SIEMENS

SIMATIC

S7-1500

CPU 1511C-1 PN (6ES7511-1CK00-0AB0)

Manual

Edition 09/2016

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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.

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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.

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Preface

Purpose of the documentation

This manual supplements the system manual of the S7-1500 automation system / ET 200MP distributed I/O system as well as the function manuals. This manual contains a description of the module-specific information. The system-related functions are described in the system manual. Cross-system functions are described in the function manuals.

The information provided in this manual and the system manual enables you to commission the CPU 1511C-1 PN.

Conventions

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)".

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.

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.

Customer is responsible to prevent unauthorized access to its plants, systems, machines and networks. Systems, machines and components should only be connected to the enterprise network or the internet if and to the extent necessary and with appropriate security measures (e.g. use of firewalls and network segmentation) in place.

Additionally, Siemens' guidance on appropriate security measures should be taken into account. For more information about industrial security, please visit (http://www.siemens.com/industrialsecurity).

Siemens' products and solutions undergo continuous development to make them more secure. Siemens strongly recommends to apply product updates as soon as available and to always use the latest product versions. 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).

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- **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

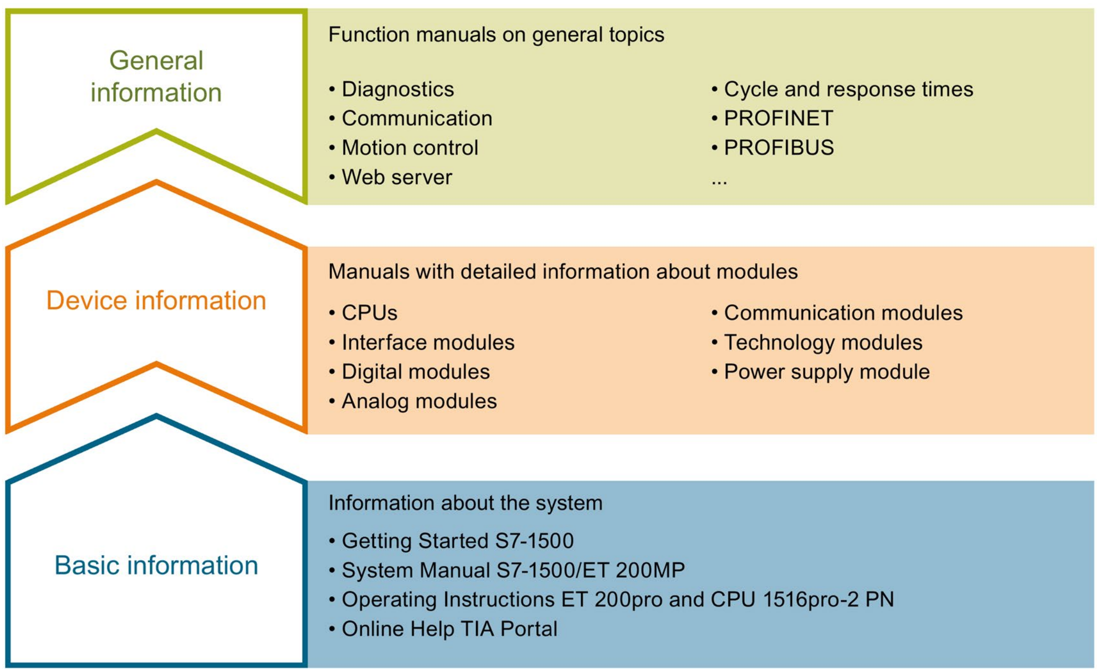
The Industry Mall is the catalog and order system of Siemens AG for automation and drive solutions on the basis of Totally Integrated Automation (TIA) and Totally Integrated Power (TIP).

Catalogs for all the products in automation and drives are available on the Internet (https://mall.industry.siemens.com).

Table of contents

1 Documentation guide

The documentation for the SIMATIC S7-1500 automation system, the CPU 1516pro-2 PN based on SIMATIC S7-1500 and the SIMATIC ET 200MP 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 S7-1500 and ET 200MP systems. For CPU 1516pro-2 PN you use the corresponding operating instructions. 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 S7-1500 and ET 200MP systems, e.g. diagnostics, communication, motion control, Web server, 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/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/68052815).

Manual Collection S7-1500/ET 200MP

The Manual Collection contains the complete documentation on the SIMATIC S7-1500 automation system and the ET 200MP 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/86140384).

SIMATIC S7-1500 comparison list for programming languages

The comparison list contains an overview of which instructions and functions you can use for which controller families.

You can find the comparison list on the Internet (https://support.industry.siemens.com/cs/ww/en/view/86630375).

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

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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 run commissioning and maintenance activities simultaneously on various SIMATIC S7 stations as a bulk operation independently of the TIA Portal.

The SIMATIC Automation Tool provides a multitude of functions:

- Scanning of a PROFINET/Ethernet 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
- Operating mode switchover RUN/STOP
- Localization of the CPU by means of LED flashing
- Reading out CPU error information
- Reading the CPU diagnostic buffer
- Reset to factory settings
- Updating the firmware 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

With SIEMENS PRONETA (PROFINET network analysis), you analyze the PROFINET network during commissioning. PRONETA features two core functions:

- The topology overview independently scans PROFINET 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).

Product overview 2

2.1 New functions in firmware version V2.0

New functions of the CPU in firmware version V2.0

This section lists the new features of the CPU with firmware version V2.0.

You can find additional information in the sections of this manual.

Table 2- 1 New functions of the CPU with firmware version 2.0 as compared to firmware version V1.8

New functions	Applications	Customer benefits
Support for pulse generators by digital on-board I/O of the compact CPU		
Pulse-width modulation (PWM) mode	The PWM mode is used when an output module is to control greatest possible outputs with low power loss (heating, size). You use pulse width modulation, for example, to control: • the temperature in a heating resistor • the force of a coil in a proportional valve and thus the position of a valve from closed to completely open • the speed of a motor from standstill to full speed	With pulse width modulation, a signal with defined cycle duration and variable on-load factor is output at the digital output. The on-load factor is the relationship of the pulse duration to the cycle duration. In PWM mode, you can control the on-load factor and the cycle duration. With pulse width modulation, you vary the mean value of the output voltage. Depending on the connected load, you can control the load current or the power with this.
Frequency output mode	You can implement frequencies up to 100 kHz and thus work in ranges that cannot be reached by a CPU with a simple digital output with a frequency up to 100 Hz.	You can generate frequencies very precisely. The receiver can reconstruct the information exactly when transmission conditions are less than ideal. In frequency output mode, you assign a frequency value with high frequencies more precisely than by using period duration (PWM).

New functions	Applications	Customer benefits
Mode Pulse Train Output (PTO)	Pulse Train Output is a widely used interface for drive control. It is used in many positioning applications, such as for retooling axes and feed axes.	PTO (Pulse Train Output) is divided into four different types of signals. The signal "PTO (pulse (A) and the direction (B))", for example, consists of 2 signals. The frequency of the pulse output represents the speed and the number of output pulses for the route to be traversed. The direction output defines the traversing direction. The position is thus specified precisely for the specific increment. The outputs are controlled with S7-1500 Motion Control via technology objects. PTO is a simple and universal interface between control system and drive. As a result, it is supported worldwide by many stepper and servo drives.
OPC UA Server	Data exchange is implemented between various systems, both within the process level and also with systems at the control and company management level: • To embedded systems with controllers • To controllers with MES systems and systems of the enterprise level (ERP, asset systems) • To Siemens controllers with controllers from other manufacturers • To intelligent sensors with controllers Supported standard: OPC Data Access, DA.	OPC UA is a uniform standard for data communication and is independent of any particular operating system platforms. You have integrated safety mechanisms on various automation systems, e.g. with data exchange, at application level, for the legitimation of the user. OPC UA servers provide a wide range of data: • Values of PLC tags that clients can access • Data types of these PLC tags • Information about the OPC UA server itself and about the CPU Clients can thus obtain an overview and read in specific values.
PROFINET IO		
MRPD: Media Redundancy for Planned Duplication for IRT	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.
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. You share the remaining bandwidth based on demand.
Display and Web server		
Backing up and restoring via the display	You can back up and restore the CPU configuration to/from the SIMATIC memory card without a programming device/PC.	You can make a backup copy of an operational project without STEP 7 (TIA Portal). In an "emergency", you can simply use an existing configuration without STEP 7 (TIA Portal), for example, during commissioning or after a program download.
Backing up and restoring via the Web server	Among other things, you can back up and restore the configuration of the CPU to the PG/PC on which the Web server is running.	

<table>
<tr><th>New functions</th><th>Applications</th><th>Customer benefits</th></tr>
<tr><td>Display and Web server provide up to three project languages for comments and message texts</td><td>When you export your plants worldwide, for example, comments or message texts can be stored on the card in up to 3 languages. For example, German - the language of the author, English - readable internationally, Portuguese - language of the end user.</td><td>You provide customers with better service.</td></tr>
<tr><td>Trace via Web server</td><td>When you enable trace functions via the Web server, you have better service support. You can send your trace recordings to your service partner via Web service, for example.</td><td rowspan="2">You receive plant/project information for diagnostics and maintenance requirements without STEP 7 (TIA Portal).
You can provide trace recordings via the Web server.
You save time in troubleshooting.</td></tr>
<tr><td>Monitoring of configured technology objects via a Web server</td><td>You can monitor states, errors, technology alarms and the current values of technology objects with the Web server.</td></tr>
<tr><td>Formatting, deleting or converting a SIMATIC memory card via the display</td><td colspan="2">Without the method using STEP 7 (TIA Portal), your SIMATIC memory card is formatted, deleted or converted into a program card directly via the display. You save time.</td></tr>
<tr><td>Motion Control</td><td></td><td></td></tr>
<tr><td>Greater number of axes for Motion Control applications and new technology objects: Output cam, cam track and probe</td><td>Speed specification for, for example:
• Pumps, fans, mixers
• Conveyor belts
• Auxiliary drives
Positioning tasks, such as:
• Lifting and vertical conveyors
• Feeding and gate control
• Palletizing equipment
Output cams and cam tracks make other applications possible, for example:
• Applying glue tracks
• Triggering switching operations with precise positioning
• Very precise processing of products on a conveyor belt
Operate probe. e.g.:
• For measuring products
• For detecting the position of the product on a conveyor belt</td><td>You can implement additional Motion Control applications with a CPU.
You can implement numerous applications using the scalability in the configuration limits.
High machine speeds result in greater productivity with better accuracy.</td></tr>
<tr><td>Support of the value status (QI) for digital and analog on-board I/O</td><td>You can use the value status to evaluate whether the input and output data is correct and react accordingly in the user program in the case of error, for example skip specific program sequences.</td><td>In the user program, you can respond quickly and easily to faults and errors.</td></tr>
</table>

2.2 Applications of the S7-1500 CPUs

Application area

The SIMATIC S7-1500 is the modular control system for numerous automation applications in discrete automation.

The modular and fanless design, the simple implementation of distributed structures and the user-friendly handling transform the SIMATIC S7-1500 into a cost-effective and convenient solution for a wide variety of tasks.

Application area of the SIMATIC S7-1500 are for example:

- Special-purpose machines
- Textile machinery
- Packaging machines
- General mechanical engineering
- Controller engineering
- Machine tool engineering
- Installation engineering
- Electrical industry and crafts
- Automotive
- Water/waste water
- Food & Beverage

Application area of the SIMATIC S7-1500T are for example:

- Packaging machines
- Converting application
- Assembly automation

Several CPUs with various levels of performance and a comprehensive range of modules with many convenient functions are available. Fail-safe CPUs enable use in fail-safe applications. The modular design allows you to use only the modules that you need for your application. The controller can be retrofitted with additional modules at any time to expand its range of tasks.

The high EMC and high resistance to shock and vibration stress make the SIMATIC S7-1500 suitable for universal use.

Performance segments of the standard, compact, fail-safe and technology CPUs

The CPUs can be used for smaller and medium-sized applications, as well as for the high-end range of machine and plant automation.

Table 2- 2 Standard CPUs

CPU	Performance segment	PROFIBUS interfaces	PROFINET IO RT/IRT interface	PROFINET IO RT interface	PROFINET basic functionality	Work memory	Processing time for bit operations
CPU 1511-1 PN	Standard CPU for small to medium-sized applications	--	1	--	--	1.15 MB	60 ns
CPU 1513-1 PN	Standard CPU for medium-sized applications	--	1	--	--	1.8 MB	40 ns
CPU 1515-2 PN	Standard CPU for medium-sized to large applications	--	1	1	--	3.5 MB	30 ns
CPU 1516-3 PN/ DP	Standard CPU for high-end applications and communication tasks	1	1	1	--	6 MB	10 ns
CPU 1517-3 PN/ DP	Standard CPU for high-end applications and communication tasks	1	1	1	--	10 MB	2 ns
CPU 1518-4 PN/ DP CPU 1518-4 PN/ DP ODK	Standard CPU for high-performance applications, demanding communications tasks and very short reaction times	1	1	1	1	24 MB	1 ns

Table 2- 3 Compact CPUs

CPU	Performance segment	PROFIBUS interfaces	PROFINET IO RT/IRT interfaces	PROFINET IO RT interface	PROFINET basic functionality	Work memory	Processing time for bit operations
CPU 1511C-1 PN	Compact CPU for small to medium-sized applications	--	1	--	--	1.175 MB	60 ns
CPU 1512C-1 PN	Compact CPU for medium-sized applications	--	1	--	--	1.25 MB	48 ns

Table 2- 4 Fail-safe CPUs

CPU	Performance segment	PROFIBUS interfaces	PROFINET IO RT/IRT interface	PROFINET IO RT interface	PROFINET basic functionality	Work memory	Processing time for bit operations
CPU 1511F-1 PN	Fail-safe CPU for smaller to medium-sized applications	--	1	--	--	1.23 MB	60 ns
CPU 1513F-1 PN	Fail-safe CPU for medium-sized applications	--	1	--	--	1.95 MB	40 ns
CPU 1515F-2 PN	Fail-safe CPU for medium-sized to large applications	--	1	1	--	3.75 MB	30 ns
CPU 1516F-3 PN/DP	Fail-safe CPU for demanding applications and communications tasks	1	1	1	--	6.5 MB	10 ns
CPU 1517F-3 PN/DP CPU 1517TF-3 PN/DP	Fail-safe CPU for demanding applications and communications tasks	1	1	1	--	11 MB	2 ns
CPU 1518F-4 PN/DP CPU 1518F-4 PN/DP ODK	Fail-safe CPU for high-performance applications, demanding communications tasks and very short reaction times	1	1	1	1	26 MB	1 ns

Table 2- 5 Technology CPUs

CPU	Performance segment	PROFIBUS interfaces	PROFINET IO RT/IRT interface	PROFINET IO RT interface	PROFINET basic functionality	Work memory	Processing time for bit operations
CPU 1511T-1 PN	Technology CPU for small to medium-sized applications	--	1	--	--	1.23 MB	60 ns
CPU 1515T-2 PN	Technology CPU for medium-sized to large applications	--	1	1	--	3.75 MB	30 ns
CPU 1517T-3 PN/DP	Technology CPU for high-end applications and communication tasks	1	1	1	--	11 MB	2 ns
CPU 1517TF-3 PN/DP	This CPU is described in the fail-safe CPUs						

Performance segments of compact CPUs

The compact CPUs can be used for smaller to medium-sized applications and have an integrated analog and digital on-board I/O as well as integrated technology functions. The following table shows the differences in performance between the two compact CPUs.

Table 2- 6 Performance overview of compact CPUs

	CPU 1511C-1 PN	CPU 1512C-1 PN
PROFIBUS interfaces	--	--
PROFINET interfaces	1	1
Work memory (for program)	175 KB	250 KB
Work memory (for data)	1 MB	1 MB
Processing time for bit operations	60 ns	48 ns
Integrated analog inputs/outputs	5 inputs/2 outputs	5 inputs/2 outputs
Integrated digital inputs/outputs	16 inputs/16 outputs	32 inputs/32 outputs
High-speed counters	6	6
Pulse generators • PWM (pulse-width modulation) • PTO (pulse train output or stepper motor control) • Frequency output	4 (PTOx/PWMx)	4 (PTOx/PWMx)

Supported technology functions

The CPUs of the SIMATIC S7-1500 family support Motion Control functions. STEP 7 (TIA Portal) offers PLCopen standardized blocks for configuring and connecting a drive to the CPU. Motion Control supports speed-controlled, positioning and synchronous axes (synchronizing without specification of the synchronous position) as well as external encoders, cams, cam tracks and probes.

The CPUs of theSIMATIC S7-1500T support advanced Motion Control functions in addition to the Motion Control functions offered by the standard CPUs. Additional Motion Control functions are absolute synchronous axes (synchronization with specification of synchronous position) and the cam.

For effective commissioning, diagnostics and fast optimization of drives and controls, the SIMATIC S7-1500 controller family offers extensive trace functions for CPU tags.

In addition to drive integration, the SIMATIC S7-1500 has extensive closed-loop control functions, such as easy-to-configure blocks for automatic optimization of the controller parameters for optimized control quality.

Compact CPU 1511C-1 PN and CPU 1512C-1 PN CPUs support technology functions such as high-speed counting, pulse generators (PWM, PTO and frequency output). Due to the supported technology functions, the compact CPUs are suitable for controlling pumps, fans, mixers, conveyor belts, lifting platforms, gate control systems, building management systems, synchronized axes, etc.

SIWAREX is a versatile and flexible weighing module, which you can use as a static scale for operation.

Security Integrated

In conjunction with STEP 7 (TIA Portal), each CPU offers password-based know-how protection against unauthorized reading out or modification of the program blocks.

The copy protection provides greater protection against unauthorized reproduction of program blocks. With copy protection, individual blocks on the SIMATIC memory card can be tied to its serial number so that the block can only be run if the configured memory card is inserted into the CPU.

In addition, four different authorization levels in the CPUs can be used to assign different access rights to various user groups.

Improved manipulation protection allows the CPUs to detect changed or unauthorized transfers of the engineering data.

The use of an Ethernet CP (CP 1543-1) provides the user with additional access protection by means of a firewall and/or the option of secured VPN connections.

Safety Integrated

The fail-safe CPUs are intended for users who want to implement demanding standard and fail-safe applications both centrally and distributed.

These fail-safe CPUs allow the processing of standard and safety programs on a single CPU. This allows fail-safe data to be evaluated in the standard user program. The integration provides the system advantages and the extensive functionality of SIMATIC also for fail-safe applications.

The fail-safe CPUs are certified for use in safety mode up to:

- Safety class (Safety Integrity Level) SIL 3 according to IEC 61508:2010
- Performance Level (PL) e and Category 4 according to ISO 13849-1:2006 or according to EN ISO 13849-1:2008

Additional password protection for F-configuration and F-program is set up for IT security.

Design and handling

All CPUs of the SIMATIC S7-1500 product series feature a display with plain text information. The display provides the user with information on the order numbers, firmware version, and serial number of all connected modules. In addition, the IP address of the CPU and other network settings can be adapted locally without a programming device. Error messages are immediately shown on the display in plain text, thus helping customers to reduce downtimes.

Uniform front connectors for all modules and integrated potential jumpers for flexible formation of potential groups simplifies storage. Additional components such as circuit breakers, relays, etc., can be installed quickly and easily, since a DIN rail is implemented in the rail of the S7-1500. The CPUs of the SIMATIC S7-1500 product series can be expanded centrally and modularly with signal modules. Space-saving expansion enables flexible adaptation to each application.

The system cabling for digital signal modules enables fast and clear connection to sensors and actuators from the field (fully modular connection consisting of front connector modules, connection cables and I/O modules), as well as simple wiring inside the control cabinet (flexible connection consisting of front connectors with assembled single cores).

System diagnostics and alarms

Integrated system diagnostics is enabled by default for the CPUs. The different types of diagnostics are configured instead of programmed. System diagnostics information is shown uniformly and in plain text on the display of the CPU, in STEP 7 (TIA Portal), on the HMI and on the Web server, even for alarms related to drives. This information is available in RUN mode, but also in STOP mode of the CPU. The diagnostics information is updated automatically when you configure new hardware components.

The CPU is available as a central interrupt server for 3 languages. The CPU, STEP 7 (TIA Portal) and your HMI guarantee data consistency. You can skip the various engineering steps, just load it into the CPU. The maintenance work is easier.

2.3 Properties

The hardware of the CPU 1511C-1 PN consists of a CPU part, an analog on-board I/O module (X10) and a digital on-board I/O module (X11). When configured in the TIA Portal, the compact CPU therefore occupies a single shared slot (slot 1).

The properties of the CPU part, the analog on-board I/O and the digital on-board I/O can be found in the subsections below.

Article number of the compact CPU

6ES7511-1CK00-0AB0

Accessories

The following accessories are included in the scope of delivery and can also be ordered separately as spare parts:

- 2 x front connector (push-in terminals) including cable ties
- 2 x shield clamp
- 2 x shield terminal
- 2 x infeed element (push-in terminals)
- 2 x labeling strip
- 2 x universal front cover

For more information on accessories, refer to the S7-1500, ET 200MP system manual (http://support.automation.siemens.com/WW/view/en/59191792).

2.3.1 Properties of the CPU part

View of the CPU

The figure below shows the CPU part of the CPU 1511C-1 PN.

Figure 2-1 CPU 1511C-1 PN

Note

Protective film

Note that a protective film is attached to the display of the CPU when shipped from the factory. Remove the protective film if necessary.

Properties

The CPU 1511C-1 PN has the following technical properties:

- Communication:
  - Interfaces

    The CPU 1511C-1 PN has a PROFINET interface (X1) with two ports (P1 R and P2 R). It supports not only PROFINET basic functionality but also PROFINET IO RT (real time) and IRT (isochronous real time), which means you can configure PROFINET IO communication or real time settings on the interface. Port 1 and port 2 can also be used as ring ports for configuring redundant ring structures in Ethernet (media redundancy).
    PROFINET basic functionality supports HMI communication, communication with the configuration system, communication with a higher-level network (backbone, router, Internet) and communication with another machine or automation cell.
    You can find more information on "PROFINET IO" in the online help of STEP 7 (TIA Portal) and the PROFINET Function Manual (http://support.automation.siemens.com/WW/view/en/68039307).
  - OPC UA

    With OPC UA, data is exchanged via an open and vendor-neutral communication protocol. The CPU, as OPC UA server, can communicate with OPC UA clients such as HMI panels, SCADA systems, etc.

- Integrated Web server:

  A Web server is integrated in the CPU. The Web server enables monitoring and administering of the CPU by authorized users over a network. Evaluations, diagnostics, and modifications are thus possible over long distances. All you need is a Web browser.

  With the Web server, you can read out the following data from the CPU and, in some cases, modify and write back the data to the CPU.

  - Start page with general CPU information
  - Identification information
  - Contents of the diagnostics buffer
  - Querying module information
  - Firmware update
  - Alarms (without acknowledgment option)
  - Information about communication
  - PROFINET topology
  - Tag status, writing tags
  - Watch tables
  - Memory usage
  - User pages
  - Data logs (if used)
  - Online backup and restoration of the configuration
  - Diagnostics information for the Motion Control technology objects
  - Display of trace recordings stored on the SIMATIC memory card
  - Readout service data
  - Basic websites
  - Display of the Web server in 3 project languages, for example, comments and message texts
  - Recipes
  - User pages

- Supported technology:
  - Counting, measuring, position detection and pulse generators

    The technology functions high-speed counting, measuring, position detection and pulse generators (PWM/frequency output/PTO) are integrated in the compact CPU. For more information on integrated technology functions, refer to the section Technology functions.
  - Motion Control

    Through technology objects, the Motion Control functionality supports speed-controlled axes, positioning axes, synchronous axes and external encoders, cams, cam tracks and probes as well as PLC open blocks for programming the motion control functionality.
    For more information about Motion Control, refer to the section Technology functions.
    For a detailed description of the use of motion control and its configuration, refer to the S7-1500 Motion Control (http://support.automation.siemens.com/WW/view/en/109739589) function manual.

    You can also use the *TIA Selection Tool* or the *SIZER* to create or configure axes.
  - Integrated closed-loop control functionality

    - PID Compact (continuous PID controller)

    - PID 3Step (step controller for integrating actuators)

    - PID Temp (temperature controller for heating and cooling with two separate actuators)
- Trace functionality:
  - The trace functionality supports troubleshooting and optimization of the user program, especially for motion control and closed-loop control applications.
    For more information on "Trace", refer to the Using the trace and logic analyzer function (http://support.automation.siemens.com/WW/view/en/64897128) function manual.
- Integrated system diagnostics:
  - The system automatically generates the alarms for the system diagnostics and outputs these alarms via a PG/PC, HMI device, the Web server or the integrated display. System diagnostics is also available when the CPU is in STOP mode.

- Integrated security:
  - Copy protection

    Copy protection links user blocks to the serial number of the SIMATIC memory card or to the serial number of the CPU. User programs cannot run without the corresponding SIMATIC memory card or CPU.
  - Know-how protection

    The know-how protection protects user blocks against unauthorized access and modifications.
  - Access protection

    Extended access protection provides high-quality protection against unauthorized configuration changes. You can use authorization levels to assign separate rights to different user groups.
  - Integrity protection

    The system protects the data transferred to the CPU against manipulation. The CPU detects incorrect or manipulated engineering data.
- Additional supported functions:
  - PROFIenergy
    For information on "PROFIenergy", refer to the PROFINET (http://support.automation.siemens.com/WW/view/en/68039307) function manual and the PROFINET specification on the Internet (http://www.profibus.com).
  - Shared device
    For information on "Shared device", refer to the PROFINET (http://support.automation.siemens.com/WW/view/en/68039307) function manual.
  - Configuration control
    For information on "Configuration control", refer to the S7-1500, ET 200MP system manual (http://support.automation.siemens.com/WW/view/en/59191792) and the PROFINET (http://support.automation.siemens.com/WW/view/en/68039307) function manual.

Reference

You can find more information on the topic of "Integrated security/Access protection" in the S7-1500, ET 200MP system manual (http://support.automation.siemens.com/WW/view/en/59191792).

2.3.2 Properties of the analog on-board I/O

View

The following figure shows the analog on-board I/O (X10) of the CPU 1511C-1 PN.

Figure 2-2 Analog on-board I/O

Properties

The analog on-board I/O has the following technical properties:

- Analog inputs
  - 5 analog inputs
  - Resolution 16 bits including sign
  - Voltage measurement type can be set individually for channel 0 to 3
  - Current measurement type can be set individually for channel 0 to 3
  - Resistor measurement type can be set for channel 4
  - Thermal resistor measurement type can be set for channel 4
  - Configurable diagnostics (per channel)
  - Hardware interrupt on limit violation can be set per channel (two low and two high limits in each case)
  - Support of the value status (Quality Information, QI)
- Analog outputs
  - 2 analog outputs
  - Resolution: 16 bits incl. sign
  - Voltage output selectable by channel
  - Current output selectable by channel
  - Configurable diagnostics (per channel)
  - Support of the value status (Quality Information, QI)

The analog on-board I/O supports the following functions:

- Reconfiguration in RUN
  (for more information, refer to the section Parameter assignment and structure of the parameter data records of the analog on-board I/O (Page 148))

2.3.3 Properties of the digital on-board I/O

View

The following figure shows the digital on-board I/O (X11) of the CPU 1511C-1 PN.

Figure 2-3 Digital on-board I/O

Properties

The digital on-board I/O has the following technical properties:

- Digital inputs
  - 16 high-speed digital inputs for signals up to max. 100 kHz
    The inputs can be used as standard inputs and as inputs for technology functions.
  - Rated input voltage 24 V DC
  - Suitable for switches and 2-/3-/4-wire proximity switches
  - Configurable diagnostics
  - Hardware interrupt can be set (for each channel)
  - Support of the value status (Quality Information, QI)
- Digital outputs
  - 16 digital outputs, 8 of which can be used as high-speed outputs for technology functions
    The outputs can be used as standard outputs and as outputs for technology functions.
  - Rated output voltage 24 V DC
  - Rated output current
    - as output for standard mode 0.5 A per channel
    - as output for technology functions, you can select between an output current of up to 0.5 A for an output frequency up to 10 kHz (load-dependent) and a reduced output current of max. 0.1 A at an increased output frequency of up to 100 kHz
  - Suitable, for example, for solenoid valves, DC contactors and indicator lights as well as for signal transmission or proportional valves
  - Configurable diagnostics
  - Support of the value status (Quality Information, QI)

  You can find a table showing the output frequencies and output currents through which outputs is available in the section Interconnection overview of the outputs (Page 99).

  The digital outputs feature driver blocks with push-pull outputs. Due to their basic functional design, such driver blocks always contain parasitic diodes, that act as freewheeling diodes when shutting off inductive loads (see figure "Current flow with correct wiring using the digital on-board I/O X11 as an example" in the section Wiring and block diagrams of the digital on-board I/O (Page 82)). The shutdown voltage is limited to -0.8 V. Therefore, the demagnetization of inductive loads takes longer and can be approximately calculated using the following formula.

  tau = L / R (tau= time constant, L = inductance value, R = ohmic resistance value)

  After the expiration of a period of 5 * tau, the current has decreased in effect to 0 A due to the inductive load.

  The maximum value is derived from: tau = 1.15H / 48 Ohm = 24ms. After
  5 * 24 ms = 120 ms, the current has decreased in effect to 0 A.

  For comparison: With standard modules, inductive shutdown voltage, for example, is limited to Vcc -53 V (supply voltage – 53 V), so that the current has decreased to about to 0 A after 15 ms.

The digital on-board I/O supports the following functions:

- Reconfiguration in RUN
  You can reconfigure some of the technological functions in RUN mode of the CPU (for more information, refer to the section Parameter assignment and structure of the parameter data records of the digital on-board I/O (Page 156)).

Simultaneous use of technology and standard functions

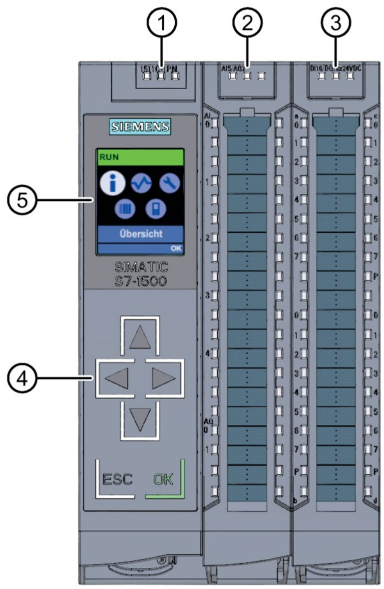
You can use technology and standard functions at the same time, provided the hardware allows this. For example, all the digital inputs not assigned to the counting, measuring or position detection or PTO technology functions can be used as standard DI.

Inputs to which technology functions are assigned can be read. Outputs to which technology functions are assigned cannot be written.

2.4 Operator controls and display elements

2.4.1 Front view with closed front panels

The following figure shows the front view of the CPU 1511C-1 PN.



① LEDs for the current operating mode and diagnostics status of the CPU
② Status and error displays RUN/ERROR of the analog on-board I/O
③ Status and error displays RUN/ERROR of the digital on-board I/O
④ Control keys
⑤ Display

Figure 2-4 View of the CPU 1511C-1 PN with closed front panels (front)

Note

Temperature range for display

To increase its service life, the display switches off at a temperature below the permitted operating temperature of the device. When the display cools down again, it automatically switches itself on again. When the display is switched off, the LEDs continue to show the status of the CPU.

You can find additional information on the temperatures at which the display switches itself on and off in the Technical specifications (Page 125).

Pulling and plugging the front panel with display

You can pull and plug the front panel with display during operation. The CPU retains its operating mode when the front panel is pulled and plugged.

⚠ WARNING
Personal injury and damage to property may occur
If you pull or plug the front panel of an S7-1500 automation system during operation, personal injury or damage to property can occur in zone 2 hazardous areas.
Before you pull or plug the front panel in hazardous area zone 2, always ensure that the S7-1500 automation system is de-energized.

Locking the front panel

You can lock the front panel to protect your CPU against unauthorized access.

You can attach a security seal or a padlock with a hoop diameter of 3 mm to the front panel.

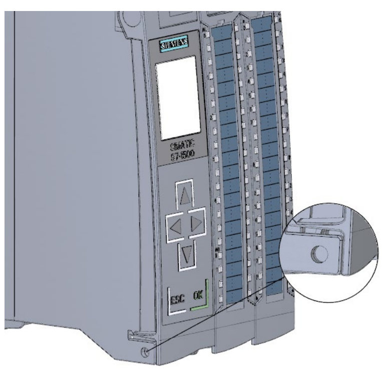


Figure 2-5 Locking latch on the CPU

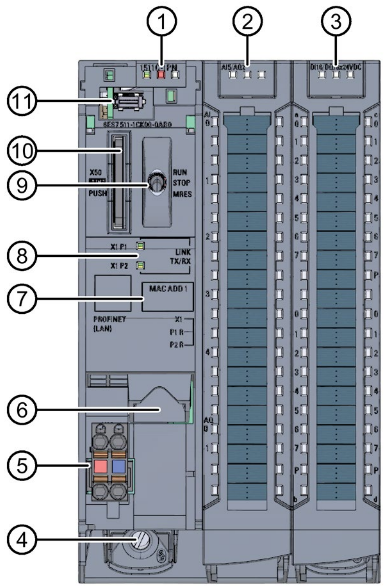
In addition to the mechanical lock, you can also block access to a password-protected CPU on the display (local lock) and assign a password for the display. For more information on the display, the configurable protection levels and the local lock, refer to the S7-1500, ET 200MP (http://support.automation.siemens.com/WW/view/en/59191792) system manual.

Reference

You will find detailed information on the individual display options, a training course and a simulation of the available menu commands 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).

2.4.2 Front view without front panel on the CPU

The following figure shows the operator control and connection elements of the CPU 1511C-1 PN with the front cover of the CPU open.

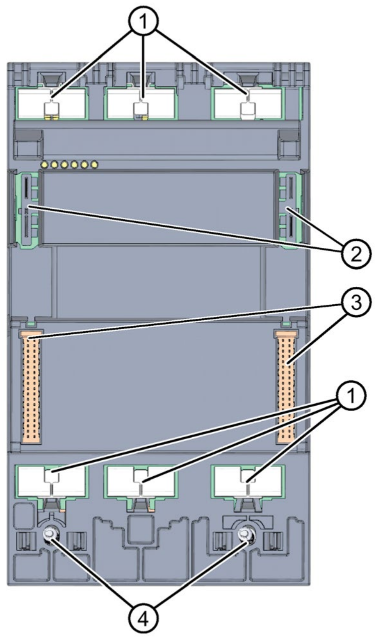


① LEDs for the current operating mode and diagnostics status of the CPU
② Status and error displays RUN/ERROR of the analog on-board I/O
③ Status and error displays RUN/ERROR of the digital on-board I/O
④ Fastening screw
⑤ Connection for supply voltage
⑥ PROFINET interface (X1) with 2 ports (X1 P1 and X1 P2)
⑦ MAC address
⑧ LEDs for the 2 ports (X1 P1 and X1 P2) of the PROFINET interface X1
⑨ Mode selector
⑩ Slot for the SIMATIC memory card
⑪ Display connection

Figure 2-6 View of the CPU 1511C-1 PN without front panel on the CPU (front)

2.4.3 Rear view

The following figure shows the connection elements on the rear of the CPU 1511C-1 PN.



① Shield contact surfaces
② Plug-in connection for power supply
③ Plug-in connection for backplane bus
④ Fastening screws

Figure 2-7 View of the CPU 1511C-1 PN - rear

2.5 Mode selector

You use the mode selector to set the operating mode of the CPU.

The following table shows the position of the selector and the corresponding meaning:

Position of the mode selector

Position	Meaning	Explanation
RUN	RUN mode	The CPU executes the user program.
STOP	STOP mode	The user program is not executed.
MRES	Memory reset	Position for CPU memory reset.

Technology functions 3

3.1 High-speed counters

Key statement

The technology functions of the compact CPU have the following technical properties:

- 16 high-speed digital inputs (up to 100 kHz), isolated
  - 6 high-speed counters (High Speed Counter/HSC), 4 of which can be used as A/B/N
- Interfaces
  - 24 V encoder signals of sourcing or push-pull encoders and sensors
  - 24 V encoder supply output, short-circuit-proof
  - Up to 2 additional digital inputs per high-speed counter for possible HSC DI functions (Sync, Capture, Gate)
  - 1 digital output per high-speed counter for fast reaction to the count
- Counting range: 32 bits
- Diagnostics and hardware interrupts can be configured
- Supported encoder/signal types
  - 24 V incremental encoder
    (with 2 tracks A and B, phase-shifted by 90°, up to 4 incremental encoders also with zero track N)
  - 24 V pulse encoder with direction signal
  - 24 V pulse encoder without direction signal
  - 24 V pulse encoder each for forward pulse & reverse pulse

The high-speed counters support reconfiguration in RUN. You can find additional information in section Parameter data records of the high-speed counters (Page 159).

3.1.1 Functions

3.1.1.1 Counting

Counting refers to the detection and adding up of events. The counters acquire and evaluate encoder signals and pulses. You can specify the count direction using suitable encoder or pulse signals or through the user program.
You can control counting processes using the digital inputs. You can switch the digital outputs exactly at defined count values, regardless of the user program.
You can configure the response of the counters using the functionalities described below.

Counting limits

The counting limits define the count value range used. The counting limits are selectable and can be modified during runtime by the user program.
The highest counting limit that can be set is 2147483647 (2^{31}–1). The lowest counting limit that can be set is –2147483648 (–2^{31}).
You can configure the response of the counter at the counting limits:

- Continue or stop counting (automatic gate stop) on violation of a counting limit
- Set count value to start value or to opposite counting limit on violation of a counting limit

Start value

You can configure a start value within the counting limits. The start value can be modified during runtime by the user program.
Depending on the parameter assignment, the compact CPU can set the current count value to the start value during synchronization, during the Capture function, on violation of a counting limit or when the gate is opened.

Gate control

The opening and closing of the hardware gate (HW gate) and software gate (SW gate) defines the period of time during which the counting signals are acquired.
The digital inputs of the digital on-board I/O control the HW gate. The user program controls the software gate. You can enable the hardware gate using the parameter assignment. The software gate (bit in the control interface of the cyclic I/O data) cannot be disabled.

Capture

You can configure an external reference signal edge that triggers the saving of the current count value as a Capture value. The following external signals can trigger the Capture function:

- Rising or falling edge of a digital input
- Both edges of a digital input
- Rising edge of signal N at the encoder input

You can configure whether counting continues from the current count value or from the start value after the Capture function.

Hysteresis

You can specify hysteresis for the comparison values, within which a digital output is prevented from switching again. An encoder may stop at a certain position, and slight movements may make the count value fluctuate around this position. If a comparison value or a counting limit lies within this fluctuation range, the corresponding digital output will be switched on and off often if hysteresis is not used. The hysteresis prevents these unwanted switching operations.

Reference

For more information on the counter, refer to the S7-1500, ET 200MP, ET 200SP Counting, measurement and position detection function manual (http://support.automation.siemens.com/WW/view/en/59709820).

3.1.1.2 Measuring

Measuring functions

The following measuring functions are available:

Table 3- 1 Overview of available measuring functions

Measurement type	Description
Frequency measurement	A measuring interval calculates the average frequency based on the time sequence of the count pulses, and returns this frequency as a floating-point number in units of hertz.
Period measurement	A measuring interval calculates the average period duration based on the time sequence of the count pulses, and returns this period duration as a floating-point number in units of seconds.
Velocity measurement	A measuring interval calculates the average velocity based on the time sequence of the count pulses, and returns this velocity in the configured unit.

The measured value and count value are both available in the feedback interface.

Update time

You can configure the interval at which the compact CPU updates the measured values cyclically as the update time. Greater update times smooth uneven measured variables and increase the measuring accuracy.

Gate control

Opening and closing the hardware gate and software gate defines the period of time during which the count signals are acquired. The update time is asynchronous to the opening of the gate, which means that the update time is not started when the gate is opened. After the gate is closed, the last measured value calculated is still returned.

Measuring ranges

The measuring functions have the following measuring range limits:

Table 3- 2 Overview of low and high measuring range limits

Measurement type	Low measuring range limit	High measuring range limit
Frequency measurement	0.04 Hz	400 kHz *
Period measurement	2.5 μs *	25 s
Velocity measurement	Depending on the configured number of "increments per unit" and the "timebase for velocity measurement"	

* Applies to 24 V incremental encoder and "quadruple" signal evaluation

All measured values are returned as signed values. The sign indicates whether the count value increased or decreased during the relevant time period. For example, a value of -80 Hz means that the count value decreases at 80 Hz.

