SIEMENS

SIMATIC

S7-1500 / ET 200MP

Analog Input Module AI 4xU/I/RTD/TC ST (6ES7531-7QD00-0AB0)

Manual

Edition 09/2014

Answers for industry.

SIEMENS

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S7-1500/ET 200MP Analog Input Module AI 4xU/I/RTD/TC ST (6ES7531-7QD00-0AB0)

Manual

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A5E32366209-AB

Legal information

Warning notice system

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

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⚠ CAUTION

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

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

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Siemens AG
Industry Sector
Postfach 48 48
90026 NÜRNBERG
GERMANY

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Preface

Purpose of the documentation

This product manual supplements the system manuals:

- S7-1500 Automation System
- ET 200MP distributed I/O system

Functions that relate in general to the systems are described in these system manuals.

The information provided in this product manual and in the system/function manuals supports you in commissioning the systems.

Changes compared to previous version

Changes described in this manual, compared to the previous version:

- Detailed information on the module functions, for example, as of which STEP 7 version the function is supported.
- Diagnostic alarms section revised.

Conventions

The term "CPU" is used in this manual both for the CPUs of the S7-1500 automation system, as well as for interface modules of the ET 200MP distributed I/O system.

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.

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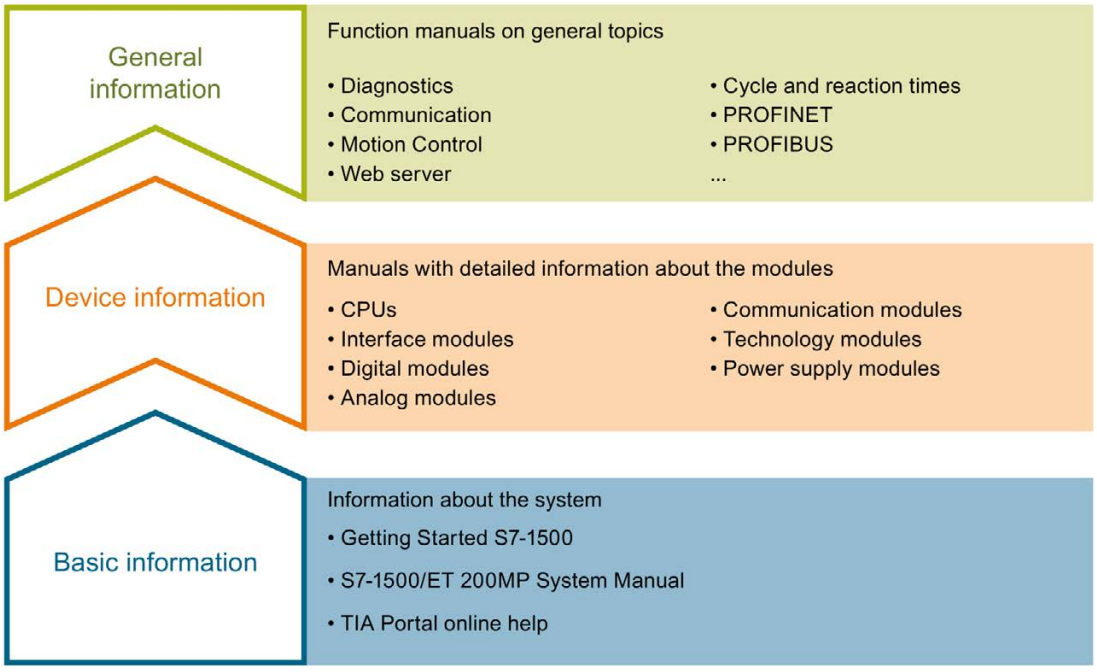
For legal reasons, we are obliged to publish the original text of the license conditions and copyright notices. Please read the information relating to this in the appendix.

Table of contents

Guide to documentation

1

The documentation for the SIMATIC S7-1500 automation system 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

System Manual and Getting Started describe in detail the configuration, installation, wiring and commissioning of the SIMATIC S7-1500 and ET 200MP systems. The STEP 7 online help supports you in the configuration and programming.

Device information

Manuals contain a compact description of the module-specific information, such as properties, terminal diagrams, characteristics, 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.

You can download the documentation free of charge from the Internet (http://www.automation.siemens.com/mcms/industrial-automation-systems-simatic/en/manual-overview/tech-doc-controllers/Pages/Default.aspx).

Changes and supplements to the manuals are documented in a Product Information.

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 (http://support.automation.siemens.com/WW/view/en/86140384).

My Documentation Manager

The My Documentation Manager is used to combine entire manuals or only parts of these to your own manual.
You can export the manual as PDF file or in a format that can be edited later.

You can find the My Documentation Manager on the Internet (http://support.automation.siemens.com/WW/view/en/38715968).

Applications & Tools

Applications & Tools supports you with various tools and examples for solving your automation tasks. Solutions are shown in interplay with multiple components in the system - separated from the focus in individual products.

You can find Applications & Tools on the Internet (http://support.automation.siemens.com/WW/view/en/20208582).

CAx Download Manager

The CAx Download Manager is used to access the current product data for your CAx or CAe systems.

You configure your own download package with a few clicks.

In doing so you can select:

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

You can find the CAx Download Manager on the Internet (http://support.automation.siemens.com/WW/view/en/42455541).

Product overview

2

2.1 Properties

Article number

6ES7531-7QD00-0AB0

View of the module

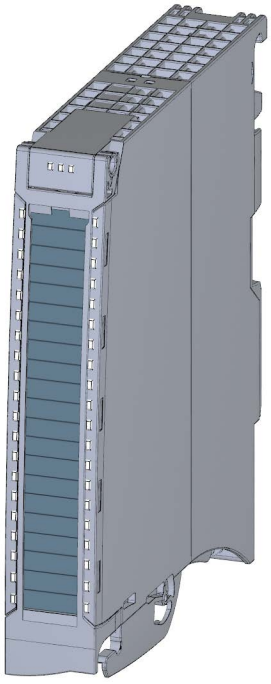


Figure 2-1 View of the AI 4xU/I/RTD/TC ST module

Properties

The module has the following technical properties:

- 4 analog inputs
- Resolution 16 bits including sign
- Voltage measurement type can be set per channel
- Current measurement type can be set per channel
- Resistance measurement type can be set for channel 0 and 2
- Resistance thermometer (RTD) measurement type can be set for channel 0 and 2
- Thermocouple (TC) measurement type can be set per channel
- Configurable diagnostics (per channel)
- Hardware interrupt on limit violation can be set per channel (two low and two high limits per channel)

The module supports the following functions:

Table 2- 1 Version dependencies of the module functions

Function	Firmware version of the module	Configuration software	
		STEP 7 (TIA Portal)	GSD file in STEP 7 (TIA Portal) V12 or higher, or STEP 7 V5.5 SP3 or higher
Firmware update	V1.0.0 or higher	V13 or higher with HSP 0102	X
Calibration in runtime	V1.0.0 or higher	V13 or higher with HSP 0102	X
Identification data I&M0 to I&M3	V1.0.0 or higher	V13 or higher with HSP 0102	X
Parameter assignment in RUN	V1.0.0 or higher	V13 or higher with HSP 0102	X
Module internal shared input (MSI)	V1.0.0 or higher	V13 Update 3 or higher (PROFINET IO only)	X (PROFINET IO only)
Configurable submodules / submodules for Shared Device	V1.0.0 or higher	V13 Update 3 or higher (PROFINET IO only)	X (PROFINET IO only)

You can configure the module with STEP 7 (TIA Portal) and with a GSD file.

Accessories

The following accessories are supplied with the module and can also be ordered separately as spare parts:

- Front connector (push-in terminals) including cable tie
- Shield bracket
- Shield terminal
- Power supply element (push-in terminals)
- Labeling strips
- U connector
- Universal front door

For more information on accessories, refer to the system manual S7-1500 Automation System (http://support.automation.siemens.com/WW/view/en/59191792) and the system manual Distributed I/O System ET 200MP (http://support.automation.siemens.com/WW/view/en/59193214).

Wiring

3

3.1 Wiring and block diagrams

This section contains the block diagram of the module and outlines various connection options.

For more information on front connector wiring and creating cable shields, etc., refer to the "Wiring" section in the Automation System S7-1500 (http://support.automation.siemens.com/WW/view/en/59191792) and Distributed I/O System ET 200MP (http://support.automation.siemens.com/WW/view/en/59193214) system manuals.

You can find additional information on compensating the reference junction temperature in the function manual Analog value processing (http://support.automation.siemens.com/WW/view/en/67989094), the structure of a data record in the section Structure of a data record for dynamic reference temperature (Page 59).

Note

You may use and combine the different wiring options for all channels.

Abbreviations used

U_n+/U_n-	Voltage input channel n (voltage only)
M_n+/M_n-	Measuring input channel n
I_n+/I_n-	Current input channel n (current only)
$I_{c\,n}+/I_{c\,n}-$	Current output for RTD, channel n
U_{Vn}	Supply voltage at channel n for 2-wire transmitters (2WT)
L+	Connection for supply voltage
M	Ground connection
M_{ANA}	Reference potential of the analog circuit
CHx	Channel or display of the channel status
PWR	Display for the supply voltage

Pin assignment for the power supply element

The power supply element is plugged onto the front connector for powering the analog module. Wire the supply voltage to terminals 41 (L+) and 43 (M).

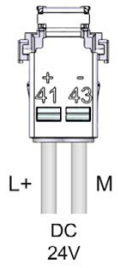
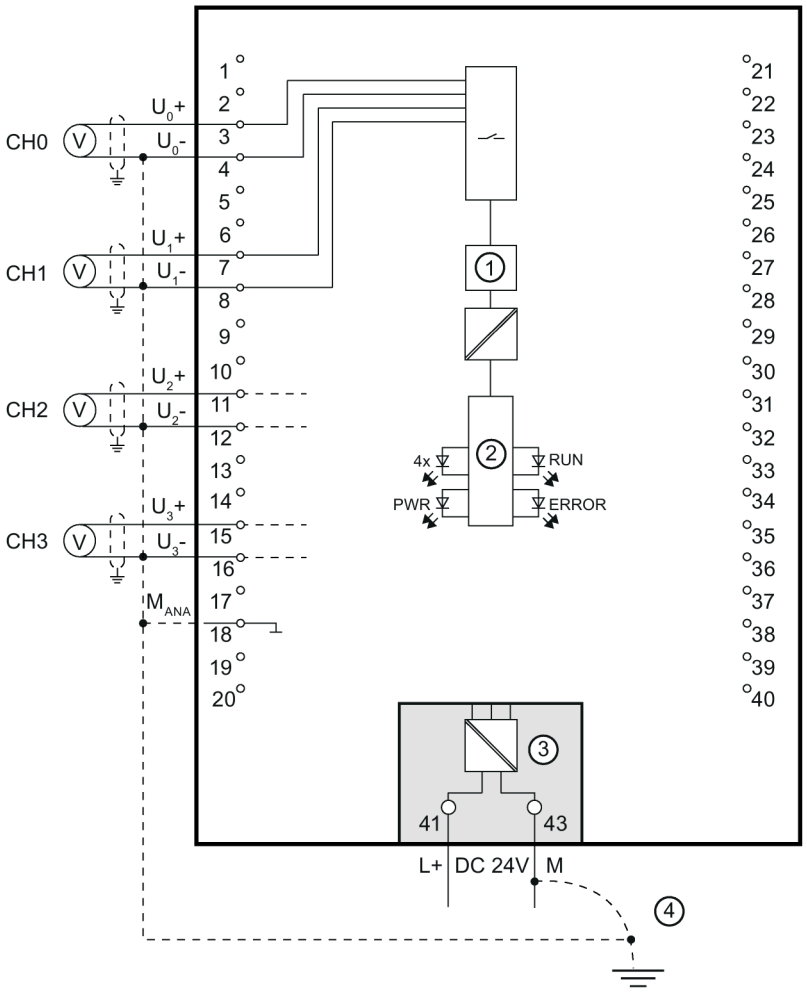


Figure 3-1 Power supply element wiring

Connection: Voltage measurement

The example in the following figure shows the pin assignment for voltage measurement.

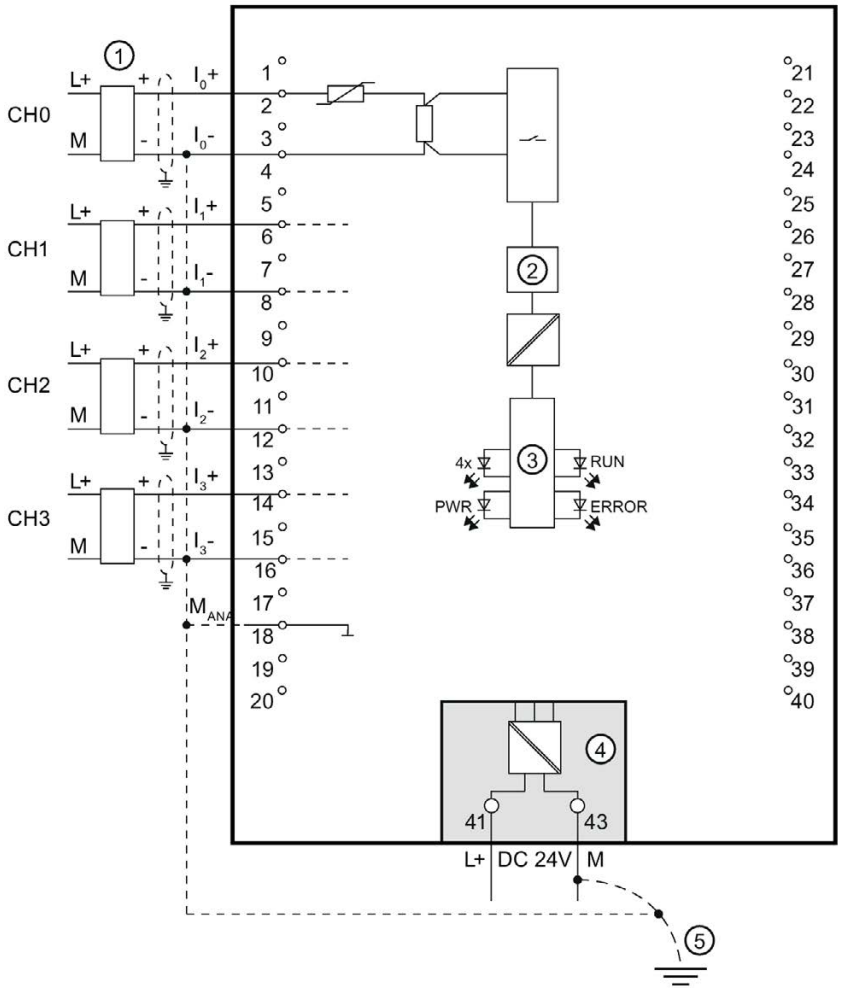


① Analog digital converter (ADC)
② Backplane bus interface
③ Supply voltage via power supply element
④ Equipotential bonding cable (optional)

Figure 3-2 Block diagram and pin assignment for voltage measurement

Connection: 4-wire transmitters for current measurement

The example in the following figure shows the pin assignment for current measurement with 4-wire transmitters.

