SIEMENS

SIMATIC

S7-1500 / ET 200MP

Analog Input Module AI 8xU/R/RTD/TC HF (6ES7531-7PF00-0AB0)

Manual

Edition 09/2016

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A5E36647959-AB

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

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Siemens AG
Division Digital Factory
Postfach 48 48
90026 NÜRNBERG
GERMANY

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Preface

Purpose of the documentation

This manual supplements the S7-1500/ET 200MP (http://support.automation.siemens.com/WW/view/en/59191792) system manual.

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

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

Changes compared to previous version

Compared to the previous version, this manual contains the following changes:

- As of firmware version V1.1.0, the module supports the scalable measuring range function.
- Original texts of the license conditions and copyright notes for open-source software are available on the Internet as of 09/2016.

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 regarding the product described in the documentation or its handling, or draws special attention to a section of the documentation.

Security information

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

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Open Source Software

Open-source software is used in the firmware of the I/O modules. Open Source Software is provided free of charge. We are liable for the product described, including the open-source software contained in it, pursuant to the conditions applicable to the product. Siemens accepts no liability for the use of the open source software over and above the intended program sequence, or for any faults caused by modifications to the software.

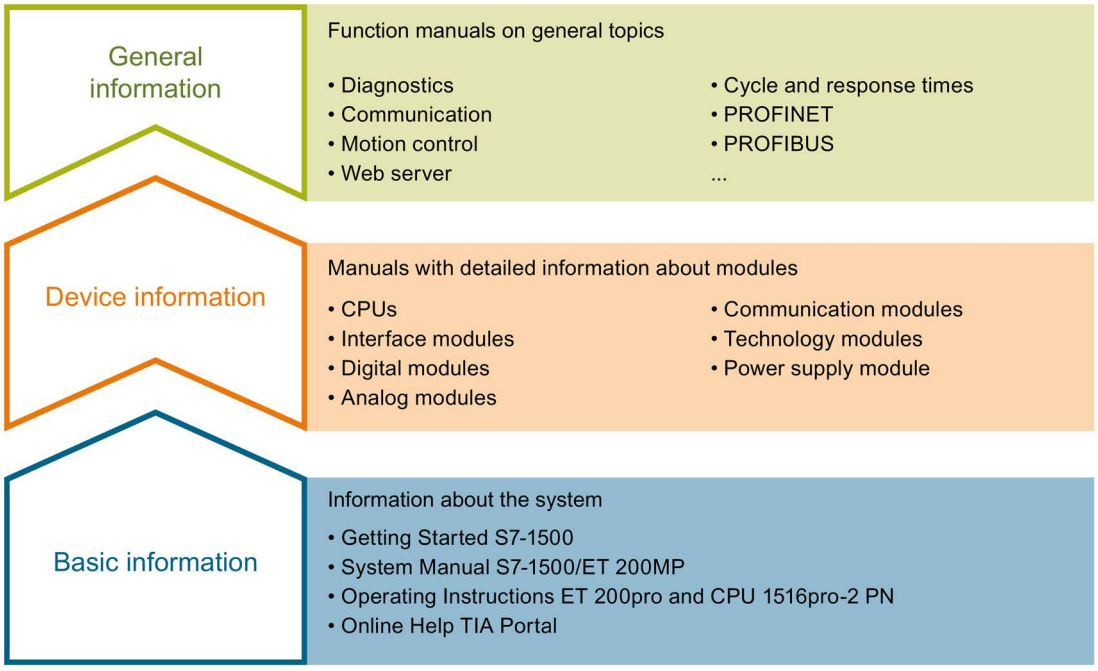
For legal reasons, we are obliged to publish the original text of the license conditions and copyright notices. Please read the information relating to this on the Internet (https://support.industry.siemens.com/cs/ww/en/view/109739516).

Table of contents

Documentation guide

1

The documentation for the SIMATIC S7-1500 automation system, the CPU 1516pro-2 PN based on SIMATIC S7-1500 and the SIMATIC ET 200MP distributed I/O system is arranged into three areas.
This arrangement enables you to access the specific content you require.



Basic information

The System Manual and Getting Started describe in detail the configuration, installation, wiring and commissioning of the SIMATIC S7-1500 and ET 200MP systems. For CPU 1516pro-2 PN you use the corresponding operating instructions. The STEP 7 online help supports you in the configuration and programming.

Device information

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

General information

The function manuals contain detailed descriptions on general topics regarding the SIMATIC S7-1500 and ET 200MP systems, e.g. diagnostics, communication, motion control, Web server, OPC UA.

You can download the documentation free of charge from the Internet (http://w3.siemens.com/mcms/industrial-automation-systems-simatic/en/manual-overview/Pages/Default.aspx).

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

You can download the product information free of charge from the Internet (https://support.industry.siemens.com/cs/us/en/view/68052815).

Manual Collection S7-1500/ET 200MP

The Manual Collection contains the complete documentation on the SIMATIC S7-1500 automation system and the ET 200MP distributed I/O system gathered together in one file.

You can find the Manual Collection on the Internet (https://support.industry.siemens.com/cs/ww/en/view/86140384).

SIMATIC S7-1500 comparison list for programming languages

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

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

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

"mySupport" - Documentation

In the Documentation area in "mySupport" you can combine entire manuals or only parts of these to your own manual.
You can export the manual as PDF file or in a format that can be edited later.

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

"mySupport" - CAx data

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

You configure your own download package with a few clicks.

In doing so you can select:

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

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

Application examples

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

You will find the application examples on the Internet (https://support.industry.siemens.com/sc/ww/en/sc/2054).

TIA Selection Tool

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

You can find the TIA Selection Tool on the Internet (http://w3.siemens.com/mcms/topics/en/simatic/tia-selection-tool).

SIMATIC Automation Tool

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

The SIMATIC Automation Tool provides a multitude of functions:

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

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

PRONETA

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

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

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

Product overview

2

2.1 Properties

Article number

6ES7531-7PF00-0AB0

View of the module

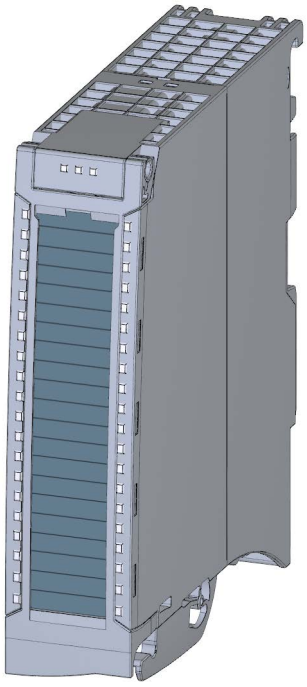


Figure 2-1 View of the AI 8xU/R/RTD/TC HF module

Properties

The module has the following technical properties:

- 9 electrically isolated analog inputs
- Measurement type can be set for each channel:
  - Voltage
  - Resistor
  - Thermal resistor (RTD)
  - Thermocouple (TC) including external compensation via CH 8 (reference channel)
- Resolution 16 bits including sign
- Two operating modes:
  - Fast: shortest integration time 2.5 ms
  - Standard: shortest integration time 7.5 ms
- Configurable diagnostics (per channel)
- Hardware interrupt on limit violation can be set per channel (two low and two high limits per channel)
- Supports thermoresistors and thermocouples according to the GOST standard

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) as of V13, SP1 and HSP 0166	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	X	--- / X
Identification data I&M0 to I&M3	V1.0.0 or higher	X	X
Parameter assignment in RUN	V1.0.0 or higher	X	X
Module internal Shared Input (MSI)	V1.0.0 or higher	X (PROFINET IO only)	X (PROFINET IO only)
Configurable submodules / submodules for Shared Device	V1.0.0 or higher	X (PROFINET IO only)	X (PROFINET IO only)
Scalable measuring range	V1.1.0 or higher	V14 or higher and HSP 0186 (only PROFINET IO)	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:

- Shield bracket
- Shield terminal
- Power supply element
- Labeling strips
- U connector
- Universal front cover

Other components

The following component can be ordered separately:

Front connectors, including potential jumpers and cable ties

You can find additional information on accessories in the S7-1500/ET 200MP (http://support.automation.siemens.com/WW/view/en/59191792) system manual.

2.2 Functions

2.2.1 Scalable measuring range

Introduction

The scalable measuring range is available for the temperature measuring ranges of thermal resistors (RTD) standard and thermocouples (TC). The measuring ranges for voltage, resistor and thermal resistor climatic are not supported.

Function

The scalable measuring range is a limited section of a measuring range supported by the module.

It allows you to increase the resolution for a configurable section.

- The "Measuring range resolution" parameter determines the resolution to 2 or 3 decimal places.
- The "Measuring range center" parameter determines the temperature over which the scalable measuring range is symmetrically spanned.

Typical areas of applications

Temperature measurements and temperature controls with high resolution save energy and are required for:

- Manufacturing of special glass
- Manufacturing of semiconductors
- Heat processes / heat treatment in metals for the aerospace industry.

Value ranges

Table 2- 2 Value ranges for the scalable measuring range

Scalable measuring range	Measuring range resolution		Values hex.
	2 decimal places	3 decimal places	
Overflow	> 325.11	> 32.511	$7FFF_H$
High limit	325.11	32.511	$7EFF_H$
Measuring range center	0	0	0_H
Low limit	-325.12	-32.512	8100_H
Underflow	<-325.12	<-32.512	8000_H

To obtain the absolute temperature, the measuring range center in the user program (as offset) must be calculated with the value of the user data of the scalable measuring range.

The measuring range center is always output in the user data as the value "0". The user data is correspondingly mapped to the bipolar input ranges in S7 format. Underflow/overflow is also formed in accordance with the limits of S7.

Rules

- The measuring range center must be within the nominal range of the underlying measuring range. It is specified in integers.
- The scalable measuring range is spanned symmetrically over the measuring range center. Depending on the resolution, different value ranges result.
- The scalable measuring range is limited by underflow and overflow of the underlying measuring range:

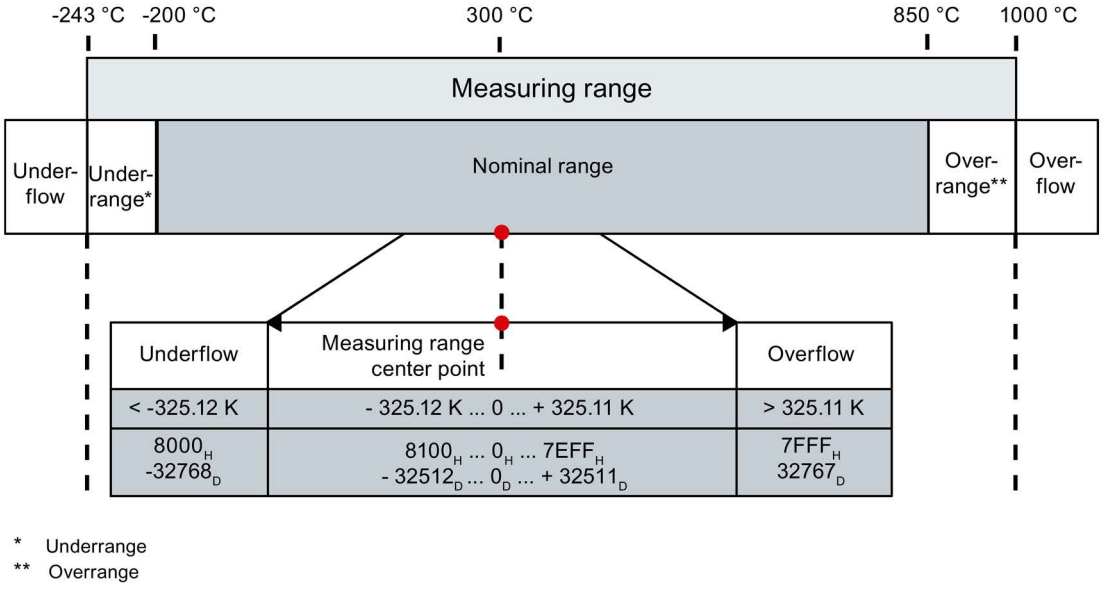
  If the low limit is violated, the scaled measuring range is cut off at the underflow.

  If the high limit is violated, the scaled measuring range is cut off at the overflow.

Examples

The following example shows the scaled measuring range with 2 decimal places for a thermal resistor Pt 100 standard.

At the scaled measuring range with 2 decimal places, the measured value lies between -325.12 K and +325.11 K around the measuring range center. In the figure, the measuring range center is drawn at 300 °C.