Reference

For more information on measuring, refer to the S7-1500, ET 200MP, ET 200SP Counting, measurement and position detection function manual (http://support.automation.siemens.com/WW/view/en/59709820).

3.1.1.3 Position detection for motion control

You can use the digital on-board I/O, e.g. with an incremental encoder, for position detection with S7-1500 Motion Control. The position detection is based on the counting function, which evaluates the acquired encoder signals and provides them for S7-1500 Motion Control.
In the hardware configuration of the CPU 1511C-1 PN in STEP 7 (TIA Portal), select the "Position input for Motion Control" mode.

Reference

For a detailed description of the use of motion control and its configuration, refer to the S7-1500 Motion Control function manual (http://support.automation.siemens.com/WW/view/en/59381279). In the function manual, the interface between the drives and encoders is referred to as a technology module (TM). In this context, a technology module (TM) also refers to the digital on-board I/O of the compact CPU described here.

3.1.1.4 Additional functions

Synchronization

You can configure an external reference signal edge to load the counter with the specified start value. The following external signals can trigger a synchronization:

- Rising or falling edge of a digital input
- Rising edge of signal N at the encoder input
- Rising edge of signal N at the encoder input depending on the level of the assigned digital input

Comparison values

The integrated counter supports 2 comparison values and digital output HSC DQ1. If the counter or measured value meets the set comparison condition, HSC DQ1 can be set in order to trigger direct control operations in the process.

Both comparison values can be set in the parameters and can be changed during runtime via the user program.

Hardware interrupts

If you have enabled a hardware interrupt in the hardware configuration, the counter can trigger a hardware interrupt in the CPU when a comparison event occurs, if there is overflow or underflow, at a zero crossing of the counter, and/or at a change of count direction (direction reversal). You can specify which events are to trigger a hardware interrupt during operation in the hardware configuration.

Diagnostics interrupts

If you have enabled a diagnostics interrupt in the hardware configuration, the counter can trigger a diagnostics interrupt if the supply voltage is missing, if there is an incorrect A/B count signal or lost hardware interrupt.

3.1.2 Configuring the high-speed counters

3.1.2.1 General

You configure the high-speed counters (HSC) in STEP 7 (TIA Portal).

The functions are controlled via the user program.

Reference

A detailed description of configuring the counting and measuring functions can be found in:

- S7-1500, ET 200MP, ET 200SP Counting, measurement and position detection (http://support.automation.siemens.com/WW/view/en/59709820) function manual
- in the STEP 7 online help under "Using technology functions > Counting, measuring and position detection > Counting, measuring and position detection (S7-1500)"

A detailed description of configuring Motion Control be found in:

- S7-1500 Motion Control (http://support.automation.siemens.com/WW/view/en/59381279) function manual
- in the STEP 7 online help under "Using technology functions > Motion Control > Motion Control (S7-1500)"

3.1.2.2 Assignment of the control interface of the high-speed counters

The user program uses the control interface to influence the behavior of the high speed counter.

Note

Operation with High_Speed_Counter technology object

The High_Speed_Counter technology object is available for high-speed counting mode. We therefore recommend use of the High_Speed_Counter technology object instead of the control interface/feedback interface for controlling the high speed counter.

For information on configuring the technology object and programming the associated instruction, refer to the S7-1500, ET 200MP, ET 200SP Counting, measurement and position detection (http://support.automation.siemens.com/WW/view/en/59709820) function manual.

Control interface per channel

The following table shows the control interface assignment:

Table 3- 3 Assignment of the control interface

Offset from start address	Parameter	Meaning				
Bytes 0 to 3	Slot 0	Load value (meaning of the value is specified in LD_SLOT_0)				
Bytes 4 to 7	Slot 1	Load value (meaning of the value is specified in LD_SLOT_1)				
Byte 8	LD_SLOT_0*	Specifies the meaning of the value in Slot 0				
		Bit 3	**Bit 2**	**Bit 1**	**Bit 0**	
		0	0	0	0	No action, idle state
		0	0	0	1	Load counter
		0	0	1	0	Reserve
		0	0	1	1	Load start value
		0	1	0	0	Load comparison value 0
		0	1	0	1	Load comparison value 1
		0	1	1	0	Load low counting limit
		0	1	1	1	Load high counting limit
		1	0	0	0	Reserve
		to				
		1	1	1	1	
	LD_SLOT_1*	Specifies the meaning of the value in Slot 1				
		Bit 7	**Bit 6**	**Bit 5**	**Bit 4**	
		0	0	0	0	No action, idle state
		0	0	0	1	Load counter
		0	0	1	0	Reserve
		0	0	1	1	Load start value
		0	1	0	0	Load comparison value 0
		0	1	0	1	Load comparison value 1
		0	1	1	0	Load low counting limit
		0	1	1	1	Load high counting limit
		1	0	0	0	Reserve
		to				
		1	1	1	1	
Byte 9	EN_CAPTURE	Bit 7: Enable capture function				
	EN_SYNC_DN	Bit 6: Enable downward synchronization				
	EN_SYNC_UP	Bit 5: Enable upward synchronization				
	SET_DQ1	Bit 4: Set DQ1				
	SET_DQ0	Bit 3: Set DQ0				
	TM_CTRL_DQ1	Bit 2: Enable technological function DQ1				
	TM_CTRL_DQ0	Bit 1: Enable technological function DQ0				
	SW_GATE	Bit 0: Software gate				

Offset from start address	Parameter	Meaning
Byte 10	SET_DIR	Bit 7: Count direction (with encoder without direction signal)
	–	Bits 2 to 6: Reserve; bits must be set to 0
	RES_EVENT	Bit 1: Reset of saved events
	RES_ERROR	Bit 0: Reset of saved error states
Byte 11	–	Bits 0 to 7: Reserve; bits must be set to 0

* If values are loaded simultaneously via LD_SLOT_0 and LD_SLOT_1, the value from Slot 0 is taken first internally and then the value from Slot 1 . This may lead to unexpected intermediate states.

Reference

You can find a graphic representation of the processing of the various SLOT parameters in the section Handling the SLOT parameter (control interface) (Page 65).

3.1.2.3 Assignment of the feedback interface of the high-speed counters

The user program receives current values and status information from the high speed counter via the feedback interface.

Note

Operation with High_Speed_Counter technology object

The High_Speed_Counter technology object is available for high-speed counting mode. We therefore recommend use of the High_Speed_Counter technology object instead of the control interface/feedback interface for controlling the high speed counter.

For information on configuring the technology object and programming the associated instruction, refer to the S7-1500, ET 200MP, ET 200SP Counting, measurement and position detection (http://support.automation.siemens.com/WW/view/en/59709820) function manual.

Feedback interface per channel

The following table shows the feedback interface assignment:

Table 3- 4 Assignment of the feedback interface

Offset from start address	Parameter	Meaning
Bytes 0 to 3	COUNT VALUE	Current count value
Bytes 4 to 7	CAPTURED VALUE	Last Capture value acquired
Bytes 8 to 11	MEASURED VALUE	Current measured value
Byte 12	–	Bits 3 to 7: Reserve; set to 0
	LD_ERROR	Bit 2: Error when loading via control interface
	ENC_ERROR	Bit 1: Incorrect encoder signal
	POWER_ERROR	Bit 0: Incorrect supply voltage L+
Byte 13	–	Bits 6 to 7: Reserve; set to 0
	STS_SW_GATE	Bit 5: Software gate status
	STS_READY	Bit 4: Digital on-board I/O started up and parameters assigned
	LD_STS_SLOT_1	Bit 3: Load request for Slot 1 detected and executed (toggling)
	LD_STS_SLOT_0	Bit 2: Load request for Slot 0 detected and executed (toggling)
	RES_EVENT_ACK	Bit 1: Reset of event bits active
	–	Bit 0: Reserve; set to 0
Byte 14	STS_DI2	Bit 7: Reserve; set to 0
	STS_DI1	Bit 6: Status HSC DI1
	STS_DI0	Bit 5: Status HSC DI0
	STS_DQ1	Bit 4: Status HSC DQ1
	STS_DQ0	Bit 3: Status HSC DQ0
	STS_GATE	Bit 2: Internal gate status
	STS_CNT	Bit 1: Count pulse detected within last approx. 0.5 s
	STS_DIR	Bit 0: Direction of last count value change
Byte 15	STS_M_INTERVAL	Bit 7: Count pulse detected in previous measuring interval
	EVENT_CAP	Bit 6: Capture event has occurred
	EVENT_SYNC	Bit 5: Synchronization has occurred
	EVENT_CMP1	Bit 4: Comparison event for DQ1 has occurred
	EVENT_CMP0	Bit 3: Comparison event for DQ0 has occurred
	EVENT_OFLW	Bit 2: Overflow has occurred
	EVENT_UFLW	Bit 1: Underflow has occurred
	EVENT_ZERO	Bit 0: Zero crossing has occurred

3.2 Pulse generators

3.2.1 Operating modes

3.2.1.1 Operating mode: Pulse-width modulation (PWM)

Properties

The pulse-width modulation (PWM) mode of the compact CPU has the following technical properties:

	Minimum			Maximum		
	Standard output	**High-speed output deactivated**	**High-speed output activated**	**Standard output**	**High-speed output deactivated**	**High-speed output activated**
Pulse duration	100 µs with load > 0.1 A [1)] 200 µs with load ≥ 2 mA [1)]	20 µs with load > 0.1 A [1)] 40 µs with load ≥ 2 mA [1)]	2 µs [1)]	10 000 000 µs (10 s)		
Period duration	10 ms [2)]	100 µs [2)]	10 µs			

1) A lower value is theoretically possible but, depending on the connected load, the output voltage can no longer be output as complete rectangular pulse

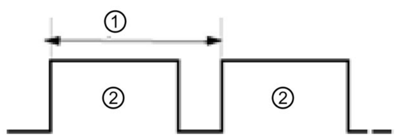
2) Load-dependent

Principle of operation

With pulse width modulation, a signal with defined cycle duration and variable on-load factor is output at the digital output. The on-load factor is the relationship of the pulse duration to the cycle duration. In PWM mode, you can control the on-load factor and the cycle duration.

With pulse width modulation, you vary the mean value of the output voltage. Depending on the connected load, you can control the load current or the power with this.

You can specify the pulse duration as one-hundredth of the period duration (0 to 100), as one-thousandth (0 to 1 000), as one ten-thousandth (0 to 10 000) or in S7 analog format.



① Period duration

② Pulse duration

The pulse duration can be between 0 (no pulse, always off) and full scale (no pulse, period duration always on).

The PWM output can, for example, be used to control the speed of a motor from standstill to full speed or you can use it to control the position of a valve from closed to completely open.

You configure the pulse width modulation (PWM) mode in STEP 7 (TIA Portal).

The pulse width modulation mode has the following functions:

- When the option "High-speed output (0.1 A)" is activated, you can generate a minimum pulse duration of 2 μs at a current of 100 mA. If the option "High-speed output (0.1 A)" is not activated, you can generate a minimum pulse duration of 20 μs with a load > 0.1 A and a minimum pulse duration of 40 μs with a load of ≥ 2 mA and a current of maximum 0.5 A. If a standard output is used, you can generate a minimum pulse duration of 100 μs with a load of > 0.1 and a minimum pulse duration of 200 μs with a load of ≥ 2 mA.
- You can control the pulse output (DQA) of the channel manually via the control and feedback interface.
- You can configure the reaction to CPU STOP. Upon change to CPU STOP, the pulse output (DQA) is set to the configured state.

Controller

For the pulse width modulation (PWM) mode, the user program directly accesses the control and feedback interface of the channel.

Reconfiguration via the instructions WRREC/RDREC and parameter assignment data record 128 is supported. You can find additional information in section Parameter data records (PWM) (Page 167).

You control the on-load factor (pulse-cycle ratio) of the pulse width via the OUTPUT_VALUE field of the control interface. Pulse width modulation generates continuous pulses based on this value. The period duration is adjustable.

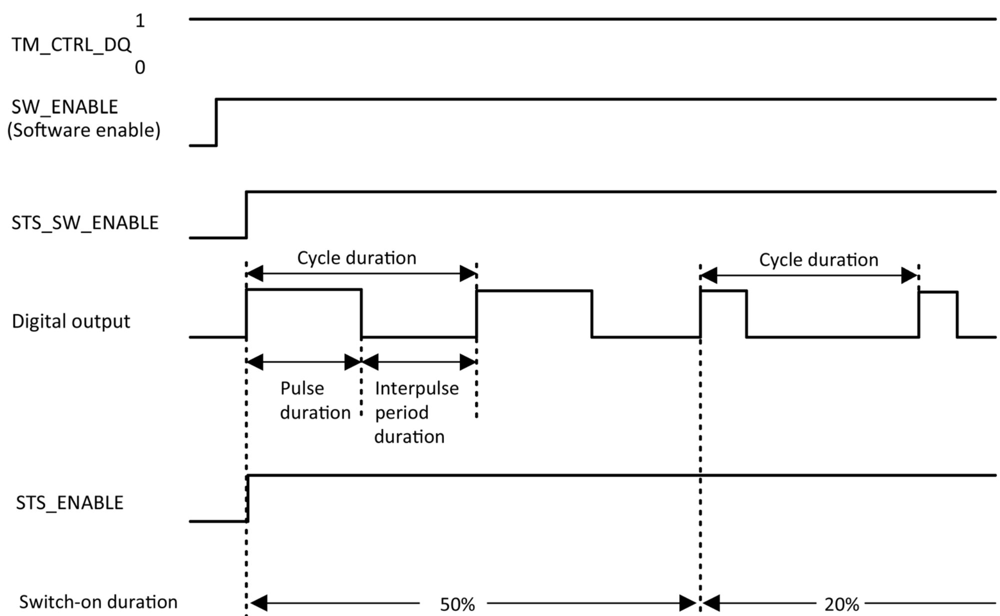


Figure 3-1 Pulse schematic

Starting the output sequence

The control program must output the enable for the output sequence with the help of the software enable (SW_ENABLE 0 → 1). The feedback bit STS_SW_ENABLE indicates that the software enable is pending at the PWM.

If the software enable is activated (rising edge), STS_ENABLE is set. The output sequence runs continuously, as long as SW_ENABLE is set.

Note

Output control signal TM_CTRL_DQ

- If TM_CTRL_DQ = 1, the technology function takes over the control and generates pulse sequences at the output PWM DQA.
- If TM_CTRL_DQ = 0, the user program takes over the control and the user can set the output PWM DQA directly via the control bit SET_DQA.

Canceling the output sequence

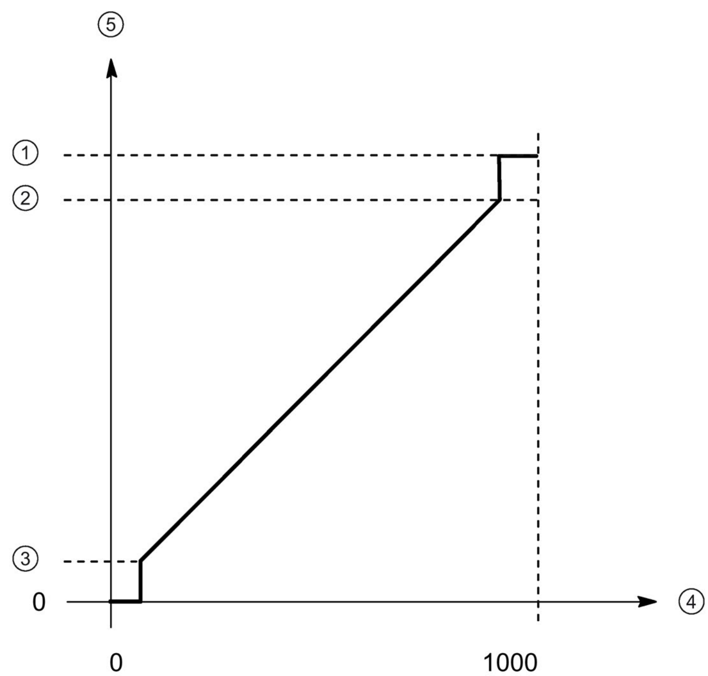
Deactivating the software enable (SW_ENABLE = 1 → 0) cancels the current output sequence. The last period duration is not completed. STS_ENABLE and the digital output PWM DQA are immediately reset to 0.

A renewed pulse output is only possible after a restart of the output sequence.

Minimum pulse duration and minimum interpulse period

You assign the minimum pulse duration and the minimum interpulse period with the parameter "Minimum pulse duration".

- A pulse duration determined by the technology function or PWM channel which is shorter than the minimum pulse duration will be suppressed.
- A pulse duration determined by the technology function or PWM channel which is longer than the cycle duration less the minimum interpulse period will be set to the value of the cycle duration (output switched on permanently).



① Cycle duration
② Cycle duration minus minimum interpulse period
③ Minimum pulse duration
④ OUTPUT_VALUE (One tenth of a percent on-load factor)
⑤ Pulse duration

Figure 3-2 Minimum pulse duration and minimum interpulse period

Setting and changing the pulse on-load factor

OUTPUT_VALUE assigns the on-load factor for the current period duration. You select the range of the field OUTPUT_VALUE of the control interface with the "Output format" parameter.

- Output format 1/100: Value range between 0 and 100
  Pulse duration = (OUTPUT_VALUE/100) x period duration.
- Output format 1/1000: Value range between 0 and 1 000
  Pulse duration = (OUTPUT_VALUE/1 000) x period duration.
- Output format 1/10000: Value range between 0 and 10 000
  Pulse duration = (OUTPUT_VALUE/10 000) x period duration.
- Output format "S7 analog output": Value range between 0 and 27 648
  Pulse duration = (OUTPUT_VALUE/27 648) x period duration.

You assign OUTPUT_VALUE directly via the control program. A new OUTPUT_VALUE is applied at the output when the next rising edge occurs.

Setting and changing the period duration

- Permanent update
  The period duration is permanently controlled via the control interface. The MODE_SLOT bit must be set ("1" means permanent update); LD_SLOT must be set to value 1 ("1" means period duration). Set the period value in the field SLOT. The unit is always a microsecond.
  – High-speed output activated: between 10 μs and 10 000 000 μs (10 s) in the field SLOT
  – High-speed output deactivated: between 100 μs and 10 000 000 μs (10 s) in the field SLOT
  – Standard output (100 Hz output): between 10 000 μs (10 ms) and 10 000 000 μs (10 s) in the field SLOT
- Individual updating
  Set the period duration in the configuration parameters. Alternatively, execute an individual update via the control interface. MODE_SLOT must be deleted ("0" means individual update); LD_SLOT must be set to value 1 ("1" means period duration). Set the period duration value in the field SLOT. The unit is always a microsecond.
  – High-speed output activated: between 10 μs and 10 000 000 μs (10 s) in the parameters
  – High-speed output deactivated: between 100 μs and 10 000 000 μs (10 s) in the parameters
  – Standard output (100 Hz output): between 10 000 μs (10 ms) and 10 000 000 μs (10 s) in the parameters

The new period duration is applied at the next rising edge of the output.

Setting the minimum pulse duration and the minimum interpulse period

You assign the minimum pulse duration and the minimum interpulse period as DWORD numerical value between 0 and 10 000 000 µs (10 s) with the help of the channel parameter configuration "Minimum pulse duration".

Parameters of the pulse width modulation (PWM) mode

Category	Parameter	Meaning	Value range	Default
Reaction to CPU STOP	Reaction to CPU STOP	The parameter "Output substitute value" generates a substitute value upon CPU STOP, which you can define with the parameter "Substitute value for pulse output (DQA)".	**Output substitute value**	Output substitute value
		On CPU STOP, the parameter "Continue" still generates the PWM output signal which was generated before the CPU STOP.	**Continue**	
	Substitute value for pulse output (DQA)	If you have set the option "Output substitute value" for "Reaction to CPU STOP", the parameter "Substitute value for pulse output (DQA)" defines the substitute value to be used for the pulse output of the channel. If you have set the option "Continue" for "Reaction to CPU STOP", the parameter "Substitute value for pulse output (DQA)" cannot be selected.	**0** (use substitute value 0)	0
			1 (use substitute value 1)	
Diagnostics interrupt	No supply voltage L+	The parameter "Missing supply voltage L+" activates the diagnostic interrupt of the channel in the case of no supply voltage L+	**Deactivated**	Deactivated
			Activated	
Parameter	High-speed output (0.1 A)	The "High-speed output (0.1 A)" parameter is used to specify whether you want to use the selected pulse output as high-speed output. The requirement for this is that the selected pulse output supports operation as high-speed output.	**Deactivated** The output supports frequencies of up to 10 kHz (load dependent) and currents of up to 0.5 A or frequencies of up to 100 Hz and currents of up to 0.5 A depending on the performance capability of the selected output.	Deactivated
			Activated The output supports frequencies of up to 100 kHz and currents of up to 0.1 A.	

Category	Parameter	Meaning	Value range	Default
	Output format	Defines the format of the ratio value (on-load factor) in the field "OUTPUT_VALUE" of the control interface of the channel.	**S7 analog output** Interprets the ratio value in the field OUTPUT_VALUE" of the control interface as 1/27648 of the current period duration. Supported value range from 0 to 27 648	1/100
			1/100 Interprets the ratio value in the field "OUTPUT_VALUE" of the control interface as percentage value of the current period duration. Supported value range 0 to 100	
			1/1000 Interprets the ratio value in the field "OUTPUT_VALUE"of the control interface as a one-tenth percentage point of the current period duration. Supported value range from 0 to 1 000	
			1/10000 Interprets the ratio value in the field "OUTPUT_VALUE" of the control interface as a one-hundredth percentage point of the current period duration. Supported value range from 0 to 10 000	
	Minimum pulse duration	Defines the minimum pulse duration and the minimum interpulse period of the output signal of the channel. The channel suppresses all pulses and pauses that are below the specified value.	**0 µs to 10 000 000 µs (10 s)**	0 µs
	Period duration	Defines the period duration of the output signal of the channel in µs. In RUN, the user program can control the period duration via the control and feedback interface of the channel.	**x to 10 000 000 µs (10 s)** at 100 kHz hardware output (high-speed output (0.1 A) activated): 10 µs to 10 000 000 µs (10 s) at 10 kHz hardware output (high-speed output (0.1 A) deactivated): 100 µs to 10 000 000 µs (10 s) at 100 kHz hardware output (high-speed output (0.1 A) deactivated): 10 000 µs (10 ms) to 10 000 000 µs (10 s)	2 000 000 µs (2 s)

Category	Parameter	Meaning	Value range	Default
Hardware inputs/ outputs	Pulse output (DQA)	The parameter "Pulse output (DQA)" defines the hardware output to use as pulse output channel.	For B: X11, terminal 21 (DQ0 / %Q4.0): 10 kHz / 0.5 A or 100 kHz / 0.1 A	Hardware output with the least significant address
			For B: X11, terminal 31 (DQ8 / %Q5.0): 100 Hz / 0.5 A	

Output signals for pulse width modulation (PWM) mode

Output signal	Meaning	Value range
Continuous pulse current at the digital output PWM DQA	A pulse is output at the digital output PWM DQA for the set on-load factor and period duration.	Continuous pulse current

3.2.1.2 Operating mode: Frequency output

In this operating mode, you can assign a frequency value with high frequencies more precisely than by using the period duration in PWM mode.

A rectangular signal with an assigned frequency and a constant on-load factor of 50% is generated at the digital output.

The frequency output mode has the following functions:

- When the option "High-speed output (0.1 A)" is activated, you can generate a minimum pulse duration of 2 µs at a current of 100 mA. If the option "High-speed output (0.1 A)" is not activated, you can generate a minimum pulse duration of 20 µs with a load > 0.1 A and a minimum pulse duration of 40 µs with a load of ≥ 2mA and a current of maximum 0.5 A.
  If you use a standard output, you can generate a minimum pulse duration of 100 µs with a load of > 0.1 A and a minimum pulse duration of 200 µs with a load of ≥ 2 mA and a current of max. 0.5 A.

	Minimum			Maximum		
	Standard output	High-speed output deactivated	High-speed output activated	Standard output	High-speed output deactivated	High-speed output activated
Frequency	0.1 Hz			100 Hz [1)]	10 kHz [1)]	100 kHz

[1)] Load-dependent

- You can control the pulse output (DQA) of the channel manually via the control and feedback interface.
- You can configure the reaction to CPU STOP. Upon change to CPU STOP, the pulse output (DQA) is set to the configured state.

Controller

For the frequency output mode, the user program directly accesses the control and feedback interface of the channel.

Reconfiguration via the instructions WRREC/RDREC and parameter assignment data record 128 is supported. You can find additional information in section Parameter data records (PWM) (Page 167).

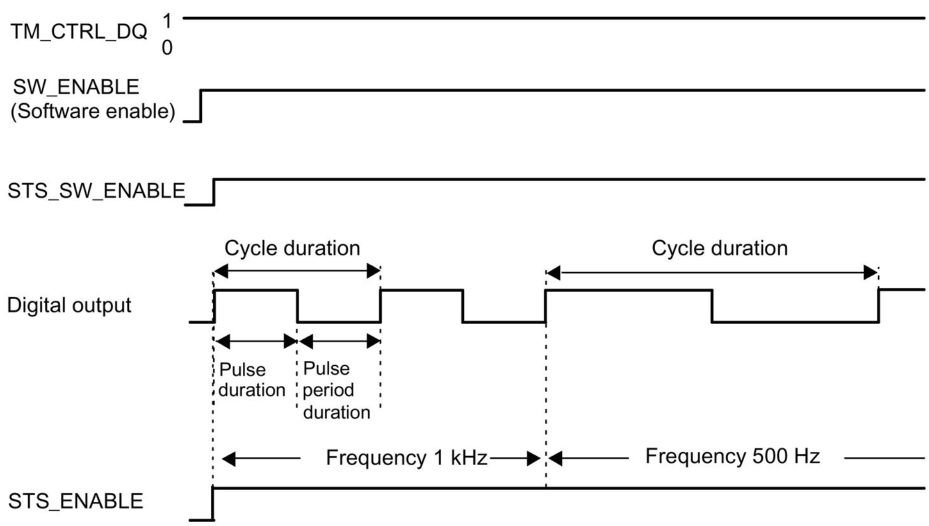


Figure 3-3 Pulse schematic

Starting the output sequence

The control program must initiate the enable for the output sequence with the help of the software enable (SW_ENABLE 0 → 1). The feedback bit STS_SW_ENABLE indicates that the software enable is pending at the pulse generator.

If the software enable is activated (rising edge), STS_ENABLE is set. The output sequence runs continuously, as long as SW_ENABLE is set.

Note

Output control signal TM_CTRL_DQ

- If TM_CTRL_DQ = 1, the technology function takes over the control and generates pulse sequences at the output PWM DQA.
- If TM_CTRL_DQ = 0, the user program takes over the control and the user can directly set the output PWM DQA via the control bit SET_DQA.

Canceling the output sequence

Deactivating the software enable (SW_ENABLE = 1 → 0) during the frequency output cancels the current output sequence. The last period duration is not completed. STS_ENABLE and the digital output PWM DQA are immediately reset to 0.

A renewed pulse output is only possible after a restart of the output sequence.

Setting and changing the output value (frequency)

You set the frequency with the OUTPUT_VALUE directly with the control program in the control interface. The value is specified in the real format and the unit is always "Hz". The possible range depends on the parameter "High-speed output (0.1 A)" as follows:

- High-speed pulse output deactivated
  - Frequency (OUTPUT_VALUE) 0.1 Hz to 10 000 Hz
- High-speed pulse output activated
  - Frequency (OUTPUT_VALUE) 0.1 Hz to 100 000 Hz
- Standard output (100 Hz output)
  - Frequency (OUTPUT_VALUE) 0.1 Hz to 100 Hz

The new frequency is applied at the start of the next period. The new frequency has no impact on the falling edge or the pulse-cycle ratio. However, the application can take up to 10 s depending on the previously set frequency.

Accuracy of the output frequency

The configured output frequency is output with a frequency-dependent accuracy at the digital output PWM DQA. You can find an overview of the accuracy as a function of the frequency used in the section Interconnection overview of the outputs (Page 99).

Parameters of the frequency output mode

<table>
<tr><th>Category</th><th>Parameter</th><th>Meaning</th><th>Value range</th><th>Default</th></tr>
<tr><td rowspan="4">Reaction to CPU STOP</td><td rowspan="2">Reaction to CPU STOP</td><td>The parameter "Output substitute value" generates a substitute value upon CPU STOP, which you can define with the parameter "Substitute value for pulse output (DQA)".</td><td>Output substitute value</td><td rowspan="2">Output substi-tute value</td></tr>
<tr><td>The parameter "Continue" still generates the frequency output signal upon CPU STOP, which was generated before the CPU STOP.</td><td>Continue</td></tr>
<tr><td rowspan="2">Substitute value for pulse output (DQA)</td><td rowspan="2">If you have set the option "Output substitute value" for "Reaction to CPU STOP", the parameter "Sub-stitute value for pulse output (DQA)" defines the substitute value to be used for the pulse output of the channel.
If you have set the option "Contin-ue" for "Reaction to CPU STOP", the parameter "Substitute value for pulse output (DQA)" cannot be selected.</td><td>0
(use substitute value 0)</td><td rowspan="2">0</td></tr>
<tr><td>1
(use substitute value 1)</td></tr>
</table>

Category	Parameter	Meaning	Value range	Default
Diagnostics interrupt	No supply voltage L+	The parameter "Missing supply voltage L+" activates the diagnostic interrupt of the channel in the case of no supply voltage L+	**Deactivated**	Deactivated
			Activated	
Parameter	High-speed output (0.1 A)	The "High-speed output (0.1 A)" parameter is used to specify whether you want to use the selected pulse output as high-speed output. The requirement for this is that the selected pulse output supports operation as high-speed output.	**Deactivated** The output supports frequencies of up to 10 kHz (load dependent) and currents of up to 0.5 A or frequencies of up to 100 Hz and currents of up to 0.5 A depending on the performance capability of the selected output.	Deactivated
			Activated The output supports frequencies of up to 100 kHz and currents of up to 0.1 A.	
	Output format	Defines the value for the frequency output in the field "OUTPUT_VALUE" of the control interface of the channel.	**1 Hz** Interprets the value of the frequency output in the field "OUTPUT_VALUE" as frequency with the unit Hz.	1 Hz
Hardware inputs/ outputs	Pulse output (DQA)	The parameter "Pulse output (DQA)" is used to define the hardware output that you want to use as pulse output channel.	For B: X11, terminal 21 (DQ0 / %Q4.0): 10 kHz / 0.5 A or 100 kHz / 0.1 A	Hardware output with the least significant address
			For B: X11, terminal 31 (DQ8 / %Q5.0): 100 Hz / 0.5 A	

Output signals for frequency output mode

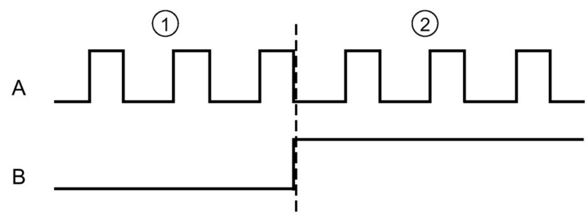
Output signal	Meaning	Value range
Continuous pulse current at the digital output PWM DQA	A pulse for the assigned frequency is output at the digital output PWM DQA.	Continuous pulse current

3.2.1.3 Operating mode: PTO

The PTO (Pulse Train Output) mode can be used to output position information. This allows you to, for example, control stepper motor drives or simulate an incremental encoder. The frequency of the pulses represents the speed, while the number of pulses represents the distance. The direction can also be specified by using two signals per channel. You can use a PTO channel for setpoint output (drive) for an axis technology object.

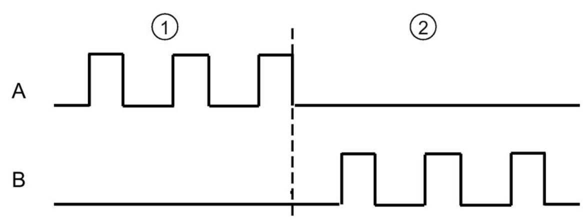
PTO mode is divided into the following four signal types:

- PTO (pulse (A) and direction (B)): If you select the PTO signal type (pulse (A) and direction (B)), an output (A) controls the pulses and an output (B) controls the direction. B is 'High' (active) when pulses are generated in a negative direction. B is 'Low' (inactive) when pulses are generated in a positive direction.



① Positive direction of rotation
② Negative direction of rotation

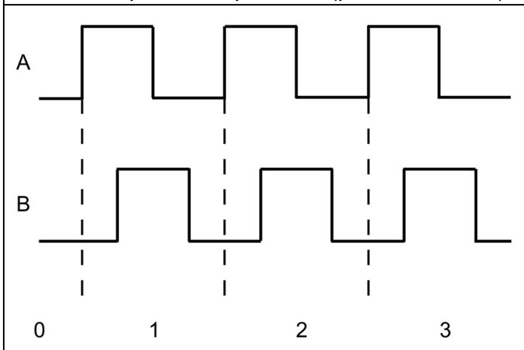
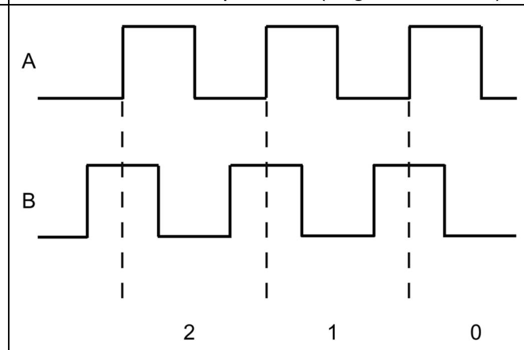
- PTO (Count up (A) and Count down (B)): When you select the PTO signal type (count up (A) and count down (B)), an output (A) outputs pulses for positive directions and another output (B) outputs pulses for negative directions.



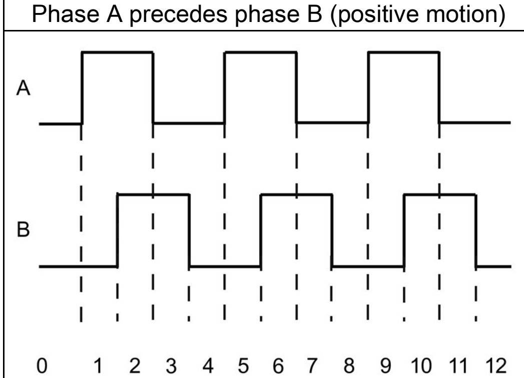
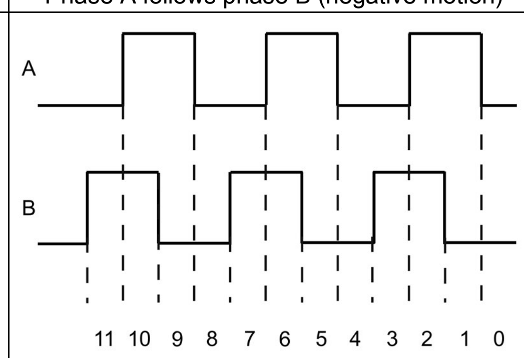
① Positive direction of rotation
② Negative direction of rotation

- PTO (A, B phase-shifted): When you select the PTO signal type (A, B phase-shifted), the two outputs pulses with the specified velocity, but phase-shifted by 90 degrees. This is a 1x combination in which the pulse shows the duration between two positive transitions of A. In this case, the direction is determined based on the output which first changes from 0 to 1. With positive direction, A precedes B. With negative direction B precedes A.

  The number of generated pulses is based on the number of 0-to-1 transitions from phase A. The phase ratio determines the direction of motion:

PTO (A, B phase-shifted)	
Phase A precedes phase B (positive motion)	Phase A follows phase B (negative motion)
	
Number of pulses	Number of pulses

- PTO (A, B phase-shifted - quadruple): When you select the PTO signal type (A, B phase-shifted, quadruple), the two outputs transmit pulses with the specified velocity, but phase-shifted by 90 degrees. The quadruple signal type is a 4x configuration in which each edge transition corresponds to an increment. Therefore, a full period of the signal A contains four increments. In this way, two outputs, each with 100 kHz signal frequency, can be used to output a control signal that supplies 400 000 increments per second. The direction is determined based on the output which first changes from 0 to 1. With positive direction, A precedes B. With negative direction B precedes A.

PTO (A, B phase-shifted - quadruple)	
Phase A precedes phase B (positive motion)	Phase A follows phase B (negative motion)
	
Number of pulses	Number of pulses

Parameters of PTO mode

Category	Parameter	Meaning	Value range	Default
Diagnostics interrupt	No supply voltage L+	With the parameter "Missing supply voltage L+", you activate the diagnostic interrupt of the channel in the event of no supply voltage L+.	Deactivated Activated	Deactivated
Data exchange with the drive	Reference speed	With the parameter "Reference speed", you define the reference value for the drive velocity. The drive velocity is defined as percentage value of the reference speed in the range from -200% to +200%.	Floating-point number: 1.0 to 20 000.0 (rpm)	3 000.0 (rpm)
	Maximum speed	The parameter "Maximum speed" is used to define the required maximum speed for your application.	The supported value range depends on: • the signal type selected under "Operating mode" • the value defined under "Increments per revolution" • the value defined under "Reference speed" The low limit of the value range is: • for the signal type "PTO (A, B phase-shifted - quadruple)": 0.1 Hz * 60 s/min * 4) / Increments per revolution • for the non-quadruple PTO signal types: (0.1 Hz * 60 s/min) / Increments per revolution The high limit of the value range is the minimum of the value: • 2 * reference speed and of the value: • for the signal type "PTO (A, B phase-shifted - quadruple)": (100 000 Hz * 60 s/min * 4) / Increments per revolution • for the non-quadruple PTO signal types: (100 000 Hz * 60 s/min) / Increments per revolution	3 000.0 (rpm)
	Increments per revolution	The "Increments per revolution" is used to define the number of increments per revolution (also in microstep mode), which is required by the drive for a revolution.	1 to 1 000 000	200

Category	Parameter	Meaning	Value range	Default
Fine resolution	Bits in incr. actual value (G1_XIST1)	The parameter defines the number of bits for the coding of the fine resolution in the current incremental value of G1_XIST1.	0	0
Stop behavior	Quick stop time	The parameter "Quick stop time" defines the time period within which the drive should go from the maximum speed to a standstill (OFF3).	1 to 65 535 (ms)	1 000 (ms)
Hardware inputs/ outputs	Reference switch input	The parameter "Reference switch input" defines the hardware input of the reference switch.	[Input address of the reference switch DI]	--
	Edge selection reference switch	The parameter "Edge selection reference switch" defines the edge type which is to be detected by the reference switch.	Rising edge Falling edge	Rising edge
	Measuring input	The parameter "Measuring input" defines the hardware input of the measuring input.	[Input address of the measuring input DI]	--
	"Drive ready" input	The parameter ""Drive ready" input" defines the hardware input of the input "Drive ready".	[Input addresses of the inputs "Drive ready" DIn]	--
	Pulse output A for "PTO (pulse (A) and direction B)"	The parameter "Pulse output A" defines the hardware output for PTO signal A.	[Output address DQ for PTO signal A (output frequency 100 kHz)]	Grayed out Read only access to the parameter
	Direction output B for "PTO (pulse (A) and direction B))"	The parameter "Direction output B" defines the hardware output for PTO signal B.	[Output address 1 of the DQ for PTO signal B (output frequency 100 kHz)] [Output address 2 of the DQ for PTO signal B (output frequency 100 kHz)]	Qn (output frequency 100 kHz)
	Count up for "PTO (Count up (A) and Count down (B))"	The "Clock generator forward (A)" parameter defines the hardware output for PTO signal A.	[Output address DQ for PTO signal A (output frequency 100 kHz)]	Grayed out Read only access to the parameter
	Count down for "PTO (Count up (A) and Count down (B))"	The "Clock generator backward (B)" parameter defines the hardware output for PTO signal B.	[Output address 1 of the DQ for PTO signal B (output frequency 100 kHz)]	Grayed out Read only access to the parameter

Category	Parameter	Meaning	Value range	Default
	Phase A for "PTO (A, B phase-shifted)" and "PTO (A, B phase-shifted, quadruple)"	The "Clock generator output (A)" parameter defines the hardware output for PTO signal A.	[Output address of the DQ for PTO signal A (output frequency 100 kHz)]	Grayed out Read only access to the parameter
	Phase B for "PTO (A, B phase-shifted)" and "PTO (A, B phase-shifted, quadruple)"	The "Clock generator output (B)" parameter defines the hardware output for PTO signal B.	[Output address 1 of the DQ for PTO signal B (output frequency 100 kHz)]	Grayed out Read only access to the parameter
	Drive enable output	The parameter "Drive enable output" defines the hardware output of the output "Drive enable output".	[Output addresses of the enable outputs DQn (output frequency 100 Hz)]	--

Reaction of the PTO channel to CPU STOP

The PTO channel reacts to a change to CPU STOP by removing the drive enable (if the drive enable output is configured) and outputting the velocity setpoint 0 at the hardware outputs configured for the signal tracks A and B. The CPU STOP reaction of the PTO channels cannot be configured.

