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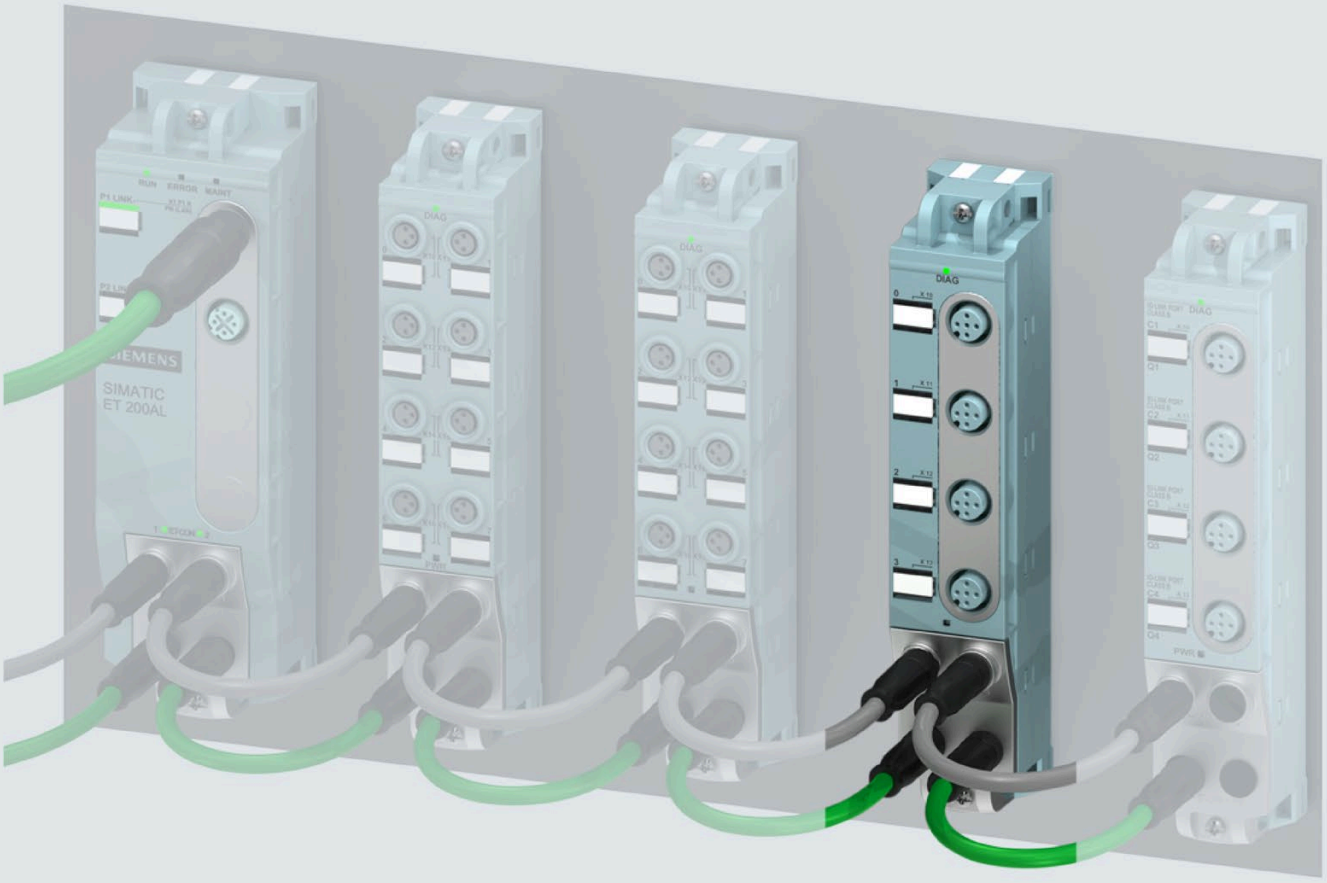

Equipment Manual

SIMATIC

ET 200AL

Analog input module AI 4xU/I/RTD 4xM12
(6ES7144-5KD00-0BA0)

Edition 08/2021

support.industry.siemens.com

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ET 200AL
Analog input module
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Equipment Manual

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A5E32350124-AG

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.

Siemens AG
Digital Industries
Postfach 48 48
90026 NÜRNBERG
GERMANY

A5E32350124-AG
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Preface

Purpose of the documentation

This manual supplements the ET 200AL distributed I/O system (http://support.automation.siemens.com/WW/view/en/89254965) system manual. Functions that are generally applicable to the ET 200AL distributed I/O system are described there.

The information provided in the present manual, the system manual and the function manuals enables you to commission the ET 200AL distributed I/O system.

Changes compared to previous version

Compared to the previous version, this manual contains the following adaptations in the section Technical specifications (Page 38).

Conventions

Also observe notes marked as follows:

Note

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

See also

Terminal and block diagram (Page 14)

Parameters (Page 21)

ET 200AL Documentation Guide (Page 6)

Security information

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

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

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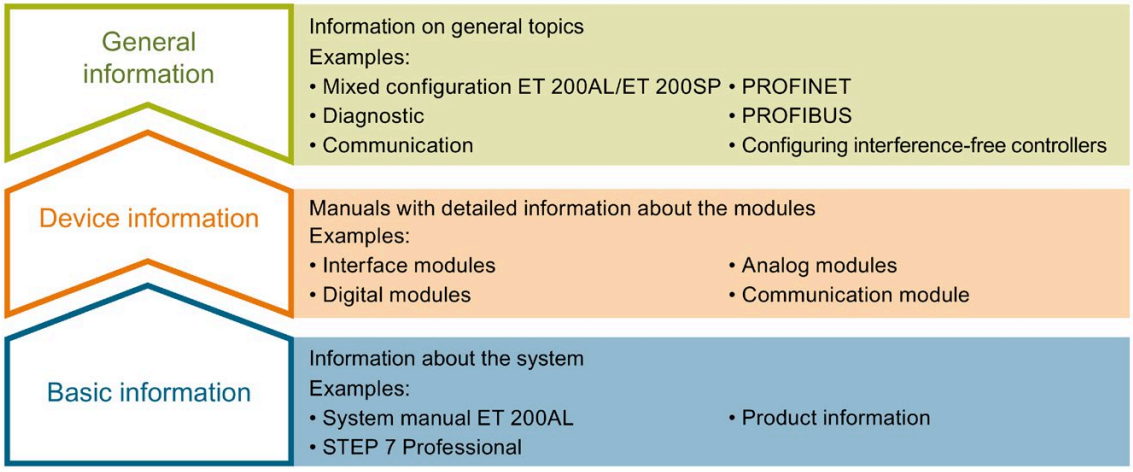
To stay informed about product updates, subscribe to the Siemens Industrial Security RSS Feed visit (https://www.siemens.com/industrialsecurity).

Table of contents

ET 200AL Documentation Guide

1

The documentation for the SIMATIC ET 200AL distributed I/O system is arranged into three areas.
This arrangement enables you to access the specific content you require.



Basic information

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

Device information

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

General information

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

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

Manual Collection ET 200AL

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

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

"mySupport"

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

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

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

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

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

"mySupport" - CAx data

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

You configure your own download package with a few clicks.

In doing so you can select:

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

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

Application examples

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

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

TIA Selection Tool

With the TIA Selection Tool, you can select, configure and order devices for Totally Integrated Automation (TIA).
This tool is the successor of the SIMATIC Selection Tool and combines the known configurators for automation technology into one tool.
With the TIA Selection Tool, you can generate a complete order list from your product selection or product configuration.

You can find the TIA Selection Tool on the Internet (https://support.industry.siemens.com/cs/ww/en/view/109767888).

SIMATIC Automation Tool

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

The SIMATIC Automation Tool provides a multitude of functions:

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

You can find the SIMATIC Automation Tool on the Internet (https://support.industry.siemens.com/cs/ww/en/view/98161300).

