and examples for solving your automation tasks. Solutions are shown in interplay with multiple components in the system - separated from the focus in individual products.

You can find Applications & Tools on the Internet (<http://support.automation.siemens.com/WW/view/en/20208582>).

## CAX Download Manager

The CAX Download Manager is used to access the current product data for your CAX or CAe systems.

You configure your own download package with a few clicks.

In doing so you can select:

- Product images, 2D dimension drawings, 3D models, internal circuit diagrams, EPLAN macro files
- Manuals, characteristics, operating manuals, certificates
- Product master data

You can find the CAX Download Manager on the Internet (<http://support.automation.siemens.com/WW/view/en/42455541>).

## **TIA Selection Tool**

With the TIA Selection Tool, you can select, configure and order devices for Totally Integrated Automation (TIA).

This tool is the successor of the SIMATIC Selection Tool and combines the known configurators for automation technology into one tool.

With the TIA Selection Tool, you can generate a complete order list from your product selection or product configuration.

You can find the TIA Selection Tool on the Internet

(<http://w3.siemens.com/mcms/topics/en/simatic/tia-selection-tool>).

## Description

### 2.1 Introduction to PROFIBUS

#### What is PROFIBUS?

PROFIBUS is a bus system that networks automation systems and field devices that are compatible with PROFIBUS. As communication medium for the field level, PROFIBUS is an important part of Totally Integrated Automation (TIA).

The different communication networks can be used independent of one another or they can be combined with each other.

#### PROFIBUS protocols

**PROFIBUS DP** (distributed I/O) is a communication network for the field level according to IEC 61158-2 / EN 61158-2 with the hybrid access protocols token bus and master-slave. The networking takes place by means of two-wire lines or fiber-optic cables. Data transmission rates of 9.6 kbps to 12 Mbps are possible.

**PROFIBUS PA** is the PROFIBUS for process automation (PA). It connects the PROFIBUS DP communication protocol with the MBP (Manchester Bus Powered) transmission technology to IEC 61158-2.

PROFIBUS PA networks can be designed based on shielded, twisted two-wire lines intrinsically safe and are therefore suitable for hazardous areas (Ex zones 0 and 1). The data transmission rate is 31.25 kbps.

## 2.1.1 Applications of PROFIBUS DP

### Introduction

The efficiency of control systems is not determined by automation devices alone, but depends to a large extent on the overall configuration of an automation solution. This includes a powerful communication system in addition to plant visualization and operator control and monitoring.

The STEP 7 engineering tool supports you during the engineering and configuration of an automation solution.

### Applications of PROFIBUS DP

The PROFIBUS network offers wireless connection of several controllers, components and subnets as electrical network, optical network or by using links. Sensors and actuators are controlled centrally by means of PROFIBUS DP.

The following figure shows connection options to PROFIBUS DP:

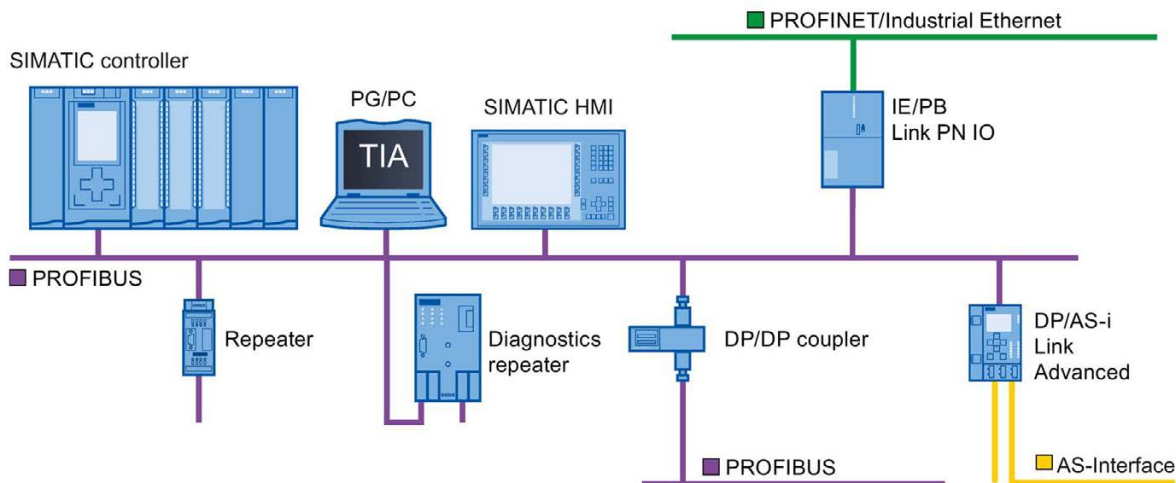


Figure 2-1 Connection options to PROFIBUS DP

## **Objectives of PROFIBUS DP**

Distributed automation systems are increasingly used in production and process automation. This means a complex control task is divided up into smaller, more transparent subtasks with distributed control systems. This creates a high demand for communication between the distributed systems.

Distributed systems offer the following benefits:

- Independent and simultaneous commissioning of individual devices is possible
- Small, manageable programs
- Parallel processing due to distributed automation systems
- Reduced response times
- Higher-level structures can take on additional diagnostics and logging functions.
- Increased plant availability because the rest of the overall system can continue to work when a subordinate station fails.

### **2.1.2 PROFIBUS terminology**

#### **Definition: Devices in the PROFIBUS environment**

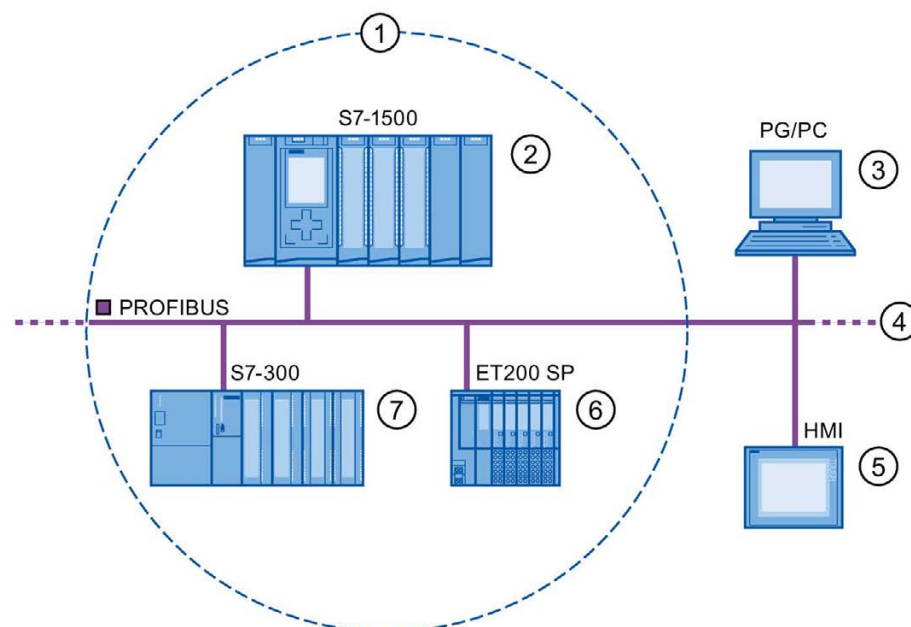
In the PROFIBUS environment, "device" is the generic term for:

- Automation systems (for example, PLC, PC)
- Distributed I/O systems
- Field devices (for example, hydraulic devices, pneumatic devices)
- Active network components (e.g., diagnostic repeater, optical link module)
- Gateways to AS interface or other fieldbus systems



## Devices with PROFIBUS DP

The figure below shows the most important components with PROFIBUS DP. The table below lists the designations of the individual components.



| Number | PROFIBUS         | Note                                                                                                                                                                                                |
|--------|------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| ①      | DP master system |                                                                                                                                                                                                     |
| ②      | DP master        | Device used to address the connected DP slaves. The DP master exchanges input and output signals with field devices.<br>The DP master is often the controller on which the automation program runs. |
| ③      | PG/PC            | PG/PC/HMI device for commissioning and diagnostics<br>DP master of class 2                                                                                                                          |
| ④      | PROFIBUS         | Network infrastructure                                                                                                                                                                              |
| ⑤      | HMI              | Device for operating and monitoring functions                                                                                                                                                       |
| ⑥      | DP slave         | Distributed field device assigned to the DP master, e.g., valve terminals, frequency converters.                                                                                                    |
| ⑦      | I-slave          | Intelligent DP slave                                                                                                                                                                                |

Figure 2-2 Devices with PROFIBUS

## Overview of I/O communication

I/O communication is the reading or writing of inputs/outputs of the distributed I/O. The figure below gives you an overview of I/O communication using PROFIBUS DP:

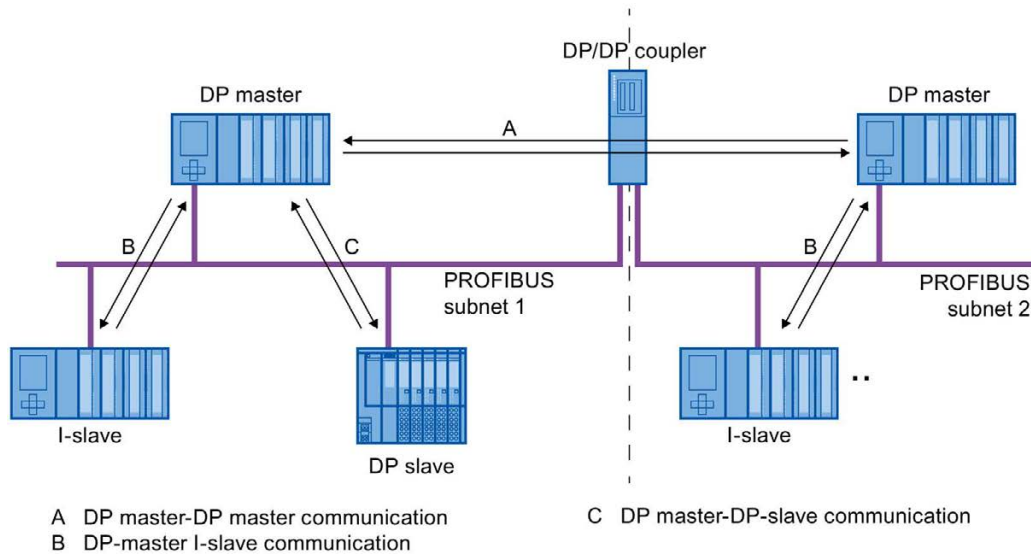


Figure 2-3 I/O communication using PROFIBUS DP

I/O communication is also available with the communication module (CM) or the interface module (IM) with integrated DP interface. These DP interfaces behave like integrated DP interfaces of the CPU.

## I/O communication using PROFIBUS DP

Table 2- 1 I/O communication using PROFIBUS DP

| Communication between ... | Explanation                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |
|---------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| DP master and DP slave    | The data exchange between a DP master and DP slaves with I/O modules takes place as follows: The DP master queries the DP slaves of its master system one after the other, receives input values from the DP slaves, and transmits output data to the DP slaves (master-slave principle).                                                                                                                                                                                                                                                                        |
| DP master and I-slave     | <p>A fixed amount of data is transmitted cyclically between the user programs in CPUs of DP masters and I-slaves.</p> <p>The DP master does not access the I/O modules of the I-slave, but instead accesses configured address areas, called transfer areas, that can be inside or outside the process image of the I-slave CPU. If parts of the process image are used as transfer areas, these may not be used for actual I/O modules.</p> <p>Data transmission takes place with load and transfer operations using the process image or by direct access.</p> |
| DP master and DP master   | <p>A fixed amount of data is transmitted cyclically between the user programs in CPUs of DP masters. A DP/DP coupler is required as additional hardware.</p> <p>The DP masters mutually access configured address areas, called transfer areas, inside or outside the process image of the CPUs. If parts of the process image are used as transfer areas, these may not be used for actual I/O modules.</p> <p>Data transmission takes place with load and transfer operations using the process image or by direct access.</p>                                 |

### Additional information

You can find additional information on the hardware configuration in the STEP 7 online help.

### 2.1.3 PROFIBUS DP interface

#### Properties

A PROFIBUS device has at least one PROFIBUS interface with an electrical (RS 485) interface or optical (Polymer Optical Fiber, POF) interface.

Table 2- 2 Properties of the PROFIBUS DP interface

|                    |                                                                       |
|--------------------|-----------------------------------------------------------------------|
| Standard           | PROFIBUS: IEC 61158/61784                                             |
| Physical bus/media | PROFIBUS cables (twisted two-wire lines RS 485 or fiber-optic cables) |
| Transmission rate  | 9.6 kbps to 12 Mbps                                                   |

#### Representation of the PROFIBUS DP interface in STEP 7

In the device view of STEP 7, the PROFIBUS DP interfaces for a DP master and a DP slave are highlighted by a purple rectangle:



Figure 2-4 PROFIBUS DP interfaces

## 2.2 Structure of PROFIBUS networks

### Contents of this chapter

The following chapter provides background information on building your communication network.

- Overview of the most important passive network components: These are network components that forward a signal without the possibility of actively influencing it, for example, cables, connectors.
- Overview of the most important active network components: These are network components that actively affect a signal, for example, repeaters, diagnostic repeaters.
- Overview of the most common network structures (topologies)

### Physical connections of industrial networks

PROFIBUS devices can be networked in industrial plants in two different physical ways:

- By means of electrical signals via copper cables
- By means of optical signals via fiber-optic cables

## Selection criteria for networking

The table below includes selection criteria for electrical and optical networking of PROFIBUS devices:

Table 2- 3 Selection criteria for electrical and optical networking

| Criteria                                     |                        | Electrical PROFIBUS                        | Optical network with OLM  | Optical network with OBT  |
|----------------------------------------------|------------------------|--------------------------------------------|---------------------------|---------------------------|
| Transmission medium                          | Shielded two-wire line | •                                          | –                         | –                         |
|                                              | POF                    | –                                          | •                         | •                         |
|                                              | PCF                    | –                                          | •                         | •                         |
|                                              | Glass                  | –                                          | •                         | –                         |
| Distances                                    | Max. network span      | PROFIBUS DP: 9.6 km<br>PROFIBUS PA: 1.9 km | 90 km                     | 9.6 km                    |
|                                              | Between two devices    | up to 1 km <sup>1)</sup>                   | up to 15 km <sup>2)</sup> | up to 300 m <sup>2)</sup> |
| Topology                                     | Bus                    | •                                          | –                         | –                         |
|                                              | Linear                 | –                                          | •                         | •                         |
|                                              | Tree                   | •                                          | •                         | •                         |
|                                              | Ring                   | –                                          | •                         | •                         |
| Transmission protocols                       |                        | DP, PA                                     | DP, PA                    | DP                        |
| Connection of devices by means of            | OLM                    | –                                          | •                         | –                         |
|                                              | Integrated interfaces  | •                                          | –                         | •                         |
|                                              | Bus terminal           | •                                          | –                         | •                         |
|                                              | Bus connector          | •                                          | –                         | –                         |
| Electrical network segments can be connected |                        | •                                          | •                         | –                         |

• Suitable

– Not relevant for this application

1) Depending on data rate and type of service used

2) Depending on cable type used

## Installation guideline for PROFIBUS networks

A PROFIBUS segment must be terminated at the start and end; passively with a connector or actively with a bus terminating resistor.

The same principles apply to the installation of a PROFIBUS network as described in the SIMATIC NET PROFIBUS networks

(<http://support.automation.siemens.com/WW/view/en/35222591>) manual.

## 2.2.1 Passive network components for RS 485 networks

### 2.2.1.1 RS 485 cables

#### Introduction

The following applies to all RS 485 cables for PROFIBUS from Siemens:

- Their double shielding makes them especially suited for laying in industrial environments with electromagnetic interference.
- A continuous grounding concept can be implemented by means of the outer shield of the bus cable and the ground terminals of the bus terminals.
- The imprinted meter marking makes it easier to determine the length (accuracy  $\pm 5\%$ ).

#### RS 485 cables for PROFIBUS

SIMATIC NET PROFIBUS cables are available in different versions which allow optimum adaptation to different areas of application:

- FC Standard Cable GP (bus cable for fixed laying inside buildings)
- FC Standard Cable IS GP (bus cable for hazardous area)
- FC-FRNC Cable GP (bus cable with halogen-free protective jacket for use inside buildings)
- FC Food Cable (bus cable with PE jacket for use in the food and beverage industry)
- FC Robust Cable (bus cable with PUR jacket for environments subject to chemical and mechanical stress)
- FC Ground Cable (ground cable with PE jacket)
- PROFIBUS FC Trailing Cable (trailing cable for tow chains)
- PROFIBUS Festoon Cable (bus cable for festoon mounting)
- PROFIBUS Torsion Cable (torsion-free bus cable for networking movable plant parts, for example, robots)
- PROFIBUS FC Flexible Cable (bus cable for machine parts that are moved infrequently or cabinet doors)
- SIENOPYR-FR ship cable (for permanent laying on ships and off-shore units in all rooms and on open deck)
- PROFIBUS Hybrid Standard Cable (hybrid cable with 2 power wires (1.5 mm<sup>2</sup>) for data and power supply of the ET 200pro)
- PROFIBUS Hybrid Robust Cable (trailable hybrid cable with 2 power wires (1.5 mm<sup>2</sup>) for data and power supply of the ET 200pro)

## Maximum cable lengths

When using copper cables, the maximum size of a PROFIBUS segment depends on the transmission rate.

If these lengths are not sufficient for your application, you can expand the network by using repeaters. You can achieve a maximum size by cascading up to nine repeaters.

Table 2- 4 Maximum cable lengths

| Transmission rate | Maximum cable length of a bus segment | Maximum distance between two stations |
|-------------------|---------------------------------------|---------------------------------------|
| 9.6 to 187.5 kbps | 1000 m                                | 10000 m                               |
| 500 kbps          | 400 m                                 | 4000 m                                |
| 1.5 Mbps          | 200 m                                 | 2000 m                                |
| 3 to 12 Mbps      | 100 m                                 | 1000 m                                |

### 2.2.1.2 PROFIBUS FastConnect system

#### PROFIBUS FastConnect (FC)

PROFIBUS FastConnect is a system for fast and easy fabrication of PROFIBUS copper cables.

The system consists of three components:

- FastConnect bus cables for quick mounting
- FastConnect stripping tool
- FastConnect bus connector for PROFIBUS with insulation displacement method

#### FastConnect bus cables and stripping tool

The special design of the FastConnect bus cables allows for the use of the FastConnect stripping tool to accurately strip away the protective jacket and the braided shield in one step. The connection of the prepared cables takes place in the FastConnect bus connectors using the insulation displacement method.

All PROFIBUS FastConnect bus cables can also be connected to the conventional bus connectors with screw-type terminals.



## Area of application

You need FastConnect bus connectors for PROFIBUS for the following applications:

- Connect devices with an electrical 9-pin D-Sub interface to IEC 61158-2 directly with SIMATIC NET PROFIBUS cables.
- Connect electrical segments or individual devices to the Optical Link Module (OLM) and Optical Bus Terminal (OBT).
- Connect devices or programming devices to the repeater.

## Versions

The FastConnect bus connector in degree of protection IP20 is available in the following versions:

- with integrated terminating resistor and isolating function
- with or without PG socket
- with a cable outlet of 35°, 90° or 180°
- with device category 3G suitable for zone 2 hazardous area

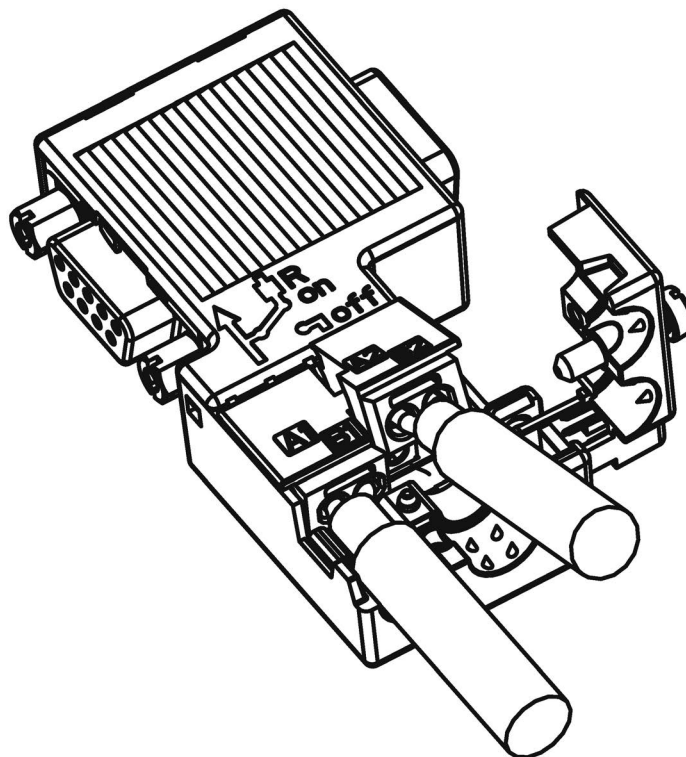


Figure 2-5 Example for PROFIBUS FastConnect bus connector with PG socket, cable outlet 90°

### **Additional information**

For additional information on the available components visit the Siemens Mall (<http://mall.industry.siemens.com>).

#### **2.2.1.3 PROFIBUS bus connector**

##### **Area of application**

You need PROFIBUS bus connectors for the following applications:

- Connect devices with a 9-pin D-Sub interface to IEC 61158-2 directly with the SIMATIC NET PROFIBUS cables.
- Connect electrical segments or individual devices to the Optical Link Module (OLM) and Optical Bus Terminal (OBT).
- Connect devices or programming devices to the repeater.

## Versions

The PROFIBUS bus connector in degree of protection IP20 is available in the following versions:

- with integrated terminating resistor and isolating function
- with or without PG socket
- with a cable outlet of 35°, 90° or 180°
- with device category 3G suitable for zone 2 hazardous area

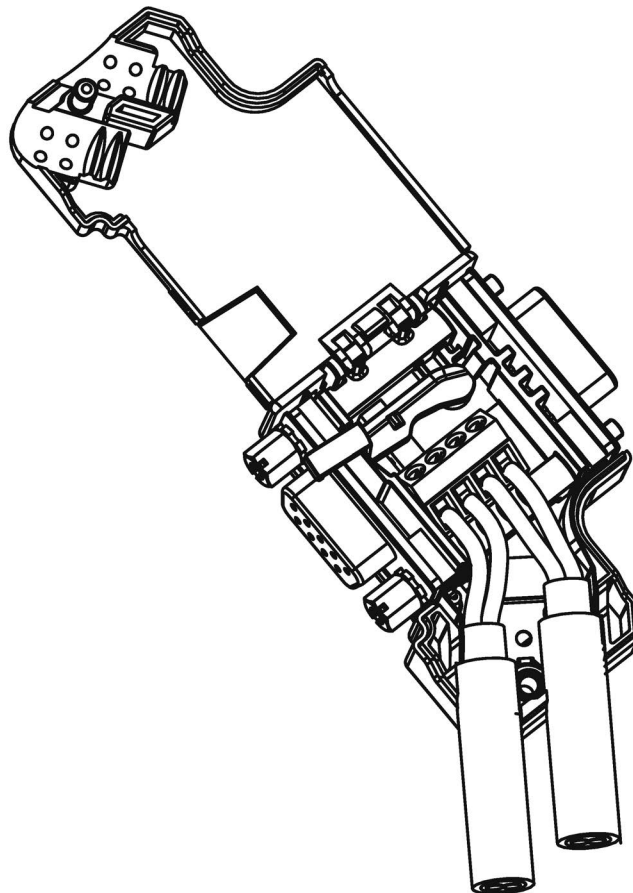


Figure 2-6 Example for PROFIBUS bus connector with PG socket, cable outlet 35°

## Additional information

For additional information on the available components visit the Siemens Mall (<http://mall.industry.siemens.com>).

#### 2.2.1.4 M12 bus connector

##### Area of application

Devices with an electrical M12 interface can use the M12 bus connector for SIMATIC NET PROFIBUS for direct connection with the SIMATIC NET PROFIBUS cables.

The M12 bus connector in degree of protection IP65 is available in the following versions:

- with screw-type terminals
- with insulation displacement termination
- with a cable outlet of 180°

#### 2.2.1.5 Bus terminals for RS 485 networks

##### Bus terminal RS 485 and bus terminal M12

A bus terminal is used for the connection of an individual PROFIBUS station with RS485 interface to the PROFIBUS bus cable.

Bus terminals in degree of protection IP20 are available in the following versions:

- Bus terminal RS 485 with or without PG interface, transmission rate 9.6 kbps to 1.5 Mbps, integrated terminating resistor combination (connectible), with 1.5 m and 3 m connecting cable
- Bus terminal M12, transmission rate 9.6 kbps to 12 Mbps, integrated terminating resistor combination with isolating function, with 1.5 m connecting cable

#### 2.2.1.6 M12 bus terminating resistor

##### Terminating segment with terminating resistor

If there is a station with M12 connection system at the beginning or end of a PROFIBUS segment, you need an M12 bus terminating resistor.

The M12 PROFIBUS connection of a device consists of an M12 socket for the infeed and an M12 male connector to loop-through the bus signal.

This means you need one bus terminating resistor with male contacts (6GK1905-0EC00) and with female contacts (6GK1905-0ED00) for each M12 bus cable.

## 2.2.2 Passive components for optical networks

### 2.2.2.1 Fiber-optic cables

#### Types of fiber-optic cables

Data transmission with fiber-optic cables takes place through modulation of electromagnetic waves in the range of visible and invisible light. These cables are made of high-quality plastic fibers and glass fibers:

- Plastic and PCF fiber-optic cables (Page 26)
- Glass fiber-optic cables (Page 27)

The different types of fiber-optic cables provide solutions matched to the operating and environmental conditions for the connection of components with each other.

#### Benefits

Fiber-optic cables offer the following benefits when compared with electrical cables:

- Galvanic isolation of the devices and segments
- No potential equalization currents
- No impact on transmission path through external electromagnetic interference
- No lightning protection elements required
- No noise radiation along the transmission route
- Low weight
- Depending on the type of fiber you can implement cable lengths up to few kilometers at even higher transmission rates.
- No dependency of the maximum permitted distances on the transmission rate

#### Additional information

Additional information of the properties and technical specifications of the passive components and connectors for fiber-optic cables is available in the PROFIBUS network manual (<http://support.automation.siemens.com/WW/view/en/35222591>).

### **2.2.2.2 Plastic and PCF fiber-optic cables**

#### **Plastic and PCF fiber-optic cables**

Plastic (POF) and PCF fiber-optic cables are used for the connection of Optical Link modules with connections for plastic fiber-optic cables (OLM/P), Optical Bus Terminal (OBT) and devices with integrated optical interfaces. Under certain conditions, they are an inexpensive alternative to conventional glass fiber-optic cables.

#### **Plastic Fiber Optic duplex core**

The plastic fiber-optic duplex core is a flat dual core with PVC inner jacket without protective jacket. The cable can be easily assembled on-site.

The cable is intended for indoor applications with low mechanical loads or inside cabinets. For OLM connections and with integrated optical interfaces you cover a length of up to 50 m between two devices with this cable.

#### **Plastic Fiber Optic standard cable**

The plastic fiber optic standard cable consists of two plastic fibers with robust polyamide inner jacket surrounded by Kevlar tensile elements and a purple PVC protective jacket. The cable can be easily assembled on-site.

The robust round cable is suited for indoor applications. The maximum distance that can be covered is 80 m for OLM/P connections and 50 m with integrated optical interfaces and OBT.

#### **PCF Standard Cable**

The pre-assembled PCF Standard Cable consists of two PCF fibers surrounded by Kevlar tensile elements and a purple PVC protective jacket. It is always supplied with a pulling aid installed on one end to pull in the cable channels.

The robust round cable is suited for indoor applications with cable lengths up to 400 m (OLM) or 300 m (integrated optical interfaces, OBT) between two devices.

#### **PCF Standard Cable GP**

The PCF Standard Cable GP consists of two PCF fibers surrounded by Aramid tensile elements and a green PVC protective jacket. The cable is pre-assembled and can be ordered by the meter. It is supplied with a pulling aid installed on one end to pull in the cable channels.

The robust round cable is suited for indoor and outdoor applications with cable lengths up to 400 m (OLM) or 300 m (integrated optical interfaces, OBT) between two devices.

### PCF Trailing Cable

The PCF Trailing Cable consists of two PCF fibers surrounded by Aramid tensile elements and a green PUR protective jacket. The cable is pre-assembled and can be ordered by the meter. It is supplied with a pulling aid installed on one end to pull in the cable channels.

The robust round cable is suited for moving indoor and outdoor applications with cable lengths up to 400 m (OLM) or 300 m (integrated optical interfaces, OBT) between two devices.

### PCF Trailing Cable GP

The PCF Trailing Cable GP consists of two PCF fibers surrounded by Aramid tensile elements and a green PVC protective jacket. The cable is pre-assembled and can be ordered by the meter. It is supplied with a pulling aid installed on one end to pull in the cable channels.

The robust round cable is suited for moving indoor and outdoor applications with cable lengths up to 400 m (OLM) or 300 m (integrated optical interfaces, OBT) between two devices.

## 2.2.2.3 Glass fiber-optic cables

### Glass fiber-optic cables

Glass fiber-optic cables are suitable for connection of optical interfaces that work in the wavelength range around 850 nm and around 1300 nm. They include two graded-index multimode fibers of the type 62.5/125  $\mu\text{m}$ .

The glass fiber-optic cables are available in different versions which makes for an optimum adaptation to different areas of application:

- Fiber Optic standard cable
- INDOOR Fiber Optic indoor cable
- Flexible Fiber Optic trailing cable

### Fiber Optic standard cable

The standard cable is the universal cable for indoor and outdoor use.

### INDOOR Fiber Optic indoor cable

The indoor cable is intended for weather-proof indoor use. It is halogen-free, non-crush and flame-retardant.

### **Flexible Fiber Optic trailing cable**

The trailing cable was designed for the special application of forced movement, for example, for constantly moved machine parts such as trailing chains. It is mechanically designed for 100,000 bending cycles by  $\pm 90^\circ$  (with the specified minimum radius). Integrated dummy elements ensure a round cross-section of the cable. The trailing cable can be used indoors and outdoors.

### **Maximum distances between two optical link modules**

The following distances may not be exceeded between two OLMs regardless of the optical power budget:

- OLM/P11, OLM/P12: 400 m
- OLM/G11, OLM/G12, OLM/G12-EEC: 3 km
- OLM/G11-1300, OLM/G12-1300: 15 km

### **Additional information**

All operating instructions (<http://support.automation.siemens.com/WW/view/en/10805951/133300>) of the SIMATIC NET bus components include information on distances that can be covered with the SIMATIC NET glass fiber-optic cables. You can configure your optical network without any calculations using simple limits.



## 2.2.3 Active network components

### 2.2.3.1 Network components in electrical networks

#### Active network components

The following active network components are available for PROFIBUS in electrical networks:

- Repeater RS485
- Diagnostics repeater
- PROFIBUS Terminator
- DP/DP coupler
- IE/PB Link PN IO
- IWLAN/PB Link PN IO
- Active components for the connection of CAN
- Active components for the gateway between PROFIBUS and AS-Interface
  - DP/AS-i LINK Advanced
  - DP/AS-Interface Link 20E
  - DP/AS-i F-Link

#### RS485 repeater

The RS485 IP20 repeater connects two PROFIBUS bus segments in RS485 technology with up to 32 devices. It provides transmission rates from 9.6 kbps to 12 Mbps.

The RS485 repeater refreshes a signal regarding amplitude, signal width and edge steepness between two segments. It is used when more than 32 stations are connected to the bus or the maximum cable length of a segment is exceeded.

Bus segments can be operated ungrounded (galvanic isolation of segments) with an RS485 repeater.

#### Diagnostics repeater

The diagnostic repeater connects three PROFIBUS segments in RS485 technology, two of which are diagnostics-capable segments with 31 devices each. It is designed as DP slave to send diagnostics alarms to the DP master.

The diagnostic function provides the location and the cause of cable faults, such as wire break or missing terminating resistors. The fault location is indicated relative to the existing devices.

The diagnostics repeater refreshes a signal regarding amplitude, signal width and edge steepness between the segments. The cascading depth between any two PROFIBUS devices is limited to nine diagnostics repeaters.

## PROFIBUS Terminator

The PROFIBUS Terminator forms an active bus termination. Bus devices can be switched off, removed or replaced without affecting data transmission. This is particularly true for bus devices on both ends of the bus cable at which terminating resistors must be connected or supplied. The PROFIBUS Terminator can be mounted on a standard mounting rail.

## IE/PB Link PN for the connection of a PROFIBUS segment to an Industrial Ethernet network

The IE/PB Link PN IO as independent component provides the seamless transition between Industrial Ethernet and PROFIBUS. Through the use of IE/PB Link PN IO as substitute on the Ethernet, the existing PROFIBUS devices can continue to be used and can be integrated into a PROFINET application.

A PROFINET IO controller is required for this configuration. The IE/PB Link PN acts as master on the PROFIBUS end.

## IWLAN/PB Link PN IO as gateway between LAN and PROFIBUS

PROFIBUS devices can be coupled to PROFINET IO by means of IWLAN/PB Link PN IO. This means you can integrate existing PROFIBUS configurations into PROFINET.

The IWLAN/PB Link PN IO supports the use of IWLAN and WLAN antennas for wireless data transmission, for example, in suspended monorail systems or conveyor systems. Because of the PROFINET support, the numerous PROFIBUS system services, for example, diagnostics by bus, can continue to be used.

A PROFINET IO controller is required for this configuration. The IWLAN/PB Link PN IO acts as master on the PROFIBUS end.

## CANopen module for connection to CAN

You can use the CANopen module to easily connect CANopen applications to PROFIBUS.

Typical areas of application:

- Control of hydraulic valves/hydraulic axes in vehicles
- Control of motors in packaging machines and on conveyor belts
- Use in wind turbines for detection of angular encoders
- Detection of HMI devices on machines, e.g., joysticks
- Detection of measured data from displacement transducers, inclination sensors or angle encoders on tower cranes or gantry cranes

## DP/DP coupler for connection of two PROFIBUS networks

The PROFIBUS DP/DP coupler is used to connect two PROFIBUS DP networks. Data (0 to 244 bytes) is transmitted from the DP master of the first network to the DP master of another network and vice versa.

The DP/DP coupler comes equipped with two independent DP interfaces that establish the connection to the two DP networks. There is one slave at each DP network. The data exchange between the two DP networks takes place by internal copying in the coupler.

## DP/PA bus link for connection of PROFIBUS PA

The DP/PA bus link is the connection between PROFIBUS DP and PROFIBUS PA. This means it connects the process control systems with the field devices of the process automation.

The following components are available for a DP/PA bus link:

- DP/PA coupler Ex [ia]
- DP/PA coupler FDC 157-0
- Interface module IM 153-2 for establishing a DP/PA link.
- Active field distributor AFDiS for hazardous areas

## Active components for the gateway between PROFIBUS and AS-Interface

- **DP/AS-i LINK Advanced:**

The **DP/AS-i LINK Advanced** is PROFIBUS DPV1 slave (according to IEC 61158-2/EN 61158-2) and AS-Interface master (according to AS-Interface specification V3.0 according to EN 50295) and provides transparent data access to AS-Interface from PROFIBUS DP.

PROFIBUS DP masters can cyclically exchange I/O data with the AS-Interface; DP masters with acyclic services can also make AS-Interface master calls. The **DP/AS-i LINK Advanced** is particularly suited for distributed configurations and for the connection of a subordinate AS-Interface network.

The DP/AS-i LINK Advanced in the version as AS-Interface single master is completely sufficient for applications with typical configuration limits.

For applications with high configuration limits, the DP/AS-i LINK Advanced is used as AS-Interface double master. In this case, the duplicate configuration limits can be used on two independently running AS-Interface strands.

- **DP/AS-Interface Link 20E:**

The DP/AS-Interface Link 20E is PROFIBUS DP slave (in accordance with EN 61158) and AS-Interface master (in accordance with AS-Interface specification V3.0 according to EN 50295) and supports operation of the AS-Interface on PROFIBUS DP.

Single PROFIBUS masters can cyclically exchange I/O data with the AS-Interface; masters with acyclic services can exchange I/O data and make master calls.

- **DP/AS-i F-Link:**

The DP/AS-i F-Link is PROFIBUS DP-V1 slave (according to EN 61158) and AS-i master (according to AS-Interface specification V3.0 to EN 50295) and provides transparent data access to AS-Interface from PROFIBUS DP. The DP/AS-i F-Link is also the only AS-i master that can forward safety-oriented input data of ASIsafe slaves to a fail-safe CPU with PROFIBUS DP master by means of the PROFIsafe protocol. Additional safety cabling or monitoring is not required (in particular, no AS-Interface safety monitor). Depending on the slave type, you can transmit binary values or analog values. All slaves according to AS-Interface specification V2.0, V2.1 or V3.0 can be operated as AS-i slaves.

As fully-featured AS-i master according to specification V3.0, you can use higher configuration limits on the AS-i network (496 inputs and outputs each, up to 62 digital or analog slaves).

### Additional information

Information on the components is available in the Siemens Mall (<http://mall.industry.siemens.com>).

Additional information is available in these manuals:

- PROFIBUS Network Manual (<http://support.automation.siemens.com/WW/view/en/35222591>)
- Diagnostic repeater (<http://support.automation.siemens.com/WW/view/en/7915183>)
- DP/DP Coupler (<http://support.automation.siemens.com/WW/view/en/1179382>)
- SIMATIC NET Twisted-Pair and Fiber-Optic Networks (<http://support.automation.siemens.com/WW/view/en/8763736>)
- Basics on Setting up an Industrial Wireless LAN (<http://support.automation.siemens.com/WW/view/en/9975764>)
- SIMATIC bus links, DP/PA coupler, active field distributors, DP/PA Link and Y Link (<http://support.automation.siemens.com/WW/view/en/1142696>)
- Information on the CANopen module is available on the Internet (<http://www.hms-networks.com/can-for-et200s>).
- DP/AS-interface LINK Advanced (<http://support.automation.siemens.com/WW/view/en/22502958/133300>) manual
- DP/AS-i F-Link (<http://support.automation.siemens.com/WW/view/en/24196041>) manual

### See also

Topology with RS485 repeater (Page 35)

OLM topology (Page 40)

WLAN topology (Page 40)

Connecting PROFIBUS to PROFINET (Page 41)

### 2.2.3.2 Network components in optical networks

#### Active network components

The following active network components are available for PROFIBUS in optical networks:

- Optical Link Module OLM
- Optical Bus Terminal OBT

#### Optical Link Module OLM

You can use the PROFIBUS Optical Link Modul OLM to install PROFIBUS networks in line, star structure and redundant ring structure.

The transmission rate of a fiber-optic cable line does not depend on the distance and can be 9.6 kbps to 12 Mbps.

Applications for OLM include, for example, plant buses on PROFIBUS base, networking across buildings using glass fiber-optic cables, mixed networks with electrical and optical segments, large networks (road tunnels, traffic guidance systems) and networks with high demands on availability (redundant ring networks).

Optical Link modules can be combined by means of an RS485 interface and individual devices or entire electrical segments can be integrated into the optical PROFIBUS network.

The following distances may not be exceeded between two OLMs regardless of the optical power budget:

- OLM/P11, OLM/P12: 400 m
- OLM/G11, OLM/G12, OLM/G12-EEC: 3 km
- OLM/G11-1300, OLM/G12-1300: 15 km

#### Optical Bus Terminal OBT (optical bus terminal)

The Optical Bus Terminal connects an individual PROFIBUS device without integrated optical interface or a PROFIBUS RS 485 segment with up to 31 devices to an optical PROFIBUS.

An individual PROFIBUS DP device is connected with its RS 485 interface by means of a PROFIBUS cable with integrated terminating resistor, for example, connecting cable 830-1T, to the RS 485 interface of the OBT. The OBT is integrated into the optical line by means of two optical interfaces.

The following optical transmission media can be connected to the OBT:

- Plastic fiber-optic cable up to 50 m single distance length. They can be assembled on-site with two 2x2 Simplex connectors.
- PCF fiber-optic cable up to 300 m single distance length. The cables are delivered pre-assembled.

### **Additional information**

Information on the components is available in the Siemens Mall (<http://mall.industry.siemens.com>).

Additional information is available in these manuals:

- PROFIBUS network manual  
(<http://support.automation.siemens.com/WW/view/en/35222591>)
- SIMATIC NET PROFIBUS, Optical Link Module  
(<http://support.automation.siemens.com/WW/view/de/56606534/0/en>)
- SIMATIC NET Twisted-Pair and Fiber-Optic Networks  
(<http://support.automation.siemens.com/WW/view/en/8763736>)

## 2.2.4 Examples for topology

### 2.2.4.1 Topology with RS485 repeater

#### Configuration options with the RS485 repeater

You can operate the RS485 repeater in the following configurations:

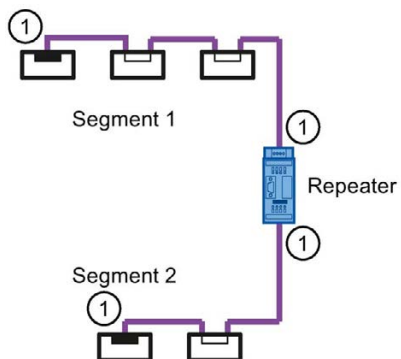


Figure 2-7 Segment 1 and segment 2 connected to RS485 repeater

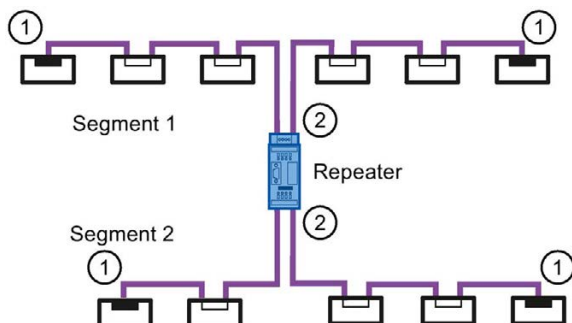


Figure 2-8 Segment 1 and segment 2 looped-through to RS485 repeater

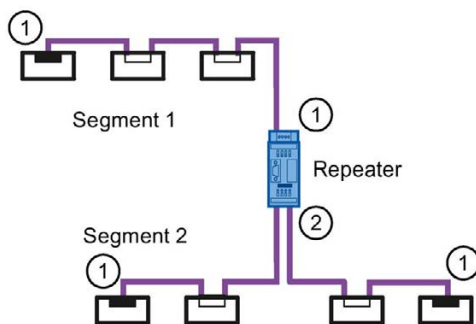


Figure 2-9 Segment 1 connected to RS485 repeater and segment 2 looped-through to RS485 repeater

- ① Connect terminating resistor
- ② Do not connect terminating resistor

## Configuration example

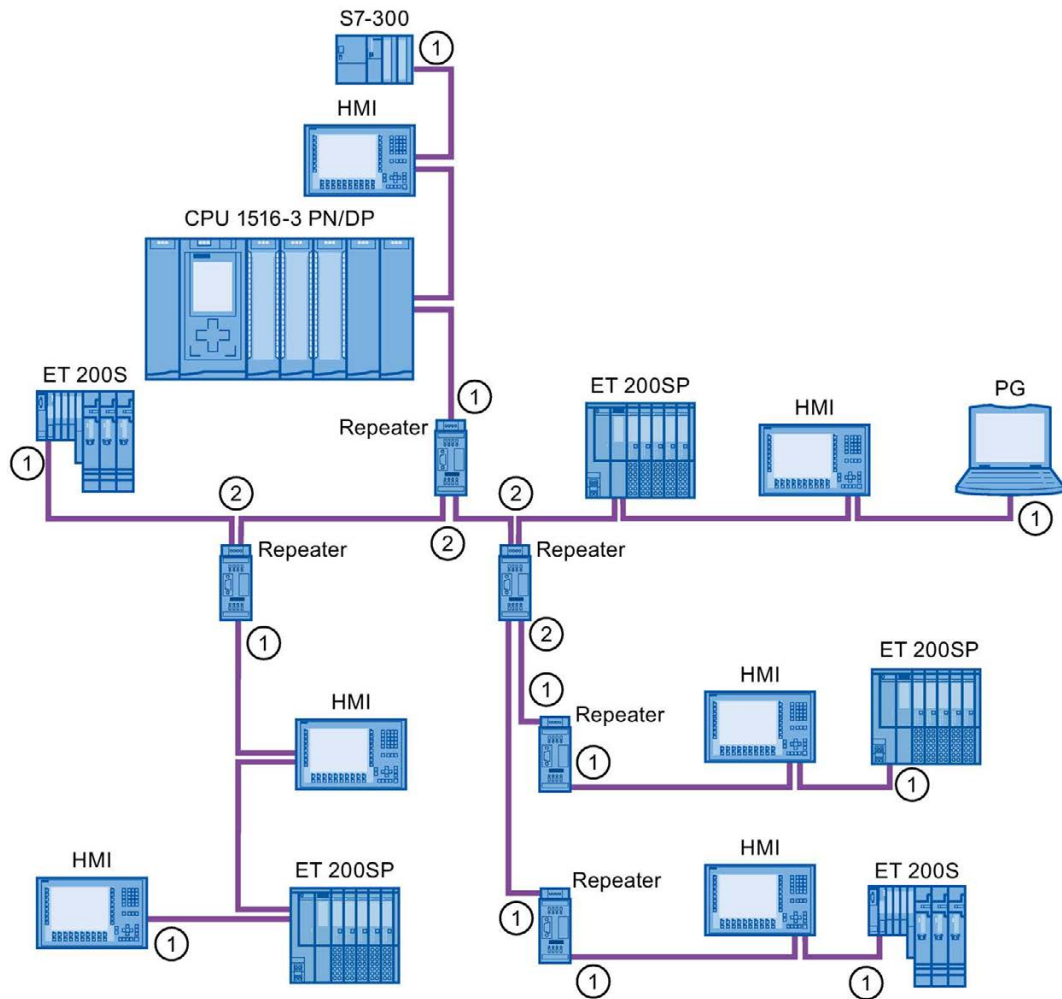


Figure 2-10 Configuration example with five RS485 repeaters

- ① Connect terminating resistor
- ② Do not connect terminating resistor

## Maximum configuration

If you install a PROFIBUS network with RS485 repeaters, you may not connect more than nine RS485 repeaters in series.



### 2.2.4.2 Topology with diagnostic repeater

#### Diagnostic repeater with three segments

You may not exceed the maximum permitted cable length of 100 m per segment that can be monitored for the diagnostic repeater. The segments connected to DP2 and DP3 are diagnostics-capable. The cable length that can be monitored is limited for some cable types.

#### Maximum cascade depth

You can connect up to nine diagnostic repeaters in series between any two PROFIBUS stations.

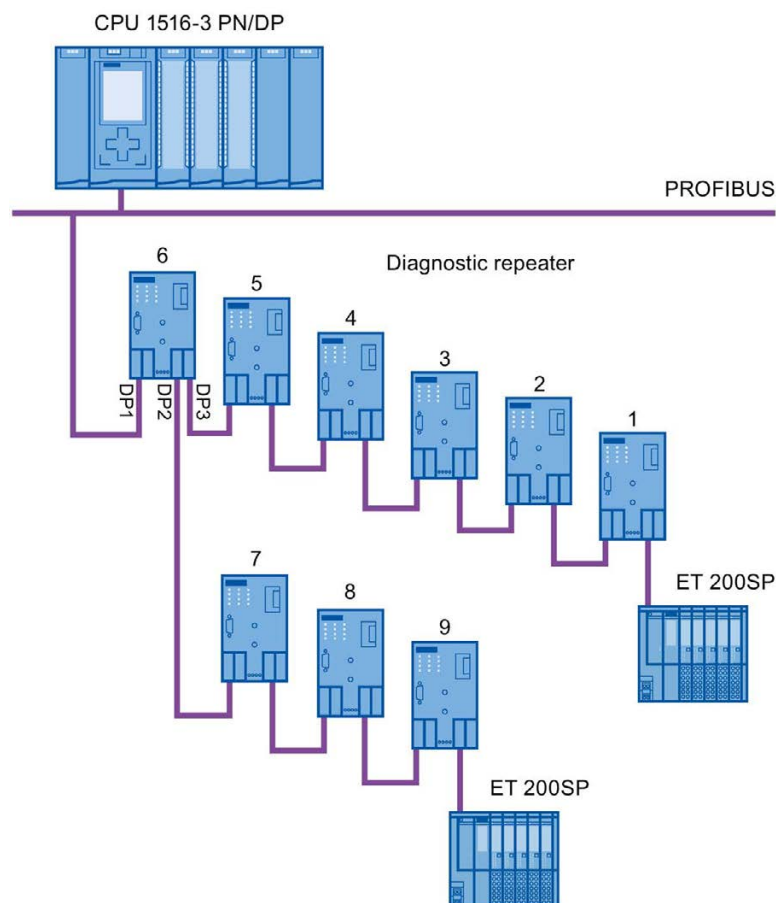


Figure 2-11 Schematic layout of a PROFIBUS network with maximum possible cascade depth at diagnostic repeaters

**Example: Maximum cascade depth exceeded**

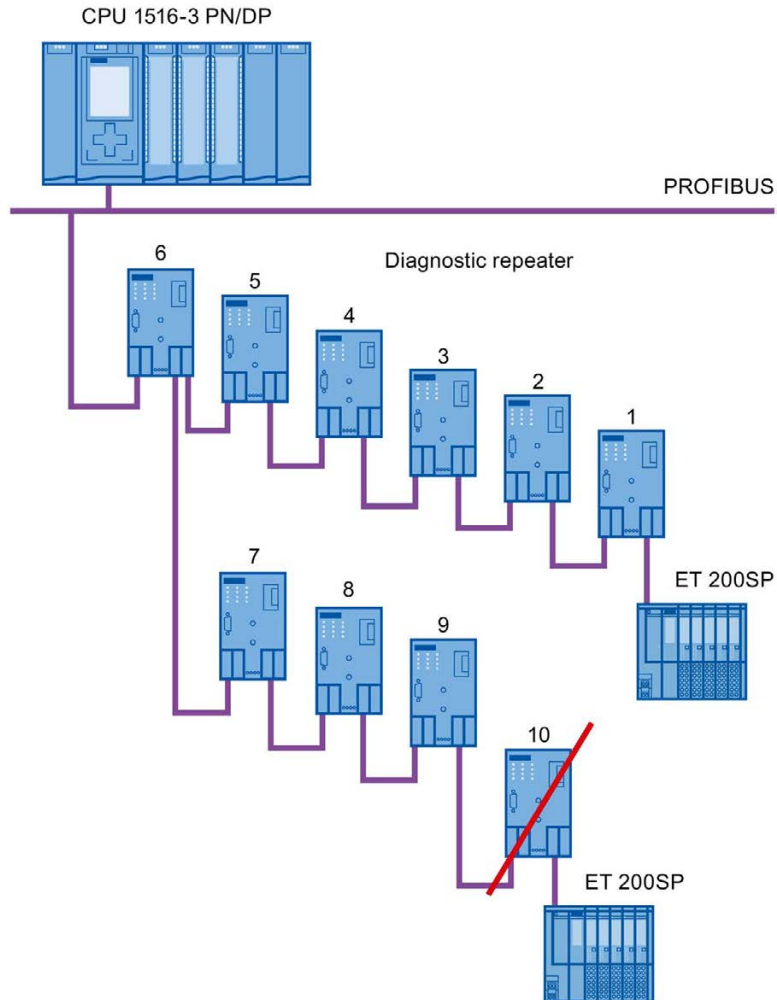


Figure 2-12 Maximum cascade depth exceeded

### Layout with several segments

You can increase the number of used diagnostic repeaters by using several segments. The example shows a layout in which the maximum cascade depth is exceeded at two segments.

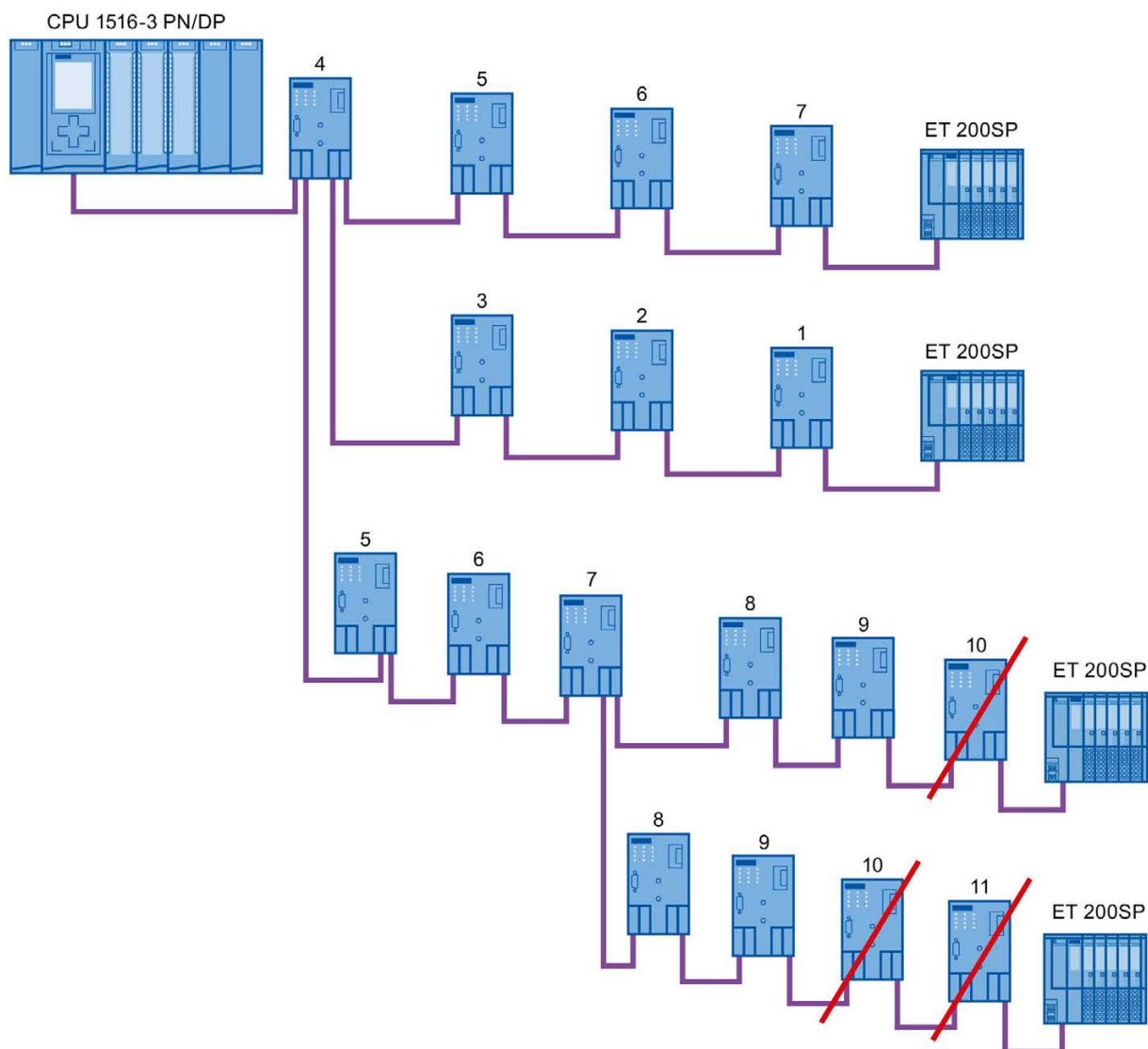


Figure 2-13 Layout with several segments, maximum cascade depth exceeded

### Additional information

Additional information is available in the Diagnostic Repeater (<http://support.automation.siemens.com/WW/view/en/7915183>) manual.

### 2.2.4.3 OLM topology

#### Combination of electrical and optical networks with OLM

Additional distances can be covered by means of the Optical Link Module.

Because bus cables across several buildings are particularly vulnerable to damage caused by overvoltage (effect of lightning), the devices in the connected bus segment must be protected against overvoltage.

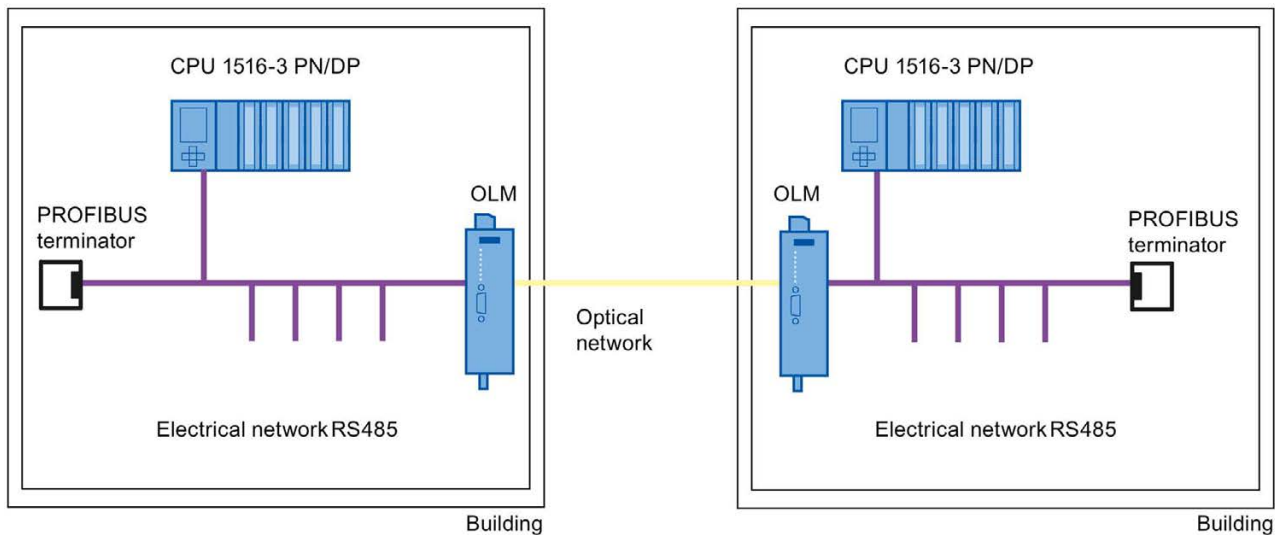


Figure 2-14 Combination of electrical and optical networks

### 2.2.4.4 WLAN topology

#### IWLAN/PB Link PN IO as gateway between Industrial Wireless LAN and PROFIBUS

The IWLAN/PB Link PN IO supports the use of IWLAN and WLAN antennas for wireless data transmission. This means the numerous PROFIBUS system services, for example, diagnostic by bus, can be used throughout.

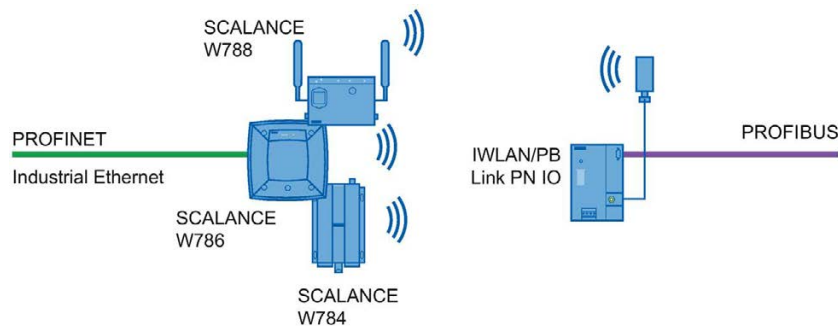


Figure 2-15 PROFIBUS and WLAN

### 2.2.4.5 Connecting PROFIBUS to PROFINET

PROFIBUS can be integrated in PROFINET. In this way, you can set up any hybrid systems consisting of fieldbus and Ethernet-based subsystems. This provides a continuous data exchange.

#### Coupling of PROFIBUS and PROFINET

With a proxy-capable PROFINET device that is equipped with a PROFIBUS interface in addition to a PROFINET interface, you can integrate existing PROFIBUS configurations into the PROFINET configuration.

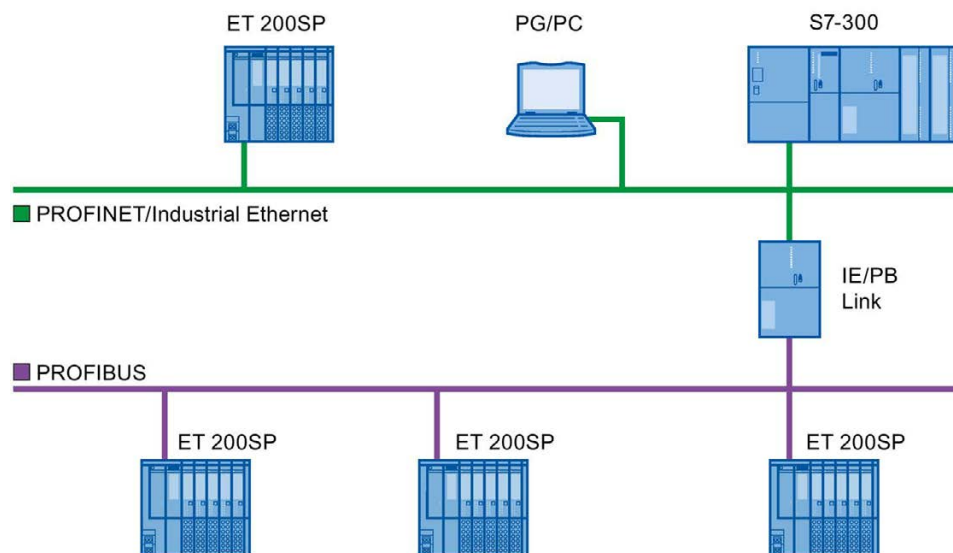


Figure 2-16 Connection of PROFIBUS and PROFINET with IE/PB link

#### PROFINET device with proxy functionality

The PROFINET device with proxy functionality is the substitute for a PROFIBUS device on Ethernet. The proxy functionality allows a PROFIBUS device to communicate not only with its master but also with all devices on PROFINET.

With PROFINET, existing PROFIBUS systems can be integrated into the PROFINET communication with the aid of an IE/PB link. The IE/PB link PN IO then handles communication via PROFINET on behalf of the PROFIBUS components.

## Parameter assignment/addressing

To set up an automation system, you will need to configure, assign parameters and link the individual hardware components. The work needed for this is undertaken in the STEP 7 device, topology and network view.

### Configuration

"Configuring" is understood to mean arranging, setting and networking devices and modules within the device or network view.

A PROFIBUS address is automatically assigned to each module. The addresses can be subsequently modified.

The CPU compares the preset configuration created in STEP 7 with the actual configuration of the plant. Errors can be detected and signaled immediately this way.

The exact procedure for configuring devices is described in detail in the STEP 7 online help.

### Parameter assignment

"Parameter assignment" is understood to mean setting the properties of the components used. The settings for the hardware components and for data exchange are assigned, for example, activating diagnostics, input delay with DI.

The parameters are downloaded into the CPU and transferred to the corresponding modules when the CPU starts up. Modules can be replaced with ease because with SIMATIC CPUs the set parameters are automatically downloaded into the new module during each startup.

### Adjusting the hardware to the project requirements

You need to adapt the hardware if you want to set up, expand or change an automation project. To do this, add hardware components to your layout, link them with existing components, and adapt the hardware properties to the tasks.

The properties of the automation systems and modules are preset so that in many cases you do not have to assign parameters again.

But parameter assignment is required in the following cases:

- You want to change the preset parameters of a module.
- You want to use special functions.
- You want to configure communication connections.

### Basic procedure for creating a PROFIBUS DP system

- Configuration
  - Creating PROFIBUS devices and modules in STEP 7
  - Assigning the DP slave to a DP master (Page 43)
- Optional: Parameter assignment
  - Assigning the PROFIBUS address (Page 45)
  - Making network settings (Page 46)
  - Considering cable configuration (Page 49)
  - Considering additional network devices (Page 51)
  - Bus parameters – creating a user-defined profile (Page 52)
  - Configuring constant bus cycle time (Page 55)

## 3.1 Assigning the DP slave to a DP master

### PROFIBUS DP system

A PROFIBUS DP system consists of a PROFIBUS DP master and its assigned PROFIBUS DP slaves. Once the devices have been placed in the network view or device view, STEP 7 assigns default parameter values to them. Initially, you only have to assign the DP slaves to one DP master.

### Requirement

- The network view of STEP 7 is open.
- A CPU has been placed (e.g., CPU 1516-3 PN/DP).
- A DP slave has been placed (e.g., IM151-1 HF).

## Procedure

To assign DP slaves to a DP master, follow these steps:

1. On the DP slave, use the left mouse button to click on the "Not assigned" link. The "Select DP master" menu opens.
2. Select the DP master in the menu to which you want to assign the DP slave.

**Result:** A subnet with a DP system is created on the CPU. The CPU is now the PROFIBUS DP master. The DP slave is assigned to the DP master.

3. Repeat steps 1 and 2 for all other DP slaves that you want to assign to the DP master.

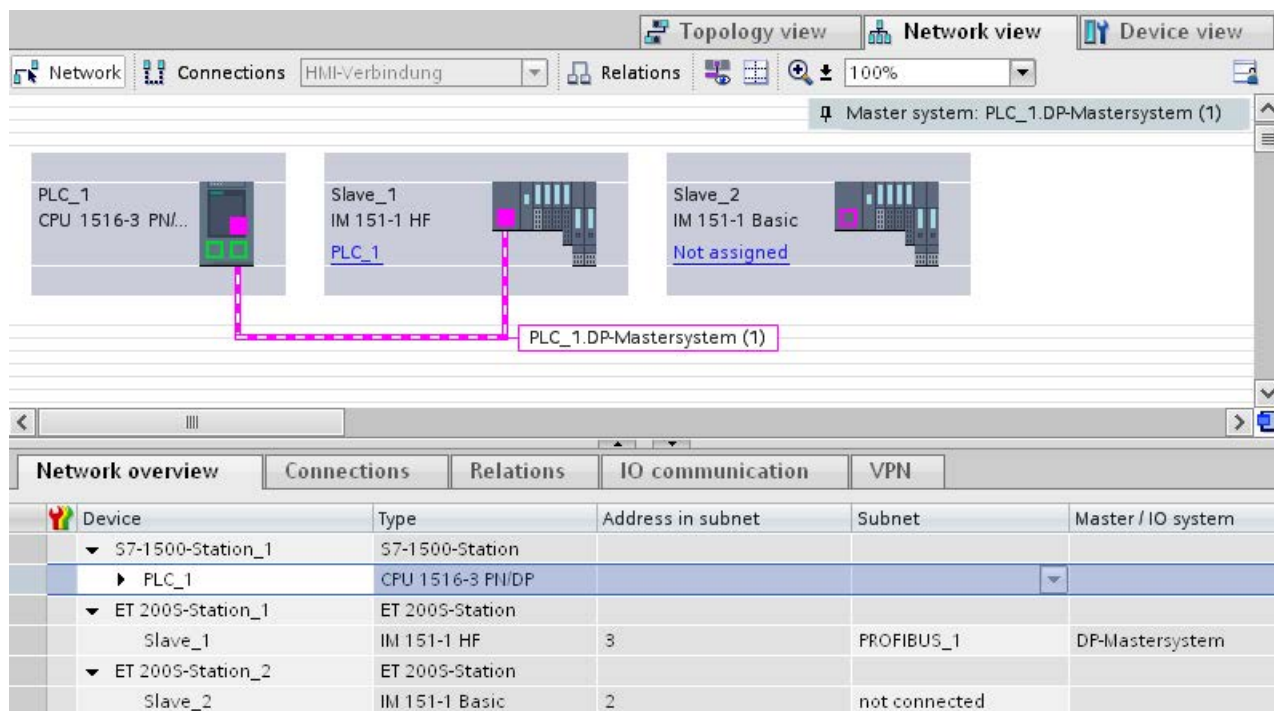


Figure 3-1 Assigning the DP slave to a DP master

## Network overview

You can check the communication relationships of the activated interface in the network overview. The network overview is context-sensitive for selection in the network view:

- The selection of the CPU shows the DP communication of the CPU.
- The selection of the station shows the communication of the entire station.
- The selection of the interface shows the DP communication of the interface.



## 3.2 PROFIBUS address

Devices can be connected to the PROFIBUS subnet that communicate by means of configured connections or that are part of a PROFIBUS DP master system.

If the DP slave has already been assigned to a DP master, the PROFIBUS subnet to which the device is connected is automatically displayed under "Interface linked with".

In the Inspector window under "PROFIBUS", select the subnet to which the interface is linked or add a new subnet.

All devices of a subnet must have different PROFIBUS addresses.

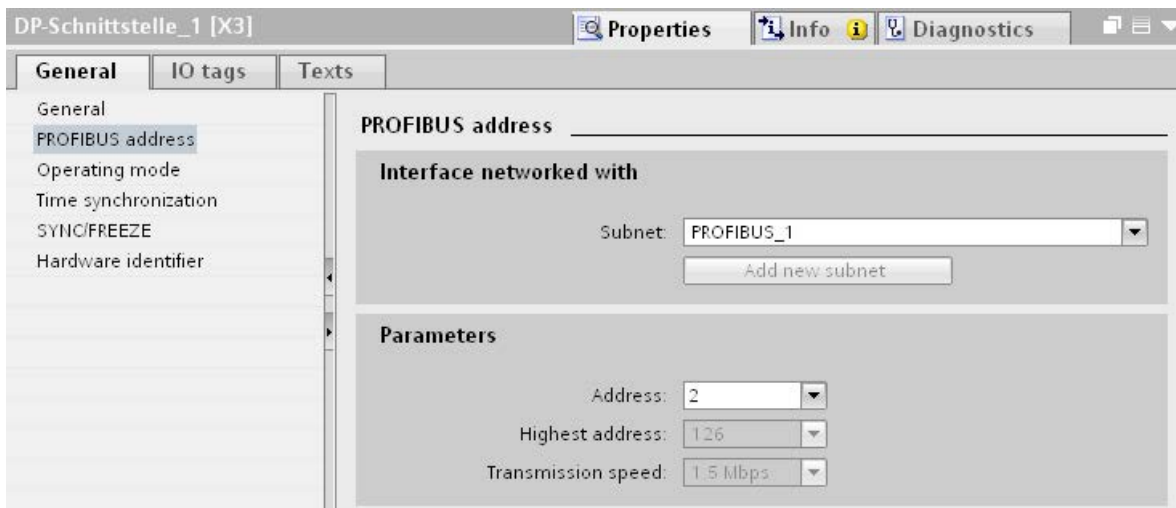


Figure 3-2 PROFIBUS address

### Rules for address assignment

STEP 7 automatically assigns device addresses.

You can change the addresses if you observe the following points:

- Assign a unique PROFIBUS address to each device in the PROFIBUS network, each DP master and each DP slave in the PROFIBUS network.
- Depending on the DP slave, not all permitted PROFIBUS addresses are supported. For devices with BCD switches, it is often the case that only the PROFIBUS addresses 1 to 99 are supported.

### Changing the PROFIBUS address

You change the PROFIBUS address under "Parameter".

### 3.3 Network settings

#### Highest PROFIBUS address (HSA)

Outputs the highest PROFIBUS address of an active device. PROFIBUS addresses greater than HSA are permitted for passive devices, but only up to 126.

#### Profile

Depending on the connected device types and the protocols used, different profiles are available on the PROFIBUS. The profiles differ with respect to their setting options and calculation of the bus parameters.

The PROFIBUS subnet will only work properly if the bus parameters of all devices have the same values.

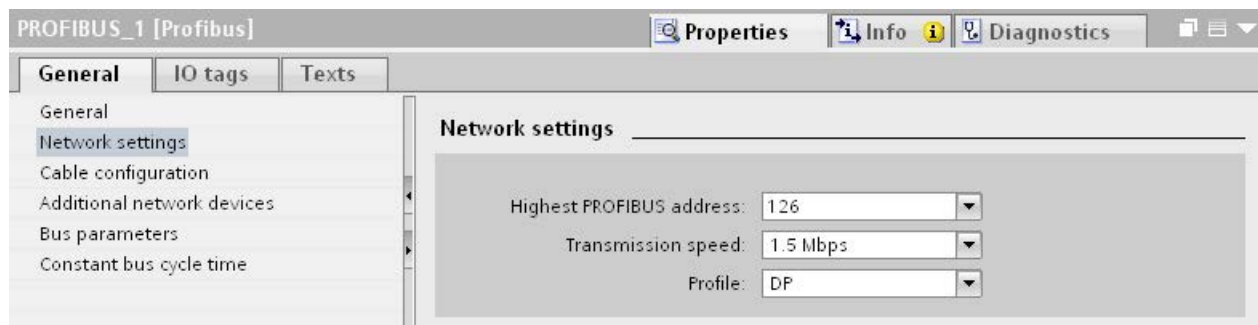


Figure 3-3 Network settings

#### Profiles and transmission rates

Table 3- 1 Profiles and transmission rates

| Profiles                                     | Supported transmission rates |
|----------------------------------------------|------------------------------|
| DP                                           | 9.6 kbps to 12 Mbps          |
| Standard                                     | 9.6 kbps to 12 Mbps          |
| Universal (DP/FMS)<br>(FMS is not supported) | 9.6 kbps to 1.5 Mbps         |
| User-defined                                 | 9.6 kbps to 12 Mbps          |

**DP (recommended profile)**

Select the "DP" profile if only devices meeting the requirements of the standard EN 61158-6-3 are connected to the PROFIBUS subnet. The setting of the bus parameters has been optimized for these devices. These include devices with DP master and DP slave interfaces of SIMATIC S7 as well as distributed I/O devices from third parties.

---

**Note****Profile for constant bus cycle time and isochronous mode**

DP is the recommended profile for the configuration of constant bus cycle time and isochronous mode.

---

**Standard**

Compared with the "DP" profile, the "Standard" profile gives you the option to take into consideration devices of another project or devices that have not been configured here for calculation of the bus parameters. The bus parameters are then calculated with a simple algorithm that was not optimized.

**Universal (DP/FMS) (FMS is not supported)**

Select the "Universal (DP/FMS)" profile if individual devices in the PROFIBUS subnet use the FMS service (e.g., CP 343-5, PROFIBUS FMS devices).

As with the "Standard" profile, here, too, you have the option to take additional devices into consideration for calculation of the bus parameters.

## User-defined

The PROFIBUS subnet will only work properly if the parameters for the profile have been synchronized. Select the "User-defined" profile if none of the other profiles "match" for operation of a PROFIBUS device and if you have to adapt the bus parameters for your special layout.

You cannot configure all theoretically possible combinations with the user-defined profile either. The PROFIBUS standard prescribes some parameter limits depending on other parameters. It is, for example, not permitted that a responder responds (Min Tsdr) before the initiator is able to receive the frame (Trdy). These standard specifications are also checked in the "User-defined" profile.

---

### Note

#### User-defined settings

Use user-defined settings only if you are familiar with the PROFIBUS parameters. It is usually better to work with the "DP" profile.

Contact Customer Support (Page 91) if you have any questions.

The bus parameters that were last valid on the PROFIBUS subnet are automatically set as user-defined. If the "DP" bus profile was valid for the subnet, for example, the bus parameters for "DP" are set in the "User-defined" bus profile. You can modify the parameters based on these settings.

---

The monitoring times are not automatically recalculated in the "User-defined settings" setting so that the uniformity of the set values is not changed without your knowledge, for example, to configure other configuration tools.

You can calculate the monitoring times Ttr and watchdog based on the parameters you have set. To do so, click on the "Recalculate" button.

## See also

Additional network stations (Page 51)

## 3.4 Cable configuration

### Considering cable configuration

Information on the cable configuration can be taken into consideration for calculation of the bus parameters. To do so, select the check box "Take into account the following cable configuration" in the properties of the PROFIBUS subnet.

The other information depends on the type of cable used.

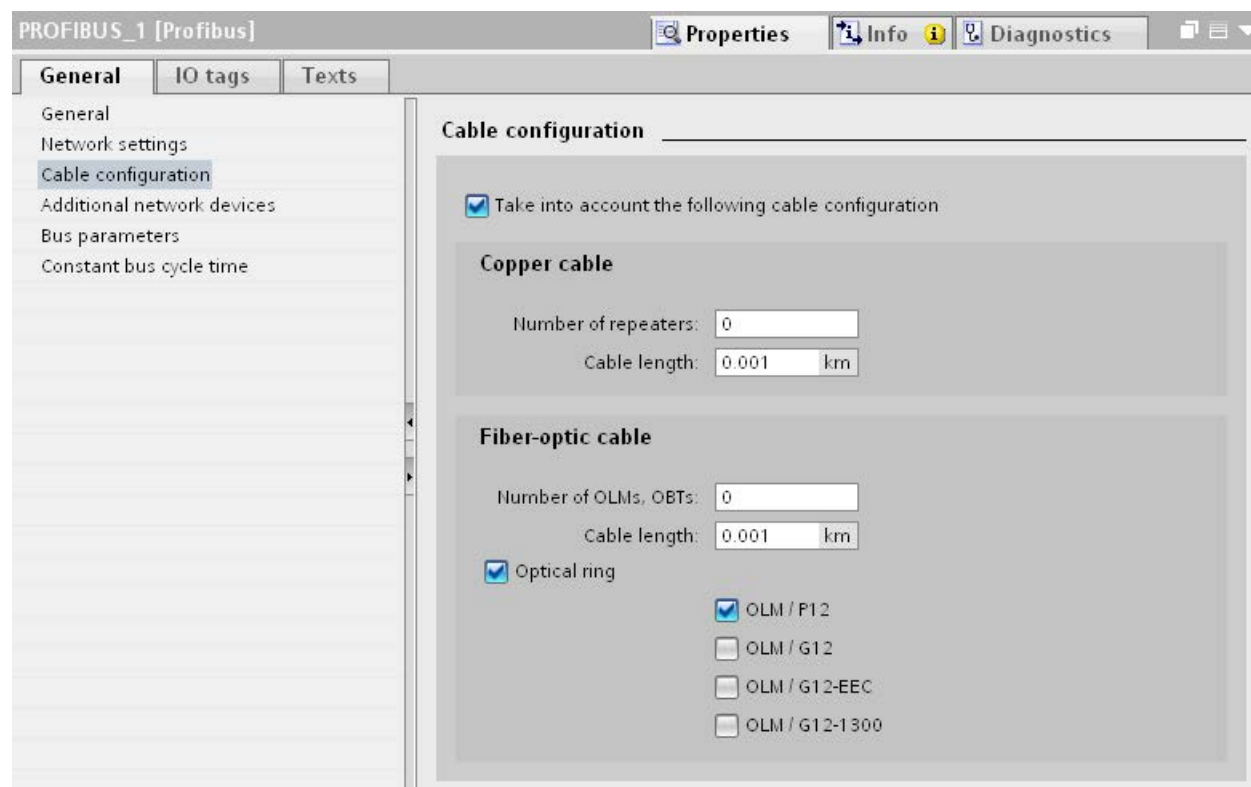


Figure 3-4 Cable configuration

### Cable configuration: Fiber-optic cables/optical ring

The calculation depends on the used OLM types. Select the corresponding check box. Multiple selections are possible.

### Adapting bus parameters in the optical ring

With the layout as ring, there is a kind of redundancy because you have the option to address all devices using the ring structure even if the connection between two devices is interrupted.

The following configuration conditions must be met in the optical ring:

- A free address below HSA (Highest Station Address)
- Increase of the retry value to at least 3  
(Network settings: user-defined profile)
- Checking and adapting of the slot time

(Network settings: user-defined profile; bus parameters: Tslot parameter:

You need short slot time values for OLM / P12, medium slot time values for OLM / G12 and OLM / G12-EEC and high slot time values for OLM / G12-1300. This results in a high performance for small networks and a medium to low performance with medium to large networks.

### Additional information

Additional information on adaptation of the retry value and the slot time is available in the PROFIBUS Network Manual

(<http://support.automation.siemens.com/WW/view/en/35222591>).

## 3.5 Additional network stations

### Communication load - considering additional network stations

The bus parameters depend on the communication volume of the active network stations. There are differences between cyclical communication (DP) and connection-oriented, acyclical communication (S7 communication, Send/Receive (FDL)). Contrary to DP, the number and size of the communication jobs (communication load) depends on the user program. This means the communication load cannot always be determined automatically.

If you select the check box "Consider the following network stations", you can consider network stations in the calculation of the bus times that were not configured in the project.

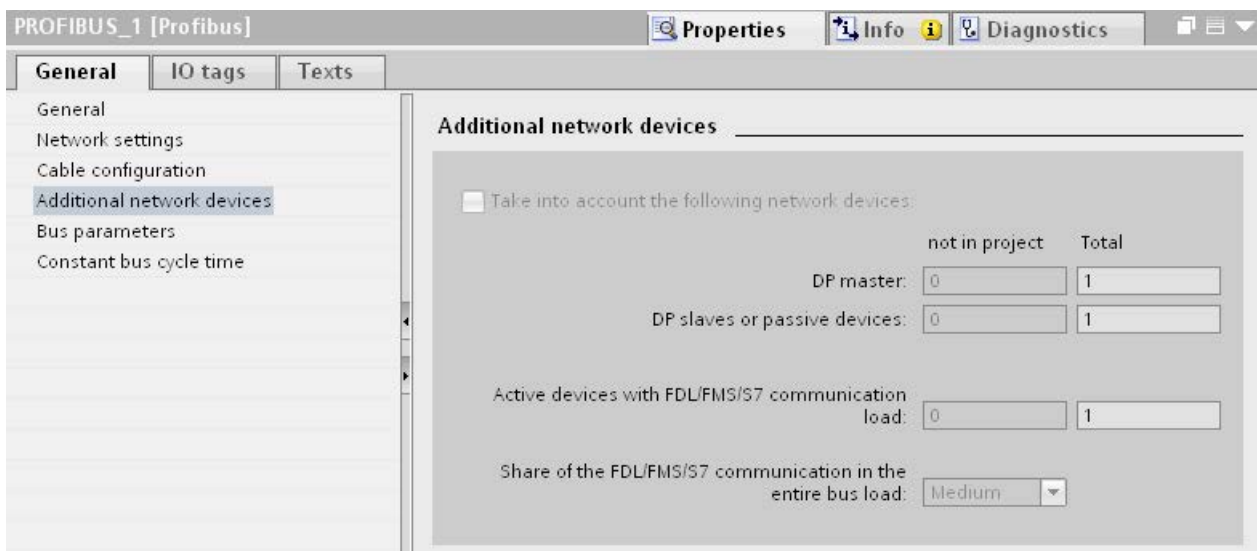


Figure 3-5 Additional network stations

### Calculating the bus times

You can specify a network configuration in the parameter group "Additional network stations" for calculation of the bus times that deviates from the configured network configuration.