Note

Reaction to CPU STOP

Upon CPU STOP, the hardware outputs assigned for the PTO outputs A and B can switch to signal state 'High' (1) and/or remain there. It is not guaranteed that the two hardware outputs switch to/remain in signal level 'Low' (0).

Controller

The pulse output channels for the four modes of the pulse generators (PTO) are controlled using Motion Control via the technology objects TO_SpeedAxis, TO_PositioningAxis and TO_SynchronousAxis. With these operating modes, the control and feedback interface of the channels is a partial implementation of the PROFIdrive interface "Telegram 3". For a detailed description of the use of motion control and its configuration, refer to the S7-1500 Motion Control function manual (http://support.automation.siemens.com/WW/view/en/59381279) and the STEP 7 online help.

3.2.2 Functions

3.2.2.1 Function: High-speed output

The function "High-speed output (0.1 A)" improves the signal clock of the digital outputs (DQ0 to DQ7). Less delay, fluctuation, jitter, and shorter rise and fall times occur at the switching edges.

The function "High-speed output (0.1 A)" is suitable for generating pulse signals in a more precise clock, but provides a lower maximum load current.

For the PWM and Frequency output modes, select the high-speed output of the channel in STEP 7 (TIA Portal). You can also change the parameter assignment during runtime with the help of the program via the data record.

High-speed pulse output (high-speed output) is available for the following operating modes:

- PWM
- Frequency output
- PTO (the pulse outputs for the PTO mode are always "High-speed output (0.1 A)")

High-speed output

	Minimum		Maximum	
	High-speed output deactivated	High-speed output activated	High-speed output deactivated	High-speed output activated
Pulse duration	20 µs with load > 0.1 A [1] 40 µs with load ≥ 2 mA [1]	2 µs [1]	10 000 000 µs (10 s)	
Period duration	100 µs [2]	10 µs		
Frequency	0.1 Hz		10 kHz [2]	100 kHz

[1] A lower value is theoretically possible but, depending on the connected load, the output voltage can no longer be output as complete rectangular pulse

[2] Load-dependent

3.2.2.2 Function: Direct control of the pulse output (DQA)

Direct control of the pulse output (DQA)

In the modes "Pulse width modulation PWM" and "Frequency output", you can set the pulse output (DQA) of a pulse generator directly via the control program. Select the function for the DQ direct control by deleting the output control bit of the PWM channel (TM_CTRL_DQ = 0) in the control interface.

The direct control of the pulse output (DQA) can be helpful when commissioning a control system for automation.

When you select the direct control of the pulse output (DQA) during a pulse output sequence, the sequence continues to run in the background so that the output sequence is continued as soon as the channel takes control again (by setting TM_CTRL_DQ = 1).

You assign the status of the pulse output (DQA) using the control bits SET_DQA.

When you set TM_CTRL_DQ = 1, you deselect the direct control of the pulse output (DQA) and the channel takes over the processing. If the output sequence is still running (STS_ENABLE still active), the PWM channel takes over the control of the output again. If TM_CTRL_DQ = 1 and STS_ENABLE is not active, the module's channel also takes over processing, but then outputs "0".

Note

Output control signal TM_CTRL_DQ of the PWM channel

- If TM_CTRL_DQ = 1, the technology function takes over the control and generates pulse sequences at the output PWM DQA.
- If TM_CTRL_DQ = 0, the user program takes over the control and the user can set the PWM DQA directly using the control bits SET_DQA.

3.2.3 Configuring the PWM and frequency output modes

3.2.3.1 Assignment of the control interface

The user program influences the behavior of the PWM channel through the control interface.

Control interface per channel

The following table shows the control interface assignment:

Table 3- 5 Assignment of the control interface

	7	6	5	4	3	2	1	0
Byte 0	OUTPUT_VALUE							
Byte 1	PWM: On-load factor * (Int)							
Byte 2	In PWM mode, the on-load factor uses only the two least significant bytes (byte 2 and byte 3).							
Byte 3	Frequency output: Frequency in Hz (Real)							
Byte 4	SLOT							
Byte 5								
Byte 6								
Byte 7								
Byte 8	Reserved = 0			MODE_SLOT	LD_SLOT Specifies the meaning of the value under SLOT			
					0000: No action			
					0001: Period duration (PWM)			
					0010 to 1111: Reserved			
Byte 9	Reserved = 0		Reserved = 0	Reserved = 0	SET_DQA	Reserved = 0	TM_CTRL_DQ	SW_ENABLE
Byte 10	Reserved = 0							RES_ERROR
Byte 11	Reserved = 0							

* The terms "On-load factor", "Pulse duty factor" and "Duty factor" can be used synonymously

Use case

1. Transfer the control for the output to the PWM channel.
2. Set SW_ENABLE so that the output can be started.
3. Set the required on-load factor using OUTPUT_VALUE.
4. If necessary, change the period duration (cyclically or once). If you do not change the value, the period duration from the hardware configuration will be used.
5. With TM CTRL_DQ and SET_DQ, set the output from the user program permanently to 1 or 0.
6. Acknowledge any errors that occur using RES_ERROR.

Additional parameters for the output sequence are defined before the start of an output sequence.

The data record of the parameter assignment is changed in the device configuration in STEP 7 (TIA Portal) or through WRREC execution.

Control interface parameters

OUTPUT_VALUE

The interpretation of the value OUTPUT_VALUE depends on the set operating mode. OUTPUT_VALUE is always updated. When an invalid value is detected (outside the permissible range), the error memory bit ERR_OUT_VAL is set until a valid value is detected. During the error condition, the invalid value is ignored and the PWM channel continues with the last valid OUTPUT_VALUE. Note that, in the frequency output mode, it is also possible that no last valid value is available. In this case, the pulse output returns the value 0, i.e. there is no pulse output.

Please note that the on-load factor is not checked in PWM mode. If the on-load factor is greater than the format permits, the PWM channel uses a ratio of 100%. For values < 0, 0% is effective.

SLOT, MODE_SLOT and LD_SLOT

Use these control interface fields if you occasionally change the period duration in PWM mode before the start of the output sequence or during operation. You can find a description of the interaction between SLOT, MODE_SLOT and LD_SLOT under Handling the SLOT parameter (control interface) (Page 65).

SW_ENABLE

If 0 → 1, activate the output sequence.

TM_CTRL_DQ

- If 1, the output is controlled by the PWM channel and generates the pulse sequences
- If 0, the output is controlled directly by the program using the SET_DQA assignments

SET_DQA

- If 1, set the output A to 1, if TM_CTRL_DQ is inactive
- If 0, set the output A to 0, if TM_CTRL_DQ is inactive

RES_ERROR

Resetting the error bit memory ERR_LD in the feedback interface

3.2.3.2 Handling the SLOT parameter (control interface)

SLOT and MODE_SLOT

SLOT has the following operating modes.

- **Mode for individual update (MODE_SLOT = 0)**
  Use this mode if you occasionally change the specific parameters (such as period duration) before the start of the output sequence or during operation.
  - The value in SLOT is always applied when the value changes in LD_SLOT.
  - The acknowledgment bit STS_LD_SLOT in the feedback interface is switched.
  - The value of LD_SLOT defines the interpretation of SLOT (see the table below "Interpretation of the SLOT parameter value").
  - If the LD_SLOT value is invalid, the setting of the feedback bit ERR_LD indicates a parameter assignment error. The user has to reset the error using the control bit RES_ERROR and enable the SLOT parameter again for the next value.
  - Changes made in this mode can be read back by the channel to the parameter assignment data record.
  - The current changes are entered in the data record 128 during readback of the parameter assignment data from the user program with RDREC. These changes are lost during a warm restart of the CPU.
- **Mode for cyclic updating (MODE_SLOT = 1)**
  Use this operating mode if the program is to continuously control another parameter in addition to the main parameter to be controlled.
  - The value in SLOT is transferred with each module cycle.
  - No acknowledgment bit is available.
  - The value of LD_SLOT defines the interpretation of SLOT (see the table below "Interpretation of the SLOT parameter value").
  - If the value in SLOT is not valid, the error ERR_SLOT_VAL occurs. The error is automatically reset as soon as a valid value is loaded.
  - In this mode, the value in the parameter assignment data record is not updated. If LD_SLOT is changed in this mode, the last value applied from LD_SLOT is valid.
  - The mode for permanent updating can be stopped by setting LD_SLOT to 0 and MODE_SLOT to 0. By stopping the mode for permanent updating, the changes made at the parameters during permanent updating are retained until the next changes via SLOT (cyclic or once) or until the next STOP-RUN transition.

Interpretation of the SLOT parameter value

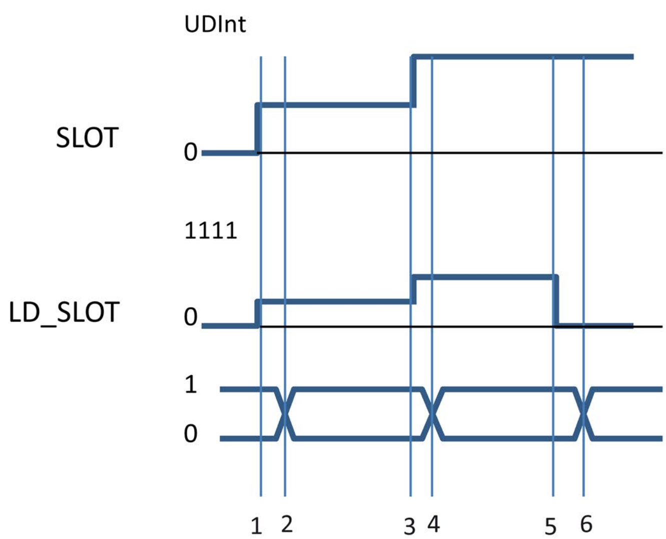
The value written in the SLOT parameter is interpreted depending on the LD_SLOT value and the mode as shown in the table below.

LD_SLOT	Meaning of SLOT value	Valid modes for using the SLOT value	SLOT data type
0	No action / idling	All operating modes	
1	Period duration	PWM	UDInt Permissible value range*: Minimum value: 10 µs, 100 µs or 10 000 µs (10 ms) Maximum value: 10 000 000 µs (10 s)

* The permissible value range depends on the selected hardware output and sometimes on the high-speed mode (high-speed/standard).

Individual updating of the parameter 'Period duration'

The following representation illustrates the sequence of the individual updating of the parameter 'Period duration'. The described workflow principle can also be used on the channels of the high-speed counters.



① User writes the first parameter in SLOT and specifies the first parameter in LD_SLOT
② Technology channel applies the first parameter and indicates the application with a change in the bit STS_LD_SLOT
③ User writes the second parameter in SLOT and specifies the second parameter in LD_SLOT
④ Technology channel applies the second parameter and indicates the application with a change in the bit STS_LD_SLOT
⑤ User writes 0 in LD_SLOT, (SLOT inactive)
⑥ Technology channel answers change in LD_SLOT with a change in STS_LD_SLOT

Figure 3-4 Individual updating

Note that the following requirements apply to the representation shown above:

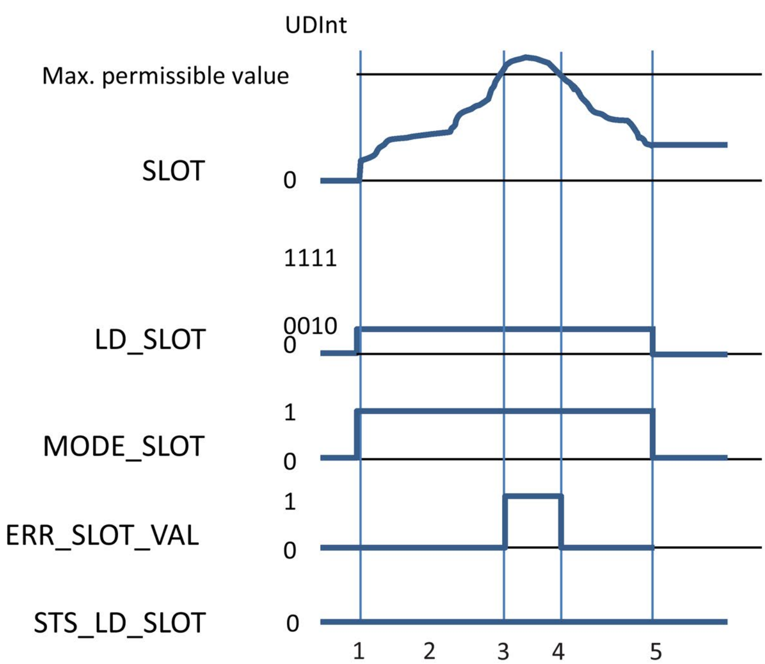
- The value MODE_SLOT must be set to 0
- Errors or invalid values are shown in the feedback bit ERR_SLOT_VAL
- The error must be acknowledged

If MODE_SLOT 0 = 1, the following applies (for PWM mode only):

- The value in SLOT is continuously evaluated according to LD_SLOT
- STS_LD_SLOT does not change
- An error is automatically reset as soon as a valid value is set in SLOT

Cyclic updating of the parameter 'Period duration'

The following representation illustrates the sequence of the cyclic updating of the parameter 'Period duration'. The described workflow principle can also be used on the channels of the high-speed counters.



①
- User sets SLOT to the required parameter
- User sets MODE_SLOT to 1
- User sets LD_SLOT to the required value (1 for period duration)

② User changes value in SLOT continuously and technology channel evaluates continuously

③ Value in SLOT exceeds permitted limit, technology channel shows this ERR_SLOT_VAL and continues working with the last valid value

④ Value in SLOT again in permitted range, technology channel resets ERR_SLOT_VAL independently and continues working with the value in SLOT

⑤ User resets LD_SLOT and MODE_SLOT, technology channel continues to work with last value

Figure 3-5 Cyclic updating

3.2.3.3 Assignment of the feedback interface

The user program receives current values and status information from the pulse width modulation via the feedback interface.

Feedback interface per channel

The following table shows the feedback interface assignment:

Table 3- 6 Assignment of the feedback interface

	7	6	5	4	3	2	1	0
Byte 0	ERR_SLOT_VAL The valid in SLOT is invalid	ERR_OUT_VAL The value in OUTPUT_VALUE is invalid	Reserved = 0	Reserved = 0	ERR_PULSE	ERR_LD Error during loading via control interface	Reserved = 0	ERR_PWR missing supply voltage L+
Byte 1	Reserved = 0		STS_SW_ENABLE SW_ENABLE detected or feedback status SW_ENABLE	STS_READY Channel parameters assigned and ready	Reserved = 0	STS_LD_SLOT Load prompt detected and exe-cuted for slot (tog-gling)	Reserved = 0	
Byte 2	Reserved = 0			Reserved = 0	Reserved = 0	Reserved = 0	STS_DQA	STS_ENABLE
Byte 3	Reserved = 0				Reserved = 0			

Feedback parameters

Table 3- 7 Status feedback

Feedback parameters	Meaning	Value range
STS_READY	The channel is correctly configured, is operating and supplying valid data.	0: Not ready to run 1: Ready to run
STS_SW_ENABLE	Current status of the software enable	0: SW_ENABLE is not active 1: SW_ENABLE detected
STS_LD_SLOT	Acknowledgment bit for each action of the SLOT in the SLOT mode for individual updating (for a description of the acknowledgment bit, refer to the section Handling the SLOT parameter (control interface) (Page 65)).	Each switching of this bit represents a successful LD_SLOT action.
STS_ENABLE	The output sequence is active. (STS_ENABLE always depends on the status of the software enable STS_SW_ENABLE)	0: No output sequence running 1: Output sequence running
STS_DQA	State of the pulse output (DQA)	0: Pulse output is not active 1: Pulse output is active

Feedback parameters	Meaning	Value range
ERR_PWR	No supply voltage L+	0: No error 1: Error
ERR_LD	Error during loading of a parameter value in the operating mode for individual updating	0: No error 1: Error
ERR_OUT_VAL	The value in OUTPUT_VALUE is invalid	0: No error 1: Error
ERR_SLOT_VAL	The value in SLOT is invalid, where MODE_SLOT = 1 (permanent updating)	0: No error 1: Error

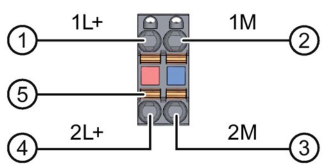
Wiring 4

4.1 Supply voltage

24 V DC supply voltage (X80)

The connecting plug for the supply voltage is plugged in when the CPU ships from the factory.

The following table shows the terminal assignment for a 24 V DC power supply.



① +24 V DC of the supply voltage
② Ground of the supply voltage
③ Ground of the supply voltage for loop-through (maximum of 10 A permitted)
④ +24 V DC of the supply voltage for loop-through (maximum of 10 A permitted)
⑤ Spring-loaded NC contact (one spring-loaded NC contact per terminal)

Bridged internally:
① and ④
② and ③

Figure 4-1 Connection for supply voltage

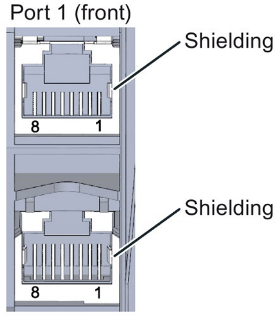
If the CPU is supplied by a system power supply, it is not necessary to connect the 24 V supply.

4.2 PROFINET interfaces

PROFINET interface X1 with 2-port switch (X1 P1 R and X1 P2 R)

The assignment corresponds to the Ethernet standard for an RJ45 plug.

- When autonegotiation is deactivated, the RJ45 socket is allocated as a switch (MDI-X).
- When autonegotiation is activated, autocrossing is in effect and the RJ45 socket is allocated either as data terminal equipment (MDI) or a switch (MDI-X).



Reference

For more information on "Wiring the CPU" and "Accessories/spare parts", refer to the S7-1500, ET 200MP system manual (http://support.automation.siemens.com/WW/view/en/59191792).

Assignment of the MAC addresses

The CPU 1511C-1 PN has a PROFINET interface with two ports. The PROFINET interface itself has a MAC address, and each of the two PROFINET ports has its own MAC address. The CPU 1511C-1 PN therefore has three MAC addresses in total.

The MAC addresses of the PROFINET ports are needed for the LLDP protocol, for example for the neighborhood discovery function.

The number range of the MAC addresses is continuous. The first and last MAC address are lasered on the rating plate on the right side of each CPU 1511C-1 PN.

The table below shows how the MAC addresses are assigned.

Table 4- 1 Assignment of the MAC addresses

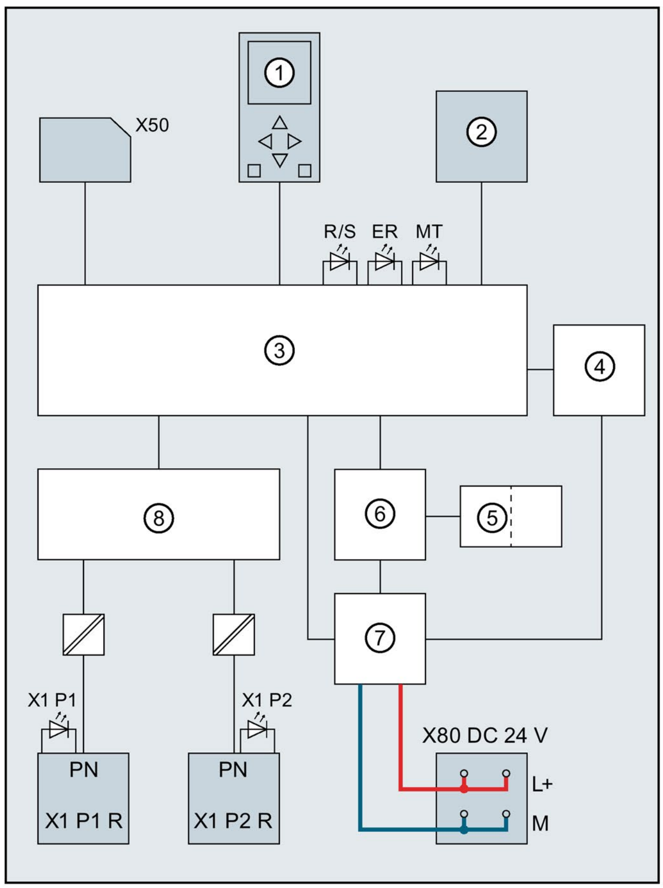
	Assignment	**Labeling**
MAC address 1	PROFINET interface X1 (visible in STEP 7 for accessible devices)	• Front, lasered • Right side, lasered (start of number range)
MAC address 2	Port X1 P1 R (required for LLDP, for example)	• Front and right side, not lasered
MAC address 3	Port X1 P2 R (required for LLDP, for example)	• Front, not lasered • Right side, lasered (end of number range)

4.3 Terminal and block diagrams

4.3.1 Block diagram of the CPU part

Block diagram

The following figure shows the block diagram of the CPU part.



①	Display	X80 24 V DC	Infeed of supply voltage
②	RUN/STOP/MRES mode selector	PN X1 P1 R	PROFINET interface X1 port 1
③	Electronics	PN X1 P2 R	PROFINET interface X1 port 2
④	Interface to on-board I/O	L+	24 V DC supply voltage
⑤	Interfaces to the backplane bus	M	Ground
⑥	Backplane bus interface	R/S	RUN/STOP LED (yellow/green)
⑦	Internal supply voltage	ER	ERROR LED (red)
⑧	2-port switch	MT	MAINT LED (yellow)
X50	SIMATIC Memory card	X1 P1, X1 P2	Link TX/RX LED

Figure 4-2 Block diagram of the CPU part

4.3.2 Terminal and block diagram of the analog on-board I/O

This section contains the block diagram of the analog on-board I/O (X10) and various wiring options.

For information on wiring the front connector, establishing the cable shield, etc., refer to the S7-1500, ET 200MP (http://support.automation.siemens.com/WW/view/en/59191792) system manual.

Note

You can use and combine the different wiring options for all channels. Note, however, that unneeded terminals of an analog input channel must not be connected.

Definition

U_n+/U_n-	Voltage input channel n (voltage only)
M_n+/M_n-	Measuring input channel n (only resistance-type transmitters or thermal resistors (RTD))
I_n+/I_n-	Current input channel n (current only)
$I_{c\,n}$+/$I_{c\,n}$-	Current output for RTD, channel n
QV_n	Voltage output channel
QI_n	Current output channel
M_{ANA}	Reference potential of the analog circuit
CHx	Channel or display of the channel status

Infeed element

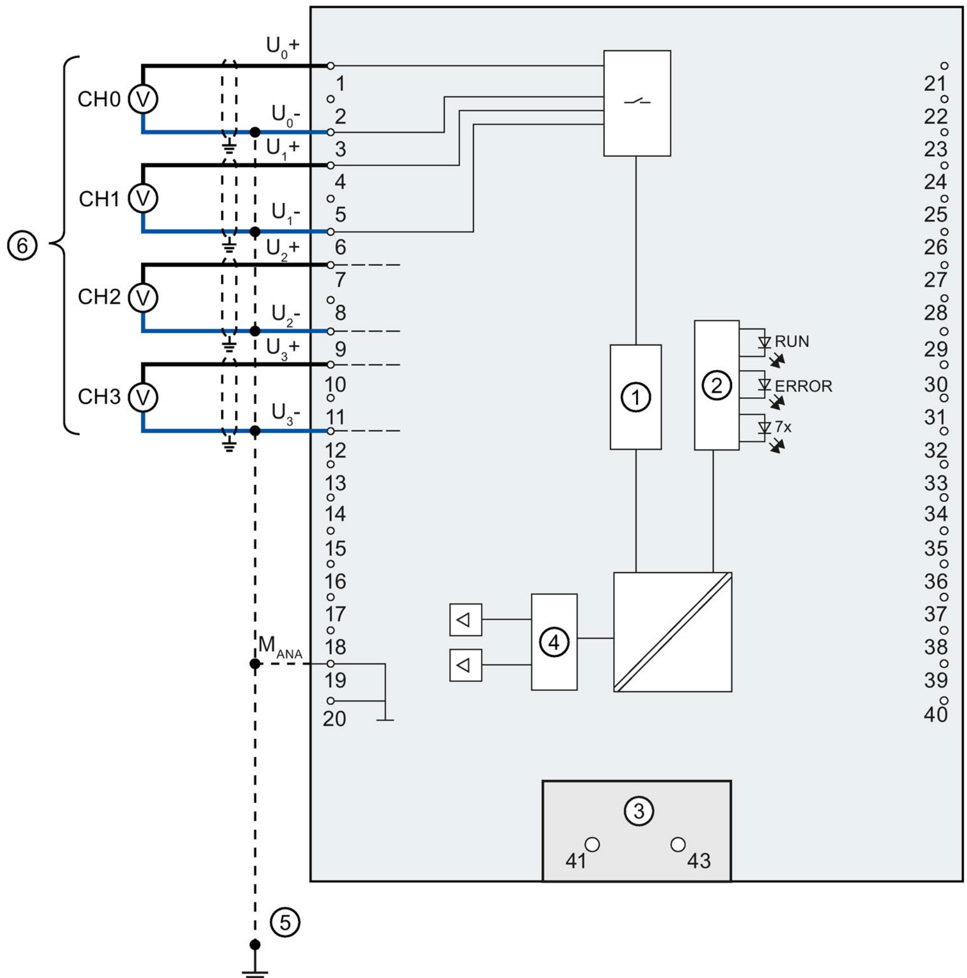
The infeed element is inserted on the front connector and serves to shield the analog on-board I/O.

Note

The analog on-board I/O does not require power to be supplied by the infeed element. The infeed element is, however, necessary for shielding.

Wiring: Voltage measurement

The following figure shows the terminal assignment for voltage measurement at the channels available for this measurement type (channels 0 to 3).

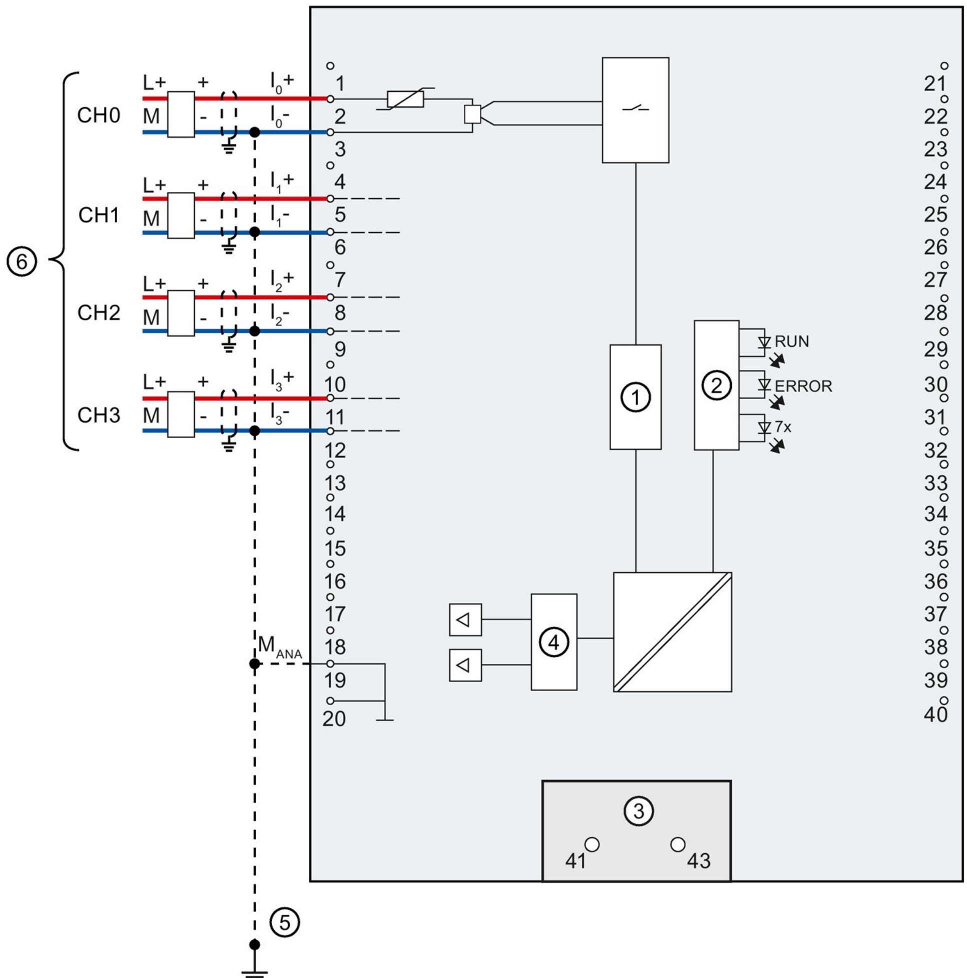


① Analog-to-digital converter (ADC)
② LED interface
③ Infeed element (for shielding only)
④ Digital-to-analog converter (DAC)
⑤ Equipotential bonding cable (optional)
⑥ Voltage measurement

Figure 4-3 Block diagram and terminal assignment for voltage measurement

Wiring: 4-wire measuring transducer for current measurement

The following figure shows the terminal assignment for current measurement with 4-wire measuring transducer at the channels available for this measurement type (channels 0 to 3).



① Analog-to-digital converter (ADC)
② LED interface
③ Infeed element (for shielding only)
④ Digital-to-analog converter (DAC)
⑤ Equipotential bonding cable (optional)
⑥ Connector 4-wire measuring transducer

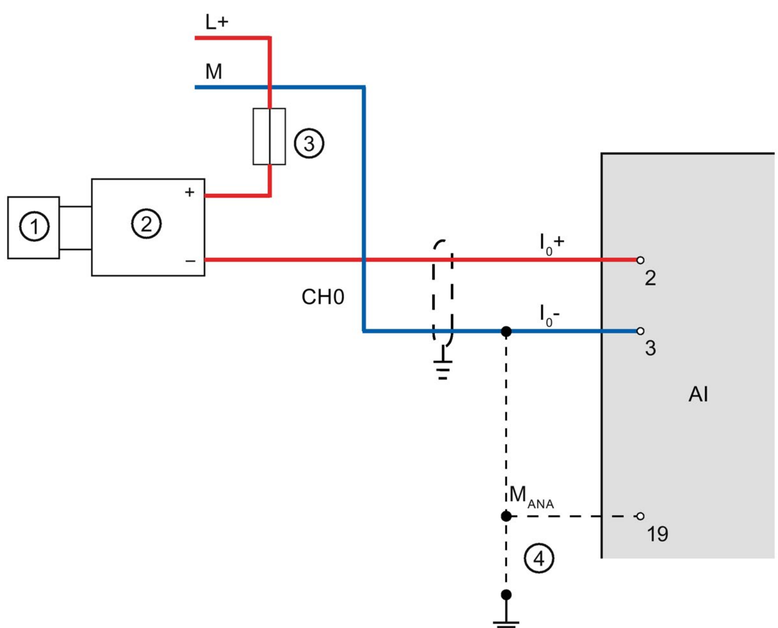
Figure 4-4 Block diagram and terminal assignment for current measurement with 4-wire measuring transducer

Wiring: 2-wire measuring transducer for current measurement

As an alternative to connecting a 4-wire measuring transducer, you can also connect 2-wire measuring transducers to channels 0 to 3. An external 24 V power supply is required to connect a 2-wire measuring transducer to the analog on-board I/O of the compact CPU. Feed this voltage short-circuit proof to the 2-wire transducer. Use a fuse to protect the power supply unit.

NOTICE
Defective measuring transducer
Note that the analog input of the measuring transducer is not protected against destruction in the event of a defect (short circuit). Take the necessary precautions against such cases.

The figure below shows an example of the connection of a 2-wire measuring transducer to channel 0 (CH0) of the analog on-board I/O.



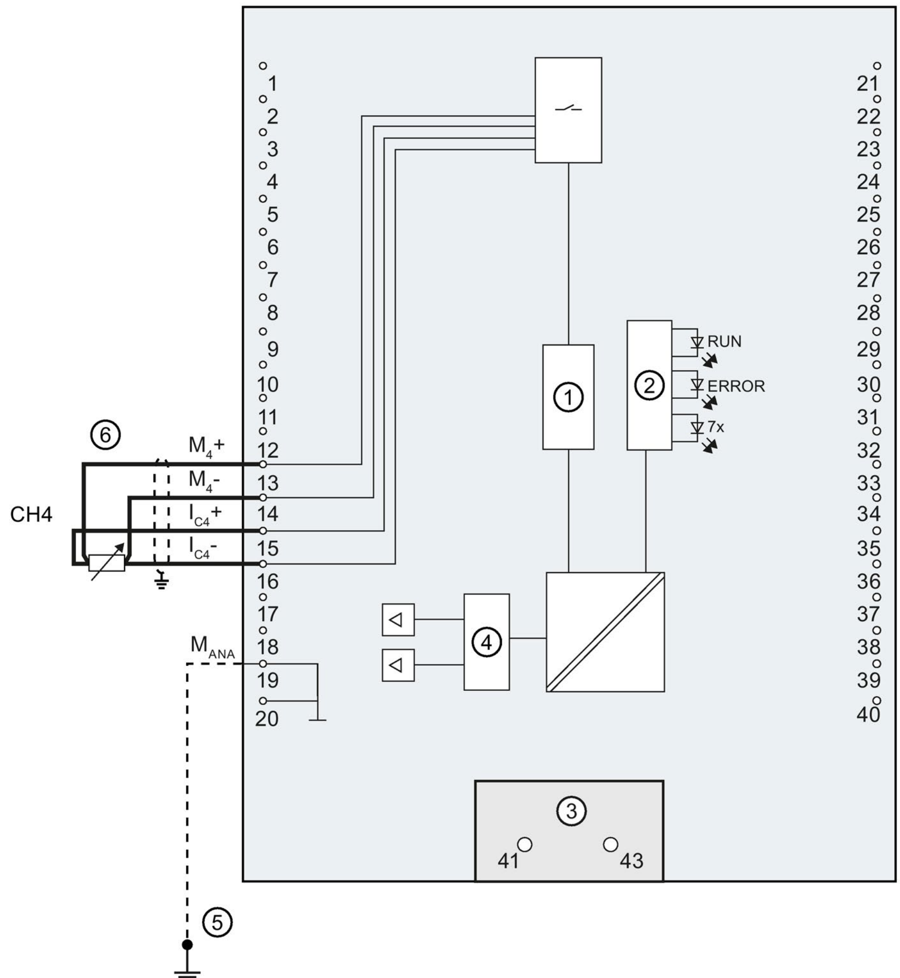
① Sensor (e.g. pressure gauge)
② 2-wire measuring transducer
③ Fuse
④ Equipotential bonding cable (optional)

Figure 4-5 2-wire measuring transducer at channel 0

Use the measurement type "Current (4-wire transducer)" and the measuring range 4 to 20 mA for the parameter assignment of the 2-wire measuring transducer in STEP 7 (TIA Portal).

Wiring: 4-wire connection of resistance-type sensors or thermal resistors (RTD)

The following figure shows the terminal assignment for 4-wire connection of resistance-type sensors or thermal resistors at the channel available for this (channel 4).



① Analog-to-digital converter (ADC)
② LED interface
③ Infeed element (for shielding only)
④ Digital-to-analog converter (DAC)
⑤ Equipotential bonding cable (optional)
⑥ 4-wire connection

Figure 4-6 Block diagram and terminal assignment for 4-wire connection

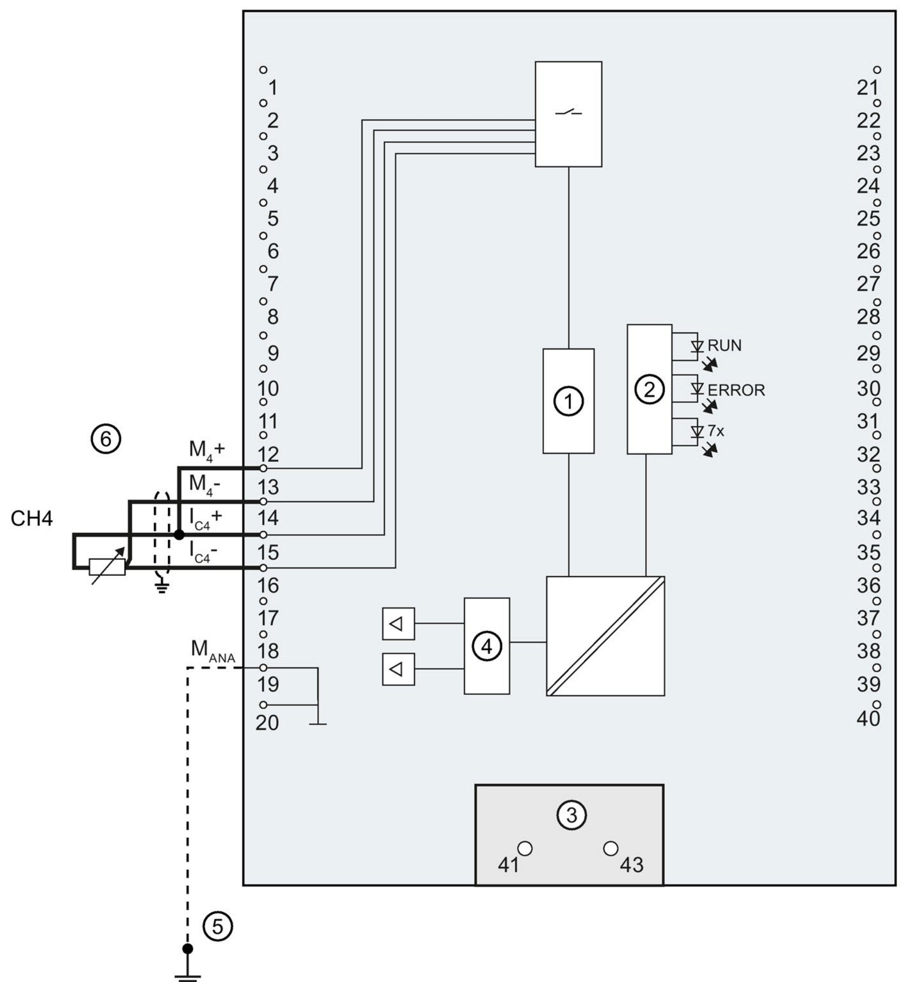
Wiring: 3-wire connection of resistance-type sensors or thermal resistors (RTD)

The following figure shows the terminal assignment for 3-wire connection of resistance-type sensors or thermal resistors at the channel available for this (channel 4).

Note

3-wire connection

Note that line resistances are not compensated with a 3-wire connection.



① Analog-to-digital converter (ADC)

② LED interface

③ Infeed element (for shielding only)

④ Digital-to-analog converter (DAC)

⑤ Equipotential bonding cable (optional)

⑥ 3-wire connection

Figure 4-7 Block diagram and terminal assignment for 3-wire connection

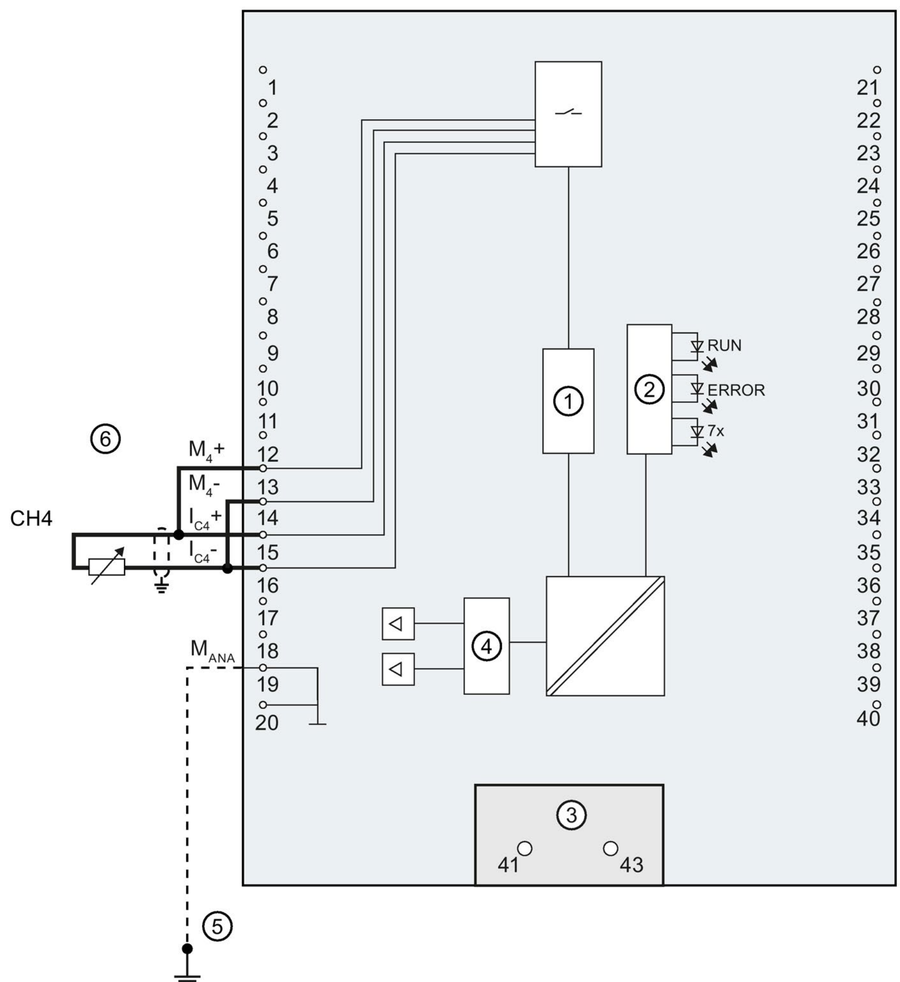
Wiring: 2-wire connection of resistance-type sensors or thermal resistors (RTD)

The following figure shows the terminal assignment for 2-wire connection of resistance-type sensors or thermal resistors at the channel available for this (channel 4).