PRONETA

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

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

You can find SIEMENS PRONETA on the Internet (https://support.industry.siemens.com/cs/ww/en/view/67460624).

SINETPLAN

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

The advantages at a glance

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

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

Product overview

2

2.1 Properties

Article number

6ES7144-5KD00-0BA0

View of the module

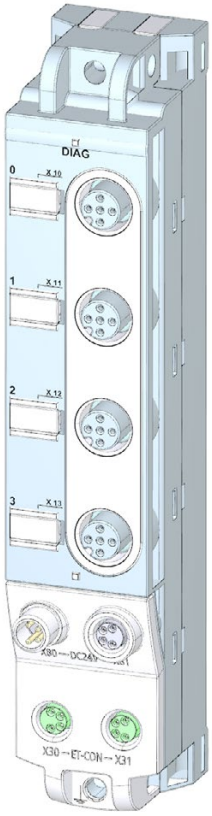


Figure 2-1 View of the analog input module AI 4xU/I/RTD 4xM12

Properties

The module has the following technical properties:

- 4 analog inputs
- M12 sockets for connection of sensors
- Measurement type can be set for each channel:
  - Voltage
  - Current (2-/4-wire transducers)
  - Resistance (2-/3-wire connection)
  - Resistance thermometer (RTD) (2-/3-wire connection)
- Resolution 16-bit
- Dimensions 30 x 159 mm
- Configurable diagnostics can be set for each channel
- Hardware interrupt on limit violation can be set per channel (two high and two low limits per channel)

The module supports the following functions:

- Firmware update
- Identification and maintenance data I&M0 to I&M3
- Value status (Quality Information)
- PROFIenergy

Note

Process values during startup

As long as no parameters have been received by the I/O module, the I/O module returns the process value $7FFF_H$.

Accessories

The following components are included in the module package:

- Identification labels
- Spacers

Other components

The following component can be ordered as spare part:

- Identification labels

The following components can be ordered as accessories:

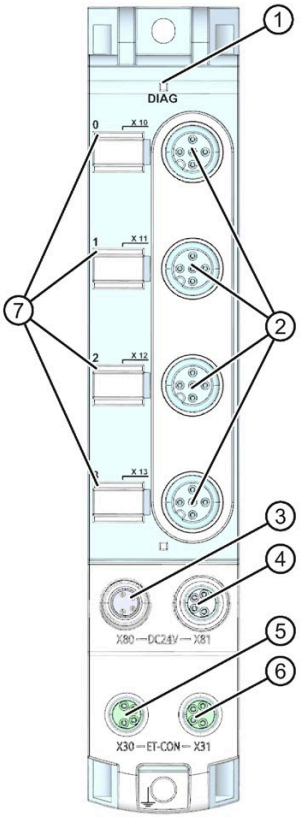
- Connectors
- Cables
- Stripping Tool for ET-Connection
- M8 sealing cap
- M12 sealing cap

See also

You can find more information on accessories in the Accessories/spare parts section of the ET 200AL distributed I/O system (http://support.automation.siemens.com/WW/view/en/89254965) system manual.

2.2 Operator controls and display elements

The figure below shows the operator controls and display elements of the analog input module AI 4xU/I/RTD 4xM12.



① DIAG: LED display for the diagnostic status
② X10 to X13: Sockets for the input signal
③ X80: Connector for infeed of the supply voltage (POWER input)
④ X81: Socket for loop-through of the supply voltage (POWER output)
⑤ X30: Socket for ET-Connection IN
⑥ X31: Socket for ET-Connection OUT
⑦ LED displays 0 to 3 for the channel status

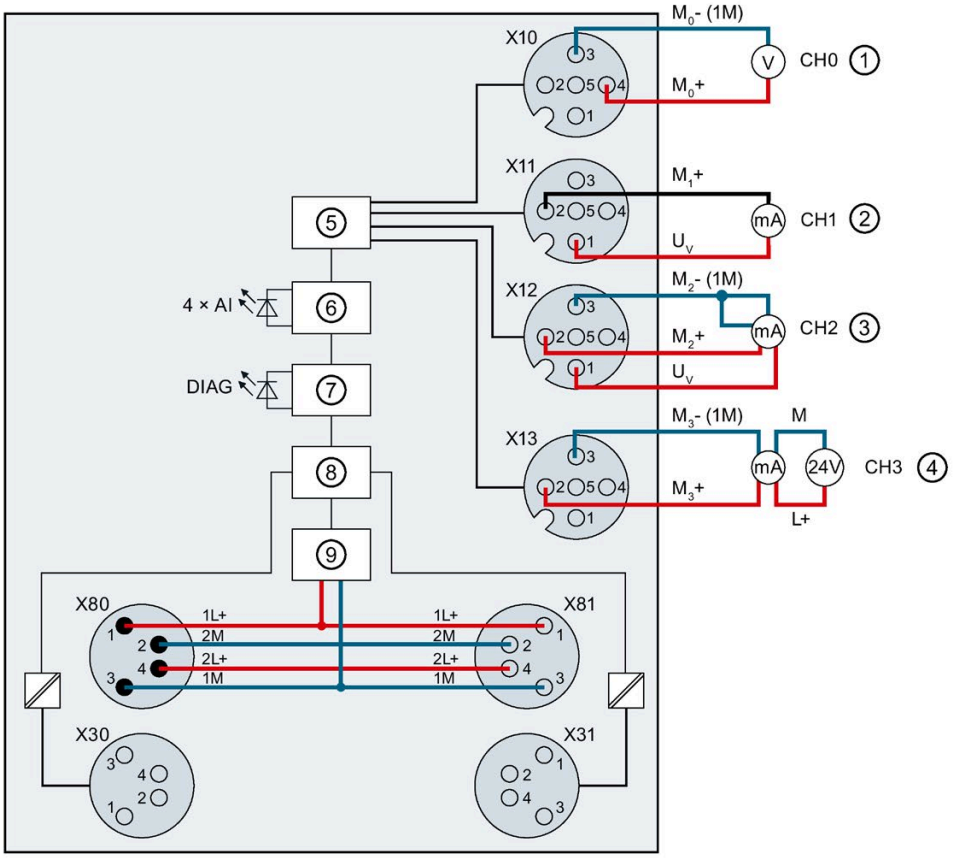
Figure 2-2 Operator controls and display elements

Wiring

3

3.1 Terminal and block diagram

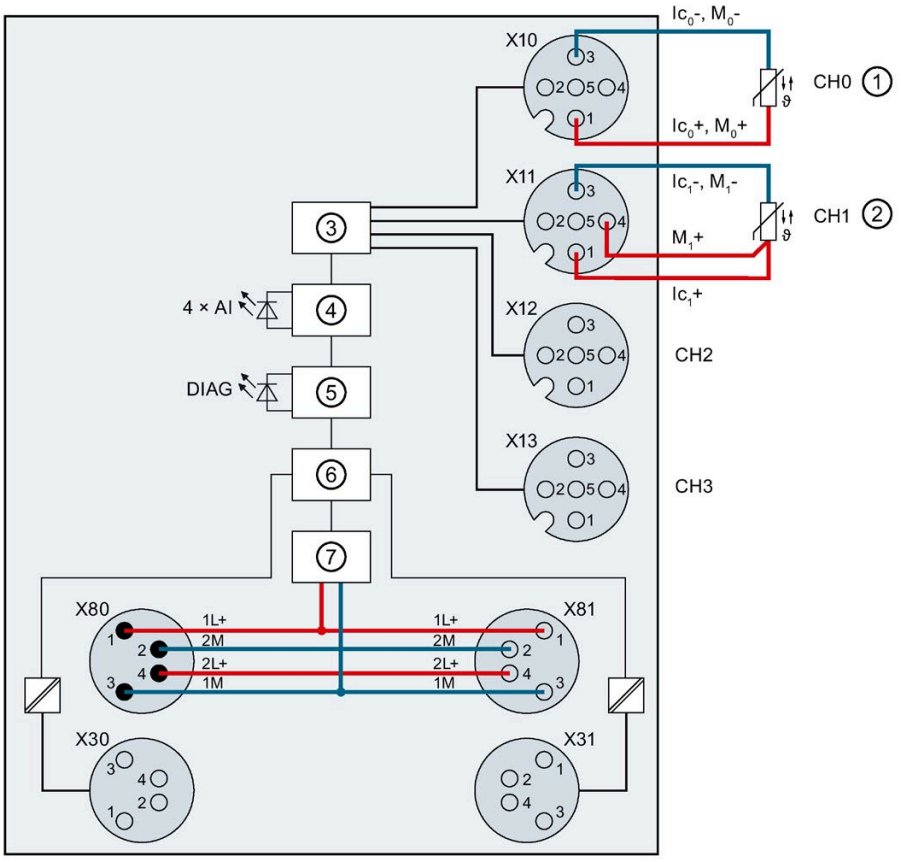
The figure below shows an example of the pin assignment for voltage measurement and current measurement.