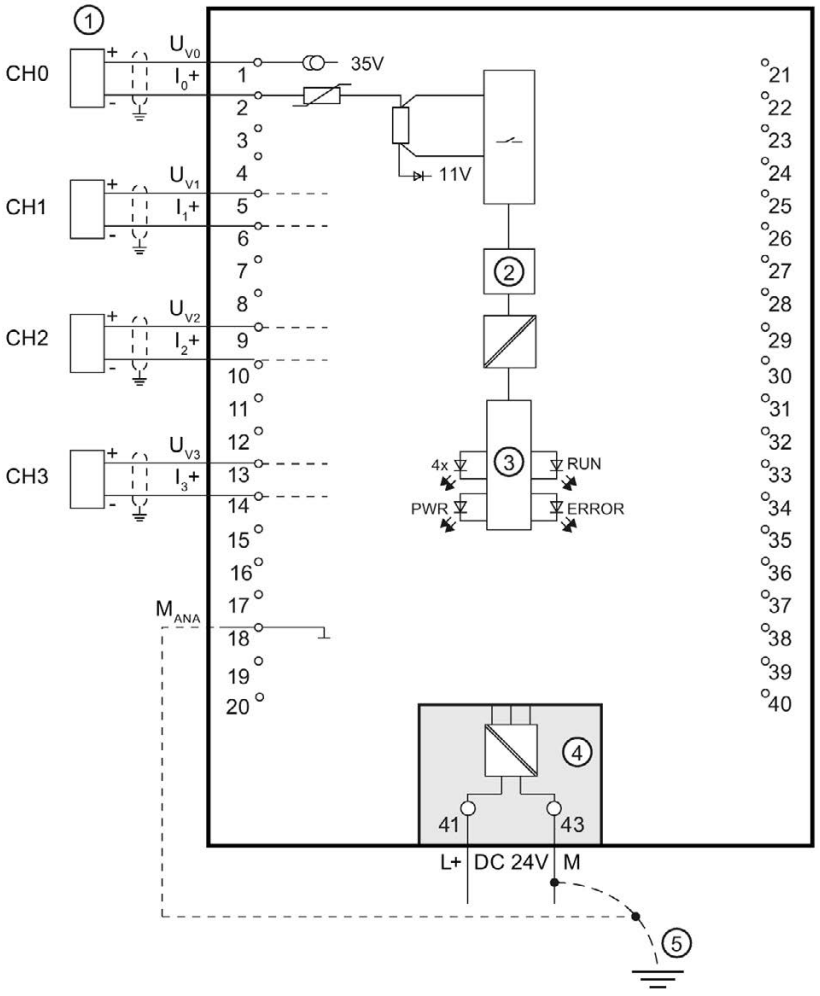


① Wiring 4-wire transmitter
② Analog digital converter (ADC)
③ Backplane bus interface
④ Supply voltage via power supply element
⑤ Equipotential bonding cable (optional)

Figure 3-3 Block diagram and pin assignment for current measurement

Connection: 2-wire transmitters for current measurement

The example in the following figure shows the pin assignment for current measurement with 2-wire transmitters.

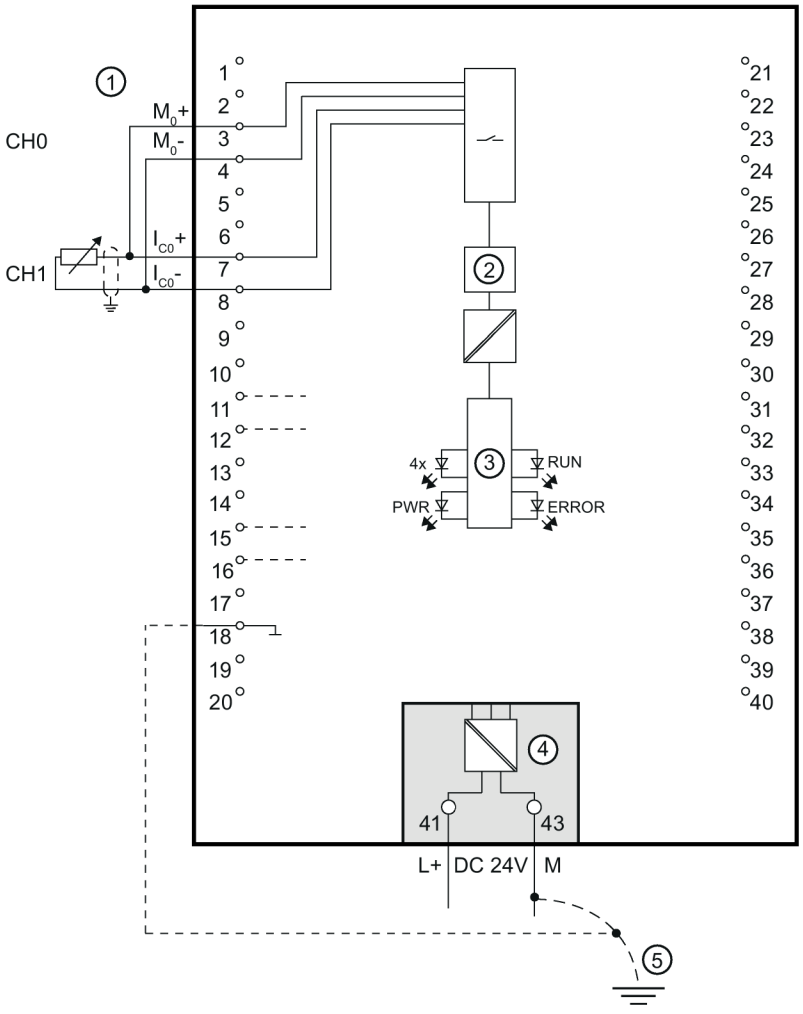


① Wiring 2-wire transmitter
② Analog digital converter (ADC)
③ Backplane bus interface
④ Supply voltage via power supply element
⑤ Equipotential bonding cable (optional)

Figure 3-4 Block diagram and pin assignment for current measurement with 2-wire transmitter

Connection: 2-wire connection of resistance-based sensors or thermistors (RTD)

The example in the figure below shows the pin assignment for 2-wire connection of resistance sensors or thermal resistors.

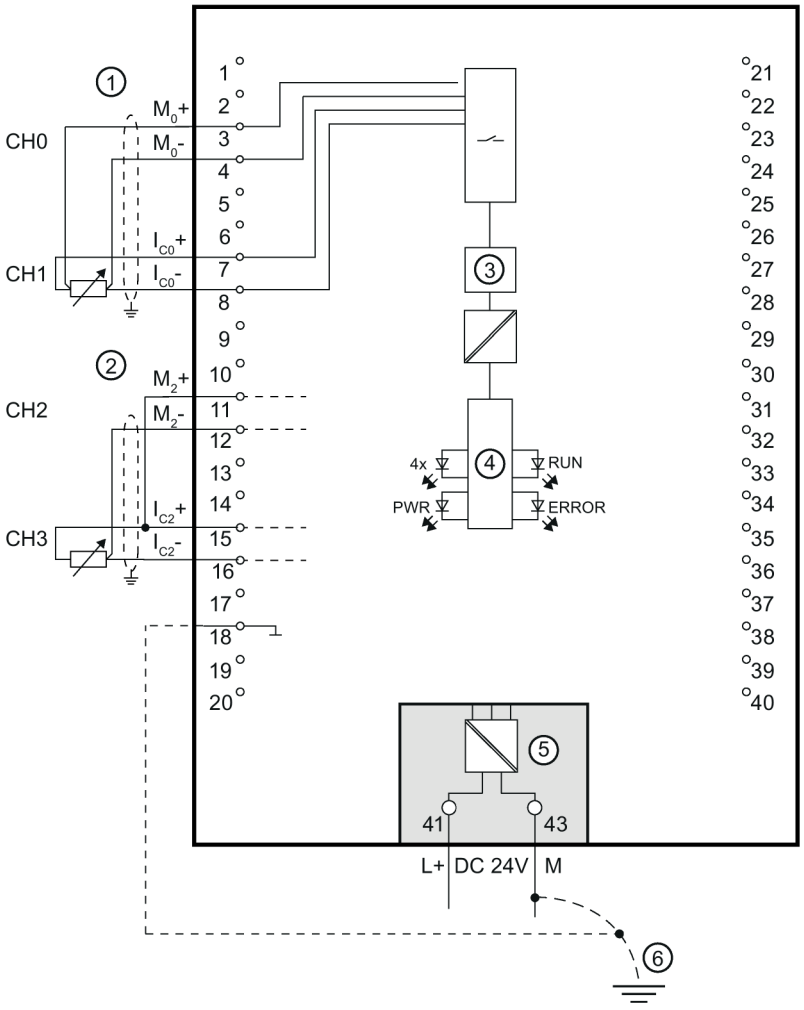


① 2-wire connection
② Analog digital converter (ADC)
③ Backplane bus interface
④ Supply voltage via power supply element
⑤ Equipotential bonding cable (optional)

Figure 3-5 Block diagram and pin assignment for 2-wire connection

Connection: 3- and 4-wire connection of resistance sensors or thermal resistors (RTD)

The example in the figure below shows the pin assignment for 3- and 4-wire connection of resistance-based sensors or thermal resistors.

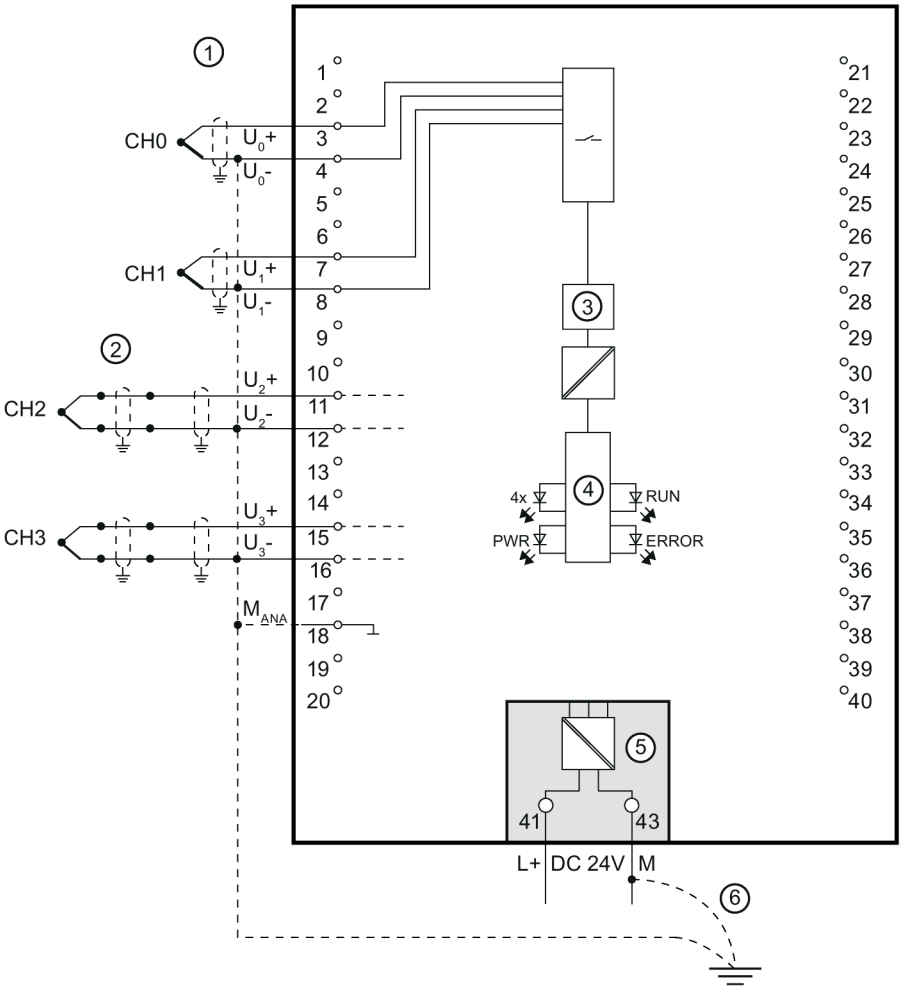


① 4-wire connection
② 3-wire connection
③ Analog digital converter (ADC)
④ Backplane bus interface
⑤ Supply voltage via power supply element
⑥ Equipotential bonding cable (optional)

Figure 3-6 Block diagram and pin assignment for 3- and 4-wire connection

Connection: Thermocouples for external/internal compensation

The figure below shows an example of the pin assignment for thermocouples for external or internal compensation.

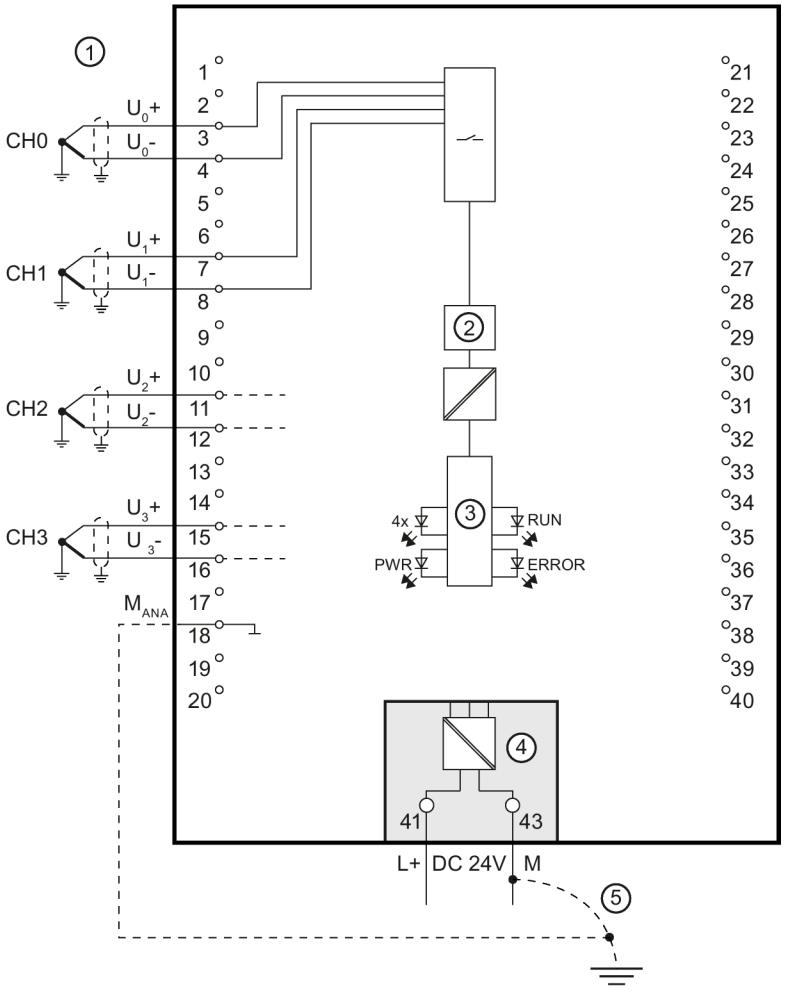


① Wiring of a thermocouple for internal compensation
② Wiring of a thermocouple for external compensation
③ Analog digital converter
④ Backplane bus interface
⑤ Supply voltage via power supply element
⑥ Equipotential bonding cable (optional)

Figure 3-7 Block diagram and pin assignment for the thermocouple

Connection: Grounded thermocouples for internal compensation

The following figure shows an example of the pin assignment for grounded thermocouples for internal compensation.