The network configuration is available for the following profiles:

- Standard
- Universal (DP/FMS)
- User-defined

### Quantification of the communication load

The following settings are possible to take the communication load into consideration:

- Number of network stations that are not configured
- Information on the communication load from the user programs for FDL or S7 communication. You can choose from the following levels:
  - Low: Typical for DP, no larger data communication except DP.
  - Medium: Typical for mixed operation of DP and other communication services (e.g., S7 communication), if DP has high time requirements and with medium, acyclical communication volume.
  - High: For mixed operation of DP and other communication services (e.g., S7 communication), if DP has low time requirements and with high, acyclical communication volume.

## 3.6 Bus parameters

### Introduction

Bus parameters control the transmission behavior on the bus. Each device on the bus must correspond with the bus parameters of other devices.

---

#### Note

The PROFIBUS subnet will only work properly if the parameters for the bus profile have been synchronized. Change the preset values only if you are familiar with the parameter assignment of the bus profile for PROFIBUS.

---



## Cyclical distribution of the bus parameters

If the check box "Activate cyclical distribution of bus parameters" is selected under "Bus parameters" with the selected PROFIBUS subnet in the Inspector window, the bus parameters are sent cyclically during operation by the modules that support this function. This way you can, for example, connect a programming device to the PROFIBUS during operation.

Disable this function in the following cases:

- In constant bus cycle time mode to minimize the bus cycle.
- If third-party devices are connected in the PROFIBUS subnet whose protocol uses the DSAP 63 (Destination Service Access Point) for multicast.

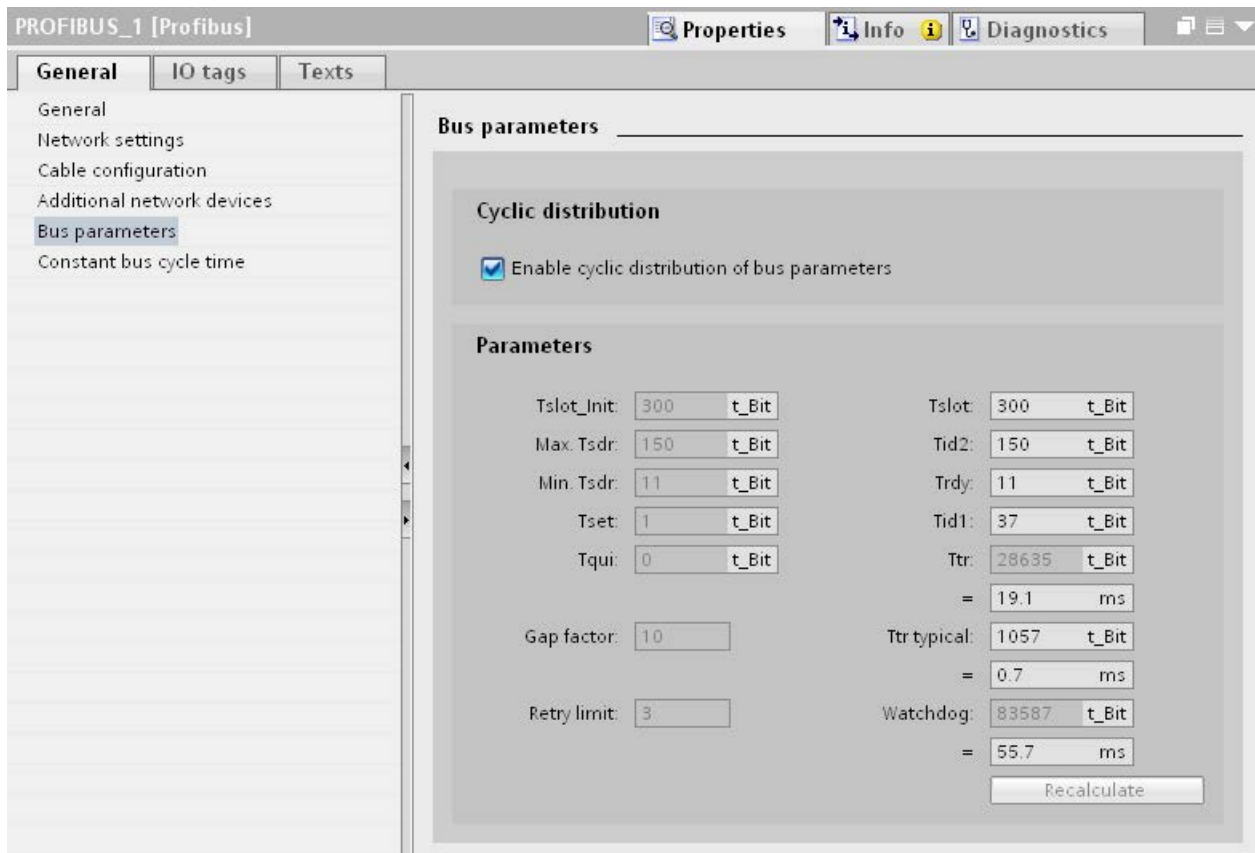


Figure 3-6 Bus parameters

## Bus parameters for the bus profile of PROFIBUS subnets

### Note

#### Display of offline values

The offline values of the bus parameters are always displayed even if they are connected online with the target system.

Table 3-2 Bus parameters - value ranges

| Bus parameters             | Adjustable <sup>1</sup> | Limit values                                                                        |
|----------------------------|-------------------------|-------------------------------------------------------------------------------------|
| Tslot_Init                 | Yes                     | Max. Tsdr + 15 ≤ Tslot_Init ≤ 16.383 t_Bit                                          |
| Max. Tsdr                  | Yes                     | 35 + 2*Tset + Tqui ≤ Max. Tsdr ≤ 1,023 t_Bit                                        |
| Min. Tsdr                  | Yes                     | 11 t_Bit ≤ Min. Tsdr ≤ MIN(255 t_Bit, ...<br>... Max. Tsdr - 1, 34 + 2*Tset + Tqui) |
| Tset                       | Yes                     | 1 t_bit ≤ Tset ≤ 494 t_bit                                                          |
| Tqui                       | Yes                     | 0 t_bit ≤ Tqui ≤ MIN(31 t_bit, Min. Tsdr - 1)                                       |
| GAP factor                 | Yes                     | 1 ≤ GAP factor ≤ 100                                                                |
| Retry limit                | Yes                     | 1 ≤ Retry limit ≤ 15                                                                |
| Tslot ( slot time)         | No                      | -                                                                                   |
| Tid2                       | No                      | Tid2 = Max. Tsdr                                                                    |
| Trdy                       | No                      | Trdy = Min. Tsdr                                                                    |
| Tid1                       | No                      | Tid1 = 35 + 2*Tset + Tqui                                                           |
| Ttr (Target Rotation Time) | Yes                     | 256 t_Bit ≤ Ttr ≤ 16,777,960 t_bit                                                  |
| Ttr typical                | No                      | This time is for information only and is not transmitted to the devices.            |
| Watchdog                   |                         | 10 ms ≤ Watchdog ≤ 650 s                                                            |

<sup>1</sup> depending on bus profile

### User-defined bus profile

Use the following settings to create a user-defined bus profile:

- minimum Target Rotation Time (Ttr) = 5000x HSA (highest PROFIBUS address of an active device)
- minimum watchdog (Watchdog) = 6250x HSA

### Recalculate

Use the button "Recalculate" to recalculate the parameters.

## 3.7 Constant bus cycle time

### Constant bus cycle time

The DP master addresses its assigned DP slaves cyclically. S7 communication may cause the intervals to vary. You can enable a "bus cycle with constant bus cycle time" to achieve identical intervals. This ensures data transmission at the same (constant bus cycle time) intervals.

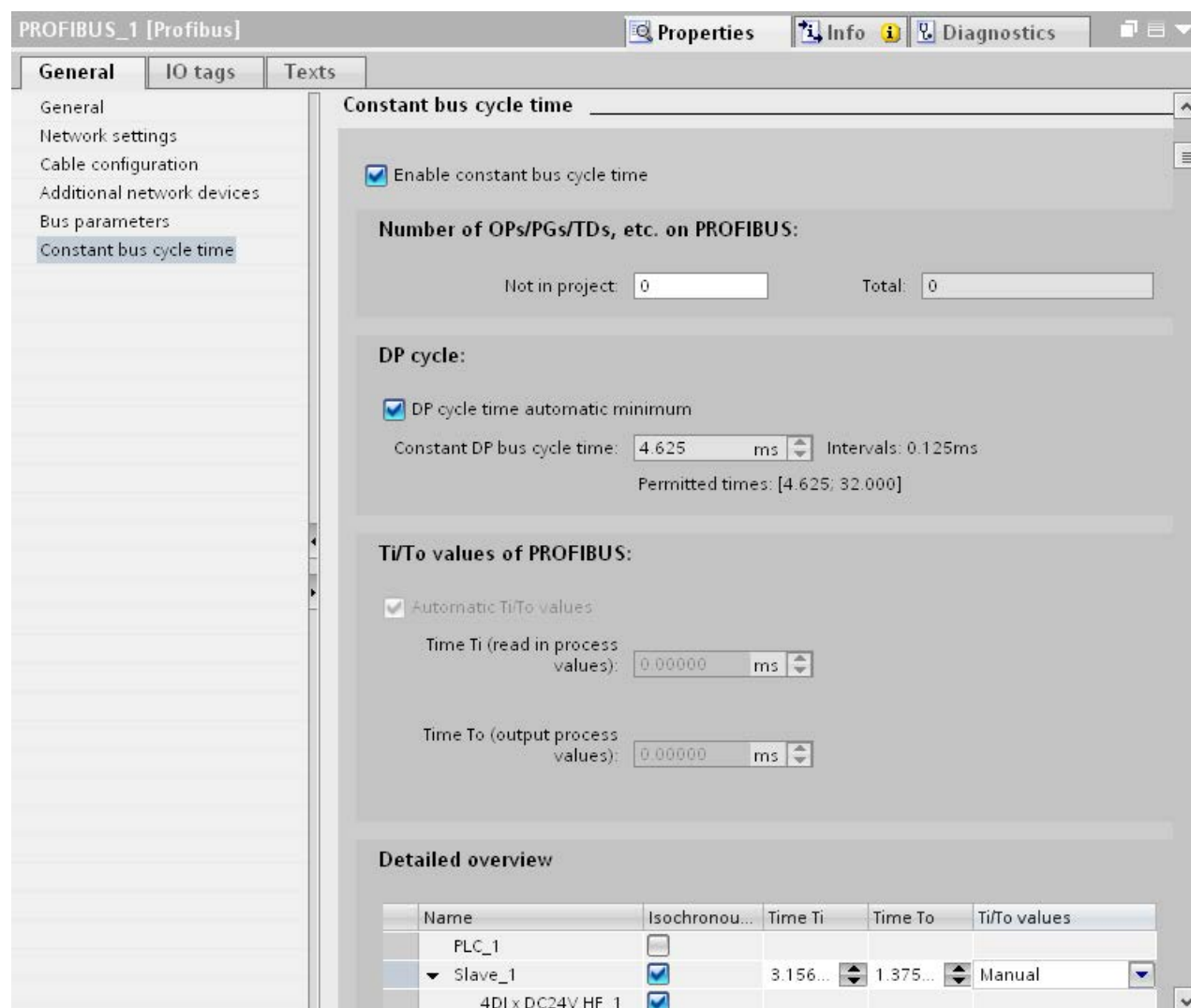


Figure 3-7 Enabling a bus cycle with constant bus cycle time

### Number of OPs/PGs/TDs at the PROFIBUS

Here you enter the number of devices that are not configured.

### **Increasing DP cycle time manually**

The following situation can occur especially with very short DP cycle times:  
The runtime of the user program is greater than the shortest cycle (see Technical specifications of the CPU, section "Isochronous mode"). You have to manually increase the automatically calculated DP cycle time in this case.

### **See also**

Configuring isochronous mode (Page 67)

# Diagnostics

## 4.1 Overview

### Diagnostics options

In case of an error you can determine the current status of your automation system and react specifically by using the event-related diagnostics and the evaluation of interrupts.

You can use the following options for diagnostics of the PROFIBUS components:

- Determine the status of the system using the Lifelist in STEP 7.
- Evaluate the module status, error and message texts by using the display of the S7-1500 CPU.
- Run cable diagnostics during operation by means of the diagnostics repeater.
- Evaluate the diagnostics and interrupt behavior in isochronous mode. (Page 70)
- Determine status information for fault localization and fault rectification by using the DP/PA coupler FDC 157-0 configured as PROFIBUS diagnostics slave.

### Additional information

Additional information on diagnostics is available in these manuals:

- In the Diagnostics repeater for PROFIBUS-DP (<http://support.automation.siemens.com/WW/view/en/7915183>) manual for diagnostics with STEP 7, diagnostics in the user program, monitoring function isochronous PROFIBUS, topology display in STEP 7.
- In the Diagnostics (<http://support.automation.siemens.com/WW/view/en/59192926>) function manual for diagnostics options that are available for the SIMATIC systems S7-1500, ET 200MP, ET 200SP and ET 200AL.
- In the PROFIBUS Network Manual (<http://support.automation.siemens.com/WW/view/en/35222591>) system manual for diagnostics of fiber-optic cables.
- In the DP/PA Coupler, Active Field Distributors, DP/PA Link and Y Link (<http://support.automation.siemens.com/WW/view/en/1142696>) operating instructions.
- In the Web Server (<http://support.automation.siemens.com/WW/view/en/59193560>) function manual for diagnostics options (based on the functionality of the CPU).

## 4.2 Diagnostics using the display of the S7-1500

### Displays

Each CPU in the S7-1500 automation system has a front cover with a display and operating buttons. Control and status information is displayed in different menus on the display. You use the operating buttons to navigate through the menus.

The following states can be evaluated on the display:

- Module status for central and distributed modules
- Error and alarm texts (system diagnostics, user-defined alarms)

### Module status

From the station overview you go to the module status for a distributed module via the module overview.

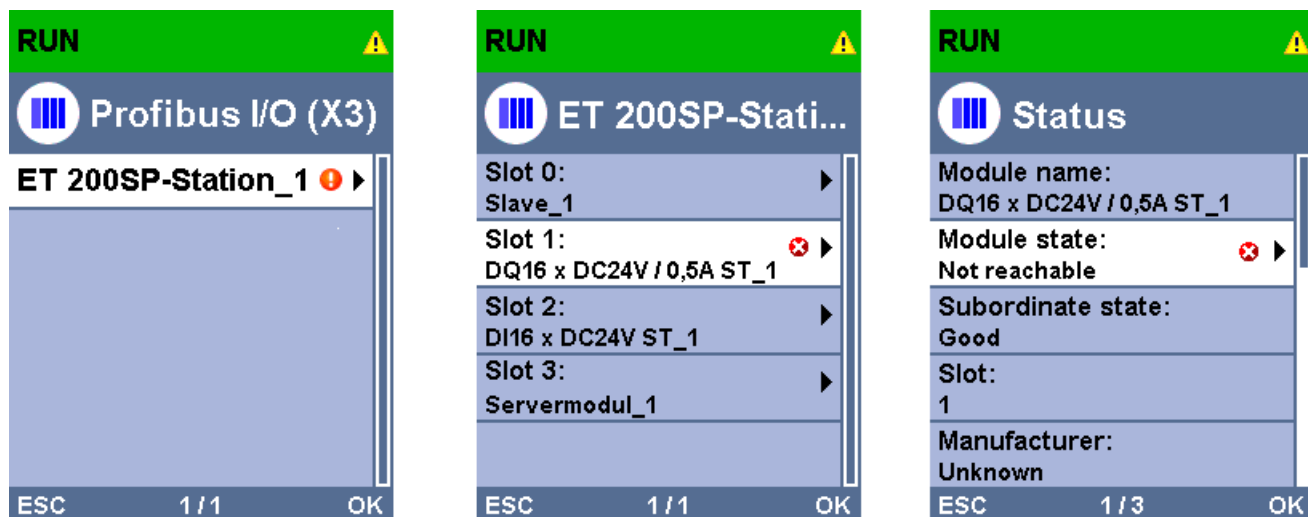


Figure 4-1 Example: Station overview, module overview, module status

## Error and alarm texts

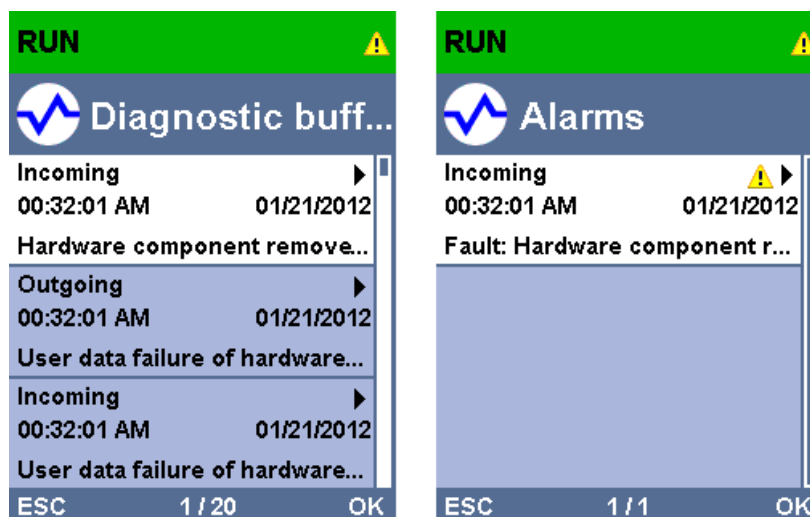


Figure 4-2 Example: Diagnostic buffer, alarms

## Additional information

Additional information on the topic "Functions and operation of the display" is available in the documentation for the S7-1500 automation system on the Internet (<http://support.automation.siemens.com/WW/view/en/59191792>).

## 4.3 Diagnostics with the diagnostic repeater

### Introduction

The diagnostic repeater is a repeater that can monitor two segments of a RS485-PROFIBUS subnet (copper cable) during operation and signal cable faults to the DP master by sending a diagnostic frame. Fault location and the cause of the fault can be displayed in plain text by means of STEP 7 as well as operator control and monitoring devices (SIMATIC HMI).

With its cable diagnostics during operation, the diagnostic repeater allows you to detect and localize cable faults early on. This means plant faults are detected early and plant downtimes can be prevented.

### Diagnostic functions

- The diagnostic function provides the location and the cause of cable faults, such as wire break or missing terminating resistors. The fault location is specified relative to the devices present, for example "Break on signal line A and/or B".
- Reading out the saved diagnostic and statistical information.
- Monitoring of the isochronous PROFIBUS, e.g., violation of cycle time.
- Providing identification data.

### Additional information

Additional information on diagnostics with STEP 7 and for reading out the diagnostics with the user program is available in the Diagnostic repeater for PROFIBUS DP (<http://support.automation.siemens.com/WW/view/en/7915183>) manual.



## 4.4 I&M data (Identification and Maintenance)

### Definition and properties

Identification and maintenance data (I&M) is information saved in a module to provide support when:

- Checking the plant configuration
- Locating hardware changes in a plant

Identification data (I data) is module information (some of which may be printed on the module housing) such as the order and serial number. I data is read-only, vendor-specific module information.

Maintenance data (M data) is system-specific information such as the installation location and date. M data is generated in the course of configuration and is written to the module memory.

The modules can be uniquely identified in online mode by means of the I&M data.

### Additional information

Information if and to what extent a DP device supports I&M data is available in the respective device manual of the device.

## Functions

### 5.1 Isochronous mode

#### 5.1.1 What is isochronous mode?

##### Why isochronous mode?

Assuming public transport were to operate at maximum speed while reducing stop times at the passenger terminals to absolute minimum, the last thing many potential passengers would notice of the departing contraption are its red tail lights. The overall travel time is, however, decided by the train, bus or underground clock, because well adjusted timing is essential to a good service. This also applies to distributed automation engineering. Not only fast cycles but also the adaptation and synchronization of the individual cycles result in optimum throughput.

##### Just-In-Time

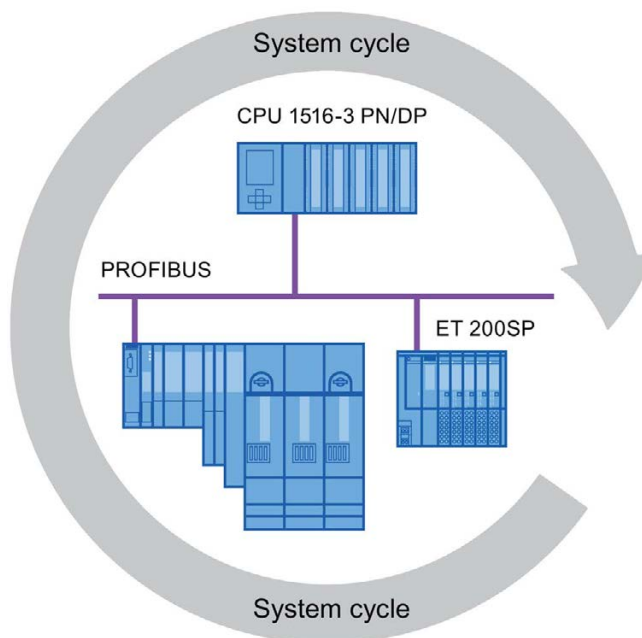


Figure 5-1 System cycle

The high speed and reliable reaction time of a system operating in isochronous mode is based on the fact that all data is provided just-in-time. The constant bus cycle time PROFIBUS DP cycle beats the time here.

### Advantages of isochronous mode

The use of isochronous mode provides:

- Optimized controls
- Determinism
- Consistent (simultaneous) reading of input data
- Consistent (simultaneous) output of output data

#### 5.1.2 Use of isochronous mode

The system property "isochronous mode" enables recording of measured values and process data in a defined system cycle. Signal processing takes place in the same system cycle all the way to switching to the "output terminal". This means isochronous mode improves the control quality and provides greater manufacturing precision. Isochronous mode drastically reduces the possible fluctuations of process response times. The time-assured processing can be used for a higher machine cycle.

Isochronous mode is basically always the choice when acquisition of measured values needs to be synchronized, movements need to be coordinated and process reactions need to be defined and take place simultaneously. This means the areas of applications for isochronous mode are manifold.

### 5.1.3 Isochronous applications

#### Example: Isochronous measurement at several measuring points

QC requires precise measurement of dimensions within a camshaft production process.

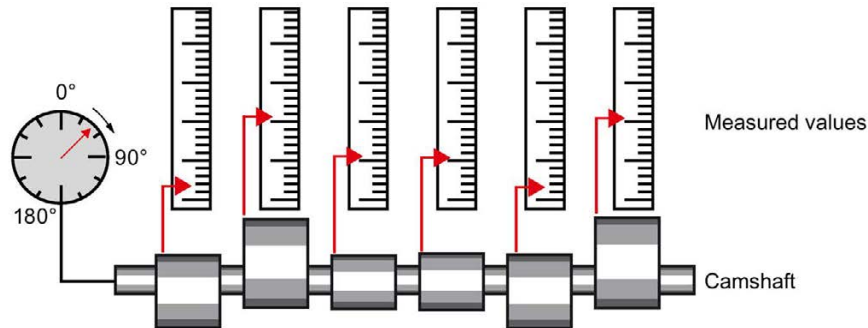


Figure 5-2 Measuring of camshafts

#### Isochronous workflow

By using the system property "isochronous mode" and the associated simultaneous measured value acquisition, measurement can be performed continuously and the time required for measurement is reduced. Resultant workflow:

- Continuous turning of the camshaft.
- During the continuous turning, measure the positions and cam excursion synchronously.
- Process the next camshaft.

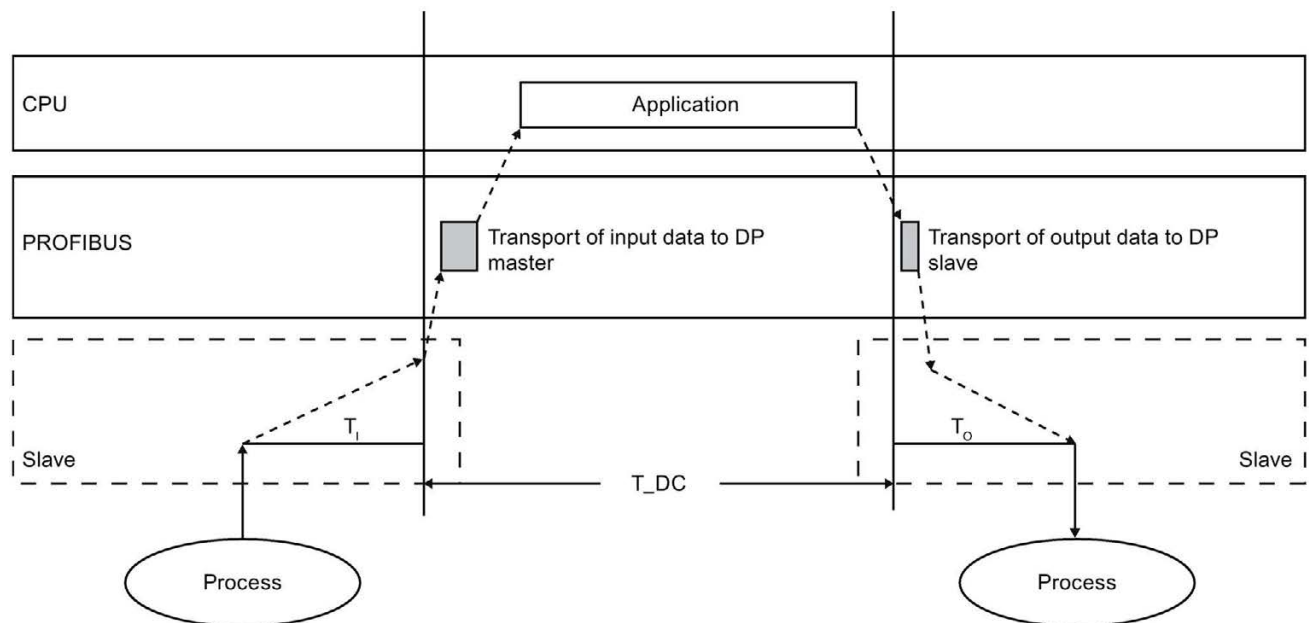
All camshaft positions and the corresponding measured values (red) are measured synchronously within a single rotation of the camshaft. This increases machine output and maintains or enhances precision of the measurement.

### 5.1.4 Sequence of synchronization

#### From reading of input data to output of output data

The sequence of all components involved in the synchronization is explained in the paragraphs below:

- Isochronous reading of input data
- Transport of input data by means of the PROFIBUS subnet to the DP master (CPU)
- Further processing in the isochronous application of the CPU
- Transport of output data by means of the PROFIBUS subnet to the output DP slave
- Isochronous output of output data



$T_{DC}$  Date cycle  
 $T_I$  Time for reading the input data  
 $T_O$  Time for output of output data

Figure 5-3 Time sequence of synchronization

To ensure that all input data is ready for transportation via the PROFIBUS DP line when the next PROFIBUS DP cycle begins, the I/O read cycle has a lead time  $T_I$  so that it starts earlier. The  $T_I$  is the "flash gun" for all inputs. This  $T_I$  is necessary to compensate for analog to digital conversion, backplane bus times, etc. The lead time  $T_I$  can be configured by STEP 7 or by the user. We recommend that you have  $T_I$  assigned automatically by STEP 7.

The PROFIBUS DP line transports the input data to the DP master. The synchronous cycle interrupt OB SynchronousCycle is called. The user program in the synchronous cycle interrupt OB decides the process reaction and provides the output data in time for the start of the next data cycle. The length of the data cycle is always configured by the user.

$T_0$  is the compensation from the backplane bus and the digital to analog conversion within the slave. The  $T_0$  is the "flash gun" for all outputs. The time  $T_0$  can be configured by STEP 7 or by the user. We recommend that you have  $T_0$  assigned automatically by STEP 7.

Without isochronous mode, application, data transmission and field devices have their own, unsynchronized processing cycles; these result in a higher total cycle time with high jitter. With isochronous mode, application, data transmission and field device are synchronized resulting in a minimum total cycle with minimum jitter.

### **Isochronous mode and non isochronous mode distributed I/O**

It is possible to combine isochronous mode distributed I/O with non isochronous mode distributed I/O on one DP master.

#### **5.1.5 Requirements for configuration**

Note the following requirements for configuration of isochronous mode:

- Isochronous mode cannot be used in optical PROFIBUS networks.
- Constant bus cycle time and isochronous mode are only possible with the bus profiles "DP" and "User-defined".
- Isochronous mode is only possible with the DP interfaces integrated in the CPU. Isochronous mode with CPs for PROFIBUS is not possible.
- Only the constant bus cycle time master is permitted as active station on the isochronous PROFIBUS DP. OPs and PGs (for example, PCs with PG functionality) influence the time behavior of the isochronous DP cycle and are therefore not permitted.
- Isochronous mode is not permitted across lines.
- Isochronous I/O can only be processed in process image partitions. Isochronous consistent data transmission is not possible without the use of process image partitions. The adherence to quantity structures is monitored because the number of slaves and bytes on the DP master system is limited for each process image partition.
- The addresses of isochronous modules must be located in a process image partition.
- Full isochronous mode from "terminal" to "terminal" is only possible if all components involved in the chain support the system property "isochronous mode".

Make sure you look for the entry "Isochronous mode" or "Isochronous processing" in the information box of the module when you select it in the catalog.

- When you configure isochronous mode, you may not assign a SYNC/FREEZE group to the slave.

## 5.1.6 Configuring isochronous mode

### Introduction

A SIMATIC automation solution can be connected to the isochronous PROFIBUS with the isochronous mode function. Isochronous mode guarantees the synchronous reading of input data, the processing and output of output data at the same (isochronous) intervals.

### Basic procedure for configuration of isochronous mode

1. Setting the properties for isochronous mode on the DP slave:
  - Isochronous DP cycle
  - Isochronous mode of the modules
2. Setting the properties for isochronous mode on the modules:
  - Synchronous cycle interrupt (SynchronousCycle)
  - Process image partition
  - Input delay
3. Create user program with access to isochronous I/O

### Requirement

- The network view in STEP 7 is open.
- A CPU has been placed (e.g., CPU 1516-3 PN/DP).
- An interface module has been placed and networked with the CPU (e.g., IM 151-1 HF).
- I/O modules have been placed (e.g., 2DI x DC24V HF and 2DO x DC24V/0,5A HF).

### Configuring isochronous mode on the DP slave

1. Select the DP slave in the network view and navigate to the "isochronous mode" area in the Inspector window.
2. Enable the option for synchronization to the DP cycle for the DP slave.  
Default: The DP slaves get the Ti/To values from the subnet which means the values are automatically the same for all DP slaves of the DP master system.
3. Enable the "Isochronous mode" option the the "Detail view" for all I/O modules you want to operate in isochronous mode.
4. Repeat steps 1 and 3 for all DP slaves that you want to operate in isochronous mode.

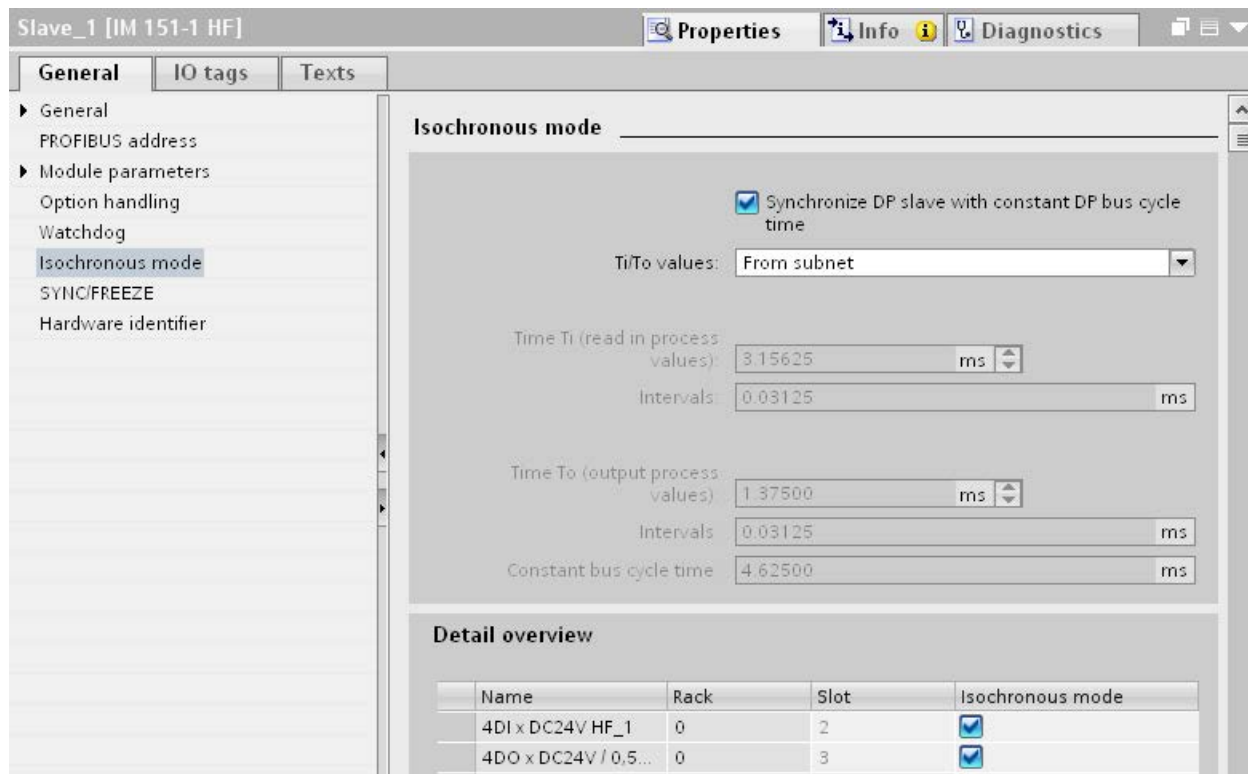


Figure 5-4 Configuring isochronous mode on the DP slave



### Configuring synchronous cycle interrupt on the I/O module

1. Select an I/O module in the device view and navigate to the "I/O addresses" area in the Inspector window.
  - The option for isochronous mode is selected.
2. Select the synchronous cycle interrupt in the drop-down list.

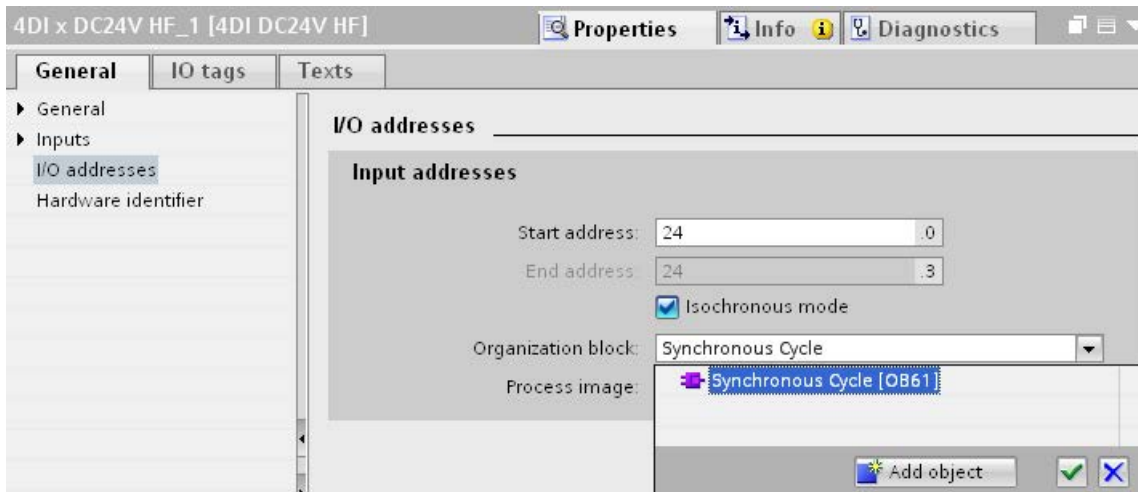


Figure 5-5 I/O addresses - creating the synchronous cycle interrupt OB

3. Assign the process image partition configured in the CPU.

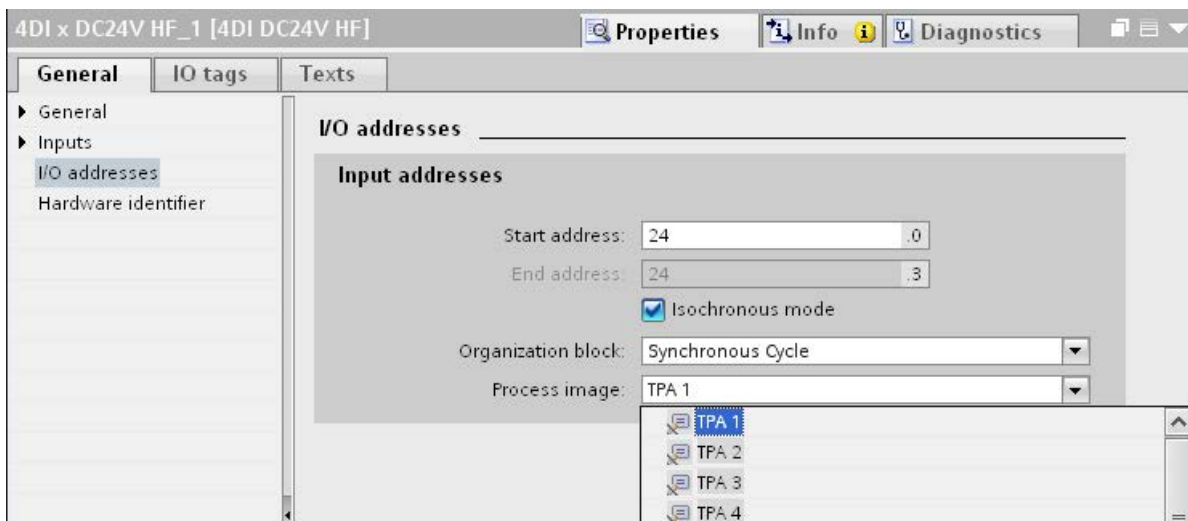


Figure 5-6 I/O addresses - assigning process image partitions

4. Repeat steps 1 and 3 for all I/O modules that you want to operate in isochronous mode.

## Programming isochronous mode

To operate your plant in isochronous mode, the user program must be structured accordingly. This means you have to add a synchronous cycle interrupt in the STEP 7 project tree.

You access the isochronous I/O by means of a process image partition, which means the addresses of the isochronous modules must be located in a process image partition. You program access to isochronous I/O with the "SYNC\_PI" instructions (updating the process image partitions of the inputs) and "SYNC\_PO" (updating the process image partition of the outputs) in the synchronous cycle interrupt OB.

You call the "SYNC\_PI" instruction at the start of the synchronous cycle interrupt OB, provided you have selected the automatic setting for the delay time. You call the "SYNC\_PO" instruction at the end of the synchronous cycle interrupt OB.

### 5.1.7 Diagnostics and interrupt functions

The diagnostic and interrupt functions of STEP 7 are available for isochronous mode. These reduce downtimes and simplify localization and elimination of faults.

#### Events, causes of errors and remedies

Below, you will find the events for diagnostic and interrupt functions and remedies for the problem.

Table 5- 1 Events, causes of errors and remedies

| Event                                                                                                                                                                                                                                                                                                                                             | Cause of the error                                                                                                                                                                        | Remedy                                                                                                                                                                                                                                  |
|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <ul style="list-style-type: none"> <li>Synchronous cycle interrupt OB is started with the input parameter EventCount &gt; 0 (number of lost OB calls since last OB call)</li> </ul> If configured: <ul style="list-style-type: none"> <li>Call of the time error OB</li> <li>Diagnostic buffer entry "Buffer overflow for OB6x events"</li> </ul> | The synchronous cycle interrupt OB takes too long.                                                                                                                                        | <ul style="list-style-type: none"> <li>Shorten the synchronous cycle interrupt OB.</li> <li>Increase the DP cycle.</li> <li>Reduce the delay time setting (setting with isochronous mode at synchronous cycle interrupt OB).</li> </ul> |
| Error (negative RetVals) when updating the isochronous process image partition with SYNC_PI / SYNC_PO: <ul style="list-style-type: none"> <li>Consistency warning</li> <li>Update time is after / before the permitted access window.</li> </ul>                                                                                                  | SYNC_PI / SYNC_PO are not called in the permitted access window in the synchronous cycle interrupt OB, which means they are called or processed during the I/O data transfer on PROFIBUS. | <ul style="list-style-type: none"> <li>Increase the delay time.</li> <li>Increase the DP cycle.</li> <li>Adapt the program.</li> </ul>                                                                                                  |
| Error when updating the isochronous process image partition with SYNC_PI / SYNC_PO: <ul style="list-style-type: none"> <li>Access error</li> </ul>                                                                                                                                                                                                | DP slave / module does not respond / is not available.                                                                                                                                    |                                                                                                                                                                                                                                         |

## 5.1.8 Parameter settings for isochronous mode

### Parameter changes as task of the field service technician

The task of a field service technician is to maintain the production process.

In this context the technician has to detect, localize and eliminate errors and performance losses of isochronous mode.

All parameters which influence isochronous mode can be checked and configured using the "Isochronous mode" dialog box.

Parameters should only be changed by experienced users or service technicians.

### 5.1.8.1 Viewing isochronous mode parameters

#### "Isochronous mode" dialog box

1. Select "Properties > Isochronous mode" in the Inspector window.

The "isochronous mode" dialog box opens with an overview of parameters which influence isochronous mode.

Information on the individual parameters is available under "Detail overview".

2. Compare the values shown with the values in the documentation, or with the value specified by a technician.

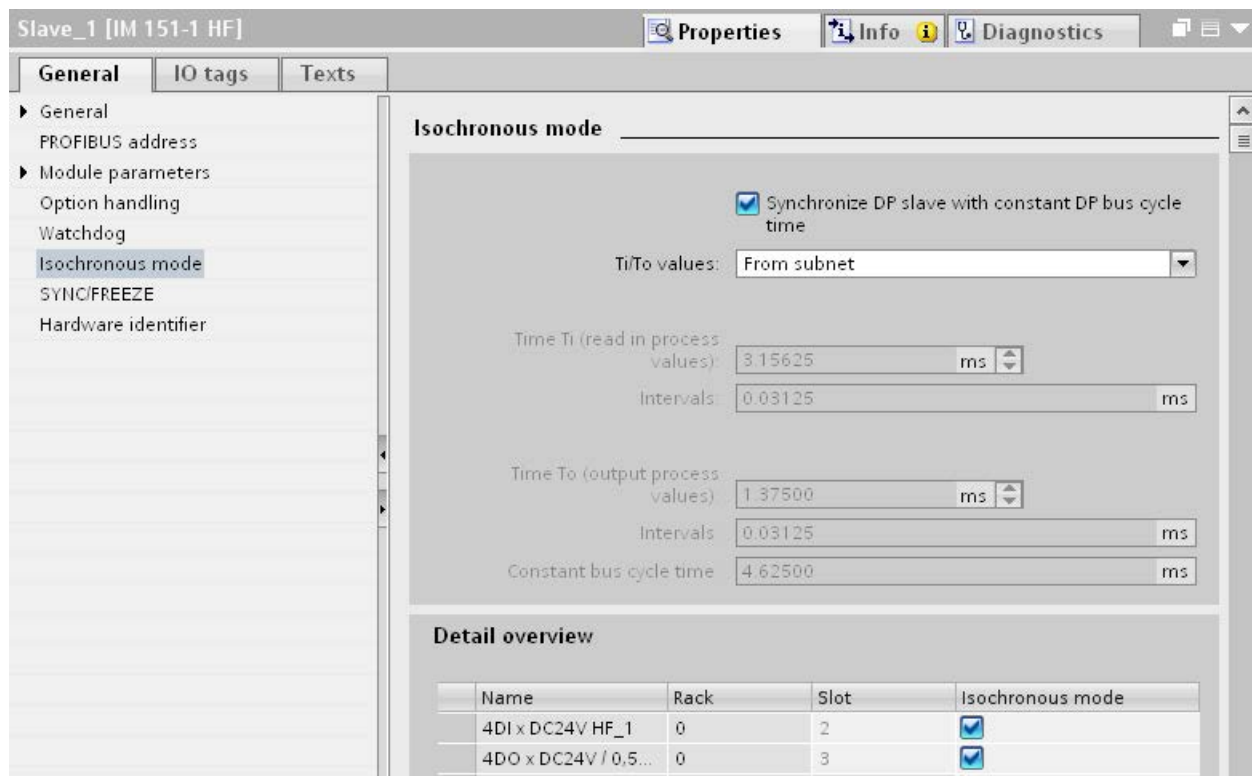


Figure 5-7 Viewing parameters for isochronous mode

## 5.1.8.2 Change parameters

## Changing parameters for the DP master system

You can change the parameters for isochronous mode in the "Constant bus cycle time" dialog box.

1. Select the DP master system in the network view.
2. Select the section "Constant bus cycle time" in the Inspector window.
3. Change the parameters according to the received instructions.

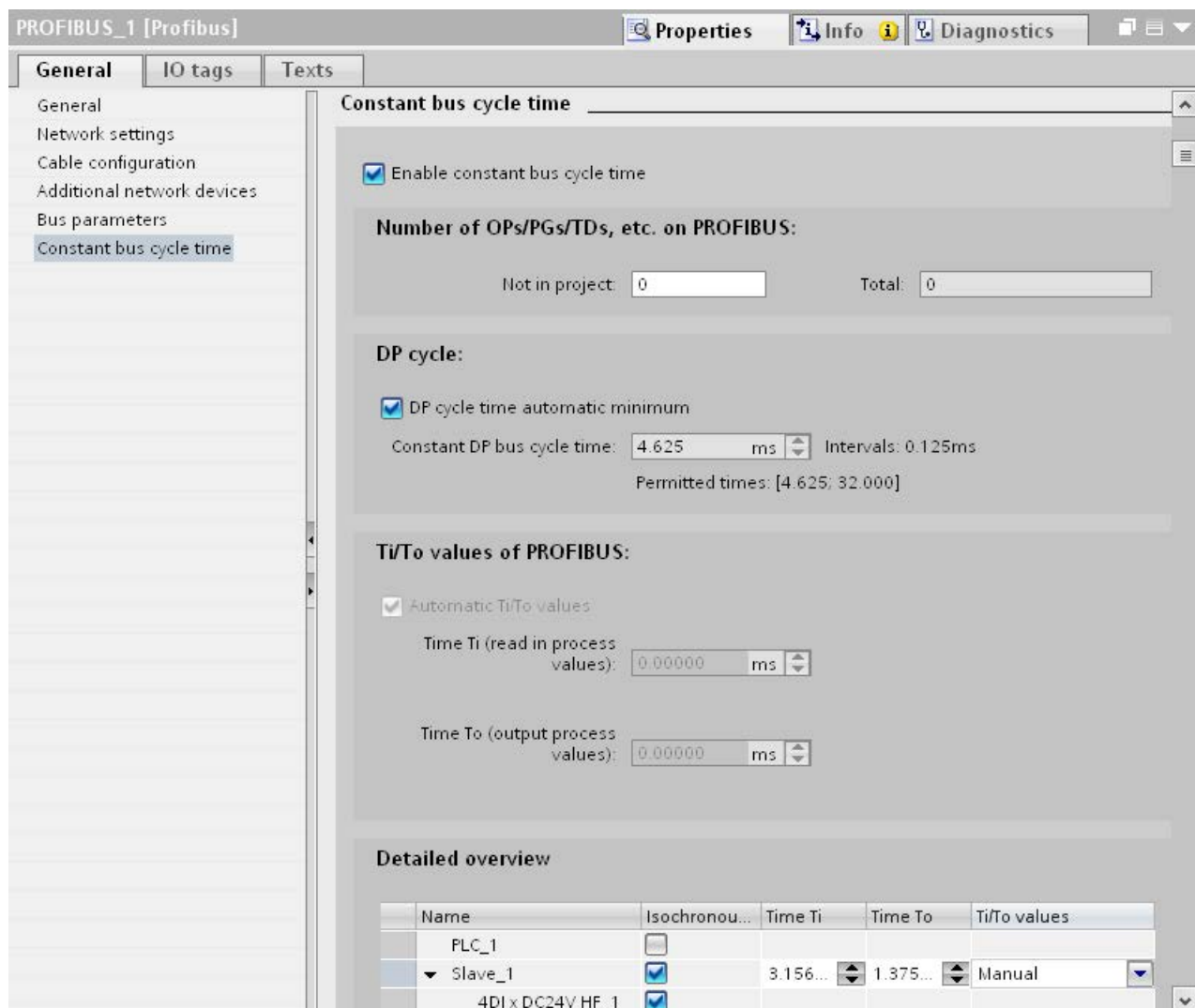


Figure 5-8 Changing parameters for the DP master system

### Adapting the input delay

1. Select the input module in the device view.
2. Select the section "Inputs" in the Inspector window.
3. Adapt the input delay.

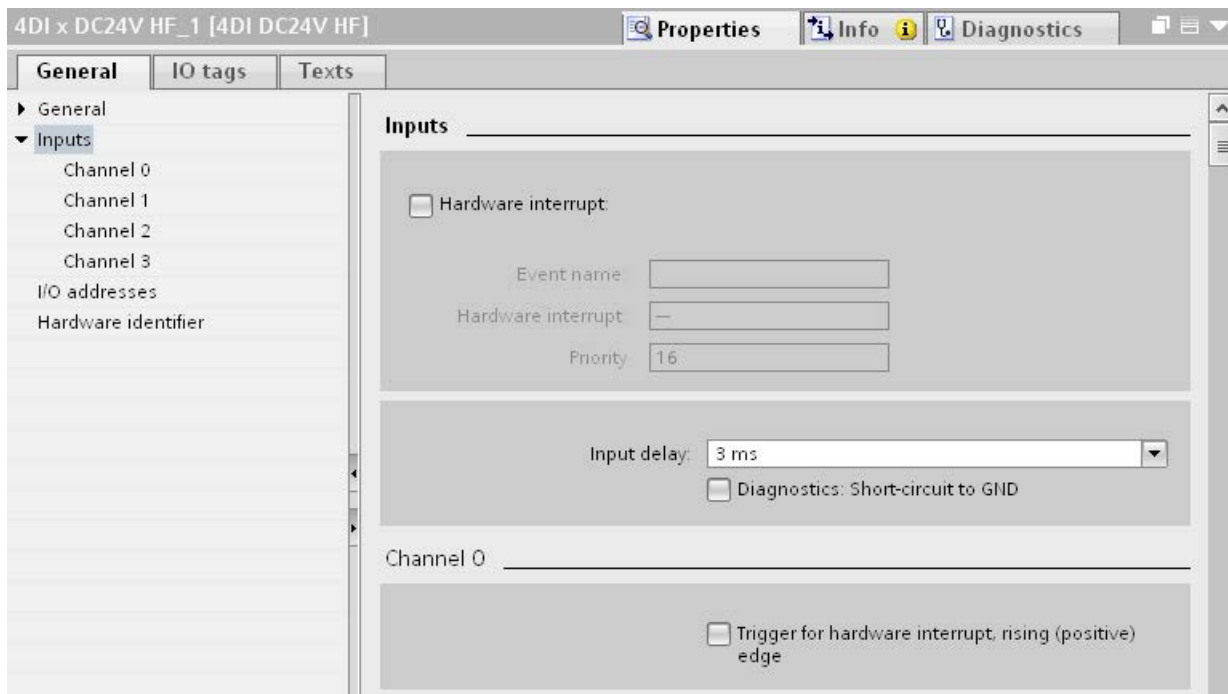


Figure 5-9 Adapting the input delay

### Compile, load and save the changed configuration

1. Put the plant out of operation.
2. Select the CPU in the project navigator.
3. Select "Compile > Hardware" in the shortcut menu.
4. Select "Download to device" in the shortcut menu.
5. Save the project.

## 5.2 Acyclical data exchange

### Additional functionality with DPV1 devices (DP master/DP slaves)

DP masters and DP slaves that support DPV1 have the following additional functions compared to the devices that support only DPV0:

- The acyclic data exchange between master and slave is supported.
- Interrupts can be set by a DPV1 slave which ensure handling of the interrupt-triggering event in the master CPU.

### Acyclic data exchange

Read/write data record, for example, to change the parameters of a slave during operation. The data records of a module and the structure of these data records is available in the documentation for the respective module.

The table below contains the instructions with their functions for access to DPV1 slaves. Detailed information is available in the STEP 7 online help.

Table 5- 2 Instructions for access to DPV1 slaves

| Instructions | Function (DPV1)                                                                                               |
|--------------|---------------------------------------------------------------------------------------------------------------|
| RDREC        | Read data record                                                                                              |
| WRREC        | Write data record                                                                                             |
| RALRM        | Receive interrupt from a DP slave.<br>(The instruction must be called in the OB that triggers the interrupt.) |

## 5.3 SYNC/FREEZE groups

### Assigning the SYNC/FREEZE group to the DP slave

A DP master with the corresponding functionality can send the control commands SYNC and/or FREEZE for synchronization of the DP slaves simultaneously to a group of DP slaves. You must assign SYNC/FREEZE groups to the DP slaves for this purpose.

Requirement: A DP master system has been created in the project.

### Procedure

To assign a DP slave to a SYNC/FREEZE group, follow these steps:

1. Select the DP interface of the DP slave you want to assign to a group in the device view or network view.
2. Select the check boxes for the required SYNC/FREEZE groups under the group "SYNC/FREEZE" in the Inspector window.

You can assign each DP slave to only one SYNC/FREEZE group.

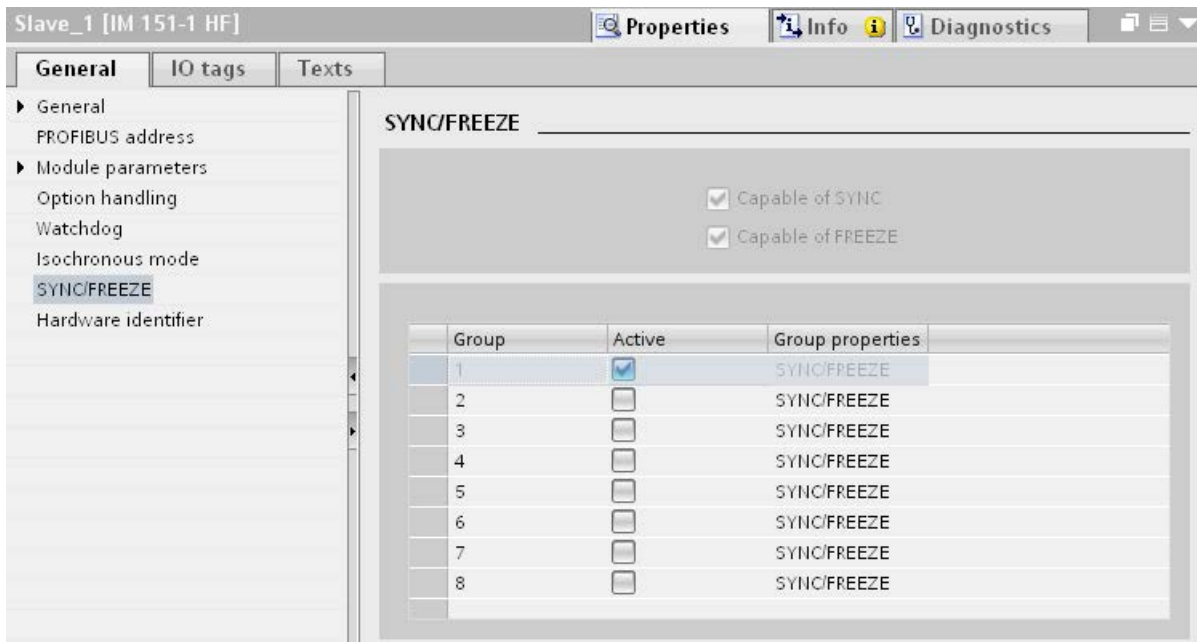


Figure 5-10 Assigning the DP slave to a SYNC/FREEZE group

## Important information on the control commands SYNC and FREEZE

You can use the control commands SYNC and FREEZE in the DP master to synchronize the DP slaves event-controlled. The DP master sends the control commands simultaneously to a group of DP slaves in its master system. It does not take into consideration DP slaves that have failed or are currently sending diagnostic information.

Requirement for synchronization using control commands is that you have assigned the DP slaves to SYNC/FREEZE groups.

For a S7 CPU use the instruction DPSYC\_FR (SFC 11) to synchronize the DP slaves.

When you select the DP master, you see a list of the eight SYNC/FREEZE groups under "Properties > DP interface > SYNC/FREEZE" in the Inspector window.

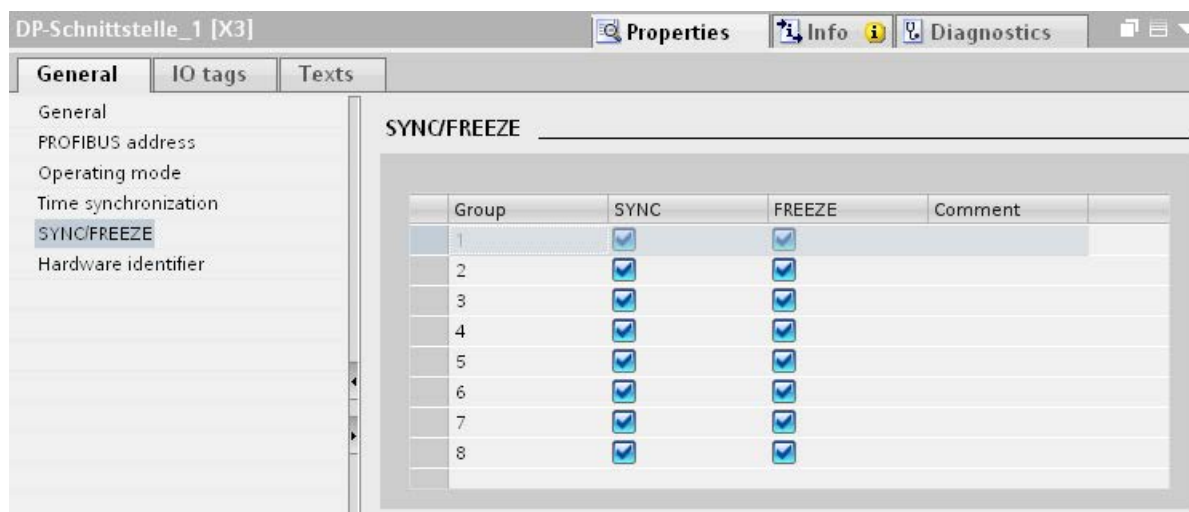


Figure 5-11 SYNC/FREEZE groups on DP master

## SYNC control command

The DP master uses the SYNC control command to cause a group of DP slaves to freeze the states of their outputs to the current value.

The DP slaves save the output data of the DP master for the following frames. But the states of the DP slave outputs remain unchanged.

Only after each new SYNC control command does the DP slave set its outputs to the values that it has saved as the output data of the DP master.

The outputs are not updated cyclically again until the DP master has sent a UNSYNC control command.



### **FREEZE control command**

After receiving the FREEZE control command from the DP master, the DP slaves of a group freeze the current status of their inputs. The DP slaves send these frozen input data to the DP master with the following cyclical frames.

The DP slaves freeze the current state of their inputs again after each new FREEZE control command.

The state of the DP slave inputs is only send to the DP master cyclically again when the DP master sends the UNFREEZE control command.

## **5.4 Interrupts**

### **Interrupts and interrupt OBs for DPV1**

Interrupts can be set by a DPV1 slave which ensure handling of the interrupt-triggering event in the master CPU. The interrupt data is evaluated in the CPU and the diagnostics buffer and the module state are updated even in the "STOP" operating mode. The OB is not processed in STOP.

The following DPV1 interrupts are supported:

- Status interrupt
- Update interrupt
- Vendor-specific interrupt

Detailed information is available in the descriptions on the OBs. You can use the corresponding OBs that are provided by the operating system of the S7 CPUs for diagnostic interrupts, hardware interrupts, and pull/plug interrupts.

#### **OB 55 interrupt - Status interrupt**

The status interrupt can be triggered when the operating mode of a device or module changes, for example, from RUN to STOP.

#### **OB 56 interrupt - Update interrupt**

An update interrupt can be triggered if the parameters of a slot were changed. This may be caused by local access or partner access to the parameters.

#### **OB 57 interrupt - Vendor-specific interrupt**

The event that triggers the vendor-specific interrupt can be specified by the manufacturer of a DPV1 slave.

### Additional information

A detailed description of the events at which interrupts are triggered is available in the documentation of the respective manufacturer of the DPV1 slave.

## 5.5 Intelligent DP slaves (I-slaves)

### 5.5.1 I-slave functionality

#### I-slave functionality

The "I-slave" (intelligent DP slave) functionality of a CPU supports the exchange of data with a DP master and thus allows the CPU to be used, for example, as intelligent preprocessing unit of subprocesses. The I-slave is connected in its role as DP slave to a "higher-level" DP master.

The preprocessing is handled by the user program in the I-slave. The process values acquired by the I/O modules are preprocessed by the user program and made available to the DP master.

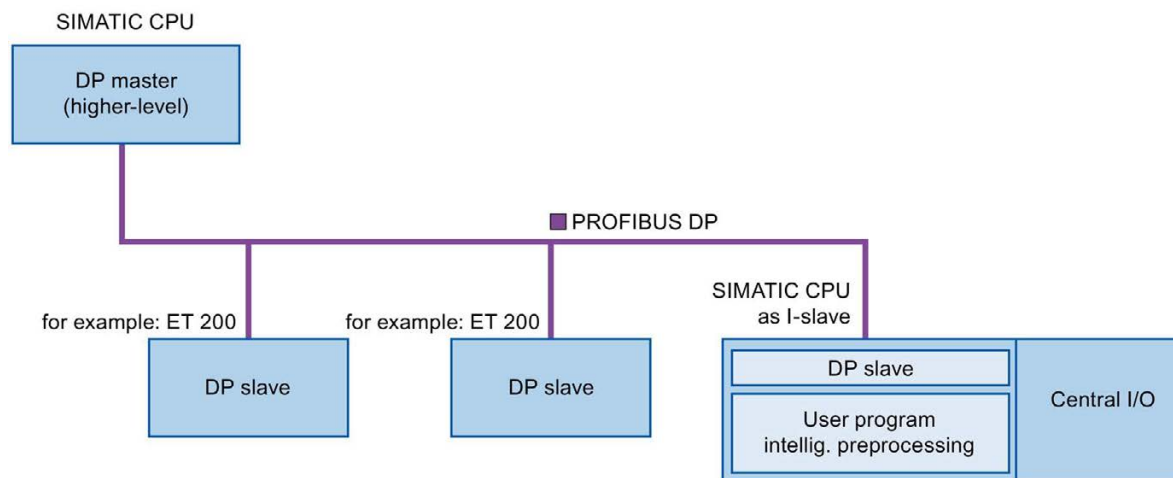


Figure 5-12 I-slave functionality

#### "I-slave" naming convention

In the remainder of this description, a CPU or a CP with I-slave functionality is simply called an "I-slave".

## Advantages of configurations with I-slaves

The I-slave offers the following advantages:

- Simple coupling of CPUs with PROFIBUS interface
- Real-time communication between CPUs and PROFIBUS interface
- Distributed processing

A complex automation task can be divided into smaller units/subprocesses. This results in manageable processes which lead to simplified subtasks.

- Relieving the DP master by distributing the computing capacity to I-devices
- Lower communication load by processing process data locally
- Separating subprocesses

Complicated, widely distributed and extensive processes can be subdivided into several subprocesses with manageable interfaces by using I-slaves. These subprocesses can be stored in individual STEP 7 projects if necessary, which can later be merged to form one master project.

- Separating STEP 7 projects

Creators and users of an I-device can have completely separated STEP 7 projects. The GSD file together with the configuration of the transfer areas of the I-slave form the interface between the STEP 7 projects. This allows coupling to standard DP masters via a standardized interface.

- Know-how protection

Plant units can now only be delivered with a GSD file and the configuration of the transfer areas instead of with a STEP 7 project for the I-slave interface description. This means that you no longer have to disclose the user program know-how.

**Difference: DP slave - I-slave**

In the case of a DP slave, the DP master accesses the distributed inputs/outputs directly.

In the case of an I-slave, the DP master accesses a transfer area in the I/O address space of the preprocessing CPU instead of accessing the connected inputs/outputs of the I-slave. The user program running on the preprocessing CPU is responsible for ensuring data exchange between the operand area and inputs/outputs.

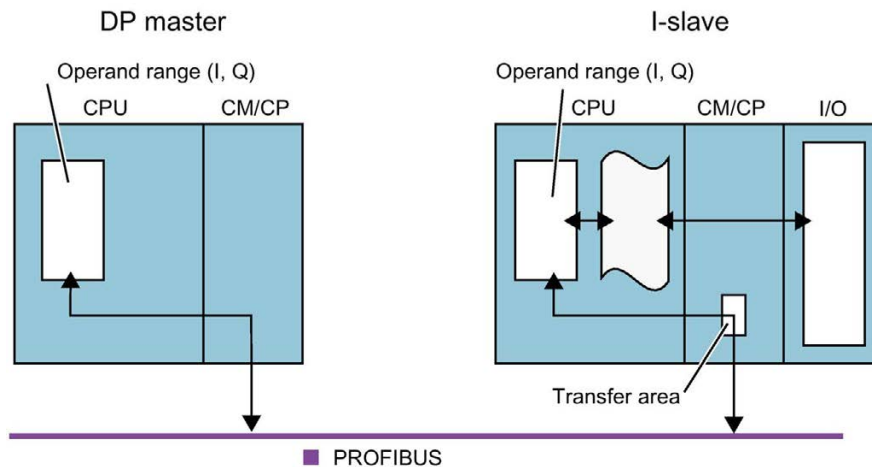


Figure 5-13 Data access to an I-slave

**Note****DP master or DP slave**

Note: The communication modules of the S7-1500 CPUs/ET 200SP CPUs, for example the CP 1542-5, support the operation as DP master or DP slave only as alternative.

**Note**

The I/O areas configured for data exchange between the DP master and DP slaves must not be used by I/O modules.

## 5.5.2 Data exchange with higher-level DP master

### Introduction

The following section describes the data exchange between the I-slave and the higher-level DP master.

### Transfer areas

Transfer areas are an interface to the user program of the I-slave CPU. Inputs are processed in the user program and outputs are the result of the processing in the user program.

The data for communication between DP master and I-slave is made available in the transfer areas. A transfer area contains an information unit that is exchanged consistently, in terms of bytes, words or overall, between DP master and I-slave. You can find more information on configuration and use of transfer areas in the section Configuring transfer areas (Page 84).

The following figure shows the data exchange between the I-slave and the higher-level DP master. The individual communication relations are explained below based on the numbers.

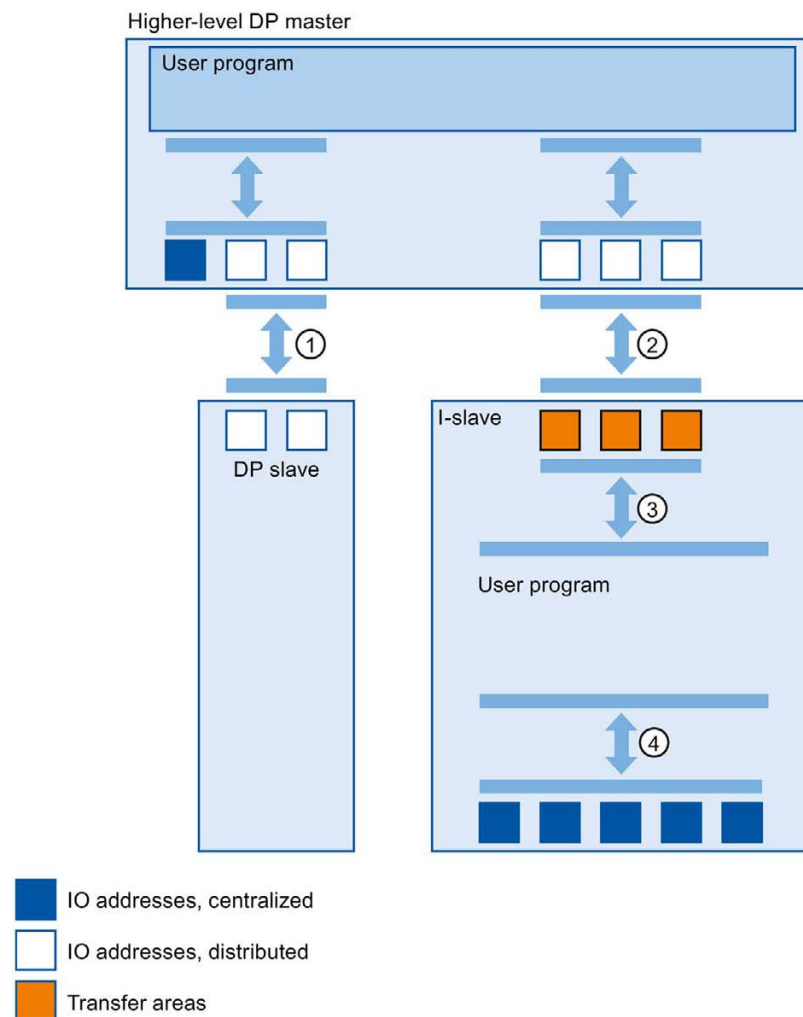


Figure 5-14 Data exchange with the DP master

**① Data exchange between higher-level DP master and normal DP slave**

In this way, the DP master and the DP slave exchange data through PROFIBUS.

**② Data exchange between higher-level DP master and I-slave**

In this way, the DP master and the slave exchange data through PROFIBUS.

The data exchange between a higher-level DP master and an I-slave is based on the conventional DP master/DP slave relationship.

For the higher-level DP master, the transfer areas of the I-slave represent submodules of a DP slave.

The output data of the DP master is the input data of the I-slave. Analogously, the input data of the DP master is the output data of the I-slave.

**③ Transfer relationship between the user program and the transfer area**

In this way, the user program and the transfer area exchange input and output data.

**④ Data exchange between the user program and the I/O of the I-slave**

In this way, the user program and the centralized I/O of the I-slave exchange input and output data.

### 5.5.3 Configuring an I-slave

#### Requirements for configuring an I-slave

The I-slave consists of:

- A CPU from S7-1500 and a communications module CM 1542-5/CP 1542-5 (STEP 7 as of V12)
- A CPU from ET 200SP and a communications module CM DP (STEP 7 as of V13 SP1)

## Procedure for configuring an I-slave

This section shows how to configure an I-slave in STEP 7 based on the example of a CPU 1512SP-1 PN. The procedure for the CPUs from S7-1500 with CM 1542-5/CP 1542-5 and for the CPU 1510SP-1 PN with CM DP is the same.

To configure an I-slave, follow these steps:

1. Drag a CPU 1512SP-1 PN from the hardware catalog to the network view.
2. Open the device view of the CPU.
3. Double-click on the CM DP communications module in the hardware catalog. STEP 7 creates the CM DP in the device view.
4. Select the PROFIBUS interface of the CM DP communications module.
5. In the Inspector window in the area navigation, select the "Operating mode" entry and enable the "DP slave" check box.
6. Now you can select the DP master in the "Assigned DP Master" drop-down list.

Once you have selected the DP master, the networking and the DP master system between both devices are displayed in the network view.

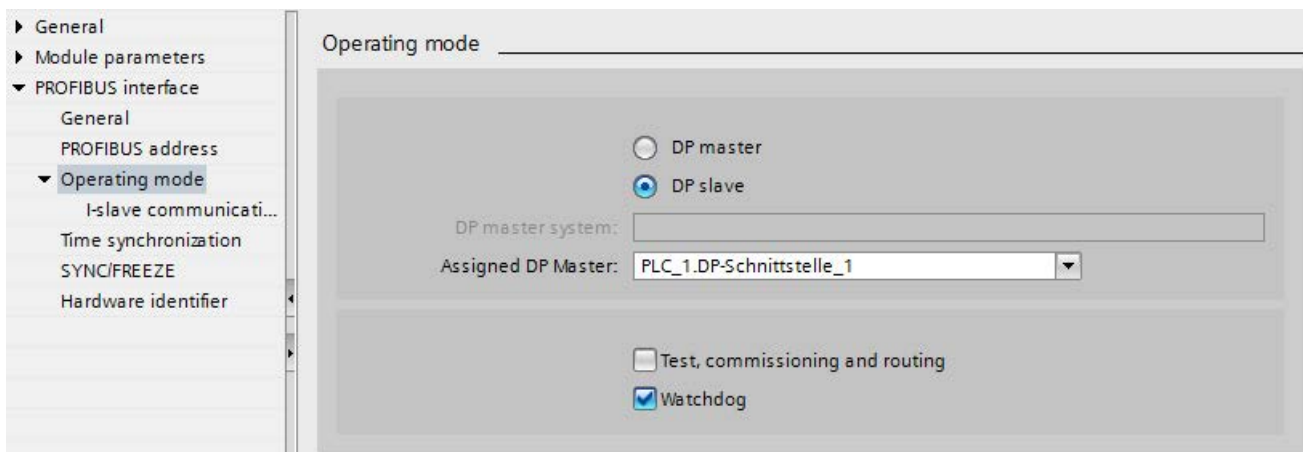


Figure 5-15 Configuring an I-slave

### Note

#### Operation using a GSD file

If you operate an I-slave using a GSD file, you should not select the "Test, commissioning and routing" check box.

Create a DP subnet on the PROFIBUS interface of the I-slave.

## Result

You have configured an I-slave.

## 5.5.4 Configuring transfer areas

### Requirements for configuring transfer areas

- You have configured an I-slave in STEP 7.
- You are in the device view of the I-device and have selected the PROFIBUS interface of the communications module.

### Procedure for configuring transfer areas

To configure transfer areas for an I-slave in STEP 7, follow these steps:

1. In the area navigation, go to the section "Operating mode" > "I-slave communication" > "Transfer areas".
2. Create transfer areas. Set the properties of the created transfer areas.

| Transfer areas |     |                   |      |                |   |               |        |             |
|----------------|-----|-------------------|------|----------------|---|---------------|--------|-------------|
|                | ①   | ②                 | ③    |                | ④ | ⑤             |        |             |
|                | ... | Transfer area     | Type | Master address | ↔ | Slave address | Length | Consistency |
| 1              |     | Transferbereich_1 | MS   | Q 0            | → | I 0           | 1 byte | Unit        |
| 2              |     | <Add new>         |      |                |   |               |        |             |
|                |     |                   |      |                |   |               |        |             |

- ① Click in the first cell of the "Transfer area" column. STEP 7 assigns a default name that you can change.
- ② Select the type of communication relation: Currently, you can only select MS for "master-slave communication relation".
- ③ STEP 7 assigns the addresses for the transfer area automatically. Correct the addresses if necessary.
- ④ Set the length of the transfer area. Specify the length of the transfer area in the cell in the following format: [1...64] Byte/Word.  
Examples: "32 Byte", "64 Word"
- ⑤ Specify whether the transfer area is exchanged in units of bytes or words or consistently over the entire length between the DP master and I-slave.

Figure 5-16 Configuring transfer areas

A separate entry is created in the area navigation for each transfer area. If you select one of these entries, you can adjust the details of the transfer area, or correct them and comment on them.



## 5.5.5 Sample program

### Introduction

This simple sample program shows how you use the transfer areas of an I-slave.

### Requirement

You have configured an I-slave.

### Task

The result of an "AND logic operation" of two inputs (preprocessing) in the I-slave is to be provided to the higher-level DP master. This result is to be assigned to a local output in the DP master (further processing).

Use a transfer area with the following addresses for this purpose:

- Address in the I-slave: Q568
- Address in the DP master: I68

### Required steps

The following steps are necessary to solve the task:

1. Configuring the transfer area
2. Programming the I-slave
3. Programming the DP master

## Configuring the transfer area

Configure a transfer area with the following properties in the I-slave:

**Details of the transfer area**

|                        |                                                                                   |                                                                                     |
|------------------------|-----------------------------------------------------------------------------------|-------------------------------------------------------------------------------------|
| Transfer area          | Transferbereich_1                                                                 |                                                                                     |
| Type of transfer area  | MS                                                                                |                                                                                     |
|                        | Partner                                                                           | Local                                                                               |
|                        |  |  |
| Data exchange between: | PLC_1                                                                             | and CP 1542-5_1                                                                     |
| Slot                   | 4                                                                                 | 4                                                                                   |
| Address type           | I                                                                                 | Q                                                                                   |
| Start address          | 68                                                                                | 568                                                                                 |
| Organization block     | --- (Automatic update) ...                                                        | --- (Automatic update) ...                                                          |
| Process image          | Automatische Aktualisierung ...                                                   | Automatische Aktualisierung ...                                                     |
| Length                 | 1                                                                                 |                                                                                     |
| Unit                   | Byte                                                                              |                                                                                     |
| Consistency            | Unit                                                                              |                                                                                     |
| Comment                |                                                                                   |                                                                                     |

Figure 5-17 Transfer area, I-slave sample program

## Programming the I-slave

To program the sample program for the I-slave, follow these steps:

1. Using the SCL programming language, create a new function with the name "preprocessing" in the project tree under "Program blocks" > "Add new block". Open the function.
2. In the interface of the function "preprocessing", create the following tags:

| Name    | Data type | Input/output type |
|---------|-----------|-------------------|
| input 1 | bool      | Input             |
| input 2 | bool      | Input             |
| result  | bool      | Output            |

3. In the instruction window of the function "preprocessing", write the following program code:  
`#result:=#input 1&#input 2;`
4. Call the function "preprocessing" in a cycle OB, for example, in OB1.
5. Wire the function "preprocessing" in the cycle OB as follows:

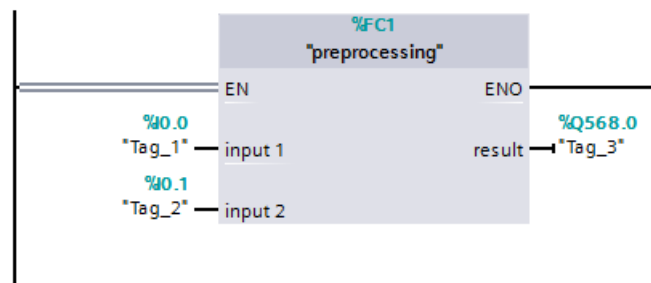


Figure 5-18 I-slave sample program

## Programming the DP master

To program the sample program for the DP master, follow these steps:

1. Using the SCL programming language, create a new function with the name "further processing" in the project tree under "Program blocks" > "Add new block". Open the function.
2. In the interface of the function "further processing", create the following tags:

| Name   | Data type | Input/output type |
|--------|-----------|-------------------|
| result | bool      | Input             |
| output | bool      | Output            |

3. In the instruction window of the function "further processing", write the following program code:  
#output:=#result;
4. Call the function "further processing" in a cycle OB, for example, in OB1.
5. Wire the function "further processing" in the cycle OB as follows:

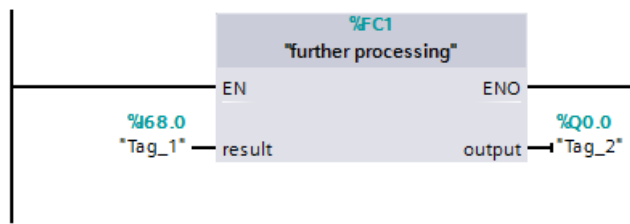


Figure 5-19 DP master sample program

## Result

You mastered the task successfully.

## 5.5.6 Diagnostics and interrupt behavior

### Diagnostics and interrupt behavior

S7 CPUs have numerous diagnostics and interrupt functions that can, for example, report errors/faults or failures of underlying DP systems. These diagnostics alarms reduce downtimes and simplify localization and elimination of problems.

### Diagnostics options in the higher-level DP master and in the I-slave

The following diagnostics mechanisms are available to the higher-level DP master and the I-slave:

- OB 82 (diagnostic interrupt)

When the I-slave changes mode, the DP master calls OB 82 (diagnostic interrupt).

When the DP master changes mode, the I-slave calls OB 82 (diagnostic interrupt).

- OB 86 (rack failure)

If the bus connection to the I-slave is interrupted, the DP master calls OB 86 (rack failure).

If the bus connection to the DP master is interrupted, the I-slave calls OB 86 (rack failure).