①	Voltage measurement	X30	Infeed of the ET-Connection
②	Current measurement (2 DMU)	X31	Loop-through of the ET-Connection
③	Current measurement (4 DMU, with internal power supply)	1L+	Supply voltage 1L+ (non-switched)
④	Current measurement (4 DMU, with external power supply)	1M	Ground 1M (non-switched)
⑤	Multiplexer	2L+	Load voltage 2L+ (switched)
⑥	Analog-to-digital converter (ADC)	2M	Ground 2M (switched)
⑦	Microcontroller	M_n+	Measuring input positive, channel n
⑧	ET-Connection interface	M_n-	Measuring input negative, channel n
⑨	Internal supply voltage	U_V	24 V encoder supply
X10 to X13	Channels 0 to 3	AI	LEDs channel status (0, 1, 2 and 3) (green)
X80	Infeed of supply voltages	DIAG	LED diagnostic status (red/green)
X81	Loop-through of supply voltages		

Figure 3-1 Terminal and block diagram for voltage and current measurement

The example in the following figure shows the pin assignment for the resistance thermometer.



①	RTD/R 2-wire connection	X30	Infeed of the ET-Connection
②	RTD/R 3-wire connection	X31	Loop-through of the ET-Connection
③	Multiplexer	1L+	Supply voltage 1L+ (non-switched)
④	Analog-to-digital converter (ADC)	1M	Ground 1M (non-switched)
⑤	Microcontroller	2L+	Load voltage 2L+ (switched)
⑥	ET-Connection interface	2M	Ground 2M (switched)
⑦	Internal supply voltage	M_n+	Measuring input positive, channel n
X10 to X13	Channels 0 to 3	M_n-	Measuring input negative, channel n
X80	Infeed of supply voltages	Ic_n+, Ic_n-	Current output, current feed, RTD/R channel n
X81	Loop-through of supply voltages	AI	LEDs channel status (0, 1, 2 and 3) (green)
		DIAG	LED diagnostic status (red/green)

Figure 3-2 Terminal and block diagram for resistance thermometer

3.2 Pin assignment

Note

Color coding

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

Pin assignment of the sockets for analog inputs

The tables below show the pin assignments of the four sockets for connection of the analog inputs.

Table 3- 1 Pin assignment of the sockets for analog inputs (voltage measurement)

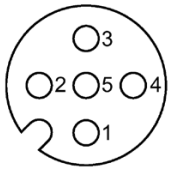
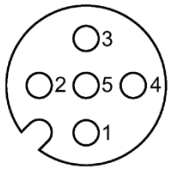
Pin	Assignment **X10 to X13 - sockets for analog inputs (voltage measurement)**	Front view of the sockets
1	24 V encoder supply $1U_S$ (derived from 1L+ non-switched)	
2	Reserved	
3	Encoder supply ground 1M	
4	Measuring input M_0+: Connector X10 Measuring input M_1+: Connector X11 Measuring input M_2+: Connector X12 Measuring input M_3+: Connector X13	
5	Functional earth FE	
Shield	Functional earth FE	

Table 3- 2 Pin assignment of the sockets for analog inputs (current measurement)

Pin	Assignment **X10 to X13 sockets for analog inputs (current measurement)**	Front view of the sockets
1	24 V encoder supply $1U_S$ (derived from 1L+ non-switched)	
2	Measuring input M_0+: Connector X10 Measuring input M_1+: Connector X11 Measuring input M_2+: Connector X12 Measuring input M_3+: Connector X13	
3	Encoder supply ground 1M	
4	Reserved	
5	Functional earth FE	
Shield	Functional earth FE	

NOTICE
Short-circuit from encoder supply to measuring input In the operating mode current measurement a short-circuit from the encoder supply to the measuring input can destroy the input channel.

Table 3- 3 Pin assignment of the sockets for analog inputs (RTD/R 2-wire connection)

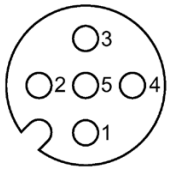
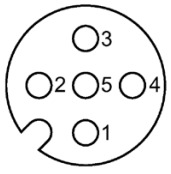
Pin	Assignment **X10 to X13 sockets for analog inputs (RTD/R 2-wire connection)**	Front view of the sockets
1	Measurement cable I_{C0}+, M_0+: Connector X10 Measurement cable I_{C1}+, M_1+: Connector X11 Measurement cable I_{C2}+, M_2+: Connector X12 Measurement cable I_{C3}+, M_3+: Connector X13	
2	Reserved	
3	Measurement cable I_{C0}-, M_0-: Connector X10 Measurement cable I_{C1}-, M_1-: Connector X11 Measurement cable I_{C2}-, M_2-: Connector X12 Measurement cable I_{C3}-, M_3-: Connector X13	
4	Reserved	
5	Functional earth FE	
Shield	Functional earth FE	

Table 3- 4 Pin assignment of the sockets for analog inputs (RTD/R 3-wire connection)

Pin	Assignment **X10 to X13 sockets for analog inputs (RTD/R 3-wire connection)**	Front view of the sockets
1	Constant current cable I_{C0}+: Connector X10 Constant current cable I_{C1}+: Connector X11 Constant current cable I_{C2}+: Connector X12 Constant current cable I_{C3}+: Connector X13	
2	Reserved	
3	Measurement cable I_{C0}-, M_0-: Connector X10 Measurement cable I_{C1}-, M_1-: Connector X11 Measurement cable I_{C2}-, M_2-: Connector X12 Measurement cable I_{C3}-, M_3-: Connector X13	
4	Measuring input M_0+: Connector X10 Measuring input M_1+: Connector X11 Measuring input M_2+: Connector X12 Measuring input M_3+: Connector X13	
5	Functional earth FE	
Shield	Functional earth FE	

NOTICE
Incorrect connection of sensors at channel If the measurement type current or voltage measurement is configured at the I/O module, a connected resistance thermometer could be destroyed.

Note

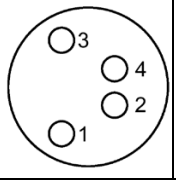
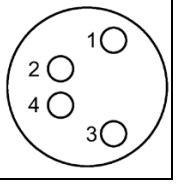
Coupler plug for RTD measurement

For RTD measurements, use a coupler plug with gold-plated contacts. Other materials can create contact resistance that can result in incorrect measured values.

Pin assignment of the sockets for ET-Connection

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

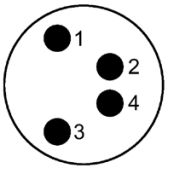
Table 3- 5 Pin assignment for ET-Connection

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

Pin assignment of the connector for infeed of the supply voltage

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

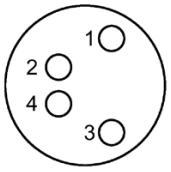
Table 3- 6 Pin assignment of the supply voltage connector

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

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

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

Table 3- 7 Pin assignment of the supply voltage socket

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

NOTICE

ET-Connection/supply voltage

Observe the correct wiring of the M8 sockets for ET-Connection and the supply voltage.