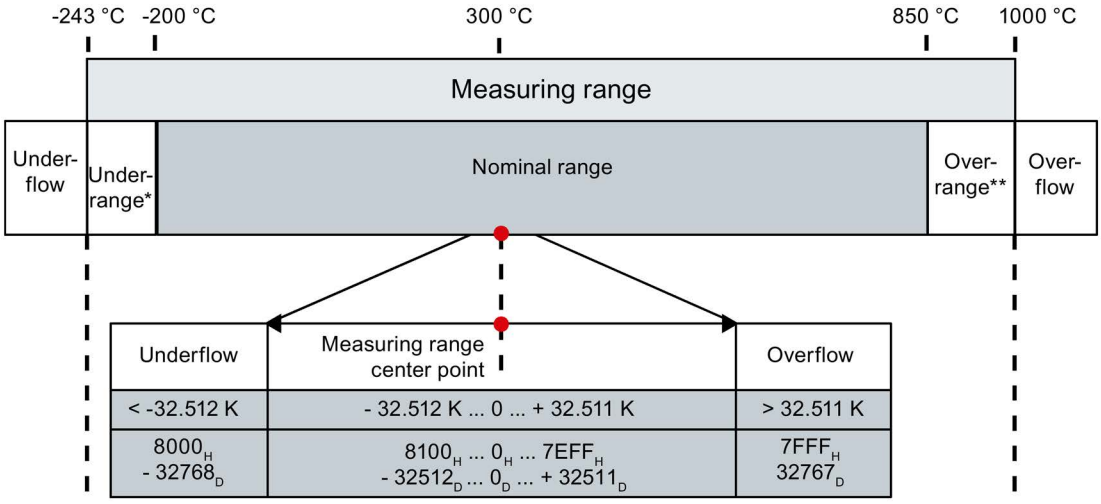


* Underrange
** Overrange

Figure 2-2 Scalable measuring range with 2 decimal places

The following example shows the scaled measuring range with 3 decimal places for a thermal resistor Pt 100 standard.

At the scaled measuring range with 3 decimal places, the measured value lies between -32.512 K and +32.511 K around the measuring range center. In the figure, the measuring range center is drawn at 300 °C.



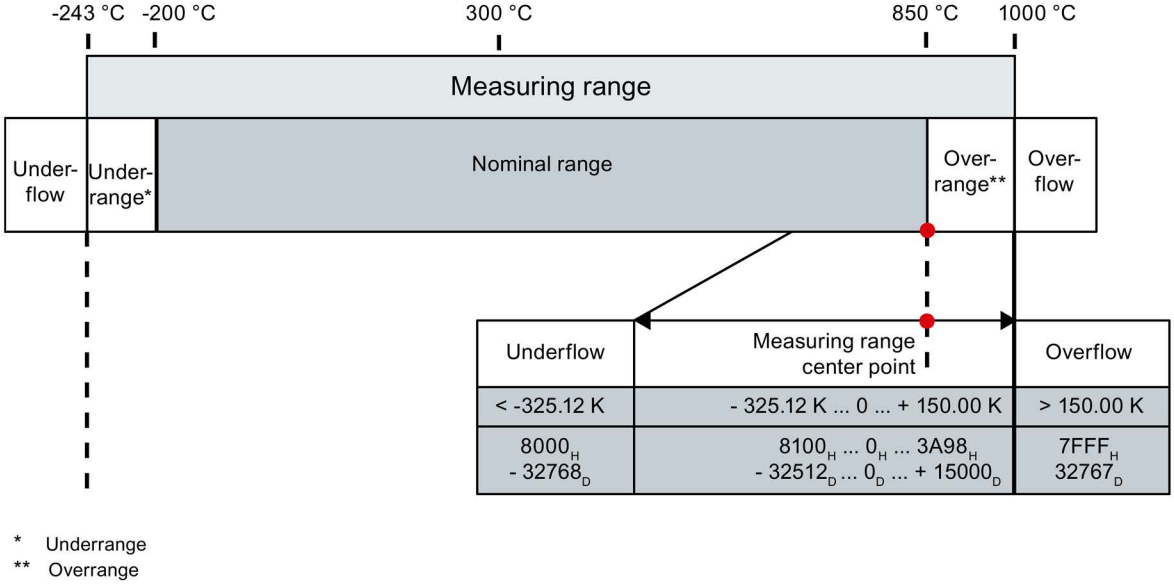
* Underrange
** Overrange

Figure 2-3 Scalable measuring range with 3 decimal places

The following example shows the scaled measuring range with 2 decimal places for a thermal resistor Pt 100 standard.

At the scaled measuring range with 2 decimal places, the measured value lies between -325.12 K and +325.11 K around the measuring range center. In the figure, the measuring range center is drawn at 850 °C.

The measuring range is cut off at 150.00 K, because the limit to the overflow has been exceeded at 1000 °C (clipping).



* Underrange
** Overrange

Figure 2-4 Scalable measuring range with 2 decimal places that is cut off at the overflow (clipping).

2.2.2 Configuration

Requirements

- Firmware version V1.1.0 or higher of the module.
- Selection of a valid temperature measuring range.

Configuration

The function is activated using the "Scalable measuring range" parameter.

The following figure shows an example for the configuration:

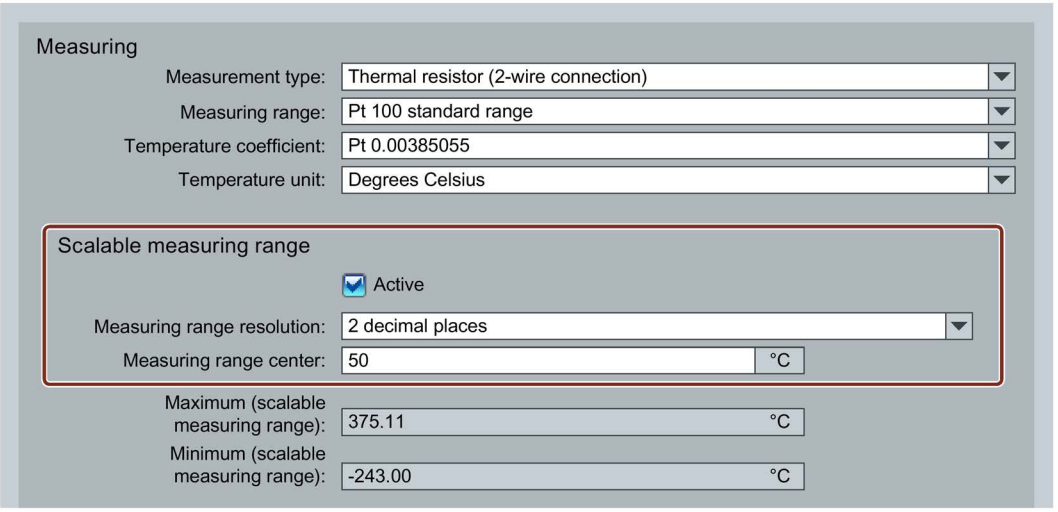


Figure 2-5 Configuration for the scalable measuring range

Reference

You can find additional information on configuration in the STEP 7 online help.

In the user program, you can evaluate the status and the limits of the scalable measuring range with data record 235, see Appendix (Page 68).

Wiring

3

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

You can find information on wiring the front connector, creating a cable shield, etc. in the Wiring section of the S7-1500/ET 200MP (http://support.automation.siemens.com/WW/view/en/59191792) system manual.

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 the data record for dynamic reference temperature (Page 66).

Note

- You may use and combine the different wiring options for all channels.
- Do not insert the potential jumpers included with the front connector!

Abbreviations used

Meaning of the abbreviations used in the following figures:

U_n+/U_n-	Voltage input channel n (voltage only)
M_n+/M_n-	Measuring input channel n
$I_{c\,n}+/I_{c\,n}-$	Current output for RTD, channel n
L+	Supply voltage connection
M	Ground connection

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 44 (M). You can use terminals 42 (L+) and 43 (M) to loop the potential to the next module.

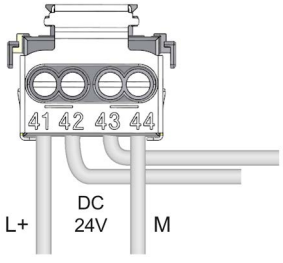
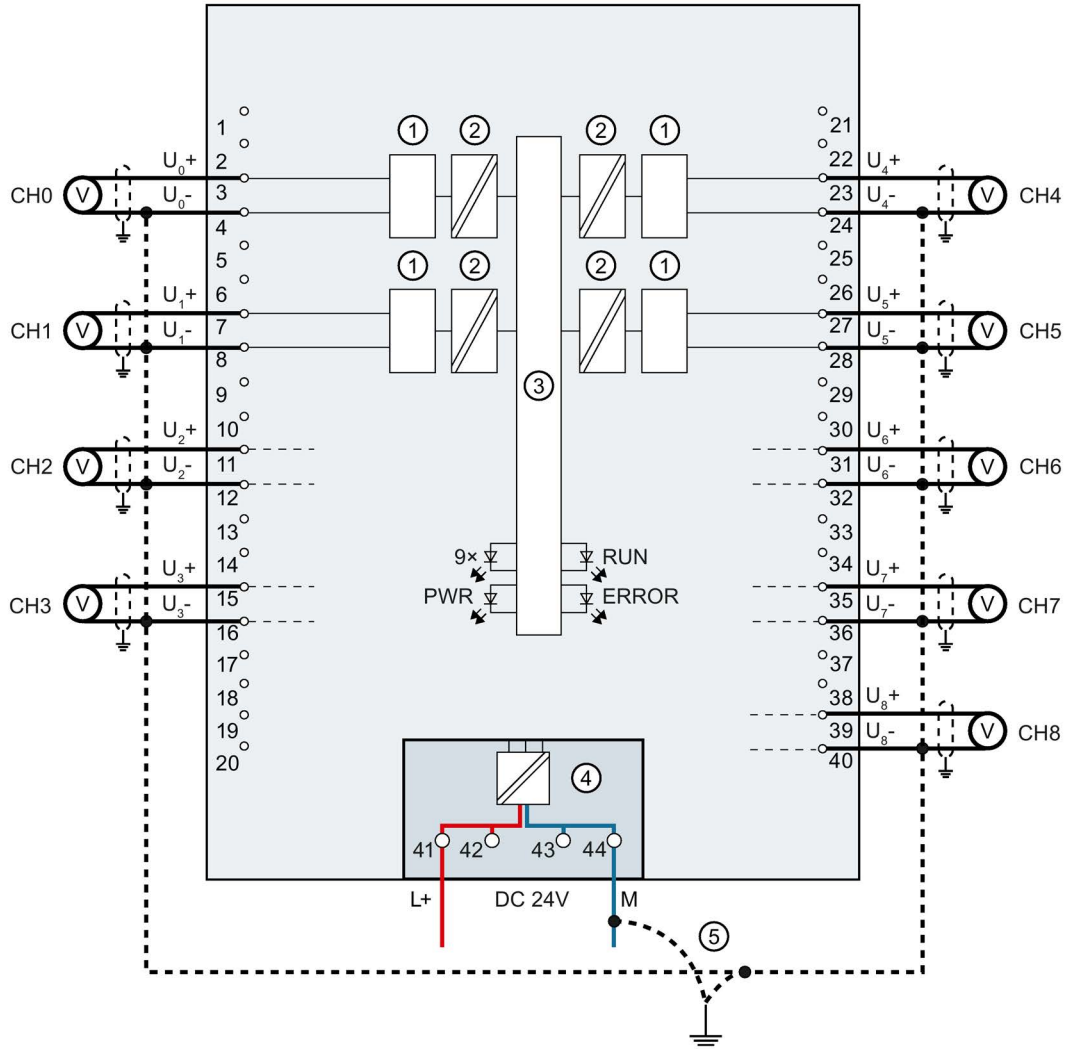


Figure 3-1 Power supply element wiring

Block diagram and pin assignment for voltage measurement

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

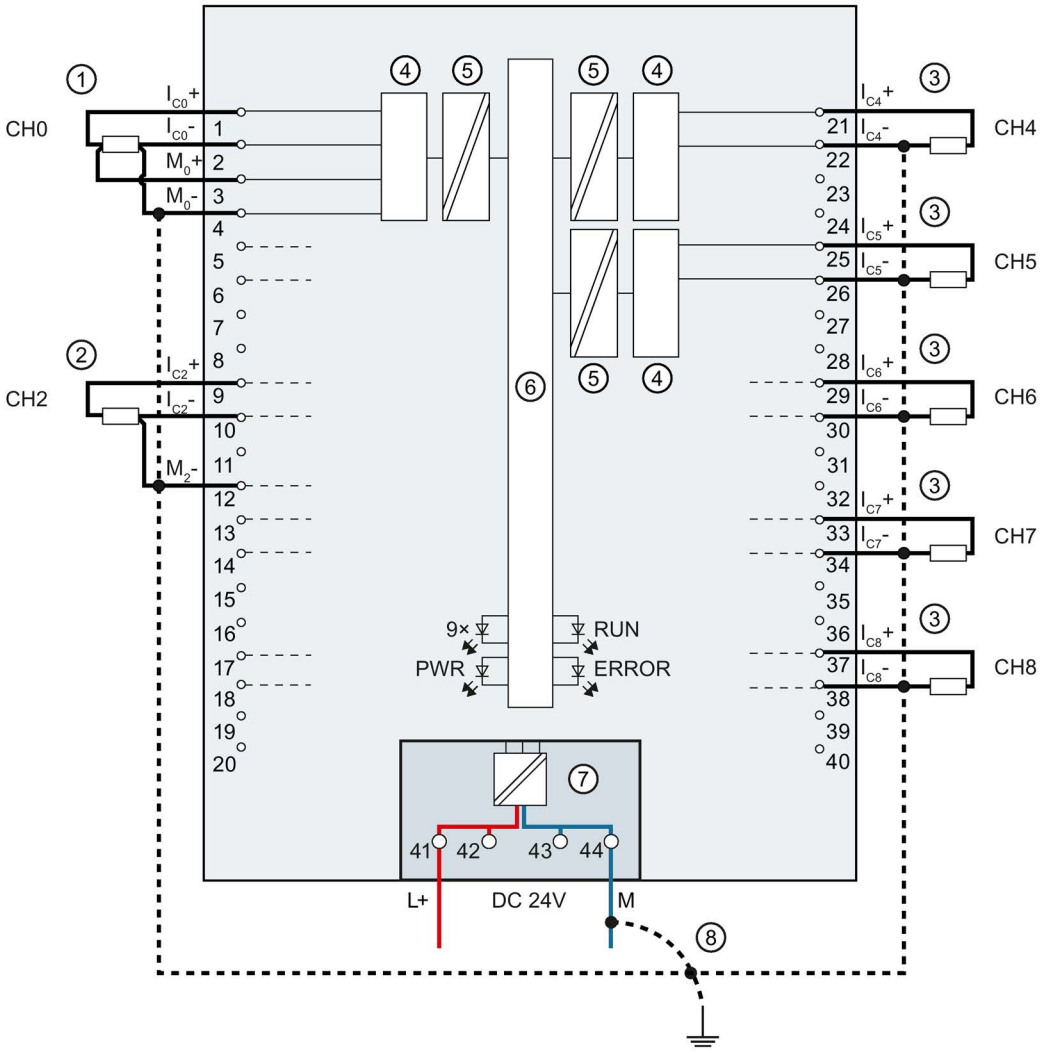


①	Analog-to-Digital Converter (ADC)	CHx	Channel or 9 x channel status (green/red)
②	Electrical isolation	RUN	Status display LED (green)
③	Backplane bus interface	ERROR	Error display LED (red)
④	Supply voltage via power supply element	PWR	LED for power supply (green)
⑤	Equipotential bonding cable (optional)		

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

Connection: 2, 3 and 4-wire connection of resistance-type transmitters or resistance thermometers (RTD)

The example in the following figure shows the pin assignment for 2, 3 and 4-wire connections of resistance-type transmitters or resistance thermometers.