Note

2-wire connection

Note that line resistances are not compensated with a 2-wire connection.



① Analog-to-digital converter (ADC)

② LED interface

③ Infeed element (for shielding only)

④ Digital-to-analog converter (DAC)

⑤ Equipotential bonding cable (optional)

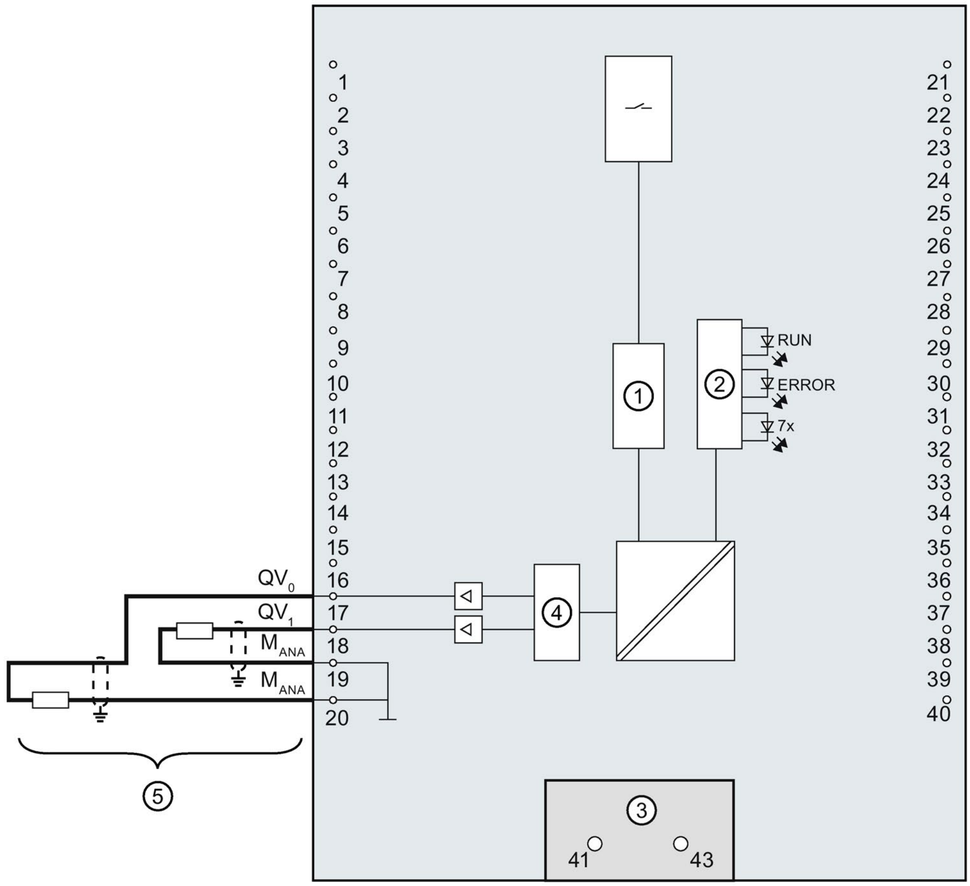
⑥ 2-wire connection

Figure 4-8 Block diagram and terminal assignment for 2-wire connection

Wiring: Voltage output

The figure below shows the terminal assignment for the wiring of the voltage outputs with:

- 2-wire connection without compensation for line resistances.



① Analog-to-digital converter (ADC)
② LED interface
③ Infeed element (for shielding only)
④ Digital-to-analog converter (DAC)
⑤ 2-wire connection CH0 and CH1

Figure 4-9 Block diagram and terminal assignment for voltage output

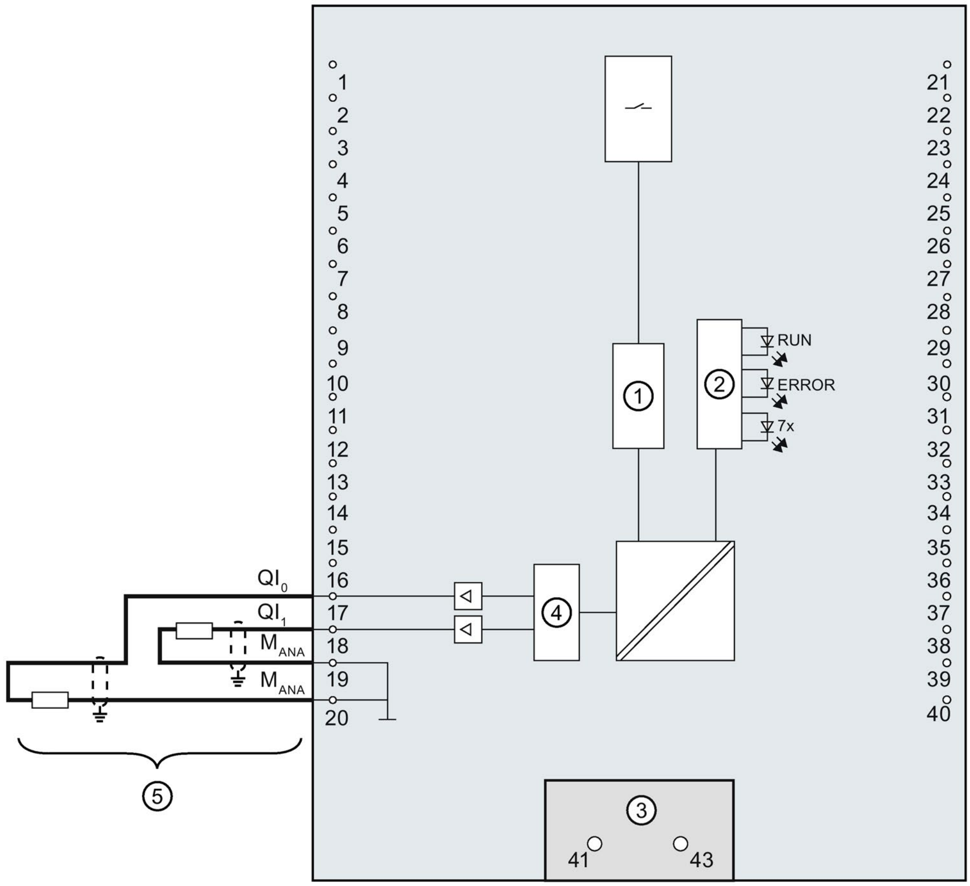
---

Note

M_{ANA} on terminals 19 and 20 is equivalent.

Wiring: Current output

The following figure shows an example of the terminal assignment for wiring current outputs.



① Analog-to-digital converter (ADC)
② LED interface
③ Infeed element (for shielding only)
④ Digital-to-analog converter (DAC)
⑤ Current output CH0 and CH1

Figure 4-10 Block diagram and terminal assignment for current output

---

Note

M_{ANA} on terminals 19 and 20 is equivalent.

4.3.3 Wiring and block diagrams of the digital on-board I/O

This section contains the block diagram of the digital on-board I/O (X11) with standard inputs and outputs and the encoder supply, as well as the rules for the correct wiring of the ground connections.

For information on wiring the front connector, establishing the cable shield, etc., refer to the S7-1500, ET 200MP (http://support.automation.siemens.com/WW/view/en/59191792) system manual.

Infeed element

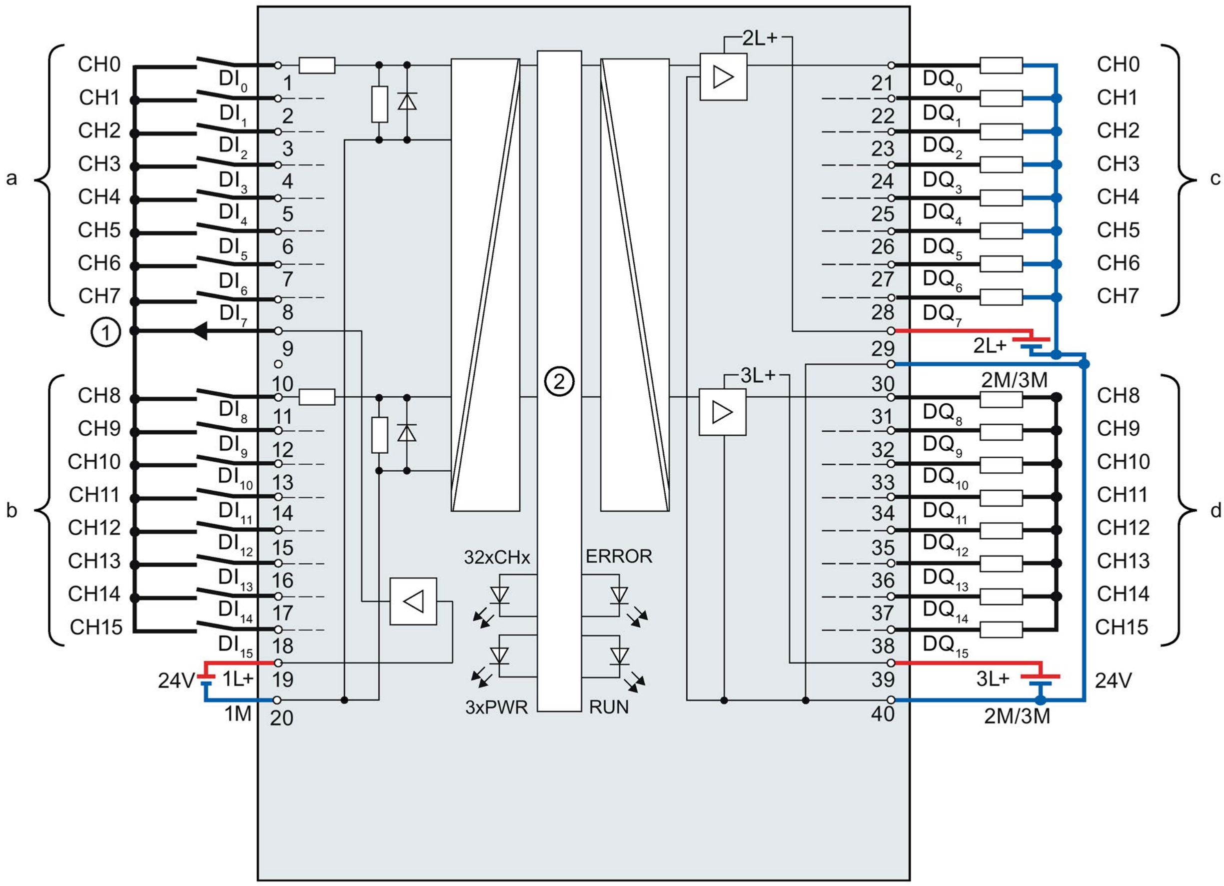
The infeed element is inserted on the front connector and serves to shield the digital on-board I/O.

Note

The digital on-board I/O is supplied via the front connector terminals and therefore does not require power to be supplied by the infeed element. The infeed element is, however, necessary for shielding.

Block diagram and terminal assignment

The figure below shows you how to connect the digital on-board I/O and the assignment of the channels to the addresses (input byte a and b, output byte c and d).



①	Encoder supply for the digital inputs
②	CPU interface
xL+	Connection for 24 V DC supply voltage
xM	Connection for ground
CHx	Channel or channel status LED (green)
RUN	Status display LED (green)
ERROR	Error display LED (red)
PWR	POWER supply voltage LED (green)

Figure 4-11 Block diagram and terminal assignment

NOTICE

Polarity reversal of the supply voltage

An internal protective circuit protects the digital on-board I/O against destruction if the polarity of the supply voltage is reversed. In the case of polarity reversal of the supply voltage, however, unexpected states can occur at the digital outputs.

Supply voltage

The inputs and outputs of the digital on-board I/O are divided into two load groups which are supplied with 24 V DC.

The digital inputs DI0 to DI15 form a load group and are supplied via the connections 1L+ (terminal 19) and 1M (terminal 20).

The digital outputs DQ0 to DQ7 are supplied via the connection 2L+ (terminal 29). The digital outputs DQ8 to DQ15 are supplied via the connection 3L+ (terminal 39). Please note that the digital outputs DQ0 to DQ15 only have a common ground. In each case, they are led through to the two terminals 30 and 40 (2M/3M) and bridged in the module. The digital outputs form a common load group.

Response of the digital outputs to a wire break at ground connection of the outputs

Due to the characteristics of the output driver used in the module, approx. 25 mA supply current flows out through the outputs via a parasitic diode in the event of a ground wire break. This behavior can lead to non-set outputs also carrying high levels and emitting up to 25 mA output current. Depending on the type of load, 25 mA can be sufficient to control the load with high level. To prevent unintended switching of the digital outputs in the event of a ground wire break, follow these steps:

Wire to ground twice

Connect ground to terminal 30 and to terminal 40.

1. Route the first ground connection from terminal 30 to the central ground connection of the plant.

2. Route the second ground connection from terminal 40 to the central ground connection of the plant.

If terminal 30 or 40 are interrupted by a ground wire break, the outputs will continue to be supplied via the second, intact ground connection.

WARNING

Wire break at ground connection

Never bridge from terminal 30 to terminal 40 in the front connector and **never** lead only one wire to the central ground connection.

Connect terminal 30 and terminal 40 to a common ground point.

As a supplement to the block diagram and terminal assignment, the following figure shows the correct wiring of the outputs in order to prevent switching of the outputs in the event of a ground wire break.

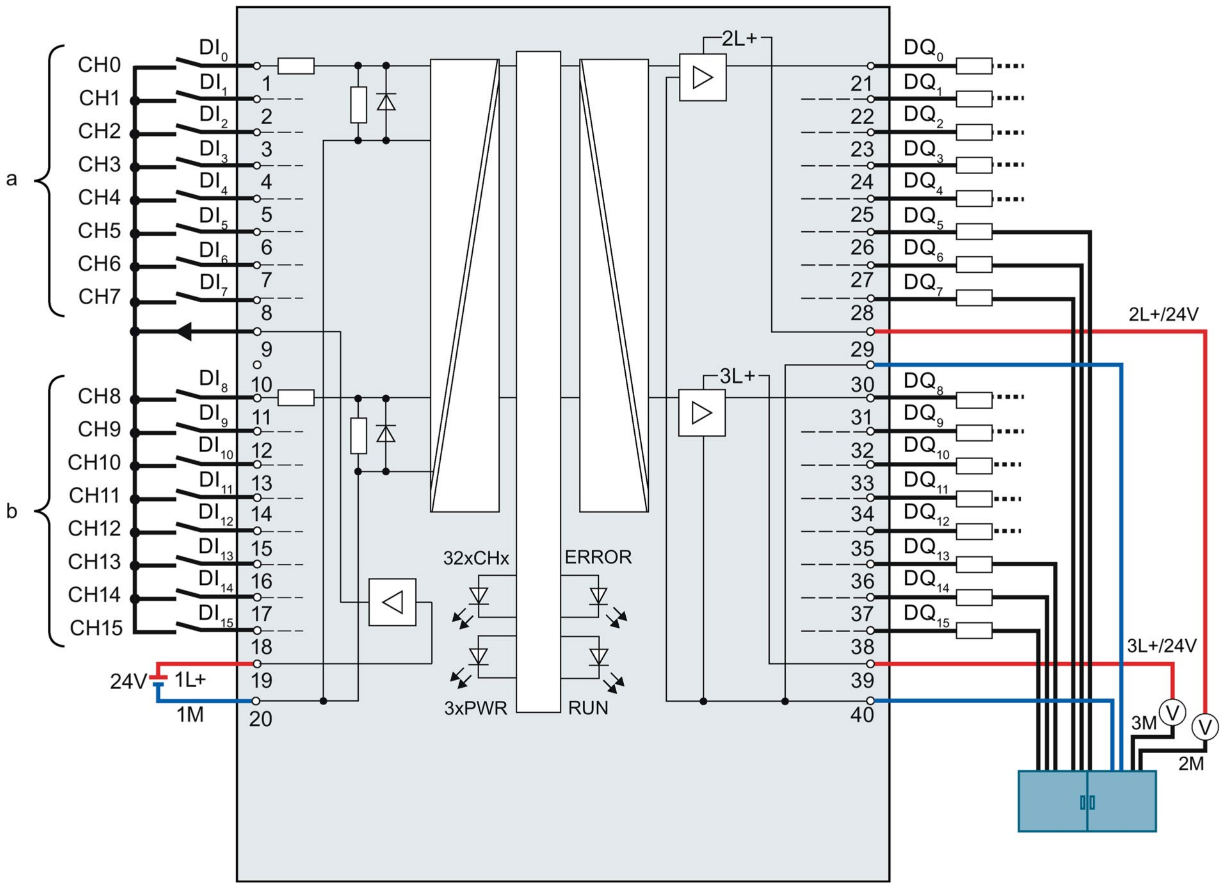


Figure 4-12 Correct wiring

The ground is supplied with a first cable from the central terminal block to terminal 30 of the module and additionally with a second cable also from the central terminal block to terminal 40 of the module.

At the digital outputs, each of the ground connections of the loads is connected with a separate cable for each load to the central terminal block.

The figure below shows the current flow with correct wiring.

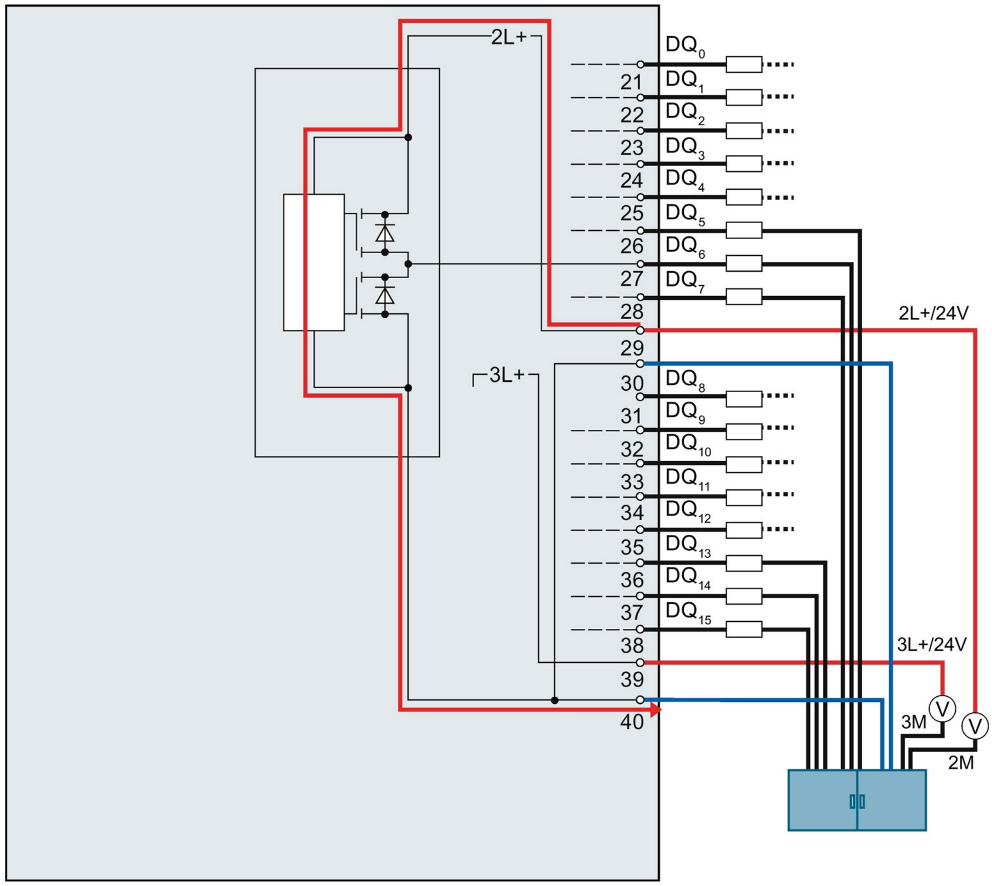


Figure 4-13 Current flow with correct wiring

With correct wiring, the supply current flows from the power supply 2L+ via terminal 29 to the module. In the module, the current flows via the output driver and exits the module via terminal 40.

The figure below shows the reaction to interruption of the first ground cable.

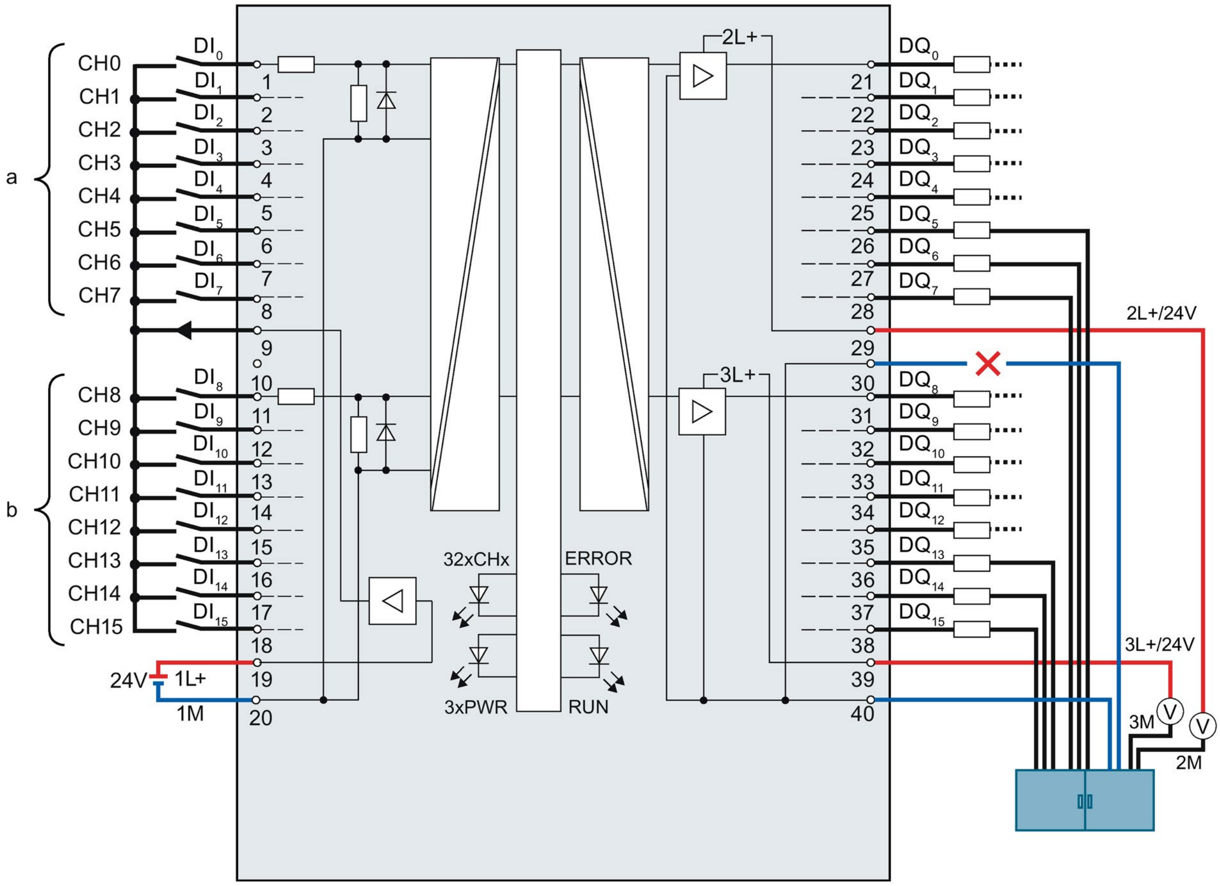


Figure 4-14 Interruption of the first ground cable

If a wire break occurs on the first ground cable from the central terminal block to terminal 30, the module can continue to operate without restrictions, as it is still connected to the ground via the second cable from the central terminal block to terminal 40.

The figure below shows the reaction to interruption of the second ground cable.

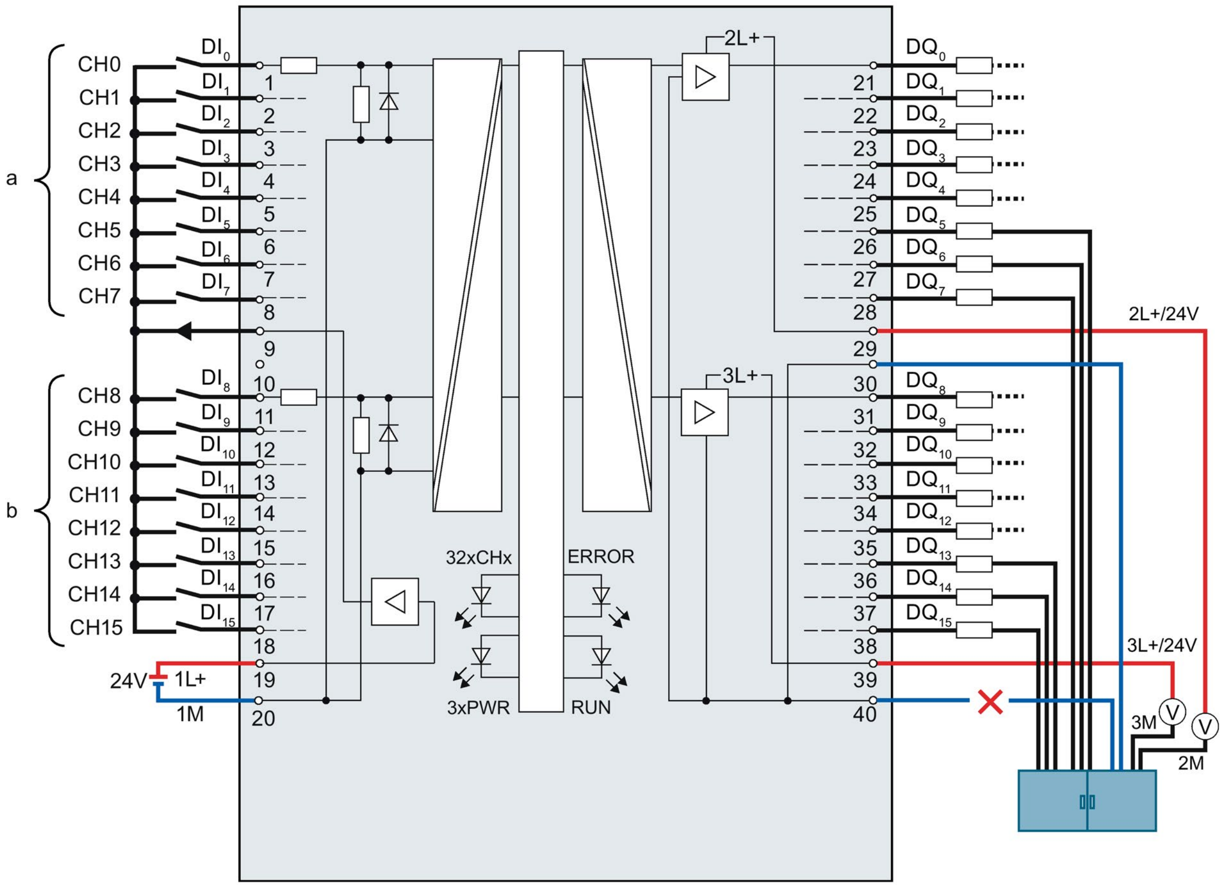


Figure 4-15 Interruption of the second ground cable

If a wire break occurs on the second ground cable from the central block terminal to terminal 30, the module can continue to operate without restrictions, as it is still connected to the ground via the first cable from the central terminal block to terminal 40.

The figure below shows the current flow upon interruption of both ground cables.

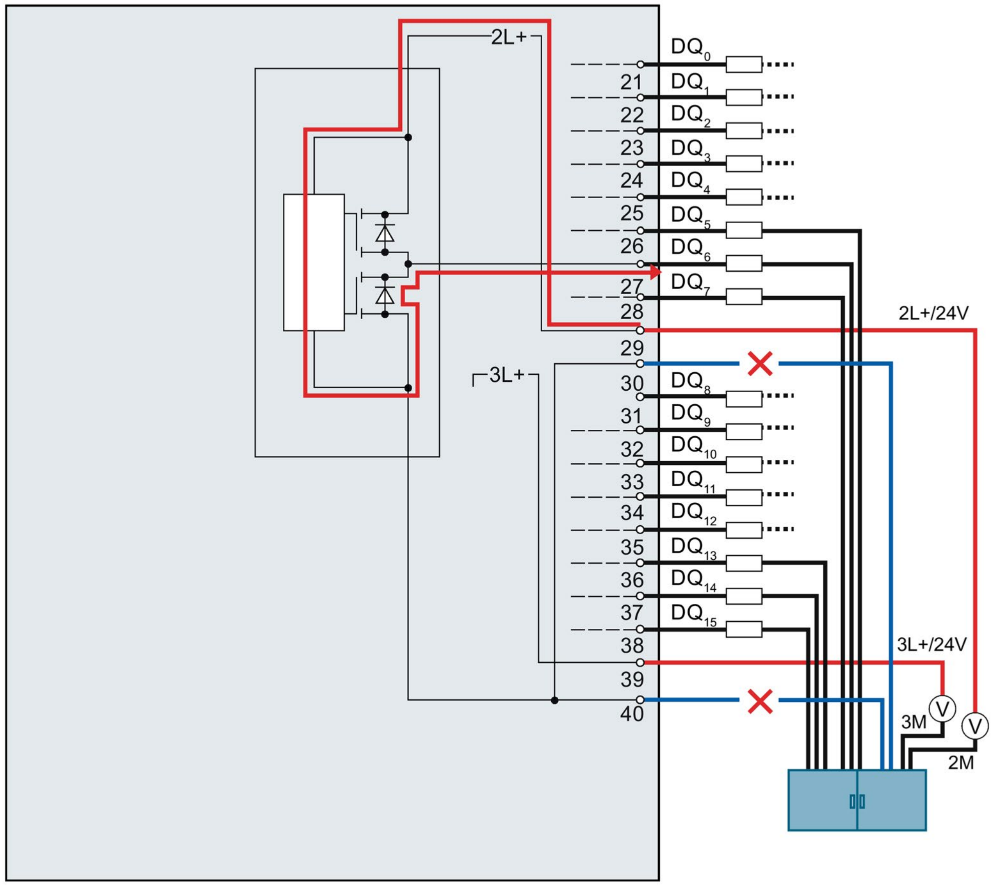


Figure 4-16 Current flow upon interruption of both ground cables

If a wire break occurs on the first and on the second ground cable from the central terminal block to the terminals 30 and 40 of the module, a malfunction occurs on the module. Both ground connections of the module are interrupted.

The supply current flows from the power supply 2L+ via terminal 29 to the module. In the module, the current flows via the output driver into the parasitic diode and exits the module via the output terminal, e.g. as shown in the figure via terminal 27. The supply current therefore flows via the connected load. The internal supply current is typically 25 mA.

> **WARNING**
>
> **Interruption of both ground cables**
>
> If the ground terminals 30 and 40 are interrupted, the following incorrect response can occur:
>
> The activated outputs, which are switched to high, start to switch back and forth between high and low. If the load connected at the output is sufficiently small, the output is continuously activated.

Faulty wiring

The following figure shows faulty wiring which has a bridge on the front connector.

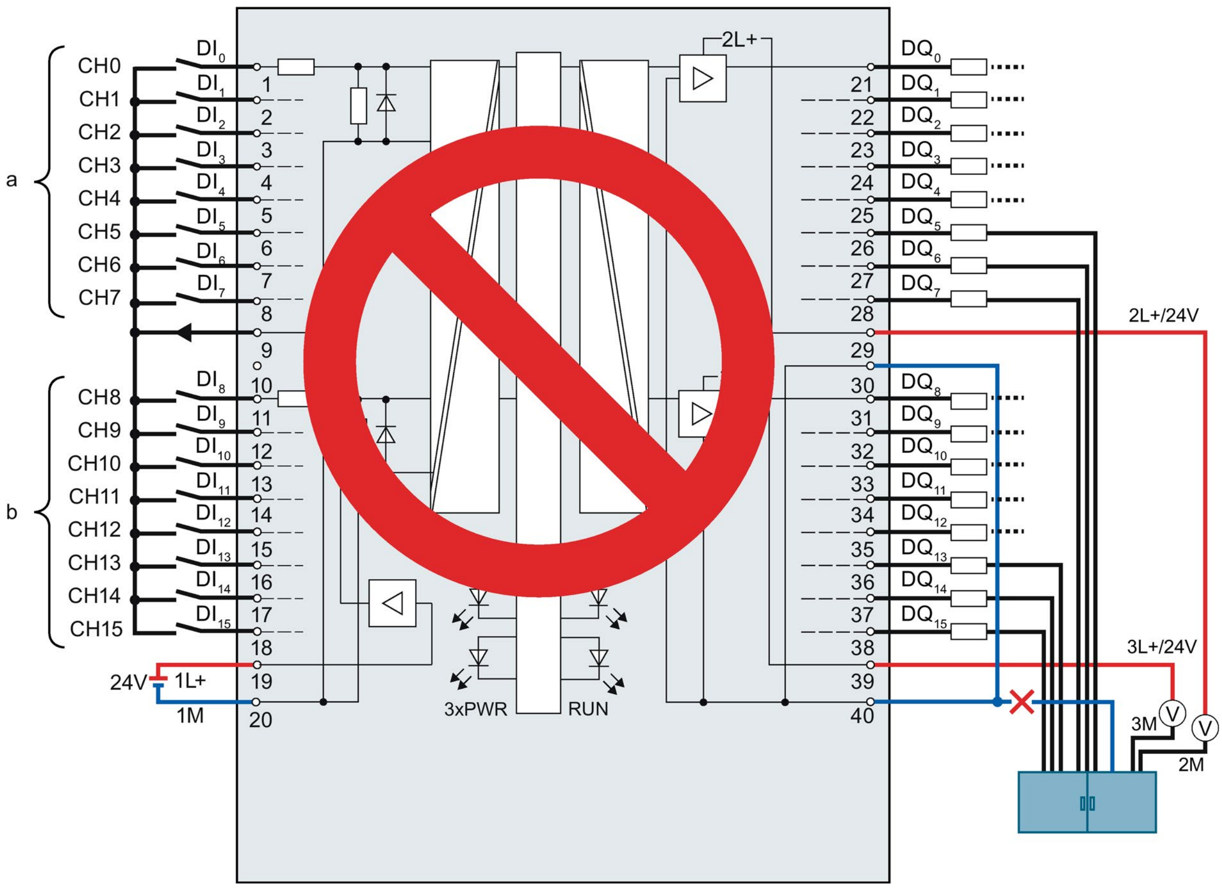
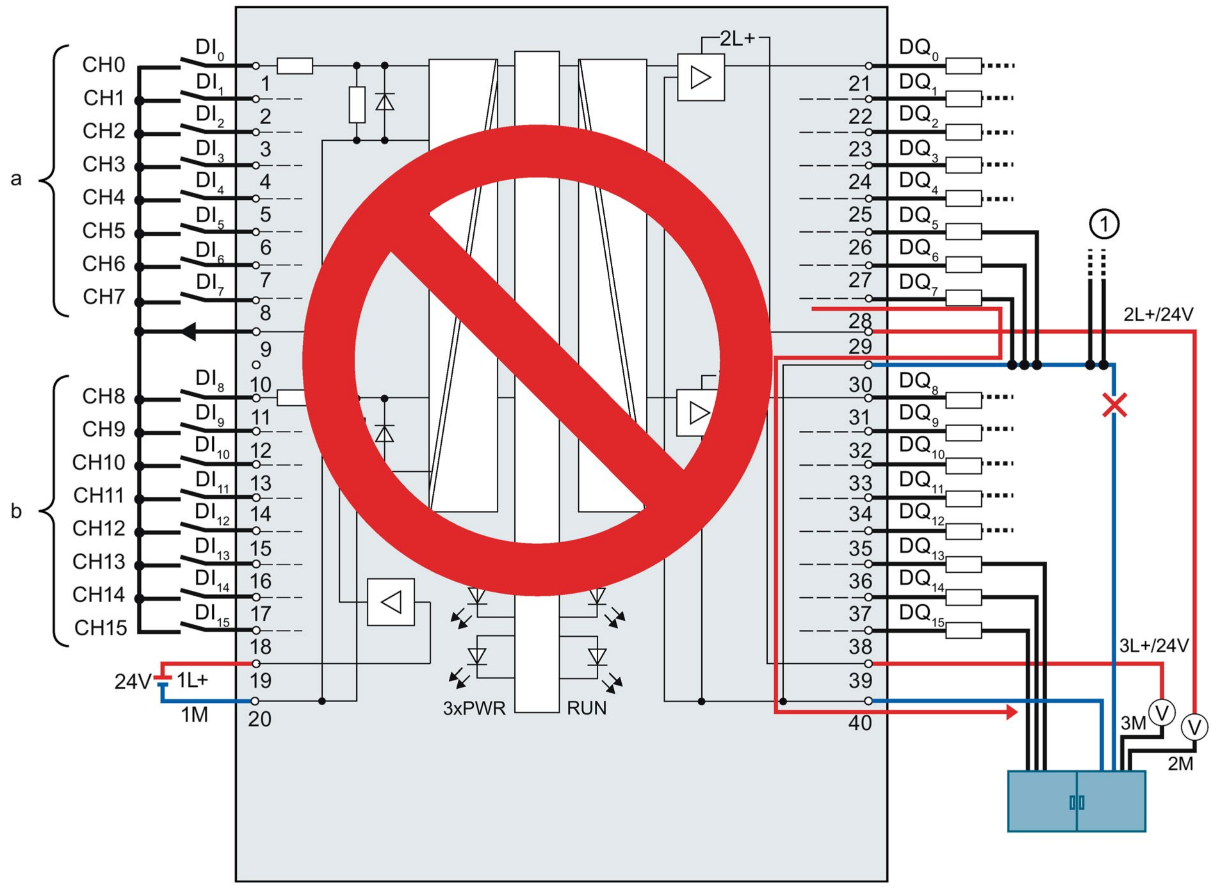


Figure 4-17 Faulty wiring: Bridge

Terminals 30 and 40 are connected in the front connector and only routed with one cable to the central terminal block. If this cable breaks, terminals 30 and 40 are no longer connected to the ground. The module's supply current flows out via the output terminal.

The figure below shows the current flow when the ground connections of the loads and the ground connection of terminal 30 are routed with a common cable to the central terminal block.



① Ground connections of other plant parts that can also carry large currents.