① Wiring of a thermocouple (grounded) for internal compensation
② Analog digital converter (ADC)
③ Backplane bus interface
④ Supply voltage via power supply element
⑤ Equipotential bonding cable (optional)

Figure 3-8 Block diagram and pin assignment for grounded thermocouple

Parameters/address space

4

4.1 Measurement types and ranges

Introduction

The module is set to voltage measurement type with measuring range ±10 V by default. You need to reassign the module parameters with STEP 7 if you want to use a different measurement type or range.

Deactivate the input if it is not going to be used. The module cycle time is shortened and the interference factors that lead to failure of the module (for example, triggering a hardware interrupt) are avoided.

Measurement types and ranges

The following table shows the measurement types and the respective measuring range.

Table 4- 1 Measurement types and ranges

Measurement type	Measuring range
Voltage	±50 mV ±80 mV ±250 mV ±500 mV ±1 V ±2.5 V 1 V to 5 V ±5 V ±10 V
Current 2WMT (2-wire transmitter)	4 mA to 20 mA
Current 4WMT (4-wire transmitter)	0 mA to 20 mA 4 mA to 20 mA ±20 mA
Resistor (2-wire connection)	 PTC
Resistor (3-wire connection) (4-wire connection)	150 Ω 300 Ω 600 Ω 6000 Ω

Measurement type	Measuring range
Thermal resistor RTD (3-wire connection) (4-wire connection)	PT100 Standard/Climatic PT200 Standard/Climatic PT500 Standard/Climatic PT1000 Standard/Climatic Ni100 Standard/Climatic Ni1000 Standard/Climatic LG-Ni1000 Standard/Climatic
Thermocouple (TC)	Type B Type E Type J Type K Type N Type R Type S Type T
Disabled	-

The tables of the input ranges, overflow, underrange, etc. are available in the appendix Representation of analog values (Page 61).

Special features for the use of PTC resistors

PTC resistors are suitable for temperature monitoring of electrical devices, such as motors, drives, and transformers.

Use Type A PTC resistors (PTC thermistor) in accordance with DIN/VDE 0660, part 302. In doing so, follow these steps:

1. Choose "Resistor (2-wire terminal)" and "PTC" in STEP 7.
2. Connect the PTC using 2-wire connection technology.

If you enable the "Underflow" diagnostics in STEP 7, it will be signaled for resistance values <18 Ω. In this case, this diagnostic signifies "Short-circuit in the wiring".

The figure below shows the address space assignment for AI 4xU/I/RTD/TC ST with PTC resistors.

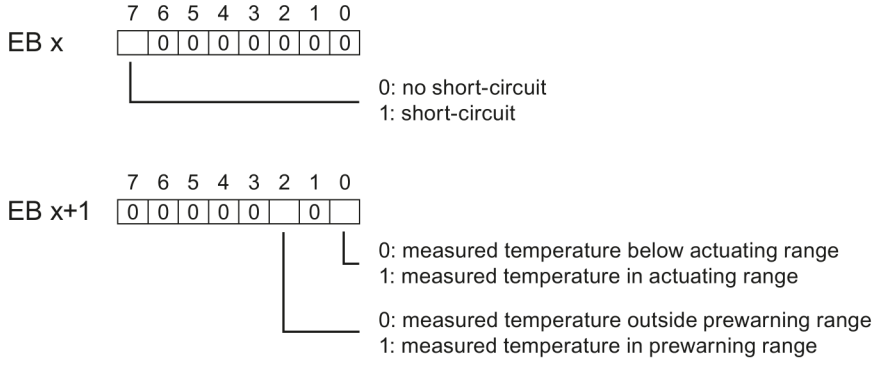


Figure 4-1 Address space for AI 4xU/I/RTD/TC ST with PTC resistors

The diagram below shows the temperature curve and the associated switching points.

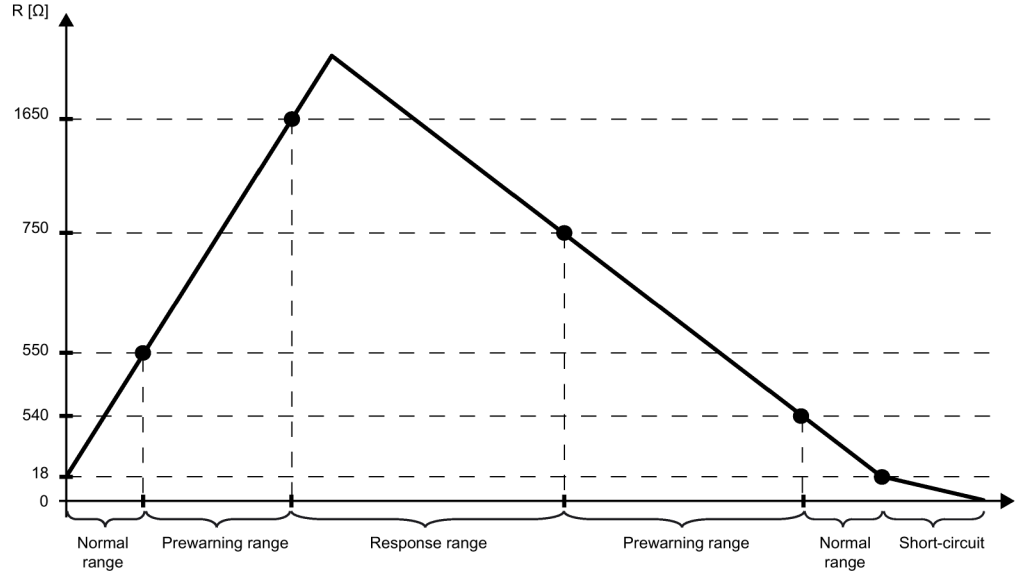


Figure 4-2 Temperature profile and the associated switching points

Special features of the measured value acquisition with PTC resistors

If faults occur (for example supply voltage L+ missing) that make it impossible to acquire measured values with PTC resistors, the corresponding channels (IB x/IB x+1) report overflow ($7FFF_H$). If the value status (QI) is enabled, the value 0 = fault is output in the corresponding bit.

4.2 Parameters

AI 4xU/I/RTD/TC ST parameters

When you assign the module parameters in STEP 7, you use various parameters to specify the module properties. The following table lists the configurable parameters. The effective range of the configurable parameters depends on the type of configuration. The following configurations are possible:

- Central operation with a S7-1500 CPU
- Distributed operation on PROFINET IO in an ET 200MP system
- Distributed operation on PROFIBUS DP in an ET 200MP system

When assigning parameters in the user program, use the WRREC instruction to transfer the parameters to the module by means of data records; refer to the section Parameter assignment and structure of the parameter data records (Page 50).

The following parameter settings are possible:

Table 4- 2 Configurable parameters and their defaults

Parameters	Range of values	Default setting	Reconfiguration in RUN	Scope with configuration software, e.g., STEP 7 (TIA Portal)	
				Integrated in the hardware catalog STEP 7, as of V13 or GSD file PROFINET IO	GSD file PROFIBUS DP
Diagnostics					
• No supply voltage L+	Yes/No	No	Yes	Channel [1]	Module [3]
• Overflow	Yes/No	No	Yes	Channel	Module [3]
• Underflow	Yes/No	No	Yes	Channel	Module [3]
• Common mode error	Yes/No	No	Yes	Channel	Module [3]
• Reference junction	Yes/No	No	Yes	Channel	Module [3]
• Wire break	Yes/No	No	Yes	Channel	Module [3]
• Current limit for wire break diagnostics [2]	1.185 mA or 3.6 mA	1.185 mA	Yes	Channel	--- [4]

Parameters	Range of values	Default setting	Reconfiguration in RUN	Scope with configuration software, e.g., STEP 7 (TIA Portal)	
				Integrated in the hardware catalog STEP 7, as of V13 or GSD file PROFINET IO	GSD file PROFIBUS DP
Measuring					
• Measurement type	See section Measurement types and ranges (Page 21)	Voltage	Yes	Channel	Channel
• Measuring range		±10 V	Yes	Channel	Channel
• Temperature coefficient	Pt: 0.003851 Pt: 0.003902 Pt: 0.003916 Pt: 0.003920 Ni: 0.00618 Ni: 0.00672 LG-Ni: 0.005000	0.003851	Yes	Channel	Channel
• Temperature unit	• Kelvin (K) • Fahrenheit (°F) • Celsius (°C)	°C	Yes	Channel	Module
• Interference frequency suppression	400 Hz 60 Hz 50 Hz 10 Hz	50 Hz	Yes	Channel	Module
• Smoothing	None/low/medium/high	None	Yes	Channel	Channel
• Reference junction	• Fixed reference temperature • Dynamic reference temperature • Internal reference junction	Internal reference junction	Yes	Channel	Module [4] • Dynamic reference temperature • Internal reference junction
• Fixed reference temperature	Temperature	25 °C	Yes	Channel	--- [4]

Parameters	Range of values	Default setting	Reconfiguration in RUN	Scope with configuration software, e.g., STEP 7 (TIA Portal)	
				Integrated in the hardware catalog STEP 7, as of V13 or GSD file PROFINET IO	GSD file PROFIBUS DP
Hardware interrupts					
• Hardware interrupt low limit 1	Yes/No	No	Yes	Channel	--- 4)
• Hardware interrupt high limit 1	Yes/No	No	Yes	Channel	--- 4)
• Hardware interrupt low limit 2	Yes/No	No	Yes	Channel	--- 4)
• Hardware interrupt high limit 2	Yes/No	No	Yes	Channel	--- 4)

1) If you enable diagnostics for multiple channels, you will receive an alarm surge on failure of the supply voltage because each enabled channel will detect this fault. You can prevent this alarm surge by assigning the diagnostics function to one channel only.

2) When "Wire break" diagnostics is disabled, the current limit of 1.185 mA is applied to the value status. For measured values below 1.185 mA, the value status is always: 0 = fault.

3) You can set the effective range of the diagnostics for each channel in the user program with data records 0 to 3.

4) You can set the current limit for wire break diagnostics, the setting "Fixed reference temperature" as well as the limits for hardware interrupts in the user program with data records 0 to 3.

4.3 Declaration of parameters

No supply voltage L+

Enabling of the diagnostics, with missing or too little supply voltage L+.

Overflow

Enabling of the diagnostics if the measured value violates the high limit.

Underflow

Enabling of the diagnostics when the measured value falls below the underrange or for voltage measurement ranges of ± 50 mV to ± 2.5 V if the inputs are not connected.

Common mode error

Enabling of diagnostics if the valid common mode voltage is exceeded.

Enable the Common mode error diagnostics when 2WMT is connected, for example, to check for a short circuit to $ground_{ANA}$ or a wire break. If you do not need the Common mode error diagnostics, disable the parameter.

Reference junction

Enabling of the diagnostics reference junction when the TC channel has no reference temperature or incorrect reference temperature.

Wire break

Enabling of the diagnostics if the module has no current flow or the current is too weak for the measurement at the corresponding configured input or the applied voltage is too low.

Current limit for wire break diagnostics

Threshold for reporting wire breaks. The value can be set to 1.185 mA or 3.6 mA, depending on the sensor used.

Temperature coefficient

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

The temperature coefficient (α value) indicates by how much the resistance of a specific material changes relatively if the temperature increases by 1 °C.

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

Interference frequency suppression

At analog input modules, this suppresses interference caused by the frequency of AC mains.

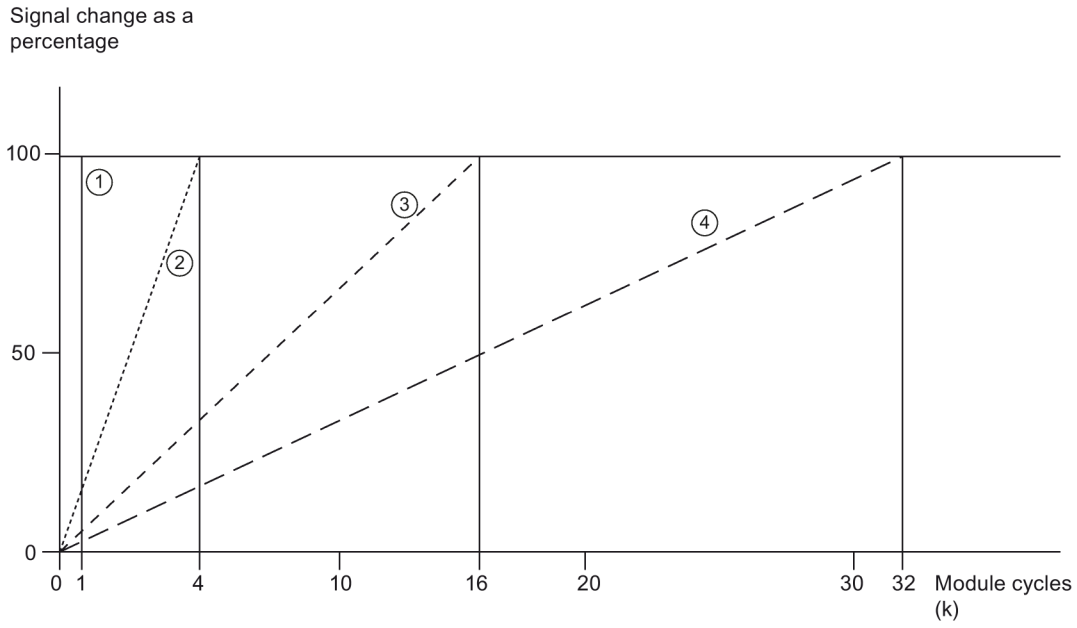
The frequency of AC network may corrupt measurements, particularly in the low voltage ranges, and when thermocouples are being used. For this parameter, the user defines the mains frequency prevailing on his system.