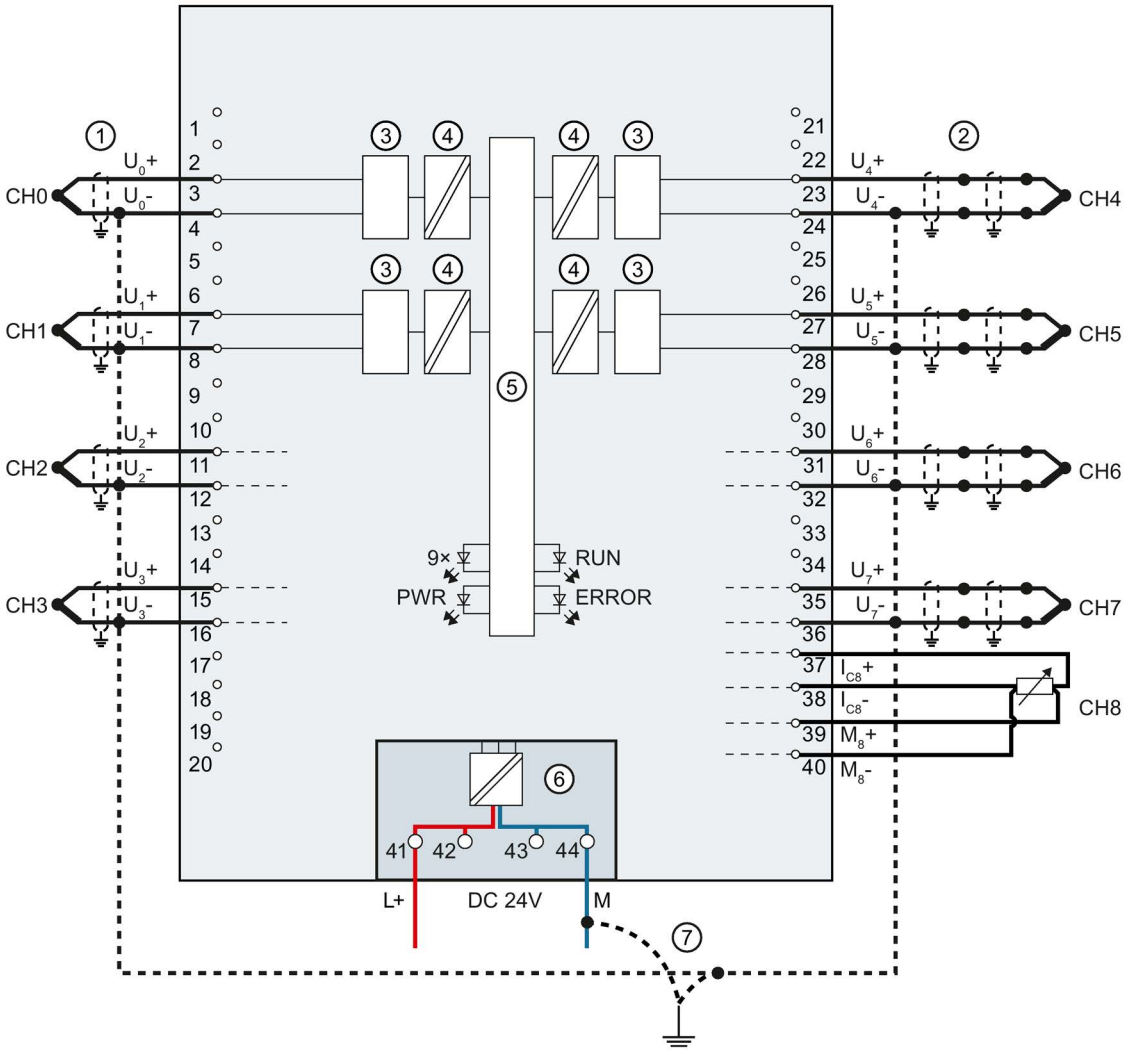


①	4-wire connection	CHx	Channel or 9 x channel status (green/red)
②	3-wire connection	RUN	Status display LED (green)
③	2-wire connection	ERROR	Error display LED (red)
④	Analog-to-Digital Converter (ADC)	PWR	LED for power supply (green)
⑤	Electrical isolation		
⑥	Backplane bus interface		
⑦	Supply voltage via power supply element		
⑧	Equipotential bonding cable (optional)		

Figure 3-3 Block diagram and terminal assignment for 2, 3, and 4-wire connection

Connection: Non-grounded thermocouples for external/internal compensation and connection of a resistance thermometer (RTD) to channel 8 (CH8) or the reference channel

The following figure shows an example of the pin assignment of non-grounded thermocouples for external/internal compensation and the connection of a resistance thermometer (RTD) at the reference channel.

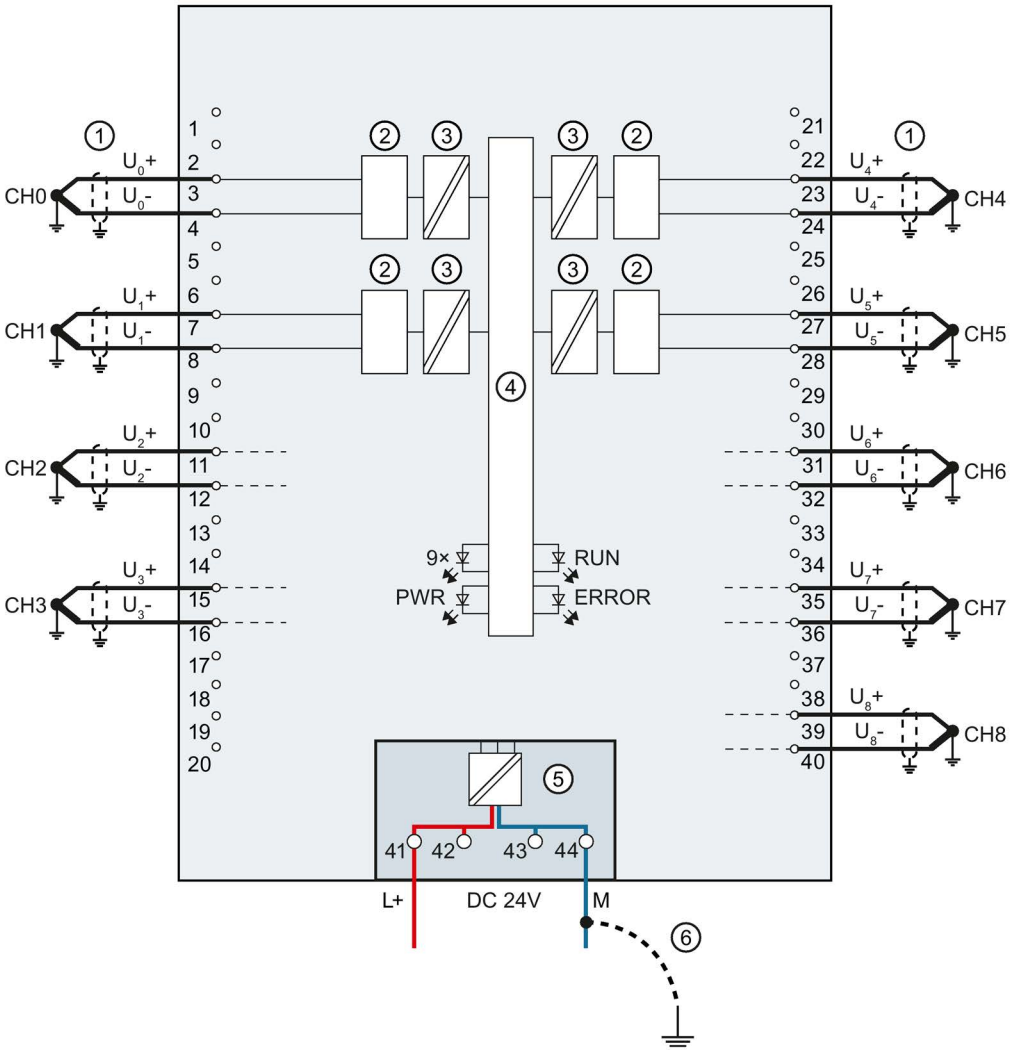


①	Wiring of a thermocouple (non-grounded) for internal compensation	CHx	Channel or 9 x channel status (green/red)
②	Wiring of a thermocouple (non-grounded) for external compensation	RUN	Status display LED (green)
③	Analog-to-Digital Converter (ADC)	ERROR	Error display LED (red)
④	Electrical isolation	PWR	LED for power supply (green)
⑤	Backplane bus interface		
⑥	Supply voltage via power supply element		
⑦	Backplane bus interface potential bonding cable (optional)		

Figure 3-4 Block diagram and pin assignment for non-grounded thermocouples and resistance thermometers

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	CHx	Channel or 9 x channel status (green/red)
②	Analog-to-Digital Converter (ADC)	RUN	Status display LED (green)
③	Electrical isolation	ERROR	Error display LED (red)
④	Backplane bus interface	PWR	LED for power supply (green)
⑤	Supply voltage via power supply element		
⑥	Equipotential bonding cable (optional)		

Figure 3-5 Block diagram and pin assignment for grounded thermocouples

Parameters/address space

4

4.1 Measuring types and ranges

Introduction

The module has a default measurement type resistance thermometer RTD (4-wire connection) and the measuring range Pt100 Standard. You need to reassign the module parameters with STEP 7 if you want to use a different measurement type or range.

You use temperature coefficients to determine the measuring ranges for resistance thermometers / thermocouples according to the GOST standard. You can find the adjustable temperature coefficients in the Parameter assignment and structure of the parameter data records (Page 56) section in the table Coding for temperature coefficient.

You can find the analog values for the usable resistance thermometer / thermocouples in the sections Analog value representation for resistance-type transmitters / resistance thermometers (Page 74) and Representation of analog values for thermocouples (Page 80).

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

Table 4- 1 Measuring types and ranges

Measurement type	Measuring range	Representation of analog values
Voltage	±25 mV ±50 mV ±80 mV ±250 mV ±500 mV ±1 V	See Appendix Representation of analog values in voltage measuring ranges (Page 73).
Resistor (2-wire connection)	150 Ω 300 Ω 600 Ω 6000 Ω PTC	
Resistor (3-wire connection) (4-wire connection)	150 Ω 300 Ω 600 Ω 6000 Ω	

Measurement type	Measuring range	Representation of analog values
Thermal resistor RTD (2-wire connection) (3-wire connection) (4-wire connection)	Pt10 Standard/Climatic Pt50 Standard/Climatic Pt100 Standard/Climatic Pt200 Standard/Climatic Pt500 Standard/Climatic Pt1000 Standard/Climatic Ni10 Standard/Climatic Ni100 standard/climate Ni120 Standard/Climatic Ni200 Standard/Climatic Ni500 Standard/Climatic Ni1000 standard/climate LG-Ni1000 standard/climate Cu10 Standard/Climatic Cu50 Standard/Climatic Cu100 Standard/Climatic	
Thermocouple TC	Type B Type C Type E Type J Type K Type N Type R Type S Type T Type TXK	See Appendix Representation of analog values for thermocouples (Page 80).
Deactivated	-	

The tables of the input ranges, overflow, undershoot range, etc. are available in appendix Representation of analog values (Page 71).

Using 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. Select "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 following figure shows the address space assignment for the AI 8xU/R/RTD/TC HF module with PTC resistors.