- OB 122 (I/O access error)

If you have not set the attribute "Handle errors within block" for OB 122, the following applies:

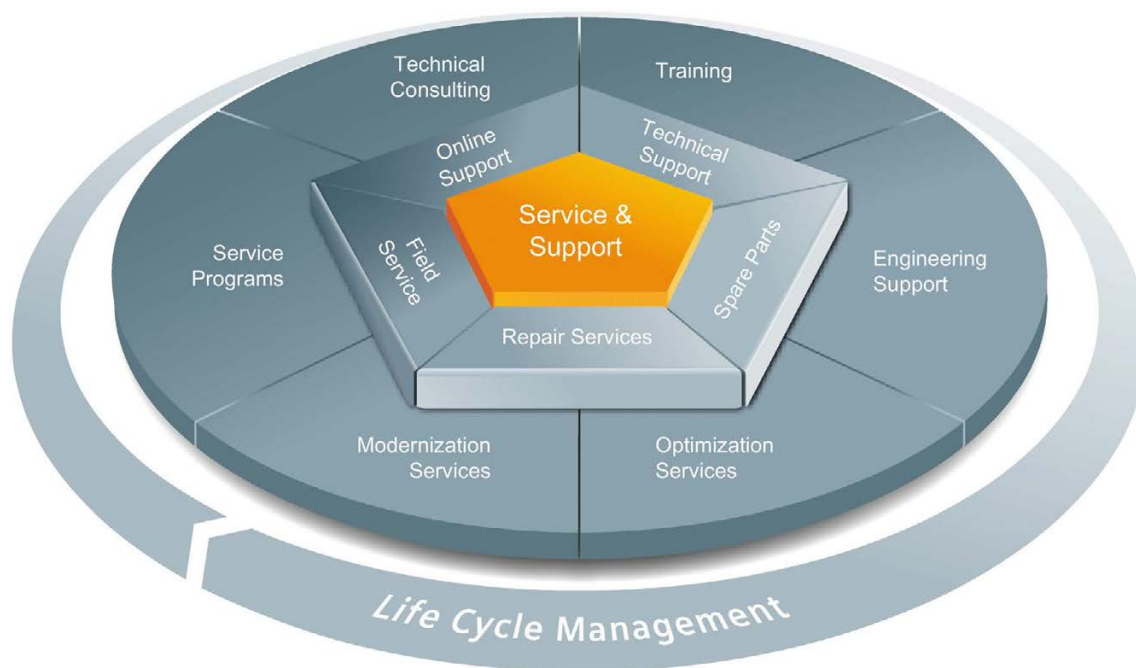
- If the bus connection to the I-slave is interrupted, the DP master calls OB 122 (I/O access error) if there is direct access to the relevant transfer areas.
- If the bus connection to the DP master is interrupted, the I-slave calls OB 122 (I/O access error) if there is direct access to the relevant transfer areas.

## Reaction of the transfer areas to mode changes

Table 5- 3 Reaction of the transfer areas to mode changes

| DP master | I-slave  | Reaction of DP master input transfer areas                                                                                                                                                   | Reaction of I-slave input transfer areas                                                                |
|-----------|----------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------|
| RUN→STOP  | RUN      | No updating of the process image                                                                                                                                                             | The input transfer areas retain their current values. (no access error)                                 |
| STOP→RUN  | RUN      | The input transfer areas are updated by the cyclic user program via the process image.                                                                                                       | The input transfer areas are updated via the process image.                                             |
| RUN       | RUN→STOP | The I-slave sets the input transfer areas on the DP master to "0".                                                                                                                           | No updating of the process image                                                                        |
| RUN       | STOP→RUN | The I-slave sets the input transfer areas on the DP master to "0".<br>After the startup program of the I-slave, the input transfer areas of the DP master are updated via the process image. | Prior to processing of the startup program, the input transfer areas are updated via the process image. |

## Service & Support



### The unmatched complete service for the entire life cycle

For machine constructors, solution providers and plant operators: The service offering from Siemens Industry Automation and Drive Technologies includes comprehensive services for a wide range of different users in all sectors of the manufacturing and process industry.

To accompany our products and systems, we offer integrated and structured services that provide valuable support in every phase of the life cycle of your machine or plant – from planning and implementation through commissioning as far as maintenance and modernization.

Our Service & Support accompanies you worldwide in all matters concerning automation and drive technology from Siemens. We provide direct on-site support in more than 100 countries through all phases of the life cycle of your machines and plants.

You have an experienced team of specialists at your side to provide active support and bundled know-how. Regular training courses and intensive contact among our employees – even across continents – ensure reliable service in the most diverse areas.

## Online Support

The comprehensive online information platform supports you in all aspects of our Service & Support at any time and from any location in the world.

You can find Online Support on the Internet at the following address: Internet (<http://www.siemens.com/automation/service&support>).

## Technical Consulting

Support in planning and designing your project: From detailed actual-state analysis, definition of the goal and consultation on product and system questions right through to the creation of the automation solution.

## Technical Support

Expert advice on technical questions with a wide range of demand-optimized services for all our products and systems.

You can find Technical Support on the Internet at the following address: Internet (<http://www.siemens.com/automation/support-request>).

## Training

Extend your competitive edge – through practical know-how directly from the manufacturer.

You can find the training courses we offer on the Internet at the following address: Internet (<http://www.siemens.com/sitrain>).

## Engineering Support

Support during project engineering and development with services fine-tuned to your requirements, from configuration through to implementation of an automation project.

## Field Service

Our Field Service offers you services for commissioning and maintenance – to ensure that your machines and plants are always available.

## Spare parts

In every sector worldwide, plants and systems are required to operate with constantly increasing reliability. We will provide you with the support you need to prevent a standstill from occurring in the first place: with a worldwide network and optimum logistics chains.

## Repairs

Downtimes cause problems in the plant as well as unnecessary costs. We can help you to reduce both to a minimum – with our worldwide repair facilities.



## Optimization

During the service life of machines and plants, there is often a great potential for increasing productivity or reducing costs.

To help you achieve this potential, we are offering a complete range of optimization services.

## Modernization

You can also rely on our support when it comes to modernization – with comprehensive services from the planning phase all the way to commissioning.

## Service programs

Our service programs are selected service packages for an automation and drives system or product group. The individual services are coordinated with each other to ensure smooth coverage of the entire life cycle and support optimum use of your products and systems.

The services of a Service Program can be flexibly adapted at any time and used separately.

Examples of service programs:

- Service contracts
- Plant IT Security Services
- Life Cycle Services for Drive Engineering
- SIMATIC PCS 7 Life Cycle Services
- SINUMERIK Manufacturing Excellence
- SIMATIC Remote Support Services

Advantages at a glance:

- Reduced downtimes for increased productivity
- Optimized maintenance costs due to a tailored scope of services
- Costs that can be calculated and therefore planned
- Service reliability due to guaranteed response times and spare part delivery times
- Customer service personnel will be supported and relieved of additional tasks
- Complete service from one source: fewer interfaces and more know-how

## Contact

At your service locally, around the globe: your partner for consultation, sales, training, service, support, spare parts... for the entire range of products supplied by Industry Automation and Drive Technologies.

You can find your personal contact in our contacts database at: Internet (<http://www.siemens.com/automation/partner>).

# Glossary

## Automation system

Programmable logic controller for the open-loop and closed-loop control of process chains of the process engineering industry and manufacturing technology. The automation system consists of different components and integrated system functions according to the automation task.

## Bus

A common transfer route to which all nodes are connected; it has two defined ends.  
In the case of PROFIBUS, the bus is a two-wire line or a fiber-optic cable.

## Bus connector

Physical connection between the node and bus cable.

## Bus system

All stations physically connected to a bus cable form a bus system.

## Device

In the PROFIBUS environment, "device" is the generic term for:

- Automation systems (for example, PLC, PC)
- Distributed I/O systems
- Field devices (for example, hydraulic devices, pneumatic devices)
- Active network components
- Gateways to AS interface or other fieldbus systems

Device that can send, receive or amplify data via the bus, for example, a DP slave by means of PROFIBUS DP.

## Device

In the PROFIBUS environment, "device" is the generic term for:

- Automation systems (for example, PLC, PC)
- Distributed I/O systems
- Field devices (for example, hydraulic devices, pneumatic devices)
- Active network components
- Gateways to AS interface or other fieldbus systems

Device that can send, receive or amplify data via the bus, for example, a DP slave by means of PROFIBUS DP.

## Diagnostics

Monitoring functions for the recognition, localization, classification, display and further evaluation of errors, faults and alarms. They run automatically during plant operation. This increases the availability of systems/plants by reducing commissioning times and downtimes.

## DP master

CPU or device that conducts the communication with the DP slaves according to a defined algorithm. To do this, the DP master uses the functions for communication with the DP slaves which are defined by PROFIBUS DP. It acts according to standard EN 50170, Part 3.

→ *Master*

## DP slave

Slave in the distributed I/O that is operated on the PROFIBUS with PROFIBUS DP protocol and acts according to standard EN 50170, Part 3. The DP slave is addressed by the DP master and provides it with specified functions (I/O data, diagnostics, etc.).

→ *Slave*

## DPV1

The designation DPV1 refers to the functional extension of acyclic services (to include new interrupts, for example) provided by the DP protocol. The DPV1 functionality is integrated in IEC 61158/EN 50170, Volume 2, PROFIBUS.

## FDL

Fieldbus Data Link (bus access protocol). Step 2 with PROFIBUS.

## HMI device

Human Machine Interface, device for visualization and control of automation processes.

## **HSA**

Highest Station Address. A bus parameter for PROFIBUS. Outputs the highest PROFIBUS address of an active device. PROFIBUS addresses greater than HSA are permitted for passive devices, up to 126.

## **Industrial Ethernet**

Guideline for setting up Ethernet in an industrial environment. The main difference to the standard Ethernet is the mechanical current carrying capacity and interference immunity of the individual components.

## **I-slave**

The "I-slave" functionality of a CPU supports the exchange of data with a DP master and can thus be used, for example, as intelligent preprocessing unit of partial processes. The I-slave is connected in its role as DP slave to a "higher-level" DP master.

## **Master**

A master device that is in possession of the token can send data to other devices and request data from them (= active device).

## **PCF**

Polymer Cladded Fiber (plastic-covered glass fiber)

## **POF**

Polymer Optical Fiber (plastic fiber-optic cable made of light-conducting plastics)

## **Process image**

Address area in the system memory of the DP master. At the start of the cyclic program the signal states of the input modules are transmitted to the process image of the inputs. And the end of cyclic program execution, the process image of the outputs is transmitted to the DP slave as signal state.

## **PROFIBUS**

PROcess Field BUS, in IEC 61158-2 as "Type 3" standardized, bit-serial fieldbus system. The standard specifies functional, electrical and mechanical properties.

PROFIBUS is a bus system that networks automation systems and field devices compatible with PROFIBUS at the cell and field level. PROFIBUS is available with the protocols DP (= distributed I/O), FMS (= fieldbus message specification) or PA (process automation).

**PROFIBUS address**

Unique identification of a device connected to PROFIBUS. The PROFIBUS address is transmitted in the frame for addressing a device. A PC or programming device has the PROFIBUS address "0". DP masters and DP slaves have a PROFIBUS address in the range from 1 to 125.

**PROFIBUS device**

A PROFIBUS device has at least one PROFIBUS interface with an electrical (RS 485) or optical (Polymer Optical Fiber, POF) interface.

**PROFIBUS DP**

A PROFIBUS with DP protocol that complies with EN 50170. DP stands for distributed I/O (fast, real-time capable, cyclic data exchange). From the perspective of the user program, the distributed I/Os are addressed in exactly the same way as the centralized I/Os.

**PROFINET**

Open component-based industrial communication system based on Ethernet for distributed automation systems. Communication technology promoted by the PROFIBUS Users Organization.

**RS 485**

Asynchronous data transmission process for PROFIBUS DP to ANSI TIA/EIA-RS485-A.

**RS 485 repeater**

Equipment for amplifying bus signals and for coupling segments over long distances.

**Segment**

The bus line between two terminating resistors forms a bus segment.

A bus segment can contain up to 32 bus nodes. Segments can be coupled, for example, by means of RS 485 repeaters or diagnostics repeaters.

**Slave**

Distributed device in a fieldbus system that may exchange data with a master after being requested to do so by the master. Slaves are all DP slaves, for example, such as ET 200SP, ET 200MP, ET 200AL.

### **Standard mounting rail**

Standardized metal profile to EN 50022.

The standard mounting rail is used for quick snap-on installation of network components, such as OLM, repeaters, etc.

### **Subnet**

Part of a network whose parameters must be synchronized with the devices (e.g., with PROFIBUS). A subnet includes the bus components and all connected stations.

### **SynchronousCycle**

Name for synchronous cycle interrupt OB in STEP 7.

### **Target-Rotation-Time (Ttr)**

Bus parameter for PROFIBUS. The token is the send permission for a device on PROFIBUS. A device compares a token rotation time it has measured with the Target-Rotation-Time and controls the sending of frames with high priority or low priority based on this comparison.

### **Terminating resistor**

Component that terminates the ends of a data transmission line to prevent reflections in the transmission medium.

### **Terminator**

Terminating resistor of bus segments with transmission rates of 9.6 kbps to 12 Mbps. The power supply is separate from the bus nodes.

### **TIA Portal**

Totally Integrated Automation Portal

### **Topology**

Structure of a network. Common structures are line topology, ring topology, star topology and tree topology.

### **Transmission rate**

Specifies the number of bits transmitted per second.

### **Watchdog**

Mechanism for monitoring the readiness for operation.

# Index

## A

- Acyclic data exchange, 74
- Address assignment, 45
- Addressing, 42

## B

- Bus connector
  - IP20, 22
  - M12 with IP65, 24
- Bus parameters
  - Adapting, 50
  - Description, 52
  - Value ranges, 54
- Bus profile, user-defined, 54
- Bus terminal
  - M12, 24
  - RS 485, 24

## C

- Cable configuration, 49
- Cables, 19
- Calculate bus times, 51
- CANopen module, 30
- Communication
  - I/O communication, 14
- Communication load, 51
- Components, (See network components)
- Configuration, 42
- Configuring isochronous mode, 68
  - Basic procedure, 67
  - DP slave, 68
  - Requirements, 66
  - Updating the process image partition, 69
- Connecting PROFIBUS DP with PROFINET IO, 41
- Constant bus cycle time, 55

## D

- Data exchange between IO systems, 81
- Diagnostic repeater
  - Cascade depth, 37

- Diagnostics, 60
  - Topology, 37
- Diagnostics, 57
  - Display alarms, 58
  - I-slave, 89
  - Isochronous mode, errors and remedies, 70
- Diagnostics repeater
  - Description, 29
- Display, diagnostic messages, 58
- DP master
  - Operated as, 80
- DP slave, 43
  - Operated as, 80
- DP/AS-i F-Link, 31
- DP/AS-i LINK Advanced, 31
- DP/AS-Interface Link 20E, 31
- DP/DP coupler, 30
- DP/PA bus link, 31

## E

- Example of isochronous mode, 64

## F

- FastConnect system, 20
- Fiber-optic, 27
- Fiber-optic cables, 25
  - Glass, 27
  - Optical ring, 49
  - PCF, 26
  - Plastic, 26

## G

- GAP factor, 54

## H

- Hardware
  - Configuring, 42
  - Parameter assignment, 42

**I**

- I/O addresses, 69
- I/O communication, 14
- Identification and maintenance data (I&M data), 61
- IE/PB Link PN, 30
- Increasing DP cycle time, 56
- Installation, 17
  - Active network components, 29
  - Bus connection, 22
  - Cables, 19
  - FastConnect, 20
  - Topology, 35
- Interrupt OBs, 77
- Interrupts
  - DPV1, 77
  - Isochronous mode, 70
- IO system
  - Data exchange, 81
- I-slave (intelligent DP slave)
  - Diagnostics, 89
  - Interrupt behavior, 89
- Isochronous mode
  - Change parameters, 71
  - Description, 62
  - Diagnostics, 70
  - Dialog box for isochronous mode, 71
  - Example, 64
  - Interrupts, 70
  - Sequence, in principle, 65
- IWLAN/PB Link PN IO, 30, 40

**M**

- M12
  - Bus connector, 24
  - Bus terminating resistor, 24
- M12 bus terminating resistor, 24
- Maximum cable lengths
  - Maximum cable lengths, 20

**N**

- Network, 18
  - electrical, conducted, 29
  - Optical, 33
  - optical, electrical, 18
  - Selection criteria, 18
  - Topology, 35
- Network components
  - Bus connections, 20
  - CANopen module, 30

- Diagnostics repeater, 29
- DP/AS-i F-Link, 31
- DP/AS-i LINK Advanced, 31
- DP/AS-Interface Link 20E, 31
- DP/DP coupler, 30
- Fiber-optic cables, 25
- IE/PB Link PN, 30
- IWLAN/PB Link PN IO, 30
- OBT, Optical Bus Terminal, 33
- OLM, Optical Link Module, 33
- PROFIBUS terminator, 30
- RS 485 cables, 19
- RS485, 29
- Network settings, 46

**O**

- Optical Bus Terminal, OBT, 33
- Optical Link Module, OLM
  - Description, 33
  - Topology, 40
- Optical ring, 49, 50

**P**

- Parameter assignment, 42
- Process image partition, 69
- PROFIBUS
  - Address, 45
  - Devices, 12
  - Installation, 17
  - PROFIBUS DP, 11
  - Protocols, 10
  - RS 485 cables, 19
- PROFIBUS address, 45
  - Change, 45
  - HSA, 46
- PROFIBUS DP
  - Applications, 11
  - Assigning the DP slave, 43
  - Connecting with PROFINET, 41
  - Definition, 10
  - Devices and designations, 13
  - Interface, 16
- PROFIBUS DP interface
  - Properties, 16
  - Representation in STEP 7, 16
- PROFIBUS terminator, 30
- Profiles for network settings
  - DP, Standard, 46
  - User-defined, 48



PROFINET Proxy functionality, 41  
Programming isochronous mode, 70

## R

Retry limit, 50, 54  
RS 485 cables, 20  
RS485 repeater  
    Description, 29  
    Topology, 35

## S

Slot time, 50, 54  
SYNC/FREEZE, 75  
Synchronization, sequence, 65  
Synchronous cycle interrupt, 69  
Synchronous cycle interrupt OB,  
SynchronousCycle, 70  
SynchronousCycle, synchronous cycle interrupt OB, 70

## T

Target Rotation Time, 54  
Topology  
    Connecting PROFIBUS DP with PROFINET, 41  
    OLM, 40  
    RS485 repeater, 35  
    WLAN, 40

# SIEMENS

## SIMATIC

## IO-Link system

### Function Manual

Preface

Guide

1

System overview

2

Integration into the  
automation system

3

12/2017

A5E31637677-AB

## Legal information

### Warning notice system

This manual contains notices you have to observe in order to ensure your personal safety, as well as to prevent damage to property. The notices referring to your personal safety are highlighted in the manual by a safety alert symbol, notices referring only to property damage have no safety alert symbol. These notices shown below are graded according to the degree of danger.

#### **DANGER**

indicates that death or severe personal injury **will** result if proper precautions are not taken.

#### **WARNING**

indicates that death or severe personal injury **may** result if proper precautions are not taken.

#### **CAUTION**

indicates that minor personal injury can result if proper precautions are not taken.

#### **NOTICE**

indicates that property damage can result if proper precautions are not taken.

If more than one degree of danger is present, the warning notice representing the highest degree of danger will be used. A notice warning of injury to persons with a safety alert symbol may also include a warning relating to property damage.

### Qualified Personnel

The product/system described in this documentation may be operated only by **personnel qualified** for the specific task in accordance with the relevant documentation, in particular its warning notices and safety instructions. Qualified personnel are those who, based on their training and experience, are capable of identifying risks and avoiding potential hazards when working with these products/systems.

### Proper use of Siemens products

Note the following:

#### **WARNING**

Siemens products may only be used for the applications described in the catalog and in the relevant technical documentation. If products and components from other manufacturers are used, these must be recommended or approved by Siemens. Proper transport, storage, installation, assembly, commissioning, operation and maintenance are required to ensure that the products operate safely and without any problems. The permissible ambient conditions must be complied with. The information in the relevant documentation must be observed.

### Trademarks

All names identified by ® are registered trademarks of Siemens AG. The remaining trademarks in this publication may be trademarks whose use by third parties for their own purposes could violate the rights of the owner.

### Disclaimer of Liability

We have reviewed the contents of this publication to ensure consistency with the hardware and software described. Since variance cannot be precluded entirely, we cannot guarantee full consistency. However, the information in this publication is reviewed regularly and any necessary corrections are included in subsequent editions.

# Preface

## Purpose of the documentation

This function manual provides a general overview of the IO-Link communication system. It shows the interaction of the various components of an IO-Link system and will help you improve your general understanding of IO-Link.

## Basic knowledge required

The following knowledge is required in order to understand the documentation:

- General knowledge of automation technology
- Knowledge of the industrial automation system SIMATIC
- Proficiency with STEP 7

## Scope of the documentation

This documentation is the basic documentation for IO-Link systems at Siemens. The product documentation is based on this documentation.

## Conventions

In this documentation, "STEP 7" is used as a synonym for all versions of the configuration and programming software "STEP 7 (TIA Portal)".

Please also observe notes marked as follows:

---

### Note

A note contains important information on the product described in the documentation, on the handling of the product or on the section of the documentation to which particular attention should be paid.

---

## Additional support

- Information about Technical Support is available in section Siemens Industry Online Support (Page 4).
- The range of technical documentation for the individual SIMATIC products and systems can be found on the Internet.
- Information about the online catalog and online order system is available in section Industry Mall (Page 5).

## Security information

Siemens provides products and solutions with industrial security functions that support the secure operation of plants, systems, machines and networks.

In order to protect plants, systems, machines and networks against cyber threats, it is necessary to implement – and continuously maintain – a holistic, state-of-the-art industrial security concept. Siemens' products and solutions constitute one element of such a concept.

Customers are responsible for preventing unauthorized access to their plants, systems, machines and networks. Such systems, machines and components should only be connected to an enterprise network or the internet if and to the extent such a connection is necessary and only when appropriate security measures (e.g. firewalls and/or network segmentation) are in place.

For additional information on industrial security measures that may be implemented, please visit (<https://www.siemens.com/industrialsecurity>).

Siemens' products and solutions undergo continuous development to make them more secure. Siemens strongly recommends that product updates are applied as soon as they are available and that the latest product versions are used. Use of product versions that are no longer supported, and failure to apply the latest updates may increase customers' exposure to cyber threats.

To stay informed about product updates, subscribe to the Siemens Industrial Security RSS Feed under (<https://www.siemens.com/industrialsecurity>).

## Siemens Industry Online Support

You can find current information on the following topics quickly and easily here:

- **Product support**

All the information and extensive know-how on your product, technical specifications, FAQs, certificates, downloads, and manuals.

- **Application examples**

Tools and examples to solve your automation tasks – as well as function blocks, performance information and videos.

- **Services**

Information about Industry Services, Field Services, Technical Support, spare parts and training offers.

- **Forums**

For answers and solutions concerning automation technology.

- **mySupport**

Your personal working area in Industry Online Support for messages, support queries, and configurable documents.

This information is provided by the Siemens Industry Online Support in the Internet (<http://www.siemens.com/automation/service&support>).

## Industry Mall

The Industry Mall is the catalog and order system of Siemens AG for automation and drive solutions on the basis of Totally Integrated Automation (TIA) and Totally Integrated Power (TIP).

You can find catalogs for all automation and drive products on the Internet (<https://mall.industry.siemens.com>).

# Table of contents

|          |                                                                    |           |
|----------|--------------------------------------------------------------------|-----------|
|          | <b>Preface .....</b>                                               | <b>3</b>  |
| <b>1</b> | <b>Guide.....</b>                                                  | <b>7</b>  |
| <b>2</b> | <b>System overview.....</b>                                        | <b>8</b>  |
| 2.1      | Advantages of IO-Link .....                                        | 9         |
| 2.2      | Overview of IO-Link system .....                                   | 10        |
| 2.3      | IO-Link interface.....                                             | 12        |
| 2.4      | IO-Link protocol.....                                              | 14        |
| 2.5      | Device profiles.....                                               | 16        |
| 2.6      | IODD and Port Configuration Tool - S7-PCT .....                    | 17        |
| 2.7      | Differences between IO-Link specifications V1.0 and V1.1 .....     | 19        |
| <b>3</b> | <b>Integration into the automation system.....</b>                 | <b>20</b> |
| 3.1      | Configuration of the IO-Link system.....                           | 20        |
| 3.1.1    | Configuration with S7-PCT .....                                    | 22        |
| 3.1.2    | Configuration without S7-PCT .....                                 | 25        |
| 3.1.3    | Overview of configuration options.....                             | 27        |
| 3.2      | Data access of the automation system and the HMI device.....       | 29        |
| 3.3      | Changing and saving device parameters during plant operation ..... | 30        |
| 3.4      | Replacing a master or device during operation .....                | 32        |
|          | <b>Index .....</b>                                                 | <b>33</b> |

## Documentation

Various IO-Link products are available from Siemens. Each of these products has a separate documentation. The IO-Link products are embedded in systems, e.g. ET 200SP. The documentation for the system consists of the respective system manual, function manuals and manuals. In addition, the STEP 7 online help and the Port Configuration Tool - S7-PCT online help assist you in configuring and programming your automation system with IO-Link.

## IO-Link components from Siemens

Siemens offers a wide range of products and support for IO-Link:

- Master
- Device, I/O modules
- Device, industrial switchgear
- Device, RFID systems (RFID = radio-frequency identification)
- Port Configuration Tool - S7-PCT  
(<https://support.industry.siemens.com/cs/ww/en/view/32469496>)
- IO-Link library (<https://support.industry.siemens.com/cs/ww/en/view/82981502>) with the blocks "IO\_LINK\_MASTER" and "IO\_LINK\_DEVICE"
- Overview of the topic IO-Link  
(<https://support.industry.siemens.com/cs/ww/en/view/109737170>)

Additional information on the products can be found on the Internet (<http://www.siemens.com/io-link>).

## Additional documentation for IO-Link

You can find a free download of the latest documentation on the IO-Link products on the Internet (<https://support.industry.siemens.com/cs/ww/en/ps/15818/man>).



# System overview

## Introduction

A continuous communication down to the lowest field level ensures enhanced use of the functions and performance capability of sensors and actuators. Enhanced use of sensors and actuators allows you to operate your machines and plants more productively.

No data other than the actual process value can be exchanged via the standard interfaces (digital, analog) used at the sensor/actuator level. Sensors and actuators with integrated intelligence are now used for increasingly complex functions and require a communication interface tailored to these requirements.

## Definition

IO-Link is an innovative, point-to-point communication interface for the sensor/actuator area that is specified in IEC 61131-9.

IO-Link consists of the following system components:

- IO-Link master
- IO-Link device
- Unshielded 3-wire or 5-wire standard cable
- Engineering tool for configuring and assigning parameters of IO-Link

## 2.1 Advantages of IO-Link

The IO-Link system offers significant advantages as digital interface when connecting sensors/actuators:

- Open standard in accordance with IEC 61131-9
  - Devices can be integrated in the same way in all conventional fieldbus systems and automation systems
- Tool supported parameter setting and central data management
  - Fast configuration and commissioning
  - Simple creation of current plant documentation even for sensors/actuators
- Single, uniform wiring and far fewer different interfaces at the sensors/actors
  - Standardized, uniform interface for sensors and actuators independent of their complexity (switching, measuring, multi-channel, binary, mixed signals, etc.)
  - Reduction in the variety of types and inventory
  - Fast commissioning
  - Any combination of IO-Link devices and sensors/actuators without IO-Link at IO-Link master
- Continuous communication between sensors/actuators and the CPU
  - Access to all process data, diagnostic data and device information
  - Access to device-specific data, such as energy data
  - Remote diagnostics can be performed
- Continuous diagnostic information down to sensor/actuator level
  - Reduction in troubleshooting effort
  - Minimizing risk of failure
  - Preventive maintenance and optimization of service and maintenance planning
- Dynamic change of sensor/actuators parameters by the controller or the operator at the HMI
  - Reduction in downtimes during product change
  - Increased variability of the machine
- Automatic reassignment of parameters when devices are replaced during operation
  - Minimization of downtimes
  - Device replacement by untrained personnel without additional aids
  - Avoidance of incorrect settings
- Integrated device identification
  - Identification of the installed devices
  - Ensure quality of result in production and manufacturing when replacing the device

## 2.2 Overview of IO-Link system

### Components

An IO-Link system consists of the following components:

- IO-Link master
- IO-Link device, for example:
  - Sensors/actuators
  - RFID readers
  - I/O modules
  - Valves
- Unshielded 3-wire or 5-wire standard cables
- Engineering tool for configuring and assigning parameters of IO-Link

### Example plant with IO-Link

The figure below shows an example of plant architecture with IO-Link.

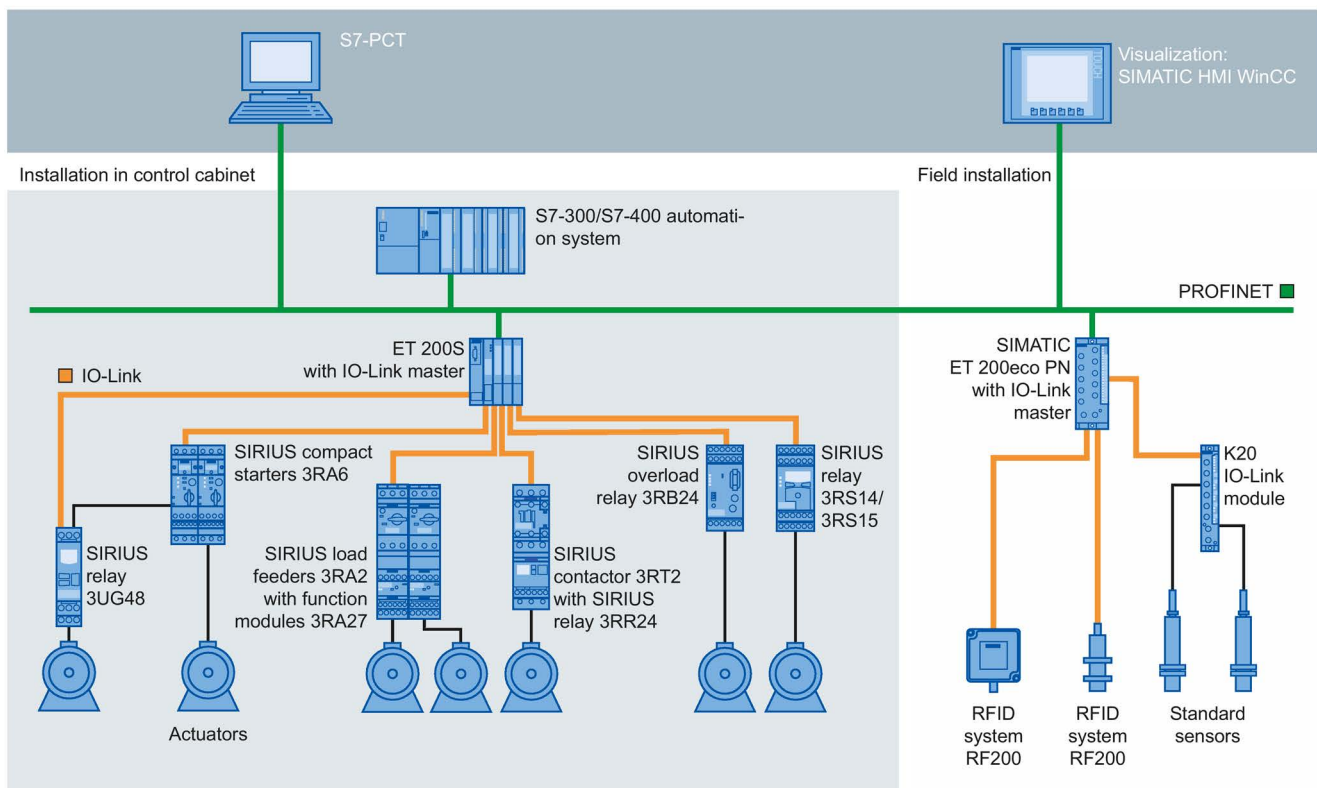


Figure 2-1 Plant architecture with IO-Link

The IO-Link master establishes the connection between the IO-Link devices and the automation system. If the IO-Link master is a component of the I/O system, it is installed either in the control cabinet or directly in the field as remote I/O in degree of protection IP65/67. The IO-Link master communicates by means of various fieldbuses or product-specific backplane buses. An IO-Link master can have multiple IO-Link ports (channels). An IO-Link device can be connected (point-to-point communication) to each port.

## **Engineering**

The IO-Link system is engineered parallel to the overall automation system and can be embedded in it and intermeshed with it.

## 2.3 IO-Link interface

### Introduction

The IO-Link is a serial, bidirectional point-to-point connection for signal transmission and power distribution under any network, fieldbus or backplane bus.

### Connection system in IP65/67

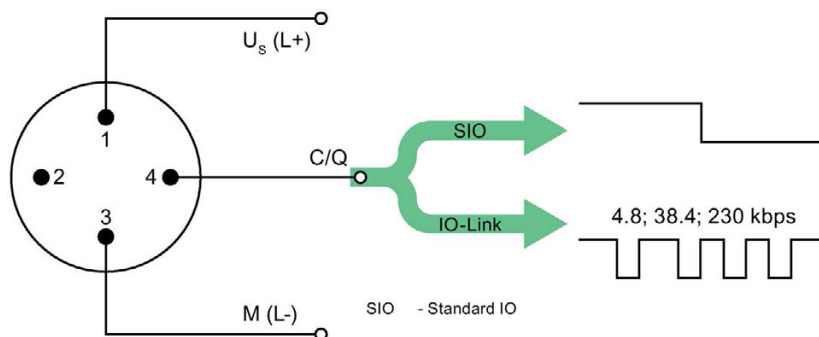
M12 connectors and other connectors are defined for the connection system in IP65/67; sensors have a 4-pin connector, actuators a 5-pin connector. IO-Link masters are always equipped with a 5-pin M12 socket.

The pin assignment according to IEC 60974-5-2 is specified as follows:

- Pin 1: 24 V
- Pin 3: 0 V
- Pin 4: Switching and communication cable (C/Q)

In addition to IO Link communication, these three pins also implement the power supply of the device.

Detailed information about the power supply can be found in the documentation of the utilized IO-Link master.



| Pin | Signal     | Definition                         | Standard    |
|-----|------------|------------------------------------|-------------|
| 1   | $U_s (L+)$ | 24 V                               | IEC 61131-2 |
| 2   | -          | not defined                        | -           |
| 3   | $M (L-)$   | 0 V                                | IEC 61131-2 |
| 4   | Q          | Switching signal DI, DQ (SIO)      | IEC 61131-2 |
| 4   | C          | "coded switching signal" (IO-Link) | IEC 61131-9 |

Figure 2-2 Pin assignment IO-Link device

## Port types in IP65/67

Two types of ports are distinguished in the specifications for IO-Link masters:

- **Port Class A (Type A)**  
With this type, the functions of pins 2 and 5 are not assigned. The manufacturer defines this function. Generally, an additional digital channel is assigned to pin 2.

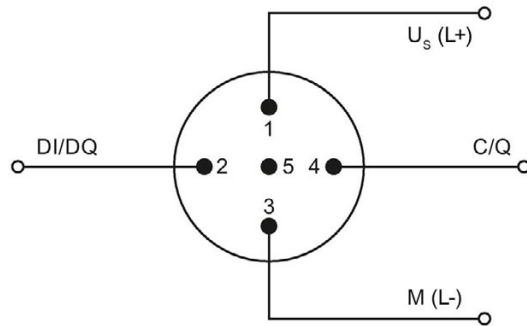


Figure 2-3 Pin assignment Port Class A

- **Port Class B (Type B)**  
This type offers an additional supply voltage and is suitable for the connection of devices that have an increased power requirement. In this case an additional (galvanically isolated) supply voltage is made available by pins 2 and 5. A 5-wire standard cable is required to use this additional supply voltage.

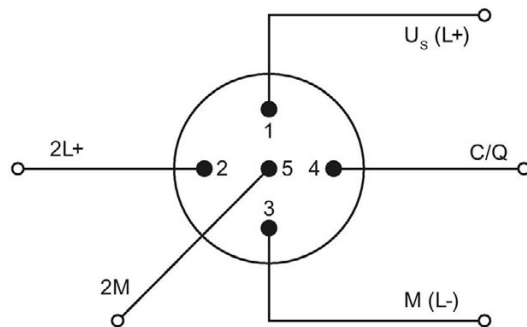


Figure 2-4 Pin assignment Port Class B

## Connecting cables

The devices are connected to the master with unshielded 3-wire or 5-wire standard cables with a maximum length of 20 m. Standard cables can be used to wire the sensors. No shielding or compliance with specific regulations is necessary for the installation of the cables.

## 2.4 IO-Link protocol

### Operating modes

The IO-Link port of the master can be operated in the following modes:

- IO-Link:  
The port is located in the IO-Link communication.
- DI:  
The port behaves like a digital input.
- DQ:  
The port behaves like a digital output.
- Disabled:  
The port is disabled.

### Transmission rate

In the IO-Link specification V1.1, three data transmission rates (baud rates) are specified for the IO-Link operating mode:

- COM 1 = 4.8 kBaud
- COM 2 = 38.4 kBaud
- COM 3 = 230.4 kBaud (optional according to Specification V1.0)

The IO-Link device only supports one of the defined data transmission rates. The IO-Link master to Specification V1.1 supports all data transmission rates and adjusts automatically to the data transmission rate supported by the device.

### Response time of the IO-Link system

The response time of the IO-Link system provides information about the frequency and speed of the data transmission between device and master. The response time depends on various factors.

A value for the minimum cycle time of the device is stored in the device description file IODD of the device (Page 17). This value indicates in which time intervals the master may address the device. The value has a big influence on the response time. The master also has an internal processing time that is factored into the calculation of the response time.

Devices with different minimum cycle time can be configured on a master. The response time for these devices differs accordingly. In other words, the response time for various devices connected to a master can vary greatly.

When you configure the master you can specify a fixed cycle time in addition to the device-specific minimum cycle time stored in the IODD. The master then addresses the device according to this specification.

The typical response time for a device thus results from the effective cycle time of the device and the typical internal processing time of the master.

## Transmission performance

IO-Link is a very robust communication system. This communication system operates with a 24V level. If transmissions fail, the frame is repeated two more times. The IO-Link master only detects a break in communication after the failure of the second repeat attempt and reports this to the higher-level CPU.

## Data types

Four data types are available:

- Process data → Cyclic data
- PQI → Cyclic data
- Device data → Acyclic data
- Events → Acyclic data

## Process data

The process data of the devices is transferred cyclically in a data frame with the process data size being determined by the device. Process data from 0 to 32 bytes is possible per device (input and output, respectively).

## Port Qualifier Information (PQI)

Each port has a Port Qualifier Information (PQI). This PQI provides information on the device status of the port and IO-Link (value status). The PQI is transmitted cyclically with the process data. The PQI is disabled by default.

## Device data

Device data can be parameters, identification data or diagnostic information. The data is exchanged cyclically and at the request of the IO-Link master. Device data can be written to the device and also read from the device.

## Events

When an event occurs, the device signals to the master that an event is present. The master then reads the event. Events can be error messages (for example, short-circuit) and warning/maintenance data (for example, dirt, overheating).

Error messages are transferred from the device to the CPU or the HMI by the IO-Link master.

The IO-Link master can also transfer events and states. Such events are, for example, wire break, break in communication or overload.

Device parameters or events are transmitted independently of the cyclic transmission of process data. The transmissions do not influence or impair each other.



## Startup of the IO system

If the port of the master is set to IO-Link mode, the IO-Link master attempts to communicate with the connected IO-Link device. For this purpose the IO-Link master sends a defined signal and waits for the reply of the IO-Link device.

The IO-Link master first attempts a communication with the highest defined data transmission rate. If this transmission attempt fails the IO-Link master attempts a communication with the lowest data transmission rate. The device always supports only one defined data transmission rate.

If the master receives a reply, communication starts. First they exchange communication parameters. If necessary the parameters stored in the system are transferred to the device.

Then the cyclic data exchange of process data and value status starts.

## 2.5 Device profiles

### Introduction

Device profiles are defined for IO-Link to standardize access of the CPU user program to the devices.

Data structure, data contents and basic functionality are defined in the device profiles. A standard user view and an identical program access is thus achieved for a number of different devices that have the same device profile.

### IO-Link profiles

The device profile "Smart Sensor Profile" is currently defined for IO-Link. This profile is especially suited for measurement sensors. In other words, measured values are transmitted in addition to switching points.

In addition, the switchgear (for example, contactors) support the LVSG (Low Voltage Switchgear) profile defined in IEC 61915-2.

## 2.6 IODD and Port Configuration Tool - S7-PCT

### Device description IODD

An electronic device description, the IODD file (IO Device Description) is available for each device. The IODD provides a wealth of information for system integration:

- Communication properties
- Device parameters with value range and default value
- Identification, process and diagnostic data
- Device data
- Text description
- Image of the device
- Manufacturer logo

The structure of the IODD is identical for all devices from all manufacturers. The structure of the IODD is always represented in the identical manner by the IO-Link Configuration Tool of the master manufacturer (for Siemens, S7-PCT). This ensures that the handling is the same for all IO-Link devices regardless of the manufacturer.

Two different IODD versions are available for devices that support both V1.0 and V1.1 functionality.

### IODDfinder

The IODDfinder is a cross-vendor, central IO-Link database.

This database provides you with the latest IODDs of the device manufacturers and offers an information and download platform.

The IODDfinder is available on the Internet (<https://ioddfinder.io-link.com>).

### IO-Link configuration tool

Configuration tools are required to configure the entire IO-Link system. The IO-Link configuration tools of the master manufacturers are able to read IODDs.

The main tasks of the IO-Link configuration tool include:

- Assigning the devices to the ports of the master
- Address assignment of ports within the address area of the master
- Assigning parameters for the IO-Link device

Diagnostics can also be carried out on the connected devices.

This means the IO-Link configuration tool supports the transparent representation of the IO-Link system down to field level.

Siemens provides S7-PCT for engineering of the IO-Link system.

S7-PCT with IODD of a device

The following figure shows a section from S7-PCT with IODD of a device and the device information contained therein.

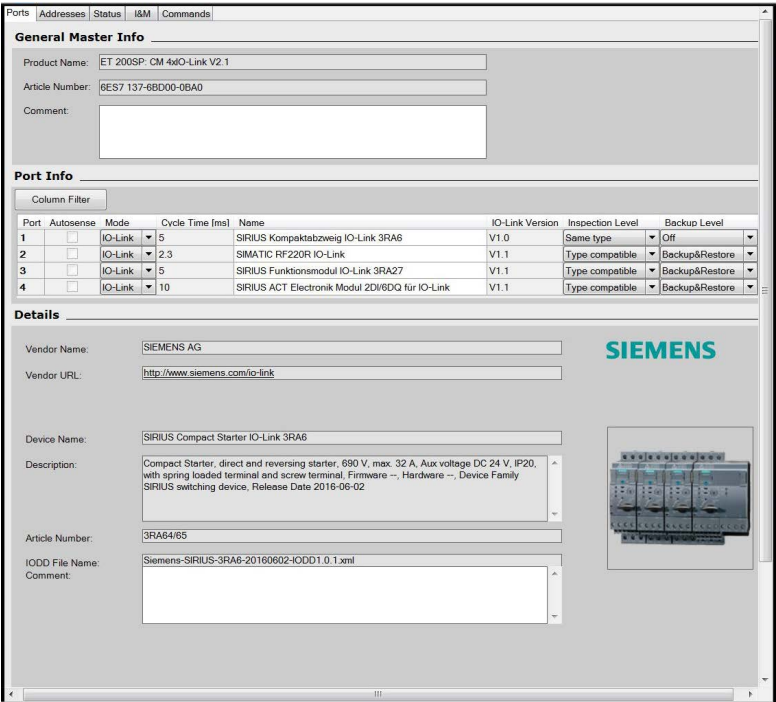


Figure 2-5 S7-PCT with IODD of a device and the device information contained therein

## 2.7 Differences between IO-Link specifications V1.0 and V1.1

### Specification

The technical definition of the IO-Link system is described in a specification of the IO-Link consortium. The first step was the creation of specification version 1.0. The further development and added functions of the IO-Link system led to version 1.1.

The main enhancements of version 1.1 are:

- Data backup for device replacement during operation (Backup&Restore)
- Data transmission rate 230.4 kBaud is mandatory for the IO-Link master

### Combination of IO-Link devices

Note the following when combining IO-Link devices:

- Only IO-Link devices that comply with V1.0 can be operated on the IO-Link master to V1.0.
- IO-Link devices that comply with V1.0 and V1.1 can be operated on the IO-Link master to V1.1.
- Data backup and a data transmission rate of 230.4 kBaud of the IO-Link master after V1.1 can only be used when these functions are also supported by the IO-Link device.

## Integration into the automation system

### 3.1 Configuration of the IO-Link system

#### Introduction

An IO-Link system is configured in several steps. In the first step, the master is integrated in the automation system and configured. In the second step, the IO-Link devices are configured.

#### Integration in the automation system

When using a SIMATIC S7 CPU, use the engineering tool STEP 7, V5.x or STEP 7 (TIA Portal) for configuration.

The IO-Link system is represented by the IO-Link master in the configuration of the automation system or the fieldbus and integrated with STEP 7 or a GSD file.

The IO-Link master itself can be a field bus node (e.g. ET 200eco PN IO-Link master) or a part of the modular IO system that is connected to the field bus (e.g. ET 200SP IO-Link master). In both cases, the number of ports, the address range and the module properties are described in STEP 7 or in the GSD file.

#### Example configuration in STEP 7 (TIA Portal)

The figure below shows a PROFINET configuration with integrated PROFINET devices ET 200SP and ET 200ecoPN with IO-Link masters.

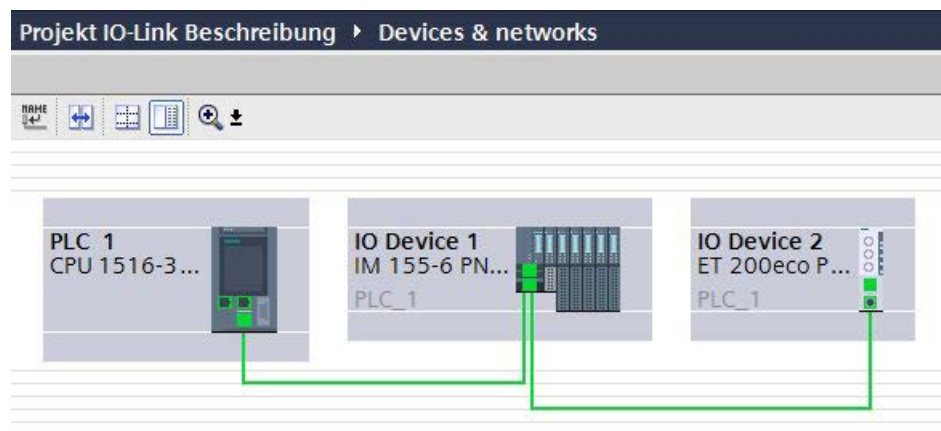


Figure 3-1 Configuration of a PROFINET network with lower-level IO-Link masters

In the device view of the PROFINET device, you can:

- Parameterize the ports
- Specify the input and output address ranges of IO-Link for exchange of cyclic data (process values).

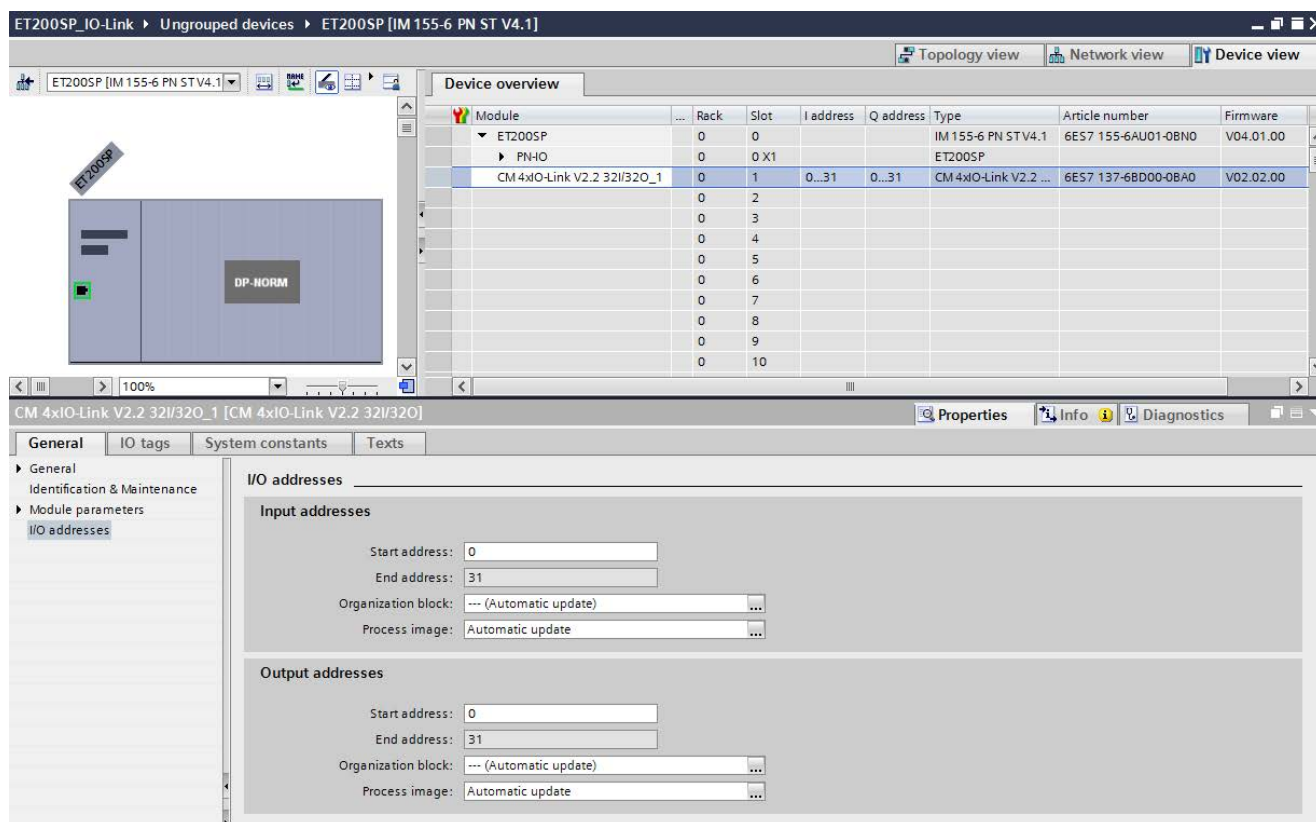


Figure 3-2 Device view with setting of the IO-Link address range

In addition, you can set in the module properties of the IO-Link master how the IO-Link system is to be configured and parameterized.

In doing so, you can select whether or not you also want to work with the S7-PCT configuration tool.

## Note

### IO data length

To ensure smooth operation, select an IO data length during configuration of the IO-Link master that corresponds at least to the IO data length of all connected IO-Link devices.

### **3.1.1 Configuration with S7-PCT**

#### **Introduction**

The following sections describe how you configure your IO-Link master with the S7-Port Configuration Tool (S7-PCT).

You need S7-PCT to display the system architecture completely and transparently all the way to the IO-Link device and to configure and parameterize the IO-Link system in detail.

With S7-PCT you can easily configure the IO-Link devices with the help of the IODD (IO-Link Device Description) supplied by the device manufacturer.

In the S7-PCT online view you can display the diagnostics states and process values of the IO-Link devices in detail.

#### **Configuration with S7-PCT**

When you have selected the option "Configuration with S7-PCT", you are also making the settings of the IO-Link master ports with S7-PCT.

These settings include:

- Specification of the address range for each port
- Behavior when replacing an IO-Link device
- Setting the identification data for checking the connected IO-Link device type

Start S7-PCT from HW Config in STEP 7.

S7-PCT shows you all Siemens IO-Link masters you have configured in your automation system.

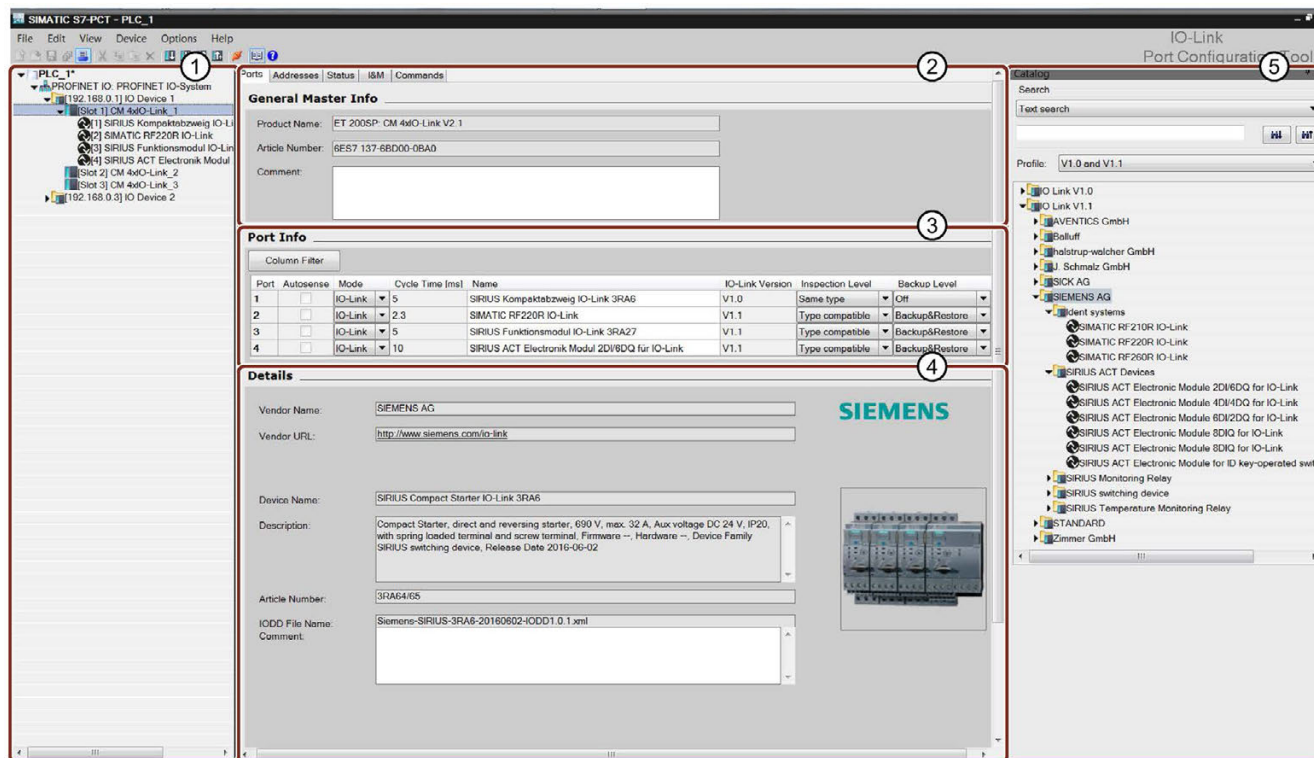
After selecting an IO-Link master, you can assign its IO-Link ports to the desired IO-Link devices.

To do so, select the corresponding IO-Link devices (or their IODDs) from the device catalog and drag them to the port of the IO-Link master.

## Example configuration in S7-PCT

The following figure shows the configuration of an IO-Link master in S7-PCT.

This S7-PCT view shows you a wide variety of information:



- ① Higher-level field bus and overview or structure of the lower-level IO-Link master
- ② Detailed information on the selected IO-Link master
- ③ Current configuration of the IO-Link ports of the selected IO-Link master
- ④ Detailed information on the selected IO-Link device
- ⑤ Device catalog with the IODDS of the IO-Link devices from different manufacturers

Figure 3-3 Configuration of an IO-Link master in S7-PCT

## Address range of the ports

In addition to the assignment of the IO-Link devices to the IO-Link master ports, the default address ranges of the ports can be changed. The IO-Link master transfers the process values that it receives from the IO-Link device in these address ranges and makes the process values available to the higher-level automation system.

To set the address range, select the "Addresses" tab.



## Setting device parameters

Specific parameter settings are required to adjust the device to the respective application task. The possible parameters and set values are contained in the IODD of each device. You set the device parameters directly in S7-PCT.

After selecting the corresponding device in the project tree (left tree), set the device parameters in the "Parameters" tab.

The figure below shows you an example of the parameter assignment of an IO-Link device:

| Identification                                     | Parameters                         | Monitoring | Diagnostics | Connection |                                                                                |
|----------------------------------------------------|------------------------------------|------------|-------------|------------|--------------------------------------------------------------------------------|
| Column Filter                                      |                                    |            |             |            |                                                                                |
| Parameter                                          | Value                              | Icon       | Unit        | Status     | Help                                                                           |
| Parameters                                         |                                    |            |             |            |                                                                                |
| Parameter Data                                     |                                    |            |             |            |                                                                                |
| System command                                     |                                    |            |             |            |                                                                                |
| Device Reset                                       | <div>Device Reset</div>            |            |             |            |                                                                                |
| Restore Factory Setting                            | <div>Restore Factory Setting</div> |            |             |            |                                                                                |
| Device access locks                                |                                    |            |             |            |                                                                                |
| Parameter (write) Access                           | Locked                             |            |             | changed    |                                                                                |
| Data Storage                                       | Unlocked                           |            |             |            |                                                                                |
| Operating system functions                         |                                    |            |             |            |                                                                                |
| index131 - Group diagnostics                       | enabled                            |            |             |            | enable/disable automatic signaling to PLC                                      |
| index131 - Group error diagnostics                 | enabled                            |            |             |            | enable/disable automatic signaling of error messages to PLC                    |
| index131 - Local threshold change                  | enabled                            |            |             |            | enable/disable local threshold changing via buttons                            |
| index131 - Local parameter change                  | enabled                            |            |             |            | enable/disable local parameter changing via buttons                            |
| index131 - Local reset                             | enabled                            |            |             |            | enable/disable local reset via buttons                                         |
| index131 - Retentive error memory                  | disabled                           |            |             |            | enable/disable remanent saving of error messages in the event of a power fa... |
| index131 - Analog value coding                     | Tmax [°C] (5)                      |            |             |            | choose the analog value trasmitted cyclically in the process image             |
| Temperature monitoring                             |                                    |            |             |            |                                                                                |
| index131 - Temperature monitoring mode             | Range monitoring                   |            |             | changed    | set the value of temperature monitoring mode                                   |
| index131 - Temperature unit                        | °C                                 |            |             |            | choose the temperature unit for display and monitoring (°C or °F)              |
| index131 - ON-delay time (at Power ON)             | enabled                            |            |             |            | enable/disable starting of delay time at Power-ON                              |
| index131 - ON-delay time (at manual reset)         | enabled                            |            |             |            | enable/disable starting of delay time at manual reset of the device            |
| index131 - ON-delay time                           | 0.0                                |            | s           |            | set the value of ON-delay time                                                 |
| index131 - Tripping delay time (if the temperat... | 0.0                                |            | s           |            | set the value of tripping delay time (temperature overshoot or undershoot)     |
| index131 - Temperature sensor type                 | PT100                              |            |             |            | choose the type of the connected temperature sensor(s)                         |
| index131 - Hysteresis                              | 3                                  |            |             | changed    | set the value of hysteresis for automatic reset after overshoot or undershoot  |
| index131 - Relay switching response                | Closed-circuit principle (NC)      |            |             |            | choose the circuit principle of relay switching                                |
| Thresholds                                         |                                    |            |             |            |                                                                                |
| index131 - Threshold #1                            | 30                                 |            |             | changed    | set temperature threshold 1 for tripping (overshoot or undershoot depends o... |
| index131 - Threshold #2                            | 20                                 |            |             | changed    | set temperature threshold 2 for tripping (overshoot or undershoot depends o... |
| index131 - Warning threshold for #1                | 28                                 |            |             | changed    | set temperature warning threshold 1 (overshoot or undershoot depends on ...    |
| index131 - Warning threshold for #2                | 22                                 |            |             | changed    | set temperature warning threshold 2 (overshoot or undershoot depends on ...    |

Figure 3-4 Setting the parameter values of the IO-Link device

Starting from the displayed defaults, you can edit and save the values in the defined value range.

The configuration of the IO-Link system and the parameters of the devices are available to the IO-Link system and the entire automation project. You have the option of saving and printing the configuration and the parameters.

### 3.1.2 Configuration without S7-PCT

#### Introduction

The following sections describe how you configure your IO-Link master without the S7-Port Configuration Tool (S7-PCT).

Your options for configuration of the IO-Link system without S7-PCT are limited. You can configure the port of the IO-Link master using STEP 7 or the GSD file, but you cannot set any parameters of the lower-level IO-Link devices.

#### Configuration without S7-PCT

You can activate the following parameters in STEP 7 or the GSD file during port configuration:

- Port Qualifier Information (PQI):  
provides information on the status, such as process data of the IO-Link port; is transmitted with the input data of the IO-Link device.
- Operating mode
  - IO-Link Autostart:  
The IO-Link master accepts each connected IO-Link device and starts it automatically.
  - IO-Link Manual:  
The IO-Link master only accepts IO-Link devices that match the Vendor ID and Device ID set below.  
The connected IO-Link device is **not** started automatically.
  - DI:  
The port is operating as a standard digital input.
  - DQ:  
The port is operating as a standard digital output.
  - Disabled:  
The port is disabled.
- Input Data Length:  
Process data length of the input data
- Output Data Length:  
Process data length of the output data
- Vendor ID  
ID number of the device manufacturer. You can find the Vendor ID on the Internet (<https://support.industry.siemens.com/cs/ww/en/view/109748852>).

- Device ID  
ID number of the device. You can find the Device ID on the Internet (<https://support.industry.siemens.com/cs/ww/en/view/109748852>).
- Inspection level for data backup:
  - Identical type (V1.0) without Backup&Restore
  - Type-compatible (V1.1) without Backup&Restore
  - Type-compatible (V1.1) with Backup&Restore
  - Type-compatible (V1.1) with Restore

The figure below shows you an example of the settings of a port configuration in STEP 7 or with GSD file:

The screenshot shows the 'Master Parameter' dialog box for 'Port 1'. It contains two checked options: 'Port Configuration without S7-PCT' and 'Port Qualifier Information (PQI)'. Below these, the 'Port 1' section includes the following settings:

| Parameter                  | Value                                      |
|----------------------------|--------------------------------------------|
| Port Mode:                 | IO-Link Autostart                          |
| Input Data Length:         | 9 Byte (8 Byte + PQI)                      |
| Output Data Length:        | 8 Byte                                     |
| Vendor ID:                 | 42                                         |
| Device ID:                 | 787201                                     |
| Inspection / Backup-Level: | Type compatible (V1.1) with Backup&Restore |

Figure 3-5 Settings of the port configuration in STEP 7 or with GSD file

### 3.1.3 Overview of configuration options

#### Introduction

The tables below show the configuration options offered by the SIMATIC IO-Link master with or without S7-PCT and which FW versions of the IO-Link master support the individual configurations.

#### Comparison of the configuration options

The following table provides an overview of the available options for configuration with and without S7-PCT:

| Requirement                                            | Configuration with S7-PCT | Configuration without S7-PCT |                                                                                                                                                              |
|--------------------------------------------------------|---------------------------|------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------|
|                                                        |                           | IO-Link Autostart            | IO-Link Manual                                                                                                                                               |
| Use of the IO-Link device description IODD             | Yes                       | No                           | No                                                                                                                                                           |
| Setting the length of input and output data (per port) | Automatic                 | Manual                       | Manual                                                                                                                                                       |
| Assignment of the Vendor ID and Device ID              | Automatic                 | -                            | Manual (see FAQ ( <a href="https://support.industry.siemens.com/cs/ww/en/view/109748852">https://support.industry.siemens.com/cs/ww/en/view/109748852</a> )) |
| Behavior during IO-Link device replacement             | Programmable              | -                            | Programmable                                                                                                                                                 |
| Adjustable IO-Link cycle time                          | Yes                       | No                           | No                                                                                                                                                           |
| Adjustable IO-Link device parameters                   | Yes                       | No                           | No                                                                                                                                                           |
| Display of the IO-Link process data structure          | Yes                       | No                           | No                                                                                                                                                           |
| Monitoring of IO-Link process data                     | Yes                       | No                           | No                                                                                                                                                           |
| Display of IO-Link device diagnostics messages         | Yes                       | No                           | No                                                                                                                                                           |

### Configuration options of the SIMATIC IO-Link masters

The following table provides an overview of the configuration options supported by the individual IO-Link masters:

| Device designation                                          | Article number     | As of FW version | Configuration... |                       |
|-------------------------------------------------------------|--------------------|------------------|------------------|-----------------------|
|                                                             |                    |                  | ...with S7-PCT   | ...without S7-PCT     |
| ET 200SP                                                    |                    |                  |                  |                       |
| Communications module IO-Link Master CM 4xIO-Link           | 6ES7137-6BD00-0BA0 | V1.0.0           | x                | -                     |
|                                                             |                    | V2.2.0           | x                | x                     |
| ET 200AL                                                    |                    |                  |                  |                       |
| Communications module CM 4xIO-Link 4xM12                    | 6ES7147-5JD00-0BA0 | V1.0.0           | x                | -                     |
|                                                             |                    | V1.1.0           | x                | x                     |
| ET 200ecoPN                                                 |                    |                  |                  |                       |
| IO-Link master<br>4 IO-L + 8 DI + 4 DO DC 24V/1,3A<br>8xM12 | 6ES7148-6JA00-0AB0 | V6.1.0           | x                | -                     |
| IO-Link master 4 IO-L 4xM12                                 | 6ES7148-6JD00-0AB0 | V1.0.0           | x                | x<br>(Autostart only) |
| ET 200pro                                                   |                    |                  |                  |                       |
| Electronic module EM 4 IO-LINK HF                           | 6ES7147-4JD00-0AB0 | V1.0.0           | x                | -                     |
| ET 200S                                                     |                    |                  |                  |                       |
| Electronic module 4SI IO-Link                               | 6ES7138-4GA50-0AB0 | V1.0.0           | x                | -                     |
| S7-1200                                                     |                    |                  |                  |                       |
| SM1278 4xIO-LINK MASTER                                     | 6ES7278-4BD32-0XB0 | V1.0.0           | x                | -                     |

## 3.2 Data access of the automation system and the HMI device

### Cyclic data exchange

To exchange cyclic process data between an IO-Link device and a CPU, the IO-Link data is assigned by the IO-Link master to the previously set address ranges. The user program of the CPU accesses and processes the process values by using these addresses. The cyclic data from the CPU to the IO-Link device (for example, IO-Link actuator) takes place in reverse order.

### Acyclic data exchange

Acyclic data, such as device parameters or events, is exchanged by means of a fixed index and subindex area. The CPU accesses the data using system mechanisms (for example, for online functions such as reading the status). You can use the index and subindex area to access specific device information (for example, to re-assign parameters of the device or master during operation).

### Function blocks "IO\_LINK\_MASTER" and "IO\_LINK\_DEVICE"

The programming of the CPU user program is another task in addition to the configuration and parameterization of the IO-Link system and its integration into the overall automation system.

For acyclic data exchange, you can use the function blocks "IO\_LINK\_MASTER" and "IO\_LINK\_DEVICE" for controllers of the S7-300, S7-400, S7-1200 and S7-1500 product lines.

The function block "IO\_LINK\_MASTER" reads all relevant functions and accesses to the IO-Link master, the function block "IO\_LINK\_DEVICE" reads all accesses to the IO-Link devices.

You can use the function block "IO\_LINK\_MASTER" to restore all parameters saved in the IO-Link master. A typical application is the replacement of the IO-Link master.

---

#### Note

#### Function blocks "IO\_LINK\_MASTER" and "IO\_LINK\_DEVICE"

The function blocks "IO\_LINK\_MASTER" and "IO\_LINK\_DEVICE" replace the functions of the previously available block "IOL\_CALL".

---

### Reference

The IO-Link block library with a description of the integration is available on the Internet (<https://support.industry.siemens.com/cs/ww/en/view/82981502>).

You can find an application example of using the block library with HMI devices on the Internet (<https://support.industry.siemens.com/cs/ww/en/view/90529409>).

### 3.3 Changing and saving device parameters during plant operation

#### Changing device parameters

You can adjust the device parameters during operation.

The changed parameters will become effective on the device in the process and are retentively saved in the device.

The parameters can be adapted during operation with:

- the engineering tool used (e.g. during plant commissioning)
- the CPU user program (program-controlled)
- HMI (through plant operator during batch change, process optimization)
- Locally through operation on the device (local operating unit on the device)

#### Saving device parameters (backup)

You can also save the parameters set in the device during commissioning or changed during operation of the plant in the IO-Link master.

This data backup takes place depending on the set behavior of the IO-Link master ports.

You can set the following data backup levels:

- None  
No data backup in the IO-Link master.
- Backup&Restore  
Every time the device parameters are changed, the changed data is automatically saved in the IO-Link master (see section "Triggering a backup").
- Restore  
No automatic data backup in the IO-Link master.

| IO-Link Version | Inspection Level | Backup Level   |
|-----------------|------------------|----------------|
| V1.0            | No check         | Off            |
| V1.1            | Type compatible  | Backup&Restore |
| V1.1            | Type compatible  | Backup&Restore |
| V1.1            | Type compatible  | Backup&Restore |

Figure 3-6 Overview of data backup level in S7-PCT

#### Note

##### IO-Link Specification V1.0

IO-Link master and devices to IO-Link specification V1.0 do not offer this function; a data backup cannot be set (Data backup: None).

Note that the behavior of the IO-Link master and the IO-Link devices during device replacement depends directly on the set data backup level.

You can find additional information on this dependency in the section Replacing a master or device during operation (Page 32).

## Triggering a backup

### Requirements

- You have set the correct data backup level.
- The IO-Link master and the IO-Link devices you are using support this function (IO-Link Specification V1.1).

### Procedure

There are several ways to trigger a backup:

- In the engineering tool:  
After you have downloaded the engineering settings to the device, the IO-Link device immediately triggers a backup.
- In the CPU user program:  
IO-Link device parameters can be changed successively by the user program.  
A backup is only triggered by a system command. The system command must be triggered by the user program after the parameter changes.  
You can implement the parameter changes and the system command for triggering the backup with function blocks of the CPU.
- Using the HMI:  
You proceed as with triggering by the user program.  
The plant operator then triggers the necessary system command on the HMI device.
- Locally by operating the IO-Link device:  
After confirming the input on the IO-Link device, the IO-Link device initiates the backup.



## 3.4 Replacing a master or device during operation

### Replacing a device

Replacing a device during operation is a scenario that occurs again and again and has to be completed without longer plant downtimes. Replace a device quickly and avoid incorrect settings. Devices can also be replaced by operators without special knowledge and aids.

When you use the backup function of the master, the master automatically supplies the saved parameters to the new device during device replacement.

You have the following setting options for device replacement:

- **Backup&Restore**

You have set the master port to Backup&Restore. The new device behaves as the replaced device because the master has saved the last parameter change with the backup function.

- **Restore**

You have set the master port to Restore. The new device applies the parameter settings that were saved in the master at the time of the last backup.

If you have made parameter changes since the last backup, these are not saved in the master and are not available to the new device.

The behavior of the new device can deviate from the behavior of the replaced device.

This may be useful if you want to make short-term plant optimizations but do not want to save them in the plant backup.

---

#### **Note**

##### **Field calibration of sensors**

When you are using sensors that must be adapted to specific rated conditions on site (field calibration), you must repeat this calibration after replacing the device.

The backup does not include the data of the field calibration. After repeating the field calibration, the new device works just like the replaced device.

---

### Replacing a master

Replacing a master during operation is a rather rare scenario. Here, too, longer plant downtimes are to be avoided. Replace a device quickly and avoid incorrect settings. Devices can also be replaced by operators without special knowledge and aids.

You can save the configuration and parameter data of the master and the devices connected to the master in the CPU and download this information to the new master after the replacement.

When using an S7-CPU, you can use function blocks for this purpose.

You can find additional information on function blocks in the section Data access of the automation system and the HMI device (Page 29).

# Index

## B

Backup, 30  
Backup&Restore, 30

## C

Configuration, 22  
    without S7-PCT, 25  
Connecting cables, 13  
Connection system in IP65/67, 12

## D

Data exchange  
    Acyclic, 29  
    Cyclic, 29  
Data types, 15  
Device data, 15  
Device parameters, 24  
    Changing, 30  
    Save, 30  
Device profiles, 16

## E

Events, 15

## F

Function block  
    IO\_LINK\_DEVICE, 29  
    IO\_LINK\_MASTER, 29

## I

IODD  
    Device description, 17  
IO-Link  
    Advantages, 9  
    Combination, 19  
    Components, 7  
    Configuration tool, 17  
    Definition, 8

IO-Link system

Function Manual, 12/2017, A5E31637677-AB

Interface, 12  
Protocol, 14  
Response time, 14  
Specification, 19

## O

Operating modes, 14

## P

Port  
    Address range, 23  
Port types in IP65/67, 13  
Process data, 15

## R

Restore, 30

## S

S7-PCT  
    Example configuration, 23  
Startup of the IO system, 16

## T

Transmission performance, 15  
Transmission rate, 14

## W

with S7-PCT, 22

## SIMATIC

S7-1500, ET 200MP,  
ET 200SP, ET 200AL,  
ET 200pro, ET 200eco PN  
Analog value processing

Function Manual

### Preface

Documentation guide

1

What you should know about  
analog technology

2

Representation of analog  
values

3

Connecting transducers

4

Thermocouples

5

Wiring loads/actuators

6

Supported functions

7

High-speed analog modules

8

## Legal information

### Warning notice system

This manual contains notices you have to observe in order to ensure your personal safety, as well as to prevent damage to property. The notices referring to your personal safety are highlighted in the manual by a safety alert symbol, notices referring only to property damage have no safety alert symbol. These notices shown below are graded according to the degree of danger.

#### **DANGER**

indicates that death or severe personal injury **will** result if proper precautions are not taken.

#### **WARNING**

indicates that death or severe personal injury **may** result if proper precautions are not taken.

#### **CAUTION**

indicates that minor personal injury can result if proper precautions are not taken.

#### **NOTICE**

indicates that property damage can result if proper precautions are not taken.

If more than one degree of danger is present, the warning notice representing the highest degree of danger will be used. A notice warning of injury to persons with a safety alert symbol may also include a warning relating to property damage.

### Qualified Personnel

The product/system described in this documentation may be operated only by **personnel qualified** for the specific task in accordance with the relevant documentation, in particular its warning notices and safety instructions. Qualified personnel are those who, based on their training and experience, are capable of identifying risks and avoiding potential hazards when working with these products/systems.

### Proper use of Siemens products

Note the following:

#### **WARNING**

Siemens products may only be used for the applications described in the catalog and in the relevant technical documentation. If products and components from other manufacturers are used, these must be recommended or approved by Siemens. Proper transport, storage, installation, assembly, commissioning, operation and maintenance are required to ensure that the products operate safely and without any problems. The permissible ambient conditions must be complied with. The information in the relevant documentation must be observed.

### Trademarks

All names identified by ® are registered trademarks of Siemens AG. The remaining trademarks in this publication may be trademarks whose use by third parties for their own purposes could violate the rights of the owner.

### Disclaimer of Liability

We have reviewed the contents of this publication to ensure consistency with the hardware and software described. Since variance cannot be precluded entirely, we cannot guarantee full consistency. However, the information in this publication is reviewed regularly and any necessary corrections are included in subsequent editions.

# Preface

## Purpose of the documentation

This documentation covers general topics applicable to all products.

In addition to introductory information about analog value processing, this manual covers the following topics:

- Wiring transducers to analog inputs
- Wiring actuators/loads to analog outputs
- Compensating for reference junction temperatures
- Calibrating analog modules
- Diagnostics options of an analog module
- High-speed analog modules

## Basic knowledge required

The following knowledge is required in order to understand the documentation:

- General knowledge of automation technology
- Knowledge of analog value processing (analog technology)
- Knowledge of the industrial automation system SIMATIC
- Knowledge about how to use STEP 7 (TIA Portal)

## Scope of the documentation

This manual is considered the basic documentation for all analog input and analog output modules of the S7-1500, ET 200MP, ET 200SP, ET 200AL, ET 200pro and ET 200eco PN product series.

## Changes compared to previous version

Changes / enhancements described in this manual, compared to the previous version (version 12/2013):

- Extension of the scope of validity to the distributed I/O system ET 200AL

## Conventions

STEP 7: In this documentation, "STEP 7" is used as a synonym for "STEP 7 as of V12 (TIA Portal)" and subsequent versions of the configuration and programming software. This documentation includes images of the products it describes. The products supplied may differ slightly from these images.

Please observe notes labeled as follows:

---

### Note

Notes contain important information on a point in the documentation of particular importance.

---

## Additional support

Additional information on SIMATIC products is available on the Internet. The associated documentation is also available on the Internet.

- The portfolio of technical documentation for SIMATIC products and systems can be accessed on the Internet (<http://www.siemens.com/simatic-tech-doku-portal>).
- The online catalog and the ordering system are available on the Internet (<http://mall.automation.siemens.com>).

## Security information

Siemens provides products and solutions with industrial security functions that support the secure operation of plants, solutions, machines, equipment and/or networks. They are important components in a holistic industrial security concept. With this in mind, Siemens' products and solutions undergo continuous development. Siemens recommends strongly that you regularly check for product updates.

For the secure operation of Siemens products and solutions, it is necessary to take suitable preventive action (e.g. cell protection concept) and integrate each component into a holistic, state-of-the-art industrial security concept. Third-party products that may be in use should also be considered. You can find more information about industrial security on the Internet (<http://www.siemens.com/industrialsecurity>).

To stay informed about product updates as they occur, sign up for a product-specific newsletter. You can find more information on the Internet (<http://support.automation.siemens.com>).

# Table of contents

|          |                                                            |           |
|----------|------------------------------------------------------------|-----------|
|          | <b>Preface .....</b>                                       | <b>3</b>  |
| <b>1</b> | <b>Documentation guide .....</b>                           | <b>7</b>  |
| <b>2</b> | <b>What you should know about analog technology .....</b>  | <b>9</b>  |
| 2.1      | Overview .....                                             | 9         |
| 2.2      | Precision/resolution .....                                 | 13        |
| 2.3      | Scaling analog values .....                                | 17        |
| 2.4      | Unscaling analog values .....                              | 19        |
| 2.5      | Linearity errors .....                                     | 21        |
| 2.6      | Repeat accuracy .....                                      | 22        |
| 2.7      | Operational and basic error limits .....                   | 23        |
| 2.8      | Temperature error .....                                    | 26        |
| 2.9      | Interference frequency suppression .....                   | 27        |
| 2.10     | Common mode interference (UCM) .....                       | 29        |
| 2.11     | Series mode interference (USM) .....                       | 31        |
| 2.12     | Interference voltage suppression .....                     | 32        |
| 2.13     | Crosstalk between channels .....                           | 34        |
| 2.14     | Diagnostics .....                                          | 36        |
| 2.15     | Value status .....                                         | 46        |
| 2.16     | Conversion time of an analog module .....                  | 49        |
| 2.17     | Cycle time of an analog module .....                       | 51        |
| 2.18     | Settling and response times of analog output modules ..... | 52        |
| 2.19     | Smoothing .....                                            | 54        |
| 2.20     | Burden with 2-wire transducers .....                       | 57        |
| <b>3</b> | <b>Representation of analog values .....</b>               | <b>60</b> |
| 3.1      | Overview .....                                             | 60        |
| 3.2      | Representation of input ranges .....                       | 62        |
| 3.3      | Representation of output ranges .....                      | 63        |

|          |                                                              |            |
|----------|--------------------------------------------------------------|------------|
| <b>4</b> | <b>Connecting transducers .....</b>                          | <b>65</b>  |
| 4.1      | Overview .....                                               | 65         |
| 4.2      | Wiring analog inputs with MANA connection .....              | 67         |
| 4.3      | Wiring analog inputs without MANA connection .....           | 69         |
| 4.4      | Wiring voltage transducers.....                              | 71         |
| 4.5      | Wiring current transducers .....                             | 72         |
| 4.6      | Wiring thermal resistors and resistors.....                  | 74         |
| 4.7      | Wiring thermocouples .....                                   | 76         |
| <b>5</b> | <b>Thermocouples .....</b>                                   | <b>77</b>  |
| 5.1      | Selecting thermocouples.....                                 | 77         |
| 5.2      | Structure and operating principle of thermocouples .....     | 79         |
| 5.3      | Compensation for the reference junction temperature .....    | 81         |
| 5.3.1    | Overview .....                                               | 81         |
| 5.3.2    | Compensation with internal reference junction .....          | 84         |
| 5.3.3    | Compensation with reference channel of the module.....       | 86         |
| 5.3.4    | Compensation, reference channel of Group 0 .....             | 88         |
| 5.3.5    | Compensation with fixed reference temperature .....          | 91         |
| 5.3.6    | Compensation by means of dynamic reference temperature ..... | 94         |
| 5.3.7    | "None" or external compensation.....                         | 98         |
| 5.3.8    | Compensation type RTD (0) .....                              | 100        |
| <b>6</b> | <b>Wiring loads/actuators.....</b>                           | <b>103</b> |
| 6.1      | Overview .....                                               | 103        |
| 6.2      | Wiring loads/actuators.....                                  | 104        |
| <b>7</b> | <b>Supported functions .....</b>                             | <b>106</b> |
| 7.1      | Calibrating analog modules.....                              | 106        |
| 7.1.1    | Overview .....                                               | 106        |
| 7.1.2    | Calibrating analog modules.....                              | 107        |
| 7.1.3    | Canceling a calibration.....                                 | 111        |
| 7.1.4    | Resetting analog modules to factory settings .....           | 112        |
| <b>8</b> | <b>High-speed analog modules.....</b>                        | <b>113</b> |
| 8.1      | Basics.....                                                  | 113        |
| 8.2      | ST modules vs HS modules.....                                | 119        |
|          | <b>Index .....</b>                                           | <b>125</b> |



# Documentation guide

## Introduction

The documentation of the SIMATIC products has a modular structure and covers diverse topics concerning your automation system.

The complete documentation for the S7-1500, ET 200MP, ET 200SP, ET 200AL, ET 200pro and ET 200eco PN systems consists of the respective system manuals, function manuals and product manuals.

## Overview of additional documents related to analog value processing

The following table lists further references that supplement this description of analog value processing.