Smoothing

The individual measured values are smoothed using filtering. The smoothing can be set in 4 levels.

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

The following figure shows the number of module cycles after which the smoothed analog value is almost 100%, depending on the set smoothing. It is valid for each signal change at the analog input.



① None (k = 1)
② Weak (k = 4)
③ Medium (k = 16)
④ Strong (k = 32)

Figure 4-3 Smoothing with AI 4xU/I/RTD/TC ST

Reference junction

The following settings can be configured for the reference junction parameter:

Table 4- 3 Possible parameter assignments for the reference junction parameter TC

Setting	Description
Fixed reference temperature	The reference junction temperature is configured and stored in the module as a fixed value.
Dynamic reference temperature	The reference junction temperature is transferred in the user program from the CPU to the module by data records 192 to 195 using the WRREC (SFB 53) instruction.
Internal reference junction	The reference junction temperature is determined using an integrated sensor of the module.

Hardware interrupt 1 or 2

Enabling of a hardware interrupt at violation of high limit 1 or 2 or low limit 1 or 2.

Low limit 1 or 2

Specifies the low limit threshold that triggers hardware interrupt 1 or 2.

High limit 1 or 2

Specifies the high limit threshold that triggers hardware interrupt 1 or 2.

4.4 Address space

The module can be configured in various ways in STEP 7. Depending on the configuration, additional/different addresses are assigned in the process image of the inputs.

Configuration options of AI 4xU/I/RTD/TC ST

You can configure the module with STEP 7 (TIA Portal) or with a GSD file.

When you configure the module by means of the GSD file, the configurations are available under different abbreviations/module names.

The following configurations are possible:

Table 4- 4 Configuration options

Configuration	Short designation/module name in the GSD file	Configuration software, e.g., with STEP 7 (TIA Portal)	
		Integrated in hardware catalog STEP 7 (TIA Portal)	GSD file in STEP 7 (TIA Portal) V12 or higher or STEP 7 V5.5 SP3 or higher
1 x 4-channel without value status	AI 4xU/I/RTD/TC ST	V13 or higher with HSP 0102	X
1 x 4-channel with value status	AI 4xU/I/RTD/TC ST QI	V13 or higher with HSP 0102	X
4 x 1-channel without value status	AI 4xU/I/RTD/TC ST S	V13 Update 3 or higher (PROFINET IO only)	X (PROFINET IO only)
4 x 1-channel with value status	AI 4xU/I/RTD/TC ST S QI	V13 Update 3 or higher (PROFINET IO only)	X (PROFINET IO only)
1 x 4-channel with value status for module-internal shared input with up to 4 submodules	AI 4xU/I/RTD/TC ST MSI	V13 Update 3 or higher (PROFINET IO only)	X (PROFINET IO only)

Value status (Quality Information, QI)

The value status is always activated for the following module names:

- AI 4xU/I/RTD/TC ST QI
- AI 4xU/I/RTD/TC ST S QI
- AI 4xU/I/RTD/TC ST MSI

An additional bit is assigned to each channel for the value status. The value status bit indicates if the read in digital value is valid. (0 = value is incorrect).

Address space for configuration as 1 x 4-channelAI 4xU/I/RTD/TC ST QI

The figure below shows the address space assignment for configuration as a 1 x 4-channel module. You can freely assign the start address for the module. The addresses of the channels are derived from the start address.

"IBx" represents the module start address input byte x.

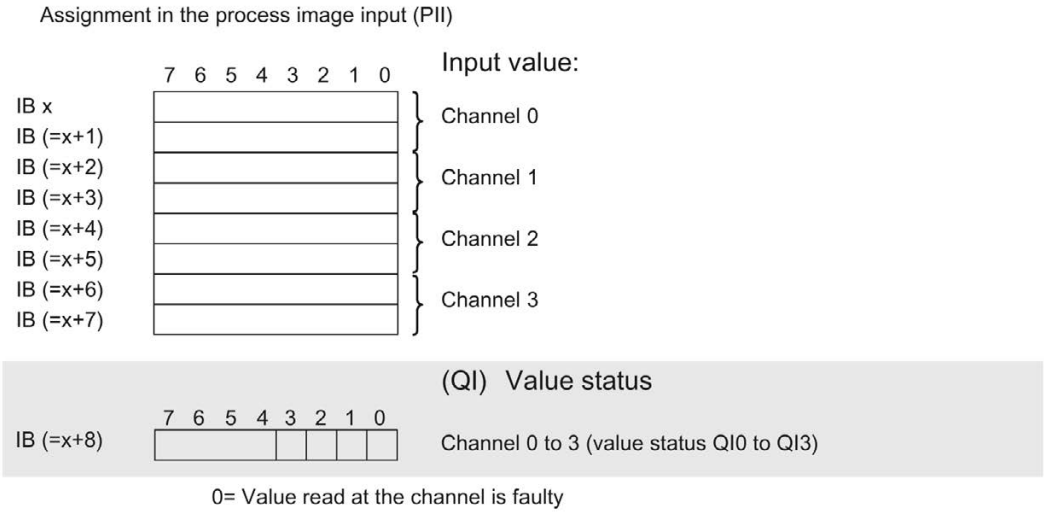


Figure 4-4 Address space for configuration as 1 x 4-channel AI 4xU/I/RTD/TC ST QI with value status

Address space for configuration as 4 x 1-channelAI 4xU/I/RTD/TC ST S QI

The channels of the module are divided up into several submodules with configuration as 4 x 1-channel module. The submodules can be assigned to different IO controllers when the module is used in a shared device.

The number of available submodules depends on the used interface module. Note the comments in the respective interface module product manual.

Unlike the 1 x 4-channel module configuration, each of the four submodules has a freely assignable start address.

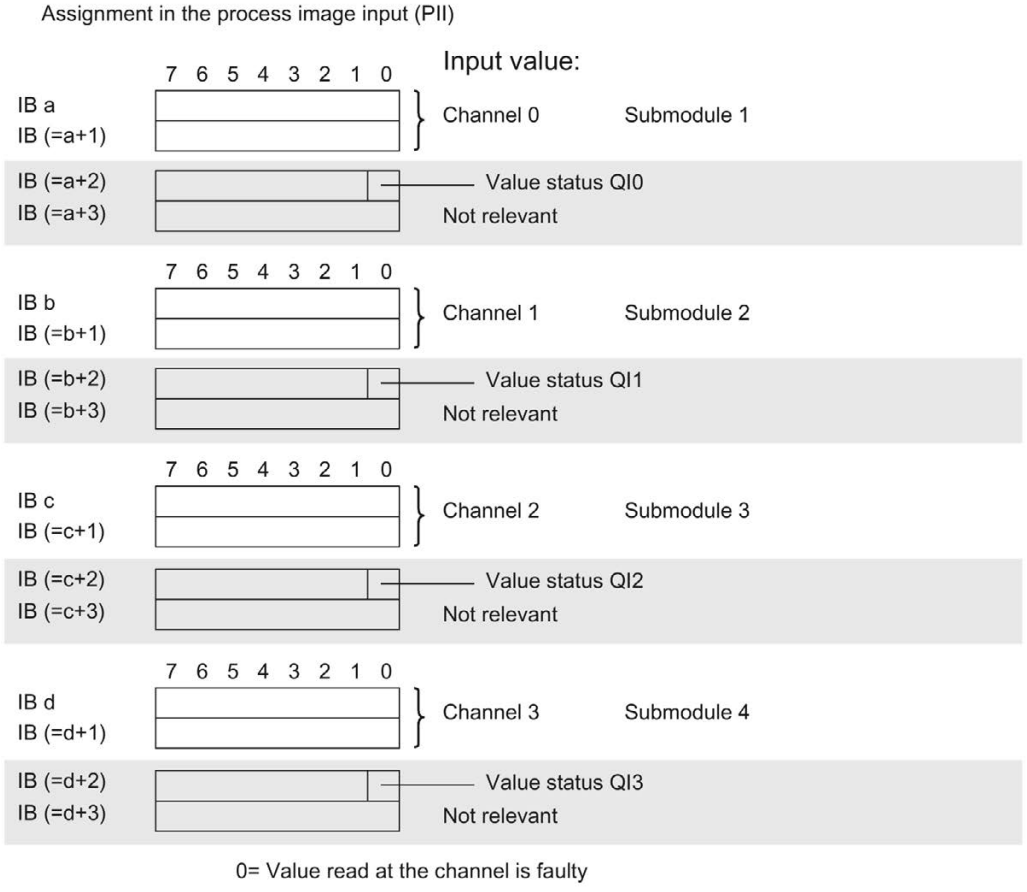


Figure 4-5 Address space for configuration as 4 x 1-channel AI 4xU/I/RTD/TC ST S QI with value status

Address space for configuration as 1 x 4-channelAI 4xU/I/RTD/TC ST MSI

The channels 0 to 3 of the module are copied in up to 4 submodules with configuration 1 x 4-channel module (Module-internal shared input, MSI). Channels 0 to 3 are then available with identical input values in different submodules. These submodules can be assigned to up to four IO controllers when the module is used in a shared device. Each IO controller has read access to the same channels.

The number of available submodules depends on the used interface module. Note the comments in the respective interface module product manual.

Value status (Quality Information, QI)

The meaning of the value status depends on the submodule on which it occurs.

For the first submodule (=base submodule), the value status 0 indicates that the value is incorrect.

For the 2nd to 4th submodule (=MSI submodule), the value status 0 indicates that the value is incorrect or the base submodule has not yet been configured (not ready).

The figure below shows the assignment of the address space with submodules 1 and 2.

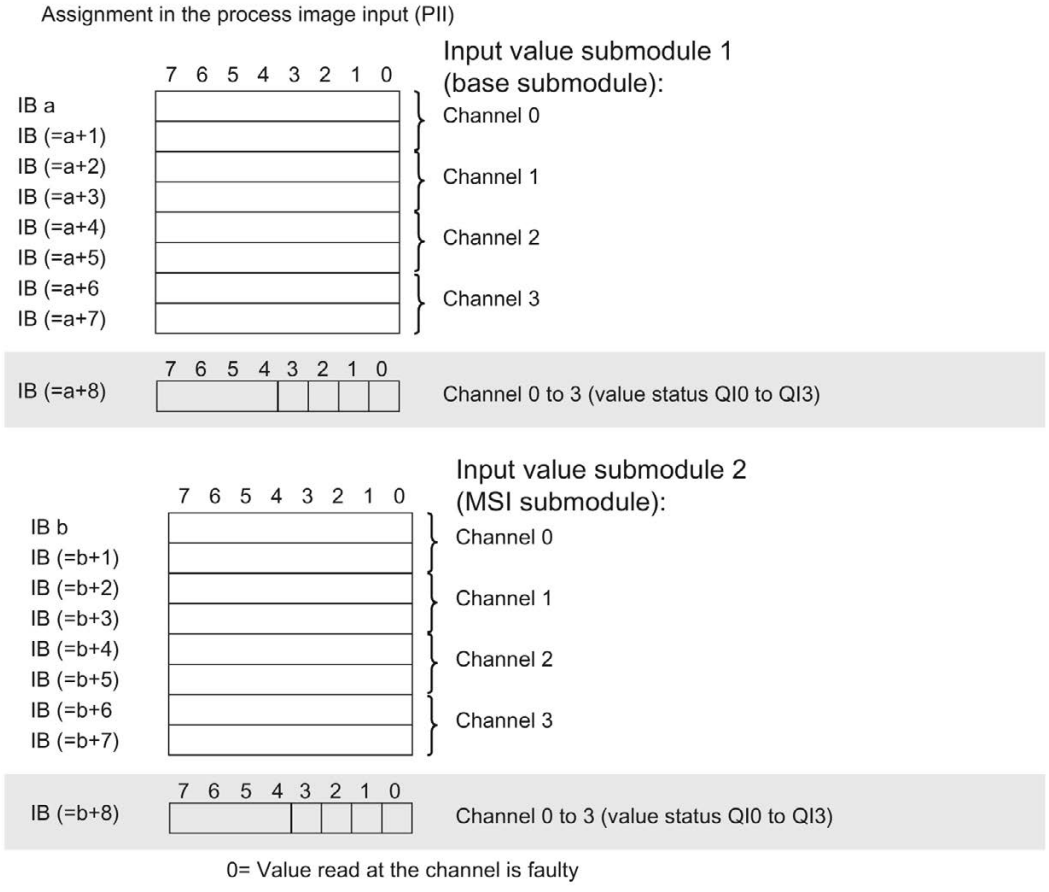


Figure 4-6 Address space for configuration as 1 x 4-channel AI 4xU/I/RTD/TC ST MSI with value status

The following figure shows the assignment of the address space with submodule 3 and 4.

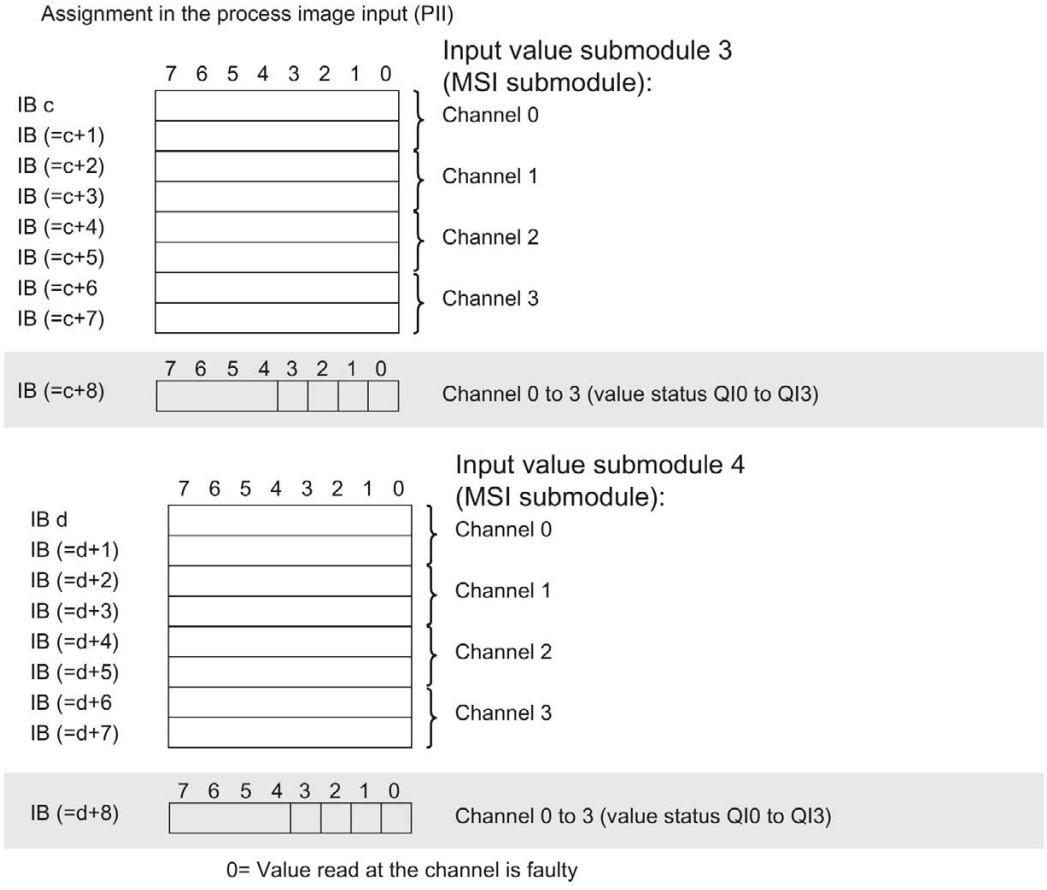


Figure 4-7 Address space for configuration as 1 x 4-channel AI 4xU/I/RTD/TC ST MSI with value status

Interrupts/diagnostics alarms

5

5.1 Status and error displays

LED displays

The figure below shows the LED displays (status and error displays) of AI 4xU/I/RTD/TC ST.