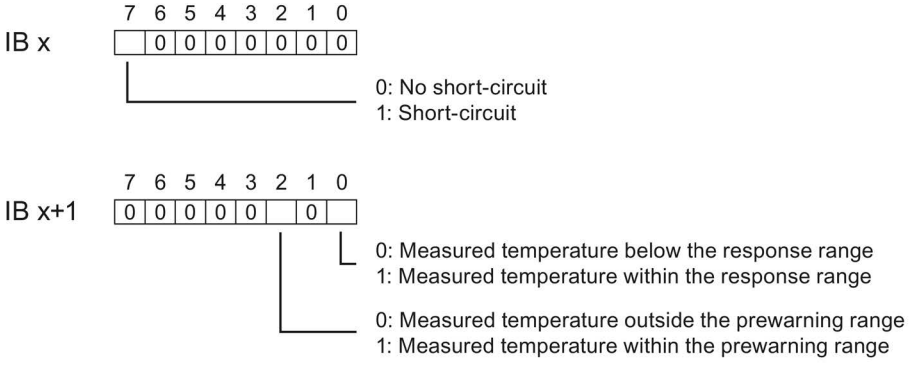


Figure 4-1 Address space for the AI 8xU/R/RTD/TC HF module with PTC resistors

The diagram below shows the temperature profile and the corresponding switching points.

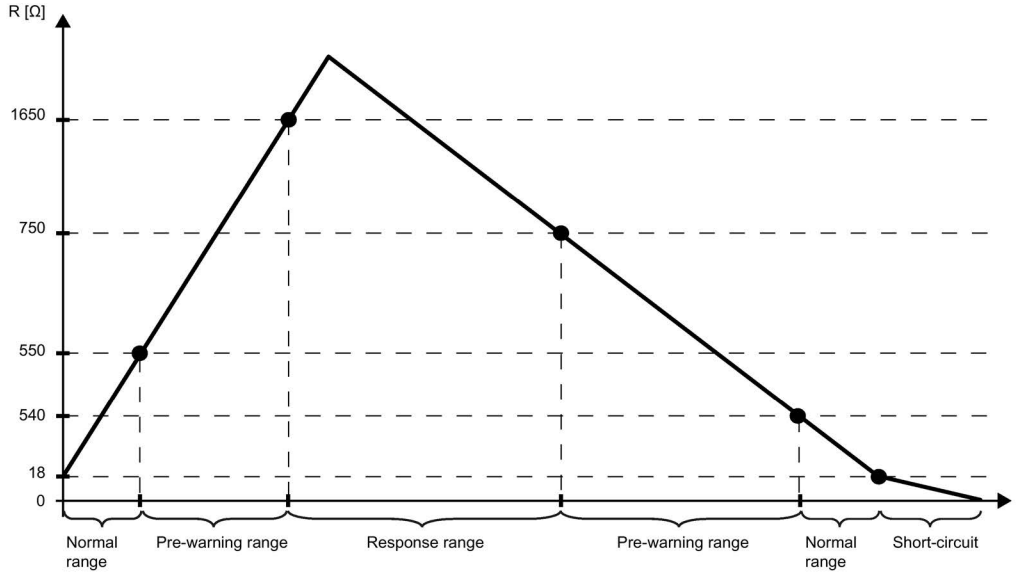


Figure 4-2 Temperature profile and the corresponding switching points

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

Parameters of AI 8xU/R/RTD/TC HF

The AI 8xU/R/RTD/TC HF is usually already integrated in the hardware catalog of STEP 7 (TIA Portal). In this case, STEP 7 (TIA Portal) checks the configured properties for plausibility during configuration.

However, you can also assign parameters to the module by means of a GSD file and the configuration software of any provider. The module does not check the validity of the configured properties until after the configuration has been loaded.

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 56).

The following parameter settings for the channels are possible:

Table 4- 2 Configurable parameters and their defaults

Parameters	Range of values	Default setting	Parameter assignment in RUN	Scope with configuration software, e.g., STEP 7 (TIA Portal)	
				Integrated in the hardware catalog STEP 7 (TIA Portal) as of V12 or GSD file PROFINET IO	GSD file PROFIBUS DP
Diagnostics					
• Missing supply voltage L+	Yes/No	No	Yes	Channel [1]	Module [2]
• Overflow	Yes/No	No	Yes	Channel	Module [2]
• Underflow	Yes/No	No	Yes	Channel	Module [2]
• Reference channel error	Yes/No	No	Yes	Channel	Module [2]
• Wire break	Yes/No	No	Yes	Channel	Module [2]
Measuring					
• Measurement type	See section Measuring types and ranges (Page 24)	Thermal resistor RTD (4-wire connection	Yes	Channel	Channel
• Measuring range		Pt100 standard	Yes	Channel	Channel
• Operating mode	• Standard • Fast	Standard	Yes	Channel	--- [4]
• Temperature coefficient	Pt: 0.003851 Pt: 0.003902 Pt: 0.003910 GOST Pt: 0.003916 Pt: 0.003920 Ni: 0.006170 GOST Ni: 0.006180 Ni: 0.006720 Cu: 0.00426 GOST Cu: 0.00427 Cu: 0.00428 GOST LG-Ni: 0.005000	0.003851	Yes	Channel	Channel
• Temperature unit	• Kelvin (K) • Fahrenheit (°F) • Celsius (°C)	°C	Yes	Channel	Module

Parameters	Range of values	Default setting	Parameter assignment in RUN	Scope with configuration software, e.g., STEP 7 (TIA Portal)	
				Integrated in the hardware catalog STEP 7 (TIA Portal) as of V12 or GSD file PROFINET IO	GSD file PROFIBUS DP
• 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 for TC	• Fixed reference temperature • Dynamic reference temperature • Internal reference junction • Reference channel of the module [3)]	Internal reference junction	Yes	Channel	Module [4)] • Dynamic reference temperature • Internal reference junction • Reference channel of the module
• Fixed reference temperature	Temperature	25 °C	Yes	Channel	--- [4)]
• Scalable measuring range	• Disable • Enable	Disable	Yes	Channel	Channel [4)]
• Measuring range resolution	• 2 decimal places • 3 decimal places	2 decimal places	Yes	Channel	Channel [4)]
• Measuring range center	Value within the nominal range of the measuring range	0	Yes	Channel	Channel [4)]

Parameters	Range of values	Default setting	Parameter assignment in RUN	Scope with configuration software, e.g., STEP 7 (TIA Portal)	
				Integrated in the hardware catalog STEP 7 (TIA Portal) as of V12 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 message burst by assigning the diagnostics function to one channel only.

2) You can set the effective range of the diagnostics for each channel in the user program with data records 0 to 8.

3) The setting is only possible for channels 0 to 7. If you use the "Reference channel of the module" setting for at least one channel, you need to operate channel 8 with the resistance thermometer RTD measurement type.

4) You can configure the "Fixed reference temperature" setting and the limits for hardware interrupts in the user program with data records 0 to 8.

4.3 Declaration of parameters

Missing 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 ± 25 mV to ± 1.0 V if the inputs are not connected.

Reference channel error

- Enable diagnostics for an error at the temperature compensation channel, e.g. wire break.
- Dynamic reference temperature compensation type is configured and no reference temperature has been transferred to the module yet.

Wire break

Enable for diagnostics to check the cable resistances.

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

Suppresses the interference affecting analog input modules that is caused by the frequency of the AC voltage network used.

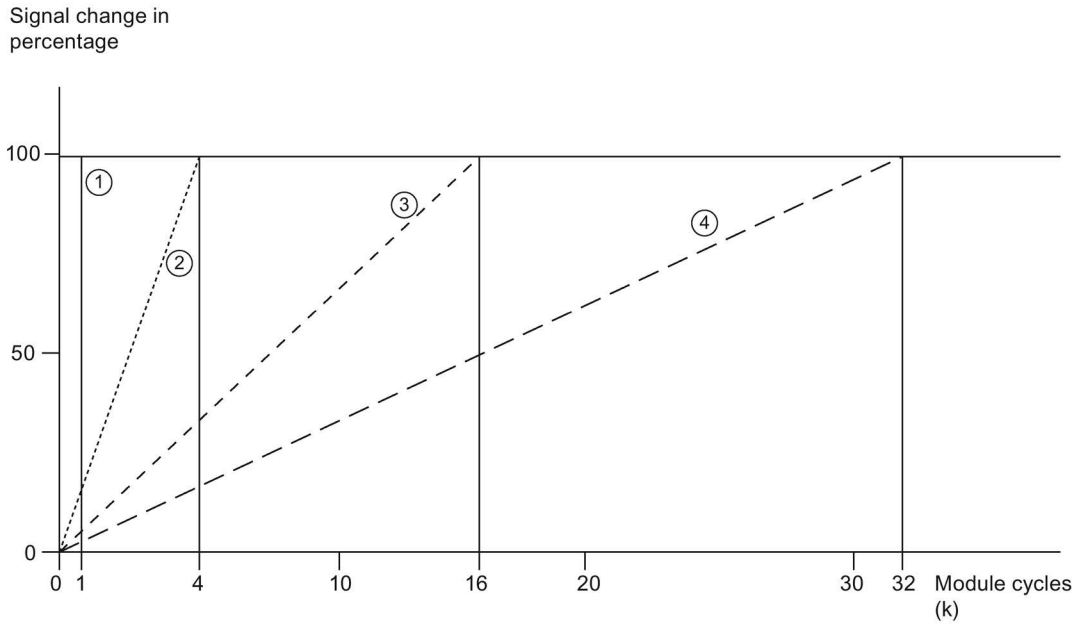
The frequency of the AC voltage network can negatively affect the measured value, in particular when measuring in low voltage ranges and with thermocouples. With this parameter, the user specifies the line frequency that is predominant in the plant.

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 after how many module cycles the smoothed analog value is almost 100%, depending on the set smoothing. 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 8xU/R/RTD/TC HF

Reference junction for TC

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 200 using the WRREC (SFB 53) instruction.
Internal reference junction	The reference junction temperature is determined using an integrated sensor of the module.
Reference channel of the module	The reference junction temperature is determined using an external resistance thermometer (RTD) at the reference channel (CH8) of the module.

Hardware interrupt 1 or 2

Enable 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.

Operating mode Fast / Standard

You can use this parameter to determine the operating mode for the module.

- Fast mode; easy integration time with less frequency suppression (minimal integration time 2.5 ms)
- Standard mode; triple integration time with higher frequency suppression (minimal integration time 7.5 ms)

Scalable measuring range

With this parameter, you disable or enable the scalable measuring range function.

Measuring range resolution

With this parameter, you determine the resolution to 2 or 3 decimal places.

Measuring range center

With this parameter, you determine the temperature over which the scaled measuring range is symmetrically spanned. The value must be within the nominal range of the underlying measuring range. It is specified in integers.

Maximum = overflow (scaled measuring range)

Minimum = underflow (scaled measuring range)

4.4 Address space

The module can be configured differently in STEP 7; see following table. Depending on the configuration, additional/different addresses are assigned in the process image of the inputs.

Configuration options of AI 8xU/R/RTD/TC HF

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 the hardware catalog STEP 7 (TIA Portal) as of V13, SP1 and HSP 0166	GSD file in STEP 7 (TIA Portal) V12 or higher or STEP 7 V5.5 SP3 or higher
1 x 9-channel without value status	AI 8xU/R/RTD/TC HF	X	X
1 x 9-channel with value status	AI 8xU/R/RTD/TC HF QI	X	X
9 x 1-channel without value status	AI 8xU/R/RTD/TC HF S	X (PROFINET IO only)	X (PROFINET IO only)
9 x 1-channel with value status	AI 8xU/R/RTD/TC HF S QI	X (PROFINET IO only)	X (PROFINET IO only)
1 x 9-channel with value status for module-internal shared input with up to 4 submodules	AI 8xU/R/RTD/TC HF MSI	X (PROFINET IO only)	X (PROFINET IO only)

Value status (Quality Information, QI)

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

- AI 8xU/R/RTD/TC HF QI
- AI 8xU/R/RTD/TC HF S QI
- AI 8xU/R/RTD/TC HF 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 of the AI 8xU/R/RTD/TC HF and AI 8xU/R/RTD/TC HF QI

The following figure shows the address space allocation for the configuration as a 9-channel module. You can freely assign the start address for the module. The addresses of the channels are derived from the start address.