Table 1- 1 References for analog value processing

| Topic              | Documentation                                                                                                                                                                                          | Most important contents                                                                                                                         |
|--------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------|
| System description | System manual<br>S7-1500 Automation System<br>( <a href="http://support.automation.siemens.com/WW/view/en/59191792">http://support.automation.siemens.com/WW/view/en/59191792</a> )                    | <ul style="list-style-type: none"> <li>• Application planning</li> <li>• Installation</li> <li>• Connecting</li> <li>• Commissioning</li> </ul> |
|                    | System manual<br>ET 200SP distributed I/O system<br>( <a href="http://support.automation.siemens.com/WW/view/en/58649293">http://support.automation.siemens.com/WW/view/en/58649293</a> )              |                                                                                                                                                 |
|                    | System Manual<br>ET 200MP Distributed I/O System<br>( <a href="http://support.automation.siemens.com/WW/view/en/59193214">http://support.automation.siemens.com/WW/view/en/59193214</a> )              |                                                                                                                                                 |
|                    | System manual<br>Distributed I/O System ET 200AL<br>( <a href="http://support.automation.siemens.com/WW/view/en/89254965">http://support.automation.siemens.com/WW/view/en/89254965</a> )              |                                                                                                                                                 |
|                    | Operating instructions<br>ET 200pro Distributed I/O System<br>( <a href="http://support.automation.siemens.com/WW/view/en/21210852">http://support.automation.siemens.com/WW/view/en/21210852</a> )    |                                                                                                                                                 |
|                    | Operating instructions<br>ET 200eco PN Distributed I/O System<br>( <a href="http://support.automation.siemens.com/WW/view/en/29999018">http://support.automation.siemens.com/WW/view/en/29999018</a> ) |                                                                                                                                                 |

| Topic                                     | Documentation                                                                                                                                                                                         | Most important contents                                                                                                                                                                |
|-------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Configuring interference-free controllers | Function manual<br>Configuring Interference-Free Controllers<br>( <a href="http://support.automation.siemens.com/WW/view/en/59193566">http://support.automation.siemens.com/WW/view/en/59193566</a> ) | <ul style="list-style-type: none"><li>• Basics</li><li>• Electromagnetic compatibility</li><li>• Lightning protection</li></ul>                                                        |
| Analog module                             | Product manual of the respective analog module                                                                                                                                                        | <ul style="list-style-type: none"><li>• Connecting</li><li>• Parameters</li><li>• Technical specifications</li><li>• Parameter data record</li><li>• Tables of analog values</li></ul> |

## SIMATIC manuals

All current manuals for SIMATIC products are available for download free of charge from the Internet (<http://www.siemens.com/automation/service&support>).

# What you should know about analog technology

## 2.1 Overview

### Introduction

This chapter is intended to familiarize you with the essential parameters of analog input modules and analog output modules based on the fundamentals of analog technology. The descriptions and examples provided on the following pages serve as a reference to the manuals for the respective analog module and are intended to facilitate the handling of these manuals.

### Analog and binary signals

Binary signals can assume only 2 signal states: signal state 1 (voltage present) and signal state 0 (no voltage present). In control engineering, it is frequently necessary to read, process and output analog signals in addition to binary signals. In contrast to binary signals, analog signals take on any number of values within a specific range. Possible analog variables include:

- Temperature
- Pressure
- Speed
- Fill level
- pH value

## Transducers

Controllers are only capable of processing analog values in the form of bit patterns. For this purpose, transducers which can be connected to the analog module measure physical variables such as pressure or temperature. The analog input module reads this analog value in the form of current, voltage or resistance. To enable the CPU to process the current or voltage measured, an integrated analog-to-digital converter in the analog input module converts the value into a 16-bit integer value. Depending on the type of measurement, you can use the following transducers:

- Voltage transducers
- Current transducers
  - 2-wire transducers
  - 4-wire transducers
- Resistance transducers
  - 4-wire connection
  - 3-wire connection
  - 2-wire connection
- Thermocouples

Additional information on wiring various types of transducers to analog inputs can be found in Wiring transducers (Page 65).

### Example

Speed is acquired using a transducer which converts the speed range of 0 to 1500 rpm to a voltage range of 1 to 5 V. At a measured speed of 865 rpm, the transducer outputs a value of 3.3 V.

The resulting voltage value is calculated as follows:

$$U = \frac{5 \text{ V} - 1 \text{ V}}{1500 \frac{\text{rpm}}{\text{min}}} * 865 \frac{\text{rpm}}{\text{min}} + 1 \text{ V} = 3.3 \text{ V}$$

The graph below illustrates voltage acquisition:

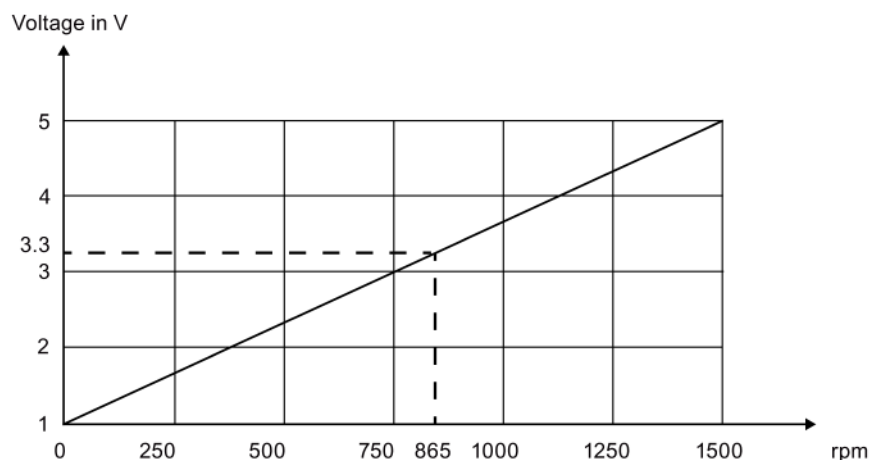


Figure 2-1 Speed measurement

## Analog-to-digital conversion

A CPU processes information exclusively in digital format. The analog value is therefore converted into a bit pattern. Conversion is done using an integrated ADC (analog-to-digital converter) in the analog input module. For the CPU, this conversion always returns a 16-bit word for SIMATIC products. The ADC used digitalizes the analog signal and approximates its value with a stepped curve. Resolution and conversion speed are the most important ADC parameters.

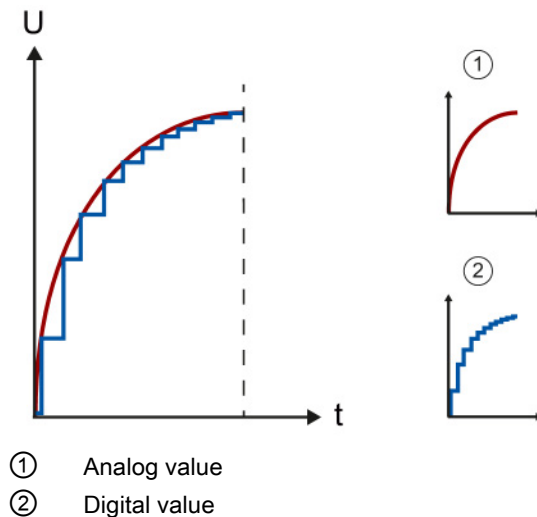


Figure 2-2 Approximation of an analog graph with low- and high-resolution stepped curves

## Digital-to-analog conversion

Once the CPU has processed the digital signal, an integrated DAC (digital-to-analog converter) in the analog output module converts the output signal to an analog current or voltage value. The resulting value of the output signal corresponds to the output value used to control the analog actuators. Such actuators include, for example, small servo drives or proportional valves. You will find more information on wiring actuators in Wiring loads/actuators (Page 103).

## Important parameters of analog modules

Alongside the type and range of measurement, the precision, resolution and conversion time are the main points to consider when selecting an analog module. For some applications such as systems which cover a large area, common mode or channel isolation are also important. The parameters listed here are examined in more detail in the following pages.

## Processing analog signals

The following figure demonstrates analog signal processing in a PLC.

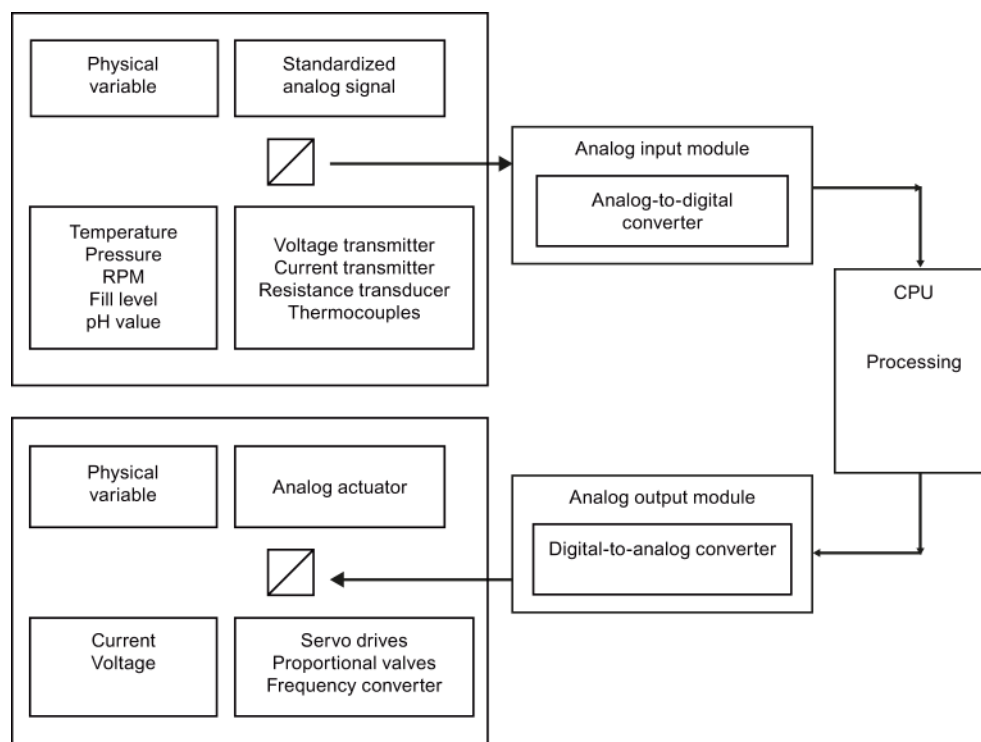


Figure 2-3 Analog value processing

## 2.2 Precision/resolution

The resolution of an analog module depends on the converter and its external circuitry. An approximation of the analog signal to be acquired/output is returned by a stepped curve. The resolution determines the number of increments of the analog value along this stepped curve. A higher module resolution reduces the length of increments and adds precision to the digitization of the analog signal.

### Approximation of an analog value

The figures below show the approximation of an analog value by means of a stepped curve. A low resolution only returns a rough approximation of the actual curve (left figure), while the approximation is more precise at higher resolutions (right figure).

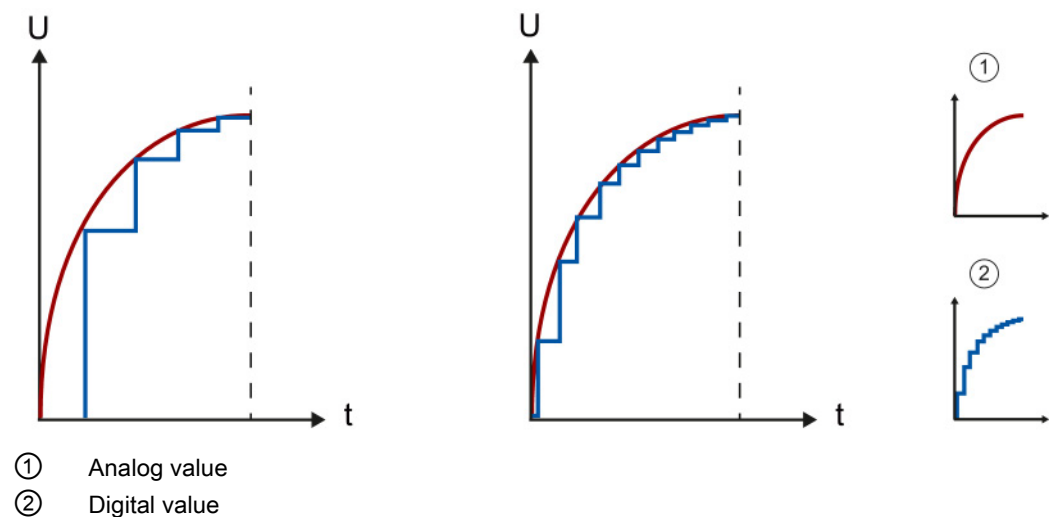


Figure 2-4 Approximation of an analog curve with a stepped curve

### Visualization of the measuring range at a resolution of 13 bits and 16 bits

The unipolar measured value from a module having a resolution of 13 bits (= 12 bits + S) is segmented into a total of  $2^{12} = 4096$  increments. The smallest increment in a measuring range of 0 to 10 V is  $10 \text{ V}/4096$ , equal to 2.4 mV.

A module with 16-bit (= 15 bits + S) resolution thus provides an increment of 0.3 mV. If the resolution increases by one bit, the number of increments doubles and the width of an increment halves.

If the resolution increases from 13 bits to 16 bits, the number of increments increases eightfold from 4096 to 32768. With a resolution of 13 bits, the smallest value that can be displayed is therefore 2.4 mV. By contrast, this value is approximately 0.3 mV at a resolution of 16 bits.

## Measuring ranges

For the display of the measuring range, SIMATIC S7 distinguishes between the rated range, the overrange and underrange, and the overflow or underflow. This distinction allows you to recognize whether the measured value is actually in the measuring range determined in the technical specifications. The overflow and underflow ranges are reserved for error detection.

At a resolution of 16 bits the theoretically possible 32768 increments are distributed across a voltage range of 11.852 V, which means that only 27648 increments are actually available for the resolution of a measuring range of 10 V. The minimum value which can be represented is therefore 0.3617 mV (see table).

Table 2- 1 Example of resolution for the 0 to 10 V measuring range of a SIMATIC S7 module

| Value (increments)                                                   | Voltage measuring range |             |
|----------------------------------------------------------------------|-------------------------|-------------|
| Decimal                                                              | 0 to 10 V               | Range       |
| 32767                                                                | 11.852 V                | Overflow    |
| 32512                                                                |                         |             |
| 32511                                                                | 11.759 V                | Overrange   |
| 27649                                                                |                         |             |
| 27648                                                                | 10.0 V                  | Rated range |
| 20736                                                                | 7.5 V                   |             |
| 1                                                                    | 361.7 $\mu$ V           |             |
| 0                                                                    | 0 V                     |             |
| not relevant for this example<br>as negative values are not possible |                         | Underrange  |
|                                                                      |                         | Underflow   |

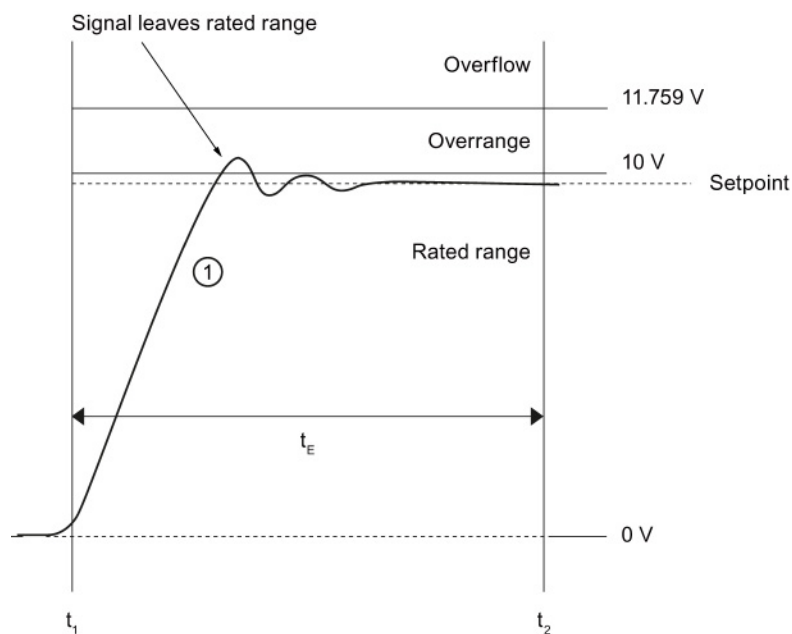
The digitized visualization of the input ranges, separated into bipolar and unipolar input ranges, is shown in the section Visualization of the input ranges (Page 62). The digitized visualization of the output ranges, separated into bipolar and unipolar output ranges, is shown in the section Visualization of the output ranges (Page 63). You will find a summary of all measuring ranges which you can use with your analog module in the corresponding device manual.



### Over and underrange

It may happen for control processes with high signal jumps that the settling curve of the signal briefly leaves the rated range until it reaches the setpoint. The over and underrange ensures that no error is reported while the signal is not in the rated range. If the signal exceeds the over or underrange, however, and reaches the overflow or underflow range, the error state "Overflow" or "Underflow" is diagnosed. This means the over or underrange correspond to a tolerance range between the rated range and the overflow or underflow. Additional information on the settling time is available in the section Settling and response times of analog output modules (Page 52).

The figure below shows the rated range, the overrange and overflow of a unipolar measuring range. The signal leaves the rated range briefly during the settling phase.



① Analog output signal

$t_E$  Settling time of the signal to the setpoint

$t_1$  Module ends conversion at the terminal of the analog output channel and outputs the signal

$t_2$  Signal has settled and the specified analog output value has been reached

### Analog module precision

The precision of an analog module is specified as a percentage value or absolute value, for example, in K or °C. This characterizes the total error of measured value acquisition. The basic error limit at 25 °C, as well as the operational limit, are specified in accordance with international standard IEC 61131, which also forms the basis for European Standard EN 61131. For more information on the operational/basic error limits, refer to the Operational and basic error limits (Page 23) section.

## **Relation between resolution and precision**

A certain resolution must be given to reach a specific precision (operational error).

### **Example**

#### **Measuring error as a result of digitization at a resolution of 8 bits and 14 bits**

An analog module has a measuring range of 0 V to 10 V. A resolution of 8 bits represents a total of 256 values. This is equivalent to a minimum possible voltage step of 39 mV or 0.4% of the measuring range end value. A resolution of 14 bits represents a total of 16384 values. This is equivalent to a minimum possible voltage step of 0.61 mV or 0.006% of the measuring range end value.

The percentages derived in this way also represent the theoretical best-case values for the operational limit. With a resolution of 8 bits and a measuring range of 0 to 10 V, it is therefore impossible to achieve a precision of more than 0.4 %. In practical life, this value would be clearly worse, depending on the implemented circuitry.

## **Calculating the maximum measuring error**

The maximum measuring error of a 0 to 10 V analog module with an operational limit of  $\pm 0.5$  % across the entire temperature range is calculated as follows:

$$10 \text{ V} \times 0.5/100 = 50 \text{ mV}$$

This means the maximum measuring error is approximately  $\pm 50$  mV. This also means that each analog voltage input is subject to a distortion of  $\pm 50$  mV across the entire input range. A voltage of 3.5 V that is to be measured can therefore be visualized by any value between 3.45 V and 3.55 V.

For more information on the operational/basic error limits, refer to the Operational and basic error limits (Page 23) section.

## 2.3 Scaling analog values

### Scaling

It is often necessary to calculate the actual process value rather than increments (e.g., 10 V = 27648 increments) for further processing of digitalized analog values. The conversion of a value range (e.g., -27648 to +27648 increments) to the original physical quantity (e.g., 0 to 500 liters) is referred to as scaling.

### Scaling blocks

STEP 7 offers the suitable program block for scaling of analog values. The SCALE block is included in the STEP 7 scope of delivery and permits input of a high and low limit (e.g., 0 to 500 liters).

### Example

In the example below the fill level of a tank with a capacity of 500 liters is to be measured. The transducer used measures a voltage of -10 V with an empty tank and a voltage of +10 V with a full tank. The analog module converts the voltage range from -10 V to +10 V into the value range -27648 to +27648 and converts this range into the original quantity of 0 to 500 liters with the SCALE program block.

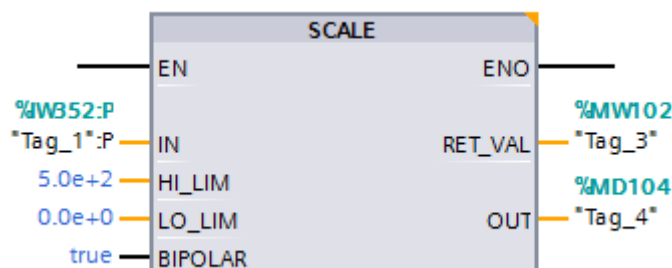


Figure 2-5 Scaling in the SCALE program block

The analog value at input **IN** is read directly by the module or is transferred by a data interface in INT format. The input **LO\_LIM** is used to determine the low limit (0 liters) and **HI\_LIM** to determine the high limit (500 liters) of the physical quantity. The output **OUT** outputs the scaled value (physical quantity) as floating-point number ( $\text{LO\_LIM} \leq \text{OUT} \leq \text{HI\_LIM}$ ). You can assign parameters via the input **BIPOLAR** to specify if only positive or only negative values are to be converted. If the parameter receives an operand with the state '0', there is a unipolar scaling. An operand with the state '1' results in a bipolar scaling. The output **RET\_VAL** outputs an error code in case of an error (e.g., overflow) and the value '0' in case of an error-free execution.

Additional information on the SCALE block can be found in the STEP 7 online help.

## Unipolar and bipolar measuring ranges

The measurement of the fill level in our example took place within a bipolar measuring range. In addition to the positive voltage the transducer also provides negative voltage. Because the tank volume is mapped to the range from -27648 to +27648 increments, the measurement of the fill level takes place with twice the resolution ( $\Delta$ ) as in the unipolar measuring range.

### Note

#### Transducers

The prerequisite for a measurement within a bipolar measuring range is that the used transducer supports bipolar measuring ranges.

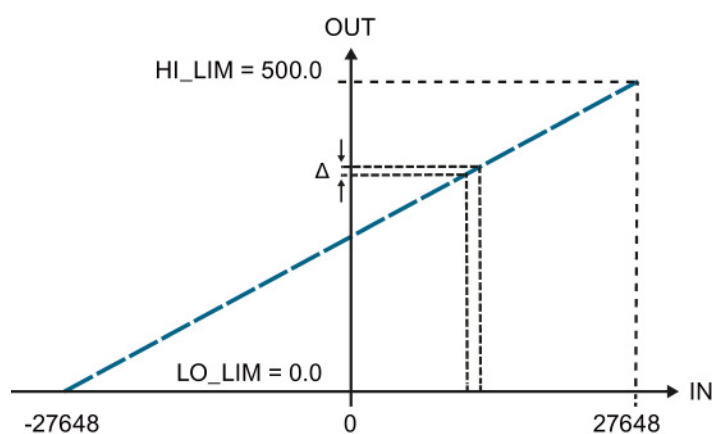


Figure 2-6 Bipolar measuring range

The measurement of the fill level in the bipolar measuring range takes place with twice the resolution ( $\Delta$ ) as in the unipolar measuring range.

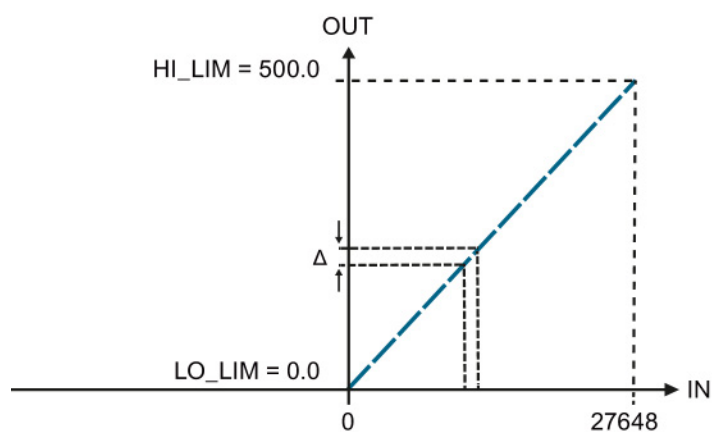


Figure 2-7 Unipolar measuring range

## 2.4 Unscaling analog values

### Unscaling

The output of scaled analog values often requires conversion of the analog value calculated by the user program into the value range of the analog output module. This conversion is referred to as unscaling.

### Unscaling blocks

STEP 7 offers the suitable program block for unscaling of analog values. The UNSCALE block is included in the STEP 7 scope of delivery and permits the input of a high and low limit that defines the range of the program value.

### Example

An analog value from 0.0 to 100.0% calculated by the user program is to be converted with the UNSCALE block to the value range -27648 to +27648. When the unscaled value is output to an analog output module, this module addresses an analog actuator (e.g., modulating valve). The actuator is to be addressed at a program value of 0% with the minimum value (-10 V or -20 mA) and at 100% with the maximum value (+10 V or +20 mA).

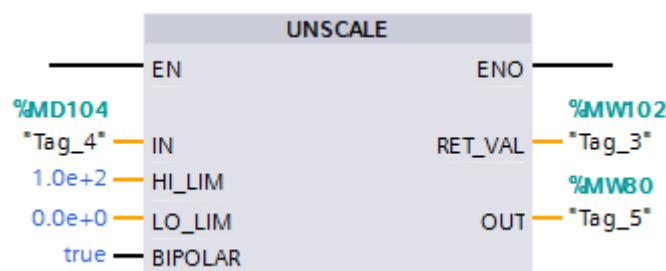


Figure 2-8 Unscaling in the UNSCALE program block

The value calculated by the program must be transferred in the REAL format (**IN**). You use the input **LO\_LIM** to determine the low limit (0.0%), and **HI\_LIM** to determine the high limit (100.0%) within which the program value moves. The unscaled value is output in INT format at the **OUT** output. You can assign parameters via the input **BIPOLAR** to specify if only positive or only negative values are to be converted. If the parameter receives an operand with the state '0', there is a unipolar scaling. An operand with the state '1' results in a bipolar scaling. The output **RET\_VAL** outputs an error code in case of an error and the value '0' in case of an error-free execution.

Additional information on the UNSCALE block can be found in the STEP 7 online help.

### Unipolar and bipolar measuring ranges

The figure below shows the scaling for an actuator that is to be addressed at a program value of 0% with the minimum value 0 (0 V or 0 mA) and at 100% (+27648) with the maximum value (10 V or 20 mA).

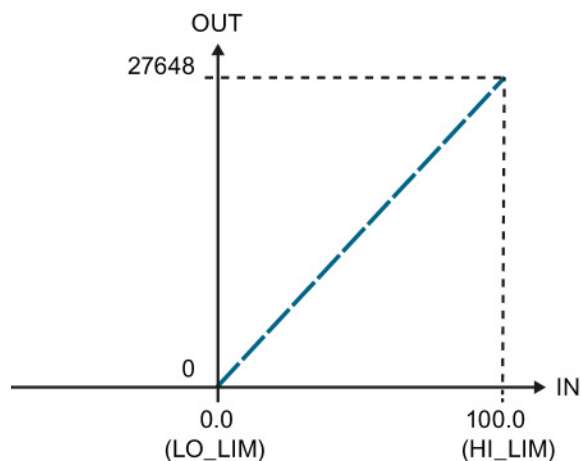


Figure 2-9 Unipolar measuring range

The figure below shows the scaling for an actuator that is to be addressed at a program value of 0% (-27648) with the minimum value 0 (-10 V or -20 mA) and at 100% (+27648) with the maximum value (+10 V or +20 mA).

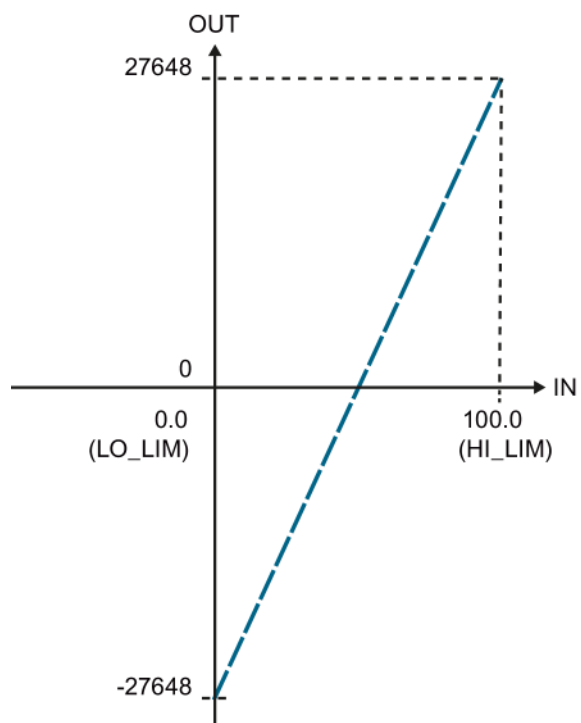


Figure 2-10 Bipolar measuring range

## 2.5 Linearity errors

### Definition

Linearity denotes the deviation of the actual A/D or D/A conversion from the ideal lines within a specified measuring range. The linearity error therefore represents the deviation of the real transmission function from the ideal straight line. The error is given in the technical data as a percentage of the rated range of the analog module.

The figure below shows the linearity error of an ADC, magnified for better visibility.

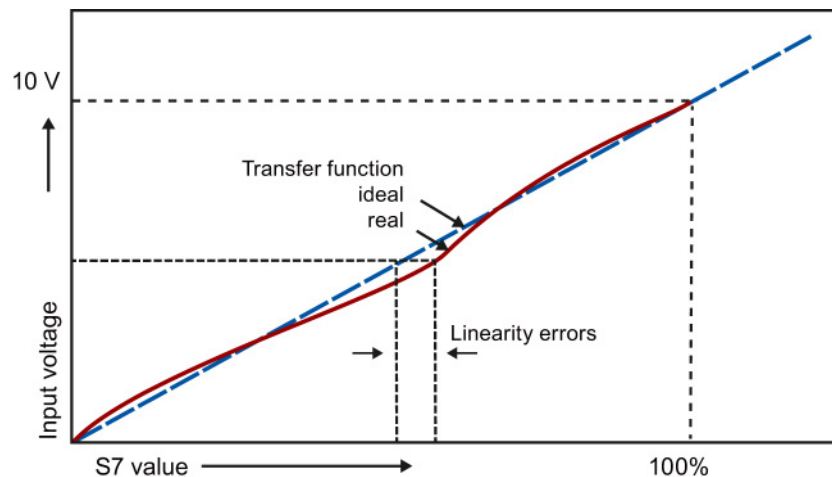


Figure 2-11 Linearity errors

### Example

An error of  $\pm 1$  mV is returned at an input range of  $\pm 10$  V and a linearity error of  $\pm 0.01\%$ . The error is calculated as follows:  $10 \text{ V} \cdot 0.01\% = 1 \text{ mV}$

The linearity error information given in the technical specifications is taken into account in the operational limit. You will find a detailed description of the operational limit in Operational and basic error limits (Page 23).

## 2.6 Repeat accuracy

### Definition

The repeat accuracy is the maximum deviation in measured/output value for the same input signal or output value after another value has been created or output. Other parameters, e.g. the Temperature parameter, remain unchanged. The repeat accuracy refers to the rated range of the module and applies in a steady temperature state.

### Measured value variance

The repeat accuracy provides information on the variance of individual measurements. The smaller the variance, the greater the repeat accuracy. The repeat accuracy is therefore one of the most important properties of measuring devices. In the technical data, the repeat accuracy is given as a percentage of the input or output range at 25°C in the steady state.

### Example

The specified repeat accuracy for an analog input module as a percentage of the measuring range end value is  $\pm 0.02\%$ . This corresponds to a repeat accuracy of 2 mV for any value within the measuring range of  $\pm 10$  V. If you change the measured value from 10 V to -10 V, for example, and then measure with 10 V again, the measured value deviation may not exceed  $\pm 2$  mV.

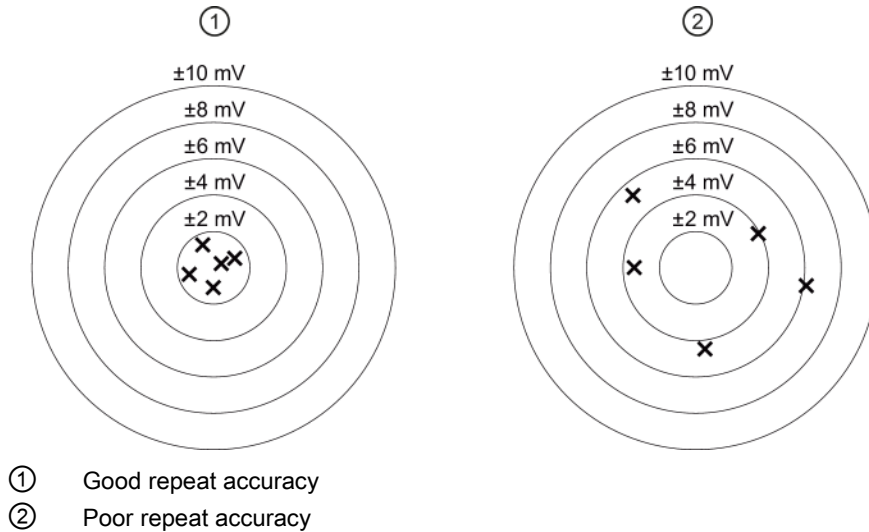


Figure 2-12 Repeat accuracy of measured values output



## **2.7 Operational and basic error limits**

### **Introduction**

The following section shows you how to determine the operational or basic error limits and thus the measurement error or output error with the help of the technical specification. The worst-case configuration ensures that the module will not exceed the specified value within the valid operational range.

The precision of analog input or output modules is only part of the precision of the entire measurement section. A measurement section usually consists of transducer, transmitter, transmission line as well as input / output module.

### **Operational limit**

The operational limit is the entire measurement or output error rate of the analog module in the rated range in temperature-settled state within the approved temperature range.

### Basic error limit

The basic error limit is the entire measurement or output error rate in the rated range at an ambient temperature of 25 °C and temperature-settled state.

The basic error limit of the module is more or less a theoretical value, because a constant ambient temperature of 25 °C is rarely maintained in plants. For this reason, the operational limit always takes priority in terms of the practical selection and assessment of a module.

#### Note

The operational limit and basic error limit percentages listed in the technical specifications always relate to the **maximum possible** I/O value (the measuring range end value) in the rated range of the module.

The following image shows an example of operational and basic error limits in comparison with the ideal curve.

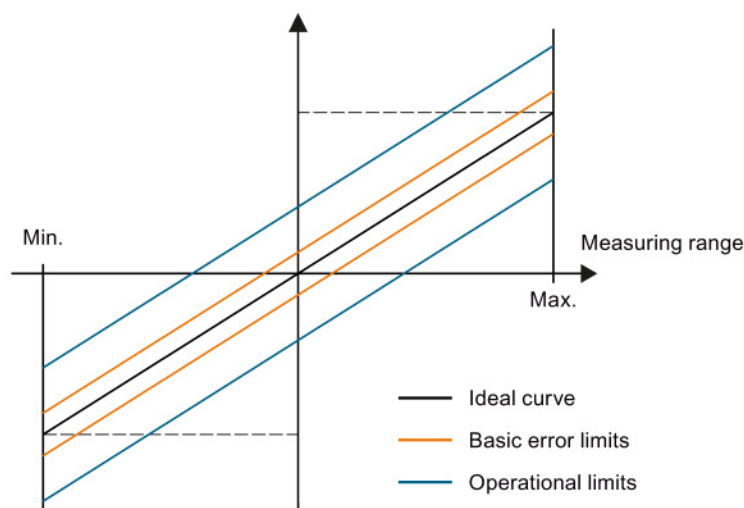


Figure 2-13 Operational and basic error limits

### **Example of output error calculation**

An analog output module is used for voltage output in a range of 0 to 10 V. The module is operating at an ambient temperature of 30 °C, which means that the operational limit applies. Technical specifications of the module:

- Operational limit for the voltage output:  $\pm 0.1 \%$

The result is an output error of approximately  $\pm 10 \text{ mV}$  ( $\pm 0.1 \%$  of 10 V) across the rated range of the module.

For example, the output value may range from 2.49 V to 2.51 V at an actual voltage of 2.50 V.

---

#### **Note**

##### **Bipolar measuring ranges**

The calculation also applies to bipolar measuring ranges.

An error of  $\pm 10 \text{ mV}$  is also returned at an input range of  $\pm 10 \text{ V}$  and a linearity error of  $\pm 0.1\%$ .

---

## 2.8 Temperature error

### Introduction

Analog modules are exposed to operational conditions that have an impact on their precision and on the measurement results they return. Temperature errors develop, for example, if the operating temperature of the module deviates from the ambient temperature of 25 °C. These temperature errors within the approved temperature range are taken into account in the operational limit.

### Definition

The temperature error identifies the maximum drift of measuring/output values caused by fluctuation of the ambient temperature at the analog module. The maximum drift can occur at any ambient temperature. The temperature error is specified depending on the module used in percent per degree Celsius and/or percent per Kelvin, e.g.  $\pm 0.005\%/K$ , and relates to the measuring range end value of the analog module.

### Operational limits of compensation

The temperature error of the reference junction temperature compensation function only occurs with thermocouple measurements. The temperature error of compensation is added to the actual temperature error if "Internal reference junction" operating mode is selected. The temperature error of compensation is defined in the technical specifications as a percentage of the physical rated range of the analog module or as an absolute value in °C.

---

#### Note

##### Calculating the error in thermocouple measurements

Add the error of a thermocouple measurement to the error of the compensation measurement to determine the total error of a thermocouple measurement. These errors are defined in the respective manual.

---

### Example

In this example, the total error of the temperature measurement is determined with the help of a type K thermocouple. The type K thermocouple takes measurements at a temperature range from -270 °C to +1372 °C.

The technical specifications state an operational limit of  $>-200\text{ °C} \pm 2.4\text{ K}$  for the type K thermocouple. The temperature error of compensation amounts to  $\pm 6\text{ °C}$ . The total temperature error is measured as follows at a temperature of  $>-200\text{ °C}$ :

Operational error ( $\pm 2.4\text{ K}$ ) + temperature error of compensation ( $\pm 6\text{ °C}$ ) =  $\pm 8.4\text{ °C}$ .

## 2.9 Interference frequency suppression

### Definition

The interference frequency suppression function is applied to analog input modules to suppress the noise caused by the frequency of the AC voltage supply used.

The frequency of the AC voltage supply is likely to have a negative effect particularly on the values returned by measurements in the low voltage range and on thermocouples.

### Parameter assignment

The line frequency at which the system is operated can be set by means of module parameters, for example, in STEP 7.

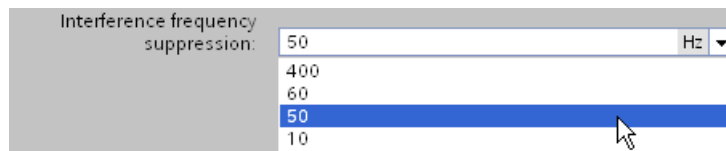


Figure 2-14 Interference frequency suppression

The conversion time changes depending on the set interference frequency suppression. The data sheets of the respective module define this dependency.

Please note the following when selecting interference frequency suppression:

The higher the frequency setting, the shorter the conversion time.

---

### Note

#### Line frequency

Always select the interference frequency based on the line frequency used. Mismatch errors must be expected if a frequency that deviates from this line frequency is set, for example, to reduce the conversion time. In this case, the specified technical data and, in particular, precision are possibly outside the specified range.

#### Smoothing

By smoothing analog values, you achieve an additional improvement for the suppression of interference frequencies. For more information on the smoothing of analog values, refer to the section Smoothing (Page 54).

---

### **Line frequencies used**

The line frequency is the frequency used in an electricity network for AC supply. It is measured in hertz and indicates the number of oscillations per second in a periodic signal. A line frequency of 50 Hz, for example, means 50 oscillations per second.

Europe, Australia and most countries in Asia and Africa use a line frequency of 50 Hz. North and Central America and most countries in South America have electricity networks with a line frequency of 60 Hz.

Frequencies of 400 Hz are most commonly used in on-board networks for airplanes, in the aerospace sector and for military applications. One reason for this is that engines with a line frequency of 400 Hz can usually be made smaller and lighter. As, however, it is not economic to transport such high frequencies over large distances, 400 Hz applications are usually subject to significant spatial limits.

A frequency of  $16 \frac{2}{3}$  Hz is used for the traction power supply in Germany, Austria and Switzerland. Some modules of the SIMATIC S7 product range also support the interference frequency suppression of this line frequency. The configurable interference frequency suppression in these cases is 16.6 Hz.

## **2.10 Common mode interference (UCM)**

### **Definition**

Common mode interference denotes interference voltages and currents in the lines connecting electrical devices and system components. They affect both the positive and negative line with the same phase angle and amplitude. The interference signal needs an additional current path to affect the utility signal. This current path is usually provided by common reference potential, e.g. earth or ground connection, of the utility signal and interference source.

### **Common mode interference in analog modules**

Common mode interference occurs in analog input and output modules if their reference potential is different from the reference potential of the connected sensor or actuator.

Common mode interference is most likely to occur when analog modules are operated with grounded sensors. The size of the overall system means that voltage differences may develop between machine components with grounded sensors and the analog module reference. These voltage differences affect both the positive and negative signal path equally, which is why they are termed common mode interference.

In operation with non-grounded sensors, the occurrence of common mode interference is not as obvious as in grounded operation. Nevertheless, capacitive or inductive coupling can also create voltage differences in such cases which have the effect of common mode interference. Depending on the conditions in grounded and non-grounded operation, common mode voltage can occur as direct or as alternating voltage.

### Example

The following figure of an analog module with two inputs (Ch<sub>1</sub>/Ch<sub>2</sub>) shows the coupled interference voltages at the inputs (U<sub>CM1</sub>/U<sub>CM2</sub>) as well as an interference voltage coupled between these inputs (U<sub>CM3</sub>). Common mode rejection indicates the extent to which these interference signals can be suppressed. It is calculated using the following equation:  
 CMR [dB] = 20 · log (U<sub>CM</sub> / U<sub>a</sub>)

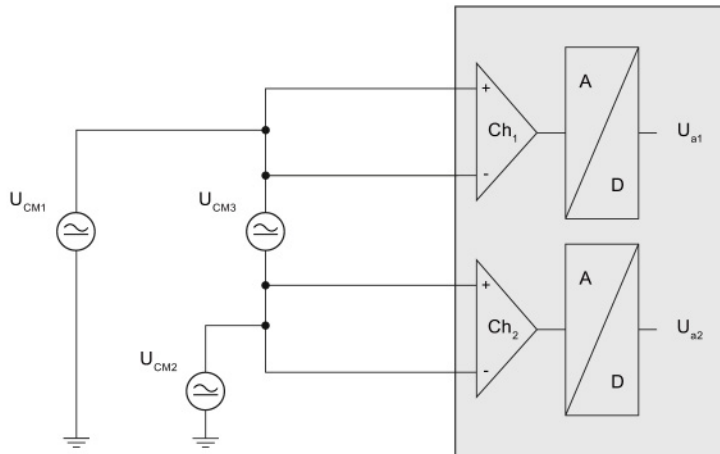


Figure 2-15 Common mode voltage coupled between two inputs

If there is common-mode voltage (U<sub>CM</sub>), the equation is solved for U<sub>a</sub> to calculate the measuring error (U<sub>a</sub>):

$$U_a = U_{CM} * 10^{-\frac{CMR}{20}}$$

### Note

The common mode rejection (CMR) is detailed in "Common mode interference" in the technical data of the device manual for your analog module.



## 2.11 Series mode interference (USM)

### Definition

Series mode interference is interference voltages and currents affecting the connection lines in opposite directions. They have opposite polarity in the positive and negative directions. Series mode interference currents cause a voltage drop at the input impedance that has the effect of an interference voltage.

### Causes

Series mode interference is caused by capacitive or inductive coupling. Inductive coupling generates a magnetic flow that is radiated between adjacent current-carrying conductors. This induces an interference voltage in the conductor. Galvanic coupling is given where different circuits influence each other due to common conductor sections, e.g. common ground connection.

The diagram below shows series mode interference as a voltage source ( $U_{SM}$ ) connected in series to the actual measuring signal ( $U_M$ ). The index "SM" stands for "Series Mode". Series Mode rejection indicates the extent to which these interference signals are suppressed. It is calculated using the following equation:  $SMR [dB] = 20 \cdot \log (U_{SM} / U_a)$

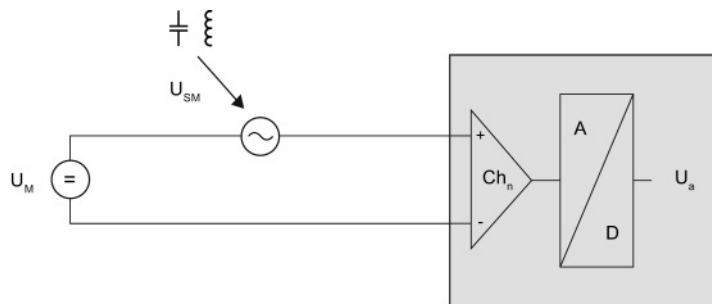


Figure 2-16 Capacitive or inductive interference coupling to the signal cable

The voltage ( $U_a$ ) measurement error is calculated by solving the equation for  $U_a$ .

$$U_a = U_{SM} * 10^{-\frac{SMR}{20}}$$

The following equation shows the calculation of current ( $I_a$ ) measuring errors using a current input.

$$I_a = \frac{U_{SM}}{R_{ein}} * 10^{-\frac{SMR}{20}}$$

### Note

The series mode rejection (SMR) is detailed in "Series mode interference" in the technical data of the device manual for your analog module. The level of input resistance ( $R_{ein}$ ) is also specified in the technical data.

## 2.12 Interference voltage suppression

### Definition

Interference voltage suppression gives the factor by which the interference signal is suppressed in measurement value acquisition. Higher values reduce the effect of interference on the measurement signal. The technical data differentiates between "Common mode interference" and "Series mode interference". Interference voltage suppression is specified in decibels.

### Example

The diagram below shows the measuring error for interference voltages in volts and interference voltage suppression of 0 to 120 dB.

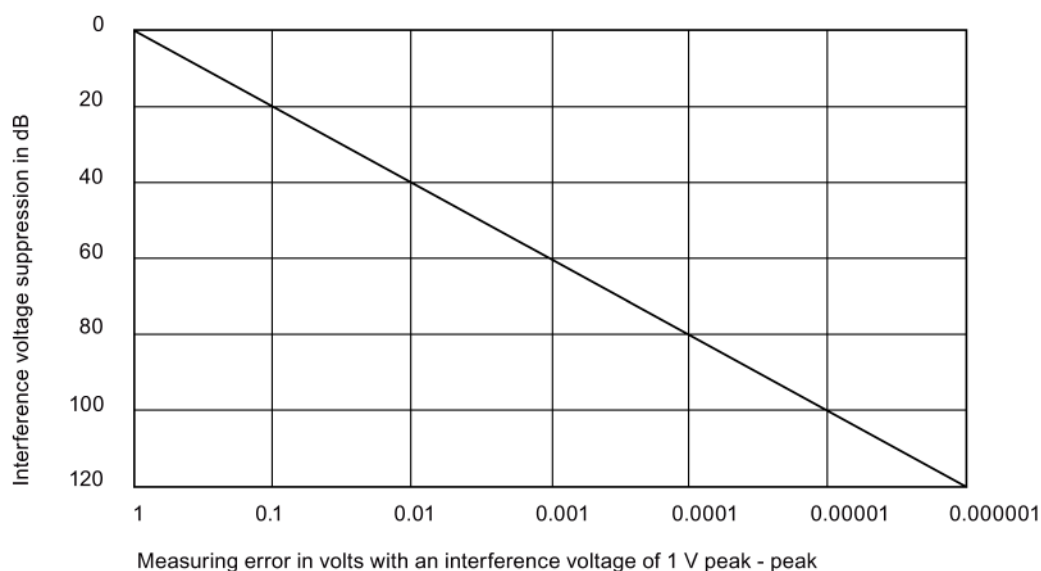


Figure 2-17 Interference voltage suppression

With an interference voltage suppression of 40 dB and an interference voltage of 1 V, the measured value is only distorted by 0.01 V.

### Note

#### Interference-free design

Disturbance variables can be substantially reduced by means of appropriate grounding and shielding to increase interference immunity of the configuration. You will find a detailed description of how to avoid interference in the Configuring interference-free controllers (<http://support.automation.siemens.com/WW/view/en/59193566>) function manual.

## Common mode rejection

The table below sets out the possible common mode rejection specifications in the technical data of an analog input module:

| Interference voltage suppression for $f = n \times (f_1 \pm 1 \%)$ , ( $f_1$ = interference frequency), $n = 1, 2, \dots$ |          |
|---------------------------------------------------------------------------------------------------------------------------|----------|
| Common mode interference                                                                                                  | > 100 dB |
| Common mode voltage, max.                                                                                                 | 10 V     |

If the interference frequency is configured as 50 Hz, the specified interference voltage suppression for common mode interference will only apply for the frequencies 50 Hz  $\pm 1 \%$ , 100 Hz  $\pm 1 \%$ , 150 Hz  $\pm 1 \%$ , etc. Immunity is lower for all other frequencies. Interferences caused by the line voltage distort the measured utility signal in the ratio of 100,000 : 1. An interference voltage amplitude of 1 V, for example, will affect the utility signal by 10  $\mu$ V.

The Common Mode voltage ( $U_{CM}$ ) defines the maximum permitted deviation of the potential between two channels and between one channel and analog ground. The interference voltage suppression defined in the technical specifications must not be exceeded. If the maximum common mode voltage specified, for example, 10 V, is exceeded, the analog signal is processed incorrectly. Depending on the module used, this error may be diagnosed and an error message output. The maximum common mode voltage may be exceeded as a result of varying input or overly long lines.

## Series mode rejection

The table below sets out the possible series mode rejection specifications in the technical data of an analog module:

| Interference voltage suppression for $f = n \times (f_1 \pm 1 \%)$ , ( $f_1$ = interference frequency), $n = 1, 2, \dots$ |         |
|---------------------------------------------------------------------------------------------------------------------------|---------|
| Series mode interference                                                                                                  | > 60 dB |

If the interference frequency is configured as 50 Hz, the specified interference voltage suppression for series mode interference will only apply for the frequencies 50 Hz  $\pm 1 \%$ , 100 Hz  $\pm 1 \%$ , 150 Hz  $\pm 1 \%$ , etc. Immunity is lower for all other frequencies. Overall, interference caused by the line voltage distorts the utility signal measured by 1000 : 1. For example, an interference voltage amplitude of 1 V will affect the utility signal by 1 mV.

## 2.13 Crosstalk between channels

### Origin of the term

The term crosstalk/XT was originally used in the field of telecommunication to denote unwanted coupling of voice signals between two cable conductors of different subscribers.

### Definition

Crosstalk between signal channels denotes the interactive influence between two independent channels as a result of leakage currents and capacitive or inductive coupling. Crosstalk between the channels changes the signal by the value of the amplitude of the crosstalk signal.

### Causes

Technically, it is not feasible to totally isolate the module channels from environmental conditions. This means that it is always possible for leakage currents or disturbance coupling having an interactive effect.

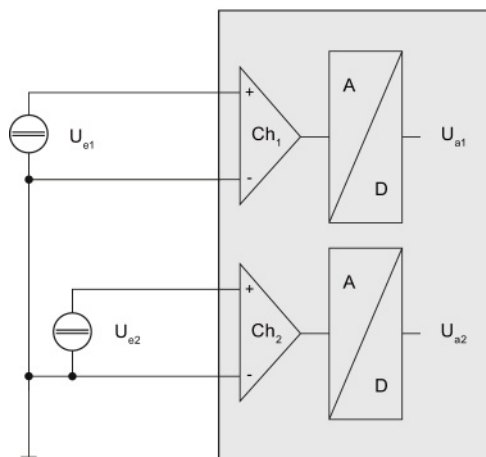


Figure 2-18 Crosstalk between two channels

The diagram shows the effects of crosstalk for the user with two channels (Ch<sub>1</sub>/Ch<sub>2</sub>) of an analog module. The crosstalk value is the factor by which the utility signal at a second channel U<sub>a2</sub> is affected by the signal at the first channel U<sub>e1</sub>. The measuring error (U<sub>a1</sub>) can be calculated using the following equation:

$$U_{a1} = U_{e2} * 10^{\frac{XT [dB]}{20}}$$

### Example of crosstalk attenuation

The "crosstalk between inputs" value in the technical specifications is defined as a value of >-100 dB at a measuring range of -10 V to +10 V on channel 1 of an eight-channel analog input module. The voltage at the input has an amplitude of 10 V. What is the error caused by crosstalk at channel 0 (measuring range  $\pm 10$  V) and channel 2 (measuring range  $\pm 80$  mV)?

100 dB are equal to a factor of 100,000. The measured values at channels 0 and 2 to 7 are therefore affected by  $10 \text{ V} / 100,000 = 100 \text{ }\mu\text{V}$ . This distortion is added to or subtracted from the pending measuring signal and its effect depends on the selected measuring range.

- Channel 0:  $100 \text{ }\mu\text{V} / 10 \text{ V} = 0.001 \%$
- Channel 2:  $100 \text{ }\mu\text{V} / 80 \text{ mV} = 0.125 \%$

A voltage of 10 V set at channel 1 distorts the measured value at channel 0 by 0.001% and the measured value at channel 2 by 0.125%. The measuring error resulting from crosstalk in this example is therefore 0.001 % or 0.125 %. The basic error limit already includes the error generated as a result of crosstalk between the channels.

### Calculating measuring error

You calculate the measurement error at channel 1 in this example based on a change in the measurement voltage of 10 V at channel 2. The crosstalk (XT [dB]) value is defined in the technical specifications in the manual of the analog module that you are using.

$$\text{Measured value error channel 1 [in V]} = \text{measured value change at channel 2 [in V]} * 10^{\frac{\text{XT [dB]}}{20}}$$

$$\text{Measured value error channel 1 [in V]} = 10 \text{ V} * 10^{\frac{-80 \text{ dB}}{20}} = 0.001 \text{ V}$$

A change in the measurement voltage of 10 V at channel 2 causes a measurement deviation of 0.001 V at channel 1.

## 2.14 Diagnostics

### Diagnostics for analog modules

SIMATIC analog modules can diagnose errors. A number of different types of diagnostics are available for analog modules in STEP 7. Please note that the parameter assignment options vary depending on the analog module and product family used. More detailed information on the types of diagnostics can be found in the device manual for your analog input or analog output module.

Proceed as follows to select the diagnostics types of the analog module used:

1. Open STEP 7.
2. Select the analog module in the Device view.
3. Select the "Properties" tab.
4. Select the inputs or the required channel of the analog module in the Inspector window.

Table 2- 2 Overview of diagnosable errors

| Type of diagnostics  | Analog input module | Analog output module |
|----------------------|---------------------|----------------------|
| Wire break           | ✓                   | ✓                    |
| No supply voltage L+ | ✓                   | ✓                    |
| Overflow             | ✓                   | ✓                    |
| Underflow            | ✓                   | ✓                    |
| Common mode error    | ✓                   | -                    |
| Short-circuit        | ✓                   | ✓                    |
| Overload             | -                   | ✓                    |
| Reference junction   | ✓                   | -                    |

Diagnostics of the analog module are carried out while the system is in operation, on the basis of the current output variables such as current or voltage. If the output current or output voltage is no longer sufficient, the module will not be able to run reliable diagnostics. The limits within which diagnostics are possible are specified in the technical data for each module.

The module reports the diagnosed state to the CPU using a diagnostics error interrupt. If several diagnostics are pending at the same time, the diagnostics with the highest priority is reported to the CPU first. Diagnostics are output on LED displays on the affected module, on the CPU display, on the Web server or on an HMI device.

The configurable diagnostics types depend on the respective selected measuring type or output type. The following tables show the relationship between the diagnostics types, measuring types or output types of an analog input module or analog output module.

## Diagnostics Analog input modules

Table 2- 3 Diagnostics types of an analog input module to be configured depending on the measurement type "Voltage"

|              | No supply voltage L+ | Wire break (1 to 5 V) | Overflow | Underflow | Common mode error | Reference junction | Short-circuit |
|--------------|----------------------|-----------------------|----------|-----------|-------------------|--------------------|---------------|
| S7-1500      | ✓                    | ✓                     | ✓        | ✓         | ✓                 | -                  | -             |
| ET 200MP     | ✓                    | ✓                     | ✓        | ✓         | ✓                 | -                  | -             |
| ET 200SP     | ✓                    | -                     | ✓        | ✓         | -                 | -                  | ✓             |
| ET 200AL     | -                    | ✓                     | ✓        | ✓         | -                 | -                  | ✓             |
| ET 200eco PN | ✓                    | ✓                     | ✓        | ✓         | -                 | -                  | -             |
| ET 200pro    | -                    | ✓                     | ✓*       | ✓*        | -                 | -                  | ✓             |

\* For ET 200pro, the parameters "Overflow" and "Underflow" are combined to the parameter "Overflow/Underflow"

Table 2- 4 Diagnostics types of an analog input module to be configured depending on the measurement type "Current (4-wire transducer)"

|              | No supply voltage L+ | Wire break (4 to 20 mA) | Overflow | Underflow | Common mode error | Reference junction | Short-circuit |
|--------------|----------------------|-------------------------|----------|-----------|-------------------|--------------------|---------------|
| S7-1500      | ✓                    | ✓                       | ✓        | ✓         | ✓                 | -                  | -             |
| ET 200MP     | ✓                    | ✓                       | ✓        | ✓         | ✓                 | -                  | -             |
| ET 200SP     | ✓                    | ✓                       | ✓        | ✓         | -                 | -                  | ✓**           |
| ET 200AL     | -                    | ✓                       | ✓        | ✓         | -                 | -                  | ✓**           |
| ET 200eco PN | ✓                    | ✓                       | ✓        | ✓         | -                 | -                  | -             |
| ET 200pro    | -                    | ✓                       | ✓*       | ✓*        | -                 | -                  | ✓             |

\* For ET 200pro, the parameters "Overflow" and "Underflow" are combined to the parameter "Overflow/Underflow"

\*\* Diagnostics for encoder supply only

Table 2- 5 Diagnostics types of an analog input module to be configured depending on the measurement type "Current (2-wire transducer)"

|              | No supply voltage L+ | Wire break (4 to 20 mA) | Overflow | Underflow | Common mode error | Reference junction | Short-circuit |
|--------------|----------------------|-------------------------|----------|-----------|-------------------|--------------------|---------------|
| S7-1500      | ✓                    | ✓                       | ✓        | ✓         | ✓                 | -                  | -             |
| ET 200MP     | ✓                    | ✓                       | ✓        | ✓         | ✓                 | -                  | -             |
| ET 200SP     | ✓                    | ✓                       | ✓        | -         | -                 | -                  | ✓**           |
| ET 200AL     | -                    | ✓                       | ✓        | ✓         | -                 | -                  | ✓**           |
| ET 200eco PN | ✓                    | ✓                       | ✓        | ✓         | -                 | -                  | -             |
| ET 200pro    | -                    | ✓                       | ✓*       | ✓*        | -                 | -                  | ✓             |

\* For ET 200pro, the parameters "Overflow" and "Underflow" are combined to the parameter "Overflow/Underflow"

\*\* Diagnostics for encoder supply only

## 2.14 Diagnostics

Table 2- 6 Configurable diagnostics types of an analog input module depending on the measurement type "Resistor (4-wire connection)"

|              | No supply voltage L+ | Wire break | Overflow | Underflow | Common mode error | Reference junction | Short-circuit |
|--------------|----------------------|------------|----------|-----------|-------------------|--------------------|---------------|
| S7-1500      | ✓                    | ✓          | ✓        | ✓         | -                 | -                  | -             |
| ET 200MP     | ✓                    | ✓          | ✓        | ✓         | -                 | -                  | -             |
| ET 200SP     | ✓                    | ✓          | ✓        | ✓         | -                 | -                  | -             |
| ET 200eco PN | ✓                    | ✓          | ✓        | -         | -                 | -                  | -             |
| ET 200pro    | -                    | ✓          | ✓*       | ✓*        | -                 | -                  | -             |

\* For ET 200pro, the parameters "Overflow" and "Underflow" are combined to the parameter "Overflow/Underflow"

Table 2- 7 Configurable diagnostics types of an analog input module depending on the measurement type "Resistor (3-wire connection)"

|              | No supply voltage L+ | Wire break | Overflow | Underflow | Common mode error | Reference junction | Short-circuit |
|--------------|----------------------|------------|----------|-----------|-------------------|--------------------|---------------|
| S7-1500      | ✓                    | ✓          | ✓        | ✓         | -                 | -                  | -             |
| ET 200MP     | ✓                    | ✓          | ✓        | ✓         | -                 | -                  | -             |
| ET 200SP     | ✓                    | ✓          | ✓        | ✓         | -                 | -                  | -             |
| ET 200AL     | -                    | ✓          | ✓        | -         | -                 | -                  | -             |
| ET 200eco PN | ✓                    | ✓          | ✓        | -         | -                 | -                  | -             |
| ET 200pro    | -                    | ✓          | ✓*       | ✓*        | -                 | -                  | -             |

\* For ET 200pro, the parameters "Overflow" and "Underflow" are combined to the parameter "Overflow/Underflow"

Table 2- 8 Configurable diagnostics types of an analog input module depending on the measurement type "Resistor (2-wire connection)"

|              | No supply voltage L+ | Wire break | Overflow | Underflow | Common mode error | Reference junction | Short-circuit |
|--------------|----------------------|------------|----------|-----------|-------------------|--------------------|---------------|
| S7-1500      | ✓                    | -          | -        | ✓         | -                 | -                  | -             |
| ET 200MP     | ✓                    | -          | -        | ✓         | -                 | -                  | -             |
| ET 200SP     | ✓                    | ✓          | ✓        | ✓         | -                 | -                  | -             |
| ET 200AL     | -                    | ✓          | ✓        | -         | -                 | -                  | -             |
| ET 200eco PN | ✓                    | ✓          | ✓        | -         | -                 | -                  | -             |
| ET 200pro    | -                    | ✓          | ✓*       | ✓*        | -                 | -                  | -             |

\* For ET 200pro, the parameters "Overflow" and "Underflow" are combined to the parameter "Overflow/Underflow"



Table 2- 9 Configurable diagnostics types of an analog input module depending on the measurement type "Thermal resistor (4-wire connection)"

|              | No supply voltage L+ | Wire break | Overflow | Underflow | Common mode error | Reference junction | Short-circuit |
|--------------|----------------------|------------|----------|-----------|-------------------|--------------------|---------------|
| S7-1500      | ✓                    | ✓          | ✓        | ✓         | -                 | -                  | -             |
| ET 200MP     | ✓                    | ✓          | ✓        | ✓         | -                 | -                  | -             |
| ET 200SP     | ✓                    | ✓          | ✓        | ✓         | -                 | -                  | -             |
| ET 200eco PN | ✓                    | ✓          | ✓        | ✓         | -                 | -                  | -             |
| ET 200pro    | -                    | ✓          | ✓*       | ✓*        | -                 | -                  | -             |

\* For ET 200pro, the parameters "Overflow" and "Underflow" are combined to the parameter "Overflow/Underflow"

Table 2- 10 Configurable diagnostics types of an analog input module depending on the measurement type "Thermal resistor (3-wire connection)"

|              | No supply voltage L+ | Wire break | Overflow | Underflow | Common mode error | Reference junction | Short-circuit |
|--------------|----------------------|------------|----------|-----------|-------------------|--------------------|---------------|
| S7-1500      | ✓                    | ✓          | ✓        | ✓         | -                 | -                  | -             |
| ET 200MP     | ✓                    | ✓          | ✓        | ✓         | -                 | -                  | -             |
| ET 200SP     | ✓                    | ✓          | ✓        | ✓         | -                 | -                  | -             |
| ET 200AL     | -                    | ✓          | ✓        | ✓         | -                 | -                  | -             |
| ET 200eco PN | ✓                    | ✓          | ✓        | ✓         | -                 | -                  | -             |
| ET 200pro    | -                    | ✓          | ✓*       | ✓*        | -                 | -                  | -             |

\* For ET 200pro, the parameters "Overflow" and "Underflow" are combined to the parameter "Overflow/Underflow"

Table 2- 11 Configurable diagnostics types of an analog input module depending on the measurement type "Thermal resistor (2-wire connection)"

|              | No supply voltage L+ | Wire break | Overflow | Underflow | Common mode error | Reference junction | Short-circuit |
|--------------|----------------------|------------|----------|-----------|-------------------|--------------------|---------------|
| S7-1500      | -                    | -          | -        | ✓         | -                 | -                  | -             |
| ET 200MP     | -                    | -          | -        | ✓         | -                 | -                  | -             |
| ET 200SP     | ✓                    | ✓          | ✓        | ✓         | -                 | -                  | -             |
| ET 200AL     | -                    | ✓          | ✓        | ✓         | -                 | -                  | -             |
| ET 200eco PN | ✓                    | ✓          | ✓        | ✓         | -                 | -                  | -             |
| ET 200pro    | -                    | ✓          | ✓*       | ✓*        | -                 | -                  | -             |

\* For ET 200pro, the parameters "Overflow" and "Underflow" are combined to the parameter "Overflow/Underflow"

Table 2- 12 Diagnostics types of an analog input module to be configured depending on the measurement type "Thermocouple"

|              | No supply voltage L+ | Wire break | Overflow | Underflow | Common mode error | Reference junction | Short-circuit |
|--------------|----------------------|------------|----------|-----------|-------------------|--------------------|---------------|
| S7-1500      | ✓                    | ✓          | ✓        | ✓         | ✓                 | ✓                  | -             |
| ET 200MP     | ✓                    | ✓          | ✓        | ✓         | ✓                 | ✓                  | -             |
| ET 200SP     | ✓                    | ✓          | ✓        | ✓         | -                 | ✓                  | -             |
| ET 200eco PN | ✓                    | -          | ✓        | ✓         | -                 | ✓                  | -             |
| ET 200pro    | -                    | -          | ✓*       | ✓*        | -                 | ✓                  | -             |

\* For ET 200pro, the parameters "Overflow" and "Underflow" are combined to the parameter "Overflow/Underflow"

### Diagnostics for analog output modules

Table 2- 13 Diagnostics types of an analog output module to be configured depending on the measurement type "Voltage"

|              | No supply voltage L+ | Wire break | Overflow | Underflow | Short-circuit | Overload |
|--------------|----------------------|------------|----------|-----------|---------------|----------|
| S7-1500      | ✓                    | -          | ✓        | ✓         | ✓             | -        |
| ET 200MP     | ✓                    | -          | ✓        | ✓         | ✓             | -        |
| ET 200SP     | ✓                    | -          | ✓        | ✓         | ✓             | -        |
| ET 200eco PN | ✓                    | -          | -        | -         | ✓             | ✓        |
| ET 200pro    | -                    | -          | -        | -         | ✓             | -        |

Table 2- 14 Diagnostics types of an analog output module to be configured depending on the measurement type "Current"

|              | No supply voltage L+ | Wire break | Overflow | Underflow | Short-circuit | Overload |
|--------------|----------------------|------------|----------|-----------|---------------|----------|
| S7-1500      | ✓                    | ✓          | ✓        | ✓         | -             | -        |
| ET 200MP     | ✓                    | ✓          | ✓        | ✓         | -             | -        |
| ET 200SP     | ✓                    | ✓          | ✓        | ✓         | -             | -        |
| ET 200eco PN | ✓                    | ✓          | -        | -         | -             | ✓        |
| ET 200pro    | -                    | ✓          | -        | -         | -             | -        |

#### Note

##### Measuring ranges

Note that the diagnostics types that can be parameterized depend on the selected measurement/output type as well as on the respective measuring range.

#### Note

##### Minimum output values

Certain errors such as wire break and short circuit cannot be diagnosed below a given current or voltage value. Diagnostics are only possible again once the output returns to above this minimum value.

## No supply voltage L+

You can diagnose a missing or low supply voltage L+ at the analog module by activating the "No supply voltage L+" checkbox. If the supply voltage is missing or too low, the status and error display on the analog module will provide the relevant information. The entry in the diagnostics buffer also makes this information available to the CPU.

If there is no supply voltage, no other types of diagnostics available are possible either.

## Wire break

The term wire break denotes a failure state that is triggered by the interruption of a usually closed electrical circuit.

### Wire break in analog input modules

The "Wire break" diagnostics function facilitates the detection of errors during system operation. In STEP 7 you define the module properties by setting various parameters. Depending on the module used, you may, for example, be able to set a current limit parameter at which a wire break is to be reported.

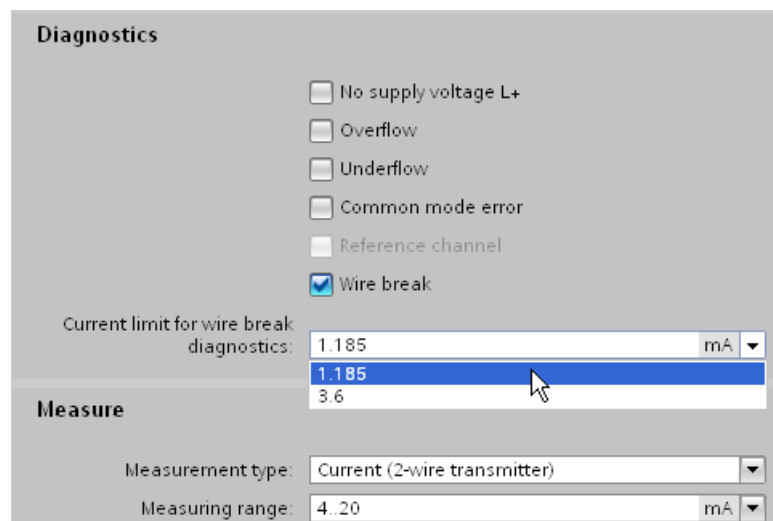


Figure 2-19 Configuring the wire break current limit for an analog input module in STEP 7

Usually, the live zero technique is deployed to detect wire breaks. The start of the measuring range for the standard live zero signal of 4 to 20 mA is assigned the 4 mA signal value. A wire break between the input and sensor can therefore be detected based on the missing current flow. Instead of a current signal, you may also use a voltage signal from 1 to 5 V to detect a wire break. The "Wire break" diagnostics function can therefore only be configured for a range of 4 to 20 mA or 1 to 5 V.

For "Resistor", "Thermal resistor" and "Thermocouple" measurements, a current is impressed into the line. If a wire break occurs, the flow of current is interrupted and the analog module therefore detects the wire break.

### Wire break in analog output modules

The analog signal output is used for wire break detection. Reliable wire break diagnostics is not possible if the voltage is too low. In this case, the diagnostics function is deactivated without triggering a change of the diagnostics status.

The current limit up to which the module will diagnose wire break can be found in the technical data for the module.

### Overflow/underflow

The resolution of the measuring range of an analog input module distinguishes between the rated range, the overrange or underrange, and the overflow or underflow. The following table assign the number of increments into which the measured signal is divided to the various voltage measuring ranges.

Table 2- 15 Voltage measuring range  $\pm 10$  V of an analog input module

| Value (increments) | Voltage measuring range      | Range       |
|--------------------|------------------------------|-------------|
| <b>Decimal</b>     | <b><math>\pm 10</math> V</b> |             |
| 32767              | $> 11.759$ V                 | Overflow    |
| 32511              | $11.759$ V                   | Overrange   |
| 27649              |                              |             |
| 27648              | $10.0$ V                     | Rated range |
| 0                  | $0$ V                        |             |
| -27648             | $-10$ V                      |             |
| -27649             |                              | Underrange  |
| -32512             | $-11.759$ V                  |             |
| -32768             | $< -11.759$ V                | Underflow   |

As of a decimal value of 32512, the value acquired is beyond the overrange and is no longer valid. If this is the case, the error status "Overflow" is diagnosed. The overrange is a tolerance range before overflow is reached.

As of a decimal value of -32513, the value acquired is below the configured measuring range and is no longer valid. If this is the case, the error status "Underflow" is diagnosed. The underrange is the equivalent of the overrange, but for negative values.

An "Overflow" or "Underflow" diagnostics may be caused, for example, by a wire break, an incorrect measuring range or incorrect wiring.

#### Note

#### Accuracy

The accuracy specified in the technical data of the relevant module is only guaranteed within the rated range.

## Common mode error

Activating the "Common mode" checkbox diagnoses a violation of the maximum potential difference  $U_{CM}$ . A violation of the permitted potential difference  $U_{CM}$  has occurred, for example, between the reference point of the measuring inputs and the analog ground  $M_{ANA}$ .

Possible causes:

- Wiring error
- Environments with EMC disturbance
- Incorrectly grounded transducers
- Long line lengths
- Sensor not connected
- 2-wire transducer connected to  $M_{ANA}$

---

### Note

With 4-wire transducers, a current meter connected in series will result in too great a drop in voltage.

---

Potential differences  $U_{CM}$  beyond the valid limits may lead to measurement errors and malfunctions. If you want to ensure that the maximum value is not exceeded, interconnect the measuring inputs and analog ground  $M_{ANA}$  with an equipotential bonding cable. More detailed information can be found in *Wiring transducers*.

## Short-circuit

Activating the "Short circuit" checkbox activates short-circuit diagnostics for an analog channel. The diagnostics function is triggered by channel overload.

Possible causes:

- Wiring error (e.g. short circuit between conductors at the connections or in the cable)
- Use of faulty or incorrect actuators (e.g. internal short circuit or low input resistance as a result of actuator failure)

The analog signal output is used for short circuit detection. If the voltage is too low, reliable short-circuit diagnostics are not possible. In this case, the diagnostics function is deactivated without triggering a change of the diagnostics status. The voltage limit up to which the module will diagnose a short circuit can be found in the technical data for the module.

SIMATIC modules have a special protective circuit to prevent short circuit. The short circuit current is limited internally in the module. The level of short circuit current is specified in the technical data of your analog module.

---

### Note

#### Overload

Please note that overload exposes the modules are exposed to a greater thermal load. This can affect the output channels. You should therefore avoid continuously running analog output modules in overload.

---

## Reference junction

This type of diagnostics can only be selected for analog input modules for "Thermocouple" measuring. Selecting the "Reference junction" check box diagnoses an error on the reference channel for compensating the reference junction temperature.

The temperature at the reference junction of a thermocouple is measured at the reference channel of the module using an external thermal resistor (RTD). If an error occurs, for example as a result of a wire break, the temperature measured at the reference junction of the thermocouple will no longer be compensated. The reference temperature may then be outside the valid range.

Additional information on connecting thermocouples and thermal resistors and on how they operate can be found in Thermocouples and Wiring transducers.

## Overload

Activating the "Overload" checkbox activates the diagnostics of the thermal monitoring of the output level. The "Overload" diagnostics is triggered when the maximum temperature is exceeded at the output and is detected channel by channel.

The maximum temperature may be exceeded for the following reasons:

- Ambient temperature is too high
- Output is being operated outside the specification

---

### **Note**

#### **Overload**

Please note that overload exposes the modules to a high thermal load. This can affect the output channels. You should therefore avoid continuously running analog output modules in overload.

---

## 2.15 Value status

### Value status

In case of a faulty analog value, the analog module outputs the error values 0x7FFF (error value for overflow and all other error states) or 0x8000 (error value for underflow) for the affected channel. The user program is now able to detect and evaluate a channel error. The user also has the option to evaluate the system diagnostics event-driven by means of diagnostics alarms.

In addition to the error values 0x7FFF or 0x8000 and the configured diagnostic types, analog input and output modules provide diagnostics information by means of the Process image input (PII). It is referred to as Value status and transferred synchronously with the user data. The value status (Quality Information = QI) provides a statement regarding the validity of the input signal. A distinction is made between the quality level "Good" (signal valid = 1) and "Bad" (signal invalid = 0).

---

#### Note

For analog input modules, the use of the value status is an alternative to the evaluation of the channels by the error values 0x7FFF or 0x8000. Compared to the error values, the binary evaluation of the value status (0 or 1) in the user program is simpler and more clearly arranged.

For analog output modules, the value status informs you as to whether the written value can be output by the respective channel. Using the value status you can respond to this information without having to evaluate the diagnostics of the module in the first place.

---



## Example

### Enabling the value status of an analog input module

To enable the value status of an analog input module, follow these steps:

- Select the required analog module in STEP 7.
- Select "AI configuration" in the "Properties" tab of the analog module.
- Click the "Value status" button.

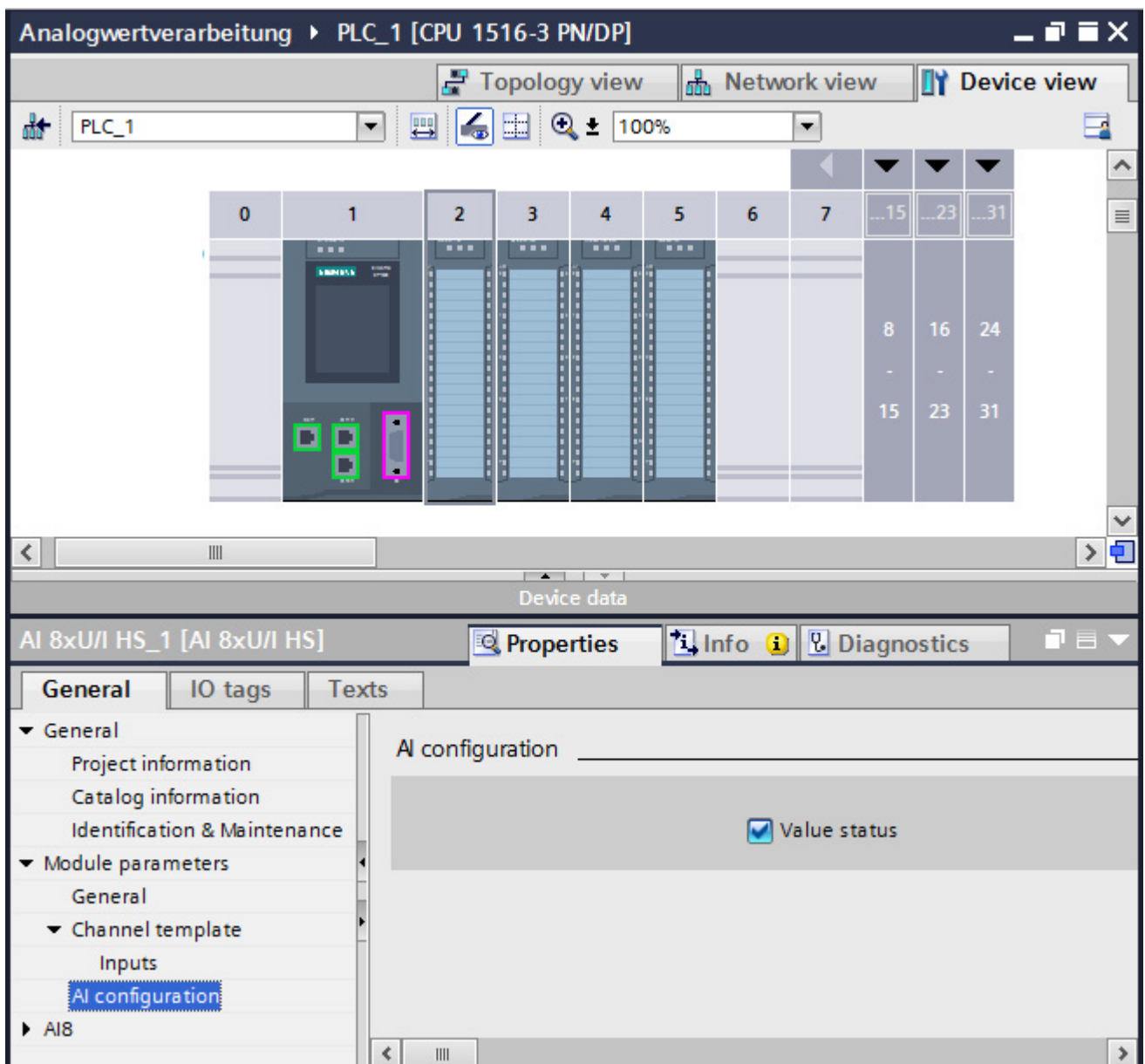


Figure 2-20 Enabling the value status in STEP 7

## **2.15 Value status**

An additional byte is occupied in the input address space of the respective module when you enable the value status. Each bit in this byte is assigned to a channel and provides information on, for example, whether the output value specified by the user program is actually queued at the module terminal (0= value is invalid; 1= value is valid).

### **Error occurrence**

If a wire break occurs at an analog input module, for example, the current signal state is entered in the process image and the value status of the signal is set to "invalid". To trigger an indicator light in case of an error, for example, evaluate the value status in the user program.

### **Diagnostics alarms and value status**

If you configure analog modules in a third-party product with the help of a GSD file and the diagnostics alarms are not evaluated event-driven, it is best to use the value status.

---

#### **Note**

The Value status represents a group diagnostics which only gives the user a Good or Bad information. The Value status is not suitable for a more specific identification of the cause of the error (e.g., wire break, short circuit in the encoder cable or load voltage failure).

---

## 2.16 Conversion time of an analog module

### Basic conversion time and conversion time of an analog input channel

The basic conversion time is the minimum time required by one single channel to convert analog values. The actual conversion time comprises both the basic conversion time and, depending on the analog input module used:

- Processing time for measuring resistance
- Processing time for wire break monitoring
- Processing time for overflow/underflow monitoring
- Processing time for checking common mode errors

### Example

This example shows channel 6 of an analog input module for resistance measurement in the range of 6000  $\Omega$ , a configured integration time of 20 ms, and activated wire break monitoring.

The conversion time of the channel is derived from the total of the following measurement variables:

| Measurement variable                                                                   | Time in ms |
|----------------------------------------------------------------------------------------|------------|
| Basic conversion time                                                                  | 27         |
| Processing time for RTD/resistance (6000 $\Omega$ )                                    | 4          |
| Processing time for wire break monitoring in the RTD/resistance and thermocouple areas | 9          |
| <b>Conversion time of the channel</b>                                                  | <b>40</b>  |

### Conversion time of the analog output channels

The conversion time of an output channel starts with the transfer of the digital value from the internal memory of the module and ends with the digital-to-analog conversion.

The conversion time does not include the settling time for the analog signal at the module terminal. Detailed information on the settling time can be found in Settling and response times of analog output modules (Page 52).

---

#### Note

##### Relationship between diagnostics and conversion time

While some diagnostics run parallel to the conversion and do not extend the conversion time, other diagnostics types can lead to an extension of the conversion time, as demonstrated in the example above.