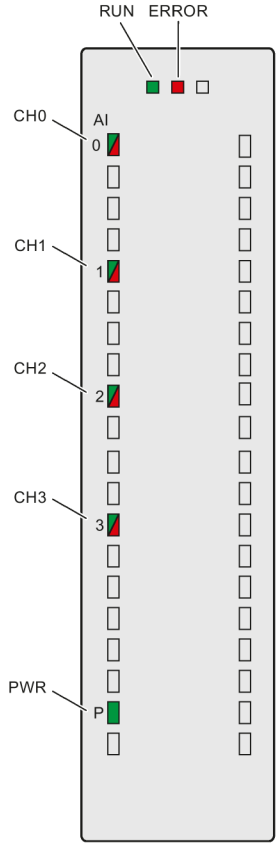


Figure 5-1 LED displays of the module AI 4xU/I/RTD/TC ST

Meaning of the LED displays

The following tables explain the meaning of the status and error displays. Corrective measures for diagnostics alarms can be found in the section Diagnostics alarms (Page 39).

LED RUN/ERROR

Table 5- 1 RUN/ERROR status and error displays

LEDs		Meaning	Solution
RUN	ERROR		
Off	Off	Voltage missing or too low at backplane bus.	• Switch on the CPU and/or the system power supply modules. • Verify that the U connectors are inserted. • Check to see if too many modules are inserted.
Flashes	Off	The module starts and flashes until the valid configuration is set.	---
On	Off	Module is configured.	
On	Flashes	Indicates module errors (at least one error at one channel, e.g., wire break).	Evaluate the diagnostics data and eliminate the error (e.g., wire break).
Flashes	Flashes	Hardware defective.	Replace the module.

PWR LED

Table 5- 2 PWR status display

LED PWR	Meaning	Solution
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 5- 3 CHx status display

LED CHx	Meaning	Solution
Off	Channel disabled.	---
On	Channel configured and OK.	---
On	Channel is configured (channel error pending). Diagnostics alarm: e.g. wire break	Check the wiring Disable diagnostics.

5.2 Interrupts

Analog input module AI 4xU/I/RTD/TC ST supports the following diagnostics and hardware interrupts.

Diagnostics interrupt

The module generates a diagnostics interrupt at the following events:

- No supply voltage L+
- Wire break
- Overflow
- Underflow
- Common mode error
- Reference junction

Hardware interrupt

The module generates a hardware interrupt at the following events:

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

For detailed information on the error event, refer to the hardware interrupt organization block with the "RALRM" instruction (read additional interrupt info) and to the STEP 7 online help.

The module channel that triggered the hardware interrupt is entered in the start information of the organization block. The diagram below shows the assignment to the bits of double word 8 in local data.

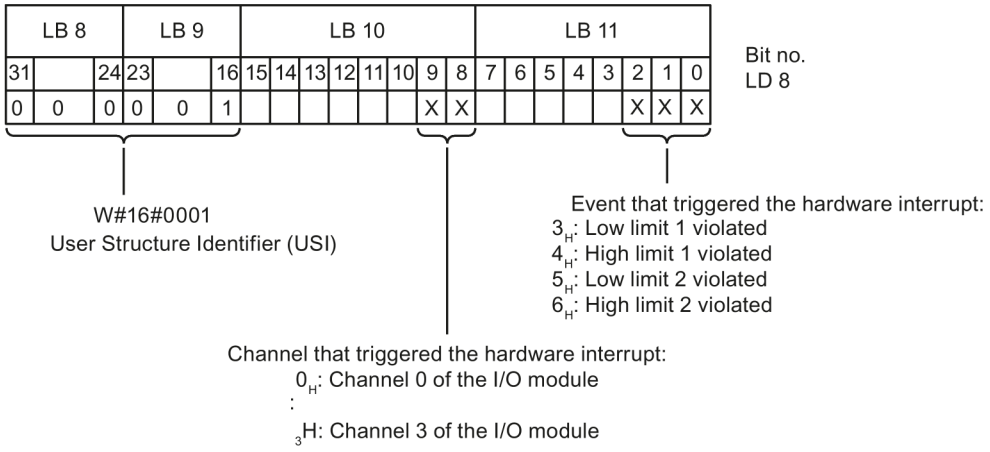


Figure 5-2 OB start information

Reaction when reaching limits 1 and 2 at the same time

If the two high limits 1 and 2 are reached at the same time, the module 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 module triggers the hardware interrupt for high limit 2.

The module has the same reaction when the low limits are reached at the same time. If the two low limits 1 and 2 are reached at the same time, the module always signals the hardware interrupt for low limit 1 first. After processing the hardware interrupt for low limit 1, the module triggers the hardware interrupt for low limit 2.

Structure of the additional interrupt information

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

Data block name		Contents	Remark	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#n	Number of the event-triggering channel (n = number of module channels -1)	1
It is followed by the event that triggered the hardware interrupt.				
	Event	B#16#03	Low limit violated 1	1
		B#16#04	High limit violated 1	
		B#16#05	Low limit violated 2	
		B#16#06	High limit violated 2	

5.3 Diagnostics alarms

A diagnostics alarm is output for each diagnostics event and the ERROR LED flashes on the module. The diagnostics alarms can, for example, be read from the diagnostics buffer of the CPU. You can evaluate the error codes with the user program.

Table 5- 5 Diagnostics alarms, their meaning and corrective measures

Diagnostics alarm	Error code	Meaning	Solution
Load voltage missing	11_H	Supply voltage L+ of the module is missing	Connect supply voltage L+ to module/channel
Wire break	6_H	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)	• Disable diagnostics • Connect the channel
Overflow	7_H	Measuring range violated	Check the measuring range
Underflow	8_H	Measuring range violated	Check the measuring range
Common mode error	118_H	Valid common mode voltage exceeded Causes when a 2WT is connected, e.g.: • Wire break • Galvanic connection to M_{ANA}	Check the wiring, e.g. sensor ground connections, use equipotential cables
Reference channel error	15_H	Reference temperature of the reference junction for the TC channel being operated with compensation is invalid.	Check the resistance thermometer. For the compensation with data record, restore communication to the module/station.
Channel temporarily unavailable	$1F_H$	User calibration is active. Channel currently not providing current/valid values.	Exit user calibration.

Diagnostics alarms with value status (QI)

If you configure the module with value status (QI), the module always checks all errors even if the respective diagnostics is not enabled. But the module cancels the inspection as soon as it detects the first error, regardless if the respective diagnostics has been enabled or not. The result may be that enabled diagnostics may not be displayed.

Example: You have enabled the diagnostics "Underflow", but the module detects the previous diagnostics "Wire break" and cancels after this error message. The "Underflow" diagnostics is not detected.

Recommendation: To ensure that all errors get diagnosed, select all check boxes under "Diagnostics".

Technical specifications

6

Technical specifications of the AI 4xU/I/RTD/TC ST

	6ES7531-7QD00-0AB0
Product type designation	AI 4xU/I/RTD/TC ST
General information	
Hardware version	I01
Firmware version	V1.0.0
Product function	
I&M data	Yes; I&M0 to I&M3
Engineering with	
STEP 7 TIA Portal can be configured/integrated as of version	V13 / V13.0.2
STEP 7 can be configured/integrated as of version	V5.5 SP3 / -
PROFIBUS as of GSD version/GSD revision	V1.0 / V5.1
PROFINET as of GSD version/GSD revision	V2.3 / -
Operating mode	
MSI	Yes
CiR Configuration in RUN	
Reconfiguration in RUN possible	Yes
Calibration in RUN possible	Yes
Supply voltage	
Rated value (DC)	24 V
Valid range, low limit (DC)	20.4 V
Valid range, high limit (DC)	28.8 V
Reverse polarity protection	Yes
Input current	
Current consumption, max.	140 mA; with 24 V DC supply
Encoder supply	
24 V encoder supply	
Short-circuit protection	Yes
Output current, max.	53 mA
Power	
Power consumption from backplane bus	0.7 W
Power loss	
Power loss, typ.	2.3 W

	6ES7531-7QD00-0AB0
Analog inputs	
Number of analog inputs	4
Number of analog inputs with current measurement	4
Number of analog inputs for voltage measurement	4
Number of analog inputs for resistance/resistance thermometer measurement	2
Number of analog inputs with thermocouple measurement	4
Permissible input voltage for voltage input (destruction limit), max.	28.8 V
Permissible input current for current input (destruction limit), max.	40 mA
Technical unit for temperature measurement adjustable	Yes
Input ranges (rated values), voltages	
1 V to 5 V	Yes
Input resistance (1 V to 5 V)	100 kΩ
-1 V to +1 V	Yes
Input resistance (-1 V to +1 V)	10 MΩ
-10 V to +10 V	Yes
Input resistance (-10 V to +10 V)	100 kΩ
-2.5 V to +2.5 V	Yes
Input resistance (-2.5 V to +2.5 V)	10 MΩ
-250 mV to +250 mV	Yes
Input resistance (-250 mV to +250 mV)	10 MΩ
-5 V to +5 V	Yes
Input resistance (-5 mV to +5 V)	100 kΩ
-50 mV to +50 mV	Yes
Input resistance (-50 mV to +50 mV)	10 MΩ
-500 mV to +500 mV	Yes
Input resistance (-500 mV to +500 mV)	10 MΩ
-80 mV to +80 mV	Yes
Input resistance (-80 mV to +80 mV)	10 MΩ
Input ranges (rated values), currents	
0 mA to 20 mA	Yes
Input resistance (0 mA to 20 mA)	25 Ω; plus approx. 42 ohm for overvoltage protection by PTC
-20 mA to +20 mA	Yes
Input resistance (-20 mA to +20 mA)	25 Ω; plus approx. 42 ohm for overvoltage protection by PTC
4 mA to 20 mA	Yes
Input resistance (4 mA to 20 mA)	25 Ω; plus approx. 42 ohm for overvoltage protection by PTC

	6ES7531-7QD00-0AB0
Input ranges (rated values), thermocouples	
Type B	Yes
Input resistance (type B)	10 MΩ
Type E	Yes
Input resistance (type E)	10 MΩ
Type J	Yes
Input resistance (type J)	10 MΩ
Type K	Yes
Input resistance (type K)	10 MΩ
Type N	Yes
Input resistance (type N)	10 MΩ
Type R	Yes
Input resistance (type R)	10 MΩ
Type S	Yes
Input resistance (type S)	10 MΩ
Type T	Yes
Input resistance (type T)	10 MΩ
Input ranges (rated values), resistance thermometers	
Ni 100	Yes; Standard/Climate
Input resistance (Ni 100)	10 MΩ
Ni 1000	Yes; Standard/Climate
Input resistance (Ni 1000)	10 MΩ
LG-Ni 1000	Yes; Standard/Climate
Input resistance (LG-Ni 1000)	10 MΩ
Pt 100	Yes; Standard/Climate
Input resistance (Pt 100)	10 MΩ
Pt 1000	Yes; Standard/Climate
Input resistance (Pt 1000)	10 MΩ
Pt 200	Yes; Standard/Climate
Input resistance (Pt 200)	10 MΩ
Pt 500	Yes; Standard/Climate
Input resistance (Pt 500)	10 MΩ
Input ranges (rated values), resistors	
0 to 150 ohm	Yes
Input resistance (0 to 150 ohm)	10 MΩ
0 to 300 ohm	Yes
Input resistance (0 to 300 ohm)	10 MΩ
0 to 600 ohm	Yes
Input resistance (0 to 600 ohm)	10 MΩ
0 to 6000 ohm	Yes
Input resistance (0 to 6000 ohm)	10 MΩ
PTC	Yes
Input resistance (PTC)	10 MΩ

	6ES7531-7QD00-0AB0
Thermocouple (TC)	
Technical unit for temperature measurement	°C/°F/K
Temperature compensation	
• Configurable	Yes
• Internal temperature compensation	Yes
• Compensation for 0 °C reference point temperature	Yes, fixed value can be set
Resistance thermometer (RTD)	
Technical unit for temperature measurement	°C/°F/K
Cable length	
Shielded cable length, max.	800 m; for U/I, 200 m for R/RTD, 50 m for TC
Analog value formation	
Integration and conversion time / resolution per channel	
Resolution with overrange (bit including sign), max.	16 bit
Configurable integration time	Yes
Integration time, ms	2,5 / 16,67 / 20 / 100
Basic conversion time, including integration time, ms	9 / 23 / 27 / 107 ms
• Additional conversion time for wire break monitoring	9 ms
• Additional conversion time for wire break measurement	150Ohm, 300Ohm, 600Ohm, Pt100, Pt200, Ni100: 2ms 6000Ohm, Pt500, Pt1000, Ni1000, LG-Ni1000, PTC: 4ms
Interference voltage suppression at interference frequency f1 in Hz	400 / 60 / 50 / 10
Smoothing of the measured values	
Configurable	Yes
Level: None	Yes
Level: Weak	Yes
Level: Medium	Yes
Level: Strong	Yes
Encoders	
Connection of the signal encoders	
For voltage measurement	Yes
for current measurement as 2-wire transducer	Yes
Load of 2-wire transmitter, max.	820 Ω
for current measurement as 4-wire transducer	Yes
for resistance measurement with two-wire connection	Yes; only for PTC
for resistance measurement with three-wire connection	Yes; all measuring ranges except PTC; internal compensation of line resistance
for resistance measurement with four-wire connection	Yes; all measuring ranges except PTC