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

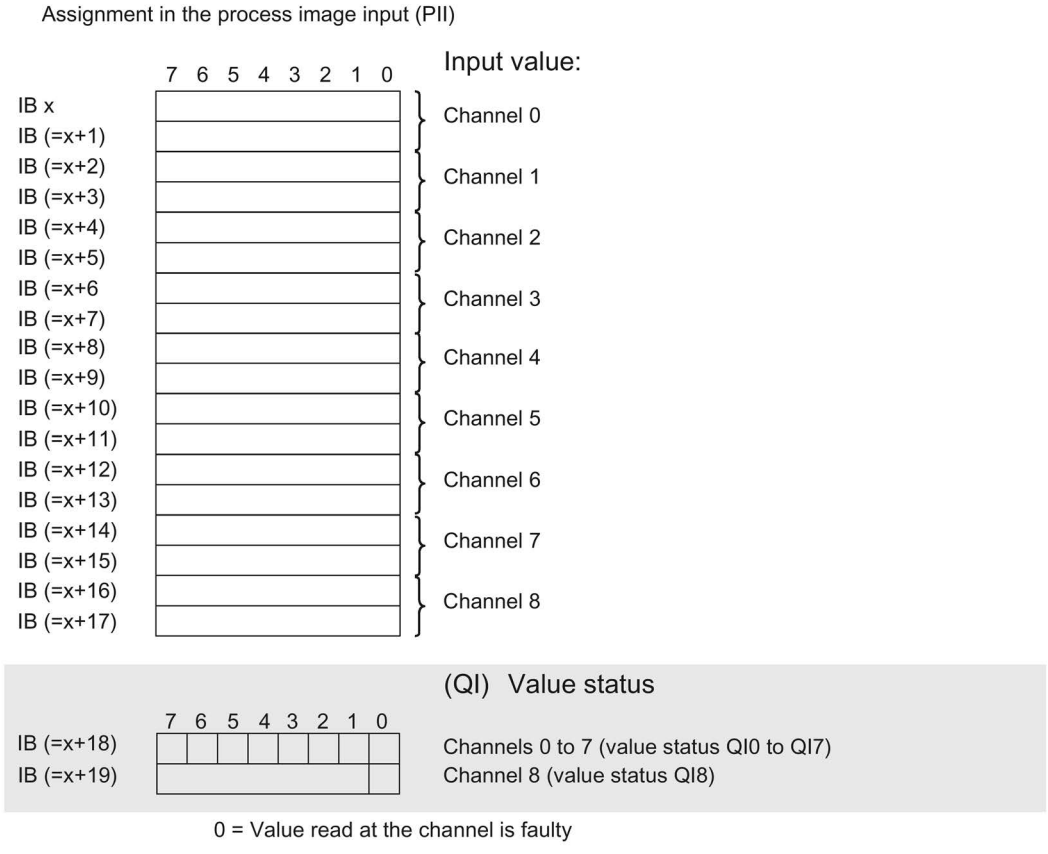


Figure 4-4 Address space for configuration as 1 x 9-channel AI 8xU/R/RTD/TC HF with value status

Address space for configuration as 9 x 1-channel AI 8xU/R/RTD/TC HF S and AI 8xU/R/RTD/TC HF S QI

For the configuration as a 9 x 1-channel module, the channels of the module are divided into multiple submodules. The submodules can be assigned to different IO controllers when the module is used in a shared device.

The number of usable submodules is dependent on the interface module used. Observe the information in the manual for the particular interface module.

In contrast to the 1 x 9-channel module configuration, each of the nine submodules has a freely assignable start address.

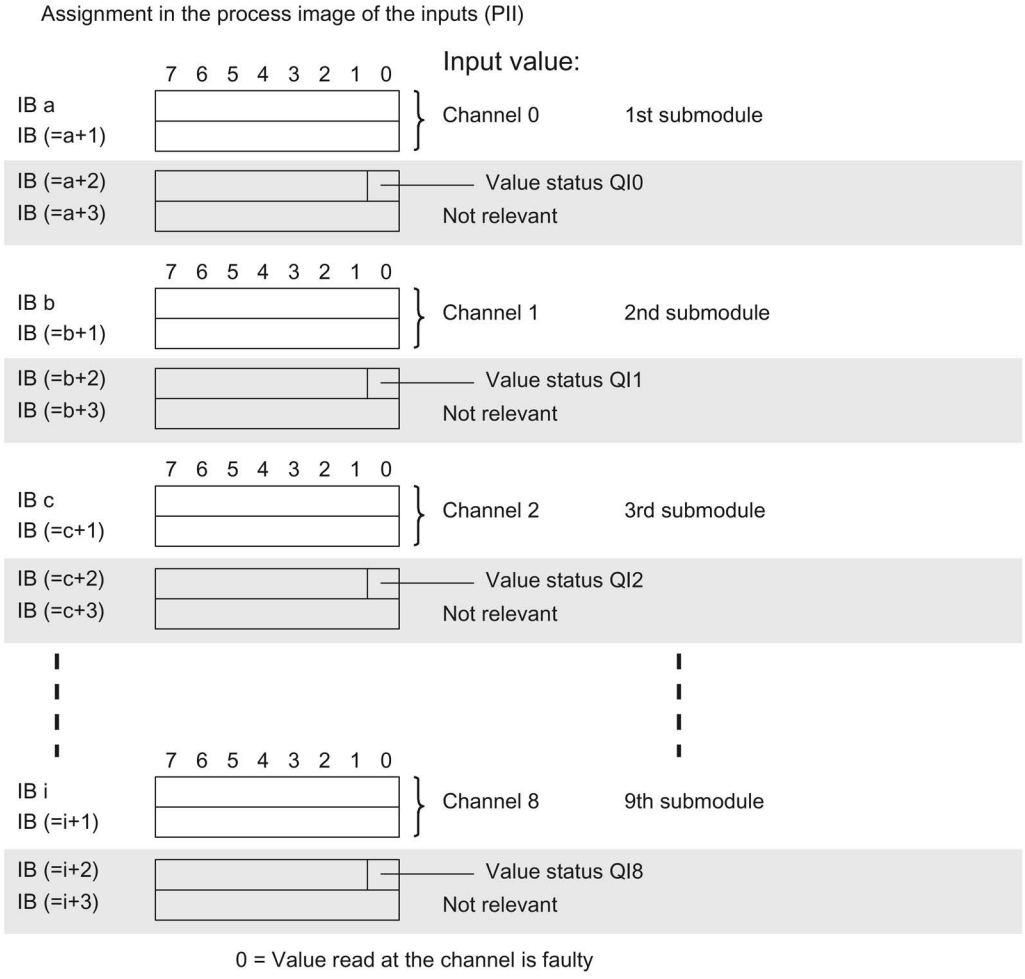


Figure 4-5 Address space for configuration as 9 x 1-channel AI 8xU/R/RTD/TC HF S QI with value status

Address space for configuration as 1 x 9-channel AI 8xU/R/RTD/TC HF MSI

The channels 0 to 8 of the module are copied in up to 4 submodules for the configuration as 1 x 9-channel module (module-internal shared input, MSI). Channels 0 to 8 are then available with identical input values in various 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 usable submodules is dependent on the interface module used. Please observe the information in the manual for the particular interface module.

Value status (Quality Information, QI)

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

For the 1st submodule (= basic 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 basic submodule has not yet been configured (not ready).

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

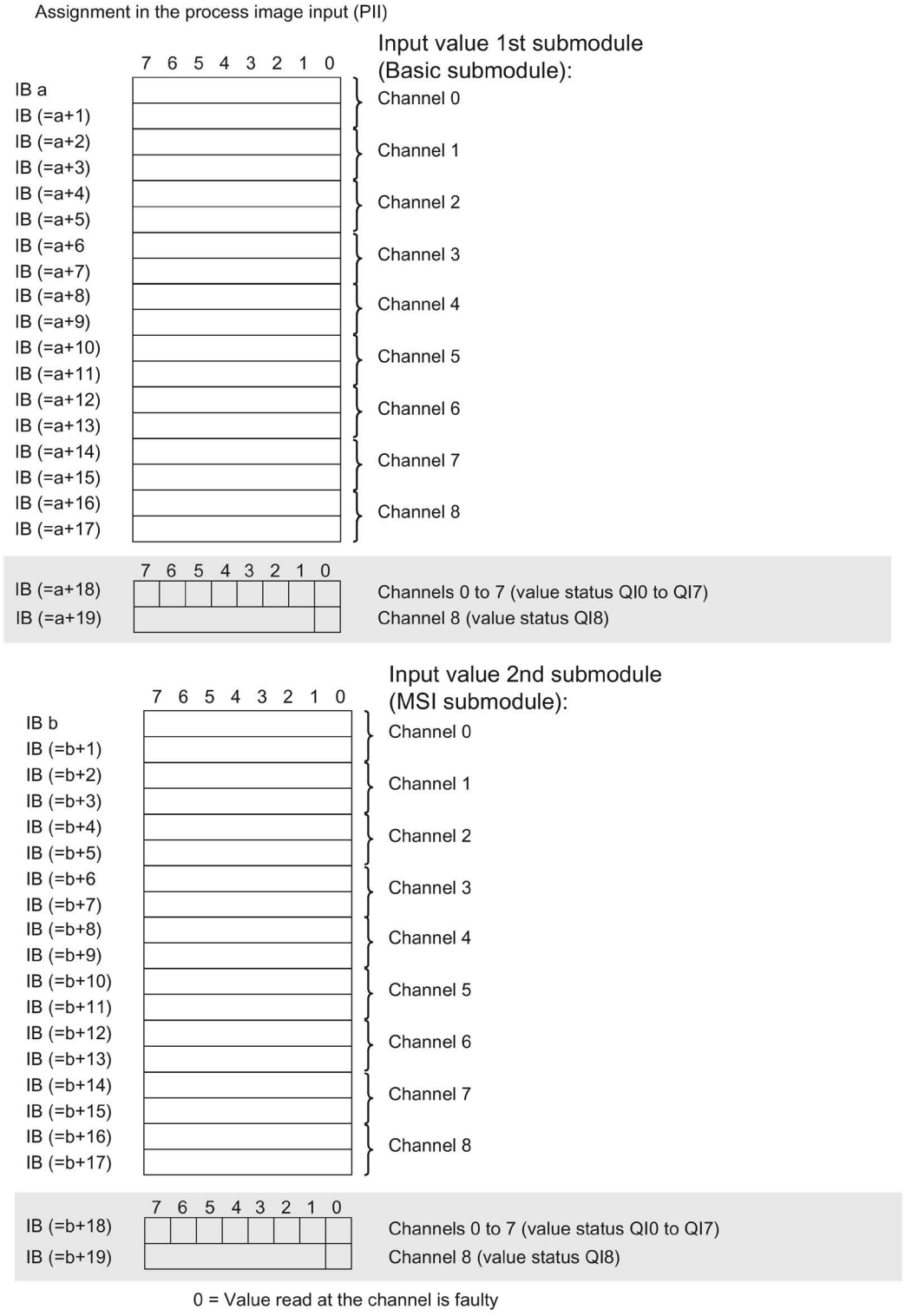


Figure 4-6 Address space for configuration as 1 x 9-channel AI 8xU/R/RTD/TC HF MSI with value status

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

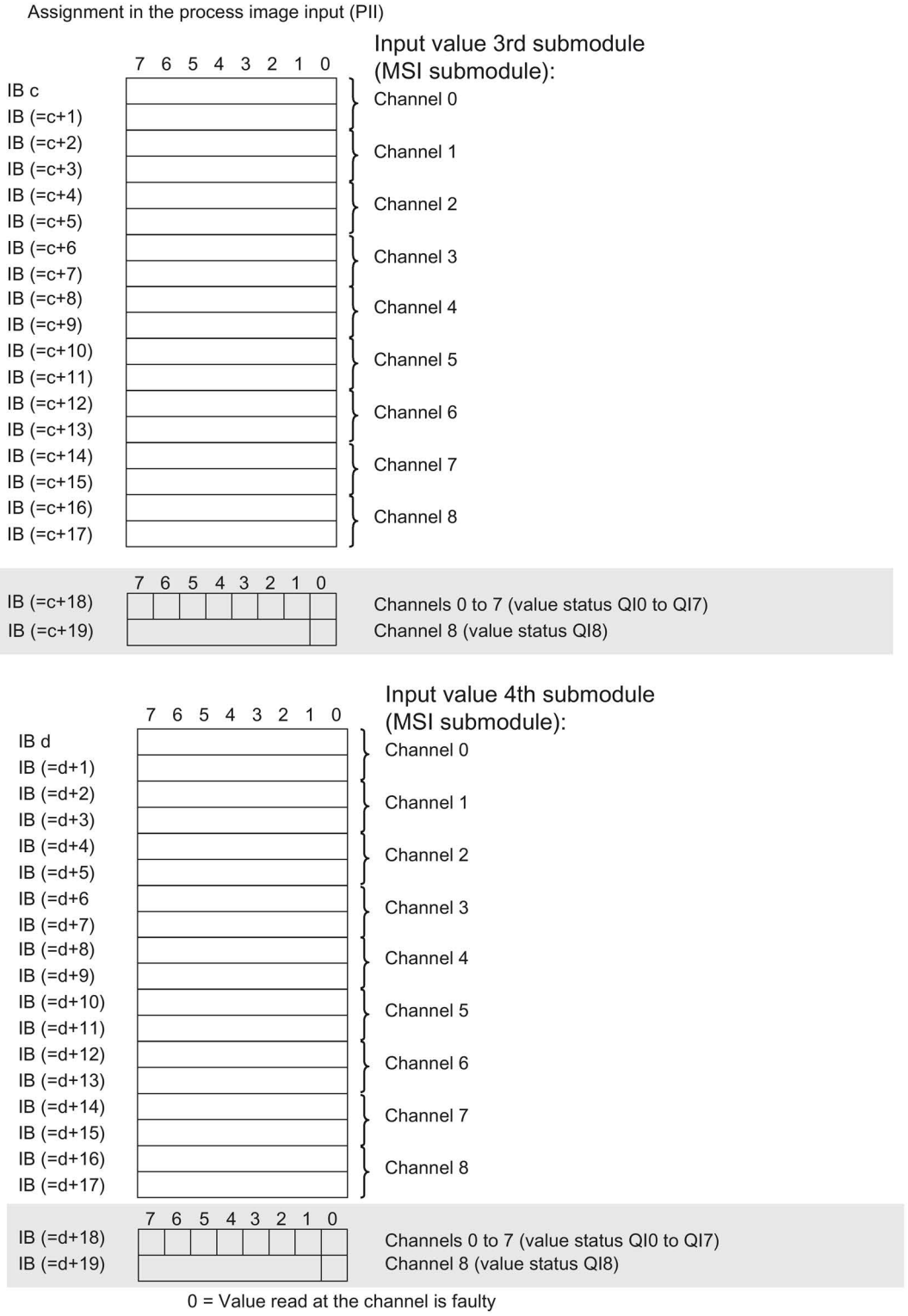


Figure 4-7 Address space for configuration as 1 x 9-channel AI 8xU/R/RTD/TC HF MSI with value status

Reference

You can find information on the Shared Input/Output (MSI/MSO) function in the section Module-Internal Shared Input/Output (MSI/MSO) of the PROFINET with STEP 7 V13 (https://support.industry.siemens.com/cs/ww/en/view/49948856) function manual.