---

### **Conversion time for high-speed analog modules**

High-Speed analog modules (HS modules) are designed for faster processing of signals. HS modules offer fewer diagnostics and measurement types than standard modules (ST modules). You can find more information on HS modules in the section High-Speed analog modules (Page 113).

## 2.17 Cycle time of an analog module

### Definition

The cycle time of an analog module represents the time that the module needs to process all channels used. The cycle time depends on the form of measured value acquisition used, e.g. multiplex or parallel measured value acquisition.

### Sequential measured value processing

This procedure processes the analog channels in the module one after another (sequentially). For analog inputs, the values are connected to a converter, for example using a multiplexer, and sequentially converted.

The cycle time of the analog module is derived from the total conversion time of all activated analog channels of the module. STEP 7 provides the option of deactivating unused analog channels. to reduce the cycle time.

The figure below gives an overview of the factors that determine the cycle time of an n-channel analog module.

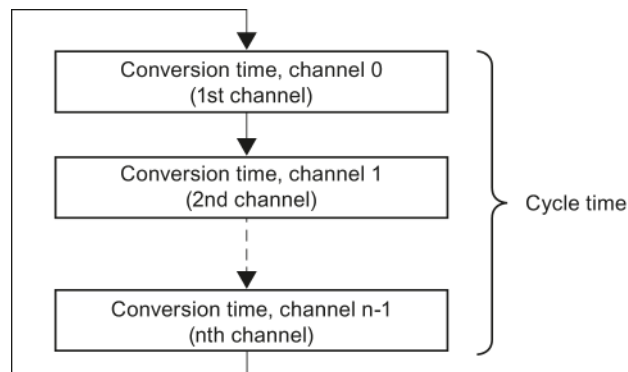


Figure 2-21 Cycle time of an analog module with multiplex conversion

### Parallel measured value acquisition

This procedure processes the analog channels of a module at the same time (in parallel) rather than one after another. In parallel measured value processing, the cycle time of the module is usually constant and does not depend on the number of channels used. The goal of parallel measured value acquisition as it is applied by high-speed analog modules, for example, is a shorter cycle time. You can find more information on HS modules in the section High-Speed analog modules (Page 113).

## 2.18 Settling and response times of analog output modules

Settling and response times provide information on the delay of the output of a specified analog output variable and its availability to the process.

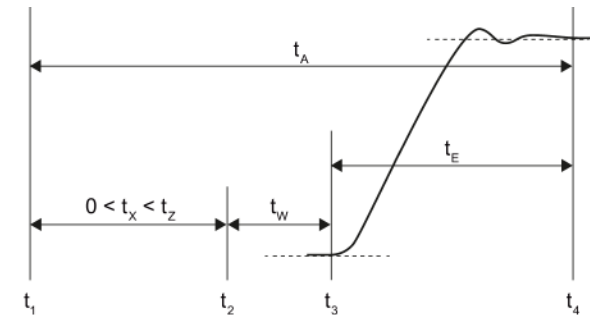
### Response time

The response time for a new output value is defined as the time between the input of a digital output value to the internal memory of the module and the value to be output at the analog output being reached (with a residual error of 1 %).

The response time ( $t_A$ ) is the sum of application time ( $t_x$ ), conversion time ( $t_w$ ) and settling time ( $t_E$ ):

$$t_A = t_x + t_w + t_E$$

### Settling and response times of analog output modules



$t_A$  Response time

$t_x$  Application time

$t_z$  Module cycle time

$t_w$  Conversion time

$t_E$  Settling time

$t_1$  New digital output value is available in the internal memory of the module

$t_2$  Module activates the digital output value and starts conversion

$t_3$  Module ends conversion at the terminal of the analog output channel and outputs the analog signal

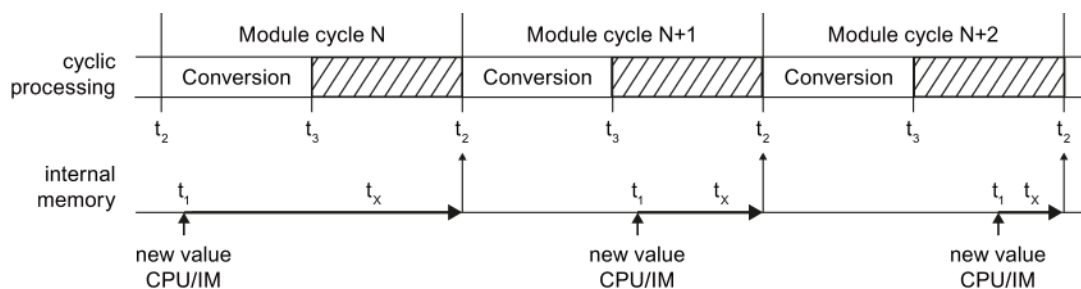
$t_4$  Signal has settled and the specified analog output value has been reached (residual error 1 %)

Figure 2-22 Settling and response time of an output channel

## Application time

The CPU/IM (interface module) writes new output values to the internal memory of the analog output module. The time required for this is not determined by the CPU/IM. These output values are converted asynchronously to their entry in buffer memory. The worst-case application time ( $t_x$ ) may be equal to the cycle time ( $t_z$ ). This situation develops if the CPU writes a new value to the internal memory of the module immediately after the transfer of the value for conversion. This new value will not be processed until the next conversion.

The figure below shows acyclic access of the analog output module to output values from the internal memory in non-isochronous mode. You can find more information on isochronous mode in the paragraph on isochronous mode of the section High-Speed analog modules (Page 113).



- $t_x$  Application time
- $t_1$  New digital output value is available in the internal memory of the module
- $t_2$  Module activates the digital output value and starts conversion
- $t_3$  Module ends conversion at the terminal of the analog output channel and outputs the analog signal

Figure 2-23 Application of the output values

## Conversion time

The conversion time of an output channel starts with the transfer of the digital value from the internal memory of the module ( $t_2$ ) and ends with the digital-to-analog conversion ( $t_3$ ).

## Settling time

The settling time starts when the analog signal is output to the module ( $t_3$ ) terminals and ends when the output value ( $t_4$ ) is reached. The output value is reached as soon as the output signal has settled at its final value, taking into account a residual error of 1%.

The settling time depends on the type of output for the module, and on the connected load. The load for the analog output consists of connecting line and connected actuator. When the output is "Current", the settling time increases with high ohmic resistance. Inductive loads cause subsequent fluctuation in the output value. When the output is "Voltage", the capacitive load causes subsequent fluctuation.

## 2.19 Smoothing

### Using the smoothing functions

Most analog input modules allow you to configure smoothing for the measuring signal in STEP 7. Smoothing analog values reduces the effect of interference signals. Smoothing is useful with slow changes in measured values, for example in temperature measurements.

### Smoothing principle

The measured values are smoothed by means of filtering. The module forms mean values from a specified number of converted (digitalized) analog values. Smoothing should not be confused with the integration of measured values over a defined period of time. It is therefore not possible to smooth measured signals to filter out a specific interference frequency. However, this smoothing returns more "stable" data values because it suppresses peaks which overlay the measured signal.

4 (none, weak, medium, strong) or more levels of smoothing can be configured by the user depending on the module used. The level determines the number of analog values from which the mean value is generated. The greater the smoothing factor, the better the filtering.

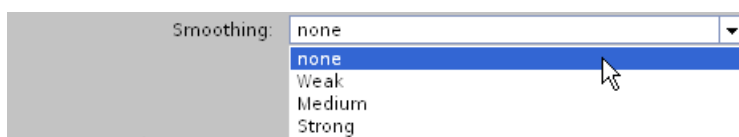


Figure 2-24 Selecting the smoothing level in STEP 7

### Smoothing method

A smoothing algorithm is applied to a configurable number of measured values (e.g. 4, 8, 32) in line with the moving average. Each new measured value is factored in, and the oldest measured value then ignored. This mechanism suppresses interference peaks which overlay the measured signal. Utility signal jumps only become evident in the data after some time (see examples below).

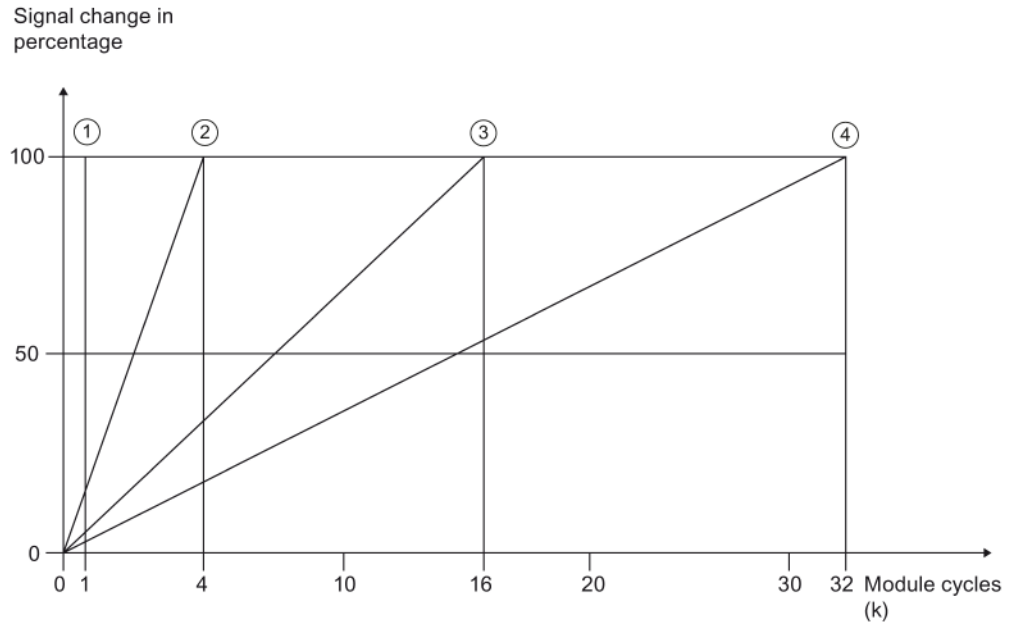
The modules of the various product ranges use different smoothing algorithms. Smoothing is either linear or exponential. The differences are apparent particularly with strong smoothing and lead to a faster or slower rate of rise depending on the product used.

For information on whether or not a specific module supports customization of the smoothing function, please refer to the manual of the analog input module.



**Example 1: Linear smoothing**

The diagram below shows the number of module cycles (k) it takes for each smoothing level setting for the smoothed analog value to reach approximately 100 % after a step response. This specification is valid for all signal changes at the analog input.



- ① No smoothing ( $k = 1$ )
- ② Weak smoothing ( $k = 4$ )
- ③ Medium smoothing ( $k = 16$ )
- ④ Strong smoothing ( $k = 32$ )

Figure 2-25 Linear smoothing with four smoothing levels

### Example 2: Exponential smoothing

The diagram below shows the step response of the smoothing factor for different numbers of module cycles.

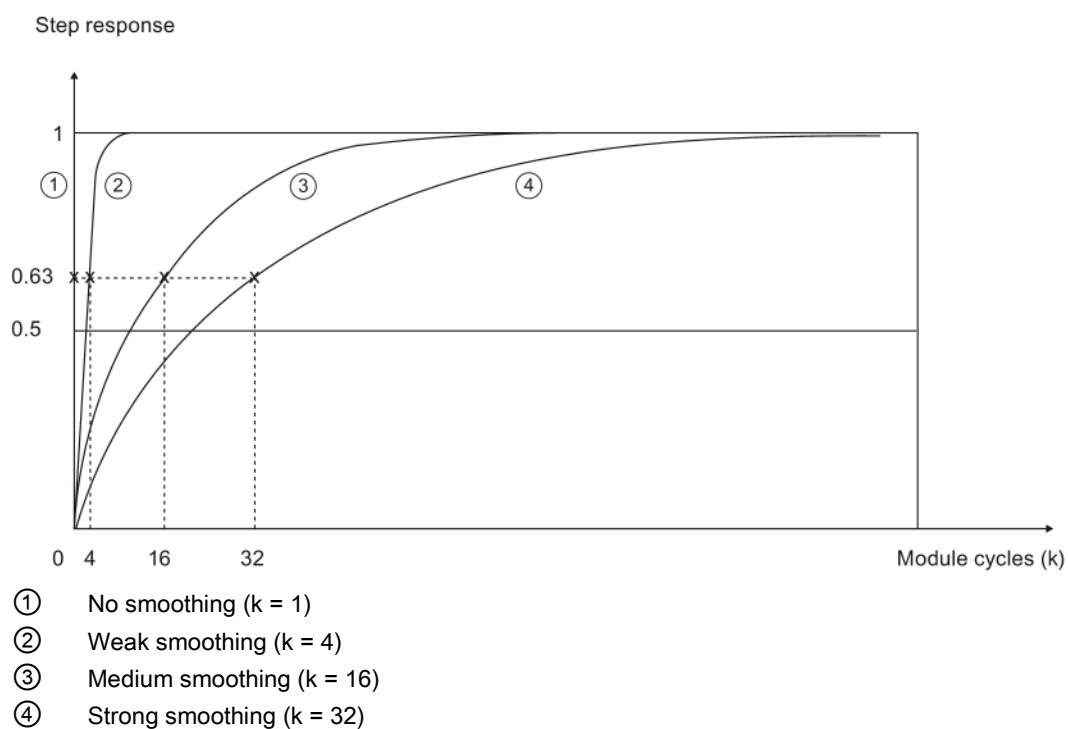


Figure 2-26 Exponential smoothing with four smoothing levels

## **2.20 Burden with 2-wire transducers**

### **2-wire transducers**

2-wire transducers are current transducers which convert the process variable into a current signal of between 4 and 20 mA. Two connection lines supply the transducer with an output current of at least 4 mA. Additional information on connecting 2-wire transducers to analog input modules can be found in the section Wiring current transducers (Page 72).

### **Burden**

The burden indicates how great the external resistance in a current loop may be. If the external resistance is greater than the specified burden, the 2-wire transducer supply voltage is too low. The burden consists of the resistance of the transducer and all other resistances connected to the current loop.

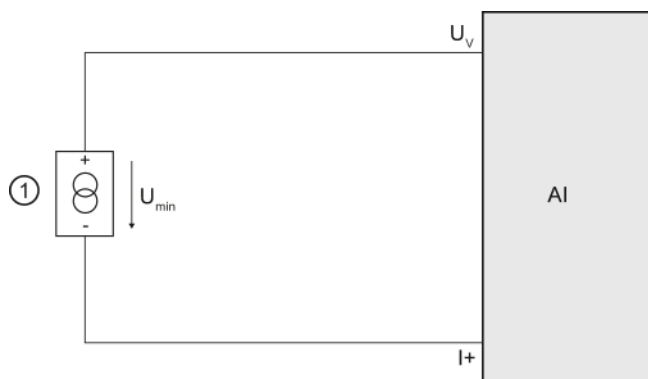
The maximum admissible burden of the transducer, e.g. 820  $\Omega$ , is specified in the technical data of the analog module.

### Example 1: Connecting a transducer to the electrical circuit

In accordance with the technical data of the 2-wire transducer used, it requires a supply voltage ( $U_{\min}$ ) of at least 8.5 V. Using Ohm's Law, you can calculate the resistance of the transducer used ( $R_{2DMU}$ ) for a current of 20 mA.

$$R_{2DMU} = \frac{U_{\min}}{I} = \frac{8.5 \text{ V}}{0.020 \text{ A}} = 425 \Omega$$

With a supply voltage of at least 8.5 V, the transducer has a resistance of 425  $\Omega$ . The resistance is less than 820  $\Omega$ . You can therefore connect the transducer to the analog input module (AI) without exceeding the maximum burden.



- ① 2-wire transducers
- $U_v$  Terminal for feed voltage at the channel
- $I+$  Terminal for current input
- $U_{\min}$  Voltage drop at 2-wire transducer

Figure 2-27 Connecting a transducer to the electrical circuit

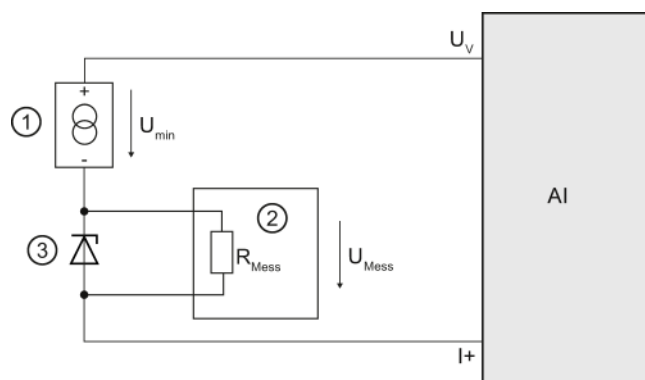
### Example 2: Connecting a transducer and other devices

If multiple measuring devices are connected in series, the sum of all connected resistances may not exceed the value of the maximum burden.

If you have connected a 2-wire transducer to a supply voltage of 8.5 V, you will need to allow for the resistance of the measuring device connected ②.

|                                                     |              |
|-----------------------------------------------------|--------------|
| Maximum transducer burden:                          | 820 $\Omega$ |
| Transducer resistance upon a voltage drop of 8.5 V: | 425 $\Omega$ |
| Maximum resistance of additional devices connected: | 395 $\Omega$ |

The resistance of the measuring instrument may therefore not exceed 395  $\Omega$ .



① 2-wire transducers

② Digital multimeter

③ Zener diode

$U_v$  Terminal for feed voltage at the channel

$I+$  Terminal for current input

$U_{min}$  Voltage drop at 2-wire transducer

$R_{Mess}$  Resistance at measuring instrument

$U_{Mess}$  Voltage drop at the measuring instrument

Figure 2-28 Connecting a transducer and other devices to the circuit

### Calculating admissible voltage drop

The maximum additional resistance in the current loop may not exceed 395  $\Omega$  at a maximum current of 20 mA. You can calculate the voltage drop at the connected measuring instrument ( $U_{Mess}$ ) as follows using Ohm's Law:

$$U_{Mess} = R_{Mess} \cdot I = 395 \, \Omega \cdot 0.020 \, A = 7.9 \, V$$

The voltage drop at the measuring instrument should therefore not exceed 7.9 V.

## Representation of analog values

### 3.1 Overview

#### Conversion of analog values

The CPU only processes analog values in digitalized format.

Analog input modules convert the analog signal into a digital value for further processing by the CPU.

Analog output modules convert the digital output value from the CPU into an analog signal.

#### Analog value representation at 16-bit resolution

The digitized analog value is the same for all I/O values at the same rated range. The analog values are represented as fixed point numbers in twos complement. This leads to the following conditions:

Table 3- 1 Representation of analog values

| Resolution               | Analog value |          |          |          |          |          |       |       |       |       |       |       |       |       |       |       |
|--------------------------|--------------|----------|----------|----------|----------|----------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|
| Bit number               | 15           | 14       | 13       | 12       | 11       | 10       | 9     | 8     | 7     | 6     | 5     | 4     | 3     | 2     | 1     | 0     |
| Significance of the bits | S            | $2^{14}$ | $2^{13}$ | $2^{12}$ | $2^{11}$ | $2^{10}$ | $2^9$ | $2^8$ | $2^7$ | $2^6$ | $2^5$ | $2^4$ | $2^3$ | $2^2$ | $2^1$ | $2^0$ |

#### Sign

The sign (S) of the analog value is always set in bit 15:

- "0" → +
- "1" → -

#### Resolution less than 16 bits

The analog value is left-aligned in the memory of analog modules with a resolution of less than 16 bits. The unused least significant digits are padded with "0" values.

This reduces the number of measured values that can be represented. Modules occupy a range of values of between +32767 and -32768 regardless of the resolution. The scaling between two successive values depends on the resolution of the module.

## Example

The following example shows how the least significant digits are padded with "0" values:

- The module with 16-bit resolution is capable of incrementing the values in steps of one unit ( $2^0 = 1$ ).
- The module with 13-bit resolution is capable of incrementing the values in steps of 8 units ( $2^3 = 8$ ).

Table 3- 2 Example: Bit pattern of a 16-bit and 13-bit analog value

| Resolution | Analog value |          |          |          |          |          |       |       |       |       |       |       |       |       |       |       |
|------------|--------------|----------|----------|----------|----------|----------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|
| Bit        | 15           | 14       | 13       | 12       | 11       | 10       | 9     | 8     | 7     | 6     | 5     | 4     | 3     | 2     | 1     | 0     |
| 16-bit     | S            | $2^{14}$ | $2^{13}$ | $2^{12}$ | $2^{11}$ | $2^{10}$ | $2^9$ | $2^8$ | $2^7$ | $2^6$ | $2^5$ | $2^4$ | $2^3$ | $2^2$ | $2^1$ | $2^0$ |
| 13-bit     | S            | $2^{14}$ | $2^{13}$ | $2^{12}$ | $2^{11}$ | $2^{10}$ | $2^9$ | $2^8$ | $2^7$ | $2^6$ | $2^5$ | $2^4$ | $2^3$ | 0     | 0     | 0     |

S = sign

### Note

For information on the resolution supported by each analog module, please refer to the technical data for the relevant module.

## 3.2 Representation of input ranges

The tables below set out the digitalized representation of the input ranges by bipolar and unipolar input ranges. The resolution is 16 bits.

Please see the device manuals for each analog input module for assignment of the values to the specific measured values in each measuring range.

Table 3- 3 Bipolar input ranges

| Dec. value | Measured value in % | Data word       |                 |                 |                 |                 |                 |                |                |                |                |                |                |                |                |                |                | Range       |
|------------|---------------------|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|-------------|
|            |                     | 2 <sup>15</sup> | 2 <sup>14</sup> | 2 <sup>13</sup> | 2 <sup>12</sup> | 2 <sup>11</sup> | 2 <sup>10</sup> | 2 <sup>9</sup> | 2 <sup>8</sup> | 2 <sup>7</sup> | 2 <sup>6</sup> | 2 <sup>5</sup> | 2 <sup>4</sup> | 2 <sup>3</sup> | 2 <sup>2</sup> | 2 <sup>1</sup> | 2 <sup>0</sup> |             |
| 32767      | >117.589            | 0               | 1               | 1               | 1               | 1               | 1               | 1              | 1              | 1              | 1              | 1              | 1              | 1              | 1              | 1              | 1              | Overflow    |
| 32511      | 117.589             | 0               | 1               | 1               | 1               | 1               | 1               | 1              | 0              | 1              | 1              | 1              | 1              | 1              | 1              | 1              | 1              | Over range  |
| 27649      | 100.004             | 0               | 1               | 1               | 0               | 1               | 1               | 0              | 0              | 0              | 0              | 0              | 0              | 0              | 0              | 0              | 1              |             |
| 27648      | 100.000             | 0               | 1               | 1               | 0               | 1               | 1               | 0              | 0              | 0              | 0              | 0              | 0              | 0              | 0              | 0              | 0              | Rated range |
| 1          | 0.003617            | 0               | 0               | 0               | 0               | 0               | 0               | 0              | 0              | 0              | 0              | 0              | 0              | 0              | 0              | 0              | 1              |             |
| 0          | 0.000               | 0               | 0               | 0               | 0               | 0               | 0               | 0              | 0              | 0              | 0              | 0              | 0              | 0              | 0              | 0              | 0              |             |
| -1         | -0.003617           | 1               | 1               | 1               | 1               | 1               | 1               | 1              | 1              | 1              | 1              | 1              | 1              | 1              | 1              | 1              | 1              |             |
| -27648     | -100.000            | 1               | 0               | 0               | 1               | 0               | 1               | 0              | 0              | 0              | 0              | 0              | 0              | 0              | 0              | 0              | 0              |             |
| -27649     | -100.004            | 1               | 0               | 0               | 1               | 0               | 0               | 1              | 1              | 1              | 1              | 1              | 1              | 1              | 1              | 1              | 1              | Under range |
| -32512     | -117.593            | 1               | 0               | 0               | 0               | 0               | 0               | 0              | 1              | 0              | 0              | 0              | 0              | 0              | 0              | 0              | 0              |             |
| -32768     | <-117.593           | 1               | 0               | 0               | 0               | 0               | 0               | 0              | 0              | 0              | 0              | 0              | 0              | 0              | 0              | 0              | 0              | Underflow   |

Table 3- 4 Unipolar input ranges

| Dec. value | Measured value in % | Data word       |                 |                 |                 |                 |                 |                |                |                |                |                |                |                |                |                |                | Range       |
|------------|---------------------|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|-------------|
|            |                     | 2 <sup>15</sup> | 2 <sup>14</sup> | 2 <sup>13</sup> | 2 <sup>12</sup> | 2 <sup>11</sup> | 2 <sup>10</sup> | 2 <sup>9</sup> | 2 <sup>8</sup> | 2 <sup>7</sup> | 2 <sup>6</sup> | 2 <sup>5</sup> | 2 <sup>4</sup> | 2 <sup>3</sup> | 2 <sup>2</sup> | 2 <sup>1</sup> | 2 <sup>0</sup> |             |
| 32767      | >117.589            | 0               | 1               | 1               | 1               | 1               | 1               | 1              | 1              | 1              | 1              | 1              | 1              | 1              | 1              | 1              | 1              | Overflow    |
| 32511      | 117.589             | 0               | 1               | 1               | 1               | 1               | 1               | 1              | 0              | 1              | 1              | 1              | 1              | 1              | 1              | 1              | 1              | Over range  |
| 27649      | 100.004             | 0               | 1               | 1               | 0               | 1               | 1               | 0              | 0              | 0              | 0              | 0              | 0              | 0              | 0              | 0              | 1              |             |
| 27648      | 100.000             | 0               | 1               | 1               | 0               | 1               | 1               | 0              | 0              | 0              | 0              | 0              | 0              | 0              | 0              | 0              | 0              | Rated range |
| 1          | 0.003617            | 0               | 0               | 0               | 0               | 0               | 0               | 0              | 0              | 0              | 0              | 0              | 0              | 0              | 0              | 0              | 1              |             |
| 0          | 0.000               | 0               | 0               | 0               | 0               | 0               | 0               | 0              | 0              | 0              | 0              | 0              | 0              | 0              | 0              | 0              | 0              |             |
| -1         | -0.003617           | 1               | 1               | 1               | 1               | 1               | 1               | 1              | 1              | 1              | 1              | 1              | 1              | 1              | 1              | 1              | 1              | Under range |
| -4864      | -17.593             | 1               | 1               | 1               | 0               | 1               | 1               | 0              | 1              | 0              | 0              | 0              | 0              | 0              | 0              | 0              | 0              |             |
| -32768     | <-17.593            | 1               | 0               | 0               | 0               | 0               | 0               | 0              | 0              | 0              | 0              | 0              | 0              | 0              | 0              | 0              | 0              | Underflow   |



### 3.3 Representation of output ranges

The tables below set out the digitalized representation of the output ranges by bipolar and unipolar range. The resolution is 16 bits.

Please see the device manuals for each analog output module for assignment of the values to the specific output values in each measuring range.

Table 3- 5 Bipolar output ranges

| Dec. value | Output value in % | Data word       |                 |                 |                 |                 |                 |                |                |                |                |                |                |                |                |                |                | Range                  |
|------------|-------------------|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|------------------------|
|            |                   | 2 <sup>15</sup> | 2 <sup>14</sup> | 2 <sup>13</sup> | 2 <sup>12</sup> | 2 <sup>11</sup> | 2 <sup>10</sup> | 2 <sup>9</sup> | 2 <sup>8</sup> | 2 <sup>7</sup> | 2 <sup>6</sup> | 2 <sup>5</sup> | 2 <sup>4</sup> | 2 <sup>3</sup> | 2 <sup>2</sup> | 2 <sup>1</sup> | 2 <sup>0</sup> |                        |
| 32511      | 117.589           | 0               | 1               | 1               | 1               | 1               | 1               | 1              | 0              | 1              | 1              | 1              | 1              | 1              | 1              | 1              | 1              | Maximum output value*  |
| 32511      | 117.589           | 0               | 1               | 1               | 1               | 1               | 1               | 1              | 0              | 1              | 1              | 1              | 1              | 1              | 1              | 1              | 1              | Over range             |
| 27649      | 100.004           | 0               | 1               | 1               | 0               | 1               | 1               | 0              | 0              | 0              | 0              | 0              | 0              | 0              | 0              | 0              | 1              |                        |
| 27648      | 100.000           | 0               | 1               | 1               | 0               | 1               | 1               | 0              | 0              | 0              | 0              | 0              | 0              | 0              | 0              | 0              | 0              | Rated range            |
| 1          | 0.003617          | 0               | 0               | 0               | 0               | 0               | 0               | 0              | 0              | 0              | 0              | 0              | 0              | 0              | 0              | 0              | 1              |                        |
| 0          | 0.000             | 0               | 0               | 0               | 0               | 0               | 0               | 0              | 0              | 0              | 0              | 0              | 0              | 0              | 0              | 0              | 0              |                        |
| -1         | -0.003617         | 1               | 1               | 1               | 1               | 1               | 1               | 1              | 1              | 1              | 1              | 1              | 1              | 1              | 1              | 1              | 1              |                        |
| -27648     | -100.000          | 1               | 0               | 0               | 1               | 0               | 1               | 0              | 0              | 0              | 0              | 0              | 0              | 0              | 0              | 0              | 0              |                        |
| -27649     | 100.004           | 1               | 0               | 0               | 1               | 0               | 0               | 1              | 1              | 1              | 1              | 1              | 1              | 1              | 1              | 1              | 1              | Under range            |
| -32512     | -117.593          | 1               | 0               | 0               | 0               | 0               | 0               | 0              | 1              | 0              | 0              | 0              | 0              | 0              | 0              | 0              | 0              |                        |
| -32512     | -117.593          | 1               | 0               | 0               | 0               | 0               | 0               | 0              | 1              | 0              | 0              | 0              | 0              | 0              | 0              | 0              | 0              | Minimum output value** |

\* When values > 32511 are specified, the output value is limited to 117.589 % or 0 % (0.0 V / 0.0 mA), depending on the module used.

\*\* When values < -32512 are specified, the output value is limited to -117.593 % or 0 % (0.0 V / 0.0 mA), depending on the module used.

## 3.3 Representation of output ranges

Table 3- 6 Unipolar output ranges

| Dec. value | Output value in % | Data word       |                 |                 |                 |                 |                 |                |                |                |                |                |                |                |                |                |                | Range                  |
|------------|-------------------|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|------------------------|
|            |                   | 2 <sup>15</sup> | 2 <sup>14</sup> | 2 <sup>13</sup> | 2 <sup>12</sup> | 2 <sup>11</sup> | 2 <sup>10</sup> | 2 <sup>9</sup> | 2 <sup>8</sup> | 2 <sup>7</sup> | 2 <sup>6</sup> | 2 <sup>5</sup> | 2 <sup>4</sup> | 2 <sup>3</sup> | 2 <sup>2</sup> | 2 <sup>1</sup> | 2 <sup>0</sup> |                        |
| 32511      | 117.589           | 0               | 1               | 1               | 1               | 1               | 1               | 1              | 1              | x              | x              | x              | x              | x              | x              | x              | x              | Maximum output value*  |
| 32511      | 117.589           | 0               | 1               | 1               | 1               | 1               | 1               | 1              | 0              | 1              | 1              | 1              | 1              | 1              | 1              | 1              | 1              | Over range             |
| 27649      | 100.004           | 0               | 1               | 1               | 0               | 1               | 1               | 0              | 0              | 0              | 0              | 0              | 0              | 0              | 0              | 0              | 1              |                        |
| 27648      | 100.000           | 0               | 1               | 1               | 0               | 1               | 1               | 0              | 0              | 0              | 0              | 0              | 0              | 0              | 0              | 0              | 0              | Rated range            |
| 1          | 0.003617          | 0               | 0               | 0               | 0               | 0               | 0               | 0              | 0              | 0              | 0              | 0              | 0              | 0              | 0              | 0              | 1              |                        |
| 0          | 0.000             | 0               | 0               | 0               | 0               | 0               | 0               | 0              | 0              | 0              | 0              | 0              | 0              | 0              | 0              | 0              | 0              |                        |
| 0          | 0.000             | 0               | 0               | 0               | 0               | 0               | 0               | 0              | 0              | 0              | 0              | 0              | 0              | 0              | 0              | 0              | 0              | Minimum output value** |

\* When values > 32511 are specified, the output value is limited to 117.589 % or 0 % (0.0 V / 0.0 mA), depending on the module used.

\*\* When values < 0 are specified, the output value is limited to 0% (0.0 V / 0.0 mA).

# Connecting transducers

## 4.1 Overview

### Introduction

This chapter describes the basic procedure for wiring transducers to analog inputs. Information on specific wiring options is available in the manual of each module.

For more information, e.g. on cable routing and shielding or potential equalization, etc., refer to the function manual for Configuring interference-free controllers (<http://support.automation.siemens.com/WW/view/en/59193566>).

### Transducers that can be wired to analog inputs

You can wire the following transducers to the analog input modules, depending on the type of measurement:

- Voltage transducers
- Current transducers
  - 2-wire transducers
  - 4-wire transducers
- Resistance transducers
  - 4-wire connection
  - 3-wire connection
  - 2-wire connection
- Thermocouples

### Isolated transducers and non-isolated transducers

Transducers are available in various models:

- Isolated transducers are **not connected** locally to the ground potential. Floating operation is possible.
- Non-isolated transducers are **connected** locally to the ground potential.

Non-isolated transducer connections are connected to the conductive enclosure.

Note: All non-isolated transducers must have a galvanic connection to each other and be locally connected to the ground potential.

## Abbreviations used in the figures

Key to the abbreviations in the figures below:

|                                           |                                                                                                                                               |
|-------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------|
| AI                                        | Analog input module                                                                                                                           |
| M                                         | Ground connection                                                                                                                             |
| L+                                        | Supply voltage connection                                                                                                                     |
| M <sub>n</sub> + / M <sub>n</sub> -       | Measuring input, channel n                                                                                                                    |
| I <sub>Cn</sub> + / I <sub>Cn</sub> -     | Current output to thermal resistor (RTD) channel n                                                                                            |
| U <sub>n</sub> + / U <sub>n</sub> -       | Voltage input channel n                                                                                                                       |
| I <sub>n</sub> + / I <sub>n</sub> -       | Current input channel n                                                                                                                       |
| COMP+ / COMP-                             | Compensation input                                                                                                                            |
| I <sub>Comp</sub> + / I <sub>Comp</sub> - | Current output for compensation                                                                                                               |
| U <sub>V</sub>                            | Feed voltage at channel (the connection can be used for 2-wire transducer (2DMU) or with ET 200eco PN and ET 200pro for 2/4-wire transducer). |
| U <sub>CM</sub>                           | Potential difference between the reference points of the measuring inputs / the analog ground M <sub>ANA</sub>                                |
| U <sub>ISO</sub>                          | Potential difference between the reference points of the measuring inputs and the central ground                                              |
| M <sub>ANA</sub>                          | Reference point of the analog ground                                                                                                          |

## Lines for analog signals

Always use shielded twisted-pair cables to wire the analog signals. This improves immunity.

## 4.2 Wiring analog inputs with MANA connection

The reference potentials of the measuring inputs and the central ground are electrically isolated in analog input modules with MANA connection.

### Limited potential difference $U_{ISO}$ (insulation voltage)

Always verify that the admissible potential difference  $U_{ISO}$  between the reference point of the analog ground  $M_{ANA}$  and the central ground is not exceeded.

Potential difference  $U_{ISO}$  may be caused by: Maximum line lengths exceeded.

If you want to ensure that the permitted value  $U_{ISO}$  is not exceeded, install an equipotential bonding cable between the terminal  $M_{ANA}$  and the central grounding point.

### Limited potential difference $U_{CM}$ (common mode)

Always verify that the admissible potential difference  $U_{CM}$  between the reference point of the measuring inputs and the analog ground  $M_{ANA}$  is not exceeded.

Potential differences  $U_{CM}$  may be caused by:

- Environments with EMC disturbance
- Use of grounded transducers
- Use of long cable lengths

Measuring errors / malfunctions can occur if the admissible potential difference  $U_{CM}$  is exceeded.

Some modules can detect an invalid potential difference  $U_{CM}$  and report this error with an entry in the diagnostics buffer of the CPU.

If you want to ensure that the maximum value  $U_{CM}$  is not exceeded, interconnect the reference points of the measuring inputs and the analog ground  $M_{ANA}$  with an equipotential bonding cable.

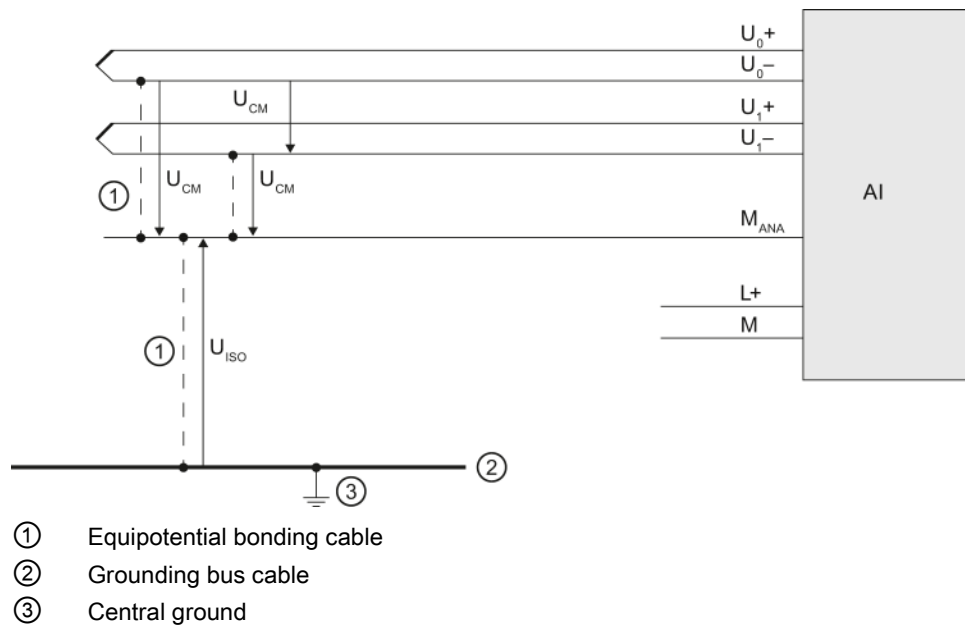


Figure 4-1 Example: Reference potential for analog input modules with MANA connection

## 4.3 Wiring analog inputs without MANA connection

The reference potentials of the measuring inputs and the central ground are electrically isolated from each other in analog input modules without an MANA connection.

### Limited potential difference $U_{ISO}$ (insulation voltage)

Always verify that the maximum potential difference  $U_{ISO}$  between the reference points of the measuring inputs and central ground is not exceeded.

Potential difference  $U_{ISO}$  may be caused by: Maximum line lengths exceeded.

If you want to ensure that the permitted value  $U_{ISO}$  is not exceeded, install an equipotential bonding cable between the reference points of the measuring inputs and the central grounding point.

### Limited potential difference $U_{CM}$ (common mode)

Always ensure that the permitted potential difference  $U_{CM}$  between the reference points of the measuring inputs is not exceeded.

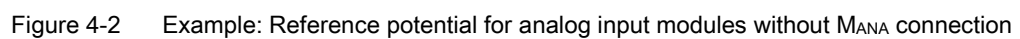
Potential differences  $U_{CM}$  may be caused by:

- Environments with EMC disturbance
- Use of grounded transducers
- Use of long cable lengths

Measuring errors / malfunctions can occur if the admissible potential difference  $U_{CM}$  is exceeded.

Some modules can detect an invalid potential difference  $U_{CM}$  and report this error with an entry in the diagnostics buffer of the CPU.

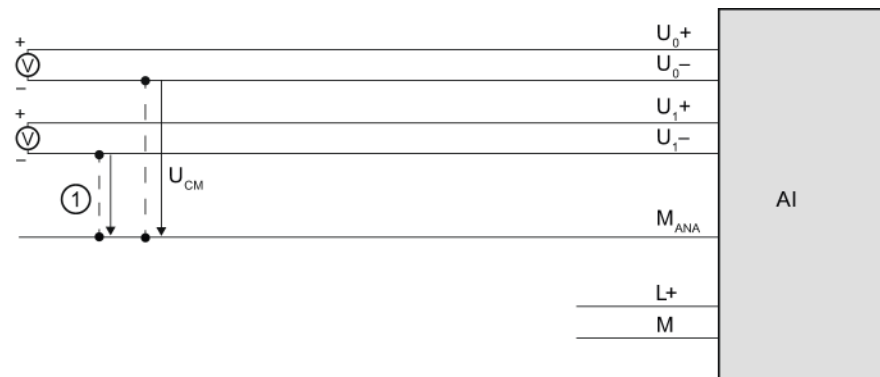
If you want to ensure that the permitted value  $U_{CM}$  is not exceeded, install equipotential bonding cables between the reference points of the measuring inputs or, with the ET 200eco PN and ET 200pro, between the reference points of the measuring inputs and ground.





## 4.4 Wiring voltage transducers

The figure below shows how to connect voltage transducers. If you want to ensure that the permitted value  $U_{CM}$  is not exceeded, install equipotential bonding cables to connect the reference points of the measuring inputs to the analog ground  $M_{ANA}$ , or with ET 200eco PN and ET 200pro the reference points of the measuring inputs to the ground.



① Equipotential bonding cable (only relevant to modules with  $M_{ANA}$  connection)

Figure 4-3 Example: Wiring voltage transducers to an analog input module

## 4.5 Wiring current transducers

Current transducers are available as 2-wire transducers and 4-wire transducers. Below are a number of ways to supply current transducers with voltage.

### Wiring 2-wire transducers with power supply from the module

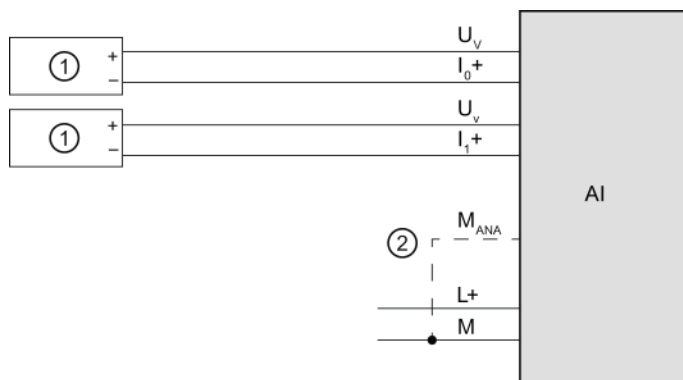
The 2-wire transducer converts the process variable into a current. The 2-wire transducer is wired to the short circuit-proof supply voltage at the terminals of the analog input module. The transducer is therefore frequently also called a "passive transducer". Its simple wiring means that the 2-wire transducer is frequently used in industrial environments. If you use this type of connection, you will need to set the "Current (2-wire transducer)" measurement type in STEP 7.

---

#### Note

2-wire transducers must be electrically isolated.

---



① 2-wire transducers (2WT)

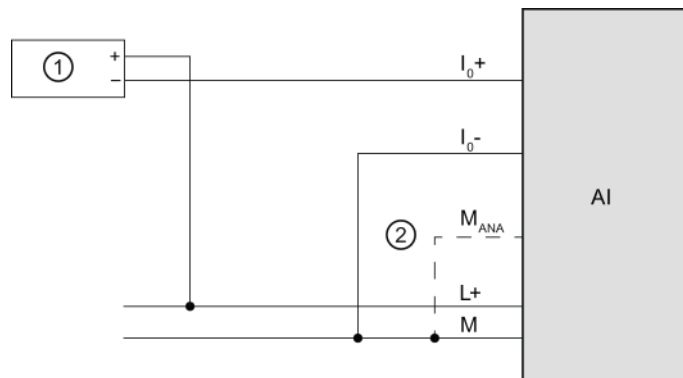
② Equipotential bonding cable (only relevant to modules with  $M_{ANA}$  connection)

Figure 4-4 Example: Wiring 2-wire transducers to an analog input module

### Wiring 2-wire transducers to an analog input for 4-wire transducers

The figure below shows an alternative to the above connection: supplying the 2-wire transducer from supply line L+ of the module. If you use this type of connection, you will need to set the "Current (**4-wire transducer**)" measurement type in STEP 7.

In this type of connection, galvanic isolation between the supply voltage L+ and the analog circuit will be removed.

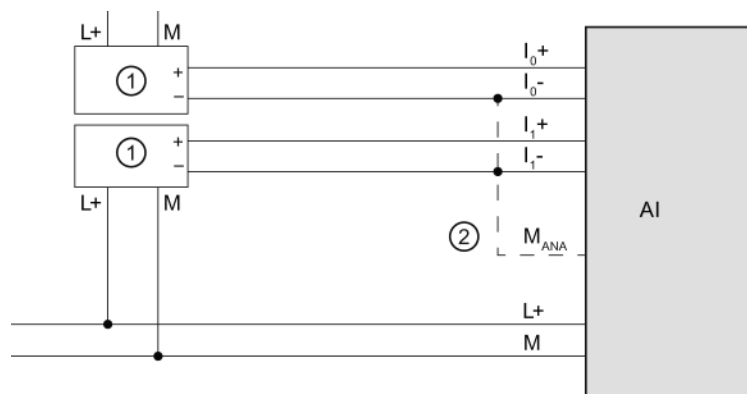


- ① 2-wire transducers (2WT)
- ② Equipotential bonding cable (only relevant to modules with M<sub>ANA</sub> connection)

Figure 4-5 Example: Wiring 2-wire transducers to an analog input for 4-wire transducers

### Wiring and connecting 4-wire transducers

4-wire transducers provide terminals for connecting a separate supply voltage. They are powered with an external supply and are frequently called "active transducers". If you use this type of connection, you will need to set the "Current (**4-wire transducer**)" measurement type in STEP 7.



- ① 4-wire transducers (4WT)
- ② Equipotential bonding cable (only relevant to modules with M<sub>ANA</sub> connection)

Figure 4-6 Example: Wiring 4-wire transducers to an analog input module

## 4.6 Wiring thermal resistors and resistors

The module provides a constant current at terminals  $I_{C+}$  and  $I_{C-}$  for resistance measurements. The constant current is fed to the resistance to be measured where it is measured as voltage drop. It is important to wire the connected constant current cables directly to the thermal resistor/resistor.

Measurements with 4-wire or 3-wire connection compensate for line resistance and therefore achieve greater accuracy compared to measurements with 2-wire connection.

Measurements with two-wire connection always acquire line resistance in addition to the actual resistance; you must therefore allow for a significant loss of precision in the measuring results.

The figures below give some connection examples.

### 4-wire connection of a thermal resistor

The voltage at the thermal resistor is acquired using high-impedance measurement via the  $M_0+$  and  $M_0-$  terminals. Make sure the wiring is correctly poled ( $I_{C0+}$  and  $M_0+$ , and  $I_{C0-}$  and  $M_0-$  at the thermal resistor).

Always wire the  $I_{C0+}$  and  $M_0+$  lines, and the  $I_{C0-}$  and  $M_0-$  lines directly to the thermal resistor.

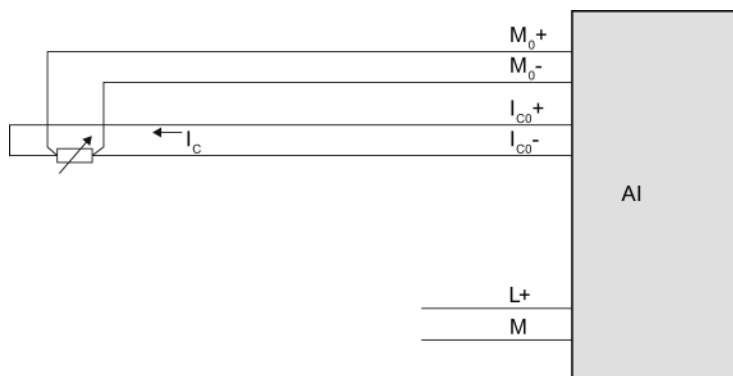


Figure 4-7 Example: 4-wire connection of thermal resistor to an analog input module

### 3-wire connection of a thermal resistor

Depending on the module, for a 3-wire connection to modules with 4 terminals (per channel), you may need to insert a bridge between **M<sub>0</sub>-** and **I<sub>C0</sub>-** (see figure below) or between **M<sub>0</sub>+** and **I<sub>C0</sub>+**. Always wire the **I<sub>C0</sub>+** and **M<sub>0</sub>+** lines directly to the thermal resistor. Use cable with wires with identical cross-section.

For ET 200AL, ET 200eco PN and ET 200pro, no bridge is required as all necessary connections are implemented internally.

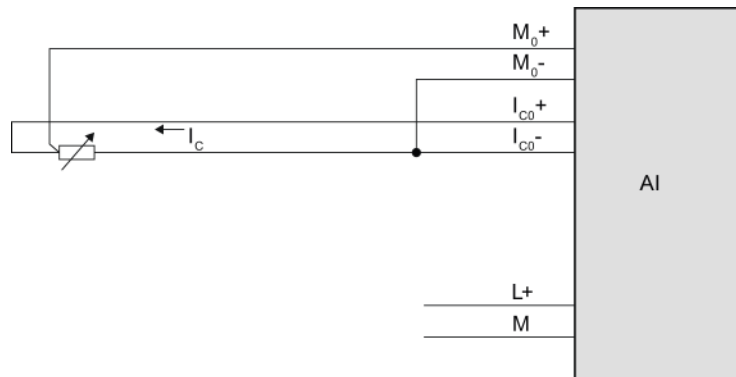


Figure 4-8 Example: 3-wire connection of thermal resistor to an analog input module

### 2-wire connection of a thermal resistor

When installing a 2-wire device on modules with 4 terminals (per channel), you will need to insert bridges at the module between **M<sub>0</sub>+** and **I<sub>C0</sub>+** and between **M<sub>0</sub>-** and **I<sub>C0</sub>-** as shown in the figure below. The line resistance is measured, but not compensated. As a result of physical limitations, this measurement type is less accurate than measurement with 3-wire or 4-wire connections. The wiring for this type of measurement is, however, simple as the bridges required can be wired in the plug, saving line.

For ET 200AL, ET 200eco PN and ET 200pro, no bridge is required as all necessary connections are implemented internally.

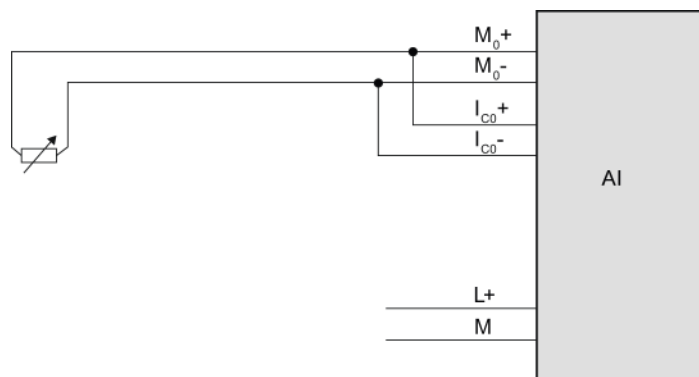


Figure 4-9 Example: 2-wire connection of thermal resistor to an analog input module

## 4.7 Wiring thermocouples

### Introduction

Thermocouples are generally supplied ready-to-use. Protective casing prevents the thermocouples from being destroyed by mechanical force, for example.

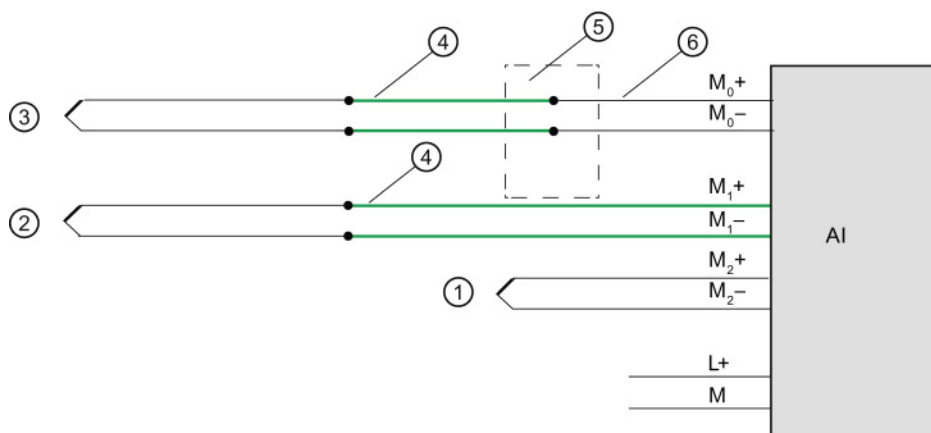
### Compensating lines

The compensating lines belonging to the respective thermocouples are identified by a special color code, because only the compensating line that is made of the material matching the thermocouple may be used. The standardized compensating lines are specified in DIN EN 60584. Observe the maximum temperatures in the manufacturer's specifications.

### Thermocouple connection options

There are various different ways to wire thermocouples to an analog input module:

- Directly ①.
- Using compensating lines ②.
- With a compensating line to the reference junction, connected with a supply line, e.g. copper ③.



- ① Thermocouple without compensating line
- ② Thermocouple with compensating line
- ③ Thermocouple with compensating line and supply line
- ④ Compensating line (same material as thermocouple)
- ⑤ External reference junction
- ⑥ Copper supply cable, for example

Figure 4-10 Example: Wiring thermocouples to an analog input module

### Further information

Further information, such as the selection of thermocouples and how they operate, can be found in the section Thermocouples (Page 77).

# Thermocouples

## 5.1 Selecting thermocouples

### Introduction

Thermocouples are electrical devices for precise temperature measurement. They consist of two different metals connected at one point. Temperature affecting this point generates a voltage difference from which the temperature can be calculated.

Thermocouples can measure a wide range of temperatures and come in extremely robust models. They are therefore frequently used in industrial applications. Below are some of the criteria to consider when selecting the right thermocouple:

- Temperature range
- Atmospheric conditions
- Price

### Grounded thermocouples

In grounded thermocouples, a conductive thermocouple wire is attached to the inside of the sensor housing. This results in good heat transfer from the sensor housing to the thermocouple measuring tip.

### Non-grounded thermocouples

In non-grounded thermocouples, the thermocouple is not connected to the sensor housing. The response time following temperature changes is longer than with grounded thermocouples. The measuring point is galvanically isolated.

## Type and temperature range

The different thermocouple types are derived from different material compositions.

### Note

Due to physical conditions, thermocouples are extremely inaccurate outside the specified temperature range. Only use thermocouple in the temperature range specified by the manufacturer.

The following table lists the types and material compositions, as well as the temperature measuring range of different thermocouples:

| Type           | Material composition | Temperature range |
|----------------|----------------------|-------------------|
| <b>B</b>       | PtRh-PtRh            | 250 to 1820 °C    |
| <b>C</b>       | W-Re                 | 0 to 2315 °C      |
| <b>E</b>       | NiCr-CuNi            | -270 to 1000 °C   |
| <b>J</b>       | Fe-CuNi              | -210 to 1200 °C   |
| <b>K</b>       | NiCr-Ni              | -270 to 1372 °C   |
| <b>L</b>       | Fe-CuNi              | -200 to 900 °C    |
| <b>N</b>       | NiCrSi-NiSi          | -270 to 1300 °C   |
| <b>R</b>       | PtRh-Pt (Pt 13%)     | - 50 to 1769 °C   |
| <b>S</b>       | PtRh-Pt (Pt 10%)     | -50 to 1769 °C    |
| <b>T</b>       | Cu-CuNi              | -270 to 400 °C    |
| <b>U</b>       | Cu-CuNi              | -200 to 600 °C    |
| <b>TXK/XKL</b> | NiCr-CuCr            | -200 to 800 °C    |



## 5.2 Structure and operating principle of thermocouples

### Thermocouple structure

A thermocouple consists of a pair of thermal sensors and the respective installation and wiring elements. Two wires made of different metals/alloys are welded together at their ends (hot end). The welding point forms the so-called measuring point, while the free ends of the thermocouple form the reference junction.

The free ends are interconnected with the evaluation device (e.g. analog input module) via insulated wires or cables.

The different thermocouple types, e.g. K/J/N, are derived from different material composition; the same measuring principle is applied to all thermocouples, independent on their type.

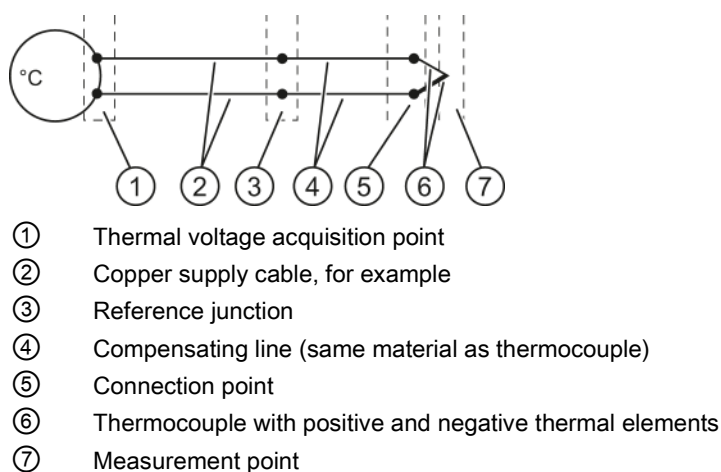


Figure 5-1 Thermocouple

### **Operating principle of thermocouples**

Temperature differences between the measuring point and the free ends of the pair of thermal sensors (connection point) generate a thermal voltage at the reference junction. The value of the thermal voltage is determined by the temperature difference between the measuring point and the free ends, as well as by the material composition of the pair of thermal sensors.

Thermocouples always acquire a differential temperature, which means that the temperature at their free ends (reference junction) must be known to determine the temperature at the measuring point.

The thermocouple can be extended with compensating lines from the connection point. This allows the reference junction to be located at a specific point, for example, where the temperature can be kept constant or the temperature sensor is easy to install. The compensating lines and thermocouple wires are made of the same material. Copper cables are used to connect the reference junction to the module.

---

#### **Note**

Always observe the polarity, as incorrect wiring will result in unacceptable measuring errors.

---

## 5.3 Compensation for the reference junction temperature

### 5.3.1 Overview

#### Introduction

You have several options for measuring the reference junction temperature in order to obtain a correct temperature value as a function of the temperature difference between the reference junction and the measuring point.

You have various compensation options to suit requirements at the location of the reference junction.

The compensation options supported by the analog module used are specified in the manual of the respective module.

#### Options of compensating for the reference junction temperature

Table 5- 1 Compensation options: Explanation and use case

| Compensation options        | Explanation                                                                                                                                                                                                                                                                                                                                                         | Use case / special feature                                                                                                                                                                                                                                                                                                                                                                                                                                                                |
|-----------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Internal reference junction | <p><b>Function principle</b></p> <p>With this type of compensation, the temperature of the reference junction is measured using an integrated sensor in the analog module.</p> <p><b>Procedure</b></p> <p>Connect the thermocouple to the I/O module directly, or with compensating lines; see chapter Compensation with internal reference junction (Page 84).</p> | <ul style="list-style-type: none"> <li>• For the connection, use compensating lines that match the thermocouple material.</li> <li>• If the reference junction temperature and the module temperature are identical in your system, you may also use lines made from a different material.</li> <li>• Advantages: <ul style="list-style-type: none"> <li>– Inexpensive</li> <li>– No external reference junction required</li> <li>– No additional wiring required</li> </ul> </li> </ul> |

### 5.3 Compensation for the reference junction temperature

| Compensation options            | Explanation                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      | Use case / special feature                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |
|---------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Reference channel of the module | <p><b>Properties</b></p> <p>With this type of compensation, the reference junction temperature is determined using an external thermal resistor (RTD).</p> <p><b>Procedure</b></p> <p>Connect the thermocouple to the supply lines directly at the reference junction, or indirectly using compensating lines. Wire the supply lines to the corresponding terminals of the module.</p> <p>Wire the thermal resistor (RTD) to the reference channel of the module. The thermal resistor (RTD) must be positioned in the area of the reference junction; see chapter Compensation with reference channel of the module (Page 86).</p>                                                                                              | <ul style="list-style-type: none"> <li>• They acquire the temperature directly at the reference junction.</li> <li>• The measured temperatures of all channels that you have configured for this compensation type will be corrected automatically by the temperature value of the reference junction.</li> <li>• Advantages: <ul style="list-style-type: none"> <li>– More precise compared to compensation with internal reference junction; however, you need to install and wire an additional thermal resistor.</li> </ul> </li> </ul> |
| Reference channel of group 0    | <p><b>Properties</b></p> <p>With the "TC" (thermocouple...) setting, the channel acts as receiver for the reference junction temperature of group 0.</p> <p>The associated transmitter of group 0 is set up to for the RTD channel.</p> <p><b>Procedure</b></p> <p>Connect the thermocouple to the supply lines directly at the reference junction, or indirectly using compensating lines. Wire the supply lines to the corresponding terminals of the module.</p> <p>Wire the thermal resistor (RTD) to the configured reference channel for group 0 of the module. The thermal resistor (RTD) must be positioned in the area of the reference junction; see chapter Compensation, reference channel of Group 0 (Page 88).</p> | <ul style="list-style-type: none"> <li>• They acquire the temperature directly at the reference junction.</li> <li>• The measured temperatures of all channels that you have configured for this compensation type will be corrected automatically by the temperature value of the reference junction (transmitter).</li> </ul>                                                                                                                                                                                                             |
| Fixed reference temperature     | <p><b>Properties</b></p> <p>With this type of compensation, the reference junction temperature is stored in the module as fixed value.</p> <p><b>Procedure</b></p> <p>Connect the thermocouple to the supply lines directly at the reference junction, or indirectly using compensating lines. Wire the supply lines to the corresponding terminals of the module.</p> <p>Depending on the module, you can enter a fixed reference junction temperature in the configuration data (e.g. 20 °C), or use the fixed reference junction temperature of the module (0 °C); see chapter Compensation with fixed reference temperature (Page 91).</p>                                                                                   | <ul style="list-style-type: none"> <li>• You keep the reference junction temperature constant and know the temperature value.</li> <li>• To ensure high precision, you must ensure that the temperature remains constant (this can be complicated, depending on the application).</li> </ul>                                                                                                                                                                                                                                                |

## 5.3 Compensation for the reference junction temperature

| Compensation options          | Explanation                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        | Use case / special feature                                                                                                                                                                                                                                                                                                           |
|-------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Dynamic reference temperature | <p><b>Properties</b></p> <p>With this type of compensation, the reference junction temperature is determined using a module. Transfer this temperature value to other modules in the user program by means of a data record.</p> <p><b>Procedure</b></p> <p>Wire the thermal resistor (RTD) for the reference junction to any channel.</p> <p>The reference junction temperature is transferred with a function block by means of data records from the CPU or IM to the module, see section Compensation by means of dynamic reference temperature (Page 94).</p> | <ul style="list-style-type: none"> <li>You are using multiple modules at the reference junction and can therefore compensate for all channels using a common temperature value.</li> <li>You only need a thermal resistor (RTD) or a thermocouple to measure the temperature value.</li> </ul>                                       |
| No/external compensation      | <p><b>Properties</b></p> <p>With this type of compensation, the reference junction temperature is measured outside the analog input module. You can, for example, connect a compensating box to the thermocouple for this purpose.</p> <p><b>Procedure</b></p> <p>Connect the compensating box with the connection module of the analog input module with copper cables, see section "None" or external compensation (Page 98).</p>                                                                                                                                | <ul style="list-style-type: none"> <li>The temperature of the reference junction for this type of compensation is specified as 0 °C. This can be achieved by using a compensating box. A separate compensating box is required for each thermocouple.</li> <li>Thermocouples of type B do not require a compensating box.</li> </ul> |
| RTD (0)                       | <p><b>Properties</b></p> <p>This compensation is based on a measurement of the resistance value of a Pt1000 at the clamping unit of a compensation connector or of an external resistance value Pt1000.</p> <p><b>Procedure</b></p> <p>Additional information about the connection options with and without compensation connector is available in the section Type of compensation RTD (0) (Page 100).</p>                                                                                                                                                        | <ul style="list-style-type: none"> <li>The reference junction temperature is determined with resistance value of the Pt1000.</li> <li>All channels of the analog input module that you select for this type of compensation receive the same reference junction temperature.</li> </ul>                                              |

### 5.3.2 Compensation with internal reference junction

#### Function principle

The reference junction for compensation via internal reference junction is at the terminals of the analog input module. Wire the thermocouples or compensating lines directly to the module inputs. The internal temperature sensor acquires the module temperature and returns a compensating voltage.

Note that compensation via internal reference junction will not always reach the precision of external compensation!

#### Procedure

Configuration steps:

1. Open the project in STEP 7.
2. In the device view, select the required analog module and the corresponding channel.
3. Select the "General" tab in the Inspector window of the selected module.
4. Select the "Inputs/Measuring" area.
5. Select the "Thermocouple" value as "Measurement type".
6. As "Reference junction", select the value "Internal reference junction".

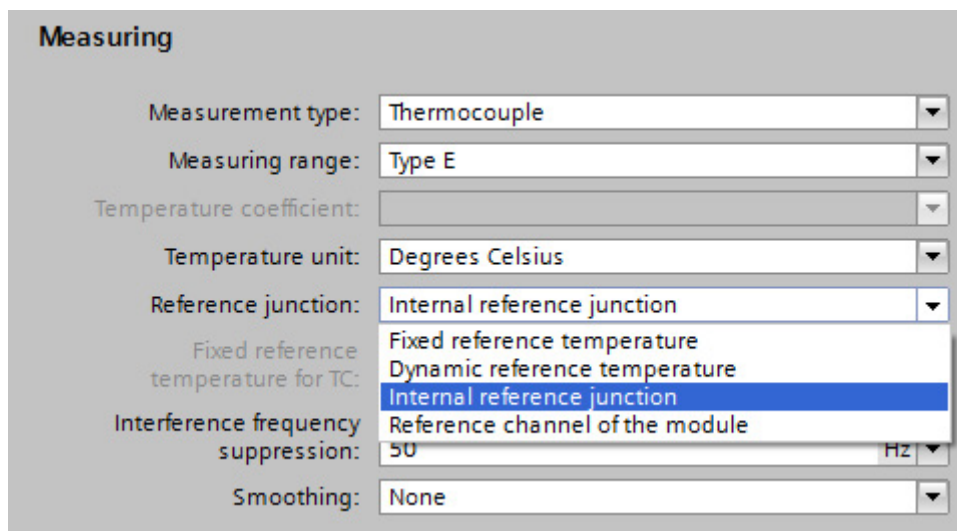


Figure 5-2 Internal reference junction

## Wiring thermocouples

Wire the thermocouples directly or indirectly via compensating lines to the module inputs.

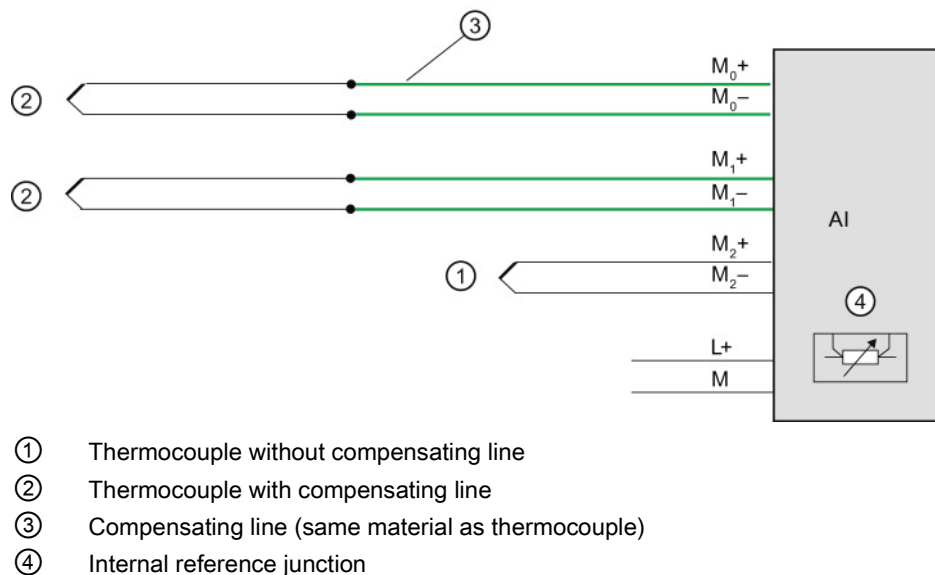


Figure 5-3 Example: Wiring thermocouples for compensation via internal reference junction

### 5.3.3 Compensation with reference channel of the module

#### Function principle

With this type of compensation, the reference junction temperature is determined using an external thermal resistor (RTD). Certain modules provide an internal reference channel.

#### Procedure

Configuration steps:

1. Open the project in STEP 7.
2. In the device view, select the required analog module and the corresponding channel.
3. Select the "General" tab in the Inspector window of the selected module.
4. Select the "Inputs/Measuring" area.
5. Select the "Thermocouple" value as "Measurement type".
6. As "Reference junction", select the value "Reference channel of the module".

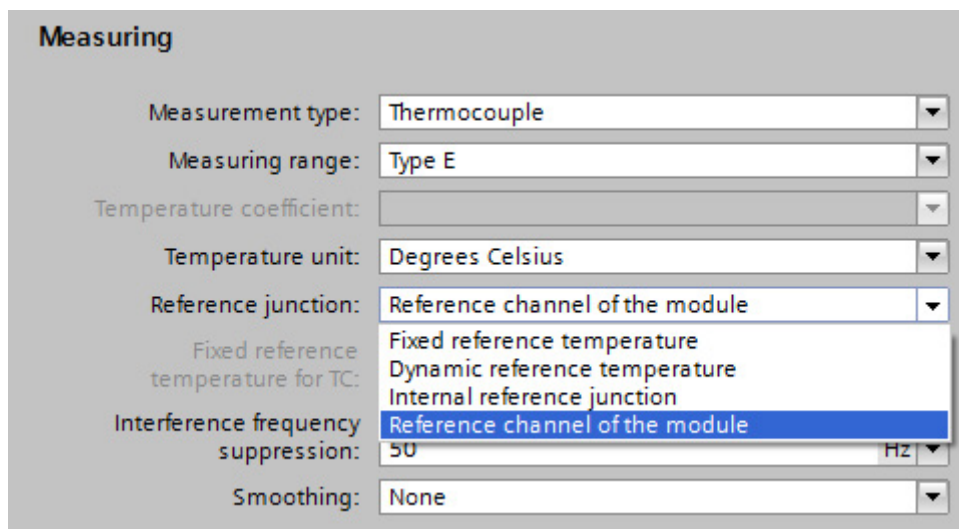


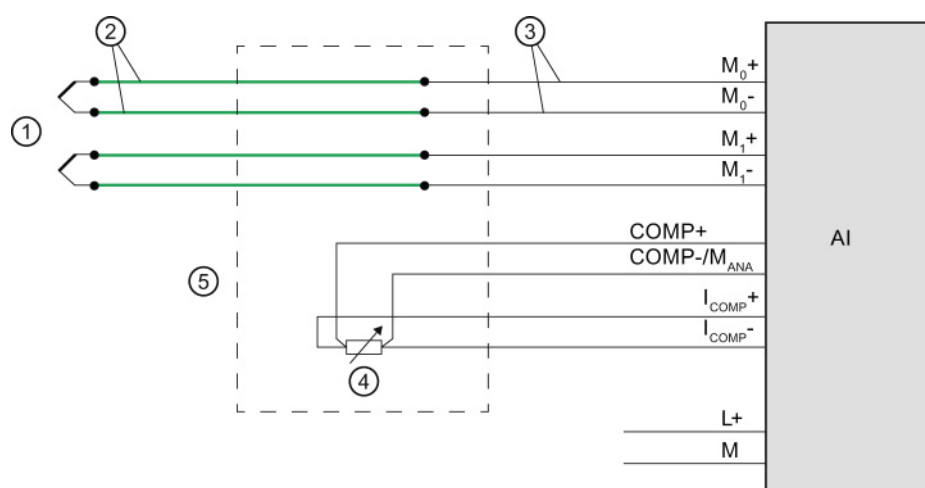
Figure 5-4 Reference channel of the module



## Wiring thermocouples and thermal resistors

Connect the thermocouple to the supply lines directly at the reference junction, or indirectly using compensating lines. Wire the supply lines to the corresponding terminals of the module.

You may use cables made of any material to wire the thermal resistor to the module terminals.



- ① Thermocouple
- ② Compensating line (same material as thermocouple)
- ③ Copper supply cable, for example
- ④ Thermal resistor (RTD)
- ⑤ Reference junction

Figure 5-5 Example: Wiring thermocouples/thermal resistors for compensation by means of reference channel of the module

### 5.3.4 Compensation, reference channel of Group 0

#### Function principle

For this compensation, a module channel with a connected thermal resistor (RTD) acts as "Reference temperature transmitter". Other channels (reference temperature receivers) with connected thermocouples can be compensated using this reference temperature. The measured temperatures of all channels (receivers) that you have configured for this compensation type will be compensated automatically by the temperature value of the reference junction (transmitter).

The reference junction temperature is determined by means of an external thermal resistor (RTD).

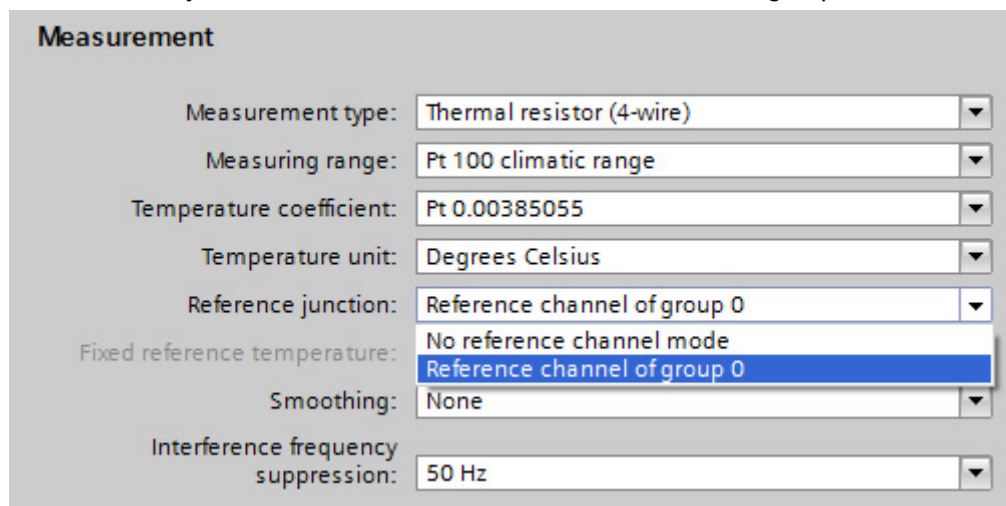
#### Procedure

Configuration steps:

1. Open the project in STEP 7.
2. In the device view, select the required analog module and the corresponding channel.
3. Select the "General" tab in the Inspector window of the selected module.
4. Select the area "Inputs/measurement".
5. For the channel of the relevant module, specify as transmitter:

As "Measurement type" select, for example, "Thermal resistor (4-wire connection)".

As "Reference junction", select the value "Reference channel of group 0".



**Measurement**

|                                     |                              |
|-------------------------------------|------------------------------|
| Measurement type:                   | Thermal resistor (4-wire)    |
| Measuring range:                    | Pt 100 climatic range        |
| Temperature coefficient:            | Pt 0.00385055                |
| Temperature unit:                   | Degrees Celsius              |
| Reference junction:                 | Reference channel of group 0 |
| Fixed reference temperature:        | No reference channel mode    |
|                                     | Reference channel of group 0 |
| Smoothing:                          | None                         |
| Interference frequency suppression: | 50 Hz                        |

Figure 5-6 Transmitter: Reference channel of group 0

6. For the channels you specify as receivers:

Select the "Thermocouple" value as "Measurement type".

As "Reference junction", select the value "Reference channel of group 0".

The screenshot shows a configuration window titled "Measurement". It contains several dropdown menus and text fields. The "Measurement type" is set to "Thermocouple". The "Measuring range" is set to "Type E". The "Temperature coefficient" is set to an empty dropdown. The "Temperature unit" is set to "Degrees Celsius". The "Reference junction" dropdown is open, showing three options: "Reference channel of group 0", "Reference channel of the module", and "Internal reference junction". The "Smoothing" dropdown is also open, showing three options: "Reference channel of group 0", "Fixed reference temperature", and "Internal reference junction". The "Interference frequency suppression" is set to "50 Hz".

|                                     |                                 |
|-------------------------------------|---------------------------------|
| Measurement type:                   | Thermocouple                    |
| Measuring range:                    | Type E                          |
| Temperature coefficient:            |                                 |
| Temperature unit:                   | Degrees Celsius                 |
| Reference junction:                 | Reference channel of group 0    |
| Fixed reference temperature:        | Reference channel of the module |
| Smoothing:                          | Reference channel of group 0    |
| Interference frequency suppression: | 50 Hz                           |

Figure 5-7 Receivers: Reference channel of group 0

### Connecting thermocouples and thermal resistors

The example below shows:

- An analog module with thermal resistor as reference temperature transmitter and
- Two analog modules with thermocouple as reference temperature receivers.

Connect the thermocouples to the supply lines at the reference junction, either directly or with compensating lines. Wire the supply lines to the corresponding terminals of the module.

You may use cables made of any material to wire the thermal resistor to the module terminals.

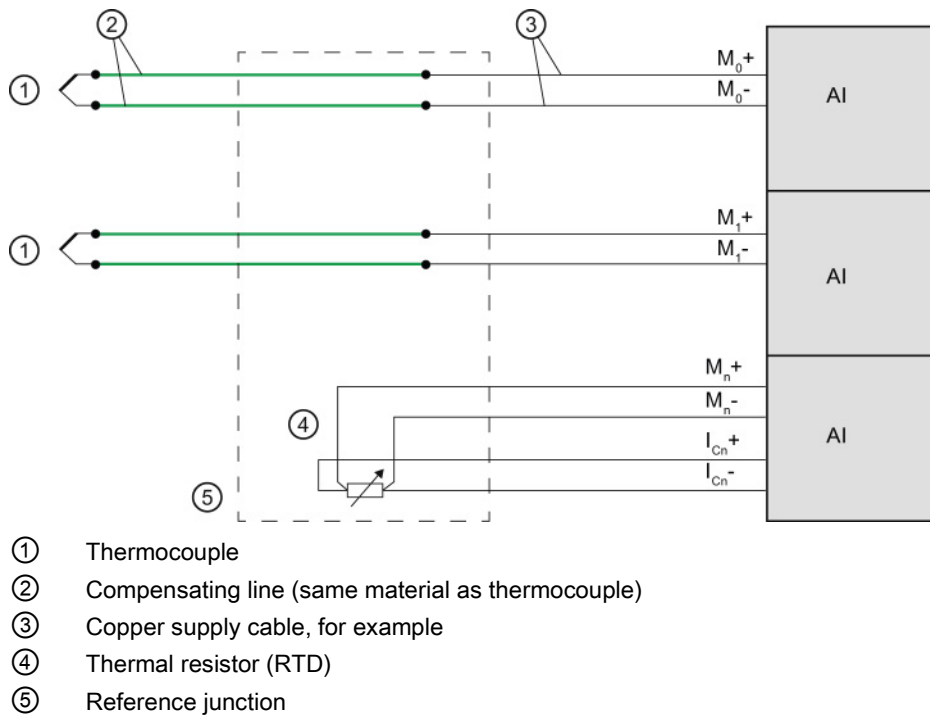


Figure 5-8 Example: Connecting thermocouples/thermal resistors for group 0 compensation

### 5.3.5 Compensation with fixed reference temperature

#### Function principle

With this type of compensation, the reference junction temperature is stored in the module as fixed value.

#### Procedure

Configuration steps:

1. Open the project in STEP 7.
2. Select the required analog module in the Device view.
3. Select the "General" tab in the Inspector window of the selected module.
4. Select the "Inputs/Measuring" area.
5. Select the "Thermocouple" value as "Measurement type".
6. As "Reference junction", select the value "Fixed reference temperature".
7. Specify the temperature of the reference junction in the "Fixed reference temperature" area, for example, 20 °C.