	6ES7531-7QD00-0AB0
Errors/accuracies	
Linearity error (in relation to input range), (+/-)	0,02 %
Temperature error (in relation to input range), (+/-)	0.005%/K; for TC typ. T 0.02 +/- %/K
Crosstalk between the inputs, max.	-80 dB
Repeat accuracy in settled state at 25 °C (in relation to input range), (+/-)	0.02 %
Temperature errors of internal compensation	+/-6 °C
Operational limits across the entire temperature range	
Voltage in relation to input range, (+/-)	0.3 %
Current in relation to input range, (+/-)	0.3 %
Resistance in relation to input range, (+/-)	0.3 %
Resistance thermometer in relation to input range, (+/-)	0.3 %; Pt xxx Standard: ±1.5 K, Pt xxx Climate: ±0.5 K, Ni xxx Standard: ±0.5 K, Ni xxx Climate: ±0.3 K
Thermocouple in relation to input range, (+/-)	0.3 %; Type B: >600°C +/- 4.6K Type E: >-200°C +/- 1.5K Type J: >-210°C +/- 1.9K Type K: >-200°C +/- 2.4K Type N: >-200°C +/- 2.9K Type R: >0°C +/- 4.7K Type S: >0°C +/- 4.6K Type T: >-200°C +/- 2.4 K
Basic error limit (operational limit at 25 °C)	
Voltage in relation to input range, (+/-)	0,1 %
Current in relation to input range, (+/-)	0,1 %
Resistance in relation to input range, (+/-)	0,1 %
Resistance thermometer in relation to input range, (+/-)	0.1 %; Pt xxx Standard: ±0.7 K, Pt xxx Climate: ±0.2 K, Ni xxx Standard: ±0.3 K, Ni xxx Climate: ±0.15 K
Thermocouple in relation to input range, (+/-)	0.1 %; Type B: >600°C +/- 1.7K Type E: >-200°C +/- 0.7K Type J: >-210°C +/- 0.8K Type K: >-200°C +/- 1.2K Type N: >-200°C +/- 1.2K Type R: >0°C +/- 1.9K Type S: >0°C +/- 1.9K Type T: >-200°C +/- 0.8K

	6ES7531-7QD00-0AB0
Interference voltage suppression for f = n x (f1 +/- 1 %), f1 = interference frequency	
Series mode interference (peak value of interference < rated value of input range), min.	40 dB
Common mode voltage, max.	10 V
Common mode interference, min.	60 dB
Interrupts/diagnostics/status information	
Interrupts	
Diagnostics interrupt	Yes
Limit interrupt	Yes; two high limits and two low limits each
Diagnostics alarms	
Diagnostics	Yes
Monitoring of supply voltage	Yes
Wire break	Yes, only for 1 ... 5V, 4 ... 20mA, TC, R and RTD
Overflow/underflow	Yes
Diagnostics display LED	
RUN LED	Yes; green LED
ERROR LED	Yes; red LED
Monitoring of supply voltage	Yes; green LED
Channel status display	Yes; green LED
For channel diagnostics	Yes; red LED
For module diagnostics	Yes; red LED
Electrical isolation	
Electrical isolation channels	
Between the channels	No
Between the channels, in groups of	4
Between the channels and the backplane bus	Yes
Between the channels and the supply voltage of the electronics	Yes
Permissible potential difference	
Between the inputs (UCM)	20 V DC
Between inputs and MANA (UCM)	10 V DC
Between M internally and the inputs	75 V DC / 60 V AC (basic isolation)
Isolation	
Isolation tested with	707 V DC (type test)
Distributed mode	
Prioritized startup	No
Dimensions	
Width	25 mm
Height	147 mm
Depth	129 mm

	6ES7531-7QD00-0AB0
Weights	
Weight, approx.	210 g
Miscellaneous	
Note:	Package includes 40-pin push-in front connector Additional basic error and noise for integration time = 2.5 ms: Voltage: +/- 250 mV: +/- 0.02% +/- 80mV: +/- 0.05% +/- 50 mV: +/- 0.05% resistance: 150 ohm: +/- 0.02% resistance thermometer: Pt100 climate: +/- 0.08 K Ni100 Climate: +/-0.08K thermocouple: Type B, R, S: +/- 3K Type E, J, K, N, T: +/-1 K

Dimension drawing

A

The dimension drawing of the module on the mounting rail, as well as a dimension drawing with open front panel are provided in the appendix. Always adhere to the specified dimensions for installation in cabinets, control rooms, etc.

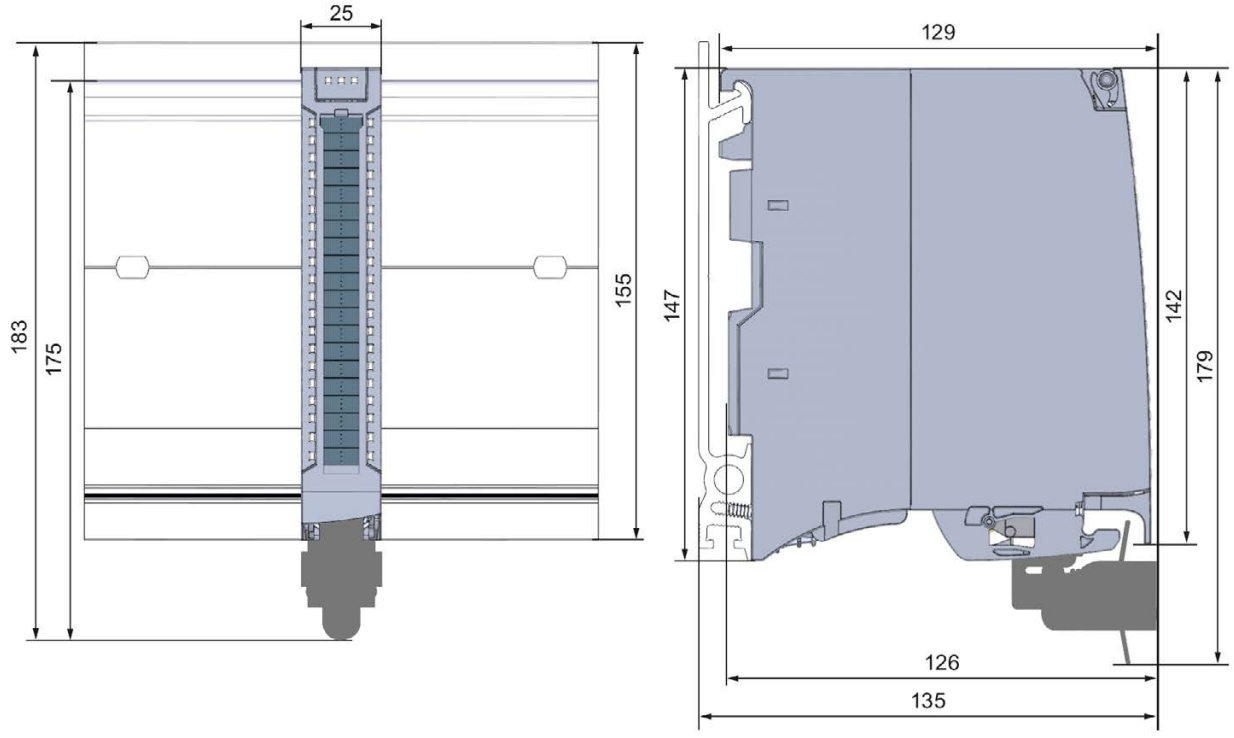


Figure A-1 Dimension drawing of the AI 4xU/I/RTD/TC ST module

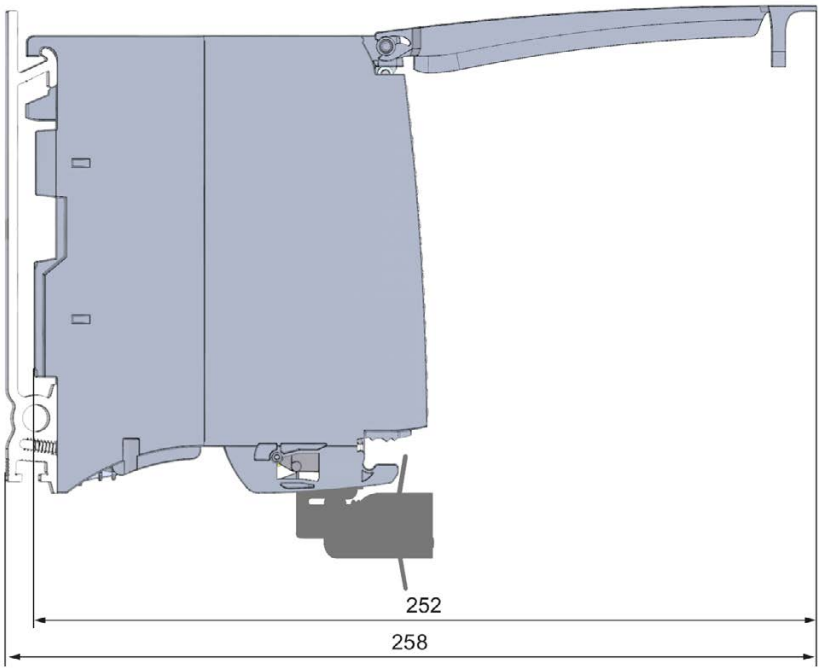


Figure A-2 Dimension drawing of the AI 4xU/I/RTD/TC ST module, side view with open front panel

Parameter data records

B

B.1 Parameter assignment and structure of the parameter data records

The data records of the module have an identical structure, regardless of whether you configure the module with PROFIBUS DP or PROFINET IO.

Dependencies for configuration with GSD file

When configuring the module with a GSD file, remember that the settings of some parameters are dependent on each other. The parameters are only checked for plausibility by the module after the transfer to the module.

The following table lists the parameters that depend on one another.

Table B- 1 Dependencies of parameters for configuration with GSD file

Device-specific parameters (GSD file)	Dependent parameters
Current limit for wire break	Only for **measurement type** current with **measuring range** 4 to 20 mA.
Wire break	Only for **measurement type** resistance, thermistor RTD, thermocouple TC, voltage with **measuring range** 1V to 5 V and current with **measuring range** 4 to 20 mA.
Common mode error	Only for **measuring type** voltage, current and thermocouple TC.
Reference junction	Only for **measurement type** thermocouple TC.
Measurement type resistance (4-wire connection, 3-wire connection, 2-wire connection)	Configurable for even channels (0 and 2) only. The next odd channel (1 and 3) must be disabled.
Measurement type thermistor RTD (4-wire connection, 3-wire connection)	
Hardware interrupt limits	Only if hardware interrupts are enabled.
Fixed reference temperature	Only if the **Reference junction** parameter and the **Fixed reference temperature** value is configured.

Parameter assignment in the user program

The module parameters can be assigned in RUN (for example, measuring ranges of selected channels can be edited in RUN without having an effect on the other channels).

Parameter assignment in RUN

The WRREC instruction is used to transfer the parameters to the module using data records 0 to 3. The parameters set in STEP 7 do not change in the CPU, which means the parameters set in STEP 7 are still valid after a restart.

The parameters are only checked for plausibility by the module after the transfer to the module.

Output parameter STATUS

If errors occur during the transfer of parameters with the WRREC instruction, the module continues operation with the previous parameter assignment. However, a corresponding error code is written to the STATUS output parameter.

The description of the WRREC instruction and the error codes is available in the STEP 7 online help.

Operation of the module downstream from a PROFIBUS DP interface module

If the module is operated downstream from a IM PROFIBUS DP interface module, the parameter data records 0 and 1 cannot be read back. You get the diagnostics data records 0 and 1 for the read back parameter data records 0 and 1. You can find more information in the Interrupts section of the PROFIBUS DP interface module product manual on the Internet (http://support.automation.siemens.com/WW/view/en/78324181).

Assignment of data record and channel

For the configuration as a 1 x 4-channel module, the parameters are located in data records 0 to 3 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

For configuration 1 x 4-channel, the module has 4 submodules with one channel each. The parameters for the channel are available in data record 0 and are assigned as follows:

- Data record 0 for channel 0 (submodule 1)
- Data record 0 for channel 1 (submodule 2)
- Data record 0 for channel 2 (submodule 3)
- Data record 0 for channel 3 (submodule 4)

Address the respective submodule for data record transfer.

Data record structure

The example in the following figure shows the structure of data record 0 for channel 0. The structure of channels 1 to 3 is identical. The values in byte 0 and byte 1 are fixed and may not be changed.

Enable a parameter by setting the corresponding bit to "1".