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 8xU/R/RTD/TC HF.

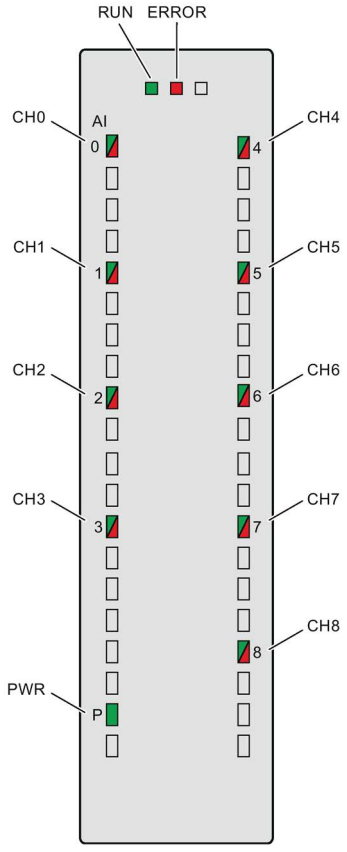


Figure 5-1 LED displays of the module AI 8xU/R/RTD/TC HF

Meaning of the LED displays

The following tables explain the meaning of the status and error displays. Remedial measures for diagnostic alarms can be found in section Diagnostic alarms (Page 45).

RUN and ERROR LED

Table 5- 1 Status and error displays RUN and ERROR

LEDs		Meaning	Remedy
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 whether too many modules are inserted.
Flashes	Off	The module starts and flashes until the valid parameter assignment 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	Remedy
Off	Supply voltage L+ to module too low or missing	Check supply voltage L+.
On	Supply voltage L+ is present and OK.	---

CHx LED

Table 5- 3 CHx status display

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

5.2 Interrupts

Analog input module AI 8xU/R/RTD/TC HF supports the following diagnostic and hardware interrupts.

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

Diagnostic interrupt

The module generates a diagnostic interrupt at the following events:

- Missing supply voltage L+
- Wire break
- Overflow
- Underflow
- Reference channel error
- Parameter assignment error

Hardware interrupt

The module generates a hardware interrupt at the following events:

- Low limit violated 1
- High limit violated 1
- Low limit violated 2
- Violation of high limit 2

The module channel that triggered the hardware interrupt is entered in the start information of the organization block. The following figure shows the assignment of the local data double word 8 by the start information of the hardware interrupt organization block.

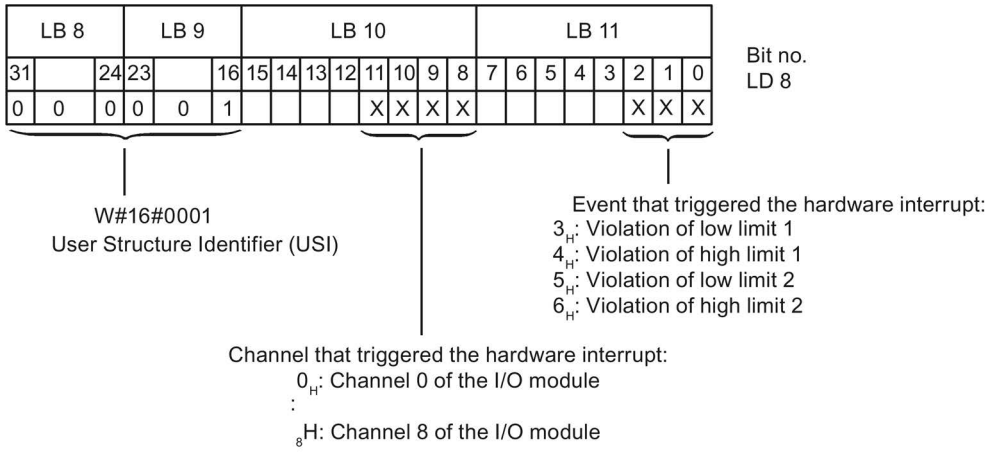


Figure 5-2 OB start information

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 follows the error 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	Violation of high limit 2	

5.3 Diagnostics alarms

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

If the module is operated distributed with PROFIBUS DP in an ET 200MP system, you have the option to read out diagnostics data with the instruction RDREC or RD_REC using data record 0 and 1. The structure of the data records is available on the Internet in the "Manual for interface module IM 155-5 DP ST (6ES7155-5BA00-0AB0)".

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

Diagnostics alarm	Error code	Meaning	Remedy
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
Parameter assignment error	10_H	• The module cannot evaluate parameters for the channel • Incorrect parameter assignment.	Correct the parameter assignment
Load voltage missing	11_H	Supply voltage L+ of the module is missing	Connect supply voltage L+ to module
Reference channel error	15_H	Invalid reference temperature for the used TC channel with compensation	Check compensation with reference channel parameterization or thermoresistor. Check communication to the module/station for the compensation with data record.

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 "Underflow" diagnostics, but the module detects the previous "Wire break" diagnostics and aborts after this error message. The "Underflow" diagnostics is not detected.

Recommendation: To ensure that all errors are subjected to the diagnostics, select all check boxes under "Diagnostics".

Technical specifications

6

Technical specifications of the AI 8xU/R/RTD/TC HF

	6ES7531-7PF00-0AB0
General information	
Product type designation	AI 8xU/R/RTD/TC HF
Hardware functional status	FS01
Firmware version	V1.1.0
• FW update possible	Yes
Product function	
I&M data	Yes; I&M0 to I&M3
Measuring range scalable	Yes
Measured values scalable	No
Measuring range adjustment	No
Engineering with	
STEP 7 TIA Portal can be configured/integrated as of version	V14 / -
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	
Oversampling	No
MSI	Yes
CiR Configuration in RUN	
Configuration 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.	55 mA; with 24 V DC supply
Power	
Power consumption from the backplane bus	0.85 W
Power loss	
Power loss, typ.	1.9 W

	6ES7531-7PF00-0AB0
Analog inputs	
Number of analog inputs	8; plus an additional RTD (reference) channel
• For voltage measurement	8; plus an additional RTD (reference) channel
• For resistance/resistance thermometer measurement	8; plus an additional RTD (reference) channel
• for thermocouple measurement	8; plus an additional RTD (reference) channel
Permissible input voltage for voltage input (destruction limit), max.	20 V
Technical unit for temperature measurement, can be set	Yes; °C / °F / K
Input ranges (rated values), voltages	
-1 to +1 V	Yes
Input resistance (-1 to +1 V)	10 MΩ
-25 mV to +25 mV	Yes
Input resistance (-25 mV to +25 mV)	10 MΩ
-250 to +250 mV	Yes
Input resistance (-250 to +250 mV)	10 MΩ
-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), thermocouples	
Type B	Yes
Input resistance (type B)	10 MΩ
Type C	Yes
Input resistance (Type C)	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
Type TXK/TXK(L) according to GOST	Yes

	6ES7531-7PF00-0AB0
Input resistance (Type TXK/TXK(L) according to GOST)	10 MΩ
Input ranges (rated values), resistance thermometer	
Cu 10	Yes; Standard/Climatic
Input resistance (Cu 10)	10 MΩ
Cu 10 according to GOST	Yes; Standard/Climatic
Input resistance (Cu 10 according to GOST)	10 MΩ
Cu 50	Yes; Standard/Climatic
Input resistance (Cu 50)	10 MΩ
Cu 50 according to GOST	Yes; Standard/Climatic
Input resistance (Cu 50 according to GOST)	10 MΩ
Cu 100	Yes; Standard/Climatic
Input resistance (Cu 100)	10 MΩ
Cu 100 according to GOST	Yes; Standard/Climatic
Input resistance (Cu 100 according to GOST)	10 MΩ
Ni 10	Yes; Standard/Climatic
Input resistance (Ni 10)	10 MΩ
Ni 10 to GOST	Yes; Standard/Climatic
Input resistance (Ni 10 according to GOST)	10 MΩ
Ni 100	Yes; Standard/Climatic
Input resistance (Ni 100)	10 MΩ
Ni 100 according to GOST	Yes; Standard/Climatic
Input resistance (Ni 100 according to GOST)	10 MΩ
Ni 1000	Yes; Standard/Climatic
Input resistance (Ni 1000)	10 MΩ
Ni 1000 to GOST	Yes; Standard/Climatic
Input resistance (Ni 1000 according to GOST)	10 MΩ
LG-Ni 1000	Yes; Standard/Climatic
Input resistance (LG-Ni 1000)	10 MΩ
Ni 120	Yes; Standard/Climatic
Input resistance (Ni 120)	10 MΩ
Ni 120 to GOST	Yes; Standard/Climatic
Input resistance (Ni 120 according to GOST)	10 MΩ
Ni 200	Yes; Standard/Climatic
Input resistance (Ni 200)	10 MΩ
Ni 200 to GOST	Yes; Standard/Climatic
Input resistance (Ni 200 according to GOST)	10 MΩ
Ni 500	Yes; Standard/Climatic
Input resistance (Ni 500)	10 MΩ
Ni 500 to GOST	Yes; Standard/Climatic
Input resistance (Ni 500 according to GOST)	10 MΩ
Pt 10	Yes; Standard/Climatic
Input resistance (Pt 10)	10 MΩ

	6ES7531-7PF00-0AB0
Pt 10 according to GOST	Yes; Standard/Climatic
Input resistance (Pt 10 according to GOST)	10 MΩ
Pt 50	Yes; Standard/Climatic
Input resistance (Pt 50)	10 MΩ
Pt 50 according to GOST	Yes; Standard/Climatic
Input resistance (Pt 50 according to GOST)	10 MΩ
Pt 100	Yes; Standard/Climatic
Input resistance (Pt 100)	10 MΩ
Pt 100 according to GOST	Yes; Standard/Climatic
Input resistance (Pt 100 according to GOST)	10 MΩ
Pt 1000	Yes; Standard/Climatic
Input resistance (Pt 1000)	10 MΩ
Pt 1000 according to GOST	Yes; Standard/Climatic
Input resistance (Pt 1000 according to GOST)	10 MΩ
Pt 200	Yes; Standard/Climatic
Input resistance (Pt 200)	10 MΩ
Pt 200 according to GOST	Yes; Standard/Climatic
Input resistance (Pt 200 according to GOST)	10 MΩ
Pt 500	Yes; Standard/Climatic
Input resistance (Pt 500)	10 MΩ
Pt 500 according to GOST	Yes; Standard/Climatic
Input resistance (Pt 500 according to GOST)	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

	6ES7531-7PF00-0AB0
Thermocouple (TC)	
Temperature compensation	
• Configurable	Yes
• Internal temperature compensation	Yes
• External temperature compensation via RTD	Yes
• Compensation for 0 °C reference point temperature	Yes, fixed value can be set
• Reference channel of the module	Yes; 9th channel that can be used regardless of the parameterization of the other channels than as the genuine 9th RTD channel or for compensation for TC measurement
Cable length	
shielded, max.	800 m; with U; 200 m with R/RTD/TC
Analog value generation for the inputs	
Integration and conversion time/resolution per channel	
Resolution with overrange (bit including sign), max.	16 bit
Configurable integration time	Yes
Integration time (ms)	Fast mode: 2.5 / 16.67 / 20 / 100 ms; standard mode: 7.5 / 50 / 60 / 300 ms
Basic conversion time, including integration time (ms)	Fast mode: 4 / 18 / 22 / 102 ms; standard mode: 9 / 52 / 62 / 302 ms
• Additional conversion time for wire break monitoring	Thermocouples. 150 Ohm, 300 Ohm, 600 Ohm, Cu10, Cu50, Cu100, Ni10, Ni50, Ni100, Ni120, Ni200, Pt10, Pt50, Pt100, Pt200: 4 ms; 6 kilohm, Ni500, Ni1000, LG-Ni1000, Pt500, Pt1000: 13 ms
Interference voltage suppression for interference frequency f1 in Hz	400 / 60 / 50 / 10 Hz
Basic execution time of the module (all channels enabled)	Corresponds to the channel with the highest basic conversion time
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 resistance measurement with two-wire connection	Yes
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