Figure 4-18 Faulty wiring: Common cable

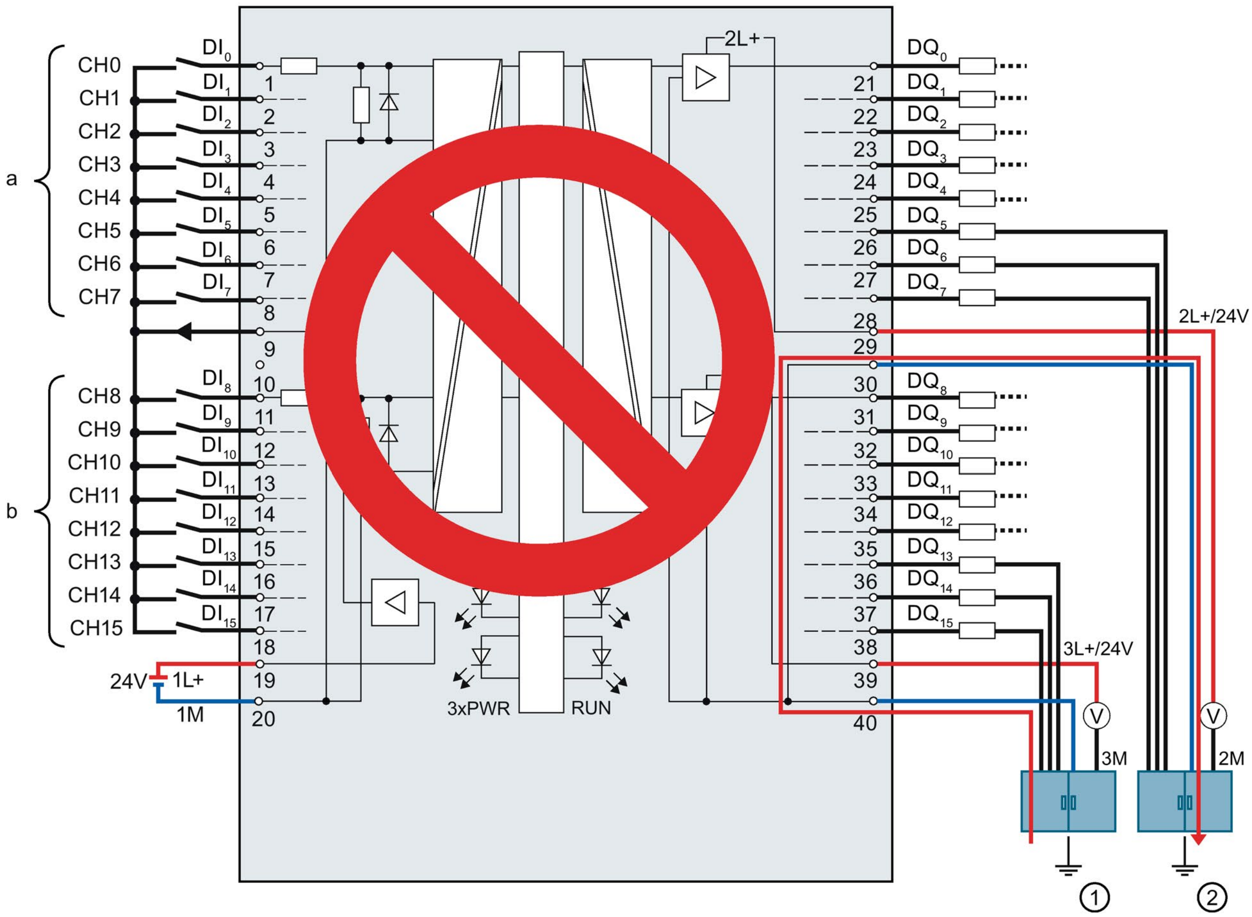
If a break occurs in the common cable, the current of the outputs flows via terminal 30 to the module and via terminal 40 to the central terminal block. The current flows via the module.

WARNING

Current flow with faulty wiring

If a break occurs in the common cable, the current can be very high, depending on the plant, and lead to the destruction of the module.

The figure below shows the current flow with correct wiring when a potential difference exits between the grounding points.



① Grounding point functional earth 1 (FE 1)
② Grounding point functional earth 2 (FE 2)

Figure 4-19 Potential difference

Equipotential bonding occurs via terminals 30 and 40. When a potential difference exists between the grounding points FE1 and FE2, the compensating current flows via terminals 30 and 40.

WARNING

Current flow with faulty wiring

In the event of a potential difference, the current can be very high, depending on the potential conditions, and lead to the destruction of the module.

Input filter for digital inputs

To suppress disruptions, you can configure an input delay for the digital inputs.

You can specify the following values for the input delay:

- None
- 0.05 ms
- 0.1 ms
- 0.4 ms
- 1.6 ms
- 3.2 ms (default setting)
- 12.8 ms
- 20 ms

Note

Shielding

If you use standard digital inputs with "None" set as the input delay, you must use shielded cables. Shielding and the infeed element are recommended for use of standard digital inputs starting from an input delay of 0.05 ms but are not absolutely necessary.

4.3.4 Addresses of the high-speed counters

You connect the encoder signals, the digital input and output signals and the encoder supplies to the 40-pin front connector of the digital on-board I/O. For information on wiring the front connector, creating the cable shield, etc., refer to the S7-1500, ET 200MP (http://support.automation.siemens.com/WW/view/en/59191792) system manual.

Encoder signals

The 24 V encoder signals are designated with letters A, B and N. You can connect the following encoder types:

- Incremental encoder with signal N:

  Signals A, B and N are connected using the correspondingly marked connections. Signals A and B are the two incremental signals, phase-shifted by 90°. N is the zero mark signal that supplies a pulse per revolution.

- Incremental encoder without signal N:

  Signals A and B are connected using the correspondingly marked connections. Signals A and B are the two incremental signals, phase-shifted by 90°.

- Pulse encoder without direction signal:

  The count signal is connected to the A connection.

- Pulse encoder with direction signal:

  The count signal is connected to the A connection. The direction signal is connected to the B connection.

- Pulse encoder with up/down count signal:

  The up count signal is connected to the A connection. The down count signal is connected to the B connection.

You can connect the following encoders or sensors to the A, B and N inputs:

- Sourcing output:
  The encoder or sensor switches the A, B and N inputs to 24 V DC.

Note

External load resistance

Note that, depending on the characteristics of the signal source, effective load and height of the signal frequency, you may require an external load resistance to limit the fall time of the signal from high level to low level.

The specifications/technical data of the signal source (e.g. sensor) are decisive for the configuration of such a load resistance.

- Push-pull:
  The encoder or sensor switches the A, B and N inputs alternately to 24 V DC and to ground M.

Digital inputs HSC DI0 and HSC DI1

The digital inputs are logically assigned to the high-speed counters (HSC). For information on the possible assignment of the on-board I/O inputs to the high-speed counters, refer to the table Interconnection overview of the inputs (Page 98). Up to two digital inputs are available for each high-speed counter (HSC DI0 and HSC DI1). You can use the digital inputs for the gate control (Gate), synchronization (Sync) and Capture functions. Alternatively, you can use one or more digital inputs as standard digital inputs without the functions mentioned and read the signal state of the respective digital input using the feedback interface.

Digital inputs that you do not use for high-speed counting are available for use as standard DIs.

Input addresses of the high-speed counters

You set the digital input addresses used by the high-speed counters (HSC) and the assignment of A/B/N, DI0, DI1 and DQ1 signals in STEP 7 (TIA Portal). You can enable and configure each HSC when you configure the compact CPU.

The compact CPU assigns the input addresses for the A/B/N signals automatically according to the configuration.

You specify the input addresses for DI0 and DI1 according to the table Interconnection overview of the inputs (Page 98). The interconnection produces a direct connection of the HSC to an input of the on-board I/O. The high-speed counter then uses this input as HSC DI0 or HSC DI1 ([DI] symbol). The [DI] symbols in the table identify the input addresses for HSC DI0 and HSC DI1 that are offered for selection in the hardware configuration.

Assignment of HSC addresses of inputs

You can find an overview of the options for interconnecting the inputs of the front connectors X11 and X12 in the section Interconnection overview of the inputs (Page 98).

Digital outputs HSC-DQ0 and HSC-DQ1

Two digital outputs are available for each high-speed counter. Digital output HSC-DQ0 is a logical output that cannot be interconnected with a digital output of the on-board I/O. Digital output HSC-DQ0 can only be used via the user program. HSC-DQ1 is a physical output that can be interconnected with a digital output of the on-board I/O.

The digital outputs are 24 V sourcing output switches relative to M and can be loaded with a rated load current of 0.1 A. The outputs used as standard outputs have a rated load current of 0.5 A. The digital outputs are protected against overload and short-circuit.

Note

It is possible to directly connect relays and contactors without external wiring. For information on the maximum possible operating frequencies and the inductance values of the inductive loads at the digital outputs, refer to the Technical specifications section.

The section Interconnection overview of the outputs (Page 99) provides an overview of which digital outputs you can interconnect to which high-speed counters. Digital outputs to which no high-speed counter is interconnected can be used as standard outputs. The maximum output delay of each digital output used as standard output is 500 µs.

Shielding

Note

When you use digital inputs/outputs with technology functions, i.e. interconnect high-speed counters with the inputs/outputs, you must use shielded cables and the infeed element for shielding.

Reference

For more information on configuring the inputs of the high-speed counters, refer to the S7-1500, ET 200MP, ET 200SP Counting, measurement and position detection (http://support.automation.siemens.com/WW/view/en/59709820) function manual and the STEP 7 online help.

4.3.5 Addresses of the pulse generators in the Pulse Width Modulation (PWM) and Frequency Output modes

Configuring the outputs as pulse generators

If you configure the memory of the outputs of the CPU as pulse generators (for PWM or PTO), the corresponding addresses of the outputs are removed from the memory of the outputs. You cannot use the addresses of the outputs for other purposes in your user program. When your user program writes a value to an output that you are using as a pulse generator, the CPU does not write this value to the physical output.

Assignment of the PWM addresses of the outputs

The section Interconnection overview of the outputs (Page 99) provides an overview of which digital outputs you can interconnect to which PWM channels.

Note

The digital inputs and outputs assigned to PWM and PTO cannot be forced.

You assign the digital inputs and outputs to the pulse duration modulation (PWM) and the pulse train output (PTO) during the device configuration. If you assign digital inputs and outputs to these functions, the values of the addresses of the assigned digital inputs and outputs cannot be changed by the function for forcing in the watch table. Instead, you can force the output bit TM_CTRL_DQ to 0 and switch the output on or off with the bit SET_DQA (relevant for the PWM and Frequency Output modes).

For more information on forcing inputs and outputs, refer to the S7-1500, ET 200MP system manual (http://support.automation.siemens.com/WW/view/en/59191792).

4.3.6 Addresses of pulse generators in the PTO mode

You connect the encoder signals, the digital input and output signals and the encoder supply to the 40-pin front connector of the digital on-board I/O. For information on wiring the front connectors, establishing the cable shields, etc., refer to the S7-1500, ET 200MP system manual. (http://support.automation.siemens.com/WW/view/en/59191792)

Encoder signals

In addition to supporting its outputs, each PTO channel also supports the three following optional inputs:

- Reference Switch (RS)
- Measuring Input (MI)
- Drive Ready (DR)

Input addresses of the pulse generators (PTO)

You make the settings of the digital input addresses used by the pulse generators (PTO) in the hardware configuration of STEP 7 (TIA Portal). When you configure the compact CPU, you can individually activate and configure the four PTO channels.

Assignment of PTO addresses of inputs

A direct connection from the PTO to an input of the on-board I/O is established through the interconnection. You can find an overview of the options for interconnecting the inputs (DI0 to DI15) to the available PTO channels (PTO1 to PTO4) in the section Interconnection overview of the inputs (Page 98).

Assignment of the PTO addresses of the outputs

The section Interconnection overview of the outputs (Page 99) provides an overview of which digital outputs you can interconnect to which PTO channels.

4.3.7 Interconnection overview of the inputs

Combined interconnection of the technology channels

The following table provides you with an overview of the possible interconnections of the inputs of front connector X11 to allow you to correctly distribute the available inputs over the possible technology channels HSC and PTO. This overview is a combination of interconnection options of technology channels for HSC and PTO.

Front connector	Terminal	Channel	PTO								High-speed counters (HSC)											
			PTO1		PTO2		PTO3		PTO4		HSC1		HSC2		HSC3		HSC4		HSC5		HSC6	
X11	1	DI0	[DR]		[DR]		[DR]		[DR]		A			[DI]		[DI]						
	2	DI1	[DR]	[MI]	[DR]		[DR]		[DR]		[B]	[DI]		[DI]		[DI]						
	3	DI2	[DR]	[RS]	[DR]		[DR]		[DR]		[N]	[DI]		[DI]		[DI]						
	4	DI3	[DR]		[DR]		[DR]		[DR]			[DI]	A			[DI]						
	5	DI4	[DR]		[DR]	[MI]	[DR]		[DR]			[DI]	[B]	[DI]		[DI]						
	6	DI5	[DR]		[DR]	[RS]	[DR]		[DR]			[DI]	[N]	[DI]		[DI]						
	7	DI6	[DR]		[DR]		[DR]	[MI]	[DR]			[DI]		[DI]	A							
	8	DI7	[DR]		[DR]		[DR]	[RS]	[DR]			[DI]		[DI]	[B]	[DI]						
	11	DI8	[DR]		[DR]		[DR]		[DR]								A			[DI]		[DI]
	12	DI9	[DR]		[DR]		[DR]		[DR]								[B]	[DI]		[DI]		[DI]
	13	DI10	[DR]		[DR]		[DR]		[DR]								[N]	[DI]		[DI]		[DI]
	14	DI11	[DR]		[DR]		[DR]		[DR]									[DI]	A			[DI]
	15	DI12	[DR]		[DR]		[DR]		[DR]									[DI]	[B]	[DI]		[DI]
	16	DI13	[DR]		[DR]		[DR]		[DR]									[DI]	[N]	[DI]		[DI]
	17	DI14	[DR]		[DR]		[DR]		[DR]	[MI]								[DI]		[DI]	A	
	18	DI15	[DR]		[DR]		[DR]		[DR]	[RS]								[DI]		[DI]	[B]	[DI]

[...] = Use is optional

[DR] = Drive ready; [MI] = Measuring input; [RS] = Reference switch

[DI] stands for [HSC DI0/HSC DI1] = DI: Is used for the HSC functions: Gate, Sync and Capture

The assignment to [B] or [N] takes precedence over the assignment to HSC DI0 or HSC DI1. This means that input addresses that are assigned to count signal [B] or [N] based on the selected signal type cannot be used for other signals such as HSC DI0 or HSC DI1.

4.3.8 Interconnection overview of the outputs

Combined interconnection of the technology channels

The following table provides you with an overview of the possible interconnections of the outputs of front connector X11 to allow you to correctly distribute the available outputs over the possible technology channels HSC, PWM and PTO. This overview is a combination of interconnection options of technology channels for HSC, PWM and PTO.

	Hardware output			Standard DQ	PWM	PTO			HSC
Front connector	**Terminal**	**Channel**	**Output module**	**Configurable as standard DQ for channel**	**Configurable as PWM output for channel**	**Configurable as PTO output A for channel 1)**	**Configurable as PTO output B for channel 2)**	**Configurable as "Drive enable output" for channel**	**Can be used as HSC-DQ1 for channel**
X11	1	DQ0	High-speed		PWM 1	PTO1			
			Standard	DQ0	PWM 1			[PTO 2/3/4]	
	2	DQ1	High-speed				PTO1)		[HSC1]
			Standard	DQ1				[PTO 1/2/3/4]	
	3	DQ2	High-speed		PWM 2	PTO2			
			Standard	DQ2	PWM 2			[PTO 1/3/4]	
	4	DQ3	High-speed				PTO2		[HSC2]
			Standard	DQ3				[PTO 1/2/3/4]	
	5	DQ4	High-speed		PWM 3	PTO3			[HSC3]
			Standard	DQ4	PWM 3			[PTO 1/2/4]	
	6	DQ5	High-speed				PTO3		[HSC4]
			Standard	DQ5				[PTO 1/2/3/4]	
	7	DQ6	High-speed		PWM 4	PTO4			[HSC6]
			Standard	DQ6	PWM 4			[PTO 1/2/3]	
	8	DQ7	High-speed				PTO4		[HSC5]
			Standard	DQ7				[PTO 1/2/3/4]	
	11	DQ8	Standard	DQ8	PWM 1			[PTO 1/2/3/4]	
	12	DQ9		DQ9			PTO1*	[PTO 1/2/3/4]	[HSC1
	13	DQ10		DQ10	PWM 2			[PTO 1/2/3/4]	
	14	DQ11		DQ11			PTO2*	[PTO 1/2/3/4]	[HSC2
	15	DQ12		DQ12	PWM 3			[PTO 1/2/3/4]	[HSC3
	16	DQ13		DQ13			PTO3*	[PTO 1/2/3/4]	[HSC4
	17	DQ14		DQ14	PWM 4			[PTO 1/2/3/4]	[HSC6
	18	DQ15		DQ15			PTO4*	[PTO 1/2/3/4]	[HSC5

* Only supports for PTO direction signal (signal type "pulse A and direction B")

1) "PTOx - Output A" stands for the signal types Pulse output A or Pulse

2) "PTOx - Output B" stands for the signal types Pulse output B or Direction

Technical characteristics of the outputs

The following table shows an overview of the technical characteristics of the individual outputs.

	Frequency range (period duration)	DQ0 to DQ7		DQ8 to DQ15
		High-speed output (0.1 A) activated	**High-Speed output (0.1 A) deactivated**	**Standard output**
		max. 100 kHz	max. 10 kHz	max. 100 Hz
		max. 0.1 A	max. 0.5 A	max. 0.5 A
		Sourcing/sinking output	Sourcing output	Sourcing output
Accuracy of the pulse duration	10 to <= 100 kHz (100 to > = 10 µs)	±100 ppm ±2 µs	---	---
	100 Hz to <10 kHz (10 ms to > 100 µs)		±100 ppm ±10 µs with load > 0.1 A	
	10 to < 100 Hz (0.1 s to > 10 ms)		±100 ppm ±20 µs with load ≥ 2mA	±100 ppm ±100 µs with load > 0.1 A ±100 ppm ±200 µs with load ≥ 2mA
	1 to <10 Hz (1 to > 0.1 s)	±150 ppm ±2 µs	±150 ppm ±10 µs with load > 0.1 A ±150 ppm ±20 µs with load ≥ 2mA	±150 ppm ±100 µs with load > 0.1 A ±150 ppm ±200 µs with load ≥ 2mA
	0.1 to < 1 Hz (10 to >1 s)	±600 ppm ±2 µs	±600 ppm ±10 µs with load > 0.1 A ±600 ppm ± 20 µs with load ≥ 2mA	±600 ppm ±100 µs with load > 0.1 A ±600 ppm ±200 µs with load ≥ 2mA
Minimum pulse duration	---	2 µs	20 µs with load > 0.1 A 40 µs with load ≥ 2 mA	100 µs with load > 0.1 A 200 µs with load ≥ 2 mA

Parameters/address space 5

5.1 Address space of the analog on-board I/O

Address space of the analog input and analog output channels

The addresses are divided into five analog input channels and two analog output channels. STEP 7 (TIA Portal) assigns the addresses automatically. You can change the addresses in the hardware configuration of STEP 7 (TIA Portal), i.e. freely assign the start address. The addresses of the channels are based on the start address.

"IB x", for example, stands for the start address input byte x. "QB x" stands, for example, for the start address output byte x.

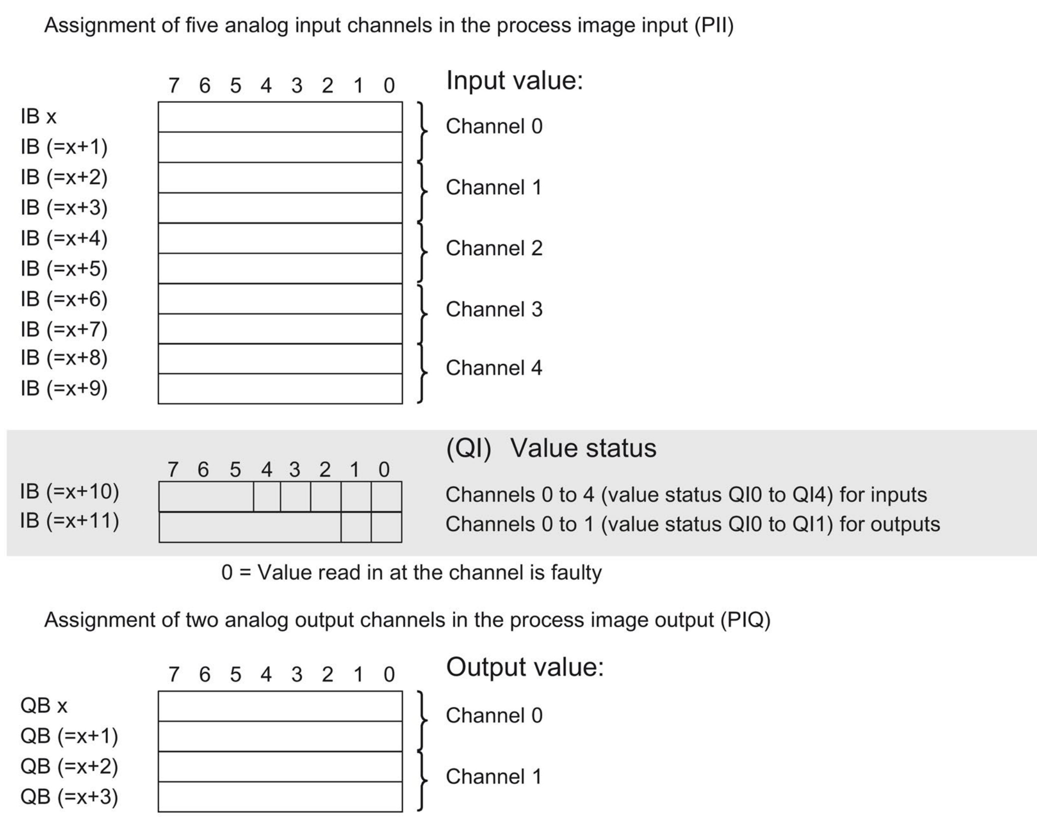


Figure 5-1 Address space 7-channel analog on-board I/O with value status

Value status (quality information, QI)

As of firmware version 2.0, the analog and digital on-board I/O support the value status as diagnostics option. You activate the use of the value status in the hardware configuration of STEP 7 (TIA Portal). Value status is deactivated by default.

When you activate the value status, the input area of the analog on-board I/O contains two additional bytes, which provide the QI bits to the five analog input channels and two analog output channels. You access the QI bits through the user program.

Value status of input channels

Value status = 1 ("Good") indicates that the value of the assigned input at the terminal is valid.

Value status = 0 ("Bad") indicates that the read value is not valid.

Possible cause for value status = 0:

- A channel has been deactivated
- A measured value was not updated after a parameter change
- A measured value is outside the low/high measuring range (overflow/underflow)
- Wire break has occurred (only for the "Voltage" measurement type in the measuring range "1 to 5 V" and for the "Current" measurement type in the measuring range "4 to 20 mA")

Value status of output channels

The value status = 1 ("Good") indicates that the process value specified by the user program is correctly output at the terminal.

The value status = 0 ("Bad") indicates that the process value output at the hardware output is incorrect.

Possible cause for value status = 0:

- A channel has been deactivated
- Outputs are inactive (for example, CPU in STOP)
- An output value is outside the high/low measuring range (overflow/underflow)
- Wire break has occurred (only for the "Current" output type)
- Short-circuit has occurred (only for the "Voltage" output type)

5.2 Address space of the digital on-board I/O

Address space of the digital input and digital output channels

The addresses are divided into 16 digital input channels and 16 digital output channels. STEP 7 (TIA Portal) assigns the addresses automatically. You can change the addresses in the hardware configuration of STEP 7 (TIA Portal), i.e. freely assign the start address. The addresses of the channels are based on the start address.

The letters "a" to "d" are lasered on the on-board I/O. "IB a", for example, stands for start address input byte a. "QB x", for example, stands for start address output byte x.

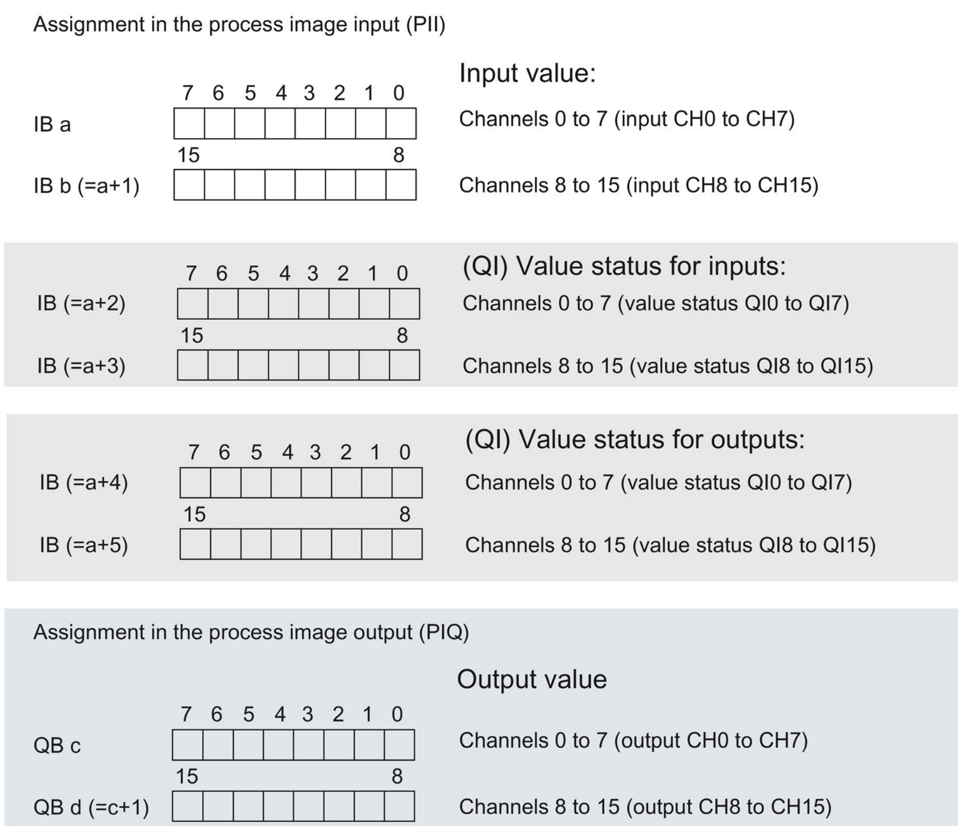


Figure 5-2 Address space 32-channel digital on-board I/O (16 digital inputs/16 digital outputs) with value status

Value status (quality information, QI)

As of firmware version 2.0, the analog and digital on-board I/O support the value status as diagnostics option. You activate the use of the value status in the hardware configuration of STEP 7 (TIA Portal). Value status is deactivated by default. You can activate/deactivate the value status of the digital on-board I/O for X11 and X12 independently of each other.

When you activate the value status, the input area of the digital on-board I/O (X11/X12) contains four additional bytes, which provide the QI bits to the 16 digital input channels and 16 digital output channels. You access the QI bits through the user program.

Value status of input channels

Value status = 1 ("Good") indicates that the value of the assigned input at the terminal is valid.

Value status = 0 ("Bad") indicates that no or too little supply voltage L+ is applied at the terminal and that the read value is therefore not valid.

Value status of output channels

The value status = 1 ("Good") indicates that the process value specified by the user program is correctly output at the terminal.

The value status = 0 ("Bad") indicates that the process value output at the hardware output is incorrect or the channel is used for technology functions.

Possible cause for value status = 0:

- The supply voltage L+ is missing at the terminals or is not sufficient
- Outputs are inactive (for example, CPU in STOP)
- Technology functions (HSC, PWM or PTO) use the channel

Note

Behavior of the value status at the output channels for technology functions

The output channels return the value status 0 ("Bad") when a technology channel (HSC, PWM or PTO) is used. It does not matter in this context whether the output value is incorrect or not.

5.3 Address space of the high-speed counters

Address space of the high-speed counters

Table 5- 1 Size of the input and output addresses of the high-speed counters

	Inputs	Outputs
Size per high-speed counter (6x)	16 bytes	12 bytes

You can find a description of the control interface in the section Assignment of the control interface of the high-speed counters (Page 41). You can find a description of the feedback interface in the section Assignment of the feedback interface of the high-speed counters (Page 43).

Table 5- 2 Size of the input and output addresses in operating mode "Position detection for Motion Control"

	Inputs	Outputs
Size per high-speed counter (6x)	16 bytes	4 bytes

5.4 Address space of the pulse generators

Address space of the pulse generators in the PWM, frequency output and PTO modes

Operating mode	Feedback interface (inputs)	Control interface (outputs)
PWM (4x)	4 bytes	12 bytes
Frequency output	4 bytes	12 bytes
PTO	18 bytes	10 bytes
Deactivated	4 bytes *	12 bytes *

* In "Deactivated" mode, the control interface is not evaluated and the feedback interface is set to 0 values

5.5 Measurement types and measuring ranges of the analog on-board I/O

Introduction

The analog on-board I/O is set to voltage measurement type and measuring range ±10 V by default for the inputs on channels 0 to 3. By default, channel 4 is set to resistance measuring type and measuring range 600 Ω. If you want to use another measurement type or measuring range, change the parameter settings of the analog on-board I/O with STEP 7 (TIA Portal).

Disable unused inputs to prevent disturbances that cause incorrect behavior (e.g. triggering of a hardware interrupt).

Measurement types and measuring ranges

The following table shows the measurement types, the measuring range and the possible channels.

Table 5- 3 Measurement types and measuring range

Measurement type	Measuring range	Channel
Voltage	0 to 10 V 1 to 5 V ±5 V ±10 V	0 to 3
Current 4WMT (4-wire measuring transducer)	0 to 20 mA 4 to 20 mA ±20 mA	0 to 3
Resistance	150 Ω 300 Ω 600 Ω	4
Thermal resistor RTD	Pt 100 Standard/Climate Ni 100 Standard/Climate	4
Deactivated	-	-

The tables of the input ranges, overflow, underrange, etc. can be found in the appendix .

5.6 Output type and output ranges of the analog on-board I/O

Introduction

The analog on-board I/O is set to voltage output type and output range ±10 V as default for the outputs. If you want to use another output range or output type, you need to change the parameter settings of the analog on-board I/O with STEP 7 (TIA Portal).

Output types and output ranges

The following table shows the output type and the corresponding output ranges.

Table 5- 4 Output type and output ranges

Output type	Output range
Voltage	1 to 5 V 0 to 10 V ±10 V
Current	0 to 20 mA 4 to 20 mA ±20 mA
Deactivated	-

5.7 Parameters of the analog on-board I/O

Parameters of the analog on-board I/O

You specify the properties of the analog on-board I/O during parameter assignment with STEP 7 (TIA Portal). The tables below list the parameters that can be set for inputs and outputs, respectively.

When parameters are assigned in the user program, they are transferred to the analog on-board I/O via data records with the WRREC instruction, see section Parameter assignment and structure of the parameter data records of the analog on-board I/O (Page 148).

Configurable parameters and default settings for inputs

Table 5- 5 Configurable "Diagnostics" parameters

Parameters [1)]	Value range	Default	Reconfiguration in RUN
Diagnostics			
• Overflow	Yes/No	No	Yes
• Underflow	Yes/No	No	Yes
• Wire break [2)]	Yes/No	No	Yes
• Current limit for wire break diagnostics	1.185 mA or 3.6 mA	1.185 mA	Yes

1) All parameters can be set for on a channel-specific basis

2) Only for the "Voltage" measurement type in the measuring range 1 to 5 V and for the "Current" measurement type in the measuring range 4 to 20 mA

Table 5- 6 Configurable "Measuring" parameters

Parameters [1]	Value range	Default	Reconfiguration in RUN
Measuring			
• Measurement type	See section Measurement types and measuring ranges of the analog on-board I/O (Page 106)	Voltage (channels 0 to 3) Resistance (channel 4)	Yes
• Measuring range		±10 V (channels 0 to 3) 600 Ω (channel 4)	Yes
• Temperature coefficient	Pt: 0.003851 Pt: 0.003916 Pt: 0.003902 Pt: 0.003920 Ni: 0.006180 Ni: 0.006720	0.003851	Yes
• Temperature unit	• Kelvin (K) [2] • Fahrenheit (°F) • Celsius (°C)	°C	Yes
• Interference frequency suppression	400 Hz 60 Hz 50 Hz 10 Hz	50 Hz	Yes [3]
• Smoothing	None/weak/medium/strong	None	Yes

1) All parameters can be set for on a channel-specific basis

2) Kelvin (K) is only possible for the "Standard range" measuring range and not for the "Climatic range" measuring range

3) The interference frequency suppression must have the same value for all active input channels. This value can only be changed by reassigning parameters in RUN with single channel parameter assignment (data records 0 to 4) if all other input channels are disabled.

Table 5- 7 Configurable "Hardware interrupt" parameters

Parameters [1]	Value range	Default	Reconfiguration in RUN
Hardware interrupts			
• Hardware interrupt low limit 1	Yes/No	No	Yes
• Hardware interrupt high limit 1	Yes/No	No	Yes
• Hardware interrupt low limit 2	Yes/No	No	Yes
• Hardware interrupt high limit 2	Yes/No	No	Yes

1) All parameters can be set for on a channel-specific basis

You can find an overview of the limits for the hardware interrupts in the section Structure of a data record for input channels of the analog on-board I/O (Page 148).

Configurable parameters and default settings for outputs

Table 5- 8 Configurable "Diagnostics" parameters

Parameters [1]	Value range	Default	Reconfiguration in RUN
Diagnostics			
• Wire break [2]	Yes/No	No	Yes
• Short-circuit to ground [3]	Yes/No	No	Yes
• Overflow	Yes/No	No	Yes
• Underflow	Yes/No	No	Yes

[1] All parameters can be set for on a channel-specific basis

[2] Only for the "Current" output type

[3] Only for the "Voltage" output type

Table 5- 9 Configurable output parameters

Parameters [1]	Value range	Default	Reconfiguration in RUN
Output parameters			
• Output type	See section Output type and output ranges of the analog on-board I/O (Page 107)	Voltage	Yes
• Output range		±10 V	Yes
• Reaction to CPU STOP	• Turn off • Keep last value • Output substitute value	Turn off	Yes
• Substitute value	Must be within the permitted voltage/current output range. See "Valid substitute value for the output range" table in the section Structure of a data record for output channels of the analog on-board I/O (Page 154)	0	Yes

[1] All parameters can be set for on a channel-specific basis

Short-circuit detection

The diagnostics for short circuit to ground can be configured for the voltage output type. Short-circuit detection is not possible for low output values. The output voltages must therefore be under -0.1 V or over +0.1 V.

Wire break detection

The diagnostics for wire break can be configured for the current output type. Wire break detection is not possible for low output values; the output currents must therefore be below -0.2 mA or above +0.2 mA.

5.8 Parameters of the digital on-board I/O

Parameters of the digital on-board I/O in standard mode

You specify the properties of the digital on-board I/O during parameter assignment with STEP 7 (TIA Portal). The tables below list the parameters that can be set for inputs and outputs, respectively.

When parameters are assigned in the user program, they are transferred to the digital on-board I/O via data records with the WRREC instruction, see section Parameter assignment and structure of the parameter data records of the digital on-board I/O (Page 156).

The use of a digital input by a technology channel

When a digital input is in use by a technology channel (HSC, PTO or PWM) the corresponding digital input channel remains fully usable without any restriction.

Use of a digital output by a technology channel

When a digital output is in use by a technology channel (HSC, PTO or PWM), the following restrictions apply to the use of the corresponding digital output channel:

- Output values for the digital output channel are not effective. The output values are specified by the technology channel.
- The CPU STOP behavior configured for the digital output channel is not effective. The reaction of the output to CPU Stop is specified by the technology channel.
- With activated value status (Quality Information) for the DI16/DQ16 submodule, the QI bit for the digital output channel shows the value 0 (= Status "Bad").
- The current state of the digital output is not returned to the process image output. In the PTO operating mode, you can only observe the switching operations of the assigned digital outputs directly at the output. In the PWM operating mode and with high-speed counters (HSC), you can observe the current state additionally via the feedback interface. Note, however, that high frequencies may no longer be observed under certain circumstances due to an excessively low sampling rate.

Configurable parameters and default settings for inputs

Table 5- 10 Configurable parameters of inputs

Parameters [1]	Value range	Default	Reconfiguration in RUN
Diagnostics			
• Missing supply voltage L+	Yes/No	No	Yes
Input delay	None, 0.05 ms, 0.1 ms, 0.4 ms, 1.6 ms, 3.2 ms, 12.8 ms, 20 ms	3.2 ms	Yes
Hardware interrupt			
• Rising edge	Yes/No	No	Yes
• Falling edge	Yes/No	No	Yes

[1] All parameters can be set for on a channel-specific basis

Configurable parameters and default settings for outputs

Table 5- 11 Configurable parameters of outputs

Parameters [1]	Value range	Default	Reconfiguration in RUN
Diagnostics			
• Missing supply voltage L+	Yes/No	No	Yes
Reaction to CPU STOP When the digital output is controlled by a technology channel (HSC, PTO or PWM), this parameter is not effective. In this case, the technology channel specifies the reaction of the digital output to CPU STOP.	• Turn off • Keep last value • Output substitute value 1	Turn off	Yes

[1] All parameters can be set for on a channel-specific basis

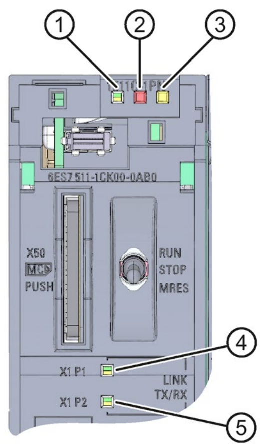
Interrupts/diagnostics alarms 6

6.1 Status and error displays

6.1.1 Status and error displays of the CPU part

LED display

The figure below shows the LED displays of the CPU part.



① RUN/STOP LED (yellow/green LED)
② ERROR LED (red LED)
③ MAINT LED (yellow LED)
④ LINK RX/TX LED for port X1 P1 (yellow/green LED)
⑤ LINK RX/TX LED for port X1 P2 (yellow/green LED)

Figure 6-1 LED display of the CPU 1511C-1 PN (without front panel)

Meaning of the RUN/STOP, ERROR and MAINT LEDs

The CPU has three LEDs for displaying the current operating mode and diagnostics status. The following table shows the meaning of the various combinations of colors for the RUN/STOP, ERROR and MAINT LEDs.

Table 6- 1 Meaning of the LEDs

RUN/STOP LED	ERROR LED	MAINT LED	Meaning
LED off	LED off	LED off	Missing or insufficient supply voltage on the CPU.
LED off	LED flashes red	LED off	An error has occurred.
LED lit green	LED off	LED off	CPU is in RUN mode.
LED lit green	LED flashes red	LED off	A diagnostics event is pending.
LED lit green	LED off	LED lit yellow	Maintenance demanded for the plant. The affected hardware must be checked/replaced within a short period of time.
			Active Force job
			PROFIenergy pause
LED lit green	LED off	LED flashes yellow	Maintenance required for the plant. The affected hardware must be checked/replaced within a foreseeable period of time.
			Bad configuration
LED lit yellow	LED off	LED flashes yellow	Firmware update successfully completed.
LED lit yellow	LED off	LED off	CPU is in STOP mode.
LED lit yellow	LED flashes red	LED flashes yellow	The program on the SIMATIC memory card is causing an error.
			CPU defective
LED flashes yellow	LED off	LED off	CPU is performing internal activities during STOP, e.g. ramp-up after STOP.
			Download of the user program from the SIMATIC memory card
LED flashes yellow/green	LED off	LED off	Startup (transition from RUN → STOP)
LED flashes yellow/green	LED flashes red	LED flashes yellow	Startup (CPU booting)
			Test of LEDs during startup, inserting a module.
			LED flashing test

Meaning of LINK RX/TX LED

Each port has a LINK RX/TX LED. The table below shows the various "LED scenarios" of the CPU ports.

Table 6- 2 Meaning of the LED

LINK TX/RX LED	Meaning
LED off	There is no Ethernet connection between the PROFINET interface of the PROFINET device and the communication partner. No data is currently being sent/received via the PROFINET interface. There is no LINK connection.
LED flashes green	The "LED flashing test" is being performed.
LED lit green	There is an Ethernet connection between the PROFINET interface of your PROFINET device and a communication partner.
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.

6.1.2 Status and error displays of the analog on-board I/O

LED displays

The figure below shows the LED displays (status and error displays) of the analog on-board I/O.

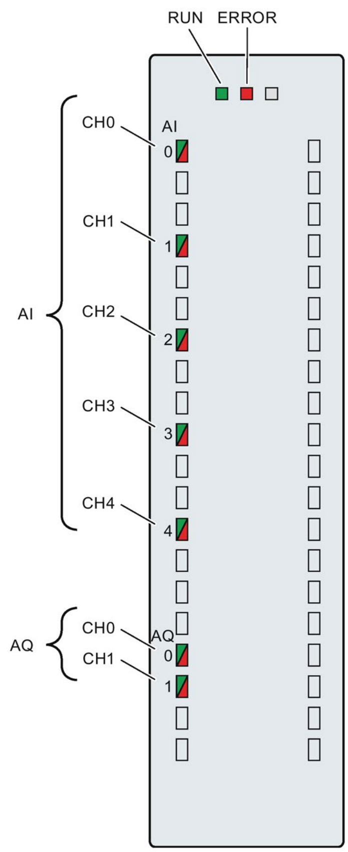


Figure 6-2 LED displays

Meaning of the LED displays

The following tables explain the meaning of the status and error displays. Corrective measures for diagnostic alarms can be found in the section Interrupts and diagnostics of the analog on-board I/O (Page 119).