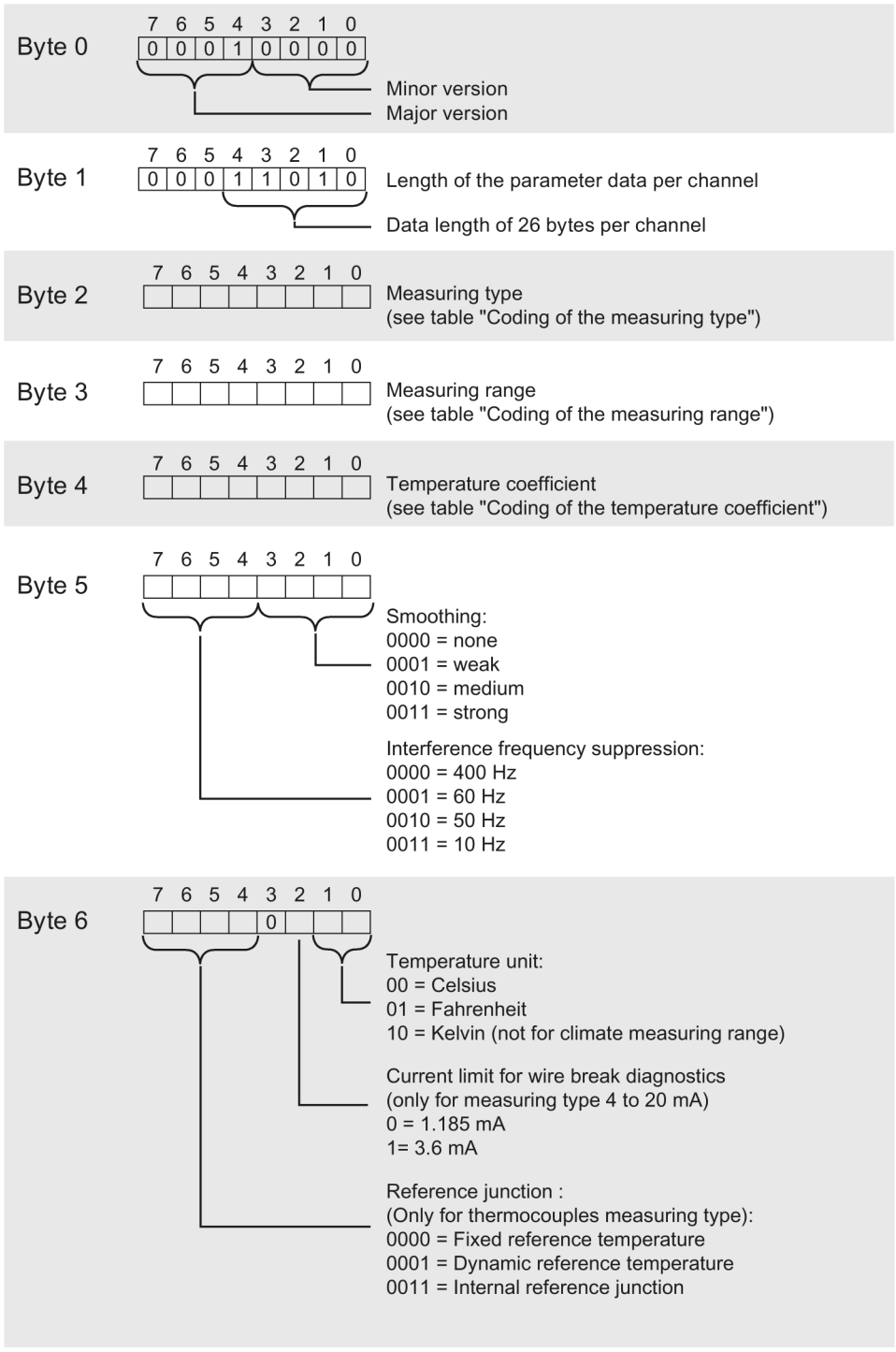
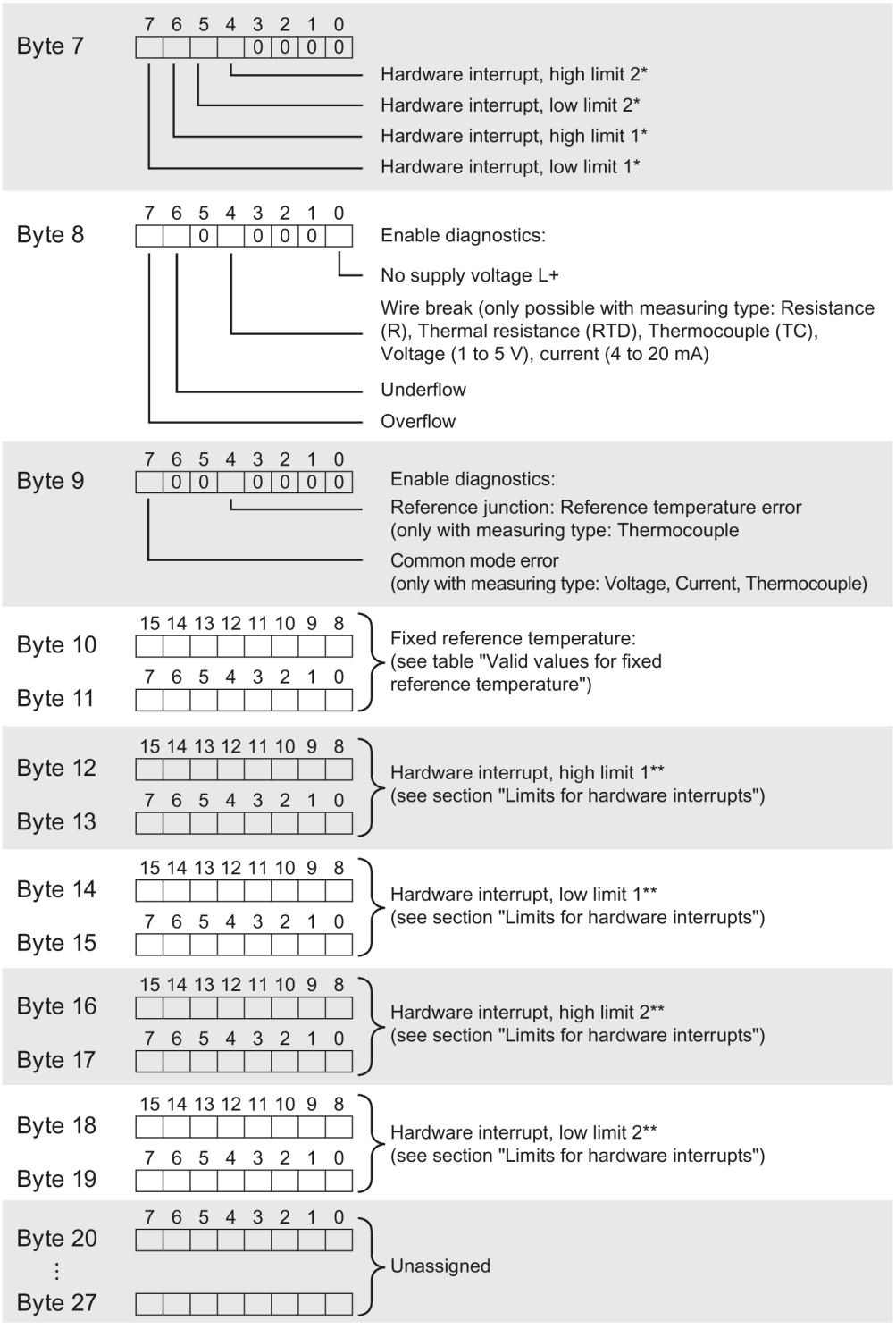


Figure B-1 Structure of data record 0: Bytes 0 to 6



* Enabling of hardware interrupts via data record is only possible if the channel is assigned to a hardware interrupt OB 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 lists all measurement types of the analog input module along with their codes. Enter these codes at byte 2 of the data record for the corresponding channel (see the figure Structure of data record 0: Bytes 7 to 27).

Table B- 2 Code for the measurement type

Measurement type	Code
Disabled	0000 0000
Voltage	0000 0001
Current, 2-wire transmitter	0000 0011
Current, 4-wire transmitter	0000 0010
Resistance, 4-wire connection *) **)	0000 0100
Resistance, 3-wire connection *) **)	0000 0101
Resistance, 2-wire connection *) ***)	0000 0110
Thermal resistor linear, 4-wire connection *)	0000 0111
Thermal resistor linear, 3-wire connection *)	0000 1000
Thermocouple	0000 1010

*) only possible for channels 0 and 2

**) only for the following measuring ranges: 150 Ω, 300 Ω, 600 Ω, 6 kΩ

***) only for measuring range PTC

Special feature for configuration

When you set one of the following measurement types at channel 0 or channel 2:

- Resistance, 4-wire connection
- Resistance, 3-wire connection
- Resistance, 2-wire connection
- Thermal resistor linear, 4-wire connection
- Thermal resistor linear, 3-wire connection

then one of the following channels must be disabled.

Example:

You have configured "Resistance, 4-wire connection" at channel 0; channel 1 must be disabled. You have configured "Resistance, 2-wire connection" at channel 2; channel 3 must be disabled.

Codes for measuring ranges

The following table lists all measuring ranges of the analog input module along with their codes. Enter these codes accordingly at byte 3 of the data record for the corresponding channel (see the figure Structure of data record 0: Bytes 7 to 27).

Table B- 3 Code for the measuring range

Measuring range	Code
Voltage	
±50 mV	0000 0001
±80 mV	0000 0010
±250 mV	0000 0011
±500 mV	0000 0100
±1 V	0000 0101
±2.5 V	0000 0111
±5 V	0000 1000
±10 V	0000 1001
1 V to 5 V	0000 1010
Current, 4-wire transmitter	
0 mA to 20 mA	0000 0010
4 mA to 20 mA	0000 0011
±20 mA	0000 0100
Current, 2-wire transmitter	
4 mA to 20 mA	0000 0011
Resistor	
150 Ω	0000 0001
300 Ω	0000 0010
600 Ω	0000 0011
6 kΩ	0000 0101
PTC	0000 1111

Thermal resistor	
Pt100 climatic	0000 0000
Ni100 climatic	0000 0001
Pt100 standard	0000 0010
Ni100 standard	0000 0011
Pt500 standard	0000 0100
Pt1000 standard	0000 0101
Ni1000 standard	0000 0110
Pt200 Climatic	0000 0111
Pt500 climatic	0000 1000
Pt1000 climatic	0000 1001
Ni1000 Climatic	0000 1010
Pt200 standard	0000 1011
LG-Ni1000 standard	0001 1100
LG-Ni1000 Climatic	0001 1101
Thermocouple	
B	0000 0000
N	0000 0001
E	0000 0010
R	0000 0011
S	0000 0100
J	0000 0101
T	0000 0111
K	0000 1000

Codes for temperature coefficients

The following table lists all temperature coefficients along with their codes for temperature measurements with the thermal resistors. These codes must be entered in byte 4 of the corresponding data record.

Table B- 4 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
LG-Ni	
0.005000	0000 1010

Valid values for fixed reference temperatures

The values that you can set for fixed reference temperatures must be in the valid range of values. The resolution is a tenth of a degree.

Table B- 5 Valid values for fixed reference temperatures

Temperature unit	Dec	Hex
Celsius (default)	-1450 to 1550	$FA56_H$ to $60E_H$
Fahrenheit (default)	-2290 to 3110	$F70E_H$ to CCC_H
Kelvin (default)	1282 to 3276	502_H to $10BA_H$

Hardware interrupt limits

The values that you can set for hardware interrupts (high/low limit) must not violate the over/underrange of the respective rated measuring range.

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

Table B- 6 Voltage limits

Voltage		
±50 mV, ±80 mV, ±250 mV, ±500 mV, ±1 V, ±2.5 V, ±5 V, ±10 V	1 V to 5 V	
32510	32510	High limit
-32511	-4863	Low limit

Table B- 7 Current and resistance limits

Current		Resistor	
±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- 8 Limits for thermocouple types B, C, E, and J

Thermocouple									
Type B			Type E			Type J			
°C	°F	K	°C	°F	K	°C	°F	K	
20699	32765	23431	11999	21919	14731	14499	26419	17231	High limit
1	321	2733	-2699	-4539	33	-2099	-3459	633	Low limit

Table B- 9 Limits for thermocouples type K, N, R, and S

Thermocouple									
Type K			Type N			Types R, S			
°C	°F	K	°C	°F	K	°C	°F	K	
16219	29515	18951	15499	28219	18231	20189	32765	22921	High limit
-2699	-4539	33	-2699	-4539	33	-1699	-2739	1033	Low limit

Table B- 10 Limits for thermocouple type T

Thermocouple			
Type T			
°C	°F	K	
5399	10039	8131	High limit
-2699	-4539	33	Low limit

Table B- 11 Limits for thermal resistor Pt xxx Standard and Pt xxx Climatic

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

Table B- 12 Limits for thermal resistor Ni xxx Standard and Ni xxx Climatic

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

B.2 Structure of a data record for dynamic reference temperature

The **WRREC** instruction is used to transfer the reference junction temperature via data record 192 to data record 195 to the module.

The description of the WRREC instruction can be found in the online help from STEP 7.

If you have set the "Dynamic reference temperature" value for the "Reference junction" parameter, the module expects a new data record at least every 5 minutes. If the module does not receive a new data record within this time, it generates the "Reference channel error" diagnostics message.

Assignment of data record and channel

The following assignment applies if no submodules (1 x 4-channel) are configured for the module:

- Data record 192 for channel 0
- Data record 193 for channel 1
- Data record 194 for channel 2
- Data record 195 for channel 3

Structure of data record 192 for dynamic reference temperature

The following figure shows an example of the structure of data record 192 for channel 0. The structure for data records 193 to 195 is identical.

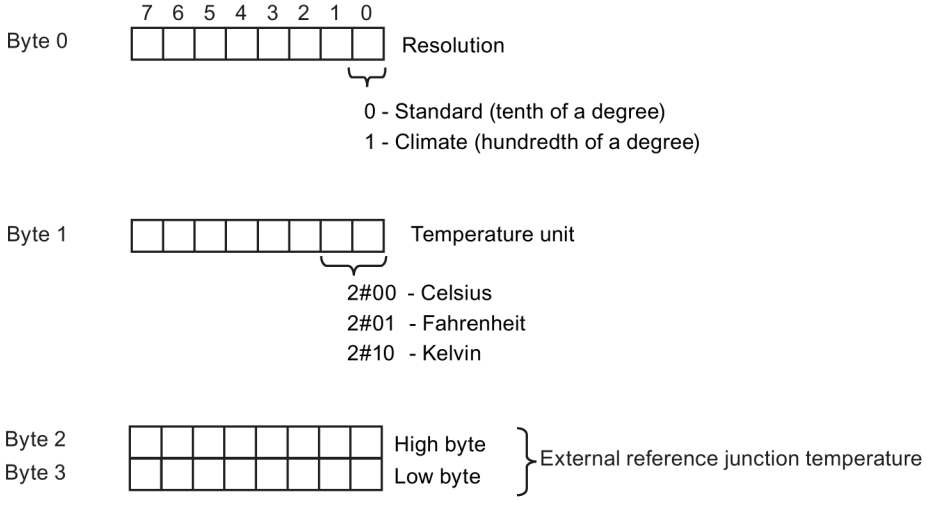


Figure B-3 Structure of data record 192

Valid values for fixed temperature compensation

You can enter the selectable values at bytes 2 and 3 of the data record for the corresponding channel. The selectable values must lie within the permitted value range, see following table. The resolution is a tenth of a degree.

Table B- 13 Valid values for temperature compensation via data record

Temperature unit	Dec	Hex
Celsius (default)	-1450 to 1550	$FA56_H$ to $60E_H$
Fahrenheit (default)	-2290 to 3110	$F70E_H$ to $C26_H$
Kelvin (default)	1282 to 3276	502_H to CCC_H
Celsius (climatic)	-14500 to 15500	$C75C_H$ to $3C8C_H$
Fahrenheit (climatic)	-22900 to 31100	$A68C_H$ to $797C_H$
Kelvin (climatic)	12820 to 32760	3214_H to $7FF8_H$

Additional information

For more information on compensation of the reference junction temperature via data record refer to the Analog value processing (http://support.automation.siemens.com/WW/view/en/67989094) function manual in the internet.

Representation of analog values

C

Introduction

This section shows the analog values for all measuring ranges supported by the AI 4xU/I/RTD/TC ST analog module.

Measured value resolution

Each analog value is written left aligned to 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 module.