Mixing up the connector for ET-Connection and the connector for the supply voltage can destroy the module.

Parameters/address space

4

4.1 Measurement types and measuring ranges

The table below indicates which measuring range is configurable.

Table 4- 1 Measurement type and measuring ranges

Measurement type	Measuring range	Temperature coefficient	Resolution
Deactivated	–	–	–
Voltage	1 V to 5 V 0 V to 10 V	–	max. 16-bit
Current (4-wire transducer)	0 mA to 20 mA 4 mA to 20 mA	–	max. 16-bit
Current (2-wire transducer)	4 mA to 20 mA	–	max. 16-bit
Resistance (3-wire connection) Resistance (2-wire connection)	150 Ω, 300 Ω	–	max. 15-bit
Resistance thermometer (3-wire connection) Resistance thermometer (2-wire connection)	Pt 100 climatic range/ Pt 100 standard range	Pt 0.003850, Pt 0.003916, Pt 0.003902, Pt 0.003920, Pt 0.003851 EN 60751	max. 16-bit incl. sign
	Ni 100 climatic range/ Ni 100 standard range	Ni 0.006180, Ni 0.006720	max. 16-bit incl. sign

4.2 Parameters

Parameters of the analog input module AI 4xU/I/RTD 4xM12

The table below lists the parameters that can be set. The effective range of the parameters that can be set depends on the type of configuration. The following configurations are possible:

- Distributed operation on PROFINET IO
- Distributed operation with PROFIBUS DP

NOTICE
Match of encoder and parameters
The default setting of the analog inputs is voltage measurement (1 V to 5 V).
Make sure that the connected encoders and the selected parameters match.
The connected encoder can be destroyed in the case of incorrect parameters.

The table below shows the PROFINET and PROFIBUS parameters for the analog input module AI 4xU/I/RTD 4xM12 for configuration with GSD file.

Explanation of abbreviations in table below:

4-DMU 4-wire transducer
2-DMU 2-wire transducer
R-3L Resistance 3-wire transducer
R-2L Resistance 2-wire transducer
RTD-3L Resistance thermometer 3-wire transducer
RTD-2L Resistance thermometer 2-wire transducer

Table 4- 2 Configurable parameters and their defaults

Parameters	**Value range**	**Default**	**GSD file PROFINET IO**	**GSD file PROFIBUS DP**
Temperature unit	• Degrees Celsius • Degrees Fahrenheit • Kelvin	Degrees Celsius	Module	Module
Measurement type/measuring range channel n	• Deactivated • 1 V to 5 V • 0 V to 10 V • 0 mA to 20 mA (4-DMU) • 4 mA to 20 mA (4-DMU) • 4 mA to 20 mA (2-DMU) • R-3L 150 ohm • R-3L 300 ohm • R-2L 150 ohm • R-2L 300 ohm	1 V to 5 V	Channel	Channel

Parameters	Value range	Default	GSD file PROFINET IO	GSD file PROFIBUS DP
Measurement type/measuring range channel n	• RTD-3L Pt100 3851 cl. EN 60751 • RTD-3L Pt100 3851 std. EN 60751 • RTD-3L Pt100 3916 cl. • RTD-3L Pt100 3916 std. • RTD-3L Pt100 3902 cl. • RTD-3L Pt100 3902 std. • RTD-3L Pt100 392 cl. • RTD-3L Pt100 392 std. • RTD-3L Pt100 3850 cl. • RTD-3L Pt100 3850 std. • RTD-2L Pt100 3851 cl. • RTD-2L Pt100 3851 std. • RTD-2L Pt100 3916 cl. • RTD-2L Pt100 3916 std. • RTD-2L Pt100 3902 cl. • RTD-2L Pt100 3902 std. • RTD-2L Pt100 392 cl. • RTD-2L Pt100 392 std. • RTD-2L Pt100 3850 cl. • RTD-2L Pt100 3850 std. • RTD-3L Ni100 618 cl. • RTD-3L Ni100 618 std. • RTD-3L Ni100 672 cl. • RTD-3L Ni100 672 std. • RTD-2L Ni100 618 cl. • RTD-2L Ni100 618 std. • RTD-2L Ni100 672 cl. • RTD-2L Ni100 672 std.	1 V to 5 V	Channel	Channel
Smoothing channel n	• None • Weak • Medium • Strong	None	Channel	Channel
Interference frequency suppression	• 3600 Hz • 60 Hz • 50 Hz • 16.67 Hz	50 Hz	Channel	Module

Parameters	Value range	Default	GSD file PROFINET IO	GSD file PROFIBUS DP
Short-circuit to ground channel n	• Disable • Enable	Disable	Channel	Channel
Wire break channel n	• Disable • Enable	Disable	Channel	Channel
Diagnostics: Overflow/underflow	• Disable • Enable	Disable	---	Module
Diagnostics: Underflow channel n	• Disable • Enable	Disable	Channel	---
Diagnostics: Overflow channel n	• Disable • Enable	Disable	Channel	---
Hardware interrupt high limit 1 channel n	• Disable • Enable	Disable	Channel	---
Hardware interrupt low limit 1 channel n	• Disable • Enable	Disable	Channel	---
Hardware interrupt high limit 2 channel n	• Disable • Enable	Disable	Channel	---
Hardware interrupt low limit 2 channel n	• Disable • Enable	Disable	Channel	---
High limit 1 channel n	The value range depends on the measurement type.		Channel	---
Low limit 1 channel n	The value range (min./max.) permitted for the measurement type is listed in the table below.		Channel	---
High limit 2 channel n			Channel	---
Low limit 2 channel n			Channel	---

Note

Unused channels

"Deactivate" unused inputs in the parameter assignment to shorten the cycle time of the module.

A deactivated input always returns the value 7FFF$_H$.

The table below shows the permitted value ranges for the measurement type.

Table 4- 3 Measuring ranges of the hardware interrupts

Measure-ment type	Measuring range	Low limit	High limit	Default		Unit
				Low limit	High limit	
Voltage	1 V to 5 V	0.297	5.703	1	5	V
		-4863	32510	0	27648	Decimal
	0 V to 10 V	-1.758	11.758	0	10	V
		-4863	32510	0	27648	Decimal
Current	0 mA to 20 mA	-3.51	23.51	0	20	mA
		-4863	32510	0	27648	Decimal
	4 mA to 20 mA	1.19	22.81	4	20	mA
		-4863	32510	0	27648	Decimal
Resistance	150 ohm	0.01	176.37	0.01	150	Ω
		1	32510	1	27648	Decimal
	300 ohm	0.01	352.75	0.01	300	Ω
		1	32510	1	27648	Decimal
Resistance thermometer	Pt100 cl.	-144.99	154.99	-120	130	°C
		-14499	15499	-12000	13000	Decimal
		-228.99	310.99	-184	266	F
		-22899	31099	-18400	26600	Decimal
	Ni100 cl.	-104.99	154.99	-60	130	°C
		-10499	15499	-6000	13000	Decimal
		-156.99	310.99	-76	266	F
		-15699	31099	-7600	26600	Decimal
	Pt100 std.	-242.9	999.9	-200	850	°C
		-2429	9999	-2000	8500	Decimal
		-405.3	1831.9	-328	1562	F
		-4053	18319	-3280	15620	Decimal
		30.3	1273.1	73.2	1123.2	K
		303	12731	732	11232	Decimal
	Ni100 std.	-104.9	294.9	-60	250	°C
		-1049	2949	-600	2500	Decimal
		-156.9	562.9	-76	482	F
		-1569	5629	-760	4820	Decimal
		168.3	568.1	213.2	523.2	K
		1683	5681	2132	5232	Decimal

4.3 Explanation of the parameters

Temperature unit

You use this parameter to set the temperature unit with which you want to measure the temperature.