Table 6- 3 RUN/ERROR status and error displays

LEDs		Meaning	Remedy
RUN	ERROR		
Off	Off	No voltage or voltage too low.	• Turn on the CPU and/or the system power supply modules.
Flashes	Off	Analog on-board I/O starts up and flashes until valid parameter assignment.	---
On	Off	Parameters have been set for the analog on-board I/O.	
On	Flashes	Indicates module errors (at least one error is present on one channel, e.g. wire break).	Evaluate the diagnostics and eliminate the error (e.g. wire break).

CHx LED

Table 6- 4 CHx status display

CHx LED	Meaning	Remedy
Off	Channel disabled.	---
On	Channel parameters set and OK.	---
On	Channel parameters set, channel error present. Diagnostics alarm: e.g. wire break	Check the wiring. Disable diagnostics.

Note

Maintenance LED

During ramp-up, the firmware of the CPU checks the consistency of the calibration data of the analog on-board I/O stored by the SIEMENS production. The yellow MAINT LED lights up if the firmware detects an inconsistency (e.g. an invalid value) or missing calibration data. The MAINT LED is located next to the red ERROR LED on the analog on-board I/O.

Note that the MAINT LED on the analog on-board I/O is only intended for troubleshooting by SIEMENS. In normal conditions, the MAINT LED should not light up. However, if this is the case, please contact SIEMENS "mySupport" on the Internet (https://support.industry.siemens.com/My/ww/en/).

6.1.3 Status and error displays of the digital on-board I/O

LED displays

The figure below shows the LED displays (status and error displays) of the digital on-board I/O. Corrective measures for diagnostics alarms can be found in the section Interrupts and diagnostics (Page 119).

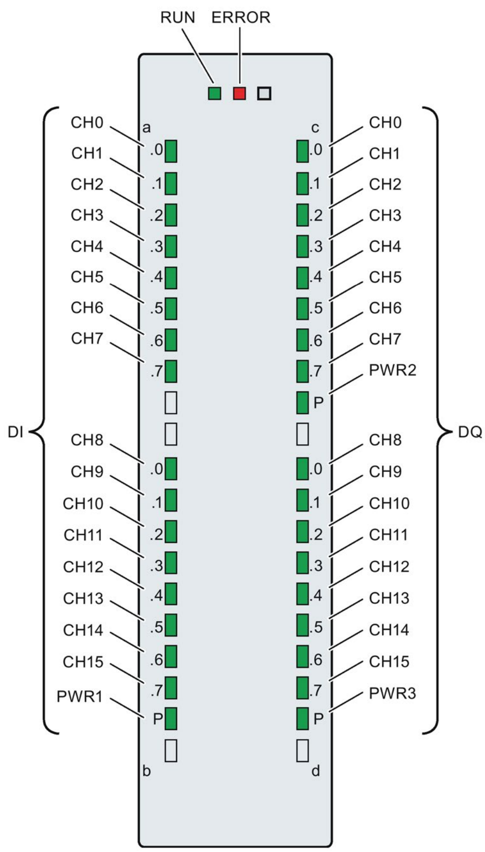


Figure 6-3 LED displays

Meaning of the LED displays

The following tables explain the meaning of the status and error displays.

RUN/ERROR LED

Table 6- 5 RUN/ERROR status and error displays

LED		Meaning	Remedy
RUN	ERROR		
Off	Off	No voltage or voltage too low.	• Turn on the CPU. • Check whether too many modules are inserted.
Flashes	Off	Digital on-board I/O starts up.	---
On	Off	Digital on-board I/O is ready for operation.	
On	Flashes	A diagnostics interrupt is pending. Supply voltage missing.	Check supply voltage L+.

PWRx LED

Table 6- 6 PWRx status display

PWRx LED	Meaning	Remedy
Off	Supply voltage L+ to module too low or missing.	Check supply voltage L+.
On	Supply voltage L+ is present and OK.	---

CHx LED

Table 6- 7 CHx status display

CHx LED	Meaning	Remedy
Off	0 = Status of the input/output signal.	---
On	1 = Status of the input/output signal.	---

6.2 Interrupts and diagnostics

6.2.1 Interrupts and diagnostics of the CPU part

For information on the topic of "Interrupts", refer to the STEP 7 (TIA Portal) online help.

For information on "Diagnostics" and "System alarms", refer to the Diagnostics (http://support.automation.siemens.com/WW/view/en/59192926) function manual.

6.2.2 Interrupts and diagnostics of the analog on-board I/O

Diagnostics interrupt

The analog on-board I/O generates a diagnostics interrupt at the following events:

Table 6- 8 Diagnostics interrupt for inputs and outputs

Event	Diagnostics interrupt	
	Inputs	Outputs
Overflow	x	x
Underflow	x	x
Wire break	x 1)	x 2)
Short-circuit to ground	---	x 3)

1) Possible for the voltage measuring range (1 to 5 V), current measuring range (4 to 20 mA)

2) Possible for current output type

3) Possible for voltage output type

Hardware interrupt for inputs

The compact CPU can generate a hardware interrupt for the following events:

- Below low limit 1
- Above high limit 1
- Below low limit 2
- Above high limit 2

You can find detailed information on the event in the hardware interrupt organization block with the "RALARM" (read additional interrupt information) instruction and in the STEP 7 (TIA Portal) online help.

The start information of the organization block includes information on which channel of the analog on-board I/O triggered the hardware interrupt. The figure below shows the assignment to the bits of double word 8 in local data.

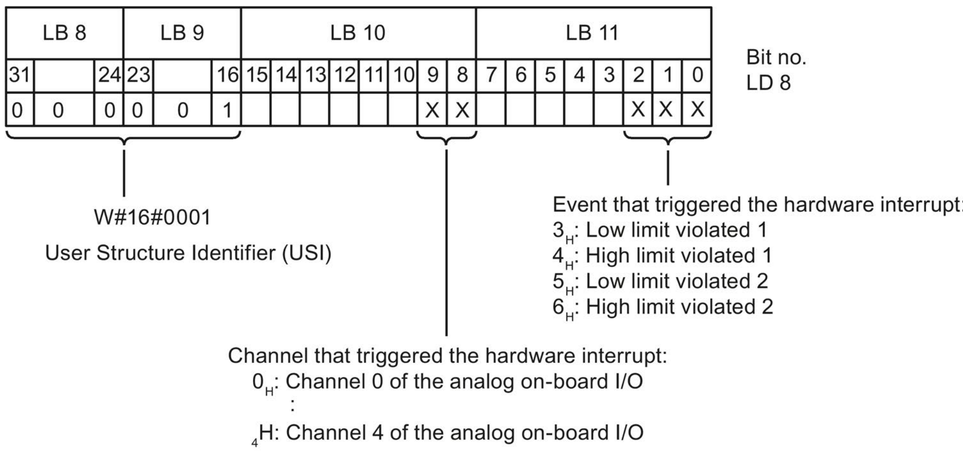


Figure 6-4 Start information of the organization block

Behavior when limits 1 and 2 are reached at the same time

If the two high limits 1 and 2 are reached at the same time, the analog on-board I/O always signals the hardware interrupt for high limit 1 first. The configured value for high limit 2 is irrelevant. After processing the hardware interrupt for high limit 1, the compact CPU triggers the hardware interrupt for high limit 2.

The analog on-board I/O behaves accordingly when the low limits are reached simultaneously. If the two low limits 1 and 2 are reached at the same time, the analog on-board I/O always signals the hardware interrupt for low limit 1 first. After processing the hardware interrupt for low limit 1, the analog on-board I/O triggers the hardware interrupt for low limit 2.

Structure of the additional interrupt information

Table 6- 9 Structure of USI = W#16#0001

Data block name		Contents	Comment	Bytes
USI (User Structure Identifier)		W#16#0001	Additional interrupt information of the analog on-board I/O	2
The channel that triggered the hardware interrupt follows.				
	Channel	B#16#00 to B#16#n	Number of the event-triggering channel (n = number of analog on-board I/O channels -1)	1
It is followed by the event that triggered the hardware interrupt.				
	Event	B#16#03	Below low limit 1	1
		B#16#04	Above high limit 1	
		B#16#05	Below low limit 2	
		B#16#06	Above high limit 2	

Diagnostics alarms

A diagnostics alarm is output for each diagnostics event and the ERROR LED flashes on the analog on-board I/O. The diagnostics alarms can, for example, be read out in the diagnostics buffer of the CPU. You can evaluate the error codes with the user program.

Table 6- 10 Diagnostics alarms, their meaning and corrective measures

Diagnostics alarm	Error code	Meaning	Remedy
Wire break	6_H	Resistance of encoder circuit too high	Use a different encoder type or modify the wiring, for example, using cables with larger cross-section
		Interruption of the cable between the analog on-board I/O and sensor	Connect the cable
		Channel not connected (open)	• Disable diagnostics • Connect the channel
Overflow	7_H	Measuring range exceeded	Check the measuring range
		The output value set by the user program exceeds the valid rated range/overrange	Correct the output value
Underflow	8_H	Value below measuring range	Check the measuring range
		The output value set by the user program is below the valid rated range/underrange	Correct the output value
Short-circuit to ground	1_H	Overload at output	Eliminate overload
		Short-circuit of output Q_V to M_{ANA}	Eliminate the short-circuit

6.2.3 Interrupts and diagnostics of the digital on-board I/O

Diagnostics interrupt

A diagnostics alarm is output for each diagnostics event and the ERROR LED flashes on the digital on-board I/O. 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 6- 11 Diagnostics alarms, their meaning and corrective measures

Diagnostics alarm	Error code	Meaning	Corrective measures
Load voltage missing	11_H	No supply voltage L+	Feed supply voltage L+
Hardware interrupt lost	16_H	The digital on-board I/O cannot trigger an interrupt because the previous interrupt was not acknowledged; possibly a configuration error	• Change the interrupt processing in the CPU and reconfigure the digital on-board I/O. • The error persists until new parameters are set for the digital on-board I/O

Diagnostics interrupt when using high-speed counters

Table 6- 12 Diagnostics alarms, their meaning and corrective measures

Diagnostics alarm	Error code	Meaning	Corrective measures
Illegal A/B signal ratio	500_H	• Time sequence of the A and B signals of the incremental encoder do not meet certain requirements • Possible causes: – Signal frequency too high – Encoder is defective – Process wiring is incorrect	• Correct the process wiring • Check the encoder/sensor • Check the parameter assignment

Hardware interrupt

The compact CPU can generate a hardware interrupt for the following events:

- Rising edge
- Falling edge

You will find detailed information on the event in the hardware interrupt organization block with the "RALRM" (read additional interrupt information) instruction and in the STEP 7 online help.

The start information of the organization block includes information on which channel triggered the hardware interrupt. The figure below shows the assignment to the bits of double word 8 in local data.

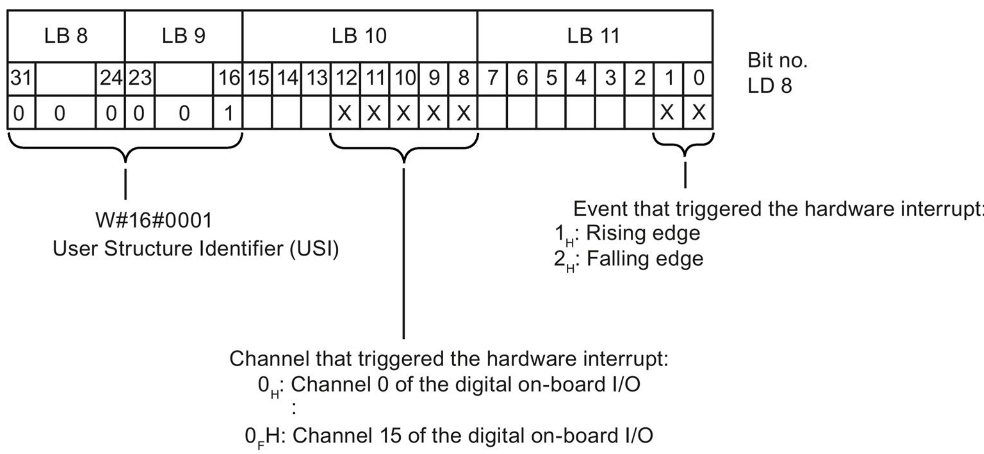


Figure 6-5 Start information of the organization block

Structure of the additional interrupt information

Table 6- 13 Structure of USI = W#16#0001

Data block name		Contents	Comment	Bytes
USI (User Structure Identifier)		W#16#0001	Additional interrupt information of the hardware interrupts of the digital on-board I/O	2
The channel that triggered the hardware interrupt follows.				
	Channel	B#16#00 to B#16#0F	Number of the event-triggering channel (channel 0 to channel 15)	1
The error event that triggered the hardware interrupt follows.				
	Event	B#16#01	Rising edge	1
		B#16#02	Falling edge	

Hardware interrupts when using the high-speed counters

Table 6- 14 Hardware interrupts and their meaning

Hardware interrupt	Event type number	Meaning
Opening of the internal gate (gate start)	1	When the internal gate is opened, the technology function triggers a hardware interrupt in the CPU.
Closing of the internal gate (gate stop)	2	When the internal gate is closed, the technology function triggers a hardware interrupt in the CPU.
Overflow (high counting limit violated)	3	When the count value exceeds the high counting limit, the technology function triggers a hardware interrupt in the CPU.
Underflow (low counting limit violated)	4	When the count value falls below the low counting limit, the technology function triggers a hardware interrupt in the CPU.
Comparison event for DQ0 occurred	5	When a comparison event for DQ0 occurs due to the selected comparison condition, the technology function triggers a hardware interrupt in the CPU. When the change of the count value for an incremental or pulse encoder was not caused by a count pulse, the technology function does not trigger a hardware interrupt.
Comparison event for DQ1 occurred	6	When a comparison event for DQ1 occurs due to the selected comparison condition, the technology function triggers a hardware interrupt in the CPU. When the change of the count value for an incremental or pulse encoder was not caused by a count pulse, the technology function does not trigger a hardware interrupt.
Zero crossing	7	At a zero crossing of the counter or position value, the technology function triggers a hardware interrupt in the CPU.
New Capture value present[1)]	8	When the current counter or position value is saved as a Capture value, the technology function triggers a hardware interrupt in the CPU.
Synchronization of the counter by an external signal	9	At the synchronization of the counter by an N signal or edge at DI, the technology function triggers a hardware interrupt in the CPU.
Direction reversal[2)]	10	When the count value or position value changes direction, the technology function triggers a hardware interrupt in the CPU.

1) Can only be set in counting mode

2) Feedback bit STS_DIR is preset to "0". When the first count value or position value change occurs in the reverse direction directly after switching on the digital on-board I/O, a hardware interrupt is not triggered.

7 Technical specifications

Technical specifications of the CPU 1511C-1 PN

	6ES7511-1CK00-0AB0
General information	
Product type designation	CPU 1511C-1 PN
Hardware functional status	FS03
Firmware version	V2.0
Engineering with	
STEP 7 TIA Portal can be configured/integrated as of version	V14
Configuration control	
Via data record	Yes
Display	
Screen diagonal (cm)	3.45 cm
Operator controls	
Number of keys	6
Mode selector	1
Supply voltage	
Type of supply voltage	24 V DC
Valid range, low limit (DC)	19.2 V; 20.4 V DC for supply of digital inputs/outputs
Valid range, high limit (DC)	28.8 V
Reverse polarity protection	Yes
Power and voltage failure backup	
Power/voltage failure backup time	5 ms; refers to the supply voltage at the CPU
Input current	
Current consumption (rated value)	0.8 A; digital on-board I/O is supplied separately
Inrush current, max.	1.9 A; rated value
I^2t	0.34 A^2s
Digital inputs	
From the load voltage L+ (no load), max.	20 mA; per group
Digital outputs	
From the load voltage L+, max.	30 mA; per group, without load
Output voltage	
Rated value (DC)	24 V

	6ES7511-1CK00-0AB0
Encoder supply	
Number of outputs	1; a common 24 V encoder supply
24 V encoder supply	
24 V	Yes; L+ (-0.8 V)
Short-circuit protection	Yes
Output current, max.	1 A
Power	
Power consumption from the backplane bus (balanced)	8.5 W
Incoming power to the backplane bus	10 W
Power loss	
Power loss, typ.	11.8 W
Memory	
SIMATIC memory card required	Yes
Work memory	
integrated (for program)	175 KB
integrated (for data)	1 MB
Load memory	
Plug-in (SIMATIC Memory Card), max.	32 GB
Buffering	
maintenance-free	Yes
CPU processing times	
for bit operations, typ.	60 ns
for word operations, typ.	72 ns
for fixed point arithmetic, typ.	96 ns
for floating point arithmetic, typ.	384 ns
CPU blocks	
Number of elements (total)	2000; blocks (OB/FB/FC/DB) and UDTs
DB	
Number range	1 ... 60 999; divided into: Number range that can be used by user: 1 ... 59 999 and number range for DBs generated by SFC 86: 60 000 ... 60 999
Size, max.	1 MB; the maximum size of the DB is 64 KB with non-optimized block access
FB	
Number range	0 ... 65 535
Size, max.	175 KB
FC	
Number range	0 ... 65 535
Size, max.	175 KB

	6ES7511-1CK00-0AB0
OB	
Size, max.	175 KB
Number of free cycle OBs	100
Number of time-of-day interrupt OBs	20
Number of time-delay interrupt OBs	20
Number of cyclic interrupt OBs	20; with minimum OB 3x cycle of 500 μs
Number of hardware interrupt OBs	50
Number of DPV1 interrupt OBs	3
Number of isochronous mode OBs	1
Number of technology synchronization interrupt OBs	2
Number of startup OBs	100
Number of asynchronous error OBs	4
Number of synchronous error OBs	2
Number of diagnostics interrupt OBs	1
Nesting depth	
per priority class	24
Counters, timers and their retentivity	
S7 counters	
Number	2048
Retentivity	
• can be set	Yes
IEC counters	
Number	Any (only limited by the work memory)
Retentivity	
• can be set	Yes
S7 timers	
Number	2048
Retentivity	
• can be set	Yes
IEC timers	
Number	Any (only limited by the work memory)
Retentivity	
• can be set	Yes
Data areas and their retentivity	
Retentive data area in total (incl. timers, counters, bit memory), max.	128 KB; in total; for bit memory, timers, counters, DBs and technological data (axes), usable reten- tive memory: 88 KB
Bit memory	
Number, max.	16 KB
Number of clock memory bits	8; there are 8 clock memory bits, grouped in one clock memory byte

	6ES7511-1CK00-0AB0
Data blocks	
Retentivity can be set	Yes
Retentivity preset	No
Local data	
per priority class, max.	64 KB; max. 16 KB per block
Address area	
Number of IO modules	1024; max. number of modules/submodules
I/O address area	
Inputs	32 KB; all inputs are within the process image
Outputs	32 KB; all outputs are within the process image
per integrated IO subsystem	
• Inputs (volume)	8 KB
• Outputs (volume)	8 KB
per CM/CP	
• Inputs (volume)	8 KB
• Outputs (volume)	8 KB
Process image partitions	
Number of process image partitions, max.	32
Hardware configuration	
Number of distributed IO systems	32; a distributed IO system is understood to mean the integration of distributed I/O via PROFINET or PROFIBUS communication modules as well as the connection of I/O via AS-i master modules or links (e.g. IE/PB link)
Number of DP masters	
via CM	4; a total of up to 4 CMs/CPs (PROFIBUS, PROFINET, Ethernet) can be inserted
Number of IO controllers	
integrated	1
via CM	4; a total of up to 4 CMs/CPs (PROFIBUS, PROFINET, Ethernet) can be inserted
Rack	
Modules per rack, max.	32; CPU + 31 modules
Number of rows, max.	1
PtP CM	
Number of PtP CMs	The number of connectable PtP CMs is only limited by the number of available slots

	6ES7511-1CK00-0AB0
Time	
Clock	
Type	Hardware clock
Backup duration	6 wk; at 40 °C ambient temperature, typ.
Deviation per day, max.	10 s; typ.: 2 s
Operating hours counter	
Number	16
Time of day synchronization	
supported	Yes
in AS, master	Yes
in AS, slave	Yes
on Ethernet via NTP	Yes
Digital inputs	
integrated channels (DI)	16
Configurable digital inputs	Yes
Sinking/sourcing input	Sinking input
Input characteristic curve acc. to IEC 61131, type 3	Yes
Digital input functions, configurable	
Gate start/stop	Yes
Capture	Yes
Synchronization	Yes
Input voltage	
Type of input voltage	DC
Rated value (DC)	24 V
for signal "0"	-3 ... +5 V
for signal "1"	+11 ... +30 V
Input current	
for signal "1", typ.	2.5 mA
Input delay (for rated value of input voltage)	
For standard inputs	
• Configurable	Yes; none / 0.05 / 0.1 / 0.4 / 1.6 / 3.2 / 12.8 / 20 ms
• at "0" to "1", min.	4 µs; with "none" configuration
• at "0" to "1", max.	20 ms
• at "1" to "0", min.	4 µs; with "none" configuration
• at "1" to "0", max.	20 ms
for interrupt inputs	
• Configurable	Yes; same as for standard inputs
for technological functions	
• Configurable	Yes; same as for standard inputs

	6ES7511-1CK00-0AB0
Cable length	
shielded, max.	1000 m; 600 m for technological functions; dependent on input frequency, encoder and cable quality; max. 50 m at 100 kHz
unshielded, max.	600 m; for technological functions: No
Digital outputs	
Type of digital output	Transistor
integrated channels (DQ)	16
Sourcing output	Yes; push-pull output
Short-circuit protection	Yes, electronic / thermal
• Response threshold, typ.	1.6 A with standard output; 0.5 A with high speed output; refer to manual for details
Limitation of inductive shutdown voltage to	-0.8 V
Activation of a digital input	Yes
Pulse duration accuracy	up to +-100 ppm +-2 µs with high-speed output; see manual for details
Minimum pulse duration	2 µs; with high-speed output, 50 µs or 5 ms with standard output; see manual for details
Digital output functions, configurable	
Switch at comparison values	Yes; as output signal of a high-speed counter
PWM output	Yes
• Number, max.	4
• Configurable cycle duration	Yes
• On-load factor, min.	0%
• On-load factor, max.	100%
• Resolution of the on-load factor	0.0036 %; with S7 analog format, min. 40 ns
Frequency output	Yes
Pulse train	Yes; including for pulse/direction interface
Switching capacity of outputs	
with resistive load, max.	0.5 A; 0.1 A at high-speed output, i.e. when a high-speed output is used; refer to manual for details
with lamp load, max.	5 W; 1 W with high-speed output, i.e. when a high-speed output is used; refer to manual for details
Load resistance range	
Low limit	48 W; 240 W with high-speed output, i.e. when a high-speed output is used; refer to manual for details
High limit	12 kΩ

	6ES7511-1CK00-0AB0
Output voltage	
Type of output voltage	DC
for signal "0", max.	1 V; with high-speed output, i.e. when a high-speed output is used; refer to manual for details
for signal "1", min.	23.2 V; L+ (-0.8 V)
Output current	
for signal "1" rated value	0.5 A; 0.1 A with high-speed output, i.e. when a high-speed output is used, observe derating; refer to manual for details
for signal "1" permissible range, min.	2 mA
for signal "1" permissible range, max.	0.6 A; 0.12 A with high-speed output, i.e. when a high-speed output is used; refer to manual for details
for signal "0" residual current, max.	0.5 mA
Output delay with resistive load	
"0" to "1", max.	100 μs
"1" to "0", max.	500 μs; load-dependent
for technological functions	
• "0" to "1", max.	5 μs; dependent on output used, see additional description in the manual
• "1" to "0", max.	5 μs; dependent on output used, see additional description in the manual
Parallel connection of two outputs	
For logic operations	Yes; For technological functions: No
For performance increase	No
For redundant activation of a load	Yes; For technological functions: No
Switching frequency	
with resistive load, max.	100 kHz; with high-speed output, 10 kHz with standard output
with inductive load, max.	0.5 Hz; acc. to IEC 60947-5-1, DC-13; observe derating curve
with lamp load, max.	10 Hz
Total current of the outputs	
Current per channel, max.	0.5 A; see additional description in the manual
Current per group, max.	8 A; see additional description in the manual
Current per power supply, max.	4 A; two power supplies per group, current per power supply max. 4 A, see additional description in the manual
for technological functions	
• Current per channel, max.	0.5 A; see additional description in the manual

	6ES7511-1CK00-0AB0
Cable length	
shielded, max.	1000 m; 600 m for technological functions; depending on output frequency, load and cable quality; max. 50 m at 100 kHz
unshielded, max.	600 m; for technological functions: No
Analog inputs	
Number of analog inputs	5; 4x for U/I, 1x for R/RTD
• for current measurement	4; max.
• for voltage measurement	4; max.
• for resistance/resistance thermometer measurement	1
permissible input voltage for voltage input (destruction limit), max.	28.8 V
permissible input current for current input (destruction limit), max.	40 mA
Cycle time (all channels), min.	1 ms; dependent on the configured interference frequency suppression, for details see Conversion method in the manual
Technical unit for temperature measurement, can be set	Yes; °C / °F / K
Input ranges (rated values), voltages	
0 to +10 V	Yes; physical measuring range: ±10 V
Input resistance (0 to 10 V)	100 kΩ
1 V to 5 V	Yes; physical measuring range: ±10 V
Input resistance (1 V to 5 V)	100 kΩ
-10 V to +10 V	Yes
Input resistance (-10 V to +10 V)	100 kΩ
-5 to +5 V	Yes; physical measuring range: ±10 V
Input resistance (-5 to +5 V)	100 kΩ
Input ranges (rated values), currents	
0 to 20 mA	Yes; physical measuring range: ±20 mA
Input resistance (0 to 20 mA)	50 Ω; plus approx. 55 ohm for overvoltage protection by PTC
-20 mA to +20 mA	Yes
Input resistance (-20 mA to +20 mA)	50 Ω; plus approx. 55 ohm for overvoltage protection by PTC
4 mA to 20 mA	Yes; physical measuring range: ±20 mA
Input resistance (4 mA to 20 mA)	50 Ω; plus approx. 55 ohm for overvoltage protection by PTC

	6ES7511-1CK00-0AB0
Input ranges (rated values), resistance-type thermometer	
Ni 100	Yes; standard/climate
Input resistance (Ni 100)	10 MΩ
Pt 100	Yes; standard/climate
Input resistance (Pt 100)	10 MΩ
Input ranges (rated values), resistances	
0 to 150 ohms	Yes; Physical measuring range: 0 to 600 ohms
Input resistance (0 to 150 ohms)	10 MΩ
0 to 300 ohms	Yes; Physical measuring range: 0 to 600 ohms
Input resistance (0 to 300 ohms)	10 MΩ
0 to 600 ohms	Yes
Input resistance (0 to 600 ohms)	10 MΩ
Cable length	
shielded, max.	800 m; with U/I, 200 m with R/RTD
Analog outputs	
Integrated channels (AQ)	2
Voltage output, short-circuit protection	Yes
Cycle time (all channels), min.	1 ms; dependent on the configured interference frequency suppression, for details see Conversion method in the manual
Output ranges, voltage	
0 to 10 V	Yes
1 V to 5 V	Yes
-10 V to +10 V	Yes
Output ranges, current	
0 to 20 mA	Yes
-20 mA to +20 mA	Yes
4 mA to 20 mA	Yes
Load resistance (in nominal range of the output)	
For voltage outputs, min.	1 kΩ
For voltage outputs, capacitive load, max.	100 nF
For current outputs, max.	500 Ω
For current outputs, inductive load, max.	1 mH
Cable length	
shielded, max.	200 m

	6ES7511-1CK00-0AB0
Analog value generation for the inputs	
Integration and conversion time/resolution per channel	
Resolution with overrange (bit including sign), max.	16 bits
Integration time configurable	Yes; 2.5 / 16.67 / 20 / 100 ms, acts on all channels
Interference voltage suppression for interference frequency f1 in Hz	400 / 60 / 50 / 10
Measured value smoothing	
Configurable	Yes
Setting: None	Yes
Setting: Weak	Yes
Setting: Medium	Yes
Setting: Strong	Yes
Analog value generation for the outputs	
Integration and conversion time/resolution per channel	
Resolution with overrange (bit including sign), max.	16 bits
Settling time	
For resistive load	1.5 ms
For capacitive load	2.5 ms
For inductive load	2.5 ms
Encoders	
Connection of the signal transmitters	
For voltage measurement	Yes
For current measurement as 4-wire transducer	Yes
For resistance measurement with two-wire connection	Yes
For resistance measurement with three-wire connection	Yes
For resistance measurement with four-wire connection	Yes
Connectable encoders	
2-wire sensor	Yes
• Permissible quiescent current (2-wire sensor), max.	1.5 mA
Encoder signals, incremental encoder (asymmetric)	
Input voltage	24 V
Input frequency, max.	100 kHz
Counting frequency, max.	400 kHz; with quadruple evaluation
Configurable signal filter	Yes
Incremental encoder with A/B tracks, 90° phase-shifted	Yes

	6ES7511-1CK00-0AB0
Incremental encoder with A/B tracks, 90° phase-shifted and zero track	Yes
Pulse encoder	Yes
Pulse encoder with direction	Yes
Pulse encoder with one pulse signal per count direction	Yes
Errors/accuracies	
Linearity error (relative to input range), (+/-)	0.1%
Temperature error (in relation to input range), (+/-)	0.005%/K
Crosstalk between the inputs, max.	-60 dB
Reproducibility in steady state condition at 25 °C (relative to input range), (+/-)	0.05%
Output ripple (relative to output range, bandwidth 0 to 50 kHz), (+/-)	0.02%
Linearity error (relative to output range), (+/-)	0.15%
Temperature error (in relation to output range), (+/-)	0.005%/K
Crosstalk between outputs, max.	-80 dB
Reproducibility in steady state condition at 25 °C (relative to output range), (+/-)	0.05%
Operational limit across the entire temperature range	
Voltage, relative to input range, (+/-)	0.3%
Current, relative to input range, (+/-)	0.3%
Resistance, relative to input range, (+/-)	0.3%
Resistance-type thermometer, relative to input range, (+/-)	Pt100 Standard: ±2 K, Pt100 Climatic: ±1 K, Ni100 Standard: ±1.2 K, Ni100 Climatic: ±1 K
Voltage, relative to output range, (+/-)	0.3%
Current, relative to output range, (+/-)	0.3%
Basic error limit (operational limit at 25 °C)	
Voltage, relative to input range, (+/-)	0.2%
Current, relative to input range, (+/-)	0.2%
Resistance, relative to input range, (+/-)	0.2%
Resistance-type thermometer, relative to input range, (+/-)	Pt100 Standard: ±1 K, Pt100 Climatic: ±0.5 K, Ni100 Standard: ±0.6 K, Ni100 Climatic: ±0.5 K
Voltage, relative to output range, (+/-)	0.2%
Current, relative to output range, (+/-)	0.2%
Interference voltage suppression for f = n x (f1 +/- 1%), f1 = interference frequency	
Series-mode interference (peak of the interference < rated value of the input range), min.	30 dB
Common mode voltage, max.	10 V
Common mode interference, min.	60 dB; at 400 Hz: 50 dB
Interfaces	
Number of PROFINET interfaces	1
1st interface	

	6ES7511-1CK00-0AB0
Interface hardware	
Number of ports	2
Integrated switch	Yes
RJ45 (Ethernet)	Yes; X1
Protocols	
PROFINET IO controller	Yes
PROFINET IO device	Yes
SIMATIC communication	Yes
Open IE communication	Yes
Web server	Yes
Media redundancy	Yes
PROFINET IO controller	
Services	
• PG/OP communication	Yes
• S7 routing	Yes
• Isochronous mode	Yes
• Open IE communication	Yes
• IRT	Yes
• MRP	Yes; as MRP redundancy manager and/or MRP client; max. number of devices in the ring: 50
• MRPD	Yes; requirement: IRT
• Prioritized startup	Yes; max. 32 PROFINET devices
• Number of connectable IO devices, max.	128; a maximum of 256 distributed I/O devices in total can be connected by means of AS-i, PROFIBUS or PROFINET
• of these, IO devices with IRT, max.	64
• Number of connectable IO devices for RT, max.	128
• of these in a line, max.	128
• Number of IO devices that can be enabled/disabled simultaneously, max.	8; in total over all interfaces
• Number of IO devices per tool, max.	8
• Update times	Minimum value of update time also depends on the communication allocation setting for PROFINET IO, the number of IO devices and the amount of configured user data

	6ES7511-1CK00-0AB0
Update time with IRT	
• with send clock of 250 µs	250 µs to 4 ms; note: with IRT with isochronous mode, the minimum update time of 625 µs of the isochronous OBs is crucial
• with send clock of 500 µs	500 µs to 8 ms; note: with IRT with isochronous mode, the minimum update time of 625 µs of the isochronous OBs is crucial
• with send clock of 1 ms	1 ms to 16 ms
• with send clock of 2 ms	2 ms to 32 ms
• with send clock of 4 ms	4 ms to 64 ms
• with IRT and "odd" send clock parameter assignment	Update time = set "odd" send clock (any multiple of 125 µs: 375 µs, 625 µs to 3 875 µs)
Update time with RT	
• with send clock of 250 µs	250 µs to 128 ms
• with send clock of 500 µs	500 µs to 256 ms
• with send clock of 1 ms	1 ms to 512 ms
• with send clock of 2 ms	2 ms to 512 ms
• with send clock of 4 ms	4 ms to 512 ms
PROFINET IO device	
Services	
• PG/OP communication	Yes
• S7 routing	Yes
• Isochronous mode	No
• Open IE communication	Yes
• IRT	Yes
• MRP	Yes
• MRPD	Yes; requirement: IRT
• PROFIenergy	Yes
• Shared device	Yes
• Number of IO controllers with shared device, max.	4
Interface hardware	
RJ 45 (Ethernet)	
100 Mbps	Yes
Autonegotiation	Yes
Autocrossing	Yes
Industrial Ethernet status LED	Yes

	6ES7511-1CK00-0AB0
Protocols	
Number of connections	
Number of connections, max.	96; via integrated interfaces of the CPU and connected CPs/CMs
Number of connections reserved for ES/HMI/Web	10
Number of connections via integrated interfaces	64
Number of S7 routing connections	16
PROFINET IO controller	
Services	
• PG/OP communication	Yes
• S7 routing	Yes
• Isochronous mode	Yes
• Open IE communication	Yes
• IRT	Yes
• MRP	Yes; as MRP redundancy manager and/or MRP client; max. number of devices in the ring: 50
• MRPD	Yes; requirement: IRT
• PROFIenergy	Yes
• Prioritized startup	Yes; max. 32 PROFINET devices
• Number of connectable IO devices, max.	128; a maximum of 256 distributed I/O devices in total can be connected by means of AS-i, PROFIBUS or PROFINET
• of these, IO devices with IRT, max.	64
• Number of connectable IO devices for RT, max.	128
• of these in a line, max.	128
• Number of IO devices that can be enabled/disabled simultaneously, max.	8; in total over all interfaces
• Number of IO devices per tool, max.	8
• Update times	Minimum value of update time also depends on the communication allocation setting for PROFINET IO, the number of IO devices and the amount of configured user data
SIMATIC communication	
S7 communication, as server	Yes
S7 communication, as client	Yes
User data per job, max.	See online help (S7 communication, user data size)

	6ES7511-1CK00-0AB0
Open IE communication	
TCP/IP	Yes
• Data length, max.	64 KB
• Multiple passive connections per port, supported	Yes
ISO-on-TCP (RFC1006)	Yes
• Data length, max.	64 KB
UDP	Yes
• Data length, max.	1472 bytes
DHCP	No
SNMP	Yes
DCP	Yes
LLDP	Yes
Web server	
HTTP	Yes; standard and user-defined sites
HTTPS	Yes; standard and user-defined sites
OPC UA	
OPC UA server	Yes; Data Access (Read, Write, Subscribe), Runtime license required
• Application authentication	Yes
• Security Policies	Available Security Policies: None, Basic128Rsa15, Basic256Rsa15, Basic256Sha256
• User authentication	"Anonymous" or with user name and password
Additional protocols	
MODBUS	Yes; MODBUS TCP
Media redundancy	
Failover time in the case of cable break, typ.	200 ms; with MRP; bumpless with MRPD
Number of devices in the ring, max.	50
Isochronous mode	
Isochronous operation (application synchronized up to terminal)	Yes; with minimum OB 6x cycle of 625 µs
Constant bus cycle	Yes
S7 alarm functions	
Number of stations that can log in for alarm functions, max.	32
Block-related alarms	Yes
Number of configurable interrupts, max.	5000
Number of simultaneously active interrupts in interrupt pool	
• Number of reserved user interrupts	300
• Number of reserved interrupts for system diagnostics	100
• Number of reserved interrupts for Motion Control technology objects	80

	6ES7511-1CK00-0AB0
Test - commissioning functions	
Joint commissioning (team engineering)	Yes; parallel online access possible for up to 5 engineering systems
Status block	Yes; up to 8 simultaneously (in total over all ES clients)
Single step	No
Status/modify	
Status/modify tag	Yes
Tags	Inputs/outputs, bit memory, DB, peripheral inputs/outputs, timers, counters
Number of tags, max.	
• of which status tags, max.	200; per job
• of which modify tags, max.	200; per job
Force	
Forcing, tags	Peripheral inputs/outputs
Number of tags, max.	200
Diagnostics buffer	
available	Yes
Number of entries, max.	1000
• of these protected against power failure	500
Traces	
Number of configurable traces	4; up to 512 KB data possible per trace
Interrupts/diagnostics/status information	
Interrupts	
Diagnostics interrupt	Yes
Hardware interrupt	Yes
Diagnostics alarms	
Monitoring of the supply voltage	Yes
Wire break	Yes; for analog inputs/outputs, see description in manual
Short-circuit	Yes; for analog outputs, see description in manual
A/B transition error with incremental encoder	Yes
Diagnostics display LED	
RUN/STOP LED	Yes
ERROR LED	Yes
MAINT LED	Yes
Monitoring of supply voltage (PWR LED)	Yes
Channel status display	Yes
For channel diagnostics	Yes; for analog inputs/outputs
Connection display LINK TX/RX	Yes

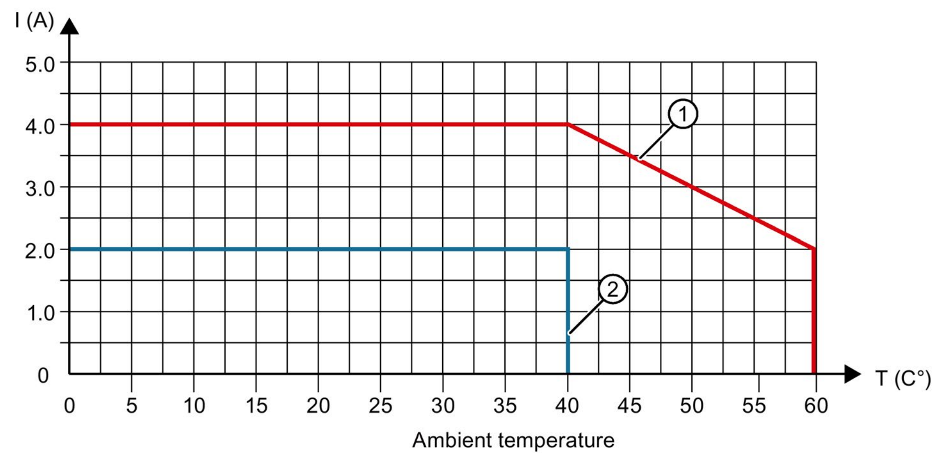
	6ES7511-1CK00-0AB0
Supported technology objects	
Motion Control	Yes; note: the number of axes affects the cycle time of the PLC program; selection guide via the TIA Selection Tool or SIZER
• Number of available motion control resources for technology objects (except cams)	800
• required Motion Control resources	
– per speed-controlled axis	40
– per positioning axis	80
– per synchronous axis	160
– per external encoder	80
– per output cam	20
– per cam track	160
– per measuring input	40
Controllers	
• PID_Compact	Yes; universal PID controller with integrated optimization
• PID_3Step	Yes; PID controller with integrated optimization for valves
• PID temp	Yes; PID controller with integrated optimization for temperature
Counting and measuring	
• High-speed counter	Yes
Integrated functions	
Number of counters	6; of which max. 4x A/B/N
Counting frequency (counter), max.	400 kHz; with quadruple evaluation
Counting functions	
Count continuously	Yes
Configurable counting behavior	Yes
Hardware gate via digital input	Yes
Software gate	Yes
Event-controlled stop	Yes
Synchronization via digital input	Yes
Configurable counting range	Yes
Comparator	
• Number of comparators	2; per counter channel; refer to manual for details
• Direction dependence	Yes
• Modifiable from user program	Yes

	6ES7511-1CK00-0AB0
Position detection	
Incremental detection	Yes
Suitable for S7-1500 Motion Control	Yes
Measuring functions	
Configurable measurement time	Yes
Dynamic measurement time configuration	Yes
Number of thresholds, configurable	2
Measuring range	
• Frequency measurement, min.	0.04 Hz
• Frequency measurement, max.	400 kHz; with quadruple evaluation
• Period measurement, min.	2.5 µs
• Period measurement, max.	25 s
Accuracy	
• Frequency measurement	100 ppm; dependent on measurement interval and signal evaluation
• Period measurement	100 ppm; dependent on measurement interval and signal evaluation
• Velocity measurement	100 ppm; dependent on measurement interval and signal evaluation
Electrical isolation	
Electrical isolation of digital inputs	
Between channels	No
Between channels, in groups of	16
Electrical isolation of digital outputs	
Between channels	No
Between channels, in groups of	16
Electrical isolation of channels	
Between the channels and backplane bus	Yes
Between the channels and load voltage L+	No
Insulation	
Insulation tested with	707 V DC (type test)
Standards, approvals, certificates	
Suitable for safety functions	No
Ambient conditions	
Ambient temperature in operation	
Horizontal installation, min.	0 °C
Horizontal installation, max.	60 °C; Note derating information for on-board I/O in the manual; Display: 50 °C, at an operating temperature of typically 50 °C, the display is switched off
Vertical installation, min.	0 °C
Vertical installation, max.	40 °C; Note derating information for on-board I/O in the manual; Display: 40 °C, at an operating temperature of typically 40 °C, the display is switched off

	6ES7511-1CK00-0AB0
Configuring	
Programming	
Programming language	
• LAD	Yes
• FBD	Yes
• STL	Yes
• SCL	Yes
• GRAPH	Yes
Know-how protection	
User program protection	Yes
Copy protection	Yes
Block protection	Yes
Access protection	
Password for display	Yes
Protection level: Write protection	Yes
Protection level: Write/read protection	Yes
Protection level: Complete protection	Yes
Cycle time monitoring	
Low limit	Configurable minimum cycle time
High limit	Configurable maximum cycle time
Dimensions	
Width	85 mm
Height	147 mm
Depth	129 mm
Weights	
Weight, approx.	1050 g

Power reduction (derating) to total current of digital outputs (per power supply)

The following figure shows the load rating of the digital outputs in relation to the mounting position and the ambient temperature.