Table C- 1 Resolution of the analog values

Resolution in bits including sign	Values		Analog value	
	Dec	Hex	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.1 Representation of input ranges

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

Table C- 2 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	Overshoot range
27649	100.004	0	1	1	0	1	1	0	0	0	0	0	0	0	0	0	1	
27648	100.000	0	1	1	0	1	1	0	0	0	0	0	0	0	0	0	0	Rated range
1	0.003617	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	
0	0.000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
-1	-0.003617	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	
-27648	-100.000	1	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0	
-27649	-100.004	1	0	0	1	0	0	1	1	1	1	1	1	1	1	1	1	Undershoot range
-32512	-117.593	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	
-32768	<-117.593	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	Underflow

Table C- 3 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	Overshoot range
27649	100.004	0	1	1	0	1	1	0	0	0	0	0	0	0	0	0	1	
27648	100.000	0	1	1	0	1	1	0	0	0	0	0	0	0	0	0	0	
1	0.003617	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	Rated range
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	Undershoot range
-4864	-17.593	1	1	1	0	1	1	0	1	0	0	0	0	0	0	0	0	
-32768	<-17.593	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	Underflow

C.2 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- 4 Voltage measuring ranges ±10 V, ±5 V, ±2.5 V, ±1 V,

Values		Voltage measuring range				Range
dec	hex	±10 V	±5 V	±2.5 V	±1 V	
32767	7FFF	>11.759 V	>5.879 V	>2.940 V	> 1.176 V	Overflow
32511	7EFF	11.759 V	5.879 V	2.940 V	1.176 V	Overshoot range
27649	6C01					
27648	6C00	10 V	5 V	2.5 V	1 V	Rated range
20736	5100	7.5 V	3.75 V	1.875 V	0.75 V	
1	1	361.7 µV	180.8 µV	90.4 µV	36.17 µV	
0	0	0 V	0 V	0 V	0 V	
-1	FFFF					
-20736	AF00	-7.5 V	-3.75 V	-1.875 V	-0.75 V	
-27648	9400	-10 V	-5 V	-2.5 V	-1 V	
-27649	93FF					Undershoot range
-32512	8100	-11.759 V	-5.879 V	-2.940 V	-1.176 V	
-32768	8000	< -11.759 V	< -5.879 V	< -2.940 V	< -1.176 V	Underflow

Table C- 5 Voltage measuring ranges ±500 mV, ±250 mV, ±80 mV, and ±50 mV,

Values		Voltage measuring range				Range
dec	hex	±500 mV	±250 mV	±80 mV	±50 mV	
32767	7FFF	>587.9 mV	> 294.0 mV	> 94.1 mV	> 58.8 mV	Overflow
32511	7EFF	587.9 mV	294.0 mV	94.1 mV	58.8 mV	Overshoot range
27649	6C01					
27648	6C00	500 mV	250 mV	80 mV	50 mV	Rated range
20736	5100	375 mV	187.5 mV	60 mV	37.5 mA	
1	1	18.08 µV	9.04 µV	2.89 µV	1.81 µV	
0	0	0 mV	0 mV	0 mV	0 mV	
-1	FFFF					
-20736	AF00	-375 mV	-187.5 mV	-60 mV	-37.5 mV	
-27648	9400	-500 mV	-250 mV	-80 mV	-50 mV	
-27649	93FF					Undershoot range
-32512	8100	-587.9 mV	-294.0 mV	-94.1 mV	-58.8 mV	
-32768	8000	<-587.9 mV	< -294.0 mV	< -94.1 mV	< -58.8 mV	Underflow

Table C- 6 Voltage measuring range 1 V to 5 V

Values		Voltage measuring range	Range
dec	**hex**	**1 V to 5 V**	
32767	7FFF	>5.704 V	Overflow
32511	7EFF	5.704 V	Overshoot range
27649	6C01		
27648	6C00	5 V	Rated range
20736	5100	4 V	
1	1	1 V + 144.7 µV	
0	0	1 V	
-1	FFFF		Undershoot range
-4864	ED00	0.296 V	
-32768	8000	< 0.296 V	Underflow

C.3 Representation of analog values in the current measuring ranges

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

Table C- 7 Current measuring range ±20 mA

Values		Current measuring range	
dec	**hex**	**±20 mA**	
32767	7FFF	>23.52 mA	Overflow
32511	7EFF	23.52 mA	Overshoot range
27649	6C01		
27648	6C00	20 mA	Rated 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		Undershoot range
-32512	8100	-23.52 mA	
-32768	8000	<-23.52 mA	Underflow

Table C- 8 Current measuring ranges 0 to 20 mA and 4 to 20 mA

Values		Current measuring 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	Overshoot range
27649	6C01			
27648	6C00	20 mA	20 mA	Rated 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			Undershoot range
-4864	ED00	-3.52 mA	1.185 mA	
-32768	8000	<- 3.52 mA	< 1.185 mA	Underflow

C.4 Representation of the analog values of resistance-based sensors/resistance thermometers

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

Table C- 9 Resistance-based sensors of 150 Ω, 300 Ω, 600 Ω, and 6000 Ω

Values		Resistance-based sensor range				
dec	**hex**	**150 Ω**	**300 Ω**	**600 Ω**	**6000 Ω**	
32767	7FFF	>176.38 Ω	>352.77 Ω	>705.53 Ω	>7055.3 Ω	Overflow
32511	7EFF	176.38 Ω	352.77 Ω	705.53 Ω	7055.3 Ω	Overshoot range
27649	6C01					
27648	6C00	150 Ω	300 Ω	600 Ω	6000 Ω	Rated range
20736	5100	112.5 Ω	225 Ω	450 Ω	4500 Ω	
1	1	5.43 mΩ	10.85 mΩ	21.70 mΩ	217 mΩ	
0	0	0 Ω	0 Ω	0 Ω	0 Ω	

The following tables list the decimal and hexadecimal values (codes) of the supported resistance thermometers.

Table C- 10 Resistance thermometers Pt 100, Pt 200, Pt 500 and Pt 1000 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	Overshoot range
850.0 : -200.0	8500 : -2000	2134 : F830	1562.0 : -328.0	15620 : -3280	3D04 : F330	1123.2 : 73.2	11232 : 732	2BE0 : 2DC	Rated 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	Undershoot range
< -243.0	-32768	8000	< -405.4	-32768	8000	< 30.2	32768	8000	Underflow

Table C- 11 Thermal resistors Pt 100, Pt 200, Pt 500 and Pt 1000 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	Overshoot range
130.00 : -120.00	13000 : -12000	32C8 : D120	266.00 : -184.00	26600 : -18400	67E8 : B820	Rated range
-120.01 : -145.00	-12001 : -14500	D11F : C75C	-184.01 : -229.00	-18401 : -22900	B81F : A68C	Undershoot range
< -145.00	-32768	8000	< -229.00	-32768	8000	Underflow

Table C- 12 Thermal resistors Ni 100, Ni 1000, LG-Ni 1000 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	Overshoot range
250.0 : -60.0	2500 : -600	9C4 : FDA8	482.0 : -76.0	4820 : -760	12D4 : FD08	523.2 : 213.2	5232 : 2132	1470 : 854	Rated 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	Undershoot range
< -105.0	-32768	8000	< -157.0	-32768	8000	< 168.2	32768	8000	Underflow

Table C- 13 Thermal resistors Ni 100, Ni 1000, LG-Ni 1000 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	Overshoot range
130.00 : -60.00	13000 : -6000	32C8 : E890	266.00 : -76.00	26600 : -7600	67E8 : E250	Rated range
-60.01 : -105.00	-6001 : -10500	E88F : D6FC	-76.01 : -157.00	-7601 : -15700	E24F : C2AC	Undershoot range
< - 105.00	-32768	8000	< - 157.00	-32768	8000	Underflow

C.5 Representation of analog values for thermocouples

The following tables list the decimal and hexadecimal values (codes) of the supported thermocouples.

Table C- 14 Thermocouple type B

Type B in °C	Values		Type B in °F	Values		Type B in K	Values		Range
	dec	hex		dec	hex		dec	hex	
> 2070,0	32767	7FFF	> 3276.6	32767	7FFF	> 2343.2	32767	7FFF	Overflow
2070,0 : 1820.1	20700 : 18201	50DC : 4719	3276.6 : 2786.6	32766 : 27866	7FFE : 6CDA	2343.2 : 2093.3	23432 : 20933	5B88 : 51C5	Overshoot range
1820.0 : 250.0	18200 : 2500	4718 : 09C4	2786.5 : 482.0	27865 : 4820	6CD9 : 12D4	2093.2 : 523.2	20932 : 5232	51C4 : 1470	Rated range
249.9 : 0,0	2499 : 0	09C3 : 0	481,9 : 32,0	4819 : 320	12D3 : 0140	523,1 : 273,2	5231 : 2732	1469 : 0AAC	Undershoot range
< 0.0	-32768	8000	< 32.0	-32768	8000	< 273.2	32768	8000	Underflow

Table C- 15 Thermocouple type E

Type E in °C	Values		Type E in °F	Values		Type E in K	Values		Range
	dec	hex		dec	hex		dec	hex	
> 1200.0	32767	7FFF	> 2192,0	32767	7FFF	> 1473.2	32767	7FFF	Overflow
1200,0 : 1000.1	12000 : 10001	2EE0 : 2711	2192.0 : 1832.2	21920 : 18322	55A0 : 4792	1473.2 : 1273.3	14732 : 12733	398C : 31BD	Overshoot range
1000.0 : -270.0	10000 : -2700	2710 : F574	1832.0 : -454.0	18320 : -4540	4790 : EE44	1273.2 : 0	12732 : 0	31BC : 0000	Rated range
< -270.0	-32768	8000	< -454.0	-32768	8000	<0	-32768	8000	Underflow

Table C- 16 Thermocouple type J

Type J in °C	Values		Type J in °F	Values		Type J in K	Values		Range
	dec	hex		dec	hex		dec	hex	
> 1450.0	32767	7FFF	> 2642.0	32767	7FFF	> 1723.2	32767	7FFF	Overflow
1450,0 : 1200.1	14500 : 12001	38A4 : 2EE1	2642.0 : 2192.2	26420 : 21922	6734 : 55A2	1723.2 : 1473.3	17232 : 14733	4350 : 398D	Overshoot range
1200.0 : -210.0	12000 : -2100	2EE0 : F7CC	2192.0 : -346.0	21920 : -3460	55A0 : F27C	1473.2 : 63.2	14732 : 632	398C : 0278	Rated range
< -210.0	-32768	8000	< -346.0	-32768	8000	< 63.2	-32768	8000	Underflow

Table C- 17 Thermocouple type K

Type K in °C	Values		Type K in °F	Values		Type K in K	Values		Range
	dec	hex		dec	hex		dec	hex	
> 1622.0	32767	7FFF	> 2951.6	32767	7FFF	> 1895,2	32767	7FFF	Overflow
1622.0 : 1372.1	16220 : 13721	3F5C : 3599	2951.6 : 2501.7	29516 : 25017	734C : 61B9	1895.2 : 1645.3	18952 : 16453	4A08 : 4045	Overshoot range
1372.0 : -270.0	13720 : -2700	3598 : F574	2501.6 : -454.0	25016 : -4540	61B8 : EE44	1645,2 : 0	16452 : 0	4044 : 0000	Rated range
< -270.0	-32768	8000	< -454.0	-32768	8000	< 0	-32768	8000	Underflow

Table C- 18 Thermocouple type N

Type N in °C	Values		Type N in °F	Values		Type N in K	Values		Range
	dec	hex		dec	hex		dec	hex	
> 1550,0	32767	7FFF	> 2822,0	32767	7FFF	> 1823,2	32767	7FFF	Overflow
1550,0 : 1300,1	15500 : 13001	3C8C : 32C9	2822,0 : 2372,2	28220 : 23722	6E3C : 5CAA	1823,2 : 1573,3	18232 : 15733	4738 : 3D75	Overshoot range
1300,0 : -270,0	13000 : -2700	32C8 : F574	2372,0 : -454,0	23720 : -4540	5CA8 : EE44	1573,2 : 0	15732 : 0	3D74 : 0000	Rated range
< -270,0	-32768	8000	< -454,0	-32768	8000	< 0	-32768	8000	Underflow

Table C- 19 Thermocouple type R and S

Type R, S in °C	Values		Type R, S in °F	Values		Types R, S in K	Values		Range
	dec	hex		dec	hex		dec	hex	
> 2019.0	32767	7FFF	> 3276.6	32767	7FFF	> 2292.2	32767	7FFF	Overflow
2019.0 : 1769.1	20190 : 17691	4EDE : 451B	3276.6 : 3216.4	32766 : 32164	7FFE : 7DA4	2292.2 : 2042.3	22922 : 20423	598A : 4FC7	Overshoot range
1769.0 : -50.0	17690 : -500	451A : FE0C	3216.2 : -58.0	32162 : -580	7DA2 : FDBC	2042,2 : 223,2	20422 : 2232	4FC6 : 08B8	Rated range
-50,1 : -170,0	-501 : -1700	FE0B : F95C	-58,1 : -274,0	-581 : -2740	FDBB : F54C	223.1 : 103.2	2231 : 1032	08B7 : 0408	Undershoot range
< -170.0	-32768	8000	< -274.0	-32768	8000	< 103.2	< 1032	8000	Underflow

Table C- 20 Thermocouple type T

Type T in °C	Values		Type T in °F	Values		Type T in K	Values		Range
	dec	hex		dec	hex		dec	hex	
> 540,0	32767	7FFF	> 1004,0	32767	7FFF	> 813,2	32767	7FFF	Overflow
540,0 : 400,1	5400 : 4001	1518 : 0FA1	1004,0 : 752,2	10040 : 7522	2738 : 1D62	813,2 : 673,3	8132 : 6733	1FC4 : 1AAD	Overshoot range
400,0 : -270,0	4000 : -2700	0FA0 : F574	752,0 : -454,0	7520 : -4540	1D60 : EE44	673,2 : 3,2	6732 : 32	1AAC : 0020	Rated range
< -270,0	-32768	8000	< -454,0	-32768	8000	< 3,2	-32768	8000	Underflow

C.6 Measured values for wire break diagnostics

Measured values on diagnostics event "wire break", dependent on diagnostics enables

Error events initiate a diagnostics entry and trigger a diagnostics interrupt if configured accordingly.

Table C- 21 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 takes priority over "Overflow/Underflow" diagnostics)	32767	$7FFF_H$	"Wire break" or "Open circuit" diagnostics alarm
	• "Wire break" diagnostics disabled • "Overflow/Underflow" diagnostics enabled	-32767	8000_H	• Measured value after leaving the undershoot range • Diagnostics alarm "Low limit violated"
	• "Wire break" diagnostics disabled • "Overflow/Underflow" diagnostics disabled	-32767	8000_H	Measured value after leaving the undershoot range

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