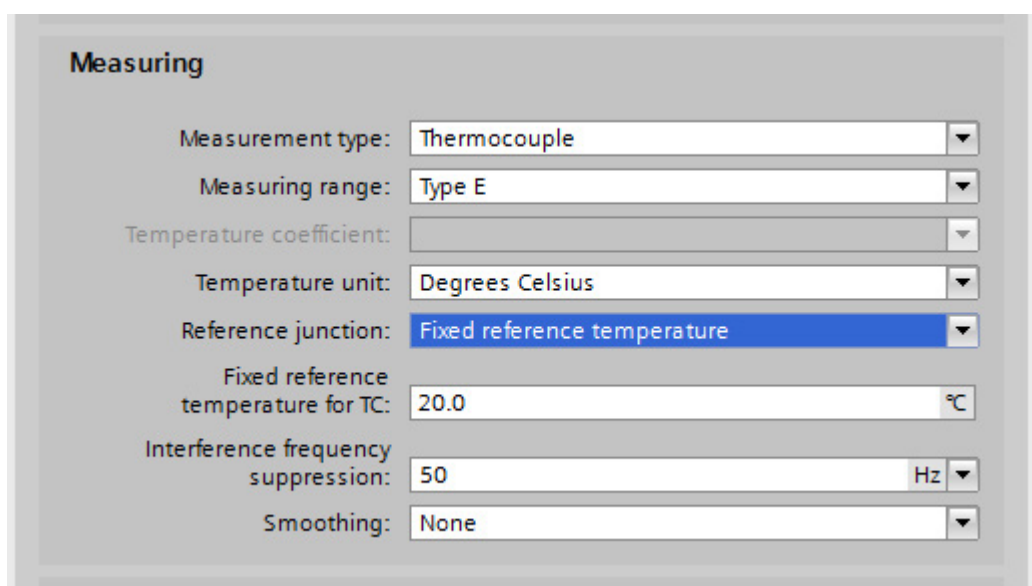
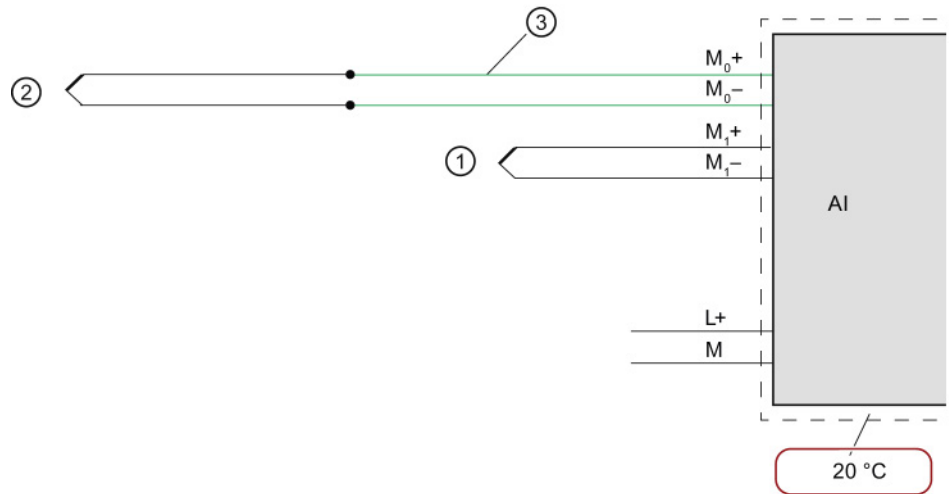


Figure 5-9 Fixed reference temperature

### Temperature condition with "Fixed reference temperature" setting

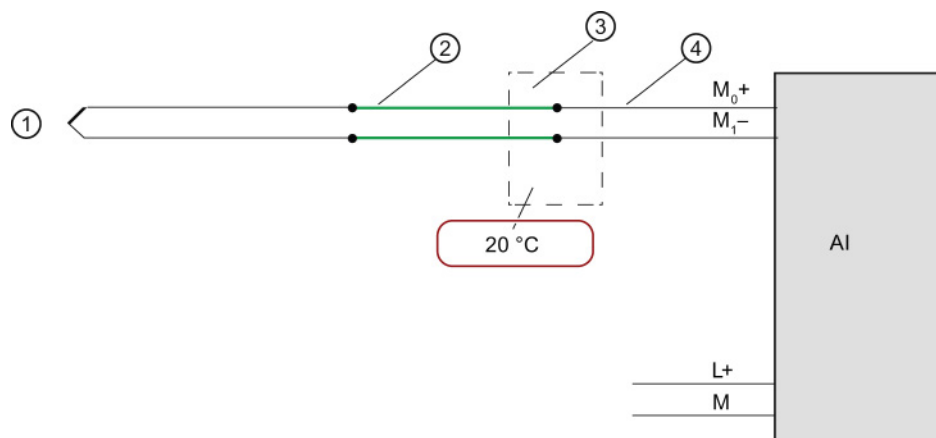
The figure below shows the connection options for thermocouples provided the temperature of the module is kept at a fixed reference temperature (20 °C), for example by installing it in an air-conditioned switch cabinet. The reference junction is in the module.



- ① Thermocouple without compensating line
- ② Thermocouple via compensating line
- ③ Compensating line (same material as thermocouple)

Figure 5-10 Example 1: Connecting a thermocouple to an analog module for compensation with "fixed reference temperature"

The figure below shows the connection options for thermocouples provided the temperature of the reference junction (outside the module) is kept at a fixed reference temperature (20 °C).



- ① Thermocouple with compensating line and supply line
- ② Compensating line (same material as thermocouple)
- ③ Reference junction
- ④ Copper supply cable, for example

Figure 5-11 Example 2: Connecting a thermocouple to an analog module for compensation with "fixed reference temperature"

### 5.3.6 Compensation by means of dynamic reference temperature

#### Function principle

This compensation type allows you to handle the reference junction temperature for temperature compensation in the user program. You can derive the temperature value from any other module of the station. The reference junction temperature is transferred via data records using the instruction **WRREC** (SFB 53).

The structure of the data records is detailed in the device manual for each module.

#### Requirement

STEP 7 project with the following contents:

- User program with WRREC (SFB 53) instruction for transferring the data records with reference temperature
- Analog module for acquisition of the process temperature using thermocouple (TC)
- Analog module for measuring the process temperature using thermal resistor (RTD)



**Analog module for acquisition of the process temperature using thermocouple (TC)**

Configuration steps:

1. Open the project in STEP 7.
2. In the device view, select the required analog module and the corresponding channel.
3. Select the "General" tab in the Inspector window of the selected module.
4. Select the "Inputs/Measuring" area.
5. Select the "Thermocouple" value as "Measurement type".
6. As "Reference junction", select the value "Dynamic reference temperature".

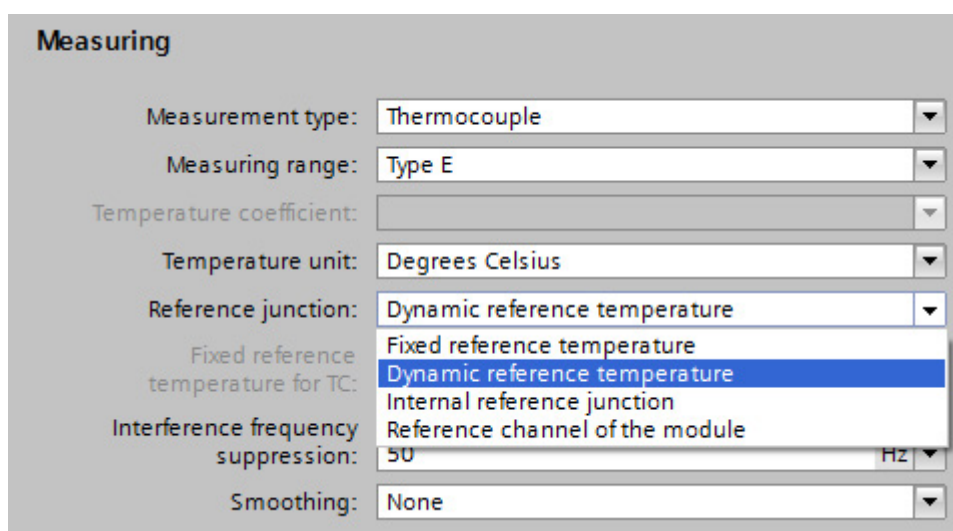
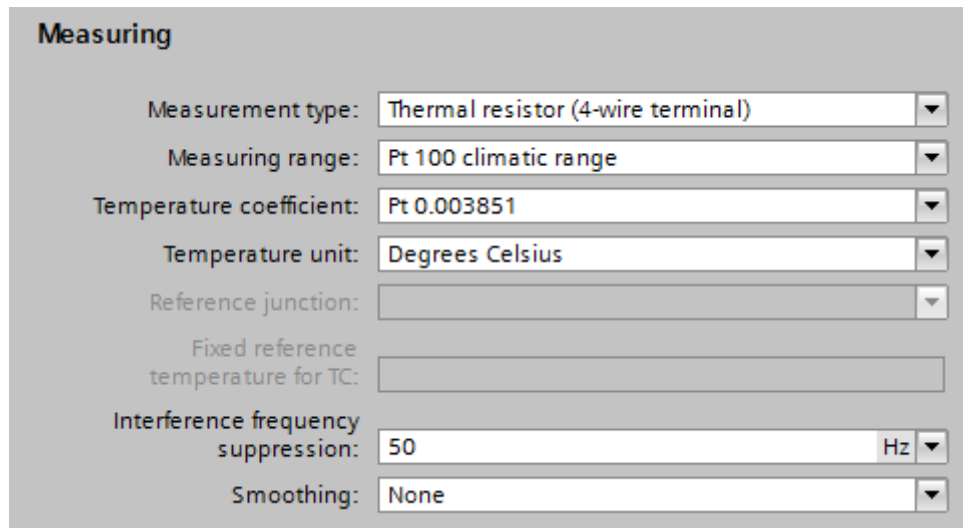


Figure 5-12 Dynamic reference temperature

## Analog module for measuring the process temperature using thermal resistor (RTD)

Configuration steps:

1. Open the project in STEP 7.
2. In the device view, select the required analog module and the corresponding channel.
3. Select the "General" tab in the Inspector window of the selected module.
4. Select the "Inputs/Measuring" area.
5. Select the "Thermal resistor (4-wire connection)" value as "Measurement type".



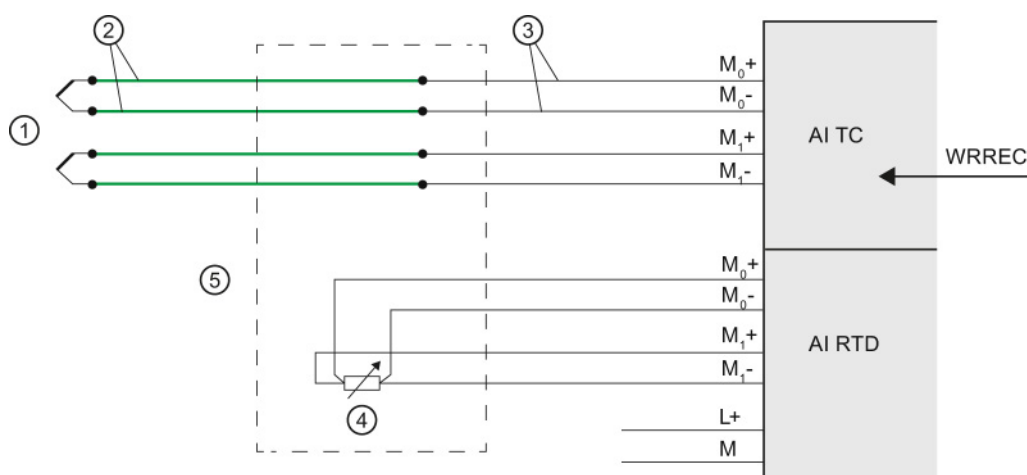
**Measuring**

|                                     |                                    |      |
|-------------------------------------|------------------------------------|------|
| Measurement type:                   | Thermal resistor (4-wire terminal) | ▼    |
| Measuring range:                    | Pt 100 climatic range              | ▼    |
| Temperature coefficient:            | Pt 0.003851                        | ▼    |
| Temperature unit:                   | Degrees Celsius                    | ▼    |
| Reference junction:                 |                                    | ▼    |
| Fixed reference temperature for TC: |                                    |      |
| Interference frequency suppression: | 50                                 | Hz ▼ |
| Smoothing:                          | None                               | ▼    |

Figure 5-13 Settings for thermal resistor (RTD) type of measurement

### Connecting thermocouples and thermal resistors

Connect the thermocouples, for example, to the module inputs using supply lines for temperature compensation with dynamic reference temperature. In this case, the temperature is acquired at the reference junction by means of a thermal resistor (RTD). This reference junction temperature determined in this way is transferred to the analog module with thermocouple via data records with the WRREC instruction.



- ① Thermocouple
- ② Compensating line (same material as thermocouple)
- ③ Copper supply cable, for example
- ④ Thermal resistor (RTD)
- ⑤ Reference junction

Figure 5-14 Example: Connecting thermocouples/thermal resistors for compensation by means of dynamic reference temperature

### 5.3.7 "None" or external compensation

#### Function principle

The reference junction temperature of the thermocouples is measured outside the analog input module, e.g., by means of a compensating box on the thermocouple. The temperature of the reference junction for this type of compensation is specified as 0° C.

The compensating box includes a bridge circuit that is calibrated for a specific reference junction temperature (compensation temperature). The connectors for the ends of the compensating line of the thermocouple form the reference junction. If the actual comparison temperature deviates from the compensation temperature, the temperature-dependent bridge resistor changes. A positive or negative compensation voltage is generated and added to the thermal voltage.

#### Note

Thermocouples of type B do not require a compensating box.

#### Procedure

Configuration steps:

1. Open the project in STEP 7.
2. Select the required analog module in the Device view.
3. Select the "Inputs" tab in the Inspector window of the selected module and the respective channel.
4. Select the "Thermocouple" value as "Measurement type" in the "Measuring" area.
5. As "Reference junction", select the value "None" or "External compensation" depending on the used module.

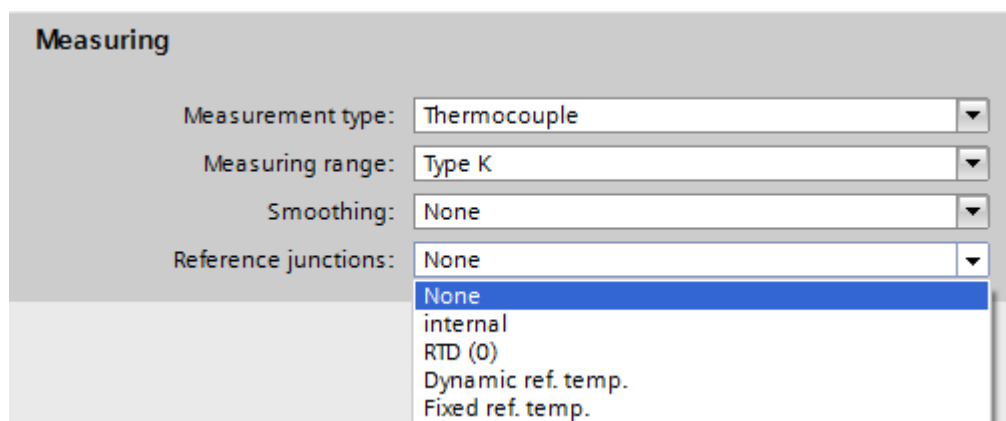


Figure 5-15 No reference junction

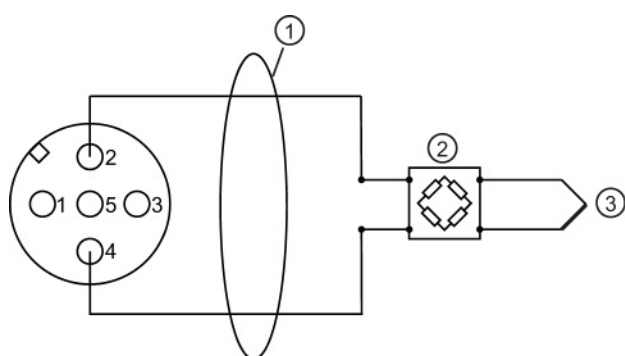
### Connection of the compensating box

The compensating box is looped into the supply lines of an individual thermocouple. The compensating box must be supplied isolated. The power supply unit must have a sufficient noise filter, e.g., by means of a grounded shielding winding.

Each channel can use its own thermocouple type supported by the analog module regardless of the other channels. A separate compensating box is required for each channel.

### Connection example "None" or external compensation

Connect the compensating box with the connection module of the analog input module using copper cables.



- ① Copper cables
- ② Compensating box (per channel), for example; thermocouple type B does not require a compensating box
- ③ Thermocouple

Figure 5-16 Connection example "No" compensation as reference junction

### 5.3.8 Compensation type RTD (0)

#### Function principle

The reference junction temperature is determined by means of the resistance value of a Pt 1000 at the clamping unit of the M12 compensation connector. The resistance measurement is only permitted at the X1 circular socket (channel 0). All of the module's channels with this type of compensation receive the same reference junction temperature.

#### Procedure

Configuration steps:

1. Open the project in STEP 7.
2. Select the required analog module in the Device view.
3. Select the "Inputs" tab in the Inspector window of the selected module.
4. Select the "Thermocouple" value as "Measurement type" in the "Measuring" area.
5. As "Reference junction", select the value "RTD (0)".

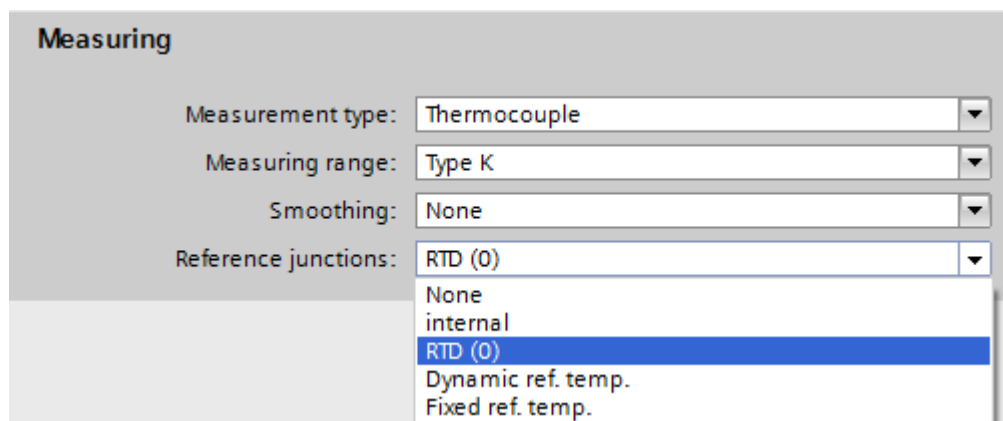


Figure 5-17 Compensation type RTD (0)

## Connection example

### Connection with M12 compensation connector

Connect the thermocouple to the M12 compensation connector directly or with compensating lines. Install the M12 compensation connector to the X1 circular socket (channel 0) of the CM IO 4 x M12 at the 4 AI TC High Feature.

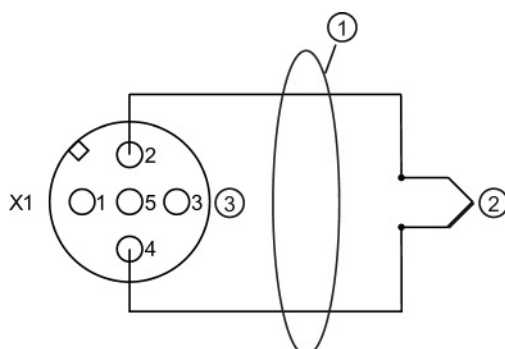
### Connection without M12 compensation connector

To measure the referent junction temperature, connect an external Pt1000 (with  $\alpha = 003851$ ) to terminals 1 and 3 using copper cables. The thermal resistor Pt1000 must be positioned in the area of the reference junction. Connect the thermocouples to terminals 2 and 4 from the reference junction with copper cables.

### Connecting additional thermocouples

You can connect additional thermocouples to the circular sockets X2 to X4 on the CM IO 4 x M12 of the 4 AI TC High Feature. The temperature of reference junction collected by measuring the resistance value at the X1 circular socket applies to all channels of the module that you have selected for this type of compensation.

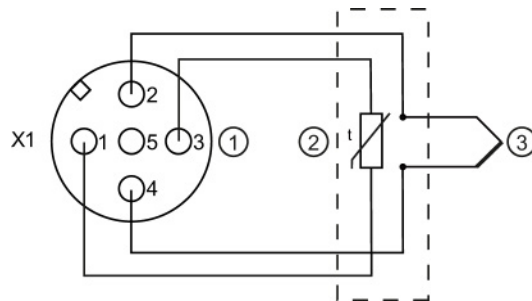
The figure below shows a connection example "RTD (0)" as reference junction with M12 compensation connector and integrated thermal resistor Pt1000:



- ① Direct connection of the thermocouple or with compensating lines
- ② Thermocouple
- ③ M12 compensation connector (terminals 1 and 3 with internal Pt1000) only at X1 circular socket. The comparison value of the M12 compensation connector at circular socket X1 also applies to thermocouples at X2, X3 and X4.

Figure 5-18 Connection example "RTD (0)" as reference junction in the M12 compensation connector

The figure below shows a connection example "RTD (0)" as reference junction with external thermal resistor Pt1000:



- ① M12 connector only at X1 circular socket
- ② External Pt1000 ( $\alpha = 0.003851$ ) in the area of the reference junction with copper cables at terminals 1 and 3. The comparison value of the external Pt1000 at circular socket X1 also applies to thermocouples at X2, X3 and X4.
- ③ Thermocouple

Figure 5-19 Connection example "RTD (0)" as reference junction with external Pt1000



## Wiring loads/actuators

### 6.1 Overview

#### Introduction

This chapter describes the basic procedure for wiring loads/actuators to analog outputs. Information on specific wiring options is available in the manual of each module.

For detailed information on cable routing and shielding, potential equalization, etc. please refer to the function manual Configuring interference-free controllers (<http://support.automation.siemens.com/WW/view/en/59193566>).

#### Abbreviations used in the figures

Key to the abbreviations in the figures below:

|               |                                      |
|---------------|--------------------------------------|
| AQ            | Analog output module                 |
| M             | Ground connection                    |
| L+            | Supply voltage connection            |
| $S_n+/S_n-$   | Sense line channel n                 |
| $QV_n+/QV_n-$ | Voltage output channel n             |
| $QI_n+/QI_n-$ | Current output channel n             |
| $M_{ANA}$     | Reference point of the analog ground |
| $U_{ISO}$     | Insulation voltage                   |

#### Lines for analog signals

Always use shielded twisted-pair cables to wire the analog signals. This improves immunity.

## 6.2 Wiring loads/actuators

### Reference potential for analog output modules with $M_{ANA}$ connection

Analog output modules have no galvanic connection between the reference point of the analog ground  $M_{ANA}$  and the central ground.

Always verify that the admissible potential difference  $U_{ISO}$  between the reference point of the analog ground  $M_{ANA}$  and the central ground is not exceeded.

Potential difference  $U_{ISO}$  may be caused by: Maximum line lengths exceeded.

If you want to ensure the maximum value  $U_{ISO}$  is not exceeded, wire terminal  $M_{ANA}$  and the central ground with an equipotential bonding cable.

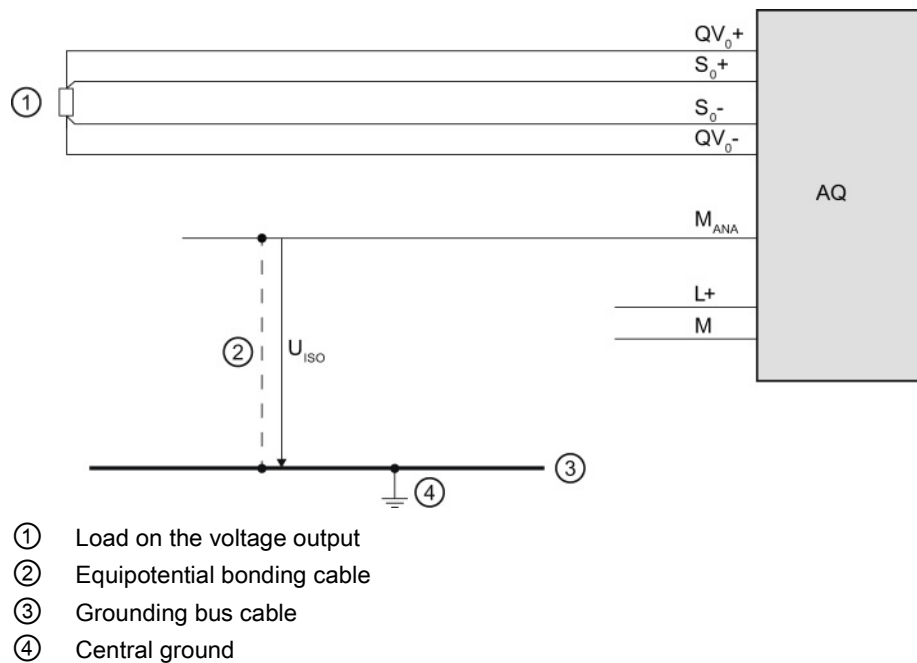


Figure 6-1 Example: Reference potential for an analog output module with  $M_{ANA}$  connection

### Reference potential for analog output modules without $M_{ANA}$ connection

Analog output modules have no galvanic connection between the reference potential of the analog output circuits and central ground.

Always verify that the maximum potential difference  $U_{ISO}$  between the reference points of the analog output circuits and the central ground is not exceeded.

Potential difference  $U_{ISO}$  may be caused by: Maximum line lengths exceeded.

If you want to ensure the maximum value  $U_{ISO}$  is not exceeded, interconnect each analog output circuit with the central ground using an equipotential bonding cable.

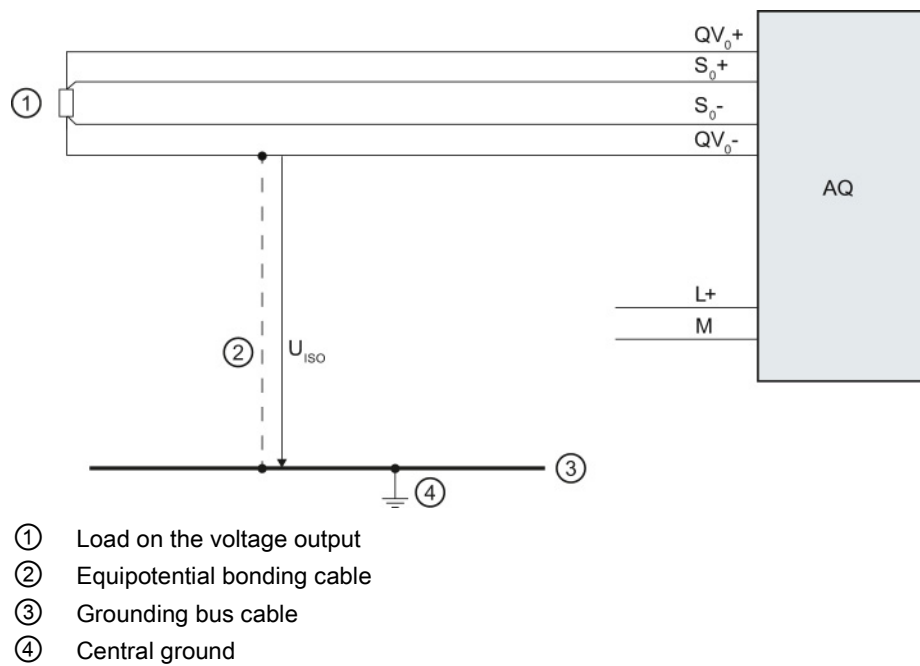


Figure 6-2 Example: Reference potential for an analog output module without  $M_{ANA}$  connection

## Supported functions

### 7.1 Calibrating analog modules

#### 7.1.1 Overview

##### Calibration

A calibration checks the process values measured by the analog input module and the process values output by the analog output module, determines the deviation from the actual values and compensates for any measurement and output errors.

##### Calibrating analog modules

The SIMATIC analog modules were calibrated before being shipped and have excellent long-term stability; calibration is therefore not required during runtime.

But certain regulations and directives, for example from the Food and Drug Administration (FDA), require regular calibration for all components in a measuring circuit. These components include analog input and output modules.

A calibration makes sense especially for plants in which sensors detect and process relatively small voltages or currents. The calibration compensates for influences on the measuring result by cables and/or temperature.

The calibration collects the new values and saves them retentively on the module. But the calibration values determined prior to delivery at the plant are not lost. You can return to these original calibration values at any time.

---

##### Note

The calibration saves the calibration values of each channel for the specific measuring range retentively on the module, which means the values apply to the same measuring range in which the user calibration took place.

If you reconfigure a channel with effective user calibration values to another type of measuring mode, the calibration values saved at the plant for this channel and for this measuring range will become effective.

But the user calibration values are not deleted. They are not overwritten until there is a new user calibration of the channel. If you set the original measuring range for this channel once again without new user calibration, the previously determined user calibration values will become effective.

---

The respective manual will include information whether or not your analog module supports the "Calibration" functionality.

### **Scope of functions**

The "Calibration" group offers the following functions:

- Specifying the current calibration of all channels
- Calibrating a channel
- Canceling a running calibration
- Resetting the calibration of a channel to the factory settings

## **7.1.2 Calibrating analog modules**

### **Manual calibration**

The following requirements must be met to start manual calibration:

- An online connection exists between STEP 7, the respective CPU and the analog module to be calibrated.
- You have opened the "Online & Diagnostics" view for the selected analog module from the shortcut menu of the project and you are now in the "Functions > Calibration" area.
- The configuration reflects the actual structure of the station.
- No calibration process is busy on the module (if you want to launch calibration).
- A 24 V load voltage must be present at each module for the calibration.
- The last step was successfully completed (if you want to continue or conclude calibration).

## Procedure

The basic mask for calibration opens once you start the "Calibration" function. The module reads the following general information data and calibration values after each new selection of a channel:

- **Calibration:** Indicates whether or not the currently effective calibration values are factory calibration values or user calibration values.
- **Measurement type:** Information about the selected measurement type
- **Measuring range:** Currently configured measuring range of the selected channel
- **Gain:** Currently effective gain correction of the analog-digital converter
- **Offset:** Currently effective offset correction of the analog-digital converter

Overview

| Channel.. | Calibration | Measuring typ | Measuring r.. | Gain: | Offset: | Date     |   |
|-----------|-------------|---------------|---------------|-------|---------|----------|---|
| 0         | Factory     | Voltage       | +/- 10 V      | 1     | 0       | 12/1 ... | ▲ |
| 1         | Factory     | Voltage       | +/- 10 V      | 1.001 | 0       | 12/1 ... | ☰ |
| 2         | Factory     | Voltage       | +/- 10 V      | 1     | 0       | 12/1 ... |   |
| 3         | Factory     | Voltage       | +/- 10 V      | 1.001 | 0       | 12/1 ... |   |
| 4         | Factory     | Voltage       | +/- 10 V      | 1.001 | 0       | 12/1 ... |   |
| 5         | Factory     | Voltage       | +/- 10 V      | 1     | 0       | 12/1 ... |   |
| 6         | Factory     | Voltage       | +/- 10 V      | 1.001 | 0       | 12/1 ... |   |
| 7         | Factory     | Voltage       | +/- 10 V      | 1     | 0       | 12/1 ... | ▼ |

Start manual calibration      Set to factory settings

Figure 7-1 Calibration table

To start the calibration, follow these steps:

1. Select the line associated with the channel to be calibrated in the overview table.
2. Click the "Start manual calibration" button.
3. Now go through the steps in the "Manual calibration" section.
4. Follow the instructions in the "Command" field.
5. Click ""Next".

The required calibration values of the selected channel according to the measuring range configured for this channel are specified once again during the user calibration.

---

**Note**

The calibration can take place in RUN mode as well as STOP mode of the CPU. If the CPU is in RUN, the calibration value that was last collected prior to the start of the calibration is supplied for the duration of the calibration.

The module channel to be calibrated cannot process any new process values during the user calibration. All analog input values of the module are set to 0x7FFF ("Invalid analog value") until the end of the calibration. When the value status is enabled, the value status of the signal is set to "invalid" for the duration of the calibration.

---

You must provide a voltage and/or temperature during a user calibration. To do so, use the corresponding external wiring and an external voltage/temperature transducer. The field "Command" includes numbers of pins to which you can connect the calibration stimulus. The first pin number identifies the positive connector, the second pin number the negative connector. The accuracy of the calibration depends on the accuracy of the provided voltage/temperature.

---

**Note**

To ensure that the module retains the specified measuring accuracy after the user calibration, the provided voltage/temperature must be twice as accurate as specified for the module. Inaccurate voltages or temperature result in a faulty calibration.

---

The figure below shows an example of channel calibration with "Voltage" measurement, measuring range "+/- 10 V".

**Manual calibration**

Step 1 of 2

Command: Please apply a voltage of 10000 mV to terminal 3.  
Please apply the ground to terminal 4.

Status: Calibration started without errors.

Measured value: 10000

Next Cancel

Figure 7-2 Manual calibration

### 7.1 Calibrating analog modules

- **Command:** The field "Command" indicates which actions the user has to execute during the current calibration step. Here you execute the specified actions and confirm them with the "Next" button. The module now executes all actions required for the current calibration step. If the calibration step was error-free, the next calibration step takes place.  
The instructions in the "Command" field are to be performed additively. For example, after you have applied the voltage/ground to the terminals 3/4, these connections must remain in place during the execution of the next calibration step.
- **Status:** Depending on the set type of measurement, several calibration steps are required for calibration of a channel. The field "Status" indicates whether or not the last calibration step included errors. If an error occurs during processing of a calibration step, the error is displayed here and calibration of the channel is aborted. All calibration values recorded up to this point are deleted. The calibration values that were in effect prior to the start of the user calibration are effective once again.

---

#### Note

##### Calibrators

If the "Wire break" diagnostics is activated for analog input modules, a test current is applied to the line for the measuring types "Resistance", "Thermistor" and "Thermocouple". This applied test current can result in inaccurate measured values in some calibrators. The wire break monitoring is therefore automatically disabled in some analog modules during the calibration.

To avoid the risk of inaccurate measured values, we recommend you disable the "Wire break" diagnostics during the calibration of analog input modules.

---

## Result

Calibration sets new settings for the channel.

## Error occurrence

If an error occurs during the calibration, the module cancels the calibration. All calibration values recorded up to this point are lost. The channel to be calibrated will then have the same settings as before the start of calibration.



### 7.1.3 Canceling a calibration

#### Requirement

- You have opened the "Online & Diagnostics" view for the selected analog module from the shortcut menu of the project and you are now in the "Functions > Calibration" area.
- The associated CPU is online.
- A calibration is currently running on the analog module.

#### Procedure

Click the "Cancel" button to cancel an ongoing calibration.

#### Result

The active calibration is canceled. The channel to be calibrated will then have the same settings as before the start of calibration.

## **7.1.4 Resetting analog modules to factory settings**

### **Requirement**

- You have opened the "Online & Diagnostics" view for the selected analog module from the shortcut menu of the project and you are now in the "Functions > Calibration" area.
- The associated CPU is online.

### **Procedure**

Proceed as follows to reset the channel of an analog module to factory settings:

1. In the overview table, select the line of the channel to be calibrated.
2. Click the "Set to factory settings" button.

### **Result**

The factory settings of the channel are restored.

---

### **Note**

When you reset the current channel to the factory settings, the original calibration values that were saved in the delivery state of the module become effective once again. Any existing user calibration values of this channel are lost. You cannot restore these user calibration values.

---

## High-speed analog modules

### 8.1 Basics

High-Speed analog modules (HS) are available for users with high demands regarding performance and speed. The main characteristics of these HS analog modules compared to Standard analog modules (ST) is their shorter cycle times. To achieve this goal, the input and output modules are equipped with components with extremely short throughput and conversion times. In addition, the entire architecture of the modules is designed for faster signal processing.

HS analog modules convert the output of measured values and output values at the same time. Each channel within the module has its own A/D or D/A converter. This means the cycle time is basically the conversion time and independent of the number of activated channels. This is true for analog input modules as well as analog output modules. This means HS modules can be used in fast isochronous mode.

Apart from isochronous mode, the HS analog modules also provide benefits in non-isochronous (free-running) mode. Due to the fast processing of the process signals, HS analog modules are able to detect changes in the process values more quickly and to respond to these events with the appropriate program blocks (for example, hardware interrupt or cyclic interrupt organization blocks). Additional information on the various organizational blocks can be found in the STEP 7 online help.

#### Isynchronous mode

Isynchronous mode refers to synchronous coupling:

- Of signal acquisition and output via the distributed I/O
- Of signal transmission via PROFIBUS or PROFINET
- Of program processing with the constant bus cycle time of PROFIBUS or PROFINET.

The result is a system that acquires its input signals in constant time intervals, processes them and outputs the output signals. Isochronous mode guarantees reproducible and defined process reaction times as well as equidistant and synchronous signal processing with distributed I/O.

The bus system and the I/O modules work synchronously with configured isochronous mode. The transmitted input and output data are linked to an "isochronous task" in the CPU. As a result, the data of a cycle are always consistent. All data of a process image belong together logically and in time. Jitter in the user program caused by the acquisition of outdated values is therefore almost impossible.

Even fast processes can be perfectly controlled by the exact timing reproducibility of all processes. Isochronous mode thus contributes to high control quality and hence to greater manufacturing precision. While possible fluctuations of the process reaction times are drastically reduced. The time-assured processing can be utilized to improve machine cycle times. Shorter cycle times increase the processing speed and help to lower production costs.

## Send clocks

When you configure isochronous mode, the input and output data is synchronized within a send clock (cycle). The data of the input modules is acquired in cycle  $n$  and simultaneously transferred to the IM. The data is available in cycle  $n+1$  in the CPU and can be processed. The CPU copies the data to the IM in the next cycle  $n+2$ . The output modules then output the data simultaneously in the same send clock. The acquisition – processing – output therefore takes place in three cycles. You can find more information on the configuration of isochronous mode in the STEP 7 online help.

### Isochronous mode

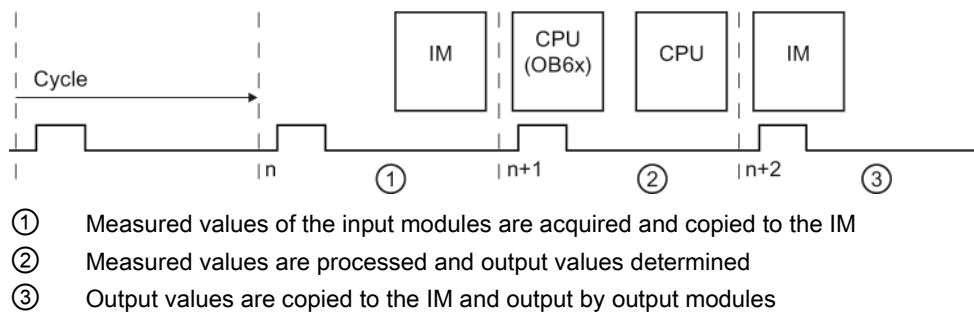


Figure 8-1 3-cycle model

## Oversampling

The use of the oversampling function in analog input or analog output modules requires an isochronous configuration.

With analog input modules, the set send clock is divided into time-equidistant sub-cycles. The send clocks can be subdivided into 2 to 16 sub-cycles. Each sub-cycle reads in a measured value. The read-in measured values of a data cycle are copied to the IM in the next send clock and are then available to the processing CPU one send clock later.

With analog output modules, the set send clock is also divided into time-equidistant sub-cycles. The send clocks can be subdivided into 2 to 16 sub-cycles. Each sub-cycle returns an output value. The output values are copied to the IM by the CPU within the same send clock and are written to the process one send clock later.

The read-in and output values are transmitted in the user data of the analog module. This way, the address space of the module is extended from 2 bytes of user data per channel to  $16 \times 2$  bytes of user data per channel. If you subdivide the send clock into less than 16 sub-cycles, the unused addresses are assigned the error value 0x7FFF during input. For output, the values of the unused addresses are ignored.

Because the sub-cycles have to be within a send clock, oversampling needs an additional send clock to copy the data to the IM, unlike the 3-cycle model of isochronous mode. The result is a 5-cycle model.

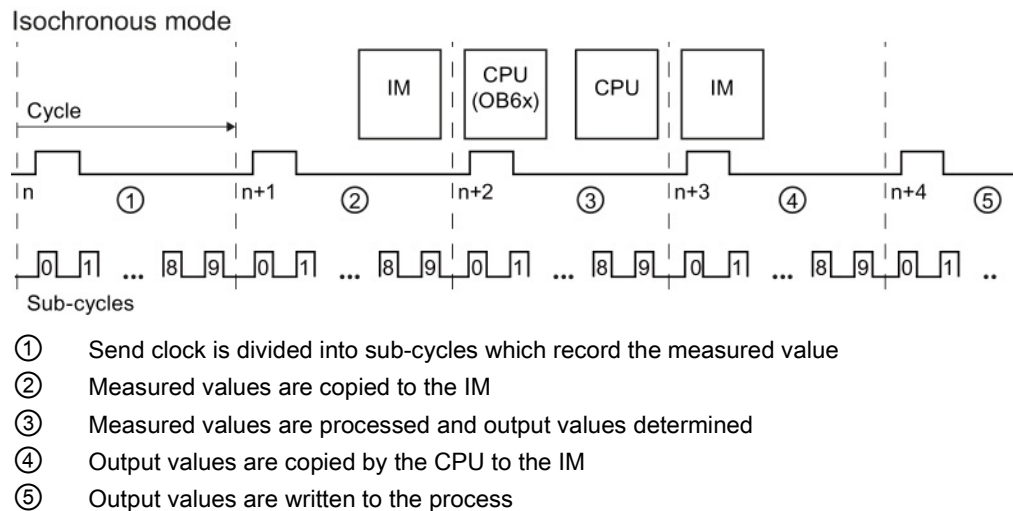


Figure 8-2 5-cycle model

Due to the configured modules, the send clock of an IO device has a minimum possible update time, which means the time interval within which an IO device/IO controller of the PROFINET IO system is supplied with new data. Modules with oversampling functionality, however, offer the option of further reducing the update time for their channels without having to shorten the send clock for the entire S7 station at the same time. The subdivision of the send clock into time-equidistant sub-cycles therefore enables an even faster signal processing speed.

### Example

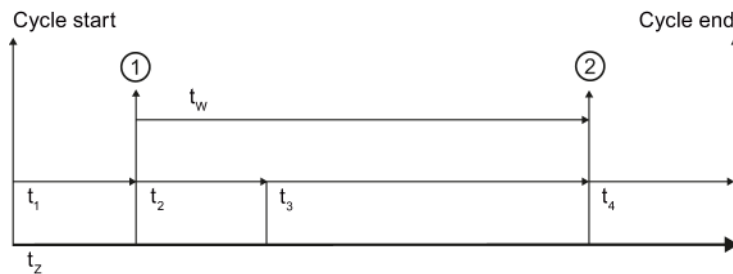
In practice, the use of oversampling makes sense when the isochronous system works with only one specific send clock (for example, 1 ms) due to the modules used and when faster sampling of the process values is required. By using oversampling and a subdivision of the send clock into 4 sub-cycles, for example, you can sample the process values in intervals of 250  $\mu$ s.

### Configuring oversampling

Enable the option "Isochronous mode" in the IO device used and set the corresponding parameters ("Send clock", etc.). You define the number of sub-cycles in the relevant distributed analog module with the "Sampling rate" parameter for analog input modules and the "Output rate" parameter for analog output modules. If, for example, you configure a "Sampling rate" of 4 "Values/cycle" for a "Send clock" of 1 ms, the send clock is subdivided into 4 sub-cycles and the process values are sampled in intervals of 250  $\mu$ s.

### Cycle time of an analog input module

If you have configured the system property "Isochronous mode" for HS modules, all analog input modules are synchronized to a shared time within the send clock (cycle) ①. The cycle time is made up of the following time intervals:  $t_z = t_1 + t_2 + t_3 + t_4$

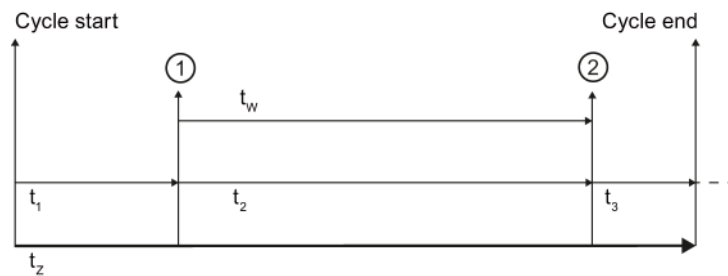


- ① Synchronization time for all analog input modules in isochronous mode and simultaneously time of the converted input signal at the terminal in this cycle
- ② Digitalized input signal is transferred to the backplane bus
- $t_z$  Cycle time
- $t_1$  Time between cycle start and synchronization
- $t_2$  Hardware-related runtime up to the analog-digital converter
- $t_3$  Processing time of digitalized input data in the module
- $t_4$  Transfer time of the backplane bus
- $t_w$  Conversion time of the module

Figure 8-3 Cycle time of the analog input module

### Cycle time of an analog output module

The synchronization time for analog output modules refers to the output of the digital-analog converter ②. Because the impedance of the connected actuator including connection cable is unknown in output modules but has a significant impact on the signal run time, the settling time cannot be added as a fixed value. The respective manuals of the output modules specify the typical load settling times as reference point. But in practice, a measurement with an oscilloscope is required for a precise measurement of the settling time. The settling time may exceed the actual end of the cycle due to very short cycle times and very high capacitive loads. The cycle time is made up of the following time intervals:  $t_z = t_1 + t_2 + t_3$



- ① Output data is available in digital form in the module
- ② Synchronization time for all analog output modules in isochronous mode and simultaneously output time of data in the digital-analog converter
- $t_z$  Cycle time
- $t_1$  Transfer time of the backplane bus
- $t_2$  Processing time of data in the module until output at digital-analog converter
- $t_3$  Settling time of hardware until setpoint of output value
- $t_w$  Conversion time of the module

Figure 8-4 Cycle time of the analog output module

## Typical applications

In principle, isochronous mode is worthwhile whenever measured values must be acquired synchronously, movements must be coordinated, and process reactions must be defined and executed at the same time. There are thus numerous areas in which isochronous mode can be used.

Typical applications include, for example, the acquisition of binary signals for quality assurance at specific times and positions. But hydraulic applications with position and pressure control can benefit as well from the equidistant and isochronous data transmission.

The following example shows the use of isochronous mode within the production process of camshafts. Precise measurements must be made at several measuring points for quality assurance.

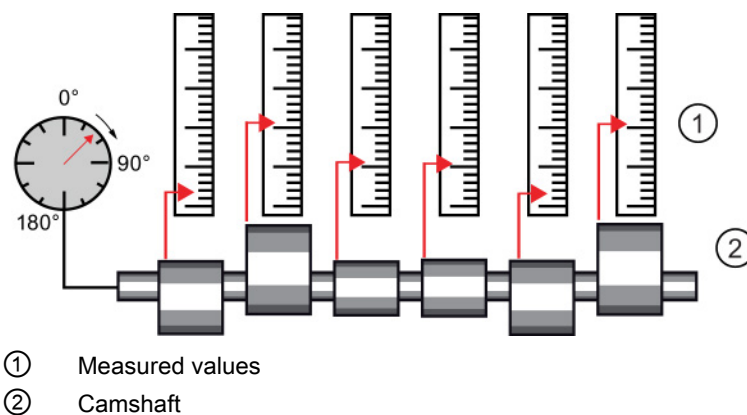


Figure 8-5 Measuring of camshafts

By using the system property "isochronous mode" and the associated simultaneous measured value acquisition, measurement can be performed continuously. The time required for measurement is reduced. Resultant workflow:

- Continuous machining of the camshaft
- During the continuous turning, measure the positions and cam excursion synchronously
- Process the next cam shaft

All camshaft positions and the corresponding measured values are measured synchronously within a single rotation of the camshaft. This increases machine output and maintains or enhances precision of the measurement.



## 8.2 ST modules vs HS modules

This section gives you an overview of other important distinctions between standard and high-speed analog modules. The specified numerical values are examples of selected modules. Keep in mind that the information can vary from module to module. The exact information of specific used analog module is available in the corresponding manual.

### Conversion method

#### Instantaneous value conversion

Instantaneous value conversion is often used to convert analog signal into digital information in HS modules. In this type of conversion a very short sample is taken from the measured signal and converted into digital data. This digital information therefore represents an instantaneous value of the measured signal. Instantaneous value conversion is used to acquire fast changes of process values, such as in the area of motion control. The quickly changing physical quantities in this case must be acquired and processed quickly in cooperation with suitable transducers. Input areas are primarily voltage, current and resistance, the latter especially for position potentiometers.

Because the measured signal is converted within a short time, there is a risk of incorrect measurements in case of faulty signals. The analog inputs working with the instantaneous value conversion method cannot detect if the sampled signal value is the target signal or an overlaying disturbing pulse. They always convert the "instantaneously" detected value. This means the pending measurement task should be carefully examined with regard to time constraints.

#### Integrating conversion

ST modules usually work according to the integrating conversion principle. The integrating conversion involves the sampling of a measured signal across a specified time period (integration time). Although this method is slower than instantaneous value conversion, it returns a conversion with higher immunity to interference. When you select the time interval for the conversion so that it corresponds to one or several periods of the surrounding network frequency, the omnipresent interference that is possibly also overlaying the signal is basically suppressed. SIMATIC modules give you the option to set the network frequency at which the plant is operated by means of parameter assignment. The resolution and conversion times may change depending on the interference frequency suppression that is set. The technical specifications of the respective module define these dependencies.

Analog inputs with integrating methods can be used universally. Even though the cabling must also be carefully designed with these analog inputs, the requirements are much less than those for analog inputs with instantaneous value conversion due to their slower signal acquisition that is basically immune to interference.

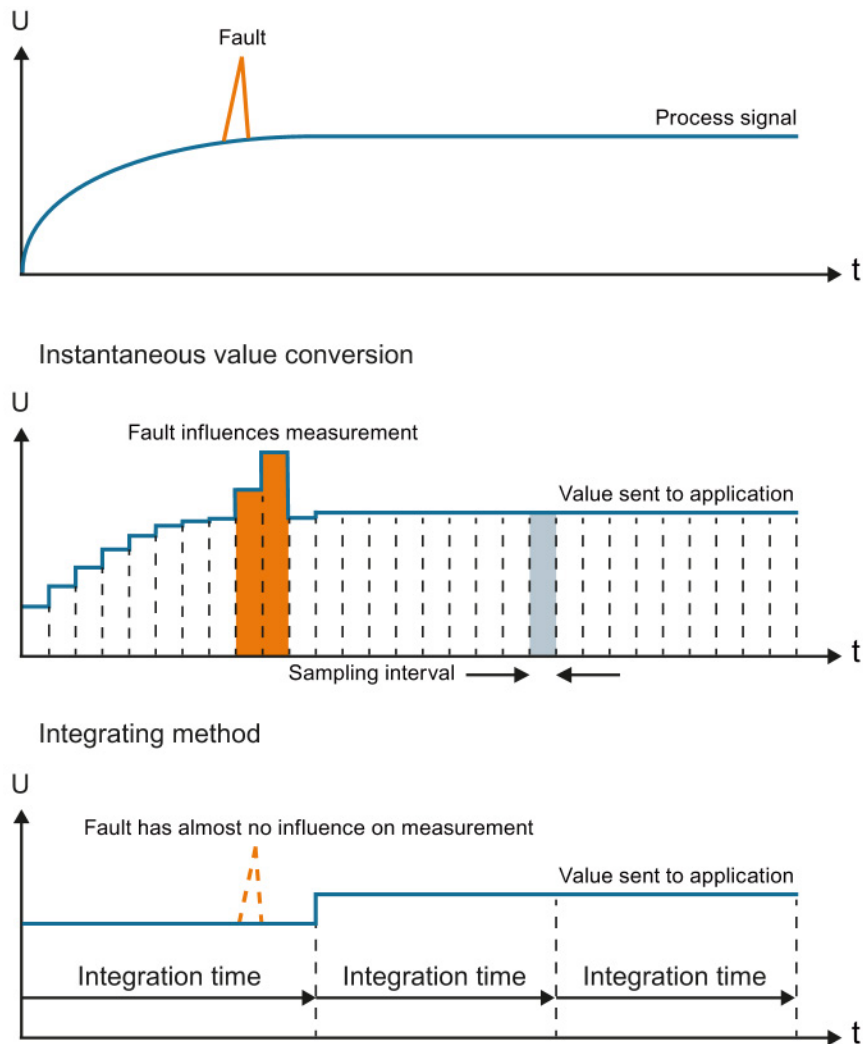


Figure 8-6 While an interference directly influences the value that is supplied to the application with instantaneous value encryption, its influence is negligible for the integrating method.

## **Electromagnetic compatibility**

The entire architecture of HS modules is designed for fast processing of the signals. An interference-free design is therefore critical when using HS modules.

The following rules apply to the wiring of HS modules with sensors and actuators:

- Keep the cables as short as possible
- Use shielded and twisted pair cables
- Low-impedance connection of the cable shield at the respective shield supports
- Short cable loop between shield support and terminal connection

---

### **Note**

#### **Interference-free design**

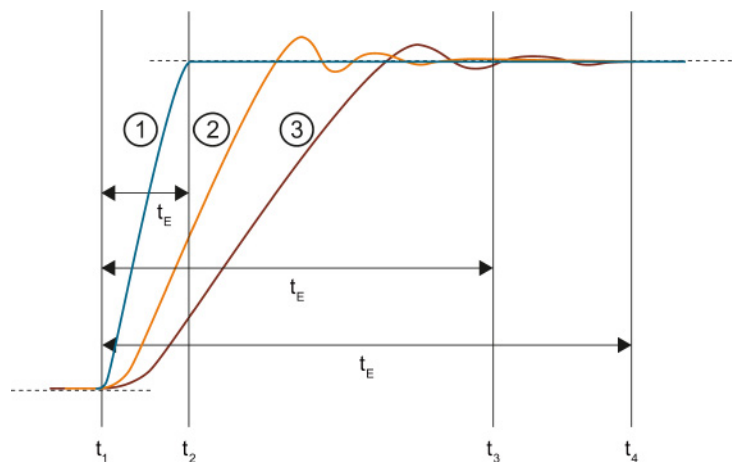
Make sure that you pay close attention to the notes listed in the function manual Configuring interference-free controllers (<http://support.automation.siemens.com/WW/view/en/59193566>) when using HS modules.

---

### Effect of load on the settling time

The settling times to the setpoint achieved with analog output modules depend on the applied load, among other things. To take advantage of the faster conversion times, only small loads (e.g., max. 47 nF) are permitted in HS modules as specified in the technical specifications.

The type of load has an effect on the form of settling to the setpoint when using output modules. Capacitive loads reduce the rise time due to the charging process and can cause the output signal to overshoot. Inductive loads result in a delayed current increase due to remagnetization and therefore also a shorter rise time. The figure below shows the output signal with no/small ①, medium ② and high ③ capacitive load.



① Reference curve of a signal with no/small load capacity

② Signal with a load capacity of 47 nF

③ Signal with a load capacity of 100 nF

$t_E$  Settling time

$t_1$  Module ends conversion at the terminal of the analog output channel and outputs the analog signal

$t_2$  Signal ① has settled and the specified analog output value has been reached (residual error 1 %)

$t_3$  Signal ② has settled and the specified analog output value has been reached (residual error 1 %)

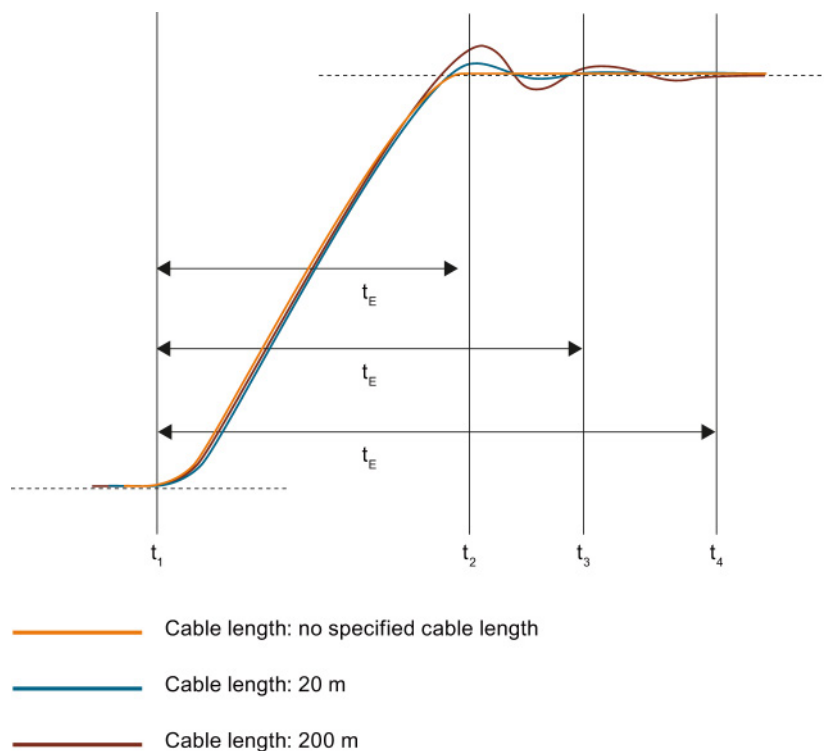
$t_4$  Signal ③ has settled and the specified analog output value has been reached (residual error 1 %)

Figure 8-7 Effect of different loads on the settling time

## Effect of the cable length on the settling time

Long cables between signal source and module are a target for interferences. You should therefore keep the cables as short as possible especially for HS modules. Cables have a capacitive and inductive component and therefore have an effect on the settling behavior of the signal.

The example below shows the jump of the output voltage of an HS output module with small, medium and long cable length. The overshoot of the input signal increases with the length of the cable and therefore the time until it reaches the setpoint.



- $t_E$  Settling time
- $t_1$  Module ends conversion at the terminal of the analog output channel and outputs the analog signal
- $t_2$  The signal running through a cable with short length has settled and the specified analog output value has been reached (residual error 1 %)
- $t_3$  The signal running through a 20 m cable has settled and the specified analog output value has been reached (residual error 1 %)
- $t_4$  The signal running through a 200 m cable has settled and the specified analog output value has been reached (residual error 1 %)

Figure 8-8 Effect of different cable lengths on the settling time

### Effect of the value jump on the settling time

The figure below shows the effect of the height of the value jump between different output values on the settling time for analog output modules. The dotted line indicates the time when the signal has reached the setpoint. The higher the value jump, the later the signal reaches the setpoint.

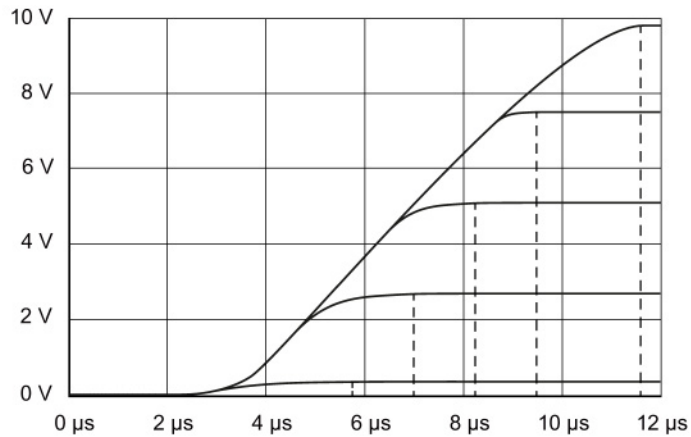


Figure 8-9 Settling time of five different analog signals with different value jumps

# Index

## A

- Abbreviations, 66, 103
- Accuracy, 15
- Actuators, 11, 103, 104
- Additional support, 4
- Analog input modules, 60, 65
- Analog output modules, 60, 104
- Analog value conversion, 60
- Application time, 53

## B

- Basic conversion time, 49
- Basic error limit, 15, 24
- Basic knowledge
  - Required, 3
- Bipolar measuring range, 25
- Blocks
  - SCALE, 17
  - UNSCALE, 19
- Burden, 57

## C

- Calibration, 106
  - Canceling, 111
- Channels
  - Calibrating, 108
  - Resetting to factory settings, 112
- Common mode, 67, 69
- Common mode rejection, 30, 33
- Common mode voltage, 67
- compensation
  - Reference channel of group 0, 88
- Compensation
  - none/external, 98
- Compensation with
  - Dynamic reference temperature, 94
  - fixed reference temperature, 91
  - internal reference junction, 84
  - RDT (0), 100
  - Reference channel of the module, 86
- conversion
  - analog-to-digital, 21, 51

- digital-to-analog, 21
- Conversion
  - analog-to-digital, 11
  - Digital-to-analog, 11
- Conversion time, 27, 49, 53
- coupling
  - capacitive, 34
  - galvanic, 31
  - inductive, 31, 34
- CPU, 11, 60, 67, 69
- Crosstalk, 34
- Crosstalk attenuation, 35
- Current, 10

## D

- Digital multimeter, 59
- Direct voltage, 69
- Documentation
  - additional, 7
- Drift, 26
- Dynamic reference temperature
  - Overview, 83

## E

- EMC, 32
- Error
  - Linearity errors, 21
  - Output error, 25
  - Temperature error, 26
- ET 200AL, 7
- ET 200eco PN, 7
- ET 200MP, 7
- ET 200pro, 7
- ET 200SP, 7
- External compensation
  - Overview, 83

## F

- Factory settings
  - Resetting channels to, 112
- Fixed reference temperature
  - Overview, 82

## G

Ground connection, 31  
GSD file, 48

## H

High-speed analog modules  
  Isochronous mode, 113

## I

Input impedance, 31  
Insulation voltage, 67, 69  
Interference frequency suppression, 27  
Interference voltage, 31  
Internal reference junction, 84  
  Overview, 81  
Isochronous mode  
  Oversampling, 114

## L

Line frequency  
  16 2/3 Hz, 28  
  400 Hz, 28  
  50 Hz, 28  
  60 Hz, 28  
Linearity, 21  
lines  
  for analog signals, 66  
Lines  
  for analog signals, 103  
Load, 53  
Loads, 103, 104

## M

Material composition  
  of thermocouples, 78  
Measurement point, 79  
Measuring ranges  
  Overflow, 42  
  Overrange, 42  
  Rated range, 42  
  Underflow, 42  
  Underrange, 42

## O

Online catalog, 4  
Operating principle  
  of thermocouples, 80  
Operational limit, 15, 23

## P

Pressure, 9  
PROFIBUS, 113  
PROFINET, 113

## Q

Quality Information (QI), 46

## R

Reference channel of group 0  
  Overview, 82  
Reference channel of the module  
  Overview, 82  
Reference junction, 79  
Reference junction temperature, 81  
Reference potential, 69, 104  
Repeat accuracy, 22  
Representation of analog values, 60  
  Binary representation, input ranges, 62, 63  
  Binary representation, output ranges, 63  
Resistance, 10  
Resistance thermometers  
  see Thermal resistor, 74  
Resistance transducers  
  4-wire connection, 74  
Resolution, 13, 60  
Response time, 52  
RTD (0)  
  Overview, 83

## S

S7-1500, 7  
Scaling, 17  
Scope  
  of the documentation, 3  
Sensors,  
Series mode rejection, 31, 33  
Settling time, 53  
Setup  
  of thermocouples, 79



Sign (S), 60

Signals

Analog, 9

Binary, 9

Processing, 12

Smoothing

exponential, 56

Linear, 55

Speed, 9

Standards

EN 61131, 15

FDA, 106

Step 7, 4

Step response, 55

## T

Temperature, 9

Temperature measuring range

of thermocouples, 78

Thermal resistor

2-wire connection, 75

3-wire connection, 75

Connecting, 74

Thermocouples

Wiring, 76

TIA Portal, 4

Transducers, 72

2-wire, 57, 72

4-wire, 73

Connecting, 65

Current transducers, 10, 57, 72

Resistance transducers, 10

Thermal resistor, 74

Thermocouples, 10, 27, 76, 79

Voltage transducers, 10, 71

Wiring, 72

Types of diagnostics, 36

Common mode error, 43

No supply voltage, 41

Overflow/underflow, 42

Overload, 45

Reference channel error, 43

Reference junction, 44

Short-circuit, 44

Wire break, 41

## U

Unscaling, 19

## V

Value status, 46

Variables

Analog, 9

physical, 10

variance

measured value, 22

Voltage, 10

Voltage drop, 59

Voltage measuring ranges

Overflow, 14

Overrange, 14

Rated range, 14

Underflow, 14

Underrange, 14

Voltage range, 27

## W

Wire break, 41

## Z

Zener diode, 59

## SIMATIC

### High-precision input/output with Time-based IO

#### Function Manual



#### Preface

#### Documentation guide

1

#### Time-based IO basics

2

#### Configuring and parameter assignment

3

#### Programming

4

## Legal information

### Warning notice system

This manual contains notices you have to observe in order to ensure your personal safety, as well as to prevent damage to property. The notices referring to your personal safety are highlighted in the manual by a safety alert symbol, notices referring only to property damage have no safety alert symbol. These notices shown below are graded according to the degree of danger.

#### **DANGER**

indicates that death or severe personal injury **will** result if proper precautions are not taken.

#### **WARNING**

indicates that death or severe personal injury **may** result if proper precautions are not taken.

#### **CAUTION**

indicates that minor personal injury can result if proper precautions are not taken.

#### **NOTICE**

indicates that property damage can result if proper precautions are not taken.

If more than one degree of danger is present, the warning notice representing the highest degree of danger will be used. A notice warning of injury to persons with a safety alert symbol may also include a warning relating to property damage.

### Qualified Personnel

The product/system described in this documentation may be operated only by **personnel qualified** for the specific task in accordance with the relevant documentation, in particular its warning notices and safety instructions. Qualified personnel are those who, based on their training and experience, are capable of identifying risks and avoiding potential hazards when working with these products/systems.

### Proper use of Siemens products

Note the following:

#### **WARNING**

Siemens products may only be used for the applications described in the catalog and in the relevant technical documentation. If products and components from other manufacturers are used, these must be recommended or approved by Siemens. Proper transport, storage, installation, assembly, commissioning, operation and maintenance are required to ensure that the products operate safely and without any problems. The permissible ambient conditions must be complied with. The information in the relevant documentation must be observed.

### Trademarks

All names identified by ® are registered trademarks of Siemens AG. The remaining trademarks in this publication may be trademarks whose use by third parties for their own purposes could violate the rights of the owner.

### Disclaimer of Liability

We have reviewed the contents of this publication to ensure consistency with the hardware and software described. Since variance cannot be precluded entirely, we cannot guarantee full consistency. However, the information in this publication is reviewed regularly and any necessary corrections are included in subsequent editions.

# Preface

## Purpose of the documentation

This function manual will support you when you use "Time-based IO" technology with the S7-1500, ET 200MP, and ET 200SP systems.

The documentation deals with the following topics:

- Using "Time-based IO" technology
- Functions of the "Time-based IO" technology
- Hardware and software requirements for "Time-based IO"
- Configuring the "Time-based IO" function with STEP 7 (TIA Portal)

## Basic knowledge required

The following knowledge is required in order to understand the Function manual:

- General knowledge of automation technology
- Knowledge of the industrial automation system SIMATIC
- Proficiency with STEP 7 (TIA Portal)
- Knowledge about isochronous mode

## Scope of the documentation

The following documentation is valid for all components of the S7-1500, ET 200MP and ET 200SP systems that support the "Time-based IO" technology.

## Conventions

The following terms are used as synonyms in this documentation:

- **TIO module:** This term is used as synonym for I/O modules of the type:
  - ET 200MP TM Timer DIDQ 16x24V
  - ET 200SP TM Timer DIDQ 10x24V
- **TIO\_Time:** This term is used as synonym for the shared time base (relative time) of the TIO modules.
- **Jitter:** This is a general term that includes various time influences affecting accuracy. This means that:
  - for input data: Deviation of the measured time from the actual event.
  - for output data: Deviation of the actual switching time from the specified time.

You should also pay particular attention to notes such as the one shown below:

---

**Note**

The notes contain important information on the product, handling the product or on part of the documentation to which particular attention should be paid.

---

## Additional support

The range of technical documentation for the individual SIMATIC products and systems can be found on the Internet (<http://www.siemens.com/simatic-tech-doku-portal>).

For more information about configuration of Time-based IO, see the following FAQs in the Siemens Industry Online Support:

- Entry ID 109738186 (<https://support.industry.siemens.com/cs/ww/en/view/109738186>)
- Entry ID 109736374 (<https://support.industry.siemens.com/cs/ww/en/view/109736374>)

Additional information on isochronous mode is available in the Isochronous mode (<http://support.automation.siemens.com/WW/view/en/49948856>) and PROFINET with STEP 7 (<https://support.industry.siemens.com/cs/ww/en/view/109755401>) manuals.

## Siemens Industry Online Support

You can find current information on the following topics quickly and easily here:

- **Product support**

All the information and extensive know-how on your product, technical specifications, FAQs, certificates, downloads, and manuals.

- **Application examples**

Tools and examples to solve your automation tasks – as well as function blocks, performance information and videos.

- **Services**

Information about Industry Services, Field Services, Technical Support, spare parts and training offers.

- **Forums**

For answers and solutions concerning automation technology.

- **mySupport**

Your personal working area in Industry Online Support for messages, support queries, and configurable documents.

This information is provided by the Siemens Industry Online Support in the Internet (<https://support.industry.siemens.com>).

## Industry Mall

The Industry Mall is the catalog and order system of Siemens AG for automation and drive solutions on the basis of Totally Integrated Automation (TIA) and Totally Integrated Power (TIP).

You can find catalogs for all automation and drive products on the Internet (<https://mall.industry.siemens.com>) and in the Information and Download Center (<https://www.siemens.com/automation/infocenter>).

## Security information

Siemens provides products and solutions with industrial security functions that support the secure operation of plants, systems, machines and networks.

In order to protect plants, systems, machines and networks against cyber threats, it is necessary to implement – and continuously maintain – a holistic, state-of-the-art industrial security concept. Siemens' products and solutions only form one element of such a concept.

Customers are responsible for preventing unauthorized access to their plants, systems, machines and networks. Such systems, machines and components should only be connected to an enterprise network or the internet if and to the extent such a connection is necessary and only when appropriate security measures (e.g. firewalls and/or network segmentation) are in place.

For additional information on industrial security measures that may be implemented, please visit (<http://www.siemens.com/industrialsecurity>).

Siemens' products and solutions undergo continuous development to make them more secure. Siemens strongly recommends that product updates are applied as soon as they are available and that the latest product versions are used. Use of product versions that are no longer supported, and failure to apply latest updates may increase customer's exposure to cyber threats.

To stay informed about product updates, subscribe to the Siemens Industrial Security RSS Feed under (<http://www.siemens.com/industrialsecurity>).

# Table of contents

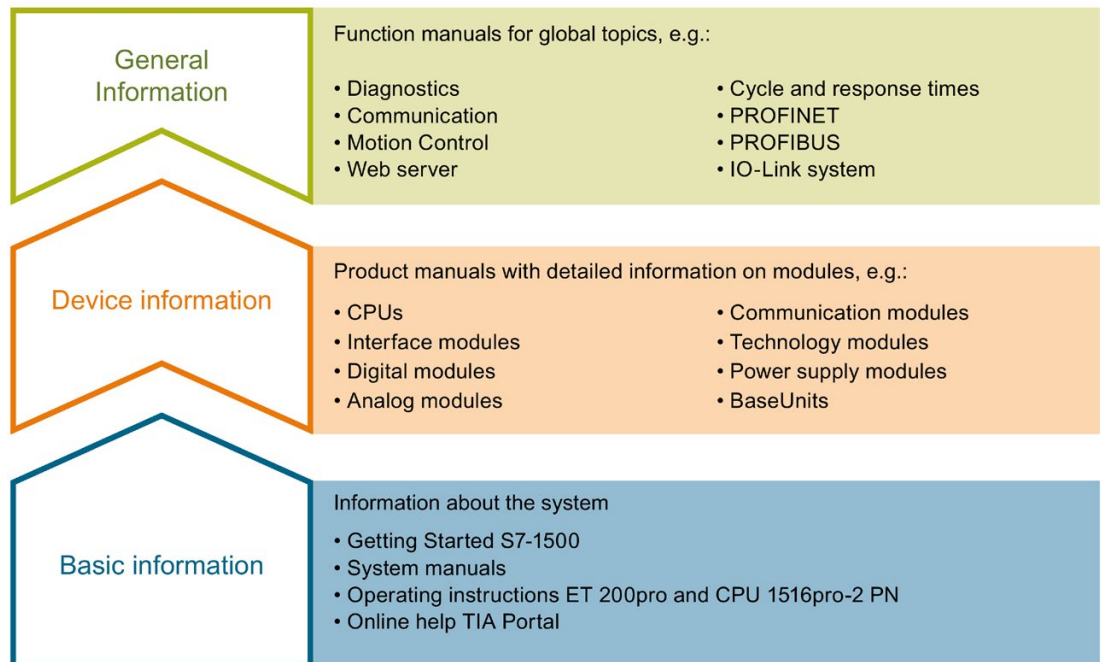
|          |                                                                                          |           |
|----------|------------------------------------------------------------------------------------------|-----------|
|          | <b>Preface .....</b>                                                                     | <b>3</b>  |
| <b>1</b> | <b>Documentation guide .....</b>                                                         | <b>7</b>  |
| 1.1      | Guide to documentation function manuals .....                                            | 7         |
| <b>2</b> | <b>Time-based IO basics .....</b>                                                        | <b>13</b> |
| 2.1      | Using Time-based IO .....                                                                | 13        |
| 2.2      | Time behavior of Time-based IO .....                                                     | 14        |
| 2.2.1    | Time behavior of standard technology .....                                               | 14        |
| 2.2.2    | Time-based IO properties .....                                                           | 15        |
| 2.3      | System environment .....                                                                 | 17        |
| 2.4      | Hardware requirements .....                                                              | 18        |
| 2.5      | Configuration software requirements .....                                                | 19        |
| 2.6      | Technical implementation .....                                                           | 20        |
| <b>3</b> | <b>Configuring and parameter assignment .....</b>                                        | <b>24</b> |
| 3.1      | Requirements .....                                                                       | 24        |
| 3.2      | Settings for Time-based IO .....                                                         | 25        |
| <b>4</b> | <b>Programming .....</b>                                                                 | <b>27</b> |
| 4.1      | Overview of instructions .....                                                           | 27        |
| 4.2      | Programming of Time-based IO .....                                                       | 28        |
| 4.3      | Time-based IO .....                                                                      | 31        |
| 4.3.1    | TIO_SYNC: Synchronizing TIO modules .....                                                | 31        |
| 4.3.2    | TIO_DI: Reading in edges at digital input and associated time stamps .....               | 36        |
| 4.3.3    | TIO_DI_ONCE: Reading in edges once at the digital input and associated time stamps ..... | 43        |
| 4.3.4    | TIO_DQ: Output edges time-controlled at the digital output .....                         | 51        |
| 4.3.5    | UDT TIO_SYNC_Data .....                                                                  | 58        |
|          | <b>Index .....</b>                                                                       | <b>59</b> |

# Documentation guide

## 1.1 Guide to documentation function manuals

The documentation for the SIMATIC S7-1500 automation system, the CPUs 1513/1516pro-2 PN based on SIMATIC S7-1500, and the distributed I/O systems SIMATIC ET 200MP, ET 200SP and ET 200AL is divided into three areas.

This division allows you easier access to the specific information you require.



### Basic information

System manuals and Getting Started manuals describe in detail the configuration, installation, wiring and commissioning of the SIMATIC S7-1500, ET 200MP, ET 200SP and ET 200AL systems. Use the corresponding operating instructions for the CPUs 1513/1516pro-2 PN. The STEP 7 online help supports you in the configuration and programming.

### Device information

Product manuals contain a compact description of the module-specific information, such as properties, terminal diagrams, characteristics and technical specifications.



### General information

The function manuals contain detailed descriptions on general topics such as diagnostics, communication, Motion Control, Web server, OPC UA.

You can download the documentation free of charge from the Internet (<https://support.industry.siemens.com/cs/ww/en/view/109742705>).

Changes and additions to the manuals are documented in product information sheets.

You will find the product information on the Internet:

- S7-1500/ET 200MP (<https://support.industry.siemens.com/cs/us/en/view/68052815>)
- ET 200SP (<https://support.industry.siemens.com/cs/us/en/view/73021864>)
- ET 200AL (<https://support.industry.siemens.com/cs/us/en/view/99494757>)

### Manual Collections

The Manual Collections contain the complete documentation of the systems put together in one file.

You will find the Manual Collections on the Internet:

- S7-1500/ET 200MP (<https://support.industry.siemens.com/cs/ww/en/view/86140384>)
- ET 200SP (<https://support.industry.siemens.com/cs/ww/en/view/84133942>)
- ET 200AL (<https://support.industry.siemens.com/cs/ww/en/view/95242965>)

### "mySupport"

With "mySupport", your personal workspace, you make the best out of your Industry Online Support.

In "mySupport", you can save filters, favorites and tags, request CAx data and compile your personal library in the Documentation area. In addition, your data is already filled out in support requests and you can get an overview of your current requests at any time.

You must register once to use the full functionality of "mySupport".

You can find "mySupport" on the Internet (<https://support.industry.siemens.com/My/ww/en>).

### "mySupport" - Documentation

With "mySupport", your personal workspace, you make the best out of your Industry Online Support.

In "mySupport", you can save filters, favorites and tags, request CAx data and compile your personal library in the Documentation area. In addition, your data is already filled out in support requests and you can get an overview of your current requests at any time.

You must register once to use the full functionality of "mySupport".

You can find "mySupport" on the Internet (<https://support.industry.siemens.com/My/ww/en/documentation>).

## "mySupport" - CAx data

In the CAx data area of "mySupport", you can access the latest product data for your CAx or CAe system.

You configure your own download package with a few clicks.

In doing so you can select:

- Product images, 2D dimension drawings, 3D models, internal circuit diagrams, EPLAN macro files
- Manuals, characteristics, operating manuals, certificates
- Product master data

You can find "mySupport" - CAx data on the Internet (<http://support.industry.siemens.com/my/ww/en/CAxOnline>).

## Application examples

The application examples support you with various tools and examples for solving your automation tasks. Solutions are shown in interplay with multiple components in the system - separated from the focus on individual products.

You will find the application examples on the Internet (<https://support.industry.siemens.com/sc/ww/en/sc/2054>).

## TIA Selection Tool

With the TIA Selection Tool, you can select, configure and order devices for Totally Integrated Automation (TIA).

This tool is the successor of the SIMATIC Selection Tool and combines the known configurators for automation technology into one tool.

With the TIA Selection Tool, you can generate a complete order list from your product selection or product configuration.

You can find the TIA Selection Tool on the Internet (<http://w3.siemens.com/mcmts/topics/en/simatic/tia-selection-tool>).

## SIMATIC Automation Tool

You can use the SIMATIC Automation Tool to perform commissioning and maintenance activities simultaneously on various SIMATIC S7 stations as a bulk operation independent of TIA Portal.

The SIMATIC Automation Tool provides a multitude of functions:

- Scanning of a PROFINET/Ethernet system network and identification of all connected CPUs
- Address assignment (IP, subnet, gateway) and station name (PROFINET device) to a CPU
- Transfer of the date and the programming device/PC time converted to UTC time to the module
- Program download to CPU

- RUN/STOP mode switchover
- CPU localization by means of LED flashing
- Reading out of CPU error information
- Reading of the CPU diagnostics buffer
- Reset to factory settings
- Firmware update of the CPU and connected modules

You can find the SIMATIC Automation Tool on the Internet (<https://support.industry.siemens.com/cs/ww/en/view/98161300>).

## PRONETA

SIEMENS PRONETA (PROFINET network analysis) allows you to analyze the plant network during commissioning. PRONETA features two core functions:

- The topology overview automatically scans the PROFINET and all connected components.
- The IO check is a fast test of the wiring and the module configuration of a plant.

You can find SIEMENS PRONETA on the Internet (<https://support.industry.siemens.com/cs/ww/en/view/67460624>).

## SINETPLAN

SINETPLAN, the Siemens Network Planner, supports you in planning automation systems and networks based on PROFINET. The tool facilitates professional and predictive dimensioning of your PROFINET installation as early as in the planning stage. In addition, SINETPLAN supports you during network optimization and helps you to exploit network resources optimally and to plan reserves. This helps to prevent problems in commissioning or failures during productive operation even in advance of a planned operation. This increases the availability of the production plant and helps improve operational safety.

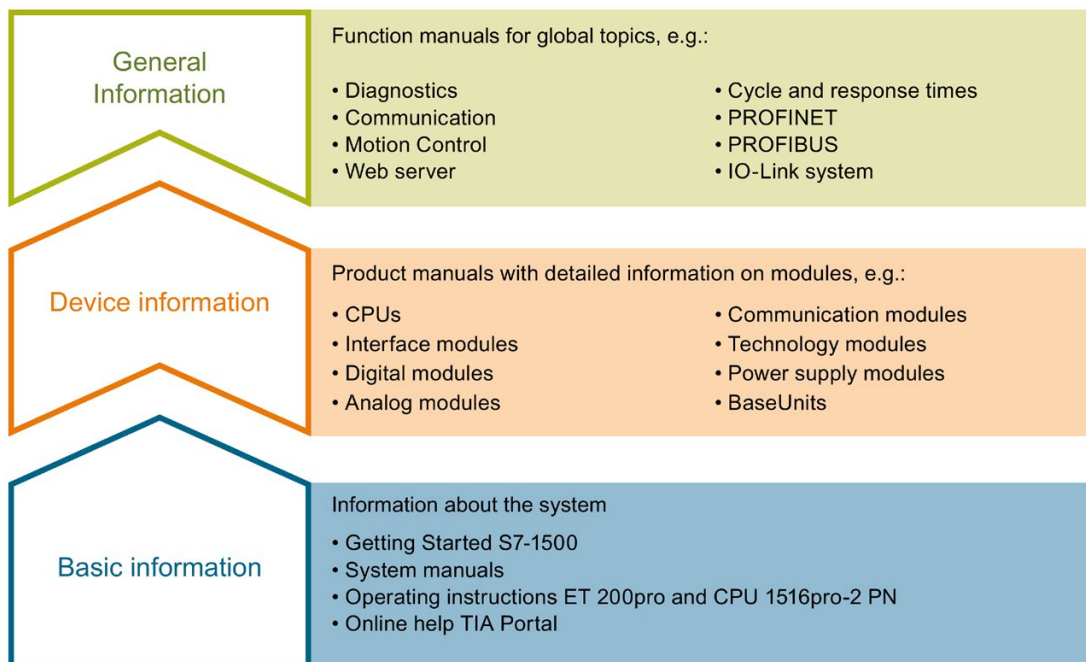
The advantages at a glance

- Network optimization thanks to port-specific calculation of the network load
- Increased production availability thanks to online scan and verification of existing systems
- Transparency before commissioning through importing and simulation of existing STEP 7 projects
- Efficiency through securing existing investments in the long term and the optimal use of resources

You can find SINETPLAN on the Internet (<https://www.siemens.com/sinetplan>).

The documentation for the SIMATIC S7-1500 automation system, for CPU 1516pro-2 PN based on SIMATIC S7-1500, and for the distributed I/O systems SIMATIC ET 200MP, ET 200SP and ET 200AL is divided into three areas.

This division allows you easier access to the specific information you require.



### Basic information

System manuals and Getting Started manuals describe in detail the configuration, installation, wiring and commissioning of the SIMATIC S7-1500, ET 200MP, ET 200SP and ET 200AL systems; use the corresponding operating instructions for CPU 1516pro-2 PN. The STEP 7 online help supports you in configuration and programming.

### Device information

Product manuals contain a compact description of the module-specific information, such as properties, terminal diagrams, characteristics and technical specifications.