Measurement type/measuring range channel n

You use this parameter to set the measurement type or the measuring range for acquiring the measured values.

Note

Unused channels

"Deactivate" unused channels in the parameter assignment to improve the cycle time of the module.

A deactivated channel always returns the value 7FFF$_H$.

Temperature coefficient (for RTD, resistance thermometer)

The temperature coefficient depends on the chemical composition of the material. In Europe, only one value is used per sensor type (default value).

The correction factor for the temperature coefficient (α value) specifies how much the resistance of a certain material changes when the temperature is raised by 1 °C.

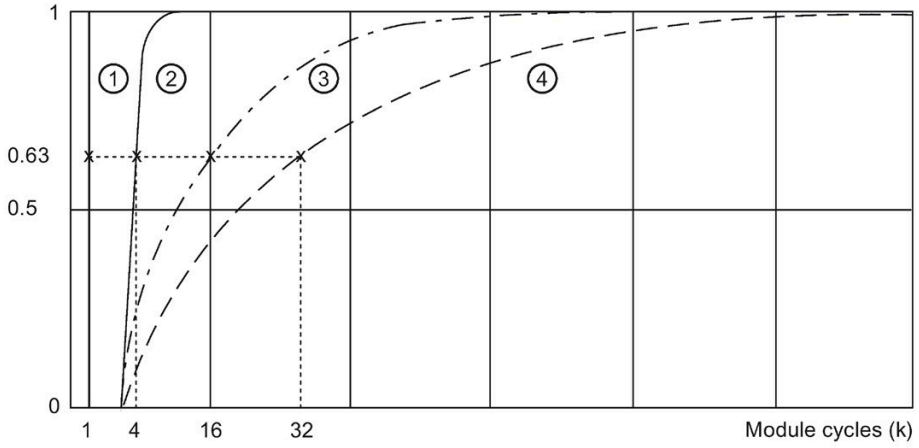
The further values facilitate sensor-specific setting of the temperature coefficient and enhance accuracy.

Smoothing channel n

The purpose of smoothing is to filter out interferences. The greater the smoothing factor, the better the filter effect. This is technically implemented in the form of a digital filter. The smoothing can be set in 4 levels. The smoothing factor k is equal to the number of module cycles. The time constant of the smoothing filter is the product of the smoothing factor k and the cycle time of the I/O module. The greater the smoothing, the greater the time constant of the filter.

Smoothing time = number of module cycles (k) × cycle time of the module.

The following figure shows how many module cycles it takes for the smoothed analog value to approach 100%, depending on the configured smoothing. This is valid for all signal changes at the analog input.



① No smoothing (k = 1)
② Weak (k = 4)
③ Medium (k = 16)
④ Strong (k = 32)

Figure 4-1 Smoothing

Interference frequency suppression channel n

This parameter suppresses interference for analog input modules which is caused by the frequency of the alternating voltage network in use.

The frequency of the alternating voltage network may negatively affect the measured value, in particular when measuring in the low voltage range and with thermocouples. With this parameter, the user specifies the line frequency that is predominant in the plant.

Diagnostics: Short-circuit to ground channel n

Enabling of the diagnostics if a short-circuit of the encoder supply to ground occurs.

Diagnostics: Wire break channel n

Enabling of the diagnostics if the analog input module has no current flow or the current is too weak for measurement at the correspondingly configured input.

Note

Wire break diagnostics

A wire break diagnostics is not possible for all measuring ranges and measurement types for analog input channels.

The table below shows the rules you must observe in the case of a wire break in the measuring ranges 1 to 5, 4 to 20 mA:

Table 4- 4 Parameters for wire break

Parameter	Event	Measured value	Explanation
Wire break enabled[1]	Wire break	7FFF$_H$	**Wire break** diagnostics
Wire break disabled[1] Underflow enabled	Wire break	8000$_H$	Measured value after leaving the underrange Diagnostics alarm **Low limit violated**
Wire break disabled[1] Underflow disabled	Wire break	8000$_H$	Measured value after leaving the underrange
[1] Measuring range limits for detection of wire break and measuring range undershoot: • 1 V to 5 V: at 0.296 V • 4 mA to 20 mA: at 1.185 mA			

The table below shows the diagnostics that can occur for wire break with the measurement type RTD/R.

Table 4- 5 Diagnostics with RTD/R

Diagnostics: Wire break	Diagnostics: Overflow	Diagnostics: Underflow*	Event	Process data	Diagnostics alarm per channel
activated	Deactivated	Deactivated	Wire break	0x7FFF	Wire break
Deactivated	Deactivated	Activated	Wire break	0x7FFF	-
Deactivated	Activated	Deactivated	Wire break	0x7FFF	High limit exceeded
Deactivated	Activated	Activated	Wire break	0x7FFF	High limit violated
Deactivated	Deactivated	Deactivated	Wire break	0x7FFF	-

* This column does not apply to the measurement type resistance.

Diagnostics: Underflow channel n

Enabling of the diagnostics when the measured value falls below the underrange.

Diagnostics: Overflow channel n

Enabling of the diagnostics when the measured value exceeds the overrange.

Diagnostics: Overflow/Underflow (for PROFIBUS only)

Enabling of the diagnostics when the measured value exceeds the overrange or falls below the underrange.

The diagnostic enable has an effect on all channels.

Hardware interrupt high/low limit 1 or 2 channel n

Enabling of a hardware interrupt when the high limit 1 or 2 or the low limit 1 or 2 is violated.

Requirement: An OB 4x must be assigned to the CPU/device.

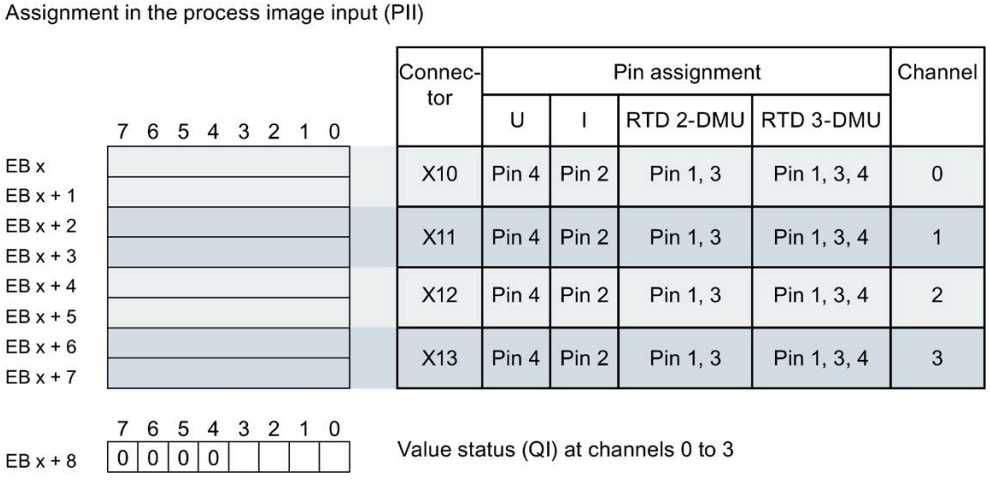
Additional information on the structure of hardware interrupts is available in the section Interrupts (Page 33).

High/low limit 1 or 2 channel n

Specify a threshold at which a hardware interrupt is triggered when it is exceeded or undershot.

4.4 Address space

The figure below shows the assignment of the address space for the analog input module AI 4xU/I/RTD 4xM12 with value status (Quality Information, QI). If you are using PROFINET and the value status was enabled, the addresses for the value status are available. The value status is not available for PROFIBUS.