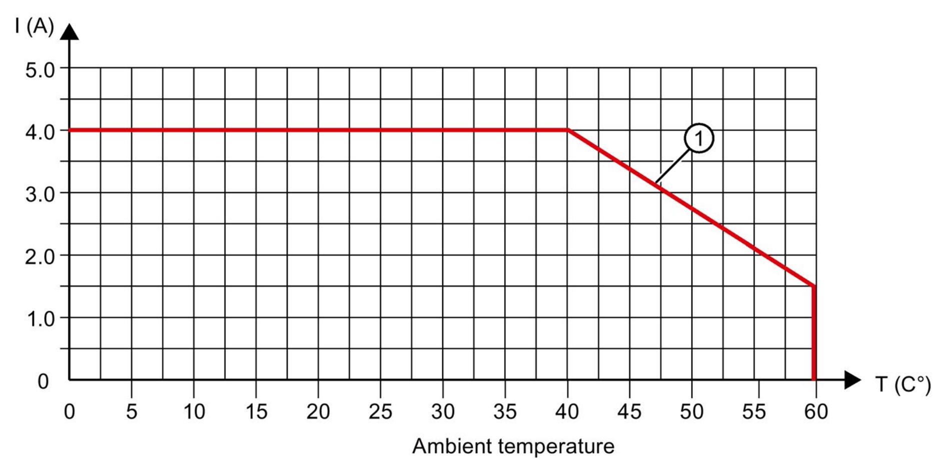


① Horizontal mounting position

② Vertical mounting position

Figure 7-1 Loading capacity of the digital outputs per mounting position

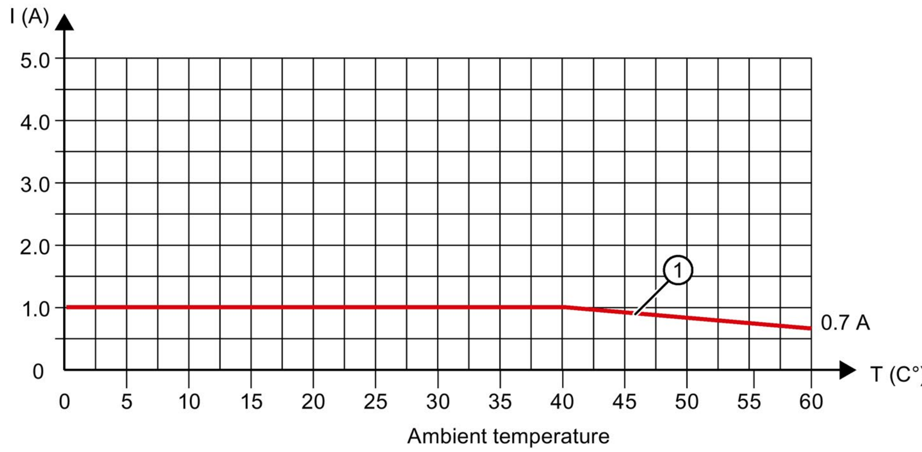
The following trends shows the load rating of the digital outputs when technology functions are used in dependence on the ambient temperature.



① Horizontal mounting position

Figure 7-2 Load rating of the digital outputs when technology functions are used

The following figure shows the load rating of the current for encoder supplies of digital inputs.



① Horizontal mounting position

Figure 7-3 Load rating of the current for encoder supplies of digital inputs when technology functions are used

Simultaneous operation of digital inputs per group

If the maximum voltage at the inputs is 24 V, all the digital inputs may be simultaneously at high level (corresponds to 100% of the digital inputs).

If the maximum voltage at the inputs is 30 V, only 12 digital inputs of 16 digital inputs of one group may be simultaneously at high level (corresponds to 75% of the digital inputs).

General technical specifications

For information on the general technical specifications, such as standards and approvals, electromagnetic compatibility, protection class, etc., refer to the S7-1500, ET 200MP system manual (http://support.automation.siemens.com/WW/view/en/59191792).

Dimension drawings

A

This appendix contains the dimension drawings of the compact CPU installed on a mounting rail. You must take the dimensions into consideration for installation in cabinets, control rooms, etc.

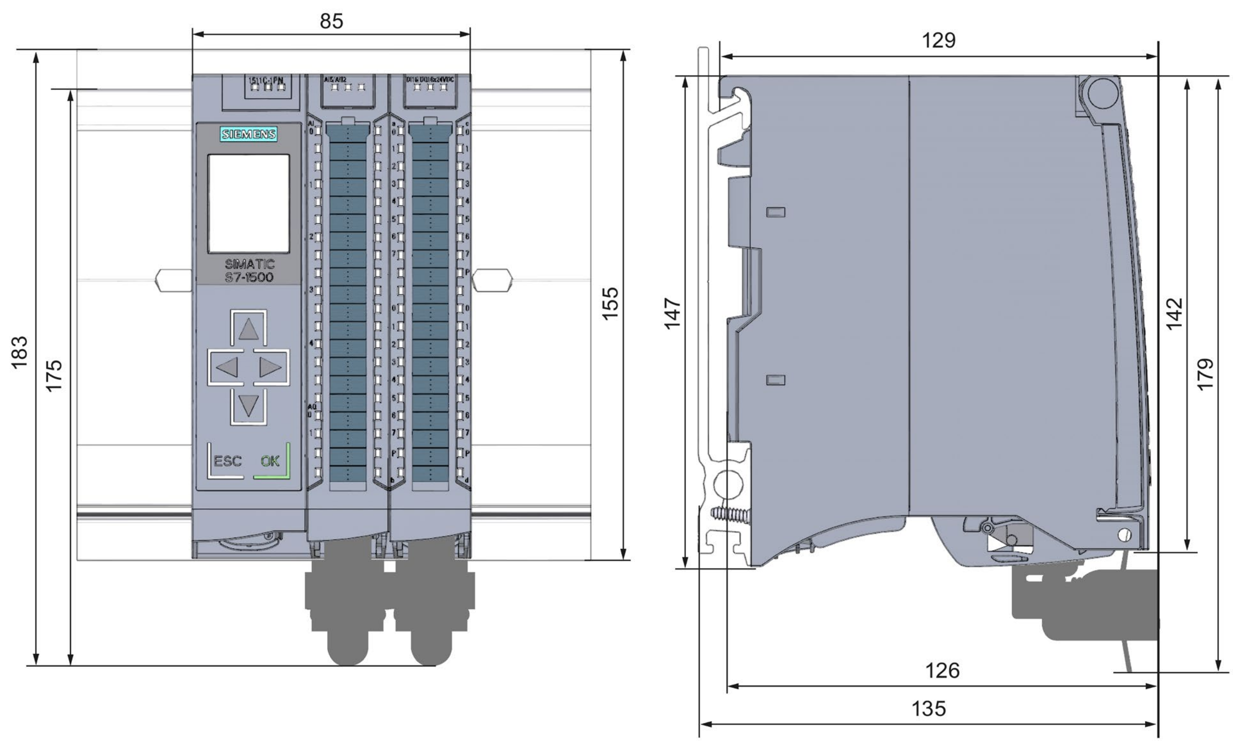


Figure A-1 Dimension drawing of CPU 1511C-1 PN – front and side views

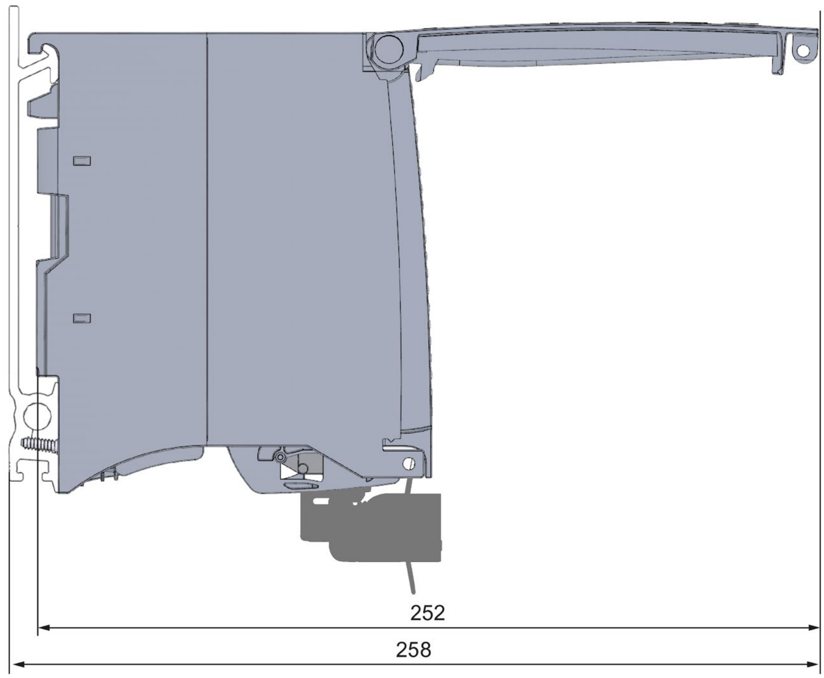


Figure A-2 Dimension drawing of CPU 1511C-1 PN – side view with front panel open

Parameter data records B

B.1 Parameter assignment and structure of the parameter data records of the analog on-board I/O

Parameter assignment in the user program

You have the option of reassigning parameters for the analog on-board I/O in RUN (for example, measuring ranges of individual channels can be modified in RUN without affecting the other channels).

Changing parameters in RUN

The parameters are transferred to the analog on-board I/O via data records with the WRREC instruction. The parameters set with STEP 7 (TIA Portal) are not changed in the CPU, which means that the parameters set in STEP 7 (TIA Portal) will be valid again after a restart.

The parameters are checked for plausibility by the analog on-board I/O only after the transfer.

Output parameter STATUS

If errors occur when transferring parameters with the "WRREC" instruction, the analog on-board I/O continues operation with the previous parameter assignment. However, a corresponding error code is written to the STATUS output parameter.

You will find a description of the "WRREC" instruction and the error codes in the STEP 7 (TIA Portal) online help.

B.2 Structure of a data record for input channels of the analog on-board I/O

Assignment of data record and channel

The parameters for the 5 analog input channels are located in data records 0 to 4 and are assigned as follows:

- Data record 0 for channel 0
- Data record 1 for channel 1
- Data record 2 for channel 2
- Data record 3 for channel 3
- Data record 4 for channel 4

Data record structure

The figure below shows the structure of data record 0 for channel 0 as an example. The structure is identical for channels 1 to 4. The values in byte 0 and byte 1 are fixed and must not be changed.

You enable a parameter by setting the corresponding bit to "1".

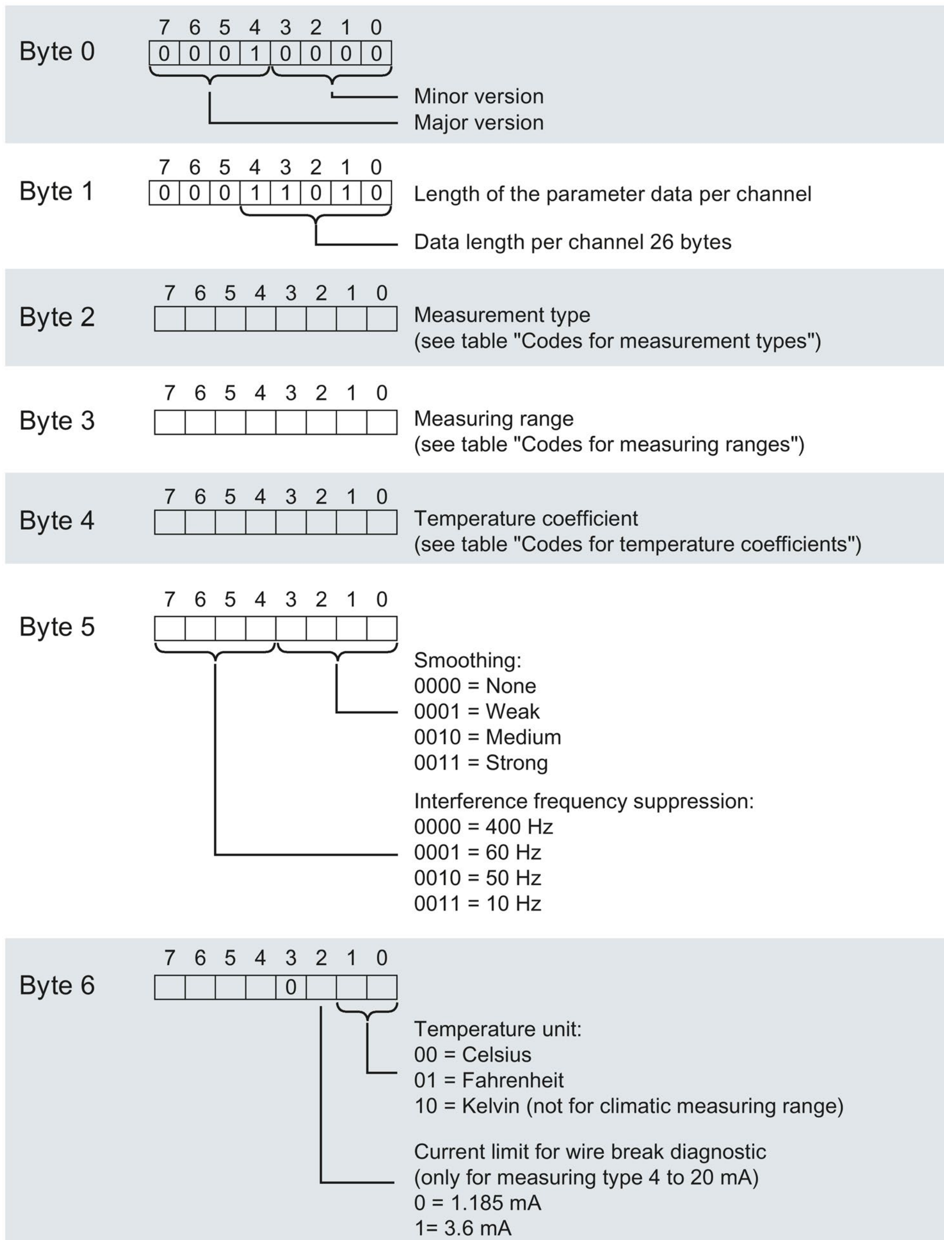
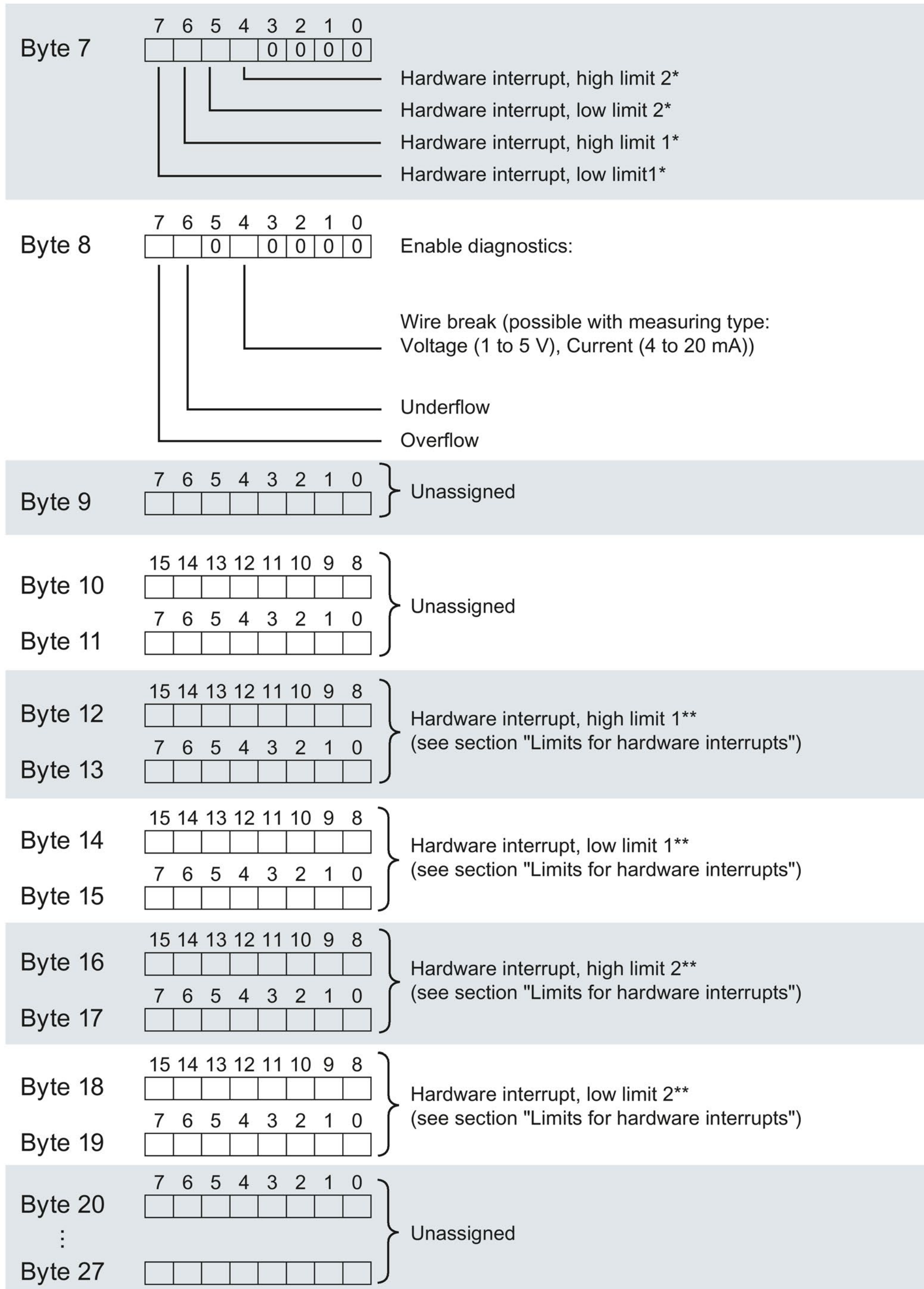


Figure B-1 Structure of data record 0: Bytes 0 to 6



* Activation of hardware limits via data records is only possible when a hardware interrupt OB is assigned to the channel in STEP 7

** High limit must be greater than low limit

Figure B-2 Structure of data record 0: Bytes 7 to 27

Codes for measurement types

The following table contains all measurement types of the inputs of the analog on-board I/O with the corresponding codes. You must enter these codes in byte 2 of the data record for the corresponding channel (refer to the figure Structure of data record 0: Bytes 0 to 6).

Table B- 1 Codes for measurement type

Measurement type	Code
Deactivated	0000 0000
Voltage (valid for channels 0 to 3)	0000 0001
Current, 4-wire measuring transducer (valid for channels 0 to 3)	0000 0010
Resistance (valid for channel 4)	0000 0100
Thermal resistor linear (valid for channel 4)	0000 0111

Codes for measuring ranges

The following table contains all measuring ranges of the inputs of the analog on-board I/O with the corresponding codes. You must enter these codes in each case in byte 3 of the data record for the corresponding channel (refer to the figure Structure of data record 0: Bytes 0 to 6).

Table B- 2 Codes for measuring range

Measuring range	Code
Voltage	
±5 V	0000 1000
±10 V	0000 1001
1 to 5 V	0000 1010
0 to 10 V	0000 1011
Current, 4-wire measuring transducer	
0 to 20 mA	0000 0010
4 to 20 mA	0000 0011
±20 mA	0000 0100
Resistance	
150 Ω	0000 0001
300 Ω	0000 0010
600 Ω	0000 0011
Thermal resistor	
Pt 100 Climate	0000 0000
Ni 100 Climate	0000 0001
Pt 100 Standard	0000 0010
Ni 100 Standard	0000 0011

Codes for temperature coefficient

The following table lists all temperature coefficients for temperature measurement of the thermal resistors along with their codes. You must enter these codes in each case in byte 4 of the data record for the corresponding channel (refer to the figure Structure of data record 0: Bytes 0 to 6)

Table B- 3 Codes for temperature coefficient

Temperature coefficient	Code
Pt xxx	
0.003851	0000 0000
0.003916	0000 0001
0.003902	0000 0010
0.003920	0000 0011
Ni xxx	
0.006180	0000 1000
0.006720	0000 1001

Hardware interrupt limits

The values that can be set for hardware interrupts (high/low limit) must be within the nominal range and overrange/underrange of the relevant measuring range.

The following tables list the permitted hardware interrupt limits. The limits depend on the selected measurement type and measuring range.

Table B- 4 Voltage limits

Voltage		
±5 V, ±10 V	1 to 5 V, 0 to 10 V	
32510	32510	High limit
-32511	-4863	Low limit

Table B- 5 Current and resistance limits

Current		Resistance	
±20 mA	4 to 20 mA / 0 to 20 mA	(all configurable measuring ranges)	
32510	32510	32510	High limit
-32511	-4863	1	Low limit

Table B- 6 Limits for thermal resistor Pt 100 Standard and Pt 100 Climate

Thermal resistor						
Pt 100 Standard			Pt 100 Climate			
°C	°F	K	°C	°F	K	
9999	18319	12731	15499	31099	---	High limit
-2429	-4053	303	-14499	-22899	---	Low limit

Table B- 7 Limits for thermal resistor Ni 100 Standard and Ni 100 Climate

Thermal resistor						
Ni 100 Standard			Ni 100 Climate			
°C	°F	K	°C	°F	K	
2949	5629	5681	15499	31099	---	High limit
-1049	-1569	1683	-10499	-15699	---	Low limit

B.3 Structure of a data record for output channels of the analog on-board I/O

Assignment of data record and channel

The parameters for the 2 analog output channels are located in data records 64 and 65 and are assigned as follows:

- Data record 64 for channel 0
- Data record 65 for channel 1

Data record structure

The figure below shows the structure of data record 64 for channel 0 as an example. The structure is identical for channel 1. The values in byte 0 and byte 1 are fixed and must not be changed.

You enable a parameter by setting the corresponding bit to "1".

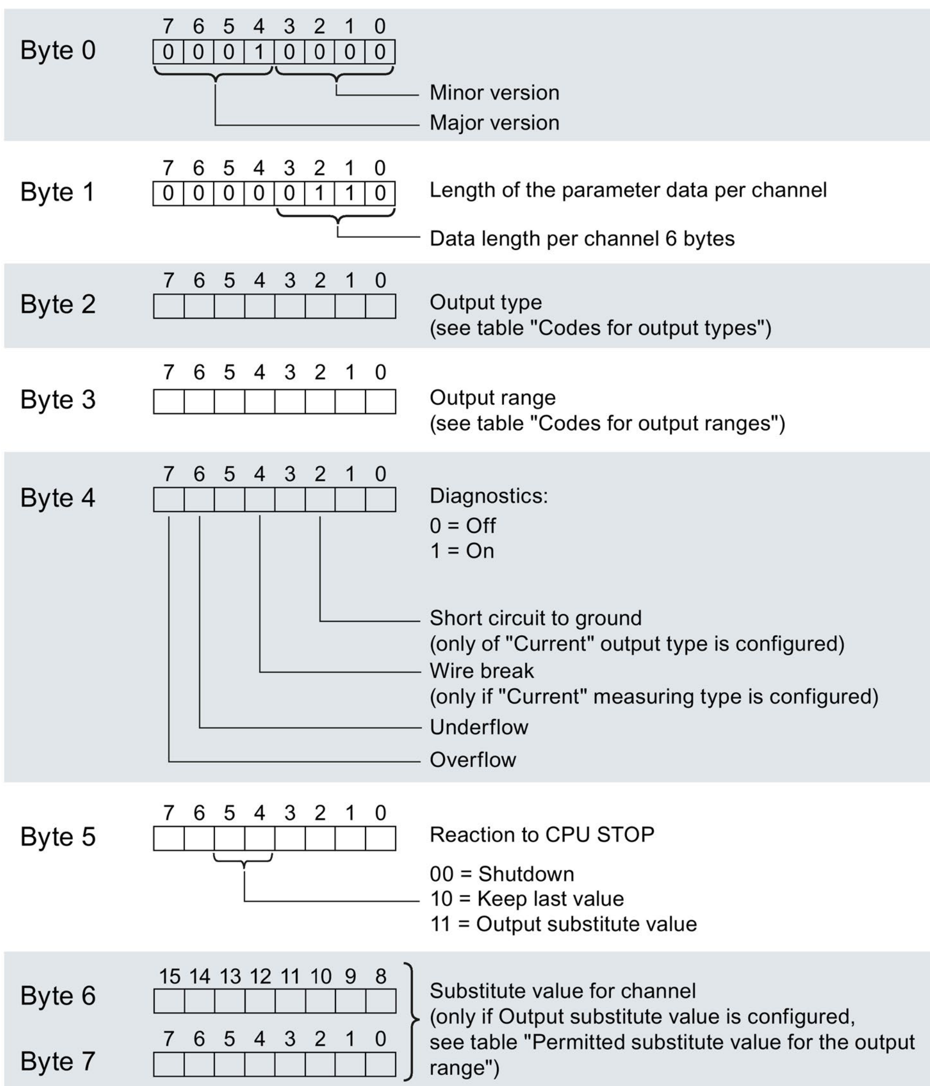


Figure B-3 Structure of data record 64: Bytes 0 to 7

Codes for the output type

The following table contains all output types of the outputs of the analog on-board I/O with the corresponding codes. You must enter these codes in each case in byte 2 of the data record for the corresponding channel (see the previous figure).

Table B- 8 Codes for the output type

Output type	Code
Disabled	0000 0000
Voltage	0000 0001
Current	0000 0010

Codes for output ranges

The following table contains all output ranges for voltage and current of the outputs of the analog on-board I/O with the corresponding codes. You must enter these codes in each case in byte 3 of the corresponding data record (see previous figure).

Table B- 9 Code for the output range

Output range for voltage	Code
1 to 5 V	0000 0011
0 to 10 V	0000 0010
±10 V	0000 0000
Output range for current	**Code**
0 to 20 mA	0000 0001
4 to 20 mA	0000 0010
±20 mA	0000 0000

Permitted substitute values

The following table lists all output ranges for the permitted substitute values. You must enter these substitute values in each case in bytes 6 and 7 of the data record for the corresponding channel (see the previous figure). You can find the binary representation of the output ranges in the section Representation of output ranges (Page 183).

Table B- 10 Permitted substitute value for the output range

Output range	Permitted substitute value
±10 V	-32512 ... +32511
1 to 5 V	-6912 ... +32511
0 to 10 V	0 ... +32511
±20 mA	-32512 ... +32511
4 to 20 mA	-6912 ... +32511
0 to 20 mA	0 ... +32511

B.4 Parameter assignment and structure of the parameter data records of the digital on-board I/O

Parameter assignment in the user program

You have the option of reassigning parameters for the digital on-board I/O in RUN (for example, values for input delay of individual channels can be modified in RUN without affecting the other channels).

Changing parameters in RUN

The parameters are transferred to the digital on-board I/O via data records 0 to 15 with the WRREC instruction. The parameters set with STEP 7 (TIA Portal) are not changed in the CPU, which means the parameters set in STEP 7 (TIA Portal) will be valid again after a restart.

The parameters are only checked for plausibility after the transfer.

Output parameter STATUS

If errors occur when transferring parameters with the "WRREC" instruction, the digital on-board I/O continues operation with the previous parameter assignment. However, a corresponding error code is written to the STATUS output parameter.

You will find a description of the "WRREC" instruction and the error codes in the STEP 7 (TIA Portal) online help.

B.5 Structure of a data record for input channels of the digital on-board I/O

Assignment of data record and channel

The parameters for the 16 digital input channels are located in data records 0 to 15 and are assigned as follows:

- Data record 0 for channel 0
- Data record 1 for channel 1
- …
- Data record 14 for channel 14
- Data record 15 for channel 15

Data record structure

The figure below shows the structure of data record 0 for channel 0 as an example. The structure is identical for channels 1 to 15. The values in byte 0 and byte 1 are fixed and must not be changed.

You enable a parameter by setting the corresponding bit to "1".

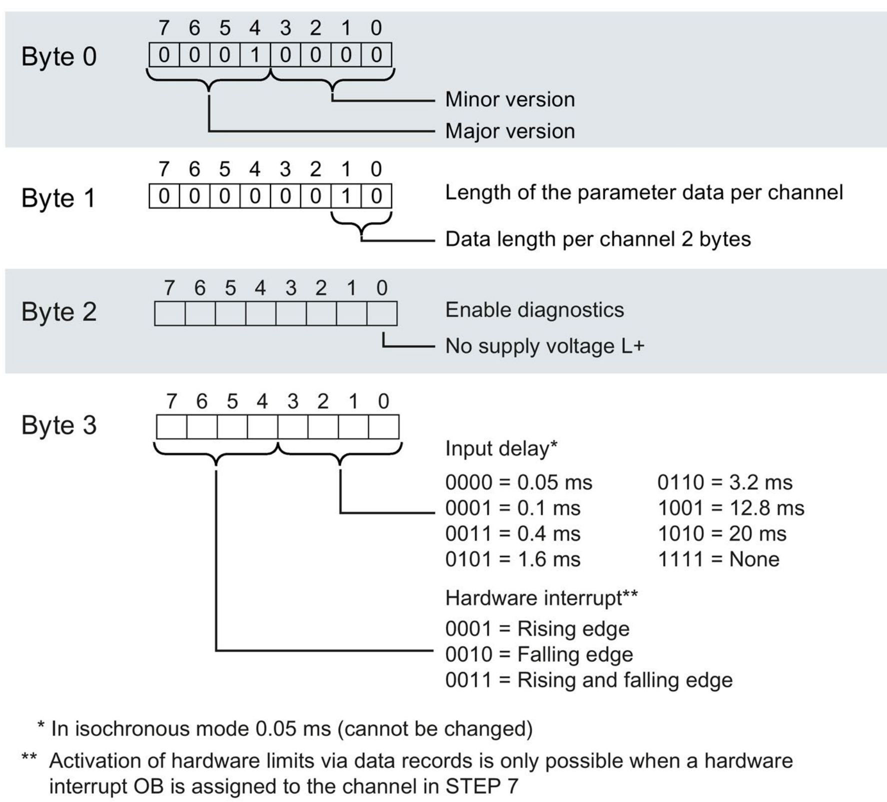


Figure B-4 Structure of data record 0: Bytes 0 to 3

B.6 Structure of a data record for output channels of the digital on-board I/O

Assignment of data record and channel

The parameters for the 16 digital output channels are located in data records 64 to 79 and are assigned as follows:

- Data record 64 for channel 0
- Data record 65 for channel 1
- …
- Data record 78 for channel 14
- Data record 79 for channel 15

Data record structure

The figure below shows the structure of data record 64 for channel 0 as an example. The structure is identical for channels 1 to 15. The values in byte 0 and byte 1 are fixed and must not be changed.

You enable a parameter by setting the corresponding bit to "1".

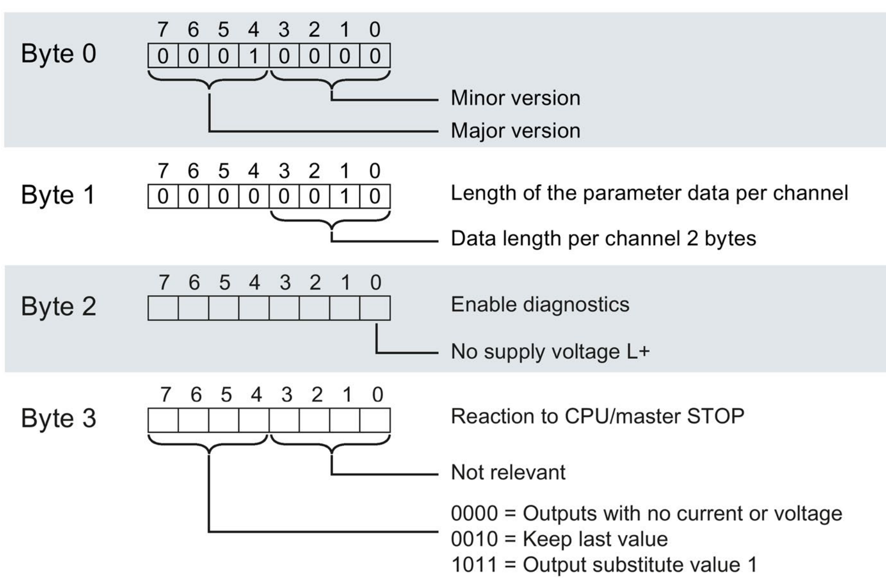


Figure B-5 Structure of data record 64: Bytes 0 to 3

B.7 Parameter data records of the high-speed counters

You can change the parameters of the High Speed Counter in RUN. The WRREC instruction is used to transfer the parameters to the High Speed Counter using data record 128.

If errors occur when transferring or validating parameters with the WRREC instruction, the High Speed Counter continues operation with the previous parameter assignment. The STATUS output parameter then contains a corresponding error code. If no error has occurred, the length of the data actually transferred is entered in the STATUS output parameter.

You will find a description of the "WRREC" instruction and the error codes in the STEP 7 (TIA Portal) online help.

Data record structure

The following table shows you the structure of data record 128 with the counter channel. The values in byte 0 to byte 3 are fixed and must not be changed. The value in byte 4 may only be changed by parameter reassignment and not in RUN mode.