### General information

The function manuals contain detailed descriptions on general topics such as diagnostics, communication, Motion Control, Web server, OPC UA.

You can download the documentation free of charge from the Internet.

Changes and additions to the manuals are documented in product information sheets.

You will find the product information on the Internet:

- S7-1500/ET 200MP
- ET 200SP
- ET 200AL

## Manual Collections

The Manual Collections contain the complete documentation of the systems put together in one file.

You will find the Manual Collections on the Internet:

- S7-1500/ET 200MP
- ET 200SP
- ET 200AL

## "mySupport"

With "mySupport", your personal workspace, you make the best out of your Industry Online Support.

In "mySupport", you can save filters, favorites and tags, request CAx data and compile your personal library in the Documentation area. In addition, your data is already filled out in support requests and you can get an overview of your current requests at any time.

You must register once to use the full functionality of "mySupport".

You can find "mySupport" on the Internet.

## Application examples

The application examples support you with various tools and examples for solving your automation tasks. Solutions are shown in interplay with multiple components in the system - separated from the focus on individual products.

You will find the application examples on the Internet.

## Time-based IO basics

### 2.1 Using Time-based IO

Many processes in a plant require a relatively precise reproducibility as far as time is concerned. The reproducibility can be optimized to a limited extent by shorter CPU cycle times. The use of high-precision input/output with Time-based IO provides a more accurate reproducibility than the one that can be achieved by optimizing the CPU cycle time. An additional advantage of Time-based IO is the independence from the time scale of the application cycle.

Below is a selection of typical areas of application that can benefit from this technology.

#### Defined response times

An output signal that responds with a precise delay time that is independent of the application cycle can be output by adding a specified time to the time stamp of an edge at the digital input.

#### Length measurement

The length of a product passing by can be determined by the difference between two input time stamps and an associated travel speed.

#### Cam controller

The ongoing movement can be extrapolated from a synchronous position information (for example, from a counter module or an axis). Based on this result, the time of a switching position (cam position) is calculated and transferred to the TIO module (output). This way the switch event takes place at the required position.

#### Dosing

By specifying a switch-on and a switch-off edge to a time-controlled digital output, a valve can be opened for a specific time and the amount of liquid can be dosed accordingly.

## 2.2 Time behavior of Time-based IO

### 2.2.1 Time behavior of standard technology

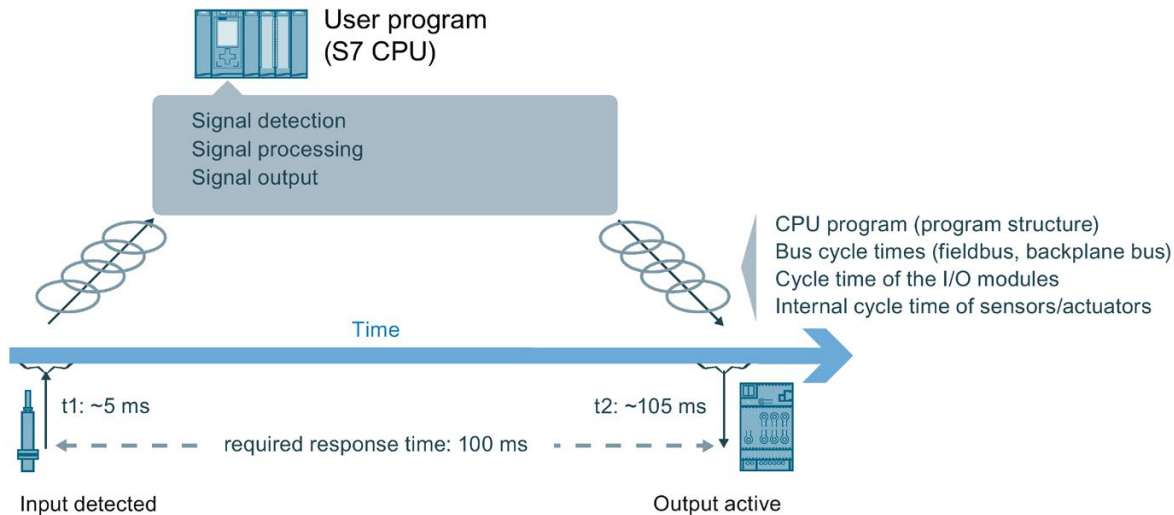
The time behavior of the inputs/outputs depends on the following factors for standard technology:

- CPU program (program structure)
- Bus cycle times (fieldbus, backplane bus)
- Cycle time of the I/O modules
- Internal cycle time of sensors/actuators

A deterministic statement as to

- when an input event (e.g., sensor signal) has taken place
- when the output event has an effect on the input event (e.g., output switches)

will become inaccurate due to the time factors listed above.

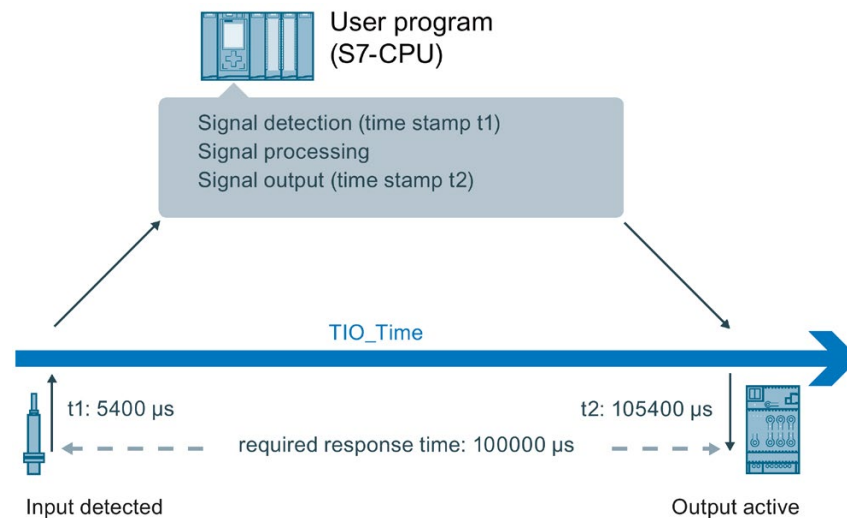


## 2.2.2 Time-based IO properties

### Time-controlled I/O functionality

Time-based IO stands for time-based processing of I/O signals. All input signals are referred to one time (TIO\_Time). The input signals receive the time stamp t1. After signal processing, the output event can also be linked with the TIO\_Time and output at the required time. Output takes place at time t2.

Here an example for Time-based IO:



### Independence and focus of Time-based IO

The shared time basis (TIO\_Time) of all components involved is the basis for Time-based IO. By using TIO\_Time, the accuracy of the output with Time-based IO does not depend on:

- CPU program (program structure)
- Bus cycle times (fieldbus, backplane bus)
- Cycle time of the I/O modules

The focus of Time-based IO is not on the I/O response time but on the predictability (determinism) of I/O signals. With Time-based IO, it is possible to respond to an input signal with an output signal within a defined time. Keep in mind the system-dependent minimum response time when using Time-based IO.

Time-based IO stands for:

- I/O functionalities executed with high precision
- I/O processes with time stamp



## **Accuracy**

Accuracy is crucial for the performance capability of Time-based IO.

The accuracy is a property of the TIO modules and indicates the deviation with which the required response is achieved. For Time-based IO, the accuracy and reproducibility of the response is in the millisecond range.

## **Response time**

In addition to a very high accuracy, a minimum response time to an input event can result depending on the configuration.

The response time is the time between the input event and the required output event.

For the minimum response time:

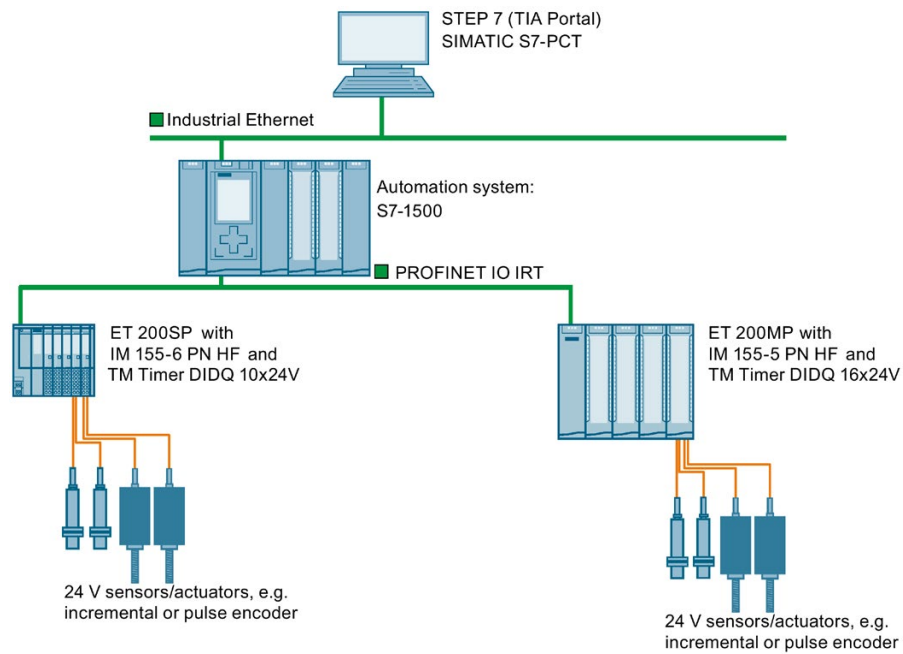
$3 \times \text{application cycle } T_{APP}$

## 2.3 System environment

### Introduction

Possible system configurations with PROFINET for the use of Time-based IO are shown below.

### Use with STEP 7 (TIA Portal)



## 2.4 Hardware requirements

### Introduction

The properties of the hardware components required for Time-based IO are listed below. You will also find specific modules as an example.

### Requirements

| Component               | Properties                                                                                           | Examples                                                                                                                                                  |
|-------------------------|------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------|
| CPU                     | Isochronous mode/ PROFINET IO IRT: provides defines response time and high-precision plant behavior. | <ul style="list-style-type: none"><li>• CPU 1511-1 PN</li></ul>                                                                                           |
| ET 200 interface module | Supports isochronous mode                                                                            | <ul style="list-style-type: none"><li>• ET 200SP with IM 155-6 PN HF (as of firmware V2.1)</li><li>• ET 200MP with IM 155-5 PN HF</li></ul>               |
| I/O module              | TIO module                                                                                           | <ul style="list-style-type: none"><li>• ET 200SP:<br/>TM Timer DIDQ 10x24V</li><li>• ET 200MP:<br/>TM Timer DIDQ 16x24V (as of firmware V1.0.1)</li></ul> |

## 2.5 Configuration software requirements

### Introduction

Below is a list of the software versions which support the "Time-based IO" function.

### Requirements

| Configuration software            | Requirements                                             | Supported hardware components                                                                                                                                                                     | Additional information          |
|-----------------------------------|----------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------|
| STEP 7 (TIA Portal) V16 and above | PROFINET IO IRT or isochronous mode on the backplane bus | <ul style="list-style-type: none"><li>• S7-1500 automation system</li><li>• ET 200SP and ET 200MP distributed I/O systems</li><li>• TM Timer DIDQ 16x24V</li><li>• TM Timer DIDQ 10x24V</li></ul> | STEP 7 (TIA Portal) online help |

Additional information on isochronous mode is available in the Isochronous mode (<http://support.automation.siemens.com/WW/view/en/49948856>) and PROFINET with STEP 7 (<https://support.industry.siemens.com/cs/ww/en/view/109755401>) manuals.

### TIO instructions

The TIO instructions are specific function blocks for use of Time-based IO. The following TIO instructions (Page 27) are available:

- TIO\_SYNC
- TIO\_DI
- TIO\_DI\_ONCE
- TIO\_DQ

## 2.6 Technical implementation

### Introduction

The information below will help you better understand the core aspects of Time-based IO and find out which SIMATIC functions are used to implement the described aspects.

### Synchronization of involved modules (shared time basis)

The Time-based IO technology uses isochronous mode for all involved stations.

Isochronous mode enables multiple TIO modules to be synchronized to a shared time basis. The basis of the shared time basis for the TIO modules is the relative time TIO\_Time.

Additional information on isochronous mode is available in the Isochronous mode (<http://support.automation.siemens.com/WW/view/en/49948856>) and PROFINET with STEP 7 (<https://support.industry.siemens.com/cs/ww/en/view/109755401>) manuals.

### TIO\_Time

The TIO\_Time is the central time basis to which all time stamps refer.

TIO\_Time has the following properties:

- Shared time basis for all TIO modules which are synchronized with the TIO instruction TIO\_SYNC.
- The time starts counting again with each CPU startup.
- The TIO\_Time has data type LTime (e.g. LT#14s830ms652us315ns).
- All valid time stamps refer to TIO\_Time:
  - Input time stamps of the TIO modules are converted to the TIO\_Time in the TIO instructions TIO\_DI and TIO\_DI\_ONCE.
  - In the TIO instruction TIO\_DQ, output time stamps are converted to the output time stamp of the TIO modules.
- The value of TIO\_TIME corresponds to the current time with respect to TIO instructions and is updated with the call of TIO\_SYNC. If you want an output to relate not to a previous input time stamp but to the current time, you can use the value of TIO\_TIME as basis for the output time stamp. Example: Output of an edge in 20 ms:  
TIO\_DQ.TimeStampRE=TIO\_SYNC\_DATA.TIO\_TIME+LT#20ms)

## TIO instructions in the isochronous OB

The TIO instructions must be called in a "Synchronous Cycle" or "MC-PostServo" OB.

You can find additional information in the chapter Programming (Page 27).

---

### Note

The TIO instructions also support geared down isochronous mode. With a clock reduction ratio, the application cycle is longer than the send clock.

---

### Note

The TIO instructions must be called in an "MC-PreServo" OB.

If you use an OB of the "MC-PostServo" type, you can decide separately for each TIO model whether it is used with Motion Control technology objects or with TIO instructions.

If you call the TIO instructions in an "MC-PostServo" type OB, you need to use the IPO model and also cannot use any reduction ratio.

Calling TIO instructions in an OB of the type "MC-PostServo" with reduction ratio "MC-Servo" can result in incorrect calculation of time stamps.

---

## Modes for updating the process image

In isochronous mode, you can influence the order of the update of the process image partition of the input and output data. In doing so, you can select the following program execution models:

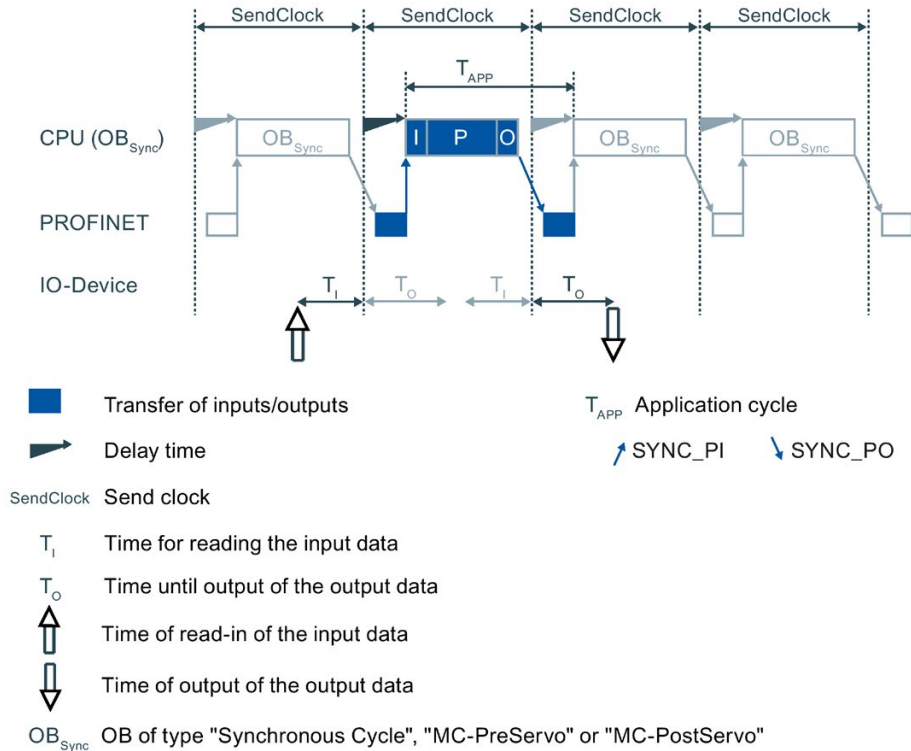
- IPO model (application cycle factor = 1)
- OIP model (application cycle factor  $\geq 1$ )

The abbreviations I, P, O stand for the following processes: I = Input, P= Processing, O = Output.

Additional information on the application cycle factor is available in the PROFINET with STEP 7 (<http://support.automation.siemens.com/WW/view/en/49948856>) Manual.

**IPO model (application cycle factor = 1)**

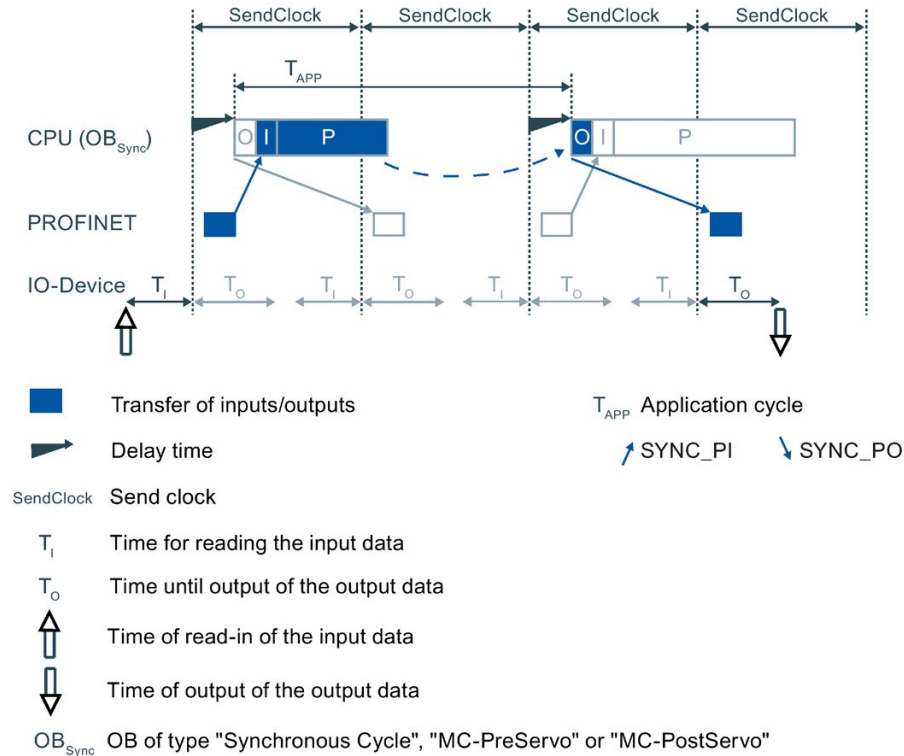
The user program is started after the delay time. Start by updating the corresponding process image partition of the inputs in the user program by calling the SYNC\_PI system instruction. Processing is started next (for example, calculation of the time stamps). The corresponding process image partition of the outputs is updated at the end of the user program in the CPU by SYNC\_PO.

**Properties of the IPO model:**

- Supports shorter response times
- The application cycle must not be greater than the send clock.  
This gives the application less time than with the OIP model.

### OIP model (application cycle factor $\geq 1$ )

The user program is started after the delay time. In PIP\_Mode 0, the TIO\_SYNC instruction updates the process image. In the other modes, you start by updating the corresponding process image partition of the outputs in the user program by calling the SYNC\_PO system instruction. As a result, the output data that was calculated in the previous network cycle will become active during the next network cycle ( $T_o$ ). Next the corresponding process image partition of the inputs is updated in the CPU by SYNC\_PI. Processing starts after the data is transmitted (for example, calculation of the time stamps).



#### Properties of the OIP model:

- The response time is longer than with the IPO model.
  - It is one application cycle longer than permitted by the send clock.
- This gives the application more time than with the IPO model.

#### Influence of accuracy

To estimate the accuracy you need the accuracy of

- TIO module
- Sensor/ actuator

Consult the data sheets of the respective module regarding the accuracy value.

You have to add the individual jitters of the TIO modules and the sensors/actuators. You can neglect any other influencing factors.

#### See also

Programming of Time-based IO (Page 28)



# Configuring and parameter assignment

## 3.1 Requirements

### Introduction

You need additional software components to use Time-based IO. You must also have created the standard configuration for your project.

Below you will learn more about the standard configuration for Time-based IO.

### Requirements

In STEP 7 (TIA Portal):

- The project has been created.
- The CPU has been created and the parameters are assigned.
- Automation system and modules have been created and the parameters have been assigned.
- When using an ET 200 station: The connection has been created and the parameters are assigned via PROFINET.
- A "Synchronous Cycle" or "MC-PostServo" type OB has been created.

### See also

System environment (Page 17)

Configuration software requirements (Page 19)

## 3.2 Settings for Time-based IO

Below you will find an overview of which settings have to be made for which components of Time-based IO.

Table 3- 1 Overview of settings for Time-based IO

| Component                                          | Where adjustable <sup>1</sup>                                      | Properties to be set                                                                                                                                                                                                                                      | Additional information                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |
|----------------------------------------------------|--------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| When using an ET 200 station: PROFINET subnet      | Properties of the PROFINET subnet > sync domain                    | Create sync domain or edit properties of sync domain<br><br>Specify devices of the sync domain: <ul style="list-style-type: none"> <li>Specify CPU as sync master.</li> <li>Specify ET 200 interface module as sync slave with RT class "IRT".</li> </ul> | <ul style="list-style-type: none"> <li>PROFINET function manual (<a href="http://support.automation.siemens.com/WW/view/en/49948856">http://support.automation.siemens.com/WW/view/en/49948856</a>)</li> <li>Online help in the STEP 7 (TIA Portal) information system</li> </ul>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |
| S7-1500 station                                    | Properties of the PROFINET interface > isochronous communication   | Enable isochronous mode                                                                                                                                                                                                                                   | <ul style="list-style-type: none"> <li>Function Manual Isochronous Mode (<a href="https://support.industry.siemens.com/cs/ww/en/view/109755401">https://support.industry.siemens.com/cs/ww/en/view/109755401</a>)</li> <li>PROFINET function manual (<a href="http://support.automation.siemens.com/WW/view/en/49948856">http://support.automation.siemens.com/WW/view/en/49948856</a>)</li> <li>Manual Technology Module TM Timer DIDQ 16x24V (<a href="http://support.automation.siemens.com/WW/view/en/95153313">http://support.automation.siemens.com/WW/view/en/95153313</a>)</li> <li>Manual Technology Module TM Timer DIDQ 10x24V (<a href="http://support.automation.siemens.com/WW/view/en/95153951">http://support.automation.siemens.com/WW/view/en/95153951</a>)</li> <li>Online help in the STEP 7 (TIA Portal) information system</li> </ul> |
| ET 200 station                                     |                                                                    | Enable isochronous mode                                                                                                                                                                                                                                   |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |
| TIO module                                         | Properties of the TIO module > I/O addresses                       | Enable isochronous mode                                                                                                                                                                                                                                   | <ul style="list-style-type: none"> <li>PROFINET function manual (<a href="http://support.automation.siemens.com/WW/view/en/49948856">http://support.automation.siemens.com/WW/view/en/49948856</a>)</li> <li>Manual Technology Module TM Timer DIDQ 16x24V (<a href="http://support.automation.siemens.com/WW/view/en/95153313">http://support.automation.siemens.com/WW/view/en/95153313</a>)</li> <li>Manual Technology Module TM Timer DIDQ 10x24V (<a href="http://support.automation.siemens.com/WW/view/en/95153951">http://support.automation.siemens.com/WW/view/en/95153951</a>)</li> </ul>                                                                                                                                                                                                                                                        |
|                                                    | Properties of the TIO module > I/O addresses                       | Assign or create a "Synchronous Cycle" or "MC-PostServo" type OB                                                                                                                                                                                          |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |
|                                                    | Properties of the TIO module > I/O addresses                       | Assignment of I/O addresses to the process image partition (e.g., PIP1)                                                                                                                                                                                   |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |
|                                                    | Properties of the TIO module > Basic parameters                    | Configure "Module use from the user program"                                                                                                                                                                                                              |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |
|                                                    | Properties of the TIO module > Basic parameters/Channel parameters | For TM Timer DIDQ 10x24V: If required, assign parameters for Configuration "Use input/output individually"                                                                                                                                                |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |
|                                                    |                                                                    | Parameter assignment for use of Timer DI and Timer DQ                                                                                                                                                                                                     |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |
| Isochronous OB (Synchronous Cycle or MC-PostServo) | Properties of the Isochronous OB > Isochronous mode                | Adjust application cycle, if necessary                                                                                                                                                                                                                    |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |

<sup>1</sup> Describes the topic area in the configuration software.

## Setting for Time-based IO

If you have no special response time requirements, the following setting is suitable as a starting point:

- Send clock: 2 ms
- Application cycle: 4 ms
- Assignment to the process image partition: PIP1
- PIP\_Mode: 0 (OIP model)

## FAQ

For more information, see the following FAQs in the Siemens Industry Online Support:

- Entry ID 109738186 (<https://support.industry.siemens.com/cs/ww/en/view/109738186>)
- Entry ID 109736374 (<https://support.industry.siemens.com/cs/ww/en/view/109736374>)

## See also

Programming of Time-based IO (Page 28)

# Programming

## 4.1 Overview of instructions

### Introduction

Time-based IO is used with special instructions (TIO instructions). The TIO\_SYNC TIO instruction is responsible for synchronizing all involved TIO modules and creates a unique time basis (TIO\_Time) to which all actions are referenced.

Additional instructions undertake the reading in of process input signals with associated time stamps and/or the time-controlled output of process output signals.

---

#### Note

The TIO instructions are helpful for general time-based IO applications. For special applications, such as cam controllers, there are also separate technology objects, for example, TO\_CamOutput.

---



---

#### Note

The TIO instructions use the time stamp functions of the TIO modules. The other functions of the TIO modules can be used independently of the TIO instructions in applications.

---

### TIO instructions

| Instruction | Short description                                                                                                                                                                                                                                             |
|-------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| TIO_SYNC    | Synchronizes the TIO modules and provides the time basis for Time-based IO                                                                                                                                                                                    |
| TIO_DI      | Detects the edges at the digital input (Timer DI) and supplies the associated time stamp                                                                                                                                                                      |
| TIO_DI_ONCE | <ul style="list-style-type: none"> <li>• Detects the edges at the digital input (timer DI) once and provides the associated time stamp</li> <li>• Controls a timer DI channel which is configured as an edge-triggered enable for another channel.</li> </ul> |
| TIO_DQ      | Outputs time-controlled edges at the digital output (Timer DQ)                                                                                                                                                                                                |

## 4.2 Programming of Time-based IO

### Introduction

To use Time-based IO, the TIO instructions must be called in an isochronous OB. The application can also run in another OB. This allows you to shorten the runtime of the isochronous OB.

You need the following TIO instructions according to the required task:

| TIO module                                                                                        | TIO instructions                                                                                                                                                                                              |
|---------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <ul style="list-style-type: none"><li>TM Timer DIDQ 16x24V</li><li>TM Timer DIDQ 10x24V</li></ul> | <ul style="list-style-type: none"><li>Per digital input, one TIO_DI or TIO_DI_ONCE for read-in</li><li>Per digital output, one TIO_DQ for output</li><li>One TIO_SYNC (for up to eight TIO modules)</li></ul> |

This section below describes the programming of the CPU for Time-based IO.

### Requirements

Hardware configuration in STEP 7 (TIA Portal):

- The TIO modules are assigned to an isochronous network.
- The TIO modules are assigned to a shared process image partition.
- The process image partition is assigned to an isochronous OB.
- The TIO modules are configured for use with instructions from the "Time-based IO" library.

Additional information on configuration of Time-based IO is available in the section Settings for Time-based IO (Page 25).

### Procedure

1. Create a TIO instruction, TIO\_SYNC, in the isochronous OB.
2. Connect all TIO modules to be synchronized at the TIO\_SYNC TIO instruction using parameters HWID\_1 to HWID\_8.

The HWID can be found in the hardware configuration under "Properties > System constants".

---

**Note**

Use of symbolic constants is generally preferred instead of absolute numerical values when interconnecting.

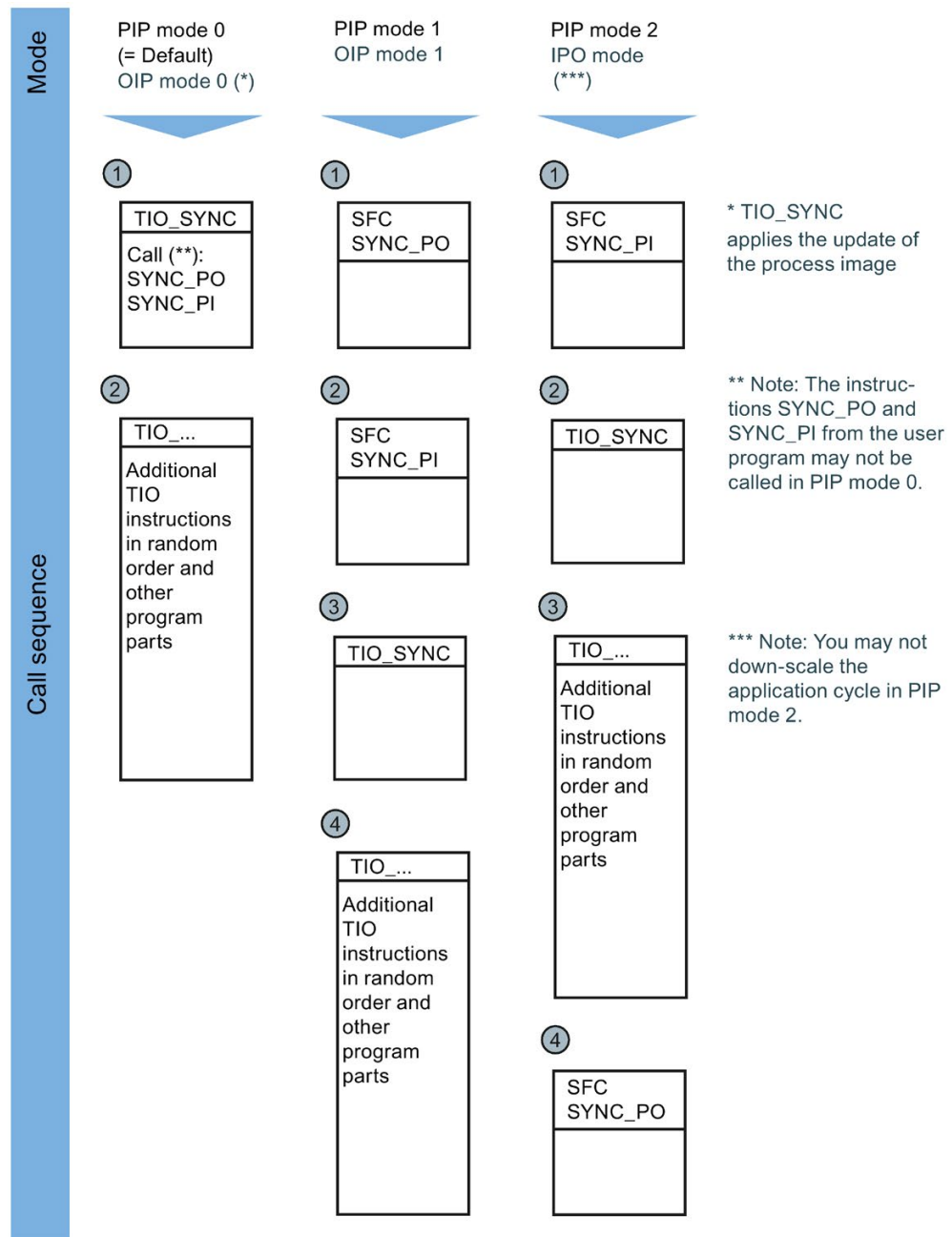
---

3. Set the data update mode at the TIO\_SYNC instruction at the PIP\_Mode input parameter.

The description of the modes is available in the chapter Technical implementation (Page 20).

The parameter assignment of the TIO\_SYNC TIO instruction is complete.

4. For the following instructions, note the call sequence depending on the selected value for PIP\_Mode:



5. Add the TIO instructions for read-in/output required for your application in the isochronous OB.
6. At the TIO instructions for read-in/output, interconnect in each case the input/output TIO\_SYNC\_Data with the same name output at the TIO\_SYNC.
7. At the TIO instructions for read-in/output, assign parameters for the input parameters HWID (see "Properties > System constants" in hardware configuration) and Channel. The Time-based IO functionality is successfully programmed.

8. Interconnect the Time-based IO functionality with your application, such as evaluating the read-in time stamp in a step sequencer in another OB.
9. If TIO\_SYNC does not automatically read out the send clock: Define the send clock manually, e.g. in OB100.
10. Compile and download the entire project to the CPU.

## Result

You have completed programming the use of Time-based IO.

## FAQ

For more information, see the following FAQs in the Siemens Industry Online Support:

- Entry ID 109738186 (<https://support.industry.siemens.com/cs/ww/en/view/109738186>)
- Entry ID 109736374 (<https://support.industry.siemens.com/cs/ww/en/view/109736374>)

## 4.3 Time-based IO

### 4.3.1 TIO\_SYNC: Synchronizing TIO modules

#### Description

TIO\_SYNC is the basis for all other TIO instructions. TIO\_SYNC synchronizes TIO modules to a shared time basis TIO\_Time.

You can synchronize up to 8 TIO modules with TIO\_SYNC. All TIO modules must be assigned to the same process image partition (PIP). If you select "0" for the input parameter PIP\_Mode, you assign the number of the process image partition at the PIP\_PART input parameter.

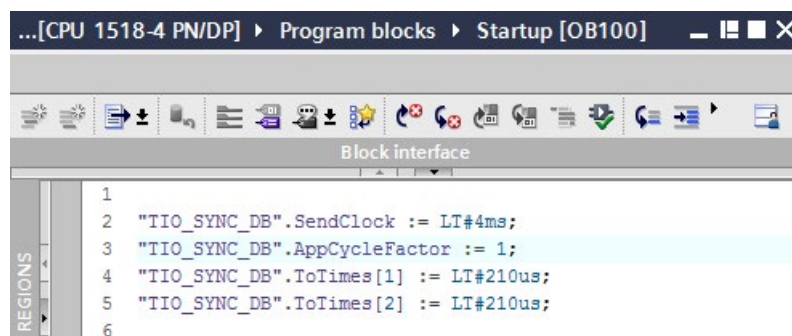
Additional information on configuration of Time-based IO is available in the Configuration and parameter assignment section.

#### Startup characteristics

At the startup of the CPU, the TIO\_SYNC instruction receives and checks the input parameters once and initializes the TIO\_Time.

You have several options for handling the optional parameters SendClock, AppCycleFactor and ToTimes:

- SendClock, AppCycleFactor and ToTimes can be read in automatically each time the system is started. This results in a time delay during startup, but the values are always consistent.
- Automatically read in SendClock, AppCycleFactor and ToTimes at each startup and apply the read-in values as set values during commissioning. This results in fast subsequent startups, but is inconsistent after changes in the hardware configuration (repeat commissioning necessary).
- Manually define SendClock, AppCycleFactor and ToTimes before the first call of the instruction, for example, in OB100:



This results in a fast startup, but you need to manually update the values after changes to the hardware configuration.

You will find information about the parameters in the table below.

If startup takes place without errors, the instruction changes to normal operation. In the event of an error, the instruction does not change to normal operation and generates an error message.



## Functional description

In normal operation, the instruction ensures synchronization of all TIO modules configured at the HWID input.

The calculated TIO\_Time for the instructions of the TIO modules is provided at the TIO\_SYNC\_Data output.

## Reaction to error

The Error output indicates if the instruction was processed correctly. In the event of an error, the cause of the error is displayed at the Status output.

## Parameter

The table below shows the parameters of the TIO\_SYNC instruction.

| Parameter          | Declaration in library version |        | Data type       | Default | Description                                                                                                                                                                                                                                                                                              |
|--------------------|--------------------------------|--------|-----------------|---------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|                    | < V2.0                         | ≥ V2.0 |                 |         |                                                                                                                                                                                                                                                                                                          |
| HWID_1 ... HWID_8* | Input                          |        | HW_IO           | 65535   | Hardware identifier for TIO module from hardware configuration                                                                                                                                                                                                                                           |
| PIP_Mode*          | Input                          |        | PIP             | 0       | Mode for the data update**: <ul style="list-style-type: none"> <li>• 0: OIP model with internal update of the process image by SYNC_PO and SYNC_PI.</li> <li>• 1: OIP model without internal update of the process image</li> <li>• 2: IPO model without internal update of the process image</li> </ul> |
| PIP_PART*          | Input                          |        | USInt           | 1       | Only relevant if PIP_Mode = 0<br>Number of the process image partition which is to be updated isochronously.                                                                                                                                                                                             |
| TIO_SYNC_Data      | Output                         |        | "TIO_SYNC_Data" |         | Calculated system time for the TIO instructions of the TIO modules and internal data used for synchronization. See UDT TIO_SYNC_Data (Page 58).                                                                                                                                                          |
| Status             | Output                         |        | DWord           | 16#0    | Status of the instruction: see description of Status parameter                                                                                                                                                                                                                                           |
| Error              | Output                         |        | Bool            | False   | Error = True: An error has occurred. For detailed information see Status parameter.<br>Error is reset as soon as the error is corrected.                                                                                                                                                                 |

| Parameter       | Declaration in library version |        | Data type           | Default | Description                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |
|-----------------|--------------------------------|--------|---------------------|---------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|                 | < V2.0                         | ≥ V2.0 | S7-1500             |         |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |
| OperatingState  |                                | Static | Int                 | 0       | <p>Internal operating state of the instruction:</p> <ul style="list-style-type: none"> <li>0: Input parameters are checked</li> <li>1: Optional parameters are read out</li> <li>2: Read-out parameters are checked</li> <li>3: Normal operation (all parameters OK, TIO modules synchronized)</li> </ul> <p>As soon as operating state 3 is reached, time stamps can be read in and edges can be output. If you want to repeat the synchronization of the TIO modules and the readout of the optional parameters, you can set the operating state to 0.</p> |
| SendClock       | Input                          | Static | LTime               | LT#0ns  | <p>Send clock of the sync domain.</p> <p>Apply the send clock from the PROFINET configuration.</p>                                                                                                                                                                                                                                                                                                                                                                                                                                                           |
| AppCycle-Factor |                                | Static | UInt                | 0       | <p>Application cycle factor:</p> <ul style="list-style-type: none"> <li>Range of values: <math>0 \leq \text{AppCycleFactor} \leq 85</math></li> <li>0: SendClock, AppCycleFactor and ToTimes are read in automatically</li> </ul> <p>The application cycle <math>T_{APP}</math> is calculated as follows:<br/> <math>T_{APP} = \text{AppCycleFactor} \times \text{SendClock}</math></p>                                                                                                                                                                      |
| ToTimes         |                                | Static | LTime array [1...8] | LT#0ns  | <p><math>T_o</math> for each TIO module: Time for output of isochronous output data.</p>                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |

\* Checked once at startup of the CPU

\*\* The IPO model (PIP\_Mode = 2) provides the shortest response times, but it also places the highest demands on system performance. Processing of all TIO instructions and other program sections must be completed within one send clock. Select the OIP model (PIP\_Mode = 0) only if you use only *one* instance of the TIO\_SYNC instruction per process image partition so that the SYNC\_PI and SYNC\_PO instructions are not called more than once in the isochronous OB. In addition, do not call SYNC\_PI and SYNC\_PO in the other program sections in the OIP model.

### Note

The TIO instructions must be called in an "MC-PreServo" OB.

If you use an OB of the "MC-PostServo" type, you can decide separately for each TIO model whether it is used with Motion Control technology objects or with TIO instructions.

If you call TIO\_SYNC in an "MC-PostServo" type OB, you need to use PIP\_Mode = 2 and also cannot use any reduction ratio.

**Status parameter**

Error codes or status information is output as double word at the Status output.

The double word is divided as follows:

| Error code<br>(DW#16#...) | Meaning                                                                                                                                                                                                                                                                                                                                                                      |
|---------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| z0yywww                   | <p>Error of a system function:</p> <ul style="list-style-type: none"> <li>during startup (z = 1)</li> <li>during normal operation (z = 0)</li> </ul> <p>System functions with subordinate use are coded in yy: See table with error codes.<br/>www specifies the RET_VAL of the system function. The error information is available in the help for the system function.</p> |
| z0yy0000                  | <p>An error that does not originate in a system function. This error receives a consecutive error number yy.<br/>The error can occur:</p> <ul style="list-style-type: none"> <li>during startup (z = 1)</li> <li>during normal operation (z = 0)</li> </ul>                                                                                                                  |

**Table with error codes**

| Error code<br>(DW#16#...) | Meaning                                                                                                                                                           | Solution                                                                                                                                                                                                                        |
|---------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 00000000                  | No error.                                                                                                                                                         | —                                                                                                                                                                                                                               |
| 1001xxxx                  | An error has occurred with system function RD_SINFO. The low word xxxx displays the error information of the RET_VAL return value from RD_SINFO.                  | <ul style="list-style-type: none"> <li>Read the description of the RD_SINFO in the STEP 7 (TIA Portal) information system.</li> <li>Make sure that TIO_SYNC is called in a "Synchronous Cycle" or "MC-PostServo" OB.</li> </ul> |
| 10020000                  | The read cycle time of the isochronous OB is invalid (LT#0ms or negative).<br>The instruction can only be used without errors in an isochronous OB.               | <ul style="list-style-type: none"> <li>Correct the value of the cycle time.</li> <li>Make sure that TIO_SYNC is called in a "Synchronous Cycle" or "MC-PostServo" OB.</li> </ul>                                                |
| 10030000                  | The TIO_SYNC instruction is not called in an isochronous OB. The instruction can only be used without errors in an isochronous OB.                                | Make sure that TIO_SYNC is called in a "Synchronous Cycle" or "MC-PostServo" OB.                                                                                                                                                |
| 10040000                  | The assigned value at the PIP_Mode input parameter is outside the valid range of 0 to 2.                                                                          | Correct the value at the PIP_Mode input parameter.                                                                                                                                                                              |
| 10050000                  | The configured send clock is outside the permitted range of 0 < SendClock <= 4 ms.                                                                                | Correct the value of the send clock.                                                                                                                                                                                            |
| 0006xxxx*                 | An error has occurred during execution of the SYNC_PI system function. The low word xxxx displays the error information of the RET_VAL return value from SYNC_PI. | Read the description of the SYNC_PI in the STEP 7 (TIA Portal) information system.                                                                                                                                              |
| 0007xxxx*                 | An error has occurred during execution of the SYNC_PO system function. The low word xxxx displays the error information of the return value RET_VAL from SYNC_PO. | Read the description of the SYNC_PO in the STEP 7 (TIA Portal) information system.                                                                                                                                              |

| Error code<br>(DW#16#...) | Meaning                                                                                                                                                  | Solution                                                                                                                                                                                                                                                                     |
|---------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 10080000                  | At least one of the hardware identifiers does not belong to a TIO module.                                                                                | Check the values of input parameters HWID_1 to HWID_8. Specify the hardware identifier of the TIO module from its module properties in the hardware configuration.                                                                                                           |
| 10090000                  | HWID_1 is not a valid hardware identifier.<br>Possible cause:<br>No module with this hardware identifier available.                                      | Check the value of the respective input parameter. In each case, specify the hardware identifier of the TIO module from its module properties in the hardware configuration. An internal system constant of data type Hw_SubModule is available for the symbolic addressing. |
| 100A0000                  | HWID_2 is not a valid hardware identifier.<br>Possible cause:<br>No module with this hardware identifier available.                                      |                                                                                                                                                                                                                                                                              |
| 100B0000                  | HWID_3 is not a valid hardware identifier.<br>Possible cause:<br>No module with this hardware identifier available.                                      |                                                                                                                                                                                                                                                                              |
| 100C0000                  | HWID_4 is not a valid hardware identifier.<br>Possible cause:<br>No module with this hardware identifier available.                                      |                                                                                                                                                                                                                                                                              |
| 100D0000                  | HWID_5 is not a valid hardware identifier.<br>Possible cause:<br>No module with this hardware identifier available.                                      |                                                                                                                                                                                                                                                                              |
| 100E0000                  | HWID_6 is not a valid hardware identifier.<br>Possible cause:<br>No module with this hardware identifier available.                                      |                                                                                                                                                                                                                                                                              |
| 100F0000                  | HWID_7 is not a valid hardware identifier.<br>Possible cause:<br>No module with this hardware identifier available.                                      |                                                                                                                                                                                                                                                                              |
| 10100000                  | HWID_8 is not a valid hardware identifier.<br>Possible cause:<br>No module with this hardware identifier available.                                      |                                                                                                                                                                                                                                                                              |
| 10110000                  | The value at input parameter PIP_PART is outside the valid range of 1 ... 31.                                                                            | Correct the value at the PIP_PART input parameter.                                                                                                                                                                                                                           |
| 10120000                  | The value "2" is configured at the input parameter PIP_Mode, while the value > 1 (reduction ratio) is configured at the static parameter AppCycleFactor. | Correct the value at the PIP_Mode input parameter. PIP_Mode with the value "2" does not allow a reduction ratio.                                                                                                                                                             |
| x0130000                  | MC-Servo (OB91) is not isochronous to the bus cycle time.                                                                                                | Correct the value of the cycle time of the MC-Servo to the value of the bus cycle time.<br>Note:<br>Calling TIO instructions in an OB of the type "MC-PostServo" with reduction ratio "MC-Servo" can result in incorrect calculation of time stamps.                         |
| x014xxxx                  | An error has occurred when reading the data record. The low word xxxx indicates the error information of the instruction RDREC.                          | Read the description of the instruction RDREC in the STEP 7 (TIA Portal) information system.                                                                                                                                                                                 |
| x0FF0000                  | General internal error.                                                                                                                                  | —                                                                                                                                                                                                                                                                            |

\* Available only when "0" is selected for the input parameter PIP\_Mode.

### 4.3.2 TIO\_DI: Reading in edges at digital input and associated time stamps

#### Description

TIO\_DI continuously detects the edges at a digital input of a TIO module and returns the associated time stamps.

#### Startup characteristics

During startup of the CPU, the instruction TIO\_DI applies the input parameters once and checks the following:

- Checking HWID
- Checking to see if the number of the digital input (Channel) is in the permitted range (depending on addressed module and channel configuration)
- Checking TIO\_SYNC\_Data.ERROR: Is an error present at TIO\_SYNC?
- Checking TIO\_SYNC\_Data.TO\_TIMES for plausibility (0 ms to 4 ms)
- Checking to see whether the OB is isochronous

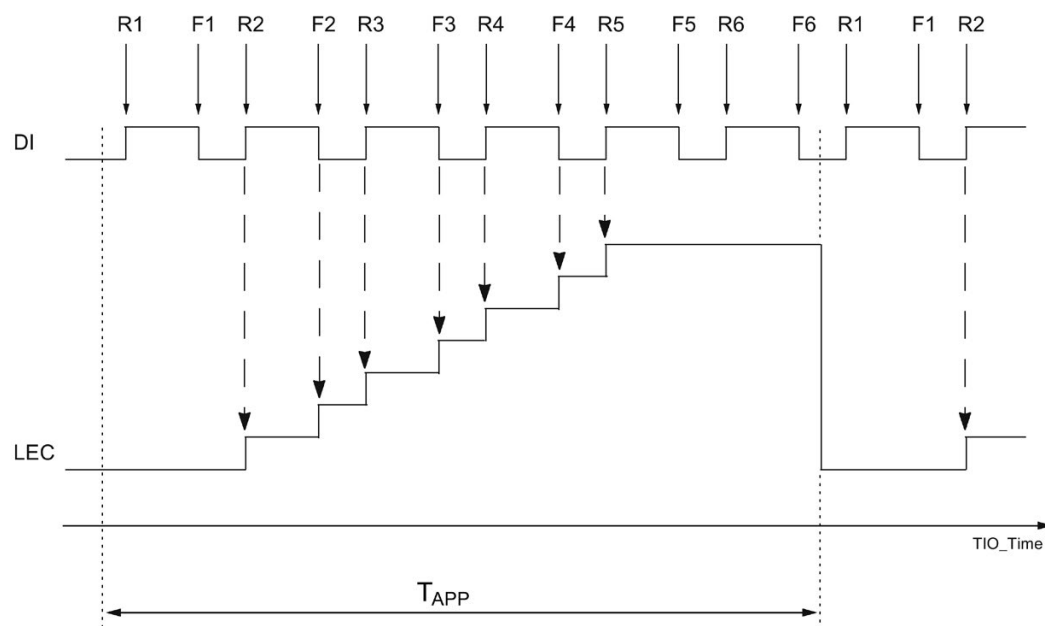
If startup takes place without errors, the instruction changes to normal operation. In the event of an error, the instruction does not change to normal operation and generates an error message.

#### Functional description

In normal operation, the instruction detects the edges at a digital input and the associated time stamps of the last valid, defined edge pair from the preceding isochronous cycle. Use the input parameter EdgeSel to determine the edges for which time stamps are detected.

You connect the input TIO\_SYNC\_Data with the output of the same name of the TIO\_SYNC instruction. This ensures a shared time basis.

The following figure shows an example of the behavior of LEC when a read-in job is started with EdgeSel = 3 (rising and falling edge, order depending on occurrence).



$T_{APP}$  Application cycle  
 $R_n$  Specified times of a positive DI edge  
 $F_n$  Specified times of a falling DI edge

The module can count a maximum of seven edges per application cycle. LEC = 7 means therefore that seven or more edges have been counted.

## Reaction to error

The Error output indicates if the instruction was processed correctly. In the event of an error, the cause of the error is displayed at the Status output.

## Parameter

The table below shows the parameters of the TIO\_DI instruction.

| Parameter    | Declaration in library version |        | Data type | Default | Description                                                                                                                                                                                                                                                                                                                           |
|--------------|--------------------------------|--------|-----------|---------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|              | < V2.0                         | ≥ V2.0 |           |         |                                                                                                                                                                                                                                                                                                                                       |
| HWID*        | Input                          |        | HW_IO     | 0       | Hardware identifier for TIO module from hardware configuration                                                                                                                                                                                                                                                                        |
| Channel*     | Input                          |        | UInt      | 0       | Number (0 ... m) of the digital input of the connected TIO module                                                                                                                                                                                                                                                                     |
| EdgeSel      | Input                          |        | UInt      | 3       | Specify the edges for which time stamps are detected:<br>0b: Invalid<br>1: Two rising edges<br>2: Two falling edges<br>3: Rising and falling edge (order depending on occurrence)<br>4: First rising, then falling edge<br>5: First falling, then rising edge<br>6 to 255: Invalid<br>EdgeSel can be changed during normal operation. |
| DI           | Output                         |        | Bool      | False   | Status of digital input.<br>If an inversion of the digital input is configured, this parameter is inverted as well.                                                                                                                                                                                                                   |
| TimeStampRE  | Output                         |        | LTime     | LT#0ns  | Time stamp: Time at which a positive edge was detected.<br>Exception:<br>EdgeSel = 2: Time at which a falling edge has been detected (if <i>multiple</i> falling edges have occurred during the application cycle).                                                                                                                   |
| TimeStampFE  | Output                         |        | LTime     | LT#0ns  | Time stamp: Time at which a falling edge was detected.<br>Exception:<br>EdgeSel = 1: Time at which a rising edge has been detected (if <i>multiple</i> rising edges have occurred during the application cycle).                                                                                                                      |
| EventCountRE | Output                         |        | UInt      | 0       | Counter: Is incremented with each new, valid time stamp at a positive edge. The counter is reset with each CPU startup.                                                                                                                                                                                                               |
| EventCountFE | Output                         |        | UInt      | 0       | Counter: Is incremented with each new, valid time stamp at a falling edge. The counter is reset with each CPU startup.                                                                                                                                                                                                                |
| LEC          | Output                         |        | UInt      | 0       | Counter: Number of edges for which no time stamp could be saved. The module can count a maximum of seven edges per application cycle. The counter is reset with each new application cycle.                                                                                                                                           |
| Status       | Output                         |        | DWord     | 16#0    | Status of the instruction: see description of Status parameter                                                                                                                                                                                                                                                                        |

| Parameter      | Declaration in library version |        | Data type       | Default | Description                                                                                                                                                                                                                           |
|----------------|--------------------------------|--------|-----------------|---------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|                | < V2.0                         | ≥ V2.0 | S7-1500         |         |                                                                                                                                                                                                                                       |
| Error          | Output                         |        | Bool            | False   | Error = True: An error has occurred. For detailed information see Status parameter.<br>Error is reset as soon as the error is corrected.                                                                                              |
| TIO_SYNC_Data* | Input                          | InOut  | "TIO_SYNC_Data" |         | System time provided for the TIO instructions of the TIO modules by the TIO_SYNC instruction. See UDT TIO_SYNC_Data (Page 58).<br>Connect this input parameter with the "TIO_SYNC_Data" output parameter of the TIO_SYNC instruction. |

\* Checked once at startup of the CPU



**Status parameter**

Error codes or status information is output as double word at the Status output.

The double word is divided as follows:

| Error code<br>(DW#16#...) | Meaning                                                                                                                                                                                                                                                                                                                                                                      |
|---------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| z0yywww                   | <p>Error of a system function:</p> <ul style="list-style-type: none"> <li>during startup (z = 1)</li> <li>during normal operation (z = 0)</li> </ul> <p>System functions with subordinate use are coded in yy: See table with error codes.<br/>www specifies the RET_VAL of the system function. The error information is available in the help for the system function.</p> |
| z0yy0000                  | <p>An error that does not originate in a system function. This error receives a consecutive error number yy.<br/>The error can occur:</p> <ul style="list-style-type: none"> <li>during startup (z = 1)</li> <li>during normal operation (z = 0)</li> </ul>                                                                                                                  |

**Table with error codes**

| Error code<br>(DW#16#...) | Meaning                                                                                                                                                             | Solution                                                                                                                                                                                                                                                 |
|---------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 00000000                  | No error.                                                                                                                                                           | —                                                                                                                                                                                                                                                        |
| 10010000                  | The assigned number of the digital input at the Channel input parameter is outside the permitted range (depending on addressed module and channel configuration).   | Correct the value at the Channel input parameter.                                                                                                                                                                                                        |
| 10020000                  | The TIO_DI instruction is not called in an isochronous OB. The instruction can only be used without errors in an isochronous OB.                                    | Make sure that TIO_DI is called in a "Synchronous Cycle" or "MC-PostServo" OB.                                                                                                                                                                           |
| 10030000                  | An error occurred when reading the HWID input parameter.                                                                                                            | Check the value at the HWID input parameter. Specify the hardware identifier of the TIO module from its module properties in the hardware configuration. An internal system constant of data type Hw_SubModule is available for the symbolic addressing. |
| x0040000                  | The data in TIO_SYNC_Data is invalid/incorrect.                                                                                                                     | Check the TIO_SYNC instruction and the interconnection of its TIO_SYNC_Data output.                                                                                                                                                                      |
| 1005xxxx                  | An error has occurred during execution of the RD_SINFO system function. The low word xxxx displays the error information of the RET_VAL return value from RD_SINFO. | <ul style="list-style-type: none"> <li>Read the description of the RD_SINFO in the STEP 7 (TIA Portal) information system.</li> <li>Make sure that TIO_DI is called in a "Synchronous Cycle" or "MC-PostServo" OB.</li> </ul>                            |

| Error code<br>(DW#16#...) | Meaning                                                                                                                                                                                                                                                                                                           | Solution                                                                                                                                                                                                                                                                  |
|---------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 10060000                  | No TIO module found.<br>Possible cause:<br>The module configured using the hardware identifier is not a TIO module.                                                                                                                                                                                               | <ul style="list-style-type: none"> <li>Make sure that the configured module is a TIO module.</li> <li>Check the value at the HWID input parameter. Specify the hardware identifier of the TIO module from its module properties in the hardware configuration.</li> </ul> |
| 10070000                  | An internal error occurred during the address calculation.                                                                                                                                                                                                                                                        | Check the value at the HWID input parameter. Specify the hardware identifier of the TIO module from its module properties in the hardware configuration. An internal system constant of data type Hw_SubModule is available for the symbolic addressing.                  |
| 00080000                  | TIO module is not synchronized using the TIO_SYNC instruction.<br>The error code can also indicate that: <ul style="list-style-type: none"> <li>A job was already present before the first run of the instruction.</li> <li>The assigned number at the Channel input parameter is not a digital input.</li> </ul> | Check the instruction TIO_SYNC.                                                                                                                                                                                                                                           |
| 10090000                  | The read cycle time of the isochronous OB is outside the permitted range of $0 < T_{APP} \leq 16$ ms and is therefore invalid.<br>The instruction can only be used without errors in an isochronous OB.                                                                                                           | <ul style="list-style-type: none"> <li>Correct the cycle time.</li> <li>Make sure that TIO_DI is called in a "Synchronous Cycle" or "MC-PostServo" OB.</li> </ul>                                                                                                         |
| 100A0000                  | The time $T_O$ of the TIO model stored in TIO_SYNC_Data is outside the permissible range of $0 < T_O \leq 4$ ms.                                                                                                                                                                                                  | Check the instruction TIO_SYNC.                                                                                                                                                                                                                                           |
| 100Bxxxx                  | An error has occurred during execution of the RD_ADDR system function. The low word xxxx displays the error information of the RET_VAL return value from RD_ADDR.                                                                                                                                                 | Read the description of the RD_ADDR in the STEP 7 (TIA Portal) information system.                                                                                                                                                                                        |
| 000C0000                  | The converted time stamp is invalid.<br>Possible cause:<br>Communication error                                                                                                                                                                                                                                    | Check the communication with the TIO module.                                                                                                                                                                                                                              |
| 000D0000                  | The Quality Information of the digital input indicates that an error has occurred at the digital input.                                                                                                                                                                                                           | Check the supply voltage L+/1L+/2L+.                                                                                                                                                                                                                                      |
| 000E0000                  | The assigned number at the Channel input parameter is not a digital input configured as Timer DI.                                                                                                                                                                                                                 | <ul style="list-style-type: none"> <li>Check the channel configuration (only for TM Timer DIDQ 16x24V).</li> <li>Check the operating mode of the digital input.</li> </ul>                                                                                                |
| 000F0000                  | The assigned value at the EdgeSel input parameter is outside the valid range of 1 to 5.                                                                                                                                                                                                                           | Correct the value at the EdgeSel input parameter.                                                                                                                                                                                                                         |

| Error code<br>(DW#16#...) | Meaning                                                                                                                                                                                                                                                                                                                                      | Solution                                                                                                                                                                                                                                                            |
|---------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 10100000                  | <p>The send clock is outside the permitted range of 0 &lt; SendClock &lt;= 4 ms and is therefore invalid.</p> <p>The error code can also indicate that</p> <ul style="list-style-type: none"> <li>• The data in TIO_SYNC_Data is invalid or does not exist.</li> <li>• The TIO_DI instruction is not called in an isochronous OB.</li> </ul> | Correct the send clock.                                                                                                                                                                                                                                             |
| x0130000                  | MC-Servo (OB91) is not isochronous to the bus cycle time.                                                                                                                                                                                                                                                                                    | <p>Correct the value of the cycle time of the MC-Servo to the value of the bus cycle time.</p> <p>Note:</p> <p>Calling TIO instructions in an OB of the type "MC-PostServo" with reduction ratio "MC-Servo" can result in incorrect calculation of time stamps.</p> |
| 10140000                  | The configured value at the HWID input parameter is not present in the structure at the TIO_SYNC_Data parameter. The HWID and TIO_SYNC_Data parameters are not consistent.                                                                                                                                                                   | Correct the value at the HWID input parameter or the structure at the TIO_SYNC_Data parameter.                                                                                                                                                                      |
| x0FF0000                  | General internal error.                                                                                                                                                                                                                                                                                                                      | —                                                                                                                                                                                                                                                                   |

### 4.3.3 TIO\_DI\_ONCE: Reading in edges once at the digital input and associated time stamps

#### Description

TIO\_DI\_ONCE detects the edges at a digital input of a TIO module **once** and returns the associated time stamps. Alternatively, you can use this instruction to control a timer DI channel that is configured as an edge-triggered enable for another channel.

#### Startup characteristics

During startup of the CPU, the instruction TIO\_DI\_ONCE applies the input parameters once and checks the following:

- Checking HWID
- Checking to see if the number of the digital input (Channel) is in the permitted range (depending on addressed module and channel configuration)
- Checking TIO\_SYNC\_Data.ERROR: Is an error present at TIO\_SYNC?
- Checking TIO\_SYNC\_Data.TO\_TIMES for plausibility (0 ms to 4 ms)
- Checking to see whether the OB is isochronous

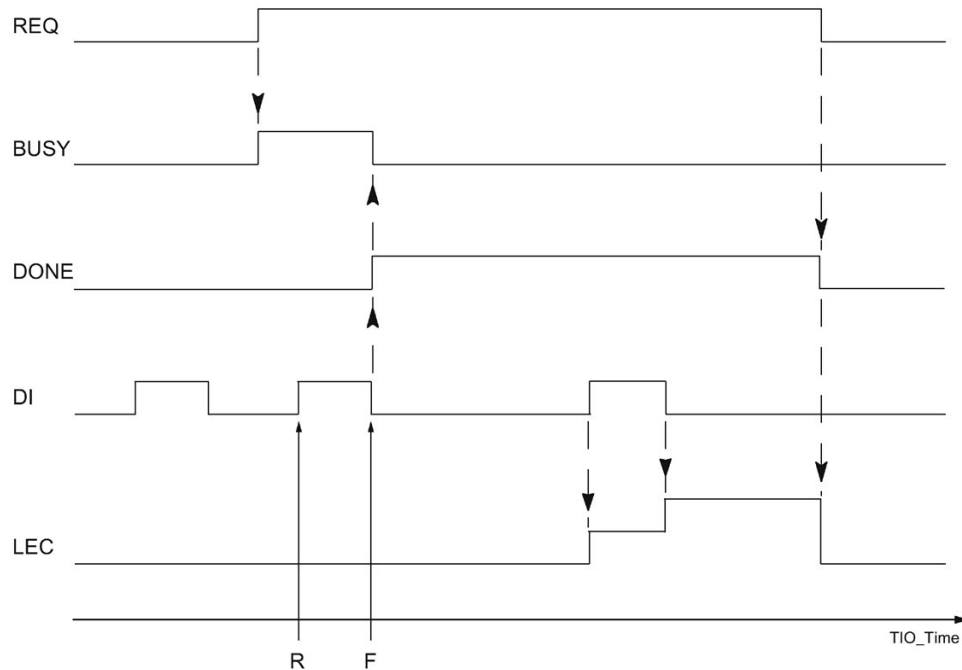
If startup takes place without errors, the instruction changes to normal operation. In the event of an error, the instruction does not change to normal operation and generates an error message.

#### Functional description: Time stamp detection

In normal operation, the instruction detects the edges at a digital input and the associated time stamps of the **first** valid, defined edge pair after the start of a read-in job. Use the input parameter EdgeSel to determine the edges for which time stamps are detected. To detect a new edge pair, a new positive edge is required at the REQ input parameter of the instruction.

You connect the input TIO\_SYNC\_Data with the output of the same name of the TIO\_SYNC instruction. This ensures a shared time basis.

The figure below shows an example for the reaction of the bits DONE and BUSY at the start of a read-in job (EdgeSel = 4).



- R Read-in time of the positive DI edge  
F Read-in time of the falling DI edge

### Functional description: edge-triggered enable

You can use this instruction to control a timer DI channel that is configured as an edge-triggered enable for another channel.

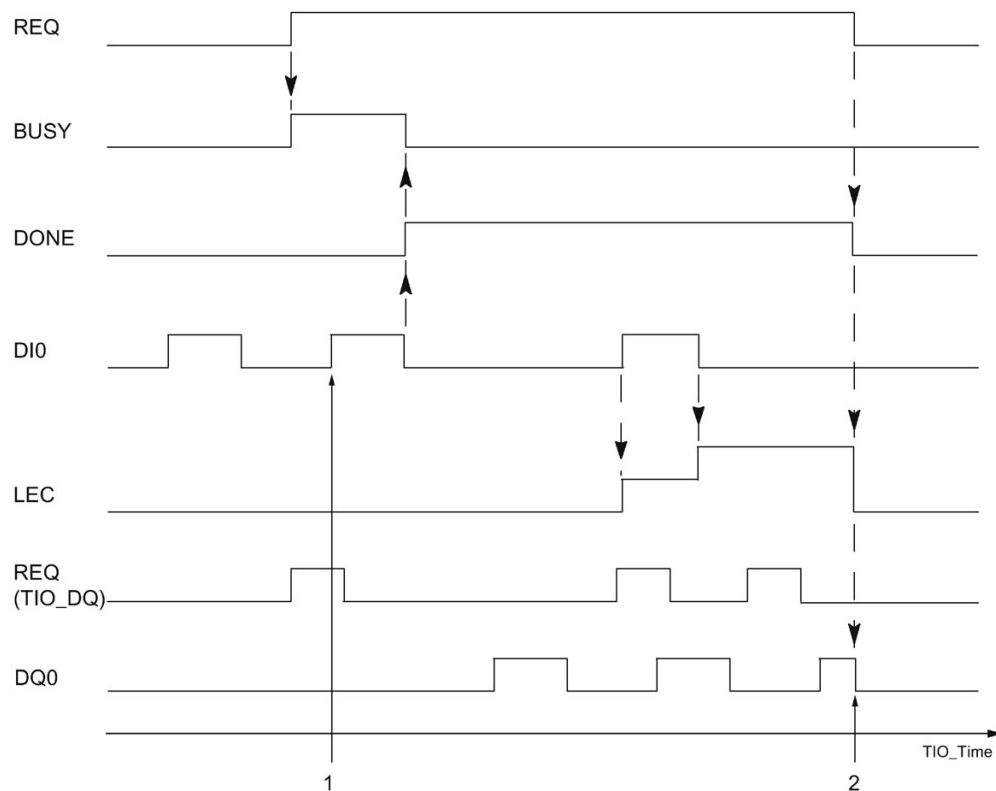
Example:

For a TIO module TM Timer DIDQ 10x24V, the following is configured in the hardware configuration for DQ0/DI0:

- Configuration DQ/DI group = timer DQ with enable
- HW enable by DI0 = edge-triggered
- DQ0 is not inverted

In this case, use the instruction TIO\_DQ for DQ0 and the instruction TIO\_DI\_ONCE for DI0. You can control the enable by means of the input parameters REQ and EdgeSel of TIO\_DI\_ONCE. As soon as TIO\_DI\_ONCE has recorded a time stamp according to the value of EdgeSel, the enable is considered granted. You take the enable back by resetting REQ.

The following figure shows an example with EdgeSel = 4n (first positive, then falling edge). In this case the first valid positive edge at DI0 grants the enable for DQ0 after the start of a read-in job.



- 1 Start of enable at positive edge of enable input
- 2 End of enable when falling edge at REQ

If required, you can use the time stamps detected by the instruction for your application.

## Reaction to error

The Error output indicates if the instruction was processed correctly. In the event of an error, the cause of the error is displayed at the Status output.

## Parameter

The table below shows the parameters of the TIO\_DI\_ONCE instruction.

| Parameter    | Declaration | Data type | Default | Description                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |
|--------------|-------------|-----------|---------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|              |             | S7-1500   |         |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |
| REQ          | Input       | Bool      | False   | Starts the job at a positive edge.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |
| HWID*        | Input       | HW_IO     | 0       | Hardware identifier for TIO module from hardware configuration                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |
| Channel*     | Input       | UInt      | 0       | Number (0 ... m) of the digital input of the connected TIO module                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |
| EdgeSel      | Input       | UInt      | 3       | Specify the edges for which time stamps are detected:<br>0: Invalid<br>1: Two rising edges<br>2: Two falling edges<br>3: Rising and falling edge (order depending on occurrence)<br>4: First rising, then falling edge<br>5: First falling, then rising edge<br>6 to 255: Invalid<br>If edge-triggered enable is used, the following also applies:<br>1: Enable at first positive DI edge<br>2: Enable at first falling DI edge<br>3: Enable at first DI edge<br>4: Enable at first positive DI edge<br>5: Enable at first falling DI edge<br>EdgeSel can be changed during normal operation. |
| DONE         | Output      | Bool      | False   | DONE = True: The job was completed without errors.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |
| BUSY         | Output      | Bool      | False   | BUSY = True: The job has not yet been completed.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |
| Error        | Output      | Bool      | False   | Error = True: An error has occurred. For detailed information see Status parameter.<br>Error is reset as soon as the error is corrected.                                                                                                                                                                                                                                                                                                                                                                                                                                                      |
| Status       | Output      | DWord     | 16#0    | Status of the instruction: see description of Status parameter                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |
| DI           | Output      | Bool      | False   | Status of digital input.<br>If an inversion of the digital input is configured, this parameter is inverted as well.                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |
| Time-StampRE | Output      | LTime     | LT#0ns  | Time stamp:<br>EdgeSel = 1: The last but one read-in time at which a positive edge was detected (if <i>multiple</i> positive edges have occurred).<br>EdgeSel = 2: The last read-in time at which a falling edge was detected (if <i>multiple</i> falling edges have occurred).<br>EdgeSel = 3; 4; 5: The last read-in time at which a falling edge was detected.                                                                                                                                                                                                                             |

| Parameter      | Declaration | Data type       | Default | Description                                                                                                                                                                                                                                                                                                                                                        |
|----------------|-------------|-----------------|---------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|                |             | S7-1500         |         |                                                                                                                                                                                                                                                                                                                                                                    |
| Time-StampFE   | Output      | LTime           | LT#0ns  | Time stamp:<br>EdgeSel = 1: The last read-in time at which a positive edge was detected (if <i>multiple</i> positive edges have occurred).<br>EdgeSel = 2: The last but one read-in time at which a falling edge was detected (if <i>multiple</i> falling edges have occurred).<br>EdgeSel = 3; 4; 5: The last read-in time at which a positive edge was detected. |
| LEC            | Output      | UInt            | 0       | Counter: Number of edges for which no time stamp could be saved. The module can count a maximum of seven edges during REQ. The counter is reset with the falling edge at REQ.                                                                                                                                                                                      |
| TIO_SYNC_Data* | InOut       | "TIO_SYNC_Data" |         | System time provided for the TIO instructions of the TIO modules by the TIO_SYNC instruction. See UDT TIO_SYNC_Data (Page 58).<br>Connect this input parameter with the "TIO_SYNC_Data" output parameter of the TIO_SYNC instruction.                                                                                                                              |
| Initialized    | Static      | Bool            | False   | Instruction is initialized and ready                                                                                                                                                                                                                                                                                                                               |

\* Checked once at startup of the CPU



**Status parameter**

Error codes or status information is output as double word at the Status output.

The double word is divided as follows:

| Error code<br>(DW#16#...) | Meaning                                                                                                                                                                                                                                                                                                                                                                      |
|---------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| z0yywww                   | <p>Error of a system function:</p> <ul style="list-style-type: none"> <li>during startup (z = 1)</li> <li>during normal operation (z = 0)</li> </ul> <p>System functions with subordinate use are coded in yy: See table with error codes.<br/>www specifies the RET_VAL of the system function. The error information is available in the help for the system function.</p> |
| z0yy0000                  | <p>An error that does not originate in a system function. This error receives a consecutive error number yy.<br/>The error can occur:</p> <ul style="list-style-type: none"> <li>during startup (z = 1)</li> <li>during normal operation (z = 0)</li> </ul>                                                                                                                  |

**Table with error codes**

| Error code<br>(DW#16#...) | Meaning                                                                                                                                                             | Solution                                                                                                                                                                                                                                                 |
|---------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 00000000                  | No error.                                                                                                                                                           | —                                                                                                                                                                                                                                                        |
| 10010000                  | The assigned number of the digital input at the Channel input parameter is outside the permitted range (depending on addressed module and channel configuration).   | Correct the value at the Channel input parameter.                                                                                                                                                                                                        |
| 10020000                  | The TIO_DI_ONCE instruction is not called in an isochronous OB. The instruction can only be used without errors in an isochronous OB.                               | Make sure that TIO_DI_ONCE is called in a "Synchronous Cycle" or "MC-PostServo" OB.                                                                                                                                                                      |
| 10030000                  | An error occurred when reading the HWID input parameter.                                                                                                            | Check the value at the HWID input parameter. Specify the hardware identifier of the TIO module from its module properties in the hardware configuration. An internal system constant of data type Hw_SubModule is available for the symbolic addressing. |
| x0040000                  | The data in TIO_SYNC_Data is invalid/incorrect.                                                                                                                     | Check the TIO_SYNC instruction and the interconnection of its TIO_SYNC_Data output.                                                                                                                                                                      |
| 1005xxxx                  | An error has occurred during execution of the RD_SINFO system function. The low word xxxx displays the error information of the RET_VAL return value from RD_SINFO. | <ul style="list-style-type: none"> <li>Read the description of the RD_SINFO in the STEP 7 (TIA Portal) information system.</li> <li>Make sure that TIO_DI_ONCE is called in a "Synchronous Cycle" or "MC-PostServo" OB.</li> </ul>                       |

| Error code<br>(DW#16#...) | Meaning                                                                                                                                                                                                                                                                                                           | Solution                                                                                                                                                                                                                                                                  |
|---------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 10060000                  | No TIO module found.<br>Possible cause:<br>The module configured using the hardware identifier is not a TIO module.                                                                                                                                                                                               | <ul style="list-style-type: none"> <li>Make sure that the configured module is a TIO module.</li> <li>Check the value at the HWID input parameter. Specify the hardware identifier of the TIO module from its module properties in the hardware configuration.</li> </ul> |
| 10070000                  | An internal error occurred during the address calculation.                                                                                                                                                                                                                                                        | Check the value at the HWID input parameter. Specify the hardware identifier of the TIO module from its module properties in the hardware configuration. An internal system constant of data type Hw_SubModule is available for the symbolic addressing.                  |
| 00080000                  | TIO module is not synchronized using the TIO_SYNC instruction.<br>The error code can also indicate that: <ul style="list-style-type: none"> <li>A job was already present before the first run of the instruction.</li> <li>The assigned number at the Channel input parameter is not a digital input.</li> </ul> | Check the instruction TIO_SYNC.                                                                                                                                                                                                                                           |
| 10090000                  | The read cycle time of the isochronous OB is outside the permitted range of $0 < T_{APP} \leq 16$ ms and is therefore invalid.<br>The instruction can only be used without errors in an isochronous OB.                                                                                                           | <ul style="list-style-type: none"> <li>Correct the cycle time.</li> <li>Make sure that TIO_DI_ONCE is called in a "Synchronous Cycle" or "MC-PostServo" OB.</li> </ul>                                                                                                    |
| 100A0000                  | The time $T_o$ of the TIO model stored in TIO_SYNC_Data is outside the permissible range of $0 < T_o \leq 4$ ms.                                                                                                                                                                                                  | Check the instruction TIO_SYNC.                                                                                                                                                                                                                                           |
| 100Bxxxx                  | An error has occurred during execution of the RD_ADDR system function. The low word xxxx displays the error information of the RET_VAL return value from RD_ADDR.                                                                                                                                                 | Read the description of the RD_ADDR in the STEP 7 (TIA Portal) information system.                                                                                                                                                                                        |
| 000C0000                  | The converted time stamp is invalid.<br>Possible cause:<br>Communication error                                                                                                                                                                                                                                    | Check the communication with the TIO module.                                                                                                                                                                                                                              |
| 000D0000                  | The Quality Information of the digital input indicates that an error has occurred at the digital input.                                                                                                                                                                                                           | Check the supply voltage L+/1L+/2L+.                                                                                                                                                                                                                                      |
| 000E0000                  | The assigned number at the Channel input parameter is not a digital input configured as Timer DI.                                                                                                                                                                                                                 | <ul style="list-style-type: none"> <li>Check the channel configuration (only for TM Timer DIDQ 16x24V).</li> <li>Check the operating mode of the digital input.</li> </ul>                                                                                                |
| 000F0000                  | The assigned value at the EdgeSel input parameter is outside the valid range of 1 to 5.                                                                                                                                                                                                                           | Correct the value at the EdgeSel input parameter.                                                                                                                                                                                                                         |

| Error code<br>(DW#16#...) | Meaning                                                                                                                                                                                                                                                                                                                                                             | Solution                                                                                                                                                                                                                                                            |
|---------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 10100000                  | <p>The send clock is outside the permitted range of <math>0 &lt; \text{SendClock} \leq 4 \text{ ms}</math> and is therefore invalid.</p> <p>The error code can also indicate that</p> <ul style="list-style-type: none"> <li>The data in TIO_SYNC_Data is invalid or does not exist.</li> <li>The TIO_DI instruction is not called in an isochronous OB.</li> </ul> | Correct the send clock.                                                                                                                                                                                                                                             |
| x0130000                  | MC-Servo (OB91) is not isochronous to the bus cycle time.                                                                                                                                                                                                                                                                                                           | <p>Correct the value of the cycle time of the MC-Servo to the value of the bus cycle time.</p> <p>Note:</p> <p>Calling TIO instructions in an OB of the type "MC-PostServo" with reduction ratio "MC-Servo" can result in incorrect calculation of time stamps.</p> |
| 10140000                  | The configured value at the HWID input parameter is not present in the structure at the TIO_SYNC_Data parameter. The HWID and TIO_SYNC_Data parameters are not consistent.                                                                                                                                                                                          | Correct the value at the HWID input parameter or the structure at the TIO_SYNC_Data parameter.                                                                                                                                                                      |
| x0FF0000                  | General internal error.                                                                                                                                                                                                                                                                                                                                             | —                                                                                                                                                                                                                                                                   |

#### 4.3.4 TIO\_DQ: Output edges time-controlled at the digital output

##### Description

TIO\_DQ enables a digital output of a TIO module to be switched at specified times.

##### Startup characteristics

During startup of the CPU, the instruction TIO\_DQ applies the input parameters once and checks the following:

- Checking HWID
- Checking to see if the number of the digital input (Channel) is in the permitted range (depending on addressed module and channel configuration)
- Checking TIO\_SYNC\_Data.Error: Is an error present at TIO\_SYNC?
- Checking TIO\_SYNC\_Data.TO\_TIMES for plausibility (0 ms to 4 ms)
- Checking to see whether the OB is isochronous

If startup takes place without errors, the instruction changes to normal operation. The input parameters REQ, Out\_Mode, TimeStampRE and TimeStampFE can be changed during normal operation. In the event of an error, the instruction does not change to normal operation and generates an error message.

##### Functional description

The instruction outputs edges time-controlled at a digital output during normal operation.

- At the time defined at the TimeStampRE input parameter, a positive edge is output at the digital output.
- At the time defined at the TimeStampFE input parameter, a falling edge is output at the digital output.

Depending on the program execution model, a time stamp must exceed the following value:

| Program execution model | TimeStampRE> ...<br>TimeStampFE > ...   |
|-------------------------|-----------------------------------------|
| IPO model               | $TIO\_Time + T_{APP} + T_O$             |
| OIP model               | $TIO\_Time + T_{APP} + SendClock + T_O$ |

Use the input parameter Out\_Mode to determine if only one edge or both edges are output.

You connect the input TIO\_SYNC\_Data with the output of the same name of the TIO\_SYNC instruction. This ensures a shared time basis.

You start an output job with a positive edge at the REQ parameter. You can only start a new job when there is no error pending and no job is active. When the output job is started, the digital output is switched at the times defined with TimeStampRE and TimeStampFE.

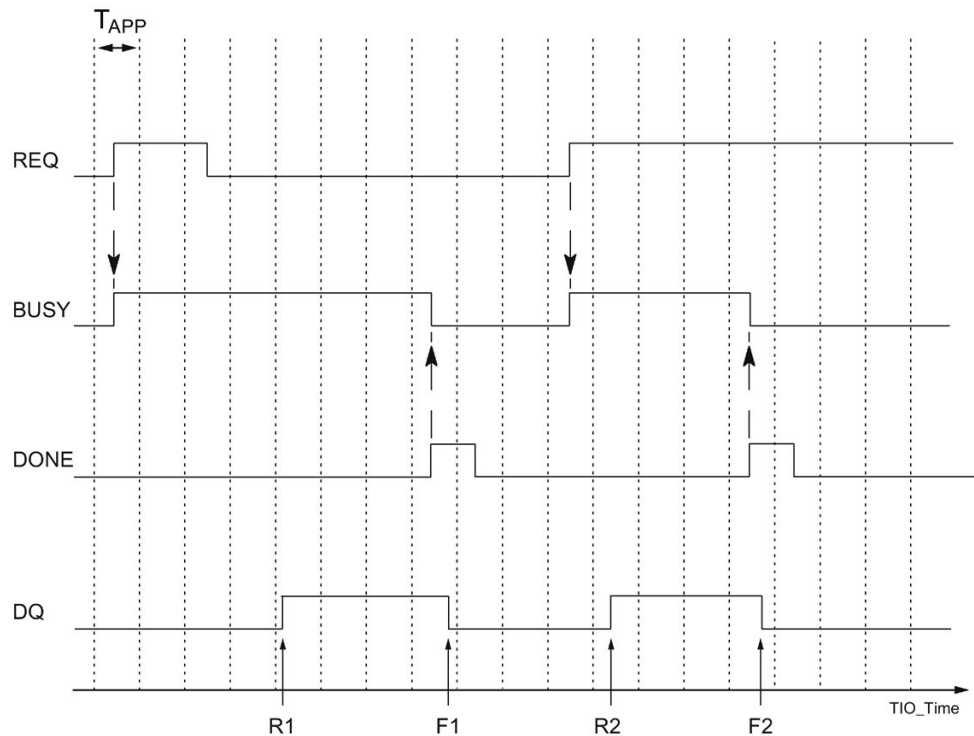
- If the digital output is already set at time TimeStampRE, the output job is not transferred to the module for the positive edge.
- If the digital output is not set at time TimeStampFE, the output job is not transferred to the module for the negative edge.