	6ES7531-7PF00-0AB0
Errors/accuracies	
Linearity error (in relation to input range), (+/-)	0.02%
Temperature error (in relation to input range), (+/-)	0.005%/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	+/-1.5 °C
Operational limit in overall temperature range	
Voltage in relation to input range, (+/-)	0.1%
Resistance in relation to input range, (+/-)	0.1%
Resistance thermometer in relation to input range, (+/-)	Cuxxx Standard: ±0.5 K, Cuxxx Climatic: ±0.5 K, Ptxxx Standard: ±1 K, Ptxxx Climatic: ±0.5 K, Nixxx Standard: ±0.5 K, Nixxx Climatic: ±0.3 K
Thermocouple, relative to input range, (+/-)	Type B: > 600 °C ±2 K, Type E: > -200 °C ±1 K, Type J: > -210 °C ±1 K, Type K: > -200 °C ±2 K, Type N: > -200 °C ±2 K, Type R: > 0 °C ±2 K, Type S: > 0 °C ±2 K, Type T: > -200 °C ±1 K, Type C: ±4 K, Type TXK/TXK(L): ±1 K
Basic error limit (operational limit at 25 °C)	
Voltage in relation to input range, (+/-)	0.05%
Resistance in relation to input range, (+/-)	0.05%
Resistance thermometer in relation to input range, (+/-)	Cuxxx Standard: ±0.3 K, Cuxxx Climatic: ±0.2 K, Ptxxx Standard: ±0.5 K, Ptxxx Climatic: ±0.2 K, Nixxx Standard: ±0.3 K, Nixxx Climatic: ±0.15 K
Thermocouple, relative to input range, (+/-)	Type B: > 600 °C ±1 K, Type E: > -200 °C ±0.5 K, Type J: > -210 °C ±0.5 K, Type K: > -200 °C ±1 K, Type N: > -200 °C ±1 K, Type R: > 0 °C ±1 K, Type S: > 0 °C ±1 K, Type T: > -200 °C ±0.5 K, Type C: ±2 K, Type TXK/TXK(L): ±0.5 K
Interference voltage suppression for f = n x (f1 +/- 1 %), f1 = interference frequency	
Series-mode interference (peak of the interference < rated value of the input range), min.	80 dB; in Standard mode, 40 dB in Fast mode
Common mode voltage, max.	60 V DC / 30 V AC
Common mode interference, min.	80 dB
Isochronous mode	
Isochronous mode (application synchronized up to terminal)	No
Interrupts/diagnostics/status information	
Diagnostics function	Yes
Interrupts	
Diagnostic interrupt	Yes
Limit interrupt	Yes; two high limits and two low limits each
Diagnostics alarms	
Monitoring of supply voltage	Yes
Wire break	Yes; only for TC. R. RTD
Overflow/underflow	Yes

	6ES7531-7PF00-0AB0
Diagnostics indicator LED	
RUN LED	Yes; green LED
ERROR LED	Yes; red LED
Monitoring of supply voltage (PWR LED)	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 of channels	
Between the channels	Yes
Between the channels, in groups of	1
Between the channels and backplane bus	Yes
Between the channels and power supply of the electronics	Yes
Permitted potential difference	
Between different circuits	60 V DC / 30 V AC; Isolation measured for 120 V AC basic isolation: Between the channels and supply voltage L+, between the channels and the backplane bus, between the channels
Isolation	
Isolation tested with	2000 V DC between the channels and the supply voltage L+, 2000 V DC between the channels and the backplane bus, 2000 V DC between the channels, 707 V DC (type test) between the supply voltage L+ and the backplane bus
Ambient conditions	
Ambient temperature during operation	
Horizontal mounting position, min.	0 °C
Horizontal mounting position, max.	60 °C
Vertical mounting position, min.	0 °C
Vertical mounting position, max.	40 °C
Distributed mode	
Prioritized startup	Yes
Dimensions	
Width	35 mm
Height	147 mm
Depth	129 mm
Weights	
Weight, approx.	290 g
Miscellaneous	
Note:	Cable compensation is performed alternately to measurement with the R/RTD three-wire measurement. Two module cycles are thus required for a measured value.

Additional information

You can learn how to calculate the cycle time of the module with an example provided on the Internet (https://support.industry.siemens.com/cs/ww/en/view/109037127).

Dimensional drawing

A

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

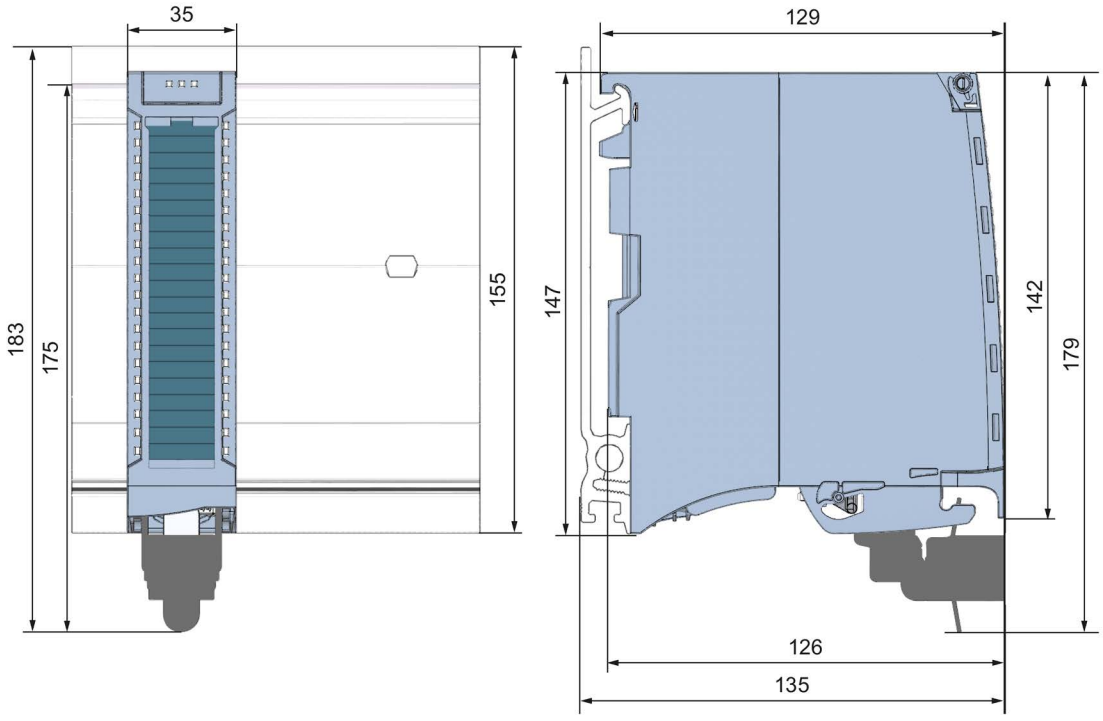


Figure A-1 Dimension drawing of the AI 8xU/R/RTD/TC HF module

Figure A-2 Dimension drawing of the AI 8xU/R/RTD/TC HF module, side view with open front cover

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
Wire break	Only for **measurement type** Resistance, Resistance Thermometer RTD, Thermocouple TC.
Reference channel error	Only for **measuring type** thermocouple TC.
Resistance measurement type (4-wire connection. 3-wire connection)	Only for measuring range 150 Ω, 300 Ω, 600 Ω and 6000 Ω.
Hardware interrupt limits	Only if hardware interrupts are enabled.
Fixed reference temperature	Only if the value **Fixed reference temperature** is configured at parameter **Reference junction for TC**.
Temperature unit Kelvin (K)	Only for **measuring type** thermistor RTD and for thermocouple TC.

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 via data records 0 to 8. 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

The module ignores errors that occurred during the transfer of parameters with the WRREC instruction and 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 behind a PROFIBUS DP interface module

If the module is operated behind a PROFIBUS DP interface module, the parameter data records 0 and 1 are not read back. You obtain the diagnostics data records 0 and 1 with the read back parameter data records 0 and 1. You can find additional information in the Interrupts section of the manual for the PROFIBUS DP interface module on the Internet (http://support.automation.siemens.com/WW/view/en/78324181).

Assignment of data record and channel

The parameters in data records 0 to 9 and in data record 9 are available for 1x 9-channel configuration and are assigned as follows:

- Data record 0 for channel 0
- Data record 1 for channel 1
- …
- Data record 6 for channel 6
- Data record 7 for channel 7
- Data record 8 for channel 8 (reference channel)

For configuration 9 x 1-channel, the module has 9 submodules with one channel each and one submodule for the reference channel. 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 6 (submodule 7)
- Data record 0 for channel 7 (submodule 8)
- Data record 0 for channel 8 (submodule 9) or reference channel

Address the respective submodule for data record transfer.

Data record structure

The figure below shows the structure of data record 0 for channel 0 as an example. The structure is identical for channels 1 to 8. 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".

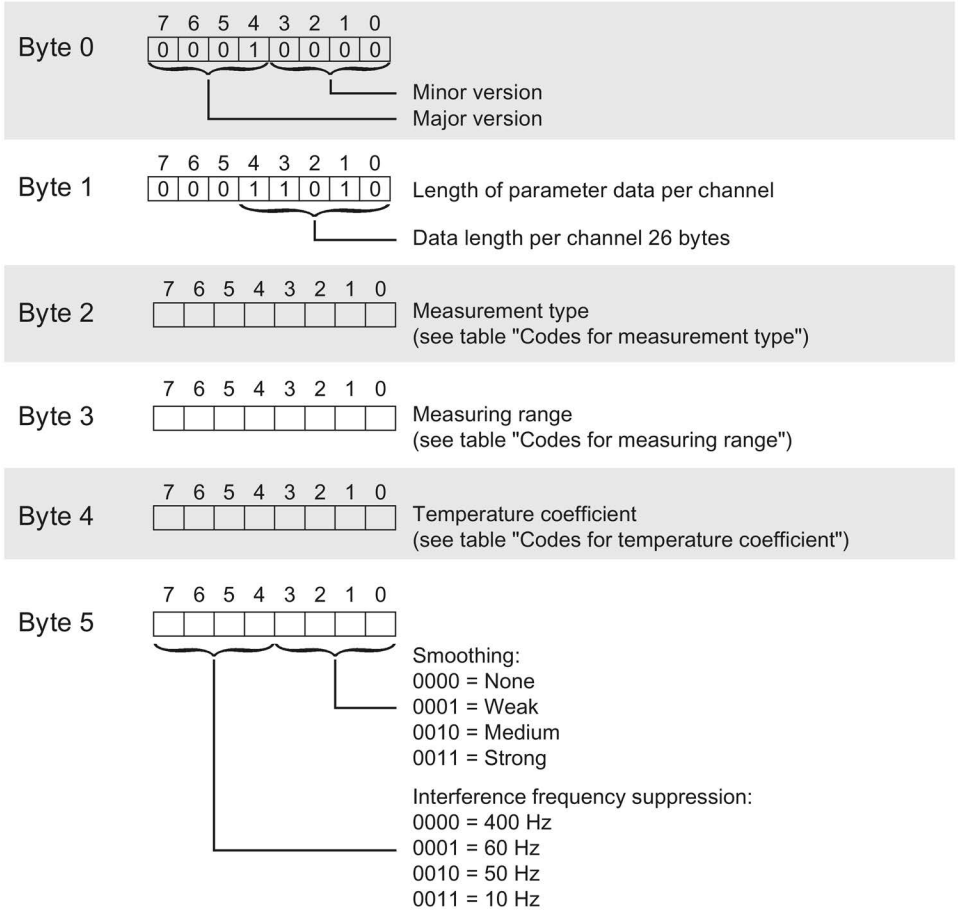
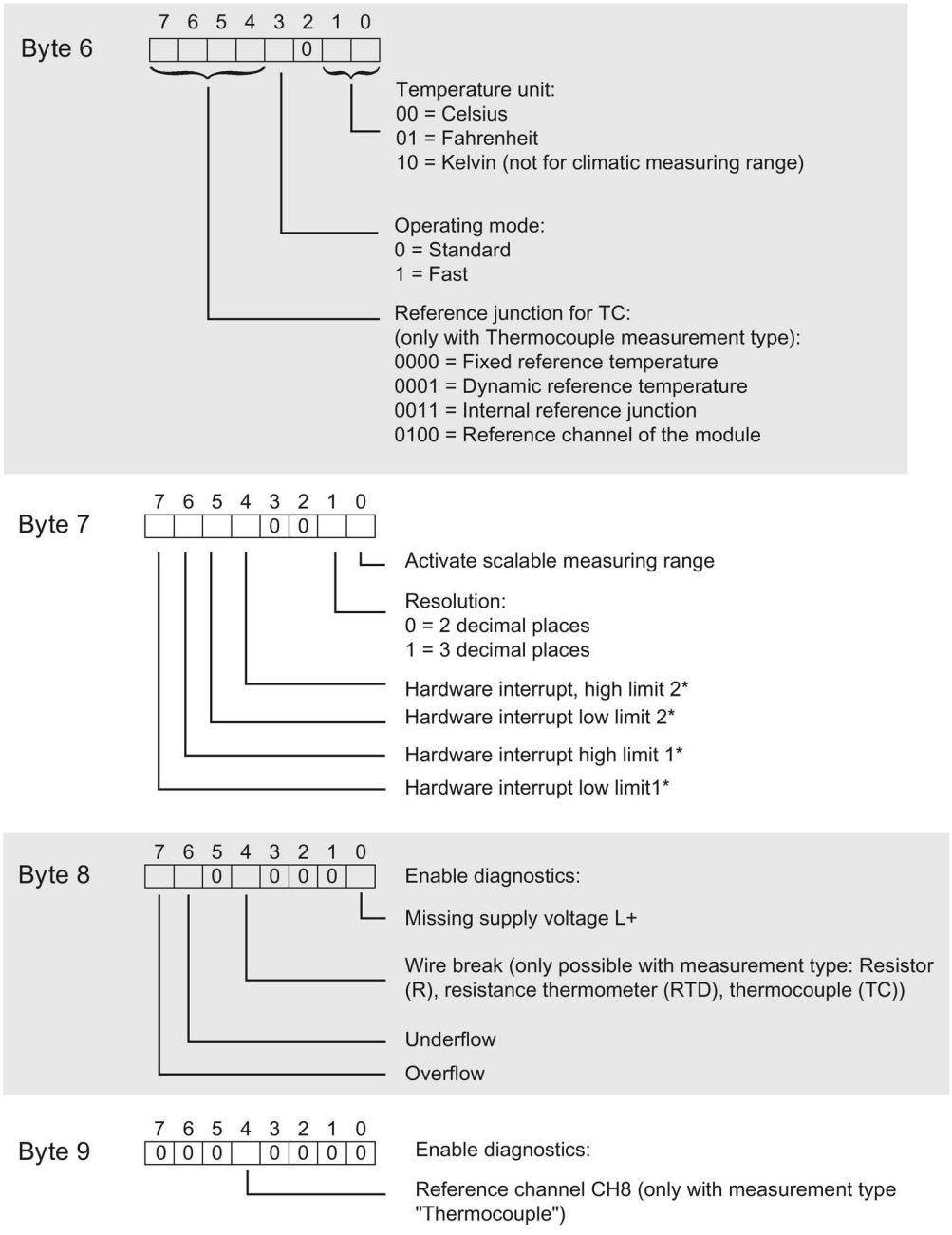
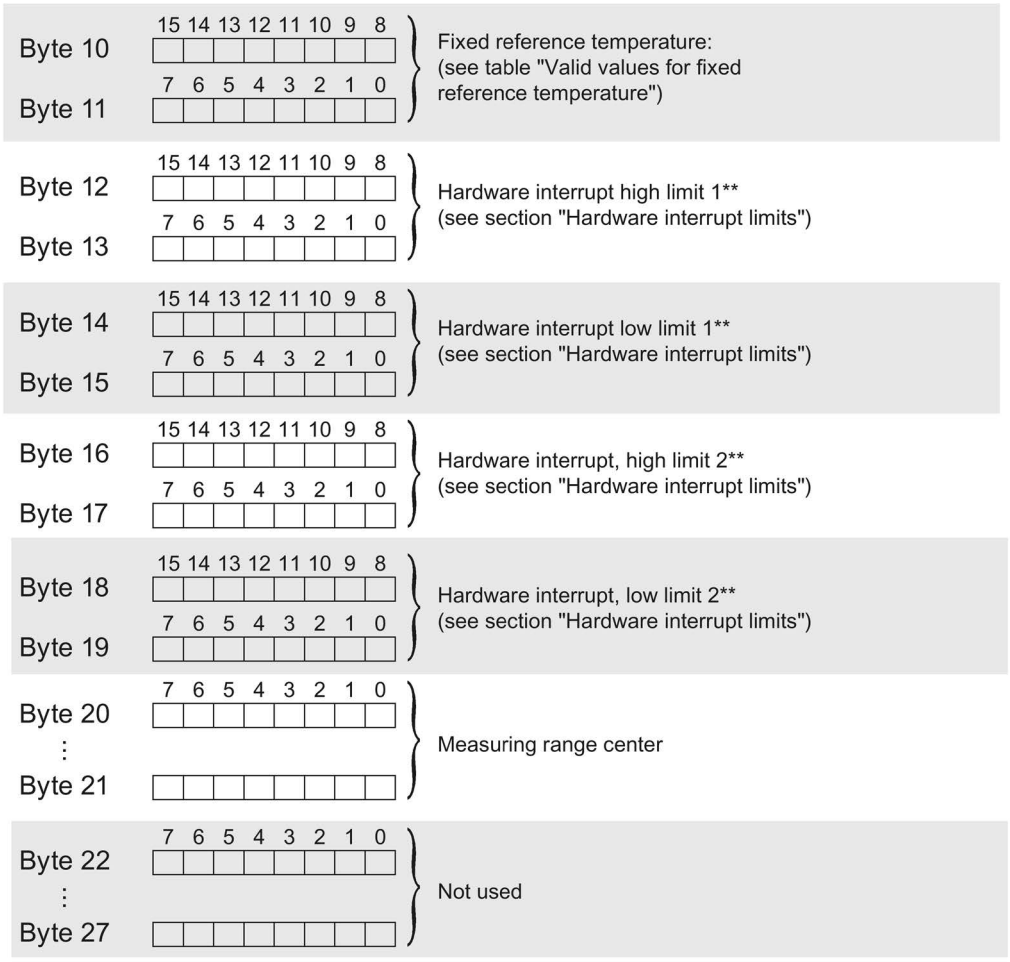