Table B- 11 Parameter data record 128 - HSC parameter header

Bit → Byte	7	6	5	4	3	2	1	0
0	Major Version = 1				Minor Version = 0			
1	Length of parameter data of the channel = 48							
2	Reserved = 0 1)							
3								

1) Reserved bits must be set to 0

Table B- 12 Parameter data record 128 - Operating mode

Bit → Byte	7	6	5	4	3	2	1	0
	Operating mode							
4	Reserved = 0 1)				Operating mode:			
					0000_B: Deactivated			
					0001_B: Counting			
					0010_B: Measuring			
					0011 to 1111_B: Reserved			

1) Reserved bits must be set to 0

Table B- 13 Parameter data record 128 - Basic parameters

Bit → Byte	7	6	5	4	3	2	1	0
	Basic parameters							
5	Reserved = 0 [1]					Enable additional diagnostic interrupts[2]	Reaction to CPU STOP:	
							00_B: Output substitute value	
							01_B: Keep last value	
							10_B: Continue	
							11_B: Reserved	

1) Reserved bits must be set to 0

2) Must be set to 1 for the activation of the diagnostic interrupts "Missing supply voltage L+, "Illegal A/B signal ratio" and "Hardware interrupt lost"

Table B- 14 Parameter data record 128 - Counter inputs

Bit → Byte	7	6	5	4	3	2	1	0
	Counter inputs							
6	Reserved = 0 [1]		Signal evaluation:		Signal type:			
			00_B: Single		0000_B: Pulse (A)			
			01_B: Double		0001_B: Pulse (A) and direction (B)			
			10_B: Quadruple		0010_B: Count up (A), count down (B)			
			11_B: Reserved		0011_B: Incremental encoder (A, B phase-shifted)			
					0100_B: Incremental encoder (A, B, N)			
					0101 to 1111_B: Reserved			
7	Response to signal N:		Invert direc-tion	Reserved = 0 [1]	Filter frequency.			
	00_B: No reaction to sig-nal N				0000_B: 100 Hz			
					0001_B: 200 Hz			
	01_B: Synchronization at signal N				0010_B: 500 Hz			
					0011_B: 1 kHz			
	10_B: Capture at signal N				0100_B: 2 kHz			
	11_B: Reserved				0101_B: 5 kHz			
					0110_B: 10 kHz			
					0111_B: 20 kHz			
					1000_B: 50 kHz			
					1001_B: 100 kHz			
					1010_B: Reserved			
					1011 to 1111_B: Reserved			

) Reserved bits must be set to 0

Table B- 15 Parameter data record 128 - Hardware interrupts

Bit → Byte	7	6	5	4	3	2	1	0
	Hardware interrupts[1]							
8	Reserved = 0 [1]	Reserved = 0 [1]	Reserved = 0 [1]	Direction reversal	Underflow (low counting limit violated)	Overflow (high counting limit violated)	Gate stop	Gate start
9	Synchronization of the counter by an external signal	New capture value available	Reserved = 0 [1]	Zero crossing	Reserved = 0 [1]	Comparison event for DQ1 occurred	Reserved = 0 [1]	Comparison event for DQ0 occurred

[1] Reserved bits must be set to 0

Table B- 16 Parameter data record 128 - Behavior DQ0/1

<table>
<tr><th>Bit →
Byte</th><th>7</th><th>6</th><th>5</th><th>4</th><th>3</th><th>2</th><th>1</th><th>0</th></tr>
<tr><td></td><td colspan="8">Behavior of DQ0/1</td></tr>
<tr><td rowspan="9">10</td><td colspan="4">Set output (DQ1):</td><td colspan="4">Set output (DQ0):</td></tr>
<tr><td colspan="4">0000_B: Use by user program</td><td colspan="4">0000_B: Use by user program</td></tr>
<tr><td colspan="4">0001_B:
Counting: Between comparison value 1 and high counting limit;
Measuring: Measured value >= Comparison value 1</td><td colspan="4">0001_B:
Counting: Between comparison value 0 and high counting limit;
Measuring: Measured value >= Comparison value 0</td></tr>
<tr><td colspan="4">0010_B:
Counting: Between comparison value 1 and low counting limit; Measuring: Measured value <= Comparison value 1</td><td colspan="4">0010_B:
Counting: Between comparison value 0 and low counting limit; Measuring: Measured value <= Comparison value 0</td></tr>
<tr><td colspan="4">0011_B:
Counting: At comparison value 1 for one pulse duration;
Measuring: Reserved</td><td colspan="4">0011_B:
Counting: At comparison value 0 for one pulse duration;
Measuring: Reserved</td></tr>
<tr><td colspan="4">0100_B: Between comparison value 0 and 1</td><td colspan="4">0100_B: Reserved</td></tr>
<tr><td colspan="4">0101_B:
Counting: After set command from CPU until comparison value 1;
Measuring: Reserved</td><td colspan="4">0101_B:
Counting: After set command from CPU until comparison value 0;
Measuring: Reserved</td></tr>
<tr><td colspan="4">0110_B:
Counting: Reserved
Measuring: Not between comparison value 0 and 1</td><td colspan="4" rowspan="2">0110 to 1111_B: Reserved</td></tr>
<tr><td colspan="4">0111 to 1111_B: Reserved</td></tr>
<tr><td rowspan="4">11</td><td colspan="2">Count direction (DQ1):</td><td colspan="2">Count direction (DQ0):</td><td colspan="2" rowspan="4">Reserved = 0 [1]</td><td rowspan="4">Substitute value for DQ1</td><td rowspan="4">Substitute value for DQ0</td></tr>
<tr><td colspan="2">00_B: Reserved</td><td colspan="2">00_B: Reserved</td></tr>
<tr><td colspan="2">01_B: Up</td><td colspan="2">01_B: Up</td></tr>
<tr><td colspan="2">10_B: Down</td><td colspan="2">10_B: Down</td></tr>
</table>

Bit → Byte	7	6	5	4	3	2	1	0
	11_B: In both directions		11_B: In both directions					
12	Pulse duration (DQ0):							
13	WORD: Value range in ms/10: 0 to 65535_D							
14	Pulse duration (DQ1):							
15	WORD: Value range in ms/10: 0 to 65535_D							

1) Reserved bits must be set to 0

Table B- 17 Parameter data record 128 - Behavior DI0

<table>
<tr><th>Bit →
Byte</th><th>7</th><th>6</th><th>5</th><th>4</th><th>3</th><th>2</th><th>1</th><th>0</th></tr>
<tr><td></td><td colspan="8">Behavior of DI0</td></tr>
<tr><td rowspan="9">16</td><td rowspan="4">Behavior of count value after Capture (DI0):</td><td colspan="2">Edge selection (DI0):</td><td rowspan="2">Level selection (DI0):</td><td rowspan="9">Reserved = 0 1)</td><td colspan="3">Set function of the DI (DI0):</td></tr>
<tr><td colspan="2">00_B: Reserved</td><td colspan="3">000_B: Gate start/stop (level-controlled)</td></tr>
<tr><td colspan="2">01_B: On a rising edge</td><td rowspan="2">0_B: Active at high level</td><td colspan="3">001_B: Gate start (edge-controlled)</td></tr>
<tr><td colspan="2">10_B: On a falling edge</td><td colspan="3">010_B: Gate stop (edge-controlled)</td></tr>
<tr><td rowspan="2">0_B: Continue counting</td><td colspan="2" rowspan="2">11_B: On rising and falling edge</td><td rowspan="5">1_B: Active at low level</td><td colspan="3">011_B: Synchronization</td></tr>
<tr><td colspan="3">100_B: Enable synchronization at signal N</td></tr>
<tr><td rowspan="3">1_B: Set to start value and continue counting</td><td colspan="2" rowspan="3"></td><td colspan="3">101_B: Capture</td></tr>
<tr><td colspan="3">110_B: Digital input without function</td></tr>
<tr><td colspan="3">111_B: Reserved</td></tr>
</table>

1) Reserved bits must be set to 0

Table B- 18 Parameter data record 128 - Behavior DI1

<table>
<tr><th>Bit →
Byte</th><th>7</th><th>6</th><th>5</th><th>4</th><th>3</th><th>2</th><th>1</th><th>0</th></tr>
<tr><td>17</td><td colspan="8">Behavior of DI1:
See byte 16</td></tr>
<tr><td>18</td><td colspan="8">Reserved = 0 1)</td></tr>
<tr><td rowspan="3">19</td><td>Sync option</td><td colspan="3" rowspan="3">Reserved = 0 1)</td><td colspan="4" rowspan="3">Reserved = 0 1)</td></tr>
<tr><td>0_B: Once</td></tr>
<tr><td>1_B: Periodically</td></tr>
</table>

1) Reserved bits must be set to 0

Table B- 19 Parameter data record 128 - Behavior DI1

Bit → / Byte	7	6	5	4	3	2	1	0
	Values							
20-23	High counting limit: DWORD: Value range: –2147483648 to 2147483647_D or 80000000 to $7FFFFFFF_H$							
24-27	Comparison value 0: Counting mode: DWORD Value range: –2147483648 to 2147483647_D or 80000000 to $7FFFFFFF_H$; Measuring mode: REAL Floating-point number in the set unit of the measured variable							
28-31	Comparison value 1: Counting mode: DWORD Value range: –2147483648 to 2147483647_D: or 80000000 to $7FFFFFFF_H$; Measuring mode: REAL Floating-point number in the set unit of the measured variable							
32-35	Start value: DWORD: Value range: –2147483648 to 2147483647_D or 80000000 to $7FFFFFFF_H$							
36-39	Low counting limit: DWORD: Value range: –2147483648 to 2147483647_D or 80000000 to $7FFFFFFF_H$							
40-43	Update time: DWORD: Value range in μs: 0 to 25000000_D							

Table B- 20 Parameter data record 128 - Counter behavior at limits and at gate start

Bit → / Byte	7	6	5	4	3	2	1	0
	Counter behavior at limits and at gate start							
44	Response to gate start:		Response to counting limit violation:			Reset at counting limit violation:		
	00_B: Set to start value		000_B: Stop counting			000_B: To other counting limit		
	01_B: Continue with current value		001_B: Continue counting			001_B: On start value		
	10 to 11_B: Reserved		010 to 111_B: Reserved			010 to 111_B: Reserved		

Table B- 21 Parameter data record 128 - Specify measured value

Bit → / Byte	7	6	5	4	3	2	1	0
	Specify measured value							
45	Reserved = 0 1)			Time base for velocity measurement:			Measured variable:	
				000_B: 1 ms			00_B: Frequency	
				001_B: 10 ms			01_B: Period duration	
				010_B: 100 ms			10_B: Velocity	
				011_B: 1 s			11_B: Reserved	
				100_B: 60 s/1 min				
				101 to 111_B: Reserved				
46	Increments per unit:							
47	WORD: Value range: 1 to 65535_D							
48	Set hysteresis range: Value range: 0 to 255_D							
49	Use of HSC DI0	Reserved = 0 1)		Selection HSC DI0 Value range: HSC1:				
	0_B: Not used							

Bit → / Byte	7	6	5	4	3	2	1	0
	1$_B$: Used			00001$_B$: Front connector X11, terminal 2 (DI1) 00010$_B$: Front connector X11, terminal 3 (DI2) 00011$_B$: Front connector X11, terminal 4 (DI3) 00100$_B$: Front connector X11, terminal 5 (DI4) 00101$_B$: Front connector X11, terminal 6 (DI5) 00110$_B$: Front connector X11, terminal 7 (DI6) 00111$_B$: Front connector X11, terminal 8 (DI7) HSC2: 00000$_B$: Front connector X11, terminal 1 (DI0) 00001$_B$: Front connector X11, terminal 2 (DI1) 00010$_B$: Front connector X11, terminal 3 (DI2) 00100$_B$: Front connector X11, terminal 5 (DI4) 00101$_B$: Front connector X11, terminal 6 (DI5) 00110$_B$: Front connector X11, terminal 7 (DI6) 00111$_B$: Front connector X11, terminal 8 (DI7) HSC3: 00000$_B$: Front connector X11, terminal 1 (DI0) 00001$_B$: Front connector X11, terminal 2 (DI1) 00010$_B$: Front connector X11, terminal 3 (DI2) 00011$_B$: Front connector X11, terminal 4 (DI3) 00100$_B$: Front connector X11, terminal 5 (DI4) 00101$_B$: Front connector X11, terminal 6 (DI5) 00111$_B$: Front connector X11, terminal 8 (DI7) HSC4: 01001$_B$: Front connector X11, terminal 12 (DI9) 01010$_B$: Front connector X11, terminal 13 (DI10) 01011$_B$: Front connector X11, terminal 14 (DI11) 01100$_B$: Front connector X11, terminal 15 (DI12) 01101$_B$: Front connector X11, terminal 16 (DI13) 01110$_B$: Front connector X11, terminal 17 (DI14) 01111$_B$: Front connector X11, terminal 18 (DI15) HSC5: 01000$_B$: Front connector X11, terminal 11 (DI8) 01001$_B$: Front connector X11, terminal 12 (DI9) 01010$_B$: Front connector X11, terminal 13 (DI10) 01100$_B$: Front connector X11, terminal 15 (DI12) 01101$_B$: Front connector X11, terminal 16 (DI13) 01110$_B$: Front connector X11, terminal 17 (DI14) 01111$_B$: Front connector X11, terminal 18 (DI15) HSC6: 01000$_B$: Front connector X11, terminal 11 (DI8) 01001$_B$: Front connector X11, terminal 12 (DI9) 01010$_B$: Front connector X11, terminal 13 (DI10) 01011$_B$: Front connector X11, terminal 14 (DI11) 01100$_B$: Front connector X11, terminal 15 (DI12) 01101$_B$: Front connector X11, terminal 16 (DI13) 01111$_B$: Front connector X11, terminal 18 (DI15) All other values: Reserved The value range also applies for the 'Selection HSC DI1' parameter in the same way.				

Bit → Byte	7	6	5	4	3	2	1	0
50	Use of HSC DI1 0_B: Not used 1_B: Used	Reserved = 0 [1)]		Selection HSC DI1 Value range: The value range also applies for the 'Selection HSC DI0' parameter in the same way.				
51	Use of HSC DQ1 0_B: Not used 1_B: Used	Reserved = 0 [1)]		Selection HSC DQ1 Value range: HSC1: 00001_B: Front connector X11, terminal 22 (DQ1) 01001_B: Front connector X11, terminal 32 (DQ9) HSC2: 00011_B: Front connector X11, terminal 24 (DQ3) 01011_B: Front connector X11, terminal 34 (DQ11) HSC3: 00100_B: Front connector X11, terminal 25 (DQ4) 01100_B: Front connector X11, terminal 35 (DQ12) HSC4: 00101_B: Front connector X11, terminal 26 (DQ5) 01101_B: Front connector X11, terminal 36 (DQ13) HSC5: 00111_B: Front connector X11, terminal 28 (DQ7) 01111_B: Front connector X11, terminal 38 (DQ15) HSC6: 00110_B: Front connector X11, terminal 27 (DQ6) 01110_B: Front connector X11, terminal 37 (DQ14) All other values: Reserved				

1) Reserved bits must be set to 0

B.8 Parameter data records (PWM)

You have the option of reassigning the pulse width modulation parameters in RUN. The parameters are transferred with the instruction WRREC via the data record 128 to the PWM submodule.

If errors occur when transferring or validating parameters with the WRREC instruction, the module continues operation with the previous parameter assignment. The output parameter STATUS then contains a corresponding error code. If no error has occurred, the length of the data actually transferred is entered in the output parameter STATUS.

You can find a description of the "WRREC" instruction and the error codes in the STEP 7 (TIA Portal) online help.

Data record structure

The following table shows the structure of the data record 128 for the pulse width modulation. The values in byte 0 to byte 3 are fixed and must not be changed.

Table B- 22 Parameter data record 128

<table>
<tr><th>Bit →
Byte</th><th>7</th><th>6</th><th>5</th><th>4</th><th>3</th><th>2</th><th>1</th><th>0</th></tr>
<tr><td>0</td><td colspan="4">Major Version = 1</td><td colspan="4">Minor Version = 0</td></tr>
<tr><td>1</td><td colspan="8">Length of the parameter data of the channel in bytes = 12</td></tr>
<tr><td>2</td><td colspan="8" rowspan="2">Reserved = 0 [1]</td></tr>
<tr><td>3</td></tr>
<tr><td rowspan="8">4</td><td>Current control</td><td>Dithering</td><td colspan="2">High-speed output</td><td colspan="4">Operating mode</td></tr>
<tr><td>0_B: Deac-tivated</td><td>0_B: Deac-tivated</td><td colspan="2">0_B: Deactivated</td><td colspan="4">0000_B: Reserved</td></tr>
<tr><td rowspan="6">1_B: Re-served</td><td rowspan="6">1_B: Re-served</td><td colspan="2">01_B: Activated</td><td colspan="4">0001_B: PWM (pulse-width modulation)</td></tr>
<tr><td colspan="2">10_B-11_B: Reserved</td><td colspan="4">0010_B: Reserved</td></tr>
<tr><td colspan="2" rowspan="4"></td><td colspan="4">0011_B: Reserved</td></tr>
<tr><td colspan="4">0100_B: Frequency output</td></tr>
<tr><td colspan="4">0110_B to 1110_B: Reserved</td></tr>
<tr><td colspan="4">1111_B: Deactivated</td></tr>
<tr><td rowspan="5">5</td><td colspan="3" rowspan="5">Reserved = 0 [1]</td><td colspan="2" rowspan="5">Reserved = 0 [1]</td><td>Diagnostics interrupt</td><td colspan="2">Reaction to CPU STOP</td></tr>
<tr><td>0_B: Deac-tivated</td><td colspan="2">00_B: DQ substitute value</td></tr>
<tr><td rowspan="3">1_B: Activat-ed</td><td colspan="2">01_B: Reserved</td></tr>
<tr><td colspan="2">10_B: Operating mode for continuation of operation</td></tr>
<tr><td colspan="2">11_B: Reserved</td></tr>
</table>

<table>
<tr><th>Bit →
Byte</th><th>7</th><th>6</th><th>5</th><th>4</th><th>3</th><th>2</th><th>1</th><th>0</th></tr>
<tr><td>6</td><td colspan="3">Reserved = 0 [1)]</td><td colspan="5">Pulse output (DQA) selection
Range of values for PWM1:
00000_B: Front connector X11, terminal 21 (DQ0)
01000_B: Front connector X11, terminal 31 (DQ8)
Range of values for PWM2:
00010_B: Front connector X11, terminal 23 (DQ2)
01010_B: Front connector X11, terminal 33 (DQ10)
Range of values for PWM3:
00100_B: Front connector X11, terminal 25 (DQ4)
01100_B: Front connector X11, terminal 35 (DQ12)
Range of values for PWM4:
00110_B: Front connector X11, terminal 27 (DQ6)
01110_B: Front connector X11, terminal 37 (DQ14)
All other values: Reserved</td></tr>
<tr><td rowspan="6">7</td><td colspan="2" rowspan="6">Reserved = 0 [1)]</td><td colspan="2">Output format</td><td rowspan="6">Reserved = 0 [1)]</td><td rowspan="6">Reserved = 0 [1)]</td><td rowspan="6">Reserved = 0 [1)]</td><td>Substitute value DQA</td></tr>
<tr><td>PWM</td><td>Frequency output</td><td>0_B: 0 V</td></tr>
<tr><td>00_B: S7 analog format</td><td>00_B: Reserved</td><td rowspan="4">1_B: 24 V</td></tr>
<tr><td>01_B: per 100 (%)</td><td>01_B: 1 Hz</td></tr>
<tr><td>10_B: per 1000</td><td>10_B: Reserved</td></tr>
<tr><td>11_B: per 10 000</td><td>11_B: Reserved</td></tr>
<tr><td rowspan="3">8-11</td><td colspan="8">DWORD minimum pulse duration</td></tr>
<tr><td colspan="8">PWM: Minimum pulse duration (default = 0 μs)</td></tr>
<tr><td colspan="8">Frequency output: Reserved</td></tr>
<tr><td rowspan="3">12-15</td><td colspan="8">DWORD period duration</td></tr>
<tr><td colspan="8">PWM: Period duration
Supported value range depending on configured values for "Pulse output (DQA)" and "High-speed output (0.1 A)"
• for 100 kHz DQ (high-speed output activated): 10 μs to 10 000 000 μs (10 s)
• for 10 kHz DQ (high-speed output deactivated): 100 μs to 10 000 000 μs (10 s)
• for 100 Hz DQ (high-speed output deactivated): 10 000 μs (10 ms) to 10 000 000 μs (10 s)
Default = 2 000 000 μs (2 s)</td></tr>
<tr><td colspan="8">Frequency output: Reserved</td></tr>
</table>

1) Reserved bits must be set to 0

Analog value processing

C

C.1 Conversion method

Conversion

An integrated analog-to-digital converter converts the analog signal into a digital signal so that the compact CPU can process the analog signal read in by an analog channel. Once the CPU has processed the digital signal, an integrated digital-to-analog converter converts the output signal into an analog current or voltage value.

Interference frequency suppression

The interference frequency suppression of the analog inputs suppresses the interference caused by the frequency of the AC voltage network used. The frequency of the AC voltage network may interfere with measured values, particularly for measurements within narrow voltage ranges.

You set the line frequency with which the plant operates (400, 60, 50 or 10 Hz) using the "Interference frequency suppression" parameter in STEP 7 (TIA Portal). The "Interference frequency suppression" parameter can only be set module-wide (for all input channels). The interference frequency suppression filters out the set interference frequency (400/60/50/10 Hz) as well as multiples of it. The selected interference frequency suppression also defines the integration time. The conversion time changes depending on the set interference frequency suppression.

For example, an interference frequency suppression of 50 Hz corresponds to an integration time of 20 ms. The analog on-board I/O supplies one measured value to the CPU every millisecond over a period of 20 ms. This measured value corresponds to the floating mean value of the last 20 measurements.

The following figure shows how this works using a 400 Hz interference frequency suppression as an example. A 400 Hz interference frequency suppression corresponds to an integration time of 2.5 ms. The analog on-board I/O supplies a measured value to the CPU every 1.25 milliseconds within the integration time.

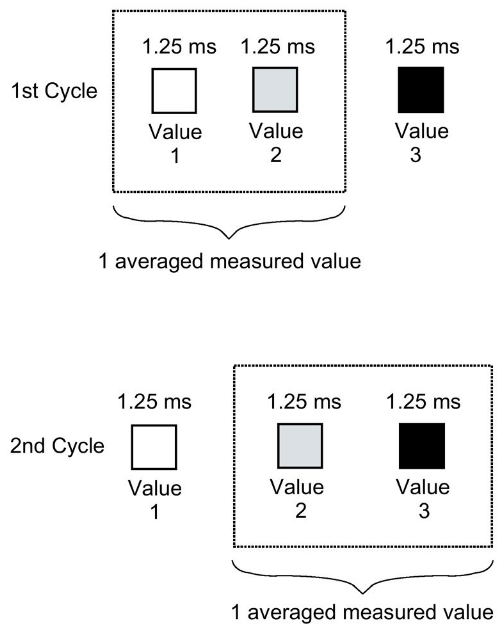


Figure C-1 Interference frequency suppression 400 Hz

The following figure shows how this works using a 60 Hz interference frequency suppression as an example. A 60 Hz interference frequency suppression corresponds to an integration time of 16.6 ms. The analog on-board I/O supplies a measured value to the CPU every 1.04 milliseconds within the integration time.

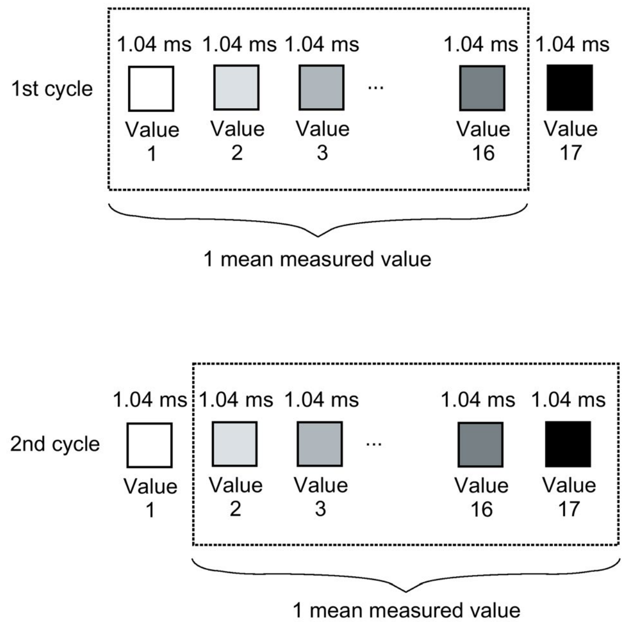


Figure C-2 Interference frequency suppression 60 Hz

The following figure shows how this works using a 50 Hz interference frequency suppression as an example. A 50 Hz interference frequency suppression corresponds to an integration time of 20 ms. The analog on-board I/O supplies a measured value to the CPU every millisecond within the integration time.

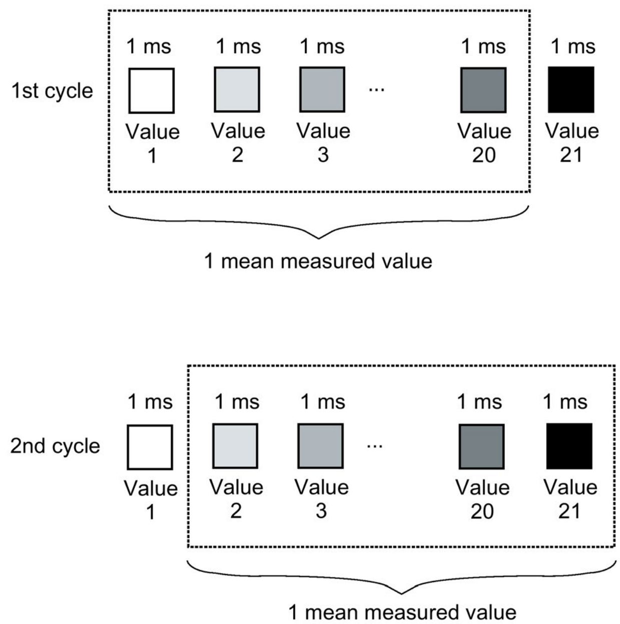


Figure C-3 Interference frequency suppression 50 Hz

The following figure shows how this works using a 10 Hz interference frequency suppression as an example. A 10 Hz interference frequency suppression corresponds to an integration time of 100 ms. The analog on-board I/O supplies a measured value to the CPU every millisecond within the integration time.

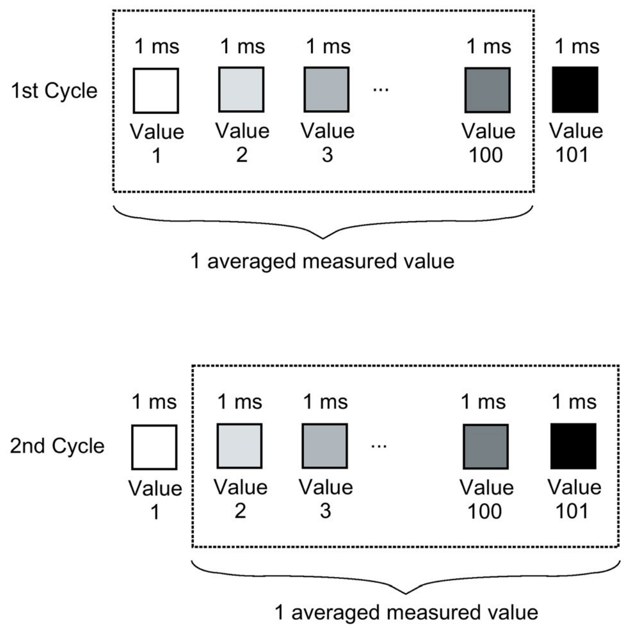


Figure C-4 Interference frequency suppression 10 Hz

The following table provides an overview of the configurable line frequencies, the integration time and the intervals within which measured values are supplied to the CPU.

Table C- 1 Overview of the configurable line frequencies

Interference frequency suppression	Integration time	Interval
400 Hz	2.5 ms	2 x 1.25 ms
60 Hz	16.6 ms	16 x 1.04 ms
50 Hz	20 ms	20 x 1 ms
10 Hz	100 ms	100 x 1 ms

Note

Basic error with an integration time of 2.5 ms.

With an integration time of 2.5 ms, the measured value is changed by the following values based on the additionally obtained basic error and noise:

- with "voltage", "current" and "resistance" by ±0.1 %
- with "Thermal resistor Pt 100 Standard" by ±0.4 K
- with "Thermal resistor Pt 100 Climatic" by ±0.3 K
- with "Thermal resistor Ni 100 Standard" by ±0.2 K
- with "Thermal resistor Ni 100 Climatic" by ±0.1 K

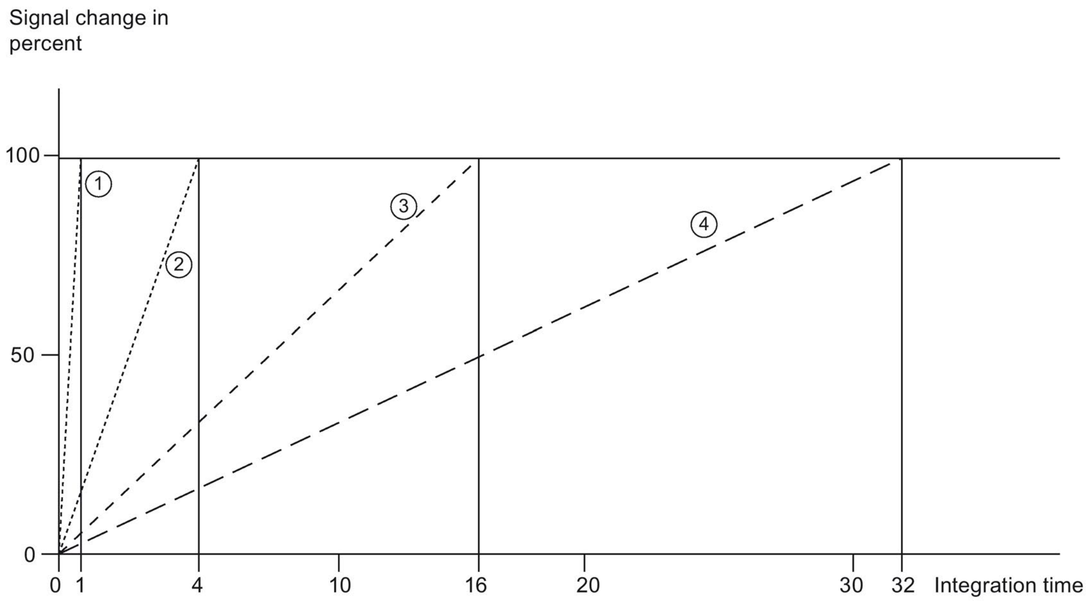
A detailed description of the basic and operating error is available in the function manual Analog value processing (http://support.automation.siemens.com/WW/view/en/67989094).

Smoothing

The individual measured values are smoothed by filtering. The smoothing can be set in 4 levels for individual channels in STEP 7 (TIA Portal).

Smoothing time = Smoothing (k) x configured integration time

The following figure shows the time it takes for the smoothed analog value to reach approximately 100% depending on the set smoothing. This is valid for all signal changes at the analog input.



① None (smoothing = 1 x integration time)
② Weak (smoothing = 4 x integration time) *
③ Medium (smoothing = 16 x integration time) *
④ Strong (smoothing = 32 x integration time) *

* The smoothing time can increase by 1 x integration time.

Figure C-5 Smoothing time depending on the set smoothing level

The following table shows the time it takes for the smoothed analog value to reach approximately 100% depending on the set smoothing and the set interference frequency suppression.

Table C- 2 Smoothing time depending on the set smoothing level and interference frequency suppression

Selection of the smoothing (mean value generation from scan values)	Interference frequency suppression/smoothing time			
	400 Hz	60 Hz	50 Hz	10 Hz
None	2.5 ms	16.6 ms	20 ms	100 ms
Weak	10 ms	66.4 ms	80 ms	400 ms
Medium	40 ms	265.6 ms	320 ms	1600 ms
Strong	80 ms	531.2 ms	640 ms	3200 ms

Cycle time

The cycle times (1 ms, 1.04 ms and 1.25 ms) result from the configured interference frequency suppression. The cycle time is independent of the number of configured analog channels. The values for the analog input channels are detected sequentially in each cycle.

Reference

For more information on conversion time, cycle time and conversion method, refer to the Analog value processing (http://support.automation.siemens.com/WW/view/en/67989094) function manual.

C.2 Representation of analog values

Introduction

The analog values for all measuring ranges that you can use with the analog on-board I/O are represented in this appendix.

For cross-product information on "analog value processing", refer to the Analog value processing (http://support.automation.siemens.com/WW/view/en/67989094) function manual.

Measured value resolution

Each analog value is entered left aligned into the tags. The bits marked with "x" are set to "0".

Note

This resolution does not apply to temperature values. The digitalized temperature values are the result of a conversion in the analog on-board I/O.

Table C- 3 Resolution of the analog values

Resolution in bits including sign	Values		Analog value	
	Decimal	Hexadecimal	High byte	Low byte
16	1	1_H	Sign 0 0 0 0 0 0 0	0 0 0 0 0 0 0 1

C.3 Representation of input ranges

The tables below set out the digitized representation of the input ranges separately for bipolar and unipolar input ranges. The resolution is 16 bits.

Table C- 4 Bipolar input ranges

Dec. value	Measured value in %	Data word																Range
		2^{15}	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}	
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	Overrange
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	Nominal 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	Underrange
-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 C- 5 Unipolar input ranges

Dec. value	Measured value in %	Data word																Range
		2^{15}	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}	
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	Overrange
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	Nominal 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	Underrange
-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

C.3.1 Representation of analog values in voltage measuring ranges

The following tables list the decimal and hexadecimal values (codes) of the possible voltage measuring ranges.

Table C- 6 Voltage measuring ranges ±10 V, ±5 V

Values		Voltage measuring range		Range
dec.	hex.	±10 V	±5 V	
32767	7FFF	>11.759 V	>5.879 V	Overflow
32511	7EFF	11.759 V	5.879 V	Overrange
27649	6C01			
27648	6C00	10 V	5 V	Nominal range
20736	5100	7.5 V	3.75 V	
1	1	361.7 µV	180.8 µV	
0	0	0 V	0 V	
-1	FFFF			
-20736	AF00	-7.5 V	-3.75 V	
-27648	9400	-10 V	-5 V	
-27649	93FF			Underrange
-32512	8100	-11.759 V	-5.879 V	
-32768	8000	<-11.759 V	<-5.879 V	Underflow

Table C- 7 Voltage measuring range 1 to 5 V, 0 to 10 V

Values		Voltage measuring range		Range
dec.	hex.	1 to 5 V	0 to 10 V	
32767	7FFF	>5.704 V	>11.759 V	Overflow
32511	7EFF	5.704 V	11.759 V	Overrange
27649	6C01			
27648	6C00	5 V	10.0 V	Nominal range
20736	5100	4 V	7.5 V	
1	1	1 V + 144.7 µV	361.7 µV	
0	0	1 V	0 V	
-1	FFFF			Underrange
-4864	ED00	0.296 V	-1.759 V	
-32768	8000	< 0.296 V	< -1.759 V	Underflow

C.3.2 Representation of analog values in current measuring ranges

The following tables list the decimal and hexadecimal values (codes) of the possible current measuring ranges.

Table C- 8 Current measuring range ±20 mA

Values		Current measuring range	
dec.	**hex.**	**±20 mA**	
32767	7FFF	>23.52 mA	Overflow
32511	7EFF	23.52 mA	Overrange
27649	6C01		
27648	6C00	20 mA	Nominal range
20736	5100	15 mA	
1	1	723.4 nA	
0	0	0 mA	
-1	FFFF		
-20736	AF00	-15 mA	
-27648	9400	-20 mA	
-27649	93FF		Underrange
-32512	8100	-23.52 mA	
-32768	8000	<-23.52 mA	Underflow

Table C- 9 Current measuring ranges 0 to 20 mA and 4 to 20 mA

Values		Current measuring range		
dec.	**hex.**	**0 to 20 mA**	**4 to 20 mA**	
32767	7FFF	>23.52 mA	>22.81 mA	Overflow
32511	7EFF	23.52 mA	22.81 mA	Overrange
27649	6C01			
27648	6C00	20 mA	20 mA	Nominal range
20736	5100	15 mA	16 mA	
1	1	723.4 nA	4 mA + 578.7 nA	
0	0	0 mA	4 mA	
-1	FFFF			Underrange
-4864	ED00	-3.52 mA	1.185 mA	
-32768	8000	<-3.52 mA	<1.185 mA	Underflow

C.3.3 Representation of the analog values of resistance-type sensors/resistance-type thermometers

The following tables list the decimal and hexadecimal values (codes) of the possible resistance-type sensor ranges.

Table C- 10 Resistance-type sensors of 150 Ω, 300 Ω and 600 Ω

Values		Resistance-type sensor range			
dec.	hex.	150 Ω	300 Ω	600 Ω	
32767	7FFF	>176.38 Ω	>352.77 Ω	>705.53 Ω	Overflow
32511	7EFF	176.38 Ω	352.77 Ω	705.53 Ω	Overrange
27649	6C01				
27648	6C00	150 Ω	300 Ω	600 Ω	Nominal range
20736	5100	112.5 Ω	225 Ω	450 Ω	
1	1	5.43 mΩ	10.85 mΩ	21.70 mΩ	
0	0	0 Ω	0 Ω	0 Ω	

Table C- 11 Resistance-type thermometer Pt 100 Standard

Pt 100 Standard in °C (1 digit = 0.1°C)	Values		Pt 100 Standard in °F (1 digit = 0.1 °F)	Values		Pt 100 Standard in K (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 : 850.1	10000 : 8501	2710 : 2135	1832.0 : 1562.1	18320 : 15621	4790 : 3D05	1273.2 : 1123.3	12732 : 11233	31BC : 2BE1	Overrange
850.0 : -200.0	8500 : -2000	2134 : F830	1562.0 : -328.0	15620 : -3280	3D04 : F330	1123.2 : 73.2	11232 : 732	2BE0 : 2DC	Nominal range
-200.1 : -243.0	-2001 : -2430	F82F : F682	-328.1 : -405.4	-3281 : -4054	F32F : F02A	73.1 : 30.2	731 : 302	2DB : 12E	Underrange
< -243.0	-32768	8000	< -405.4	-32768	8000	< 30.2	32768	8000	Underflow

Table C- 12 Resistance-type thermometer Pt 100 Climate

Pt 100 Climate/ in °C (1 digit = 0.01 °C)	Values		Pt 100 Climate/ in °F (1 digit = 0.01 °F)	Values		Range
	dec.	hex.		dec.	hex.	
> 155.00	32767	7FFF	> 311.00	32767	7FFF	Overflow
155.00 : 130.01	15500 : 13001	3C8C : 32C9	311.00 : 266.01	31100 : 26601	797C : 67E9	Overrange
130.00 : -120.00	13000 : -12000	32C8 : D120	266.00 : -184.00	26600 : -18400	67E8 : B820	Nominal range
-120.01 : -145.00	-12001 : -14500	D11F : C75C	-184.01 : -229.00	-18401 : -22900	B81F : A68C	Underrange
< -145.00	-32768	8000	< -229.00	-32768	8000	Underflow

Table C- 13 Resistance-type thermometer Ni 100 standard

Ni 100 Standard in °C (1 digit = 0.1 °C)	Values		Ni 100 Standard in °F (1 digit = 0.1 °F)	Values		Ni 100 Standard in K (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 : 250.1	2950 : 2501	B86 : 9C5	563.0 : 482.1	5630 : 4821	15FE : 12D5	568.2 : 523.3	5682 : 5233	1632 : 1471	Overrange
250.0 : -60.0	2500 : -600	9C4 : FDA8	482.0 : -76.0	4820 : -760	12D4 : FD08	523.2 : 213.2	5232 : 2132	1470 : 854	Nominal range
-60.1 : -105.0	-601 : -1050	FDA7 : FBE6	-76.1 : -157.0	-761 : -1570	FD07 : F9DE	213.1 : 168.2	2131 : 1682	853 : 692	Underrange
< -105.0	-32768	8000	< -157.0	-32768	8000	< 168.2	32768	8000	Underflow

Table C- 14 Resistance-type thermometer Ni 100 Climate

Ni 100 Climate in °C (1 digit = 0.01 °C)	Values		Ni 100 Climate in °F (1 digit = 0.01 °F)	Values		Range
	dec.	hex.		dec.	hex.	
> 155.00	32767	7FFF	> 311.00	32767	7FFF	Overflow
155.00 : 130.01	15500 : 13001	3C8C : 32C9	311.00 : 266.01	31100 : 26601	797C : 67E9	Overrange
130.00 : -60.00	13000 : -6000	32C8 : E890	266.00 : -76.00	26600 : -7600	67E8 : E250	Nominal range
-60.01 : -105.00	-6001 : -10500	E88F : D6FC	-76.01 : -157.00	-7601 : -15700	E24F : C2AC	Underrange
< - 105.00	-32768	8000	< - 157.00	-32768	8000	Underflow

C.3.4 Measured values for wire break diagnostics

Measured values for "Wire break" diagnostics as a function of diagnostics enables

With suitable parameter assignment, events that occur trigger a diagnostics entry and a diagnostics interrupt.

Table C- 15 Measured values for wire break diagnostics

Format	Parameter assignment	Measured values		Explanation
S7	• "Wire break" diagnostics enabled • "Overflow/Underflow" diagnostics enabled or disabled ("Wire break" diagnostics has a higher priority than "Overflow/Underflow" diagnostics)	32767	$7FFF_H$	"Wire break" or "Cable break" diagnostics alarm
	• "Wire break" diagnostics disabled • "Overflow/Underflow" diagnostics enabled	-32767	8000_H	• Measured value after leaving the underrange • Diagnostics alarm "Low limit" violated
	• "Wire break" diagnostics disabled • "Overflow/Underflow" diagnostics disabled	-32767	8000_H	Measured value after leaving the underrange

C.4 Representation of output ranges

The tables below set out the digitalized representation of the output ranges separately for bipolar and unipolar ranges. The resolution is 16 bits.

Table C- 16 Bipolar output ranges

Dec. value	**Output value in %**	**Data word**																**Range**
		2^{15}	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}	
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	Overrange
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	Nominal 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	Underrange
-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%.

** When values < -32512 are specified, the output value is limited to -117.593%.

Table C- 17 Unipolar output ranges

Dec. value	**Output value in %**	**Data word**																**Range**
		2^{15}	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}	
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	Overrange
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	Nominal 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	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%.

** When values < 0 are specified, the output value is limited to 0%.

C.4.1 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 C- 18 Voltage output range ±10 V

Values			Voltage output range	Range
	dec.	hex.	±10 V	
>117.589%	>32511	>7EFF	11.76 V	Maximum output value
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	
<-117.593%	<-32512	< 8100	-11.76 V	Minimum output value

Table C- 19 Voltage output range 0 V to 10 V

Values			Voltage output range	Range
	dec.	hex.	0 to 10 V	
>117.589%	>32511	>7EFF	11.76 V	Maximum output value
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	
<0%	<0	<0	0 V	Minimum output value

Table C- 20 Voltage output range 1 V to 5 V

Values			Voltage output range	Range
	dec.	**hex.**	**1 to 5 V**	
>117.589%	>32511	>7EFF	5.70 V	Maximum output value
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 µV	
0%	0	0	1 V	
	-1	FFFF	1 V -144.7 µV	Underrange
-25%	-6912	E500	0 V	
<-25%	<-6912	<E500	0 V	Minimum output value

C.4.2 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 C- 21 Current output range ±20 mA

Values			Current output range	Range
	dec.	**hex.**	**±20 mA**	
>117.589%	>32511	>7EFF	23.52 mA	Maximum output value
117.589%	32511	7EFF	23.52 mA	Overrange
	27649	6C01		
100%	27648	6C00	20 mA	Nominal range
75%	20736	5100	15 mA	
0.003617%	1	1	723.4 mA	
0%	0	0	0 mA	
	-1	FFFF	-723.4 mA	
-75%	-20736	AF00	-15 mA	
-100%	-27648	9400	-20 mA	
	-27649	93FF		Underrange
-117.593%	-32512	8100	-23.52 mA	
<-117.593%	<-32512	<8100	-23.52 mA	Minimum output value

Table C- 22 Current output range 0 to 20 mA

Values			Current output range	Range
	dec.	hex.	0 to 20 mA	
>117.589%	>32511	>7EFF	23.52 mA	Maximum output value
117.589%	32511	7EFF	23.52 mA	Overrange
	27649	6C01		
100%	27648	6C00	20 mA	Nominal range
75%	20736	5100	15 mA	
0.003617%	1	1	723.4 mA	
0%	0	0	0 mA	
<0%	<0	<0	0 mA	Minimum output value

Table C- 23 Current output range 4 to 20 mA

Values			Current output range	Range
	dec.	hex.	4 to 20 mA	
>117.589%	>32511	>7EFF	22.81 mA	Maximum output value
117.589%	32511	7EFF	22.81 mA	Overrange
	27649	6C01		
100%	27648	6C00	20 mA	Nominal range
75%	20736	5100	16 mA	
0.003617%	1	1	4 mA	
0%	0	0	4 mA	
	-1	FFFF		Underrange
-25%	-6912	E500	0 mA	
<-25%	<-6912	<E500	0 mA	Minimum output value