Connector	Pin assignment				Channel
	U	I	RTD 2-DMU	RTD 3-DMU	
X10	Pin 4	Pin 2	Pin 1, 3	Pin 1, 3, 4	0
X11	Pin 4	Pin 2	Pin 1, 3	Pin 1, 3, 4	1
X12	Pin 4	Pin 2	Pin 1, 3	Pin 1, 3, 4	2
X13	Pin 4	Pin 2	Pin 1, 3	Pin 1, 3, 4	3

Figure 4-2 Address space

Configuration options of analog input module AI 4xU/I/RTD 4xM12

You have the following configuration options:

- Configuration 1: without value status
- Configuration 2: with value status

Evaluating the value status

If you enable the value status for the analog input module, a bit is also assigned in the input address space. Bits 0 to 3 in this byte are assigned to a channel and provide information on the validity of the analog value. The value status is independent of whether or not diagnostics was configured.

Bit = 1: No error on channel.

Bit = 0: Error on channel.

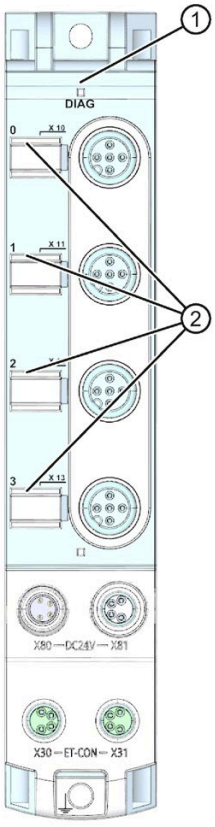
Interrupts/diagnostics alarms

5

5.1 Status and error displays

LED displays

The figure below shows the LED display (status and error displays) of the analog input module AI 4xU/I/RTD 4xM12.



① Diagnostic status (DIAG) (red/green)
② Channel status (0, 1, 2 and 3) (green)

Figure 5-1 LED displays

Meaning of the LEDs

The following tables set out the meaning of the status and error displays. Corrective measures for diagnostics alarms can be found in the section Diagnostics alarms (Page 35).

DIAG LED

Table 5- 1 Error display of the DIAG LED

DIAG LED	Meaning
▫ Off	No supply voltage 1L+
☼ Flashes	• Module parameters not assigned (after switching on the supply voltage 1L+) • Loading firmware (while the firmware update is being performed, all LEDs retain their current status) • No connection to the ET-Connection and/or the fieldbus
■ On	Module parameters assigned and no module diagnostics
☼ Flashes	Module parameters assigned and module diagnostics

LED for the channel status

Table 5- 2 Status display of the LEDs 0, 1, 2 and 3

LED 0, 1, 2 and 3	Meaning
▫ Off	• Channel deactivated • Channel activated and incorrect parameter assignment • Parameter error possible with GSD
■ On	• Channel activated and correct parameter assignment

5.2 Interrupts

Analog input module AI 4xU/I/RTD 4xM12 supports the following diagnostic and hardware interrupts.

Diagnostic interrupt

The table below shows the events for which the analog input module returns a diagnostic interrupt, depending on the parameter assignment.

Table 5- 3 Diagnostic interrupts

Measure-ment type	Measuring range	Diagnostics				
		Short-circuit to ground	Wire break	Underflow[1]	Overflow[1]	Underflow/ Overflow[2]
Voltage	1 V to 5 V	x	x	x	x	x
	0 V to 10 V	x	-	x	x	x
Current	2-DMU 4 mA to 20 mA	x	x	x	x	x
	4-DMU 0 mA to 20 mA	x	-	x	x	x
	4-DMU 4 mA to 20 mA	x	x	x	x	x
Resistance	150 Ω	-	x	-	x	x
	300 Ω	-	x	-	x	x
Resistance thermometer	PT100	-	x	x	x	x
	Ni100	-	x	x	x	x

1 Column valid for configuration with PROFINET GSD file

2 Column valid for configuration with PROFIBUS GSD file

Hardware interrupt

The analog input module generates a hardware interrupt with the following events:

- Low limit 1 violated
- High limit 1 violated
- Low limit 2 violated
- High limit 2 violated

Detailed information on the event is available in the hardware interrupt organization block with the instruction "RALRM" (Read additional interrupt information) and in the STEP 7 online help.

The start information of the organization block includes information on which channel of the analog input module triggered the hardware interrupt.

Note

Violation of two limits

If two limits are violated at the same time, limit 1 is always signaled first, followed by limit 2.

The figure below shows the assignment to the bits of the local data double word 8.

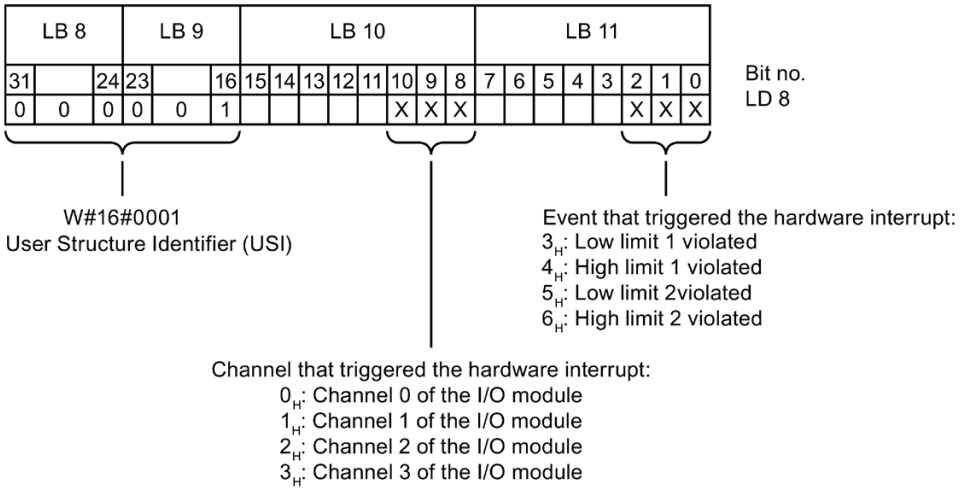


Figure 5-2 Start information of the organization block

Structure of the additional interrupt information

Table 5- 4 Structure of USI = W#16#0001

Data block name	Contents	Comment	Bytes
USI (User Structure Identifier)	W#16#0001	Additional interrupt info for hardware interrupts of the I/O module	2
The channel that triggered the hardware interrupt follows.			
Channel	B#16#00 to B#16#03	Number of channel which triggered the event	1
The error event that triggered the hardware interrupt follows.			
Event	B#16#03	Low limit 1 violated	1
	B#16#04	High limit 1 violated	
	B#16#05	Low limit 2 violated	
	B#16#06	High limit 2 violated	

5.3 Diagnostics alarms

A diagnostics alarm is output for each diagnostic event and the DIAG LED flashes red on the analog input module. You can read out the diagnostics alarms, for example, in the diagnostics buffer of the CPU. You can evaluate the error codes with the user program.

The following tables set out the diagnostics alarms for the set measuring range.