This means the digital output is not switched in both cases.

The job is done when the last application cycle is executed before the second output time is reached (DONE). Status and Error are constantly being updated during the job runtime. You can cancel an active output job by changing TimeStampRE or TimeStampFE to an invalid time stamp, e.g. LT#5 $\mu$ s.

The figure below shows an example for the reaction of the bits DONE and BUSY at the start of an output job under the following conditions:

- Out\_Mode = 2 (both edges are output)
- The two time stamps are not changed between the start of the job and the output.



T<sub>APP</sub>      Application cycle  
R1, R2      Specified times of a positive DQ edge  
F1, F2      Specified times of a falling DQ edge

---

**Note**

Once the job has been started with a positive edge at REQ, you can change the output times with a new input of TimeStampRE and TimeStampFE without having to restart the job.

Constraint:

If a changed time stamp is less than two application cycles before the output time ( $\text{TimeStampRE} - \text{TIO\_Time} < 2 \cdot T_{\text{APP}}$  or  $\text{TimeStampFE} - \text{TIO\_Time} < 2 \cdot T_{\text{APP}}$ ), it is not taken into consideration. In this case, the last valid time stamp is used because it was already transferred to the TIO module.

---

---

**Note**

If you specify the same value for TimeStampRE and TimeStampFE, the instruction ignores the job and does not output an edge.

---

If you specify the value 0 for TimeStampRE or TimeStampFE, you can output the respective edge directly at the digital output with the input parameter Out\_Mode = 3. This gives you the option to implement a direct control from the TIO module without time stamp in manual mode. You can use the direct control to interrupt an ongoing job.

## Reaction to error

The Error output indicates if the instruction was processed correctly. In the event of an error, the cause of the error is displayed at the Status output.

## Parameter

The table below shows the parameters of the TIO\_DQ instruction.

| Parameter      | Declaration in library version |        | Data type       | Default | Description                                                                                                                                                                                                                                                                                                                                                                                                              |
|----------------|--------------------------------|--------|-----------------|---------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|                | < V2.0                         | ≥ V2.0 |                 |         |                                                                                                                                                                                                                                                                                                                                                                                                                          |
| REQ            | Input                          |        | Bool            | False   | Starts the job at a positive edge.                                                                                                                                                                                                                                                                                                                                                                                       |
| HWID*          | Input                          |        | HW_IO           | 0       | Hardware identifier for TIO module from hardware configuration                                                                                                                                                                                                                                                                                                                                                           |
| Channel*       | Input                          |        | UInt            | 0       | Number (0 ... m) of the digital output of the connected TIO module                                                                                                                                                                                                                                                                                                                                                       |
| Out_Mode       | Input                          |        | UInt            | 2       | Specify the output mode for the edges at the digital output:<br>0: Only rising edge is output (TimeStampRE).<br>1: Only falling edge is output (TimeStampFE).<br>2: Both edges are output (TimeStampRE and TimeStampFE).<br>3: Each edge is output directly if TimeStampRE = 0 or TimeStampFE = 0. If both time stamps have the value "0" or if no time stamp has the value "0", no edge is output.<br>4 to 255: Invalid |
| TimeStampRE    | Input                          |        | LTime           | LT#0ns  | Time stamp: Time when a positive edge is to be output.                                                                                                                                                                                                                                                                                                                                                                   |
| TimeStampFE    | Input                          |        | LTime           | LT#0ns  | Time stamp: Time when a falling edge is to be output.                                                                                                                                                                                                                                                                                                                                                                    |
| StatusDQ       | Output                         |        | Bool            | False   | Actual status of the digital output.<br>If an inversion of the digital output is configured, StatusDQ is inverted as well.<br>StatusDQ shows the internal state of the digital output independent of the effect of any configured HW enable.                                                                                                                                                                             |
| DONE           | Output                         |        | Bool            | False   | DONE = True is displayed for one cycle: The job was completed without errors.                                                                                                                                                                                                                                                                                                                                            |
| BUSY           | Output                         |        | Bool            | False   | BUSY = True: The job has not yet been completed.                                                                                                                                                                                                                                                                                                                                                                         |
| Error          | Output                         |        | Bool            | False   | Error = True: An error has occurred. In this case, BUSY and DONE are set to False. For detailed information see Status parameter.<br>Error is reset as soon as the error is corrected.                                                                                                                                                                                                                                   |
| Status         | Output                         |        | DWord           | 16#0    | Status of the instruction: see description of Status parameter                                                                                                                                                                                                                                                                                                                                                           |
| TIO_SYNC_Data* | Input                          | InOut  | "TIO_SYNC_Data" |         | System time provided for the TIO instructions of the TIO modules by the TIO_SYNC instruction. See UDT TIO_SYNC_Data (Page 58).<br>Connect this parameter with the TIO_SYNC_Data output parameter of the TIO_SYNC instruction.                                                                                                                                                                                            |

\* Checked once at startup of the CPU

## Status parameter

Error codes or status information is output as double word at the Status output.

The double word is divided as follows:

| Error code<br>(DW#16#...) | Meaning                                                                                                                                                                                                                                                                                                                                                                      |
|---------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| z0yywww                   | <p>Error of a system function:</p> <ul style="list-style-type: none"> <li>during startup (z = 1)</li> <li>during normal operation (z = 0)</li> </ul> <p>System functions with subordinate use are coded in yy: See table with error codes.<br/>www specifies the RET_VAL of the system function. The error information is available in the help for the system function.</p> |
| z0yy0000                  | <p>An error that does not originate in a system function. This error receives a consecutive error number yy.<br/>The error can occur:</p> <ul style="list-style-type: none"> <li>during startup (z = 1)</li> <li>during normal operation (z = 0)</li> </ul>                                                                                                                  |

**Table with error codes**

| Error code<br>(DW#16#...) | Meaning                                                                                                                                                             | Solution                                                                                                                                                                                                                                                 |
|---------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 00000000                  | No error.                                                                                                                                                           | —                                                                                                                                                                                                                                                        |
| 10010000                  | The assigned number of the digital output at the Channel input parameter is outside the permitted range (depending on addressed module and channel configuration).  | Correct the value at the Channel input parameter.                                                                                                                                                                                                        |
| 10020000                  | The TIO_DQ instruction is not called in an isochronous OB. The instruction can only be used without errors in an isochronous OB.                                    | Make sure that TIO_DQ is called in an OB of the type "Synchronous Cycle" or "MC-PostServo".                                                                                                                                                              |
| 10030000                  | An error occurred when reading the HWID input parameter.                                                                                                            | Check the value at the HWID input parameter. Specify the hardware identifier of the TIO module from its module properties in the hardware configuration. An internal system constant of data type Hw_SubModule is available for the symbolic addressing. |
| x0040000                  | The data in TIO_SYNC_Data is invalid/incorrect.                                                                                                                     | Check the TIO_SYNC instruction and the interconnection of its TIO_SYNC_Data output.                                                                                                                                                                      |
| 1005xxxx                  | An error has occurred during execution of the RD_SINFO system function. The low word xxxx displays the error information of the RET_VAL return value from RD_SINFO. | <ul style="list-style-type: none"> <li>Read the description of the RD_SINFO in the STEP 7 (TIA Portal) information system.</li> <li>Make sure that TIO_DQ is called in a "Synchronous Cycle" or "MC-PostServo" OB.</li> </ul>                            |



| Error code<br>(DW#16#...) | Meaning                                                                                                                                                                                                                                                                                                            | Solution                                                                                                                                                                                                                                                                  |
|---------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 10060000                  | No TIO module found.<br>Possible cause:<br>The module configured using the hardware identifier is not a TIO module.                                                                                                                                                                                                | <ul style="list-style-type: none"> <li>Make sure that the configured module is a TIO module.</li> <li>Check the value at the HWID input parameter. Specify the hardware identifier of the TIO module from its module properties in the hardware configuration.</li> </ul> |
| 10070000                  | An internal error occurred during the address calculation.                                                                                                                                                                                                                                                         | Check the value at the HWID input parameter. Specify the hardware identifier of the TIO module from its module properties in the hardware configuration. An internal system constant of data type Hw_SubModule is available for the symbolic addressing.                  |
| x0080000                  | TIO module is not synchronized using the TIO_SYNC instruction.<br>The error code can also indicate that: <ul style="list-style-type: none"> <li>A job was already present before the first run of the instruction.</li> <li>The assigned number at the Channel input parameter is not a digital output.</li> </ul> | Check the instruction TIO_SYNC.                                                                                                                                                                                                                                           |
| 10090000                  | The read cycle time of the isochronous OB is LT#0ms or has as negative value and is therefore invalid. Correct the value.<br>The instruction can only be used without errors in an isochronous OB.                                                                                                                 | <ul style="list-style-type: none"> <li>Correct the cycle time.</li> <li>Make sure that TIO_DQ is called in a "Synchronous Cycle" or "MC-PostServo" OB.</li> </ul>                                                                                                         |
| 100A0000                  | The time $T_0$ of the TIO model stored in TIO_SYNC_Data is outside the permissible range of $0 < T_0 \leq 4$ ms.                                                                                                                                                                                                   | Check the instruction TIO_SYNC.                                                                                                                                                                                                                                           |
| 100Bxxxx                  | An error has occurred during execution of the RD_ADDR system function. The low word xxxx displays the error information of the RET_VAL return value from RD_ADDR.                                                                                                                                                  | Read the description of the RD_ADDR in the STEP 7 (TIA Portal) information system.                                                                                                                                                                                        |
| 000C0000                  | One or both time stamps at the TimeStampRE and TimeStampFE input parameters are invalid. The error is only signaled for the duration of one application cycle.                                                                                                                                                     | Check the TimeStampRE and TimeStampFE input parameters.                                                                                                                                                                                                                   |
| 000D0000                  | The Quality Information of the digital output indicates that an error has occurred at the digital output.                                                                                                                                                                                                          | <ul style="list-style-type: none"> <li>Check the parameter assignment of the digital output.</li> <li>Check the supply voltage L+/1L+/2L+.</li> <li>Check the wiring of the digital output for short-circuit, overload, and overtemperature.</li> </ul>                   |
| 000E0000                  | The number configured at the Channel input parameter is not a digital output configured as Timer DQ.                                                                                                                                                                                                               | <ul style="list-style-type: none"> <li>Check the channel configuration (only for TM Timer DIDQ 16x24V).</li> <li>Check the operating mode of the digital output.</li> </ul>                                                                                               |
| 100F0000                  | The read cycle time of the OB of type "Synchronous Cycle" is too long: $T_{APP} > 16$ ms.                                                                                                                                                                                                                          | Configure a smaller multiple of the send clock as the cycle time.                                                                                                                                                                                                         |

| Error code<br>(DW#16#...) | Meaning                                                                                                                                                                                                                                                                                                                                                               | Solution                                                                                                                                                                                                                                                            |
|---------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 10100000                  | <p>The send clock is outside the permitted range of <math>0 &lt; \text{SEND\_CLOCK} \leq 4 \text{ ms}</math> and is therefore invalid.</p> <p>The error code can also indicate that</p> <ul style="list-style-type: none"> <li>The data in TIO_SYNC_Data is invalid or does not exist.</li> <li>The TIO_DQ instruction is not called in an isochronous OB.</li> </ul> | Correct the send clock.                                                                                                                                                                                                                                             |
| 00110000                  | The assigned value at the Out_Mode input parameter is outside the valid range of 0 to 3.                                                                                                                                                                                                                                                                              | Correct the value at the Out_Mode input parameter.                                                                                                                                                                                                                  |
| x0130000                  | MC-Servo (OB91) is not isochronous to the bus cycle time.                                                                                                                                                                                                                                                                                                             | <p>Correct the value of the cycle time of the MC-Servo to the value of the bus cycle time.</p> <p>Note:</p> <p>Calling TIO instructions in an OB of the type "MC-PostServo" with reduction ratio "MC-Servo" can result in incorrect calculation of time stamps.</p> |
| 10140000                  | The configured value at the HWID input parameter is not present in the structure at the TIO_SYNC_Data parameter. The HWID and TIO_SYNC_Data parameters are not consistent.                                                                                                                                                                                            | Correct the value at the HWID input parameter or the structure at the TIO_SYNC_Data parameter.                                                                                                                                                                      |
| x0FF0000                  | General internal error.                                                                                                                                                                                                                                                                                                                                               | —                                                                                                                                                                                                                                                                   |

### 4.3.5 UDT TIO\_SYNC\_Data

#### Description

The data type UDT TIO\_SYNC\_Data contains the central structure and data for synchronization of the modules and passing of the TIO\_Time.

#### Parameter

| Parameter     | Data type           | Description                                                                                     |
|---------------|---------------------|-------------------------------------------------------------------------------------------------|
|               | S7-1500             |                                                                                                 |
| TIO_TIME      | LTime               | Shared time basis (relative time) of the TIO modules                                            |
| PIP_MODE      | USInt               | Mode for data update (is forwarded by the PIP_Mode input parameter of the TIO_SYNC instruction) |
| APP_CYC       | LTime               | Application cycle of the "MC-PostServo" or "Synchronous Cycle", "MC-PreServo" OB                |
| SEND_CLOCK    | LTime               | Send clock of sync domain (is forwarded by the SendClock parameter of the TIO_SYNC instruction) |
| SYNC_MODULES  | HW_IO array [1...8] | Hardware identifiers of the TIO modules from hardware configuration                             |
| TO_TIMES      | UDInt-Array [1...8] | T <sub>O</sub> for each TIO module:                                                             |
| TIO_TIME_BASE | LTime               | Internal use                                                                                    |
| TBASE         | LTime               |                                                                                                 |
| ERROR         | Bool                |                                                                                                 |

# Index

## A

- Accuracy, (Jitter), 16
  - Calculating TIO\_Time, 23
- Application cycle, 22, 28, 58
- Application examples Time-based IO, 13

## C

- Call sequence, 28
- Cam controller, (Application examples Time-based IO)
- Clock reduction ratio, 21
- Configuration, (System environment)
  - Standard configuration, 24
- Configuration software, 19
- Conventions
  - Jitter, 3
  - TIO module, 3
  - TIO\_Time, 3
- CPU cycle time, 13
- Cycle time, 14

## D

- Data update, (PIP\_Mode)
- Default setting, 26
- Delay time, 22
- Determinism, (Predictability)
- Digital input
  - TIO\_DI, 36
  - TIO\_DI\_ONCE, 43
- Digital output
  - TIO\_DQ, 51
- Dosing, (Application examples Time-based IO)

## E

- Error codes
  - TIO\_DI, 40, 48
  - TIO\_DQ, 55
  - TIO\_SYNC, 34
- ET 200, 18, 25
  - TM Timer DIDQ, 18

## H

- Hardware requirements, 18

## I

- IPO model
  - Understanding IPO, 22
- Isochronous communication, 20

## J

- Jitter, 3, 23

## L

- Length measurement, (Application examples Time-based IO)

## M

- MC-PostServo, 21
- MC-PreServo, 21
- Modes, (PIP\_Mode)
  - Selecting the model of program editing, 21

## O

- OIP model
  - Understanding OIP, 23

## P

- PIP\_Mode, 58
  - Setting PIP\_Mode, 28
- Predictability, 15
- Process image partition
  - PIP, 28
  - PIP1, 25
- PROFINET, 19, 24, 25
  - Using PROFINET IRT, 20
- Programming, 28

## R

- Reproducibility, 13
- Response time, 16
  - Defined response times, (Application examples Time-based IO)
  - Minimum response time, 16

## S

- Scope, 3
- Send clock, 58
- Service & Support, 4
- SIMATIC functions, 20
- STEP 7, 19
- SYNC\_PI, 22
- SYNC\_PO, 22
- Synchronous Cycle, 28
  - Understanding TIO instructions, 21
- System environment, 17

## T

- TAPP, (Application cycle)
- Time behavior
  - Standard technology, 14
  - Time-based IO, 15
- Time-based IO
  - Setting Time-based IO, 25
  - Understanding SIMATIC functions, 20
  - Using the default setting, 26
- TIO instructions, 19
  - Listing TIO instructions, 27
  - TM Timer DIDQ, 19
- TIO module, 3, 19, 25
- TIO\_DI, 36
- TIO\_DI\_ONCE, 43
- TIO\_DQ, 51
- TIO\_SYNC, 31
  - Synchronized TIO modules, 21
- TIO\_Time, 3, 15, 27
  - TIO\_DI, 36
  - TIO\_DI\_ONCE, 43
  - TIO\_DQ, 51
  - TIO\_SYNC, 31
  - UDT "TIO\_SYNC\_Data", 58
  - Understanding TIO\_Time, 20

## U

- UDT "TIO\_SYNC\_Data", 58
- User program, (Synchronous Cycle)

## SIMATIC

### S7-1500, ET 200MP, ET 200SP, ET 200AL Designing interference-free controllers

Function Manual

#### Preface

---

Documentation guide

1

Basic information on  
electromagnetic compatibility

2

Interference-free cable  
routing

3

Cable shielding

4

Equipotential bonding

5

Special measures for  
interference-free operation

6

Lightning protection and  
overvoltage protection

7

## Legal information

### Warning notice system

This manual contains notices you have to observe in order to ensure your personal safety, as well as to prevent damage to property. The notices referring to your personal safety are highlighted in the manual by a safety alert symbol, notices referring only to property damage have no safety alert symbol. These notices shown below are graded according to the degree of danger.

|                                                                                                        |
|--------------------------------------------------------------------------------------------------------|
|  <b>DANGER</b>        |
| indicates that death or severe personal injury <b>will</b> result if proper precautions are not taken. |
|  <b>WARNING</b>       |
| indicates that death or severe personal injury <b>may</b> result if proper precautions are not taken.  |
|  <b>CAUTION</b>       |
| indicates that minor personal injury can result if proper precautions are not taken.                   |
| <b>NOTICE</b>                                                                                          |
| indicates that property damage can result if proper precautions are not taken.                         |

If more than one degree of danger is present, the warning notice representing the highest degree of danger will be used. A notice warning of injury to persons with a safety alert symbol may also include a warning relating to property damage.

### Qualified Personnel

The product/system described in this documentation may be operated only by **personnel qualified** for the specific task in accordance with the relevant documentation, in particular its warning notices and safety instructions. Qualified personnel are those who, based on their training and experience, are capable of identifying risks and avoiding potential hazards when working with these products/systems.

### Proper use of Siemens products

Note the following:

|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |
|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|  <b>WARNING</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                   |
| Siemens products may only be used for the applications described in the catalog and in the relevant technical documentation. If products and components from other manufacturers are used, these must be recommended or approved by Siemens. Proper transport, storage, installation, assembly, commissioning, operation and maintenance are required to ensure that the products operate safely and without any problems. The permissible ambient conditions must be complied with. The information in the relevant documentation must be observed. |

### Trademarks

All names identified by ® are registered trademarks of Siemens AG. The remaining trademarks in this publication may be trademarks whose use by third parties for their own purposes could violate the rights of the owner.

### Disclaimer of Liability

We have reviewed the contents of this publication to ensure consistency with the hardware and software described. Since variance cannot be precluded entirely, we cannot guarantee full consistency. However, the information in this publication is reviewed regularly and any necessary corrections are included in subsequent editions.

# Preface

## Purpose of the documentation

This documentation will support you in installing and commissioning programmable controllers.

Correct configuration is essential for fault-free operation of programmable controllers.

## Basic knowledge required

The following knowledge is required in order to understand the documentation:

- General knowledge of automation technology
- Knowledge of the industrial automation system SIMATIC
- Knowledge of VDE (German Association for Electrical, Electronic and Information Technologies) and EC regulations
- Knowledge of the rules for installing controllers and switchgear

## Conventions

You should also pay particular attention to notes such as the one shown below:

---

### Note

A note contains important information on the product described in the documentation, on the handling of the product or on the section of the documentation to which particular attention should be paid.

---

## Scope of the documentation

This documentation is valid for all products of the product series SIMATIC S7-1500, ET 200MP, ET 200SP and ET 200AL.

The product series SIMATIC S7-1500, ET 200MP and ET 200SP are approved for IP20 degree of protection, i.e. the modules of these product series must be installed in a control cabinet.

The SIMATIC ET 200AL product series is approved for IP65/IP67 degree of protection, i.e. the modules need **not** be installed in a control cabinet.



## Changes compared to previous version

Changes / enhancements described in this manual, compared to the previous version (version 01/2013):

- Extension of the scope of validity to the distributed I/O system ET 200AL
- Supplement to the section Connection of the cable shielding for ET 200AL
- Components for lightning protection potential equalization amended

## Additional support

Additional information on SIMATIC products is available on the Internet. The associated documentation is also available on the Internet.

- The range of technical documentation for the individual SIMATIC products and automation systems can be found on the Internet (<http://www.siemens.com/simatic-tech-doku-portal>).
- The online catalog and the ordering system are available on the Internet (<http://mall.automation.siemens.com>).

## Security information

Siemens provides products and solutions with industrial security functions that support the secure operation of plants, solutions, machines, equipment and/or networks. They are important components in a holistic industrial security concept. With this in mind, Siemens' products and solutions undergo continuous development. Siemens recommends strongly that you regularly check for product updates.

For the secure operation of Siemens products and solutions, it is necessary to take suitable preventive action (e.g. cell protection concept) and integrate each component into a holistic, state-of-the-art industrial security concept. Third-party products that may be in use should also be considered. You can find more information about industrial security on the Internet (<http://www.siemens.com/industrialsecurity>).

To stay informed about product updates as they occur, sign up for a product-specific newsletter. You can find more information on the Internet (<http://support.automation.siemens.com>).

# Table of contents

|          |                                                                                   |           |
|----------|-----------------------------------------------------------------------------------|-----------|
|          | <b>Preface .....</b>                                                              | <b>3</b>  |
| <b>1</b> | <b>Documentation guide .....</b>                                                  | <b>6</b>  |
| <b>2</b> | <b>Basic information on electromagnetic compatibility .....</b>                   | <b>7</b>  |
| 2.1      | Overview of possible interference .....                                           | 7         |
| 2.2      | Coupling mechanisms .....                                                         | 8         |
| <b>3</b> | <b>Interference-free cable routing .....</b>                                      | <b>9</b>  |
| 3.1      | Classifying cables into cable categories .....                                    | 9         |
| 3.2      | Cable routing inside cabinets in buildings .....                                  | 11        |
| 3.3      | Cable routing outside cabinets and inside buildings .....                         | 11        |
| 3.4      | Cable routing outside buildings .....                                             | 12        |
| 3.5      | Underground cable routing .....                                                   | 13        |
| 3.6      | Bending radii and tensile strength of cables .....                                | 14        |
| <b>4</b> | <b>Cable shielding .....</b>                                                      | <b>15</b> |
| 4.1      | Connecting the cable shielding for S7-1500 and ET 200MP .....                     | 17        |
| 4.2      | Connecting the cable shielding for ET 200SP .....                                 | 19        |
| 4.3      | Connecting the cable shielding for ET 200AL .....                                 | 20        |
| 4.4      | Connecting the cable shield for bus cables .....                                  | 21        |
| 4.5      | Connecting the cable shield for other components .....                            | 22        |
| <b>5</b> | <b>Equipotential bonding .....</b>                                                | <b>23</b> |
| <b>6</b> | <b>Special measures for interference-free operation .....</b>                     | <b>25</b> |
| <b>7</b> | <b>Lightning protection and overvoltage protection .....</b>                      | <b>26</b> |
| 7.1      | What is lightning and overvoltage protection? .....                               | 26        |
| 7.2      | Lightning protection zone concept .....                                           | 27        |
| 7.3      | Rules and components for the transitions between lightning protection zones ..... | 29        |
|          | <b>Index .....</b>                                                                | <b>37</b> |

# Documentation guide

## Introduction

The documentation of the SIMATIC products has a modular structure and covers diverse topics concerning your automation system.

The complete documentation for the S7-1500, ET 200SP, ET 200MP and ET 200AL systems consists of the respective system manuals, function manuals and product manuals.

The STEP 7 information system (online help) also supports you when configuring and programming your automation system.

## Overview of documentation on the subject of designing interference-free controllers

The following table lists additional documentation which supplements this description of designing interference-free controllers.

Table 1- 1 Documentation on the subject of designing interference-free controllers

| Topic              | Documentation                                                                                                                                                                             | Most important contents                                                                                                                     |
|--------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------|
| System description | System manual<br>S7-1500 Automation System<br>( <a href="http://support.automation.siemens.com/WW/view/en/59191792">http://support.automation.siemens.com/WW/view/en/59191792</a> )       | <ul style="list-style-type: none"> <li>• Application planning</li> <li>• Installation</li> <li>• Wiring</li> <li>• Commissioning</li> </ul> |
|                    | System manual<br>ET 200SP Distributed I/O System<br>( <a href="http://support.automation.siemens.com/WW/view/en/58649293">http://support.automation.siemens.com/WW/view/en/58649293</a> ) |                                                                                                                                             |
|                    | System Manual<br>ET 200MP Distributed I/O System<br>( <a href="http://support.automation.siemens.com/WW/view/en/59193214">http://support.automation.siemens.com/WW/view/en/59193214</a> ) |                                                                                                                                             |
|                    | System manual<br>Distributed I/O System ET 200AL<br>( <a href="http://support.automation.siemens.com/WW/view/en/89254965">http://support.automation.siemens.com/WW/view/en/89254965</a> ) |                                                                                                                                             |

## SIMATIC manuals

All current manuals for SIMATIC products are available for download free of charge from the Internet (<http://www.siemens.com/automation/service&support>).

# Basic information on electromagnetic compatibility

# 2

## 2.1 Overview of possible interference

### Introduction

SIMATIC products and their components have been developed for use in industrial environment and meet the legal EMC requirements (EMC - Electromagnetic Compatibility). However, you still need to conduct an EMC assessment before installing your controller in order to identify possible sources of interference and to include these in your considerations.

### Electromagnetic compatibility

Electromagnetic compatibility describes the ability of an electrical device to function properly in its particular electromagnetic environment. Neither the environment itself nor the electrical device are influenced in an unacceptable manner.

### Possible interference

Electromagnetic interference can influence an automation system in various ways. The most significant interferences and their causes are as follows:

- Electromagnetic fields having a direct influence on the system
- Interference coupling caused by bus signals (for example, PROFINET)
- Interference influencing the system via the process wiring
- Interference which reaches the system via the power supply and/or protective ground

The figure below shows the likely paths of electromagnetic interference.

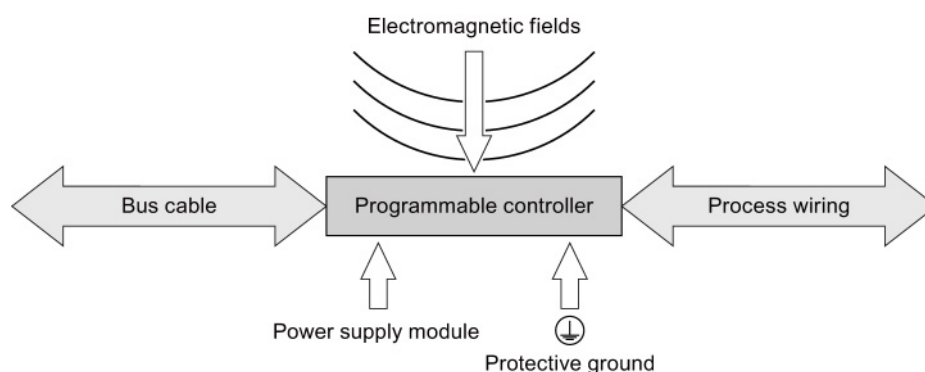


Figure 2-1 Electromagnetic interference

## 2.2 Coupling mechanisms

Depending on the emitting medium and the distance between the source of interference and the device, interference can reach the automation system via four different coupling mechanisms.

The following table shows possible causes and typical sources of interference for the various coupling mechanisms:

Table 2- 1 Coupling mechanisms

| Coupling mechanism  | Cause                                                                                                                                | Typical sources of interference                                                                                                                                                                                                                                         |
|---------------------|--------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Galvanic coupling   | Two electric circuits share the same cable                                                                                           | <ul style="list-style-type: none"> <li>• Clocked devices (influence on the network due to converters and third-party power supply units)</li> <li>• Starting motors</li> <li>• Potential differences on component enclosures with shared power supply</li> </ul>        |
| Capacitive coupling | Potential difference between conductors                                                                                              | <ul style="list-style-type: none"> <li>• Interference coupling due to parallel routing of signal cables</li> <li>• Static discharge of the operator</li> </ul>                                                                                                          |
| Inductive coupling  | Mutual influencing of current-carrying conductor loops. The magnetic fields caused by the current flow induce interference voltages. | <ul style="list-style-type: none"> <li>• Transformers, motors, electrical welding equipment</li> <li>• Power supply cables routed in parallel</li> <li>• Cables whose currents are switched</li> <li>• High-frequency signal cables</li> <li>• Unwired coils</li> </ul> |
| Radiation coupling  | Effect of an electromagnetic wave on a cable configuration. This wave induces currents and voltages.                                 | <ul style="list-style-type: none"> <li>• Neighboring transmitters (for example, walkie-talkies)</li> <li>• Spark gaps (spark plugs, collectors of electrical motors, welding devices)</li> </ul>                                                                        |

## Interference-free cable routing

This chapter describes the EMC-compatible classification of cables and cable routing for bus, data, signal and supply lines.

### 3.1 Classifying cables into cable categories

Classify the cables into cable categories according to their sensitivity to interference coupling and interference emission. The further away from one another cables of different cable categories are installed, the lower the mutual influence by capacitive and inductive coupling.

The following table shows the cable categories into which you can classify your cables accordingly.

Table 3- 1 Cable categories

|            |                                                                                                                                                                                                                                                             |
|------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Category A | <ul style="list-style-type: none"> <li>• Signal lines to I/O modules</li> <li>• Bus and data lines (for example, PROFIBUS, PROFINET)</li> <li>• Lines to HMI devices</li> <li>• Supply lines for extra-low voltages (&lt; 24V DC or &lt; 60V AC)</li> </ul> |
| Category B | <ul style="list-style-type: none"> <li>• Supply lines with safe electrical isolation (SELV)</li> <li>• Supply voltages &lt; 400 V</li> </ul>                                                                                                                |
| Category C | <ul style="list-style-type: none"> <li>• Supply voltages &gt; 400 V</li> </ul>                                                                                                                                                                              |

## 3.1 Classifying cables into cable categories

The following table shows the minimum clearance you must maintain when installing cables.

Table 3- 2 Combination of cable categories

|            | Category A                                                                                                                                                                                                     | Category B                                                                                                               | Category C                                                                                                                                                                                                     |
|------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Category A | <ul style="list-style-type: none"> <li>In common bundles or cable channels</li> </ul>                                                                                                                          | <ul style="list-style-type: none"> <li>In separate bundles or cable channels (no minimum clearance necessary)</li> </ul> | <ul style="list-style-type: none"> <li>Inside cabinets in separate bundles or cable channels</li> <li>Outside cabinets, but inside buildings, on separate cable racks with at least 10 cm clearance</li> </ul> |
| Category B | <ul style="list-style-type: none"> <li>In separate bundles or cable channels (no minimum clearance necessary)</li> </ul>                                                                                       | <ul style="list-style-type: none"> <li>In common bundles or cable channels</li> </ul>                                    |                                                                                                                                                                                                                |
| Category C | <ul style="list-style-type: none"> <li>Inside cabinets in separate bundles or cable channels</li> <li>Outside cabinets, but inside buildings, on separate cable racks with at least 10 cm clearance</li> </ul> |                                                                                                                          | <ul style="list-style-type: none"> <li>In common bundles or cable channels</li> </ul>                                                                                                                          |

If you install different cable categories in the same cable channel, use metallic cable channels with metallic partition.

The following figure show a schematic view of a cable channel with partition.

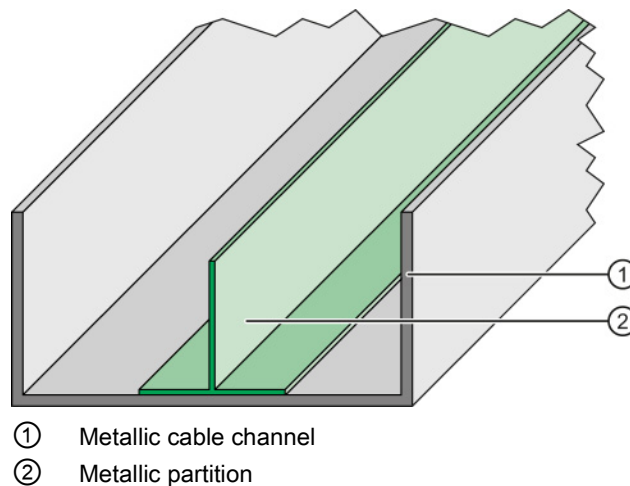


Figure 3-1 Cable channel with partition

## 3.2 Cable routing inside cabinets in buildings

### Rule

Observe the following rules for proper cable routing inside of control cabinets:

- If a crossing of cables is unavoidable, then cross the cables at an angle of 90°, if possible, in order to keep interference from electrical fields as low as possible.
- Do not route cables coming into the cabinet from outside parallel to the shield supports.

## 3.3 Cable routing outside cabinets and inside buildings

### Rule

Observe the following rules for proper cable routing outside control cabinets and inside buildings:

- Read the information in section Assigning cables to cable categories (Page 9).
- If you route the cables in metallic cable channels, you can rearrange the cable channels next to each other.
- Connect metallically conductive cable racks to the potential equalization of the building.
- If a crossing of cables is unavoidable, then cross the cables at an angle of 90°, if possible, in order to keep interference from electrical fields as low as possible.



## **3.4 Cable routing outside buildings**

If possible, lay the cables outside buildings on metallic cable holders. Connect the cable holder joints galvanically to each other and ground the cable holders.

### **Rule**

Observe the following rules when laying cables outside of buildings:

- Use metallic auxiliary terminal boxes to connect cables coming from outside at the junction to cables inside the building. Ground these boxes.
- If a crossing of cables is unavoidable, then cross the cables at an angle of 90°, if possible, in order to keep interference from electrical fields as low as possible.
- Integrate bus cables installed outside of buildings into your lightning and overvoltage concept.

### **Lightning protection**

When you lay cables for SIMATIC devices outside of buildings, you have to take internal and external lightning protection measures.

### **Reference**

For additional information about lightning protection, refer to chapter Lightning protection and overvoltage protection (Page 26).

## 3.5 Underground cable routing

### Rule

Observe the following rules for underground cable routing:

- Lay the cable at least 60 cm below the ground surface.
- Install equipotential bonding approximately 20 cm above the cable. You can use a zinc-plated ground strip, for example. The ground strips also serve as protection against lightning strikes.
- Protect the cable against mechanical damage by, for example, using a plastic pipe and/or a cable warning tape in the ground, approximately 40 cm above the cable.
- Separate the various cable categories in the ground using cable channels, for example.

The following figure shows the arrangement of cable warning tape, equipotential bonding and a cable.

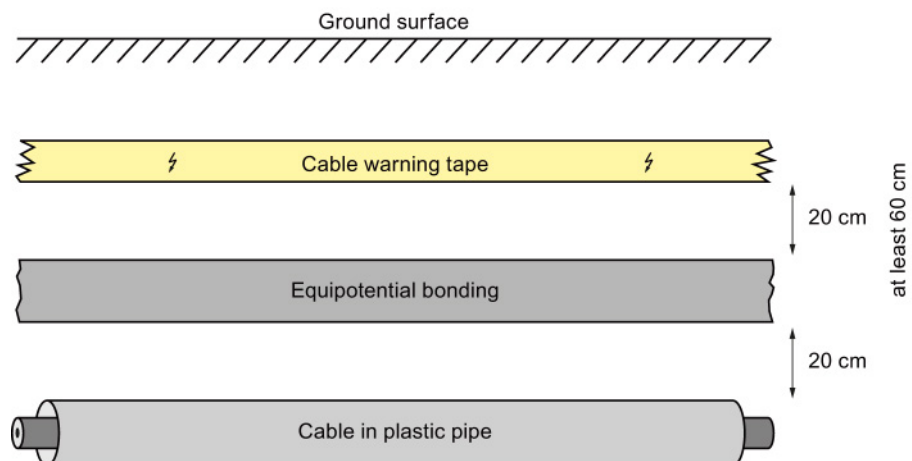


Figure 3-2 Arrangement underground

### Lightning protection

When you lay cables for SIMATIC devices outside of buildings, you have to take internal and external lightning protection measures.

### Reference

For additional information about lightning protection, refer to chapter Lightning protection and overvoltage protection (Page 26).

## **3.6 Bending radii and tensile strength of cables**

### **Tensile strain**

A high strain on the cables due to tensile forces leads to conductor material flow. The tensile forces thus cause a change in the structure of the material and lower the conductor cross-section. This decrease of the conductor cross-section leads, in turn, to a heating of the conductor and premature wear of the conductor insulation.

Use the supplied cable ties to relieve the terminal points on the plugs for the I/O modules of the product series SIMATIC S7-1500 and SIMATIC ET 200MP.

### **Bending radius**

If you select too small bending radii when laying cables, this will cause the materials to stretch and compress and changes the mechanical structure of the cables. The electrical properties are impaired as a result.

Pay particular attention to the bending radii of fiber-optic cables. If the bending radii are too small, the optical properties of the fiber-optic cable are adversely affected. Reliable transmission is no longer guaranteed.

## Cable shielding

Shielding is a measure to attenuate (dampen) magnetic, electrical or electromagnetic interference fields.

Interference currents on cable shields are diverted from the shield connection to ground. To avoid interference as a result of these currents, it is imperative to provide a low-impedance connection to the protective conductor.

### Rules

Ideally, you should use cables equipped with a protective braided shield. The shield's contacting must be more than 80% at the contact point. Avoid tensile and compression strain on cables with a foil shield. This type of strain can damage the foil shield very slightly at the fastening point. The result is a reduced shielding effect.

### Shield connection with grounding at both ends

Always connect the cable shields to the ground at both ends. Low and high frequency interference can be reduced only by connecting both ends of the shield to the ground.

---

#### Note

##### Laying an additional equipotential bonding cable

Whenever potential differences develop between the grounding points, an equalizing current flows on a shielding that is connected at both ends. In this case, lay an additional equipotential bonding cable. You can find more information on this topic in the chapter Equipotential bonding (Page 23).

---

### Shield connection with capacitive grounding at one end

If you do not have the option of installing equipotential bonding (in plants covering a large area, for example), connect capacitive grounding to one end of your shield. In this case, only high-frequency interference will be reduced.

The following figure shows the capacitive grounding of a cable shield. The values indicated in the figure are indicative and will differ from system to system. The capacity diverts the high-frequency interference. This capacity provides high-impedance protection for the power frequency (50 or 60 Hz), thus preventing equalizing currents via the shield. A parallel switched high-impedance resistance prevents the capacity from loading a direct current.

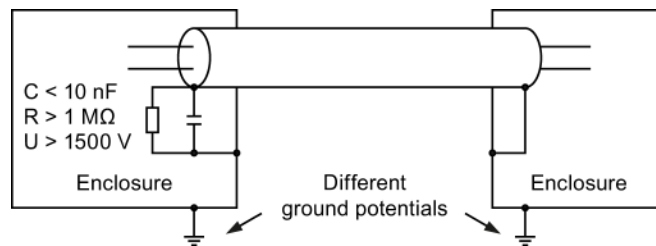


Figure 4-1 Capacitive grounding of the shield

## 4.1 Connecting the cable shielding for S7-1500 and ET 200MP

A special shield design has been developed for the automation system S7-1500 and the distributed I/O system ET 200MP for the shield connection of the signal lines. The connection element for the cable shield consists of a shield clamp and a shield terminal.

If the front connector is located in the module, the interference currents which occur are diverted by the connection element to the ground via the module and mounting rail.

The shield clamp is a pluggable mount for the analog and technology modules. The shield clamp allows the low-impedance application of cable shields with minimum installation times.

The following figure shows a front connector with mounted shield clamp and associated shield terminal.

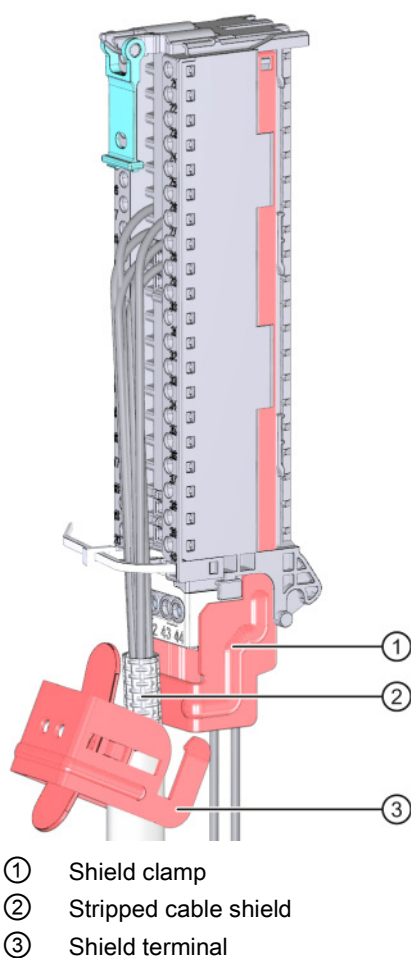


Figure 4-2 Shield clamp and shield terminal on front connector

The shield clamp is inserted from below onto the front connector until the shield clamp latches audibly. The shield terminal is fastened to the shield clamp.

### **Additional information**

For additional information on installing the shield clamp and shield terminal, refer to the "Connecting front connectors" chapter in the S7-1500 automation system (<http://support.automation.siemens.com/WW/view/en/59191792>) or ET 200MP Distributed I/O System (<http://support.automation.siemens.com/WW/view/en/59193214>) system manuals.

## 4.2 Connecting the cable shielding for ET 200SP

A special shield design has been developed for the shield connection of the signal lines of the ET 200SP distributed I/O system. The connection element for the cable shield consists of a shield terminal.

If the front connector is located in the module, the interference currents that occur are diverted by the connection element via BaseUnit and mounting rail to the ground.

The shield terminal is plugged into a mount of the BaseUnit. The shield terminal allows the low-impedance application of cable shields with minimum installation times. There is no need for the otherwise standard connection of the cable shield at the cabinet entry.

The following figure shows a BaseUnit with shield terminal and shield support.

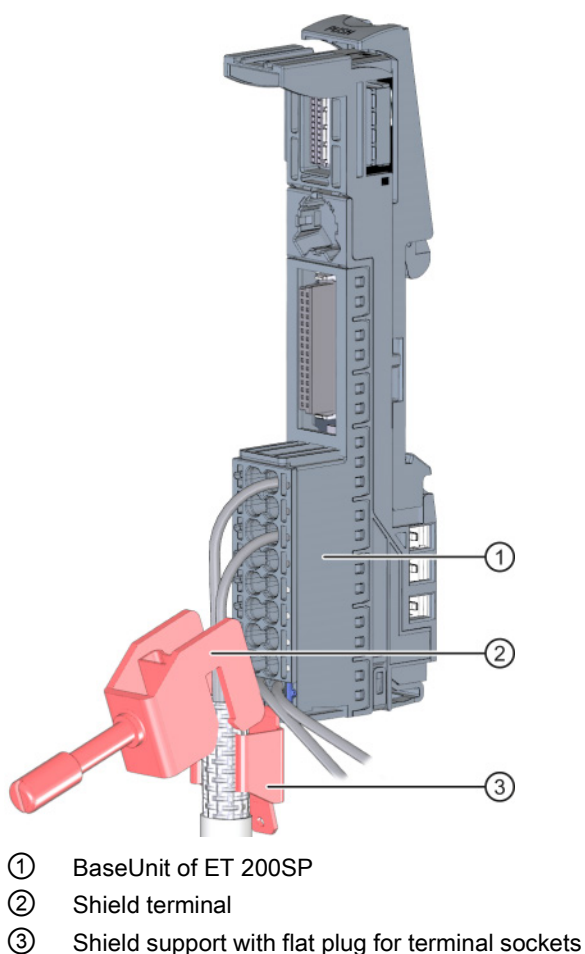


Figure 4-3 BaseUnit with shield terminal

### Additional information

For more information on mounting the shield terminal, refer to the "Connecting cable shields" chapter of the system manual ET 200SP Distributed I/O System (<http://support.automation.siemens.com/WW/view/en/58649293>).



## 4.3 Connecting the cable shielding for ET 200AL

Each module of the ET 200AL distributed I/O system features a functional ground connection.

Use only shielded cables for connection of analog signals, PROFINET and PROFIBUS signals and for the ET-Connection. If you have screwed the plug in correctly, the interference currents that occur are diverted to the metal parts and functional ground.

If you attach an ET 200AL module to a **conductive**, grounded base, the lower mounting bolt establishes a conductive connection to the earth potential.

If you attach an ET 200AL module to a **non-conductive** base, connect the lower mounting bolt to the ground wire at the same time.

The following figure shows how to connect the functional ground via a ground wire, using the IM 157-1 PN interface module as an example.

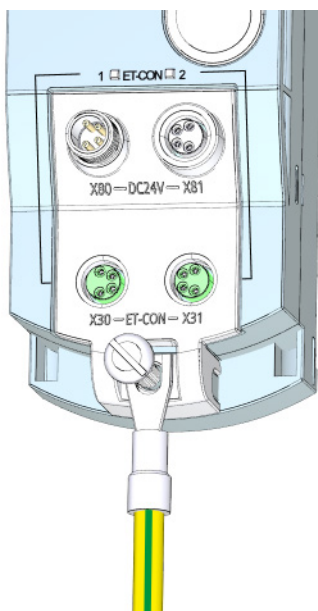


Figure 4-4 Connect functional ground via a ground wire

### Additional information

You can find more information on installing ET 200AL modules in the Installing Modules section of the system manual Distributed I/O System ET 200AL (<http://support.automation.siemens.com/WW/view/en/89254965>).

## 4.4 Connecting the cable shield for bus cables

In the S7-1500, ET 200MP and ET 200SP systems, the cable shields of PROFIBUS and PROFINET cables are connected to the existing bus connection elements. Cable shield and shield support are thus galvanically connected to each other. If the connector is plugged into the module, the coupled interferences are diverted via the module carrier to the ground. There is no need for the otherwise standard connection of the shield at the cabinet entry.

The following figure shows examples of the shield connection for various bus connection elements.

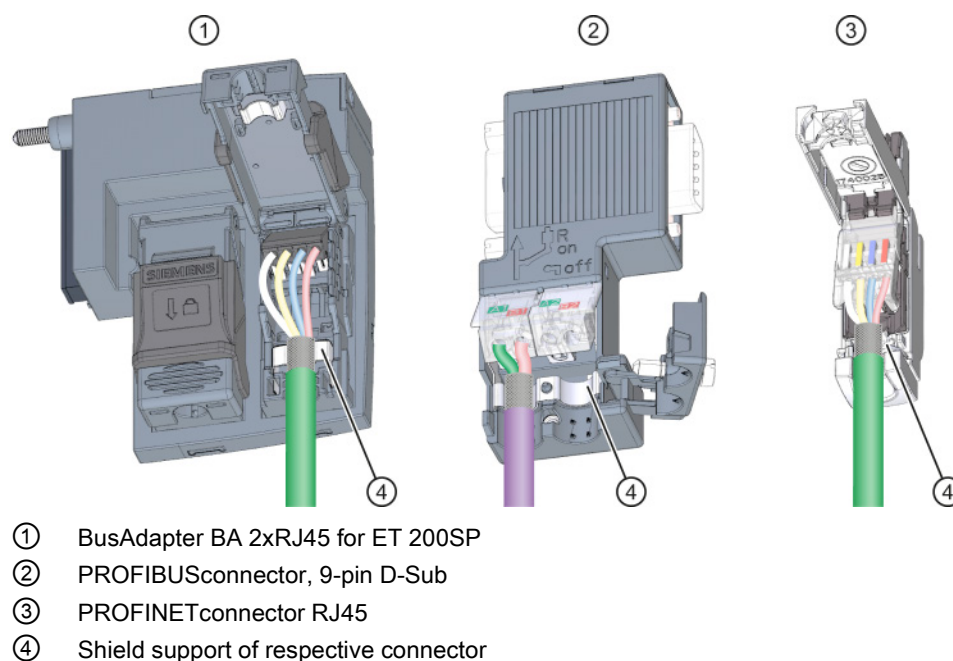


Figure 4-5 Shield connection for bus connection elements

## Reference

For more information on installing the connectors, refer to the "Connecting PROFINET IO BusAdapter BA 2xRJ45 to the interface module" chapter of the system manual ET 200SP Distributed I/O System (<http://support.automation.siemens.com/WW/view/en/58649293>) and to the supplied product information.

## 4.5 Connecting the cable shield for other components

The following procedures for connecting the shield to devices that do not have any special shield terminals have proven themselves in practice.

### Rule

Note the following points when handling the shield:

- Always use metal clamps to mount the protective braided shields of the cables. The clamps must cover a large area of the shield and provide appropriate contact force.
- Attach the shield to a shielding bus directly after the point where the cable enters the cabinet. If you route the shield further to the module, do not connect the shield again in front of the module, as this would create ground loops.

The following figure shows standard types of shield fastening.

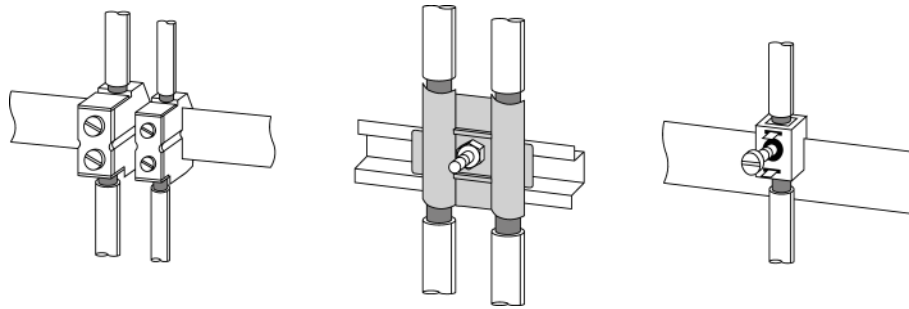


Figure 4-6 Cable shielding

# Equipotential bonding

## Definition according to DIN VDE 0100

Equipotential bonding is an electrical connection which brings the bodies of electrical equipment and external conductive parts to the same, or nearly the same, potential.

Equipotential bonding is divided into:

- Main equipotential bonding
- Additional local equipotential bonding

Both versions of equipotential bonding are of great importance not only for protection against electric shock, but also for EMC.

## Main equipotential bonding

Main equipotential bonding is required by DIN VDE 0100 Part 410 as a protective measure and is mandatory, regardless of other measures for protection against direct and indirect contact.

## Additional local equipotential bonding

Additional local equipotential bonding is required if:

- Unfavorable grounding conditions exist between plant parts due to different conductivity of the soil (for example, sandy or stony ground)
- Cables bridge a large distance
- Electrical energy is fed in from various power supplies (for example, in the case of multiple substations)
- Considerable electrical power is used (for example, welding robots, large drives)

## Measures

In such cases, an additional equipotential bonding cable between the individual potentials can solve the problem. The equipotential bonding cable must also be able to divert large currents and carry lightning stroke current. The following equipotential bonding systems have proven themselves in practice:

- 16 mm<sup>2</sup> for copper equipotential bonding cables up to 200 m long
- 25 mm<sup>2</sup> for copper equipotential bonding cables over 200 m long

To prevent ground loops, equipotential bonding cables are installed in parallel and, whenever possible, near to the signal/bus cable. This allows the area between the two cables to be kept as small as possible.

The following figure shows a schematic view of the installation of an equipotential bonding cable.

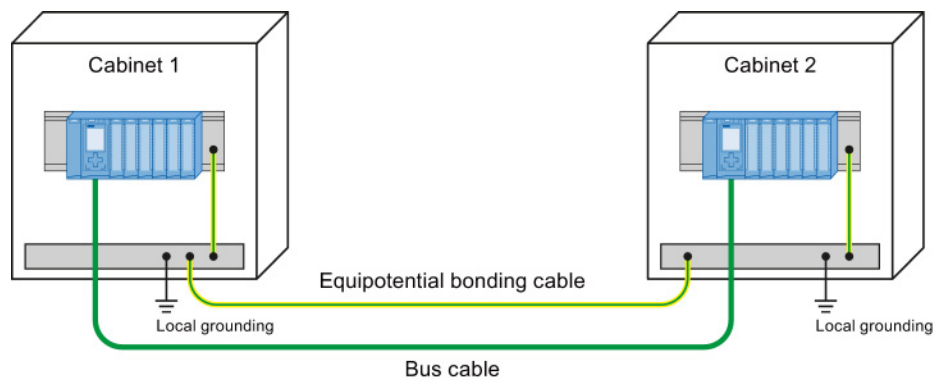


Figure 5-1 Installation of equipotential bonding cables

## Rule

Note the following issues regarding equipotential bonding:

- The lower the impedance of an equipotential bonding cable, the more effective is equipotential bonding. The impedance of the additionally installed equipotential bonding cable should not exceed 10% of the shield impedance.
- Connect the equipotential bonding cables to a large area of the grounding system.
- Protect the connection points against corrosion.
- Avoid ground loops.
- Install the equipotential bonding cables in such a way as to minimize the areas enclosed between the equipotential bonding cables and signal lines.

## Special measures for interference-free operation

### Connecting inductances to quenching elements

Ideally, the inductances (for example, contactor or relay coils) controlled by SIMATIC do not require any wiring to external quenching elements. The required quenching elements are already integrated into the modules.

If the SIMATIC output circuit can also be switched off by built-in contacts (such as relay contacts for EMERGENCY OFF), the module's integrated quenching elements are no longer effective. In this case, the inductances must be wired to quenching elements.

Wire inductances to freewheeling diodes, varistors or RC elements, for example.

Table 6- 1 Wiring inductances

| Wiring<br>DC-operated inductances |              | Wiring<br>AC-operated inductances |                 |
|-----------------------------------|--------------|-----------------------------------|-----------------|
| with diode                        | with Z diode | with varistor                     | with RC element |
|                                   |              |                                   |                 |

### Programming devices

Provide a socket in each cabinet for the supply of the programming devices. The sockets are supplied from the distribution board to which the protective conductor for the cabinet is also connected.

Observe the following points during the installation of the socket in the control cabinet:

- Include the grounding of the socket in your consideration of the equipotential bonding.
- The common star point of the two ground potentials (cabinet and socket) must be close to the two end points.
- An equipotential bonding cable is not permitted as communication cable between programming device and controller.

# Lightning protection and overvoltage protection

## 7.1 What is lightning and overvoltage protection?

### Introduction

The term "Lightning and overvoltage protection" covers both the concept and system for the protection of structural systems (such as buildings or electrical equipment). This concept also includes the protection of people and animals.

Overvoltages are most frequently caused by lightning strikes.

### Lightning protection system

The lightning protection system is the complete system used to reduce physical damage to a structural system as a result of direct lightning strikes and overvoltages. The lightning protection system is divided into external and internal lightning protection.

### External lightning protection

External lightning protection is part of the lightning protection system and comprises an interception device, an arrester and a grounding system. In the event of a lightning strike, the external lightning protection serves to divert the lightning current safely to the ground. This measure most frequently prevents fire damage.

### Internal lightning protection

Internal lightning protection is part of the lightning protection system and comprises lightning protection equipotential bonding and/or electrical isolation with respect to the external lightning protection. In the event of a lightning strike, the internal lightning protection reduces the damage caused by overvoltages resulting from the lightning.

Even at larger distances of up to 1.5 km, lightning strikes can sometimes still cause damage. You obtain effective lightning protection by expanding the external lightning protection into an overall protection system. This system includes equipotential bonding and surge protection devices.

## 7.2 Lightning protection zone concept

### Introduction

Each building requires a coordinated protection zone concept. The grading of the protection is of key importance for this. Sufficient protection can only be guaranteed if this grading requirement is satisfied.

The lightning protection zone concept described in the standards IEC 62305-4 and DIN EN 62305-4 is used for this purpose. The lightning protection zone concept groups devices and areas that have the same risk potential and can be wired to arresters of the same type.

Use overvoltage protection devices at the transitions of the lightning protection zones based on the requirements. Install the overvoltage protection devices at an appropriate location such as the main or sub-distribution board.

### Principle of the lightning protection zone concept

The principle behind the lightning protection zone concept is the division of the areas to be protected from overvoltages, for example buildings, into lightning protection zones based on EMC considerations.

### Schematic diagram of the lightning protection zone concept

The following is a schematic diagram of the lightning protection zone concept in a physical structure.

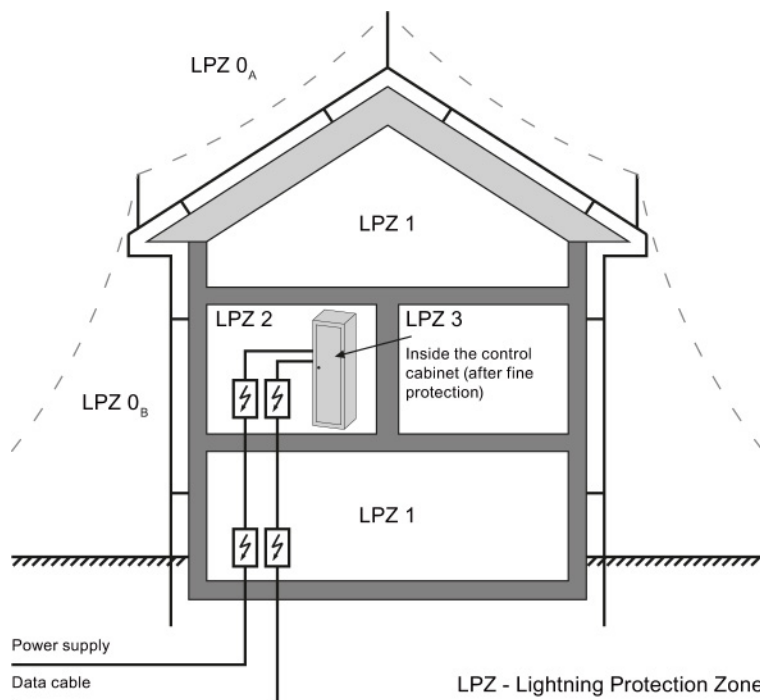


Figure 7-1 Division of a structural system into lightning protection zones



## Division of lightning protection zones

The various lightning protection zones (LPZ - Lightning Protection Zone) are limited spatially as follows and not necessarily by physical boundaries, such as walls or floors.

The following table explains the division into various lightning protection zones.

Table 7- 1 External and internal lightning protection zones

| Lightning protection zones           |                                                                                                                                                                                                                  |
|--------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| External lightning protection zones: |                                                                                                                                                                                                                  |
| LPZ 0 <sub>A</sub>                   | <ul style="list-style-type: none"><li>• Risk from direct lightning strikes</li><li>• Risk from the full electromagnetic field of the lightning</li></ul>                                                         |
| LPZ 0 <sub>B</sub>                   | <ul style="list-style-type: none"><li>• Protected against direct lightning strike</li><li>• Risk from the full electromagnetic field of the lightning</li></ul>                                                  |
| Internal lightning protection zones: |                                                                                                                                                                                                                  |
| LPZ 1                                | <ul style="list-style-type: none"><li>• Protected against direct lightning strike</li><li>• Attenuated electromagnetic field of the lightning</li></ul>                                                          |
| LPZ 2                                | <ul style="list-style-type: none"><li>• Protected against direct lightning strike</li><li>• Reduced leakage currents and electromagnetic fields compared to LPZ 1</li><li>• Protected terminal devices</li></ul> |
| LPZ 3                                | <ul style="list-style-type: none"><li>• Protected against direct lightning strike</li><li>• Protected area inside the terminal device</li><li>• Local equipotential bonding</li></ul>                            |

## Effects of the lightning strike

Direct lightning strikes occur in the lightning protection zone LPZ 0<sub>A</sub>. Effects of the lightning strike are high-energy lightning currents and strong electromagnetic fields. These effects are reduced from one lightning protection zone to the next through suitable lightning current or overvoltage arrester/shielding measures.

Frequent damage caused by lightning strikes includes:

- Injury to people and animals, which may in worst cases lead to death
- Damage to buildings
- Fire caused by strong heat development of a lightning strike

## Overvoltages

Electromagnetic fields of the lightning channel can be reduced with appropriate shielding measures. Overvoltages due to inductions can be reduced to a safe level starting in lightning protection zone LPZ 0<sub>B</sub> with overvoltage arresters.

## 7.3 Rules and components for the transitions between lightning protection zones

### Introduction

This chapter provides you with information on the rules for transitions between lightning protection zones. Measures must be taken to reduce the surge current load and the magnetic fields at the transitions between the lightning protection zones.

Each zone-penetrating metallic/electrical system is incorporated into the equipotential bonding at the zone transition.

The metallic systems include channels, structural parts, and pipes (for water, gas, and heat, for example).

Electrical systems include power and IT cables and wires (for example, power cables and bus cables).

### Transitions between lightning protection zones

Overvoltage protection must be provided at the transitions between lightning protection zones (LPZ - Lightning Protection Zone) in accordance with DIN EN 62305. The protection levels are defined at the transitions and implemented by means of overvoltage protection devices (SPD - Surge Protective Device).

- SPD Type 1 - Coarse protection for the transition from LPZ 0 to LPZ 1
- SPD Type 2 - Medium protection for the transition from LPZ 1 to LPZ 2
- SPD Type 3 - Fine protection for the transition from LPZ 2 to LPZ 3

The following figure illustrates the lightning protection zones and the type classes from the supply line to the consumer.

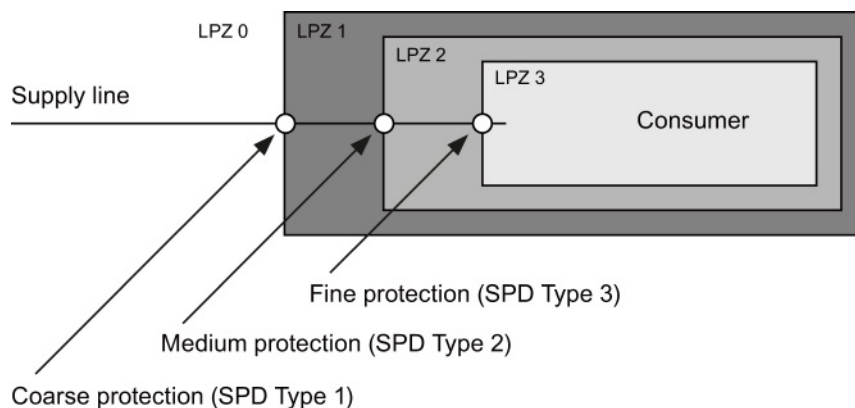


Figure 7-2 Lightning protection zone transitions

### Rule for transition from lightning protection zone 0<sub>A</sub> to 1

Lightning protection equipotential bonding is required at the transition from lightning protection zone 0<sub>A</sub> to 1. The following applies to the transition at the interface of lightning protection zone 0<sub>A</sub> to 1:

- Use of lightning arresters prevents introduction of partial lightning currents into structural systems
- Creation of local equipotential bonding at the transition of lightning protection zones, with incorporation of metallic supply systems (for example, pipes, air ducts, cable channels or cable ducts)

### Components for lightning protection equipotential bonding from lightning protection zone 0<sub>A</sub> to 1

The following table shows components for lightning protection equipotential bonding from lightning protection zone 0<sub>A</sub> to 1.

Table 7- 2 Components for transition from lightning protection zone 0<sub>A</sub> to 1

| Seq. no. | Cables for ...                                              | Connection at the 0 <sub>A</sub> interface to 1 with:                   |                |
|----------|-------------------------------------------------------------|-------------------------------------------------------------------------|----------------|
|          |                                                             | S7-1500/ET 200MP/ET 200SP/ET 200AL                                      | Article number |
| 1        | Three-phase TN-C system                                     | DEHNventil® DV M TNC 255                                                | 951 300        |
|          |                                                             | DEHNventil® DV M TNC 255 FM *                                           | 951 305 *      |
| 2        | Three-phase TN-S system                                     | DEHNventil® DV M TNS 255                                                | 951 400        |
|          |                                                             | DEHNventil® DV M TNS 255 FM *                                           | 951 405 *      |
| 3        | Three-phase TT system                                       | DEHNventil® DV M TT 255                                                 | 951 310        |
|          |                                                             | DEHNventil® DV M TT 255 FM *                                            | 951 315 *      |
| 4        | AC TN-S system                                              | DEHNventil® DV M TN 255                                                 | 951 200        |
|          |                                                             | DEHNventil® DV M TN 255 FM *                                            | 951 205 *      |
| 5        | AC TT system                                                | DEHNventil® DV M TT 2P 255                                              | 951 110        |
|          |                                                             | DEHNventil® DV M TT 2P 255 FM *                                         | 951 115 *      |
| 6        | Supply U <sub>N</sub> = 24 V DC                             | BLITZDUCTOR® XT, base section BXT BAS                                   | 920 300        |
|          |                                                             | BLITZDUCTOR® XT, module BXT ML2 B 180 (I <sub>L</sub> = 1.2 A) (2-wire) | 920 211        |
| 7        | Supply U <sub>N</sub> = 24 V DC                             | DEHNbloc® M, DB M 1 150                                                 | 961 110        |
|          |                                                             | DEHNbloc® M, DB M 1 150 FM *<br>(2 pieces required)                     | 961 115 *      |
| 8        | Bus cable MPI RS 485, RS 232 (V.24)                         | BLITZDUCTOR® XT, base section BXT BAS                                   | 920 300        |
|          |                                                             | BLITZDUCTOR® XT, module BXT ML2 B 180 (2-wire)                          | 920 211        |
| 9        | Inputs/outputs of digital modules U <sub>N</sub> = 24 V DC  | BLITZDUCTOR® XT, base section BXT BAS                                   | 920 300        |
|          |                                                             | BLITZDUCTOR® XT, module BXT ML4 B 180 (I <sub>L</sub> = 1.2 A) (4-wire) | 920 310        |
| 10       | Inputs/outputs of digital modules U <sub>N</sub> = 230 V AC | DEHNbloc® M, DB M 1 255                                                 | 961 120        |
|          |                                                             | DEHNbloc® M, DB M 1 255 *<br>(2 pieces required)                        | 961 125 *      |

| Seq. no.                                                                                                                                                                                                                                                                                                                                                                                            | Cables for ...                                           | Connection at the 0 <sub>A</sub> interface to 1 with:     |                |
|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------|-----------------------------------------------------------|----------------|
|                                                                                                                                                                                                                                                                                                                                                                                                     |                                                          | S7-1500/ET 200MP/ET 200SP/ET 200AL                        | Article number |
| 11                                                                                                                                                                                                                                                                                                                                                                                                  | Inputs/outputs of analog modules (e.g., 4-20 mA, 1-10 V) | BLITZDUCTOR® XT, base section BXT BAS                     | 920 300        |
|                                                                                                                                                                                                                                                                                                                                                                                                     |                                                          | BLITZDUCTOR® XT, module (I <sub>L</sub> = 1.2 A) (4-wire) | 920 310        |
| <p>* Version with remote indication contact</p> <p>Components of the series BLITZDUCTOR® XT can be remotely monitored with the appropriate accessories. Additional information is available on the Internet (<a href="http://www.dehn.de">http://www.dehn.de</a>)</p> <p><b>Components can be ordered directly from:</b><br/>DEHN+SÖHNE GMBH+CO.KG.<br/>Hans-Dehn-Straße 1<br/>D-92318 Neumarkt</p> |                                                          |                                                           |                |

### Rule for the transition from lightning protection zone 0<sub>B</sub> to 1, 1 to 2, or 2 to 3

The transition from lightning protection zone 0<sub>B</sub> to 1, 1 to 2, or 2 to 3 prevents strong electromagnetic coupling and serves as overvoltage protection. The following applies to the transition at the interface from lightning protection zone 0<sub>B</sub> to 1, 1 to 2, or 2 to 3:

- Use of power cables with surge current-carrying cable shields or twisted-pair IT cables
- Laying cables and lines
  - In continuous, surge current-carrying metal pipes that are grounded at both ends
  - In reinforced concrete channels capable of carrying surge current with grounding at both ends
  - On closed metal cable racks that are grounded at the beginning and end
- Use of fiber-optic cables without a metal shield if such a transmission is intended
- Creation of local equipotential bonding at the transition of lightning protection zones, with incorporation of metallic supply systems (for example, pipes, air ducts, cable channels or cable ducts)

### Additional measures

If the actions listed above cannot be implemented, protection by means of overvoltage arresters must be provided. The following sections contain tables with overvoltage arresters that are very suitable for protecting the plant.

### Components for lightning protection equipotential bonding from lightning protection zone 0<sub>B</sub> to 1 and 1 to 2

The following table shows components for lightning protection equipotential bonding from lightning protection zone 0<sub>B</sub> to 1 and 1 to 2.

Table 7- 3 Components for transition from lightning protection zone 0<sub>B</sub> to 1 and 1 to 2

| Seq. no. | Cables for ...                                              | Connection at the 0 <sub>B</sub> interface to 1 with:    |                |
|----------|-------------------------------------------------------------|----------------------------------------------------------|----------------|
|          |                                                             | S7-1500/ET 200MP/ET 200SP/ET 200AL                       | Article number |
| 1        | Three-phase TN-C system                                     | DEHNguard® DG M TNC 275                                  | 952 300        |
|          |                                                             | DEHNguard® DG M TNC 275 FM *                             | 952 305 *      |
| 2        | Three-phase TN-S system                                     | DEHNguard® DG M TNS 275                                  | 952 400        |
|          |                                                             | DEHNguard® DG M TNS 275 FM *                             | 952 405 *      |
| 3        | Three-phase TT system                                       | DEHNguard® DG M TT 275                                   | 952 310        |
|          |                                                             | DEHNguard® DG M TT 275 FM *                              | 952 315 *      |
| 4        | AC TN-S system                                              | DEHNguard® DG M TN 275                                   | 952 200        |
|          |                                                             | DEHNguard® DG M TN 275 FM *                              | 952 205 *      |
| 5        | AC TT system                                                | DEHNguard® DG M TT 2P 275                                | 952 110        |
|          |                                                             | DEHNguard® DG M TT 2P 275 FM *                           | 952 115 *      |
| 6        | Supply U <sub>N</sub> = 24 V DC                             | BLITZDUCTOR® VT, BVT AVD 24                              | 918422         |
| 7        | Bus cable MPI/DP RS 485                                     | BLITZDUCTOR® XT, base section BXT BAS                    | 920 300        |
|          |                                                             | BLITZDUCTOR® XT, module BXT ML2 BD HFS 5                 | 920 271        |
| 8        | Bus cable RS 232 (V.24)                                     | BLITZDUCTOR® XT, base section BXT BAS                    | 920 300        |
|          |                                                             | BLITZDUCTOR® XT, module BXT ML2 BE S 12                  | 920 222        |
| 9        | Industrial Ethernet                                         | DEHNpatch® DPA M CLE RJ45B 48                            | 929 121        |
| 10       | Inputs of digital modules U <sub>N</sub> = 24 V DC          | DEHNconnect® RK, DCO RK E 60 (I <sub>L</sub> = 0.5 A)    | 919 990        |
| 11       | Outputs of digital modules U <sub>N</sub> = 24 V DC         | DEHNconnect® RK, DCO RK D 5 24 (I <sub>L</sub> = 10.0 A) | 919 986        |
| 12       | Inputs/outputs of digital modules U <sub>N</sub> = 230 V AC | DEHNguard® DG S 275                                      | 952 070        |
|          |                                                             | DEHNguard® DG S 275 FM *                                 | 952 090 *      |
|          |                                                             | N-PE arrester in the TT system                           |                |
|          |                                                             | DEHNgap® C S, DGP C S                                    | 952 030        |
|          |                                                             | DEHNgap® C S, DGP C S FM *                               | 952 035 *      |
| 13       | Inputs/outputs of analog modules (e.g., 4-20 mA, 1-10 V)    | DEHNconnect® RK, DCO RK E 60 (I <sub>L</sub> = 0.5 A)    | 919 990        |

7.3 Rules and components for the transitions between lightning protection zones

| Seq. no.                                                                                                                                                                                                                                                                                                                                                                                               | Cables for ...                                    | Connection at the 0 <sub>B</sub> interface to 1 with: |                |
|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------|-------------------------------------------------------|----------------|
|                                                                                                                                                                                                                                                                                                                                                                                                        |                                                   | S7-1500/ET 200MP/ET 200SP/ET 200AL                    | Article number |
| 14                                                                                                                                                                                                                                                                                                                                                                                                     | Inputs/outputs of the fail-safe modules (24 V DC) | DEHNconnect® RK, DCO RK D 5 24                        | 919 986        |
| <p>* Version with remote indication contact</p> <p>Components of the series BLITZDUCTOR® XT can be remotely monitored with the appropriate accessories. Additional information is available on the Internet (<a href="http://www.dehn.de">http://www.dehn.de</a>)</p> <p><b>Components can be ordered directly from:</b><br/> DEHN+SÖHNE GMBH+CO.KG.<br/> Hans-Dehn-Straße 1<br/> D-92318 Neumarkt</p> |                                                   |                                                       |                |

### Components for lightning protection equipotential bonding from lightning protection zone 2 to 3

The following table shows components for lightning protection equipotential bonding from lightning protection zone 2 to 3 that you can use for S7-1500/ET 200MP and ET 200SP.

Table 7- 4 Components for transition from lightning protection zone 2 to 3 (for S7-1500/ET 200MP and ET 200SP)

| Seq. no. | Cables for ...                                     | Connection at the interface 2 to 3 with:             |                |                                                       |                |
|----------|----------------------------------------------------|------------------------------------------------------|----------------|-------------------------------------------------------|----------------|
|          |                                                    | S7-1500/ET 200MP                                     | Article number | ET 200SP                                              | Article number |
| 1        | Three-phase TN-S, TT system                        | DEHNrail® DR M 4P 255                                | 953 400        | DEHNguard® DG M TNS 275                               | 952 400        |
|          |                                                    |                                                      |                | DEHNguard® DG MOD 275                                 | 952 010        |
|          |                                                    | DEHNrail® DR M 4P 255 FM * (I <sub>L</sub> = 25.0 A) | 953 405 *      | DEHNguard® DG M TT 275                                | 952 310        |
|          |                                                    |                                                      |                | DEHNguard® DG MOD 275                                 | 952 010        |
|          |                                                    |                                                      |                | DEHNguard® DG MOD NPE                                 | 952 050        |
| 2        | AC TN-S, TT system                                 | DEHNrail® DR M 2P 255                                | 953 200        | DEHNguard® DG M TN 275                                | 952 200        |
|          |                                                    |                                                      |                | DEHNguard® DG MOD 275                                 | 952 010        |
|          |                                                    | DEHNrail® DR M 2P 255 FM * (I <sub>L</sub> = 25.0 A) | 953 205 *      | DEHNguard® DG M TT 2P 275                             | 952 110        |
|          |                                                    |                                                      |                | DEHNguard® DG MOD 275                                 | 952 010        |
|          |                                                    |                                                      |                | DEHNguard® DG MOD NPE                                 | 952 050        |
| 3        | Supply U <sub>N</sub> = 24 V DC                    | BLITZDUCTOR® VT, BVT AVD 24                          | 918 422        | BLITZDUCTOR® VT, BVT AVD 24 ® VT                      | 918 422        |
| 4        | Bus cable MPI/DP RS 485                            | BLITZDUCTOR® XT, base section BXT BAS                | 920 300        | ---                                                   | ---            |
|          |                                                    | BLITZDUCTOR® XT, module BXT ML2 BD HFS 5             | 920 271        | ---                                                   | ---            |
| 5        | Bus cable RS 232 (V.24)                            | BLITZDUCTOR® XT, base section BXT BAS                | 920 300        | ---                                                   | ---            |
|          |                                                    | BLITZDUCTOR® XT, module BXT ML2 BE S 12              | 920 222        | ---                                                   | ---            |
| 6        | Industrial Ethernet                                | DEHNpatch® DPA M CLE RJ45B 48                        | 929 121        | ---                                                   | ---            |
| 7        | Inputs of digital modules U <sub>N</sub> = 24 V DC | DEHNconnect® RK, DCO RK E60 (I <sub>L</sub> = 0.5 A) | 919 990        | BLITZDUCTOR® XT, BXT ML4 BD 24 (I <sub>L</sub> < 1 A) | 920 344        |

7.3 Rules and components for the transitions between lightning protection zones

| Seq. no.                                                                                                                                                                                                                                                                                                                                                                                            | Cables for ...                                                 | Connection at the interface 2 to 3 with:                 |                |                                                              |                |
|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------|----------------------------------------------------------|----------------|--------------------------------------------------------------|----------------|
|                                                                                                                                                                                                                                                                                                                                                                                                     |                                                                | S7-1500/ET 200MP                                         | Article number | ET 200SP                                                     | Article number |
|                                                                                                                                                                                                                                                                                                                                                                                                     |                                                                |                                                          |                | BLITZDUCTOR® XT, base section BXT BAS (I <sub>L</sub> < 1 A) | 920 300        |
| 8                                                                                                                                                                                                                                                                                                                                                                                                   | Outputs of digital modules<br>U <sub>N</sub> = 24 V DC         | DEHNconnect® RK, DCO RK D 5 24 (I <sub>L</sub> = 10.0 A) | 919 986        | BLITZDUCTOR® XT, BXT ML4 BD 24 (I <sub>L</sub> < 1 A)        | 920 344        |
|                                                                                                                                                                                                                                                                                                                                                                                                     |                                                                |                                                          |                | BLITZDUCTOR® XT, base section BXT BAS (I <sub>L</sub> < 1 A) | 920 300        |
|                                                                                                                                                                                                                                                                                                                                                                                                     |                                                                |                                                          |                | DEHNconnect® SD2, DCO SD2 E 48 (I <sub>L</sub> < 10 A)       | 917 989        |
| 9                                                                                                                                                                                                                                                                                                                                                                                                   | Inputs/outputs of digital modules<br>U <sub>N</sub> = 230 V AC | DEHNguard® DG S 275                                      | 952 070        | DEHNguard® DG S 275                                          | 952 070        |
|                                                                                                                                                                                                                                                                                                                                                                                                     |                                                                |                                                          |                | DEHNguard® DG MOD 275                                        | 952 010        |
|                                                                                                                                                                                                                                                                                                                                                                                                     |                                                                | DEHNguard® DG S 275 FM *                                 | 952 090 *      | ---                                                          | ---            |
|                                                                                                                                                                                                                                                                                                                                                                                                     |                                                                | N-PE arrester in the TT system                           |                |                                                              |                |
|                                                                                                                                                                                                                                                                                                                                                                                                     |                                                                | DEHNgap® C S, DGP C S                                    | 952 030        | ---                                                          | ---            |
|                                                                                                                                                                                                                                                                                                                                                                                                     |                                                                | DEHNgap® C S, DGP C S FM *                               | 952 035 *      | ---                                                          | ---            |
| 10                                                                                                                                                                                                                                                                                                                                                                                                  | Inputs/outputs of analog modules (e.g., 4-20 mA, 1-10 V)       | DEHNconnect® RK, DCO RK E 60 (I <sub>L</sub> = 0.5 A)    | 919 990        | BLITZDUCTOR® XT, BXT ML4 BD 24 (I <sub>L</sub> < 1 A)        | 920 344        |
|                                                                                                                                                                                                                                                                                                                                                                                                     |                                                                |                                                          |                | BLITZDUCTOR® XT, base section BXT BAS (I <sub>L</sub> < 1 A) | 920 300        |
| 11                                                                                                                                                                                                                                                                                                                                                                                                  | Inputs/outputs of the fail-safe modules (24 V DC)              | ---                                                      | ---            | DEHNconnect® RK, DCO RK D 5 24                               | 919 986        |
|                                                                                                                                                                                                                                                                                                                                                                                                     |                                                                |                                                          |                | DEHNconnect® RK, DCO RK E 60                                 | 919 990        |
| <p>* Version with remote indication contact</p> <p>Components of the series BLITZDUCTOR® XT can be remotely monitored with the appropriate accessories. Additional information is available on the Internet (<a href="http://www.dehn.de">http://www.dehn.de</a>)</p> <p><b>Components can be ordered directly from:</b><br/>DEHN+SÖHNE GMBH+CO.KG.<br/>Hans-Dehn-Straße 1<br/>D-92318 Neumarkt</p> |                                                                |                                                          |                |                                                              |                |



*7.3 Rules and components for the transitions between lightning protection zones*

The following table shows components for lightning protection equipotential bonding from lightning protection zone 2 to 3 that you can use for ET 200AL.

Table 7- 5      Components for transition from lightning protection zone 2 to 3 (for ET 200AL)

| Seq.<br>no.                                                                                                                                                                                                                                                                                                                                         | Cables for ...                    | Connection at the interface 2 to 3 with: |                   |
|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------|------------------------------------------|-------------------|
|                                                                                                                                                                                                                                                                                                                                                     |                                   | ET 200AL                                 | Article<br>number |
| 1                                                                                                                                                                                                                                                                                                                                                   | Supply<br>$U_N = 24 \text{ V DC}$ | BLITZDUCTOR® VT, BVT AVD 24 ® VT         | 918 422           |
| <p>Components of the series BLITZDUCTOR® XT can be remotely monitored with the appropriate accessories. Additional information is available on the Internet (<a href="http://www.dehn.de">http://www.dehn.de</a>)</p> <p><b>Components can be ordered directly from:</b><br/>DEHN+SÖHNE GMBH+CO.KG.<br/>Hans-Dehn-Straße 1<br/>D-92318 Neumarkt</p> |                                   |                                          |                   |

# Index

## B

Bending radius, 14

## C

Cable shielding, 15

## E

Electromagnetic compatibility, 7

Electromagnetic interference, 7

EMC, 7

## I

Interference-free operation, 25

## L

Lightning protection

    Equipotential bonding, 30

    External, 26

    Internal, 26

    Overvoltage protection, 30, 31

Lightning protection zone concept, 27

Lightning protection zones, 29

    Definition, 28

## O

Overvoltage, 28

Overvoltage protection

    Components, 30, 32, 34

## T

Tensile strain, 14