Table 5- 5 Diagnostics alarms - for the measuring range: 1 V to 5 V, 2-DMU 4 mA to 20 mA and 4-DMU 4 mA to 20 mA

Diagnostics alarm	Error code	Meaning	Remedy
Short-circuit	1H	Short-circuit encoder supply to ground	Correct interplay between module and encoder
Wire break	6H	Wire break between the module and sensor	Connect the cable
		Channel not connected (open)	• Deactivate diagnostics • Connect the channel • Deactivate channel
High limit violated	7H	Value is above overrange.	Correct interplay between module and sensor
Low limit violated	8H	Value is below underrange.	Correct interplay between module and sensor
Error	9H	Value is significantly above or below underrange/overrange.	Correct interplay between module and sensor
Parameter error	10H	Module parameter assignment is faulty	Correct the parameter assignment
Hardware interrupt lost	16H	At least one hardware interrupt could not be signaled because too many hardware interrupts are pending.	Correct the program or the process

Table 5- 6 Diagnostics alarms - for the measuring range: 0 V to 10 V and 4-DMU 0 mA to 20 mA

Diagnostics alarm	Error code	Meaning	Remedy
Short-circuit	1H	Short-circuit encoder supply to ground	Correct interplay between module and encoder
High limit violated	7H	Value is above overrange.	Correct interplay between module and sensor
Low limit violated	8H	Value is below underrange.	Correct interplay between module and sensor
Error	9H	Value is significantly above or below underrange/overrange.	Correct interplay between module and sensor
Parameter error	10H	Module parameter assignment is faulty	Correct the parameter assignment
Hardware interrupt lost	16H	At least one hardware interrupt could not be signaled because too many hardware interrupts are pending.	Correct the program or the process

Table 5- 7 Diagnostics alarms - for the measuring range: 150 Ω and 300 Ω

Diagnostics alarm	Error code	Meaning	Remedy
Wire break	6H	Impedance of encoder circuit too high	Use a different encoder type or modify the wiring, for example, using cables with larger cross-section
		Wire break between the module and sensor	Connect the cable
		Channel not connected (open)	• Deactivate diagnostics • Connect the channel • Deactivate channel
High limit violated	7H	Value is above overrange.	Correct interplay between module and sensor
Parameter error	10H	Module parameter assignment is faulty	Correct the parameter assignment
Hardware interrupt lost	16H	At least one hardware interrupt could not be signaled because too many hardware interrupts are pending.	Correct the program or the process

Note

Measurement type resistor (3-wire terminal)

A wire break of the M+ cable is not detected with measurement type resistor (3-wire terminal). An incorrect measuring value is output in this case.

Table 5- 8 Diagnostics alarms - for the measuring range: Pt100 and Ni100

Diagnostics alarm	Error code	Meaning	Remedy
Wire break	6H	Impedance of encoder circuit too high	Use a different encoder type or modify the wiring, for example, using cables with larger cross-section
		Wire break between the module and sensor	Connect the cable
		Channel not connected (open)	• Deactivate diagnostics • Connect the channel • Deactivate channel
High limit violated	7H	Value is above overrange.	Correct interplay between module and sensor
Low limit violated	8H	Value is below underrange.	Correct interplay between module and sensor
Parameter error	10H	Module parameter assignment is faulty	Correct the parameter assignment
Hardware interrupt lost	16H	At least one hardware interrupt could not be signaled because too many hardware interrupts are pending.	Correct the program or the process

Technical specifications

6

Technical specifications of the analog input module AI 4xU/I/RTD 4xM12

The following table shows the technical specifications as of the issue date. You can find a data sheet including daily updated technical specifications on the Internet (https://support.industry.siemens.com/cs/ww/en/pv/6ES7144-5KD00-0BA0/td?dl=en).

Article number	6ES7144-5KD00-0BA0
General information	
Product type designation	AI 4xU/I/RTD
HW functional status	FS04
Firmware version	V1.0.x
Product function	
• I&M data	Yes; I&M0 to I&M3
Engineering with	
• STEP 7 TIA Portal configurable/integrated from version	STEP 7 V13 SP1 or higher
• STEP 7 configurable/integrated from version	From V5.5 SP4 Hotfix 3
• PROFIBUS from GSD version/GSD revision	GSD as of Revision 5
• PROFINET from GSD version/GSD revision	GSDML V2.3.1
Supply voltage	
Load voltage 1L+	
• Rated value (DC)	24 V
• permissible range, lower limit (DC)	20.4 V
• permissible range, upper limit (DC)	28.8 V
• Reverse polarity protection	Yes; against destruction
Input current	
Current consumption (rated value)	35 mA; without load
from load voltage 1L+ (unswitched voltage)	4 A; Maximum value
from load voltage 2L+, max.	4 A; Maximum value
Encoder supply	
Number of outputs	4
24 V encoder supply	
• Short-circuit protection	Yes; per channel, electronic
• Output current, max.	0.5 A; Per channel, total current of all channels max. 1 A
Power loss	
Power loss, typ.	1.5 W

Article number	6ES7144-5KD00-0BA0
Analog inputs	
Number of analog inputs	4
• For current measurement	4
• For voltage measurement	4
• For resistance/resistance thermometer measurement	4
permissible input voltage for voltage input (destruction limit), max.	30 V
permissible input current for current input (destruction limit), max.	50 mA
Cycle time (all channels), min.	8 ms
Technical unit for temperature measurement adjustable	Yes; Degrees Celsius / degrees Fahrenheit / Kelvin
Input ranges (rated values), voltages	
• 0 to +10 V	Yes
– Input resistance (0 to 10 V)	10 MΩ
• 1 V to 5 V	Yes
– Input resistance (1 V to 5 V)	10 MΩ
Input ranges (rated values), currents	
• 0 to 20 mA	Yes
– Input resistance (0 to 20 mA)	50 Ω
• 4 mA to 20 mA	Yes
– Input resistance (4 mA to 20 mA)	50 Ω
Input ranges (rated values), resistance 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), resistors	
• 0 to 150 ohms	Yes
– Input resistance (0 to 150 ohms)	10 MΩ
• 0 to 300 ohms	Yes
– Input resistance (0 to 300 ohms)	10 MΩ
Cable length	
• shielded, max.	30 m

Article number	6ES7144-5KD00-0BA0
Analog value generation for the inputs	
Measurement principle	integrating
Integration and conversion time/resolution per channel	
• Resolution with overrange (bit including sign), max.	16 bit
• Integration time, parameterizable	Yes; channel by channel
• Integration time (ms)	0,3 / 16,7 / 20 / 60
• Interference voltage suppression for interference frequency f1 in Hz	3 600 / 60 / 50 / 16.7
• Conversion time (per channel)	2 / 18 / 21 / 61 ms
Smoothing of measured values	
• parameterizable	Yes
• Step: None	Yes; 1x cycle time
• Step: low	Yes; 4x cycle time
• Step: Medium	Yes; 16x cycle time
• Step: High	Yes; 32x cycle time
Encoder	
Connection of signal encoders	
• for voltage measurement	Yes
• for current measurement as 2-wire transducer	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
Errors/accuracies	
Linearity error (relative to input range), (+/-)	0.025 %
Temperature error (relative to input range), (+/-)	0.01 %/K
Crosstalk between the inputs, max.	-70 dB
Repeat accuracy in steady state at 25 °C (relative to input range), (+/-)	0.01 %
Operational error limit in overall temperature range	
• Voltage, relative to input range, (+/-)	0.35 %
• Current, relative to input range, (+/-)	0.45 %
• Resistance, relative to input range, (+/-)	0.25 %
• Resistance thermometer, relative to input range, (+/-)	0.25 %

Article number	6ES7144-5KD00-0BA0
Basic error limit (operational limit at 25 °C)	
• Voltage, relative to input range, (+/-)	0.25 %
• Current, relative to input range, (+/-)	0.25 %
• Resistance, relative to input range, (+/-)	0.15 %
• Resistance thermometer, relative to input range, (+/-)	0.15 %
Interference voltage suppression for f = n x (f1 +/- 0.5 %), f1 = interference frequency	
• Series mode interference (peak value of interference < rated value of input range), min.	40 dB
Interrupts/diagnostics/status information	
Alarms	
• Diagnostic alarm	Yes; Parameterizable
• Limit value alarm	Yes; Parameterizable
Diagnoses	
• Wire-break	Yes; at 4 mA to 20 mA and 1 V to 5 V
• Short-circuit	Yes; Encoder supply to M, channel by channel
• Overflow/underflow	Yes
Diagnostics indication LED	
• Channel status display	Yes; green LED
• for module diagnostics	Yes; green/red LED
Potential separation	
between the load voltages	Yes
Potential separation channels	
• between the channels	No
• between the channels and backplane bus	Yes
• between the channels and the power supply of the electronics	No
Isolation	
Isolation tested with	707 V DC (type test)
Degree and class of protection	
IP degree of protection	IP65/67
Standards, approvals, certificates	
Suitable for safety-related tripping of standard modules	Yes; From FS02
Highest safety class achievable for safety-related tripping of standard modules	
• Performance level according to ISO 13849-1	PL d
• Category according to ISO 13849-1	Cat. 3
• SILCL according to IEC 62061	SILCL 2

Article number	6ES7144-5KD00-0BA0
Ambient conditions	
Ambient temperature during operation	
• min.	-30 °C
• max.	55 °C
Connection method	
Design of electrical connection for the inputs and outputs	M12, 5-pole
Design of electrical connection for supply voltage	M8, 4-pole
ET-Connection	
• ET-Connection	M8, 4-pin, shielded
Dimensions	
Width	30 mm
Height	159 mm
Depth	40 mm
Weights	
Weight, approx.	168 g

PROFIenergy

7

7.1 Pause function

Introduction

PROFIenergy is a PROFINET-based data interface for switching off consumers centrally and in a coordinated manner during pause times regardless of the manufacturer or device type. This has the aim that the process is only provided with the energy that is absolutely required. In so doing, the majority of the energy savings come from the process itself; the PROFINET device contributes only a few watts to the possible savings. In PROFIenergy, this operating state is referred to as a "pause".

Start and end of a pause

You enable and disable the pause function of the system at the beginning and end of pauses, respectively; the IO controller then sends the PROFIenergy command "Start_Pause" or "End_Pause" to the modules.

Use the "Start_Pause" command to start a pause.

Use the "End_Pause" command to end a pause.

The following conditions will also cause a pause to be ended:

- Reconfiguration in RUN
- Controller failure
- Firmware update
- Station stop
- Restart of the interface module through:
  - POWER OFF/POWER ON of an interface module
  - POWER OFF/POWER ON of an I/O module
  - Termination of ET-Connection1 or ET-Connection2

The specific response of the analog input module is explained in the section below.

Additional information

You can find additional information on working with PROFIenergy in the "PROFIenergy" section of the manual IM 157-1 PN interface module (http://support.automation.siemens.com/WW/view/en/89254863) and the "Saving energy with PROFIenergy" section of function manual PROFINET with STEP 7 V13 (http://support.automation.siemens.com/WW/view/en/49948856).

Application examples (http://support.automation.siemens.com/WW/view/en/41986454) are also available on the Internet.

7.2 Response of the analog input module

Requirement

You can use the PROFIenergy function when you use the internal encoder supply.

Display

The channel status LEDs are not affected by PROFIenergy.

Response to error detection

All channels that are in pause mode on "PE_MODE_PROCEED" report their diagnostic status as in productive mode.

The following applies for all channels which switch to a different pause mode:

- Encoder supply switch-off upon the start of "pause" does not result in the alarm "Wire break".
- "Wire break", "Short circuit", "High limit violated" and "Low limit violated" error detection is not possible during the "pause":
  - Alarms for errors already pending before the "pause" are retained.
  - After the "pause" is over, the error status is updated and incoming/outgoing errors are reported correspondingly.
- Hardware interrupts are not signaled.

Mode parameter

The following table shows the "Mode" parameter.

Table 7- 1 Mode parameter

Element	Code	Explanation
Mode	0_D: PE_MODE_PROCEED	Proceed at "pause" • Value status "GOOD"
	1_D: PE_MODE_SHUTDOWN	Switch off at "pause" • Encoder supply U_S switched off [1] • Pause substitute value: $7FFF_H$ • Value status "BAD"
	3_D: PE_MODE_LAST_VALUE	Last value at "pause" • Encoder supply U_S switched off [1] • Pause substitute value: Last input value • Value status "BAD"
	4_D: PE_MODE_SUBST_VALUE	Substitute value at "pause" • Encoder supply U_S switched off [1] • Pause substitute value: Configured pause substitute value • Value status "BAD"

[1] Encoder supply U_S is only provided for measurement type current and voltage and can only be deactivated in these measurement types.

Dimension drawing

A

The figure below shows the dimension drawing of the AI 4xU/I/RTD 4xM12 analog input module in front and side view.

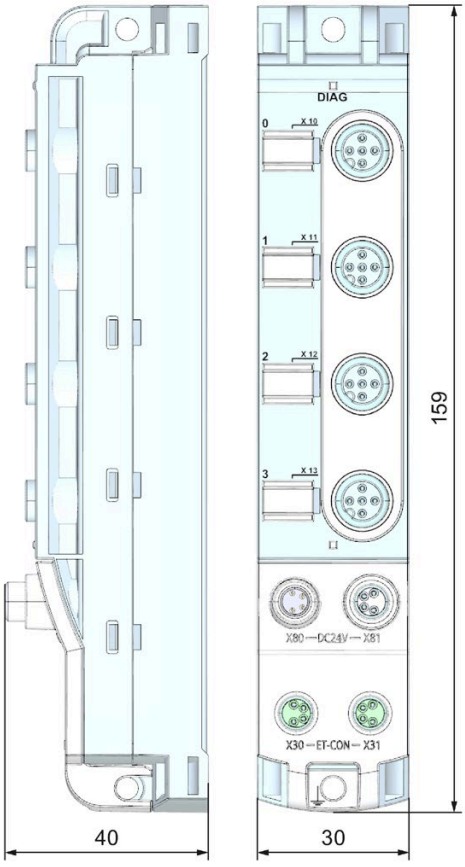


Figure A-1 Dimension drawing

Representation of analog values

B

B.1 Representation of analog values in voltage measuring ranges

Table B- 1 Voltage measuring range 1 V to 5 V and 0 V to 10 V

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

B.2 Representation of analog values in current measuring ranges

Table B- 2 Current measuring ranges 0 mA to 20 mA and 4 mA to 20 mA

Values		Current measuring range		Range
Dec.	Hex.	0 mA to 20 mA	4 mA to 20 mA	
32767	7FFF	>23.52 mA	>22.81 mA	Overflow
32511	7EFF	23.52 mA	22.81 mA	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

B.3 Representation of analog values for resistance-based sensors

Resistance-based sensor

Table B- 3 Resistance-based sensor of 150 Ω and 300 Ω

Values		**Resistance-based sensor range**		**Range**
Dec.	**Hex.**	**150 Ω**	**300 Ω**	
32767	7FFF	>176.38 Ω	>352.77 Ω	Overflow
32511	7EFF	176.38 Ω	352.77 Ω	Overrange
27649	6C01			
27648	6C00	150 Ω	300 Ω	Nominal range
20736	5100	112.5 Ω	225 Ω	
1	1	5.43 mΩ	10.85 mΩ	
0	0	0 Ω	0 Ω	
-1 : -4864	FFFF : ED00	(negative values are physically impossible)		Underrange[1]
-32768	8000			Underflow[1]

[1] If the sensors are not connected correctly

B.4 Representation of analog values for resistance thermometer

Table B- 4 Resistance thermometer Pt 100 standard

Pt x00 standard in °C (1 digit = 0.1°C)	Values		Pt x00 standard in °F (1 digit = 0.1 °F)	Values		Pt x00 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 B- 5 Resistance thermometer Pt 100 climatic

Pt x00 climatic in °C (1 digit = 0.01 °C)	Values		Pt x00 climatic 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 B- 6 Resistance thermometer Ni 100 standard

Ni x00 standard in °C (1 digit = 0.1 °C)	Values		Ni x00 standard in °F (1 digit = 0.1 °F)	Values		Ni x00 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 B- 7 Resistance thermometer Ni 100 climatic

Ni x00 climatic in °C (1 digit = 0.01 °C)	Values		Ni x00 climatic 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