Figure B-1 Structure of data record 0: Byte 0 to 5



* Hardware interrupts can only be activated via data record if the channel is assigned a hardware interrupt OB in STEP 7

Figure B-2 Structure of data record 0: Byte 6 to 9



** High limit must be greater than low limit

Figure B-3 Structure of data record 0: Byte 10 to 27:

Codes for measuring types

The following table lists all measuring 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 measuring type

Measurement type	Code
Deactivated	0000 0000
Voltage	0000 0001
Resistor, 4-wire connection *)	0000 0100
Resistor, 3-wire connection *)	0000 0101
Resistor, 2-wire connection	0000 0110
Thermal resistor linear, 4-wire connection	0000 0111
Thermal resistor linear, 3-wire connection	0000 1000
Thermal resistor linear, 2-wire connection	0000 1001
Thermocouple TC	0000 1010

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

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	
±25 mV	0000 0000
±50 mV	0000 0001
±80 mV	0000 0010
±250 mV	0000 0011
±500 mV	0000 0100
±1 V	0000 0101
Resistor	
150 Ω	0000 0001
300 Ω	0000 0010
600 Ω	0000 0011
6000 Ω	0000 0101
PTC	0000 1111

Thermal resistor	
Pt100 climate	0000 0000
Ni100 climate	0000 0001
Pt100 standard	0000 0010
Ni100 standard	0000 0011
Pt500 standard	0000 0100
Pt1000 standard	0000 0101
Ni1000 standard	0000 0110
Pt200 climate	0000 0111
Pt500 climate	0000 1000
Pt1000 climate	0000 1001
Ni1000 climate	0000 1010
Pt200 standard	0000 1011
Ni120 Standard	0000 1100
Ni120 Climatic	0000 1101
Cu10 Climatic	0000 1110
Cu10 Standard	0000 1111
Ni200 Standard	0001 0000
Ni200 Climatic	0001 0001
Ni500 Standard	0001 0010
Ni500 Climatic	0001 0011
Pt10 Standard	0001 0100
Pt10 Climatic	0001 0101
Pt50 Standard	0001 0110
Pt50 Climatic	0001 0111
Cu50 Standard	0001 1000
Cu50 Climatic	0001 1001
Cu100 Standard	0001 1010
Cu100 Climatic	0001 1011
LG-Ni1000 standard	0001 1100
LG-Ni1000 climate	0001 1101
Ni10 Standard	0001 1110
Ni10 Climatic	0001 1111
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
C	0000 1010
TXK	0000 1011

Codes for temperature coefficients

The following table lists all temperature coefficients along with their codes for temperature measurements with the resistance thermometers. You need to enter these codes in byte 4 of the data records 0, 2, 4, 6 and 8 (see Fig. Structure of data record 0: bytes 0 to 6).

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
0.003910 GOST	0000 0101
Ni xxx	
0.006180	0000 1000
0.006720	0000 1001
0.006170 GOST	0000 0111
LG-Ni	
0.005000	0000 1010
Cu xxx	
0.00426 GOST	0000 1011
0.00427	0000 1100
0.00428 GOST	0000 1101

Valid values for fixed reference temperatures

The values that you can set for fixed reference temperatures must be within the nominal range of the thermocouple used and within the permitted value range. See table below. The resolution is a tenth of a degree.

Table B- 5 Valid values for fixed reference temperatures

Temperature unit	Decimal	Hexadecimal
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 exceed the over/underrange of respective rated measuring range.

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

Table B- 6 Limits for voltage and resistance

Voltage	**Resistor**	
±25 mV, ±50 mV, ±80 mV, ±250 mV, ±500 mV, ±1 V	150 Ω, 300 Ω, 600 Ω, 6 kΩ	
32510	32510	High limit
-32511	1	Low limit

Table B- 7 Limits for thermocouple types B, C, E, and J

Thermocouple												
Type B			Type C			Type E			Type J			
°C	°F	K	°C	°F	K	°C	°F	K	°C	°F	K	
20699	32765	23431	24999	32765	27731	11999	21919	14731	14499	26419	17231	High limit
1	321	2733	-1199	-1839	1533	-2699	-4539	33	-2099	-3459	633	Low limit

Table B- 8 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- 9 Limits for thermocouple type T and TXK

Thermocouple						
Type T			Type TXK			
°C	°F	K	°C	°F	K	
5399	10039	8131	10499	19219	13231	High limit
-2699	-4539	33	-1999	-3279	733	Low limit

Table B- 10 Limits for resistance thermometer Pt xxx Standard and Pt xxx Climate

Thermal resistor						
Pt xxx standard (0.003851, 0.003902, 0.003910, 0.003916, 0.003920)			Pt xxx climate (0.003851, 0.003902, 0.003916, 0.003910, 0.003920)			
°C	°F	K	°C	°F	K	
9999	18319	12731	15499	31099	---	High limit
-2429	-4053	303	-14499	-22899	---	Low limit

Table B- 11 Limits for resistance thermometer Ni xxx Standard and Ni xxx Climate

Thermal resistor						
Ni xxx Standard (0.006180, 0.006720)			Ni xxx Climate (0.006180, 0.006720)			
°C	°F	K	°C	°F	K	
2949	5629	5681	15499	31099	---	High limit
-1049	-1569	1683	-10499	-15699	---	Low limit

Table B- 12 Limits for resistance thermometer Ni 0.006170 Standard and Ni 0.006170 Air

Thermal resistor						
Ni 0.006170 Standard			Ni 0.006170 Climatic			
°C	°F	K	°C	°F	K	
2123	4142	4855	15499	31099	---	High limit
-1049	-1569	1683	-10499	-15699	---	Low limit

Table B- 13 Limits for resistance thermometer Cu xxx Standard

Thermal resistor									
Cu 0.00426 Standard			Cu 0.00427 Standard			Cu 0.00428 Standard			
°C	°F	K	°C	°F	K	°C	°F	K	
2399	4639	5131	3119	5935	5851	2399	4639	5131	High limit
-599	-759	2133	-2399	-3999	333	-2199	-3639	533	Low limit

Table B- 14 Limits for resistance thermometer Cu xxx Climatic

Thermal resistor			
Cu xxx Climatic (0.00426, 0.00427, 0.00428)			
°C	°F	K	
17999	32765	---	High limit
-5999	-7599	---	Low limit

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

The **WRREC** instruction is used to transfer the reference junction temperature via data record 192 to data record 200 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 9-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
- Data record 196 for channel 4
- Data record 197 for channel 5
- Data record 198 for channel 6
- Data record 199 for channel 7
- Data record 200 for channel 8

If nine submodules (9 x 1-channel) are configured for the module, each submodule has only one channel. The parameters of the channel are in data record 192.

Background: Each submodule you address for the data record transfer has only one channel.

Structure of data record 192 for dynamic reference temperature

The following figure shows you an example of the structure of data record 192 for channel 0. The structure for data records 193 to 200 is identical.

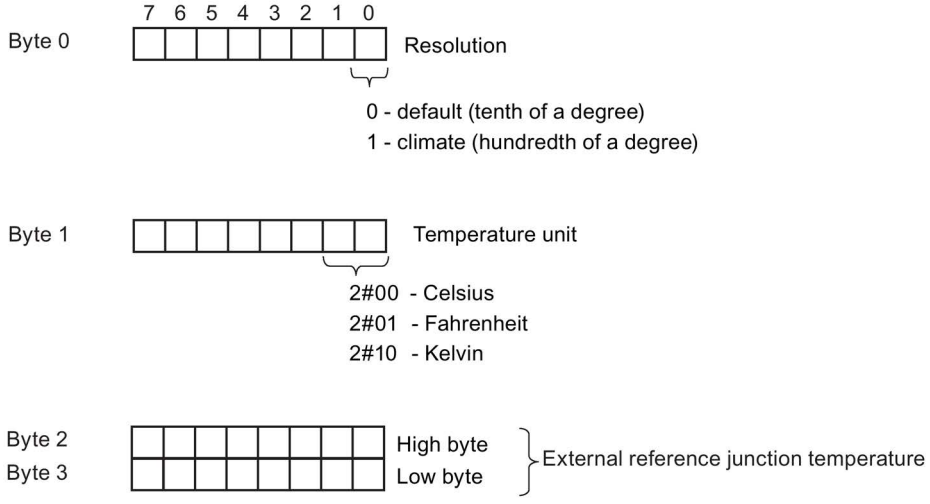


Figure B-4 Structure of data record 192

Valid values for fixed temperature compensation

You can enter the selectable values at byte 1 of the data record for the corresponding channel. The values that you can set must be within the nominal range of the thermocouple used and within the permitted value range. See table below. The resolution corresponds to one tenth of a degree with the "Standard" temperature unit and one hundredth of a degree with the "Climatic" temperature unit.

Table B- 15 Valid values for temperature compensation via data record

Temperature unit	Decimal	Hexadecimal
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

You can find additional information on compensation of the reference junction temperature via data record in the Analog value processing function manual (https://support.industry.siemens.com/cs/ww/en/view/67989094) on the Internet.

B.3 Structure of data record 235 for scalable measuring range

Evaluation in the user program

In the user program, you can evaluate the status and the limits of the scalable measuring range with data record 235, which may result by reaching underflow/overflow.

Structure of data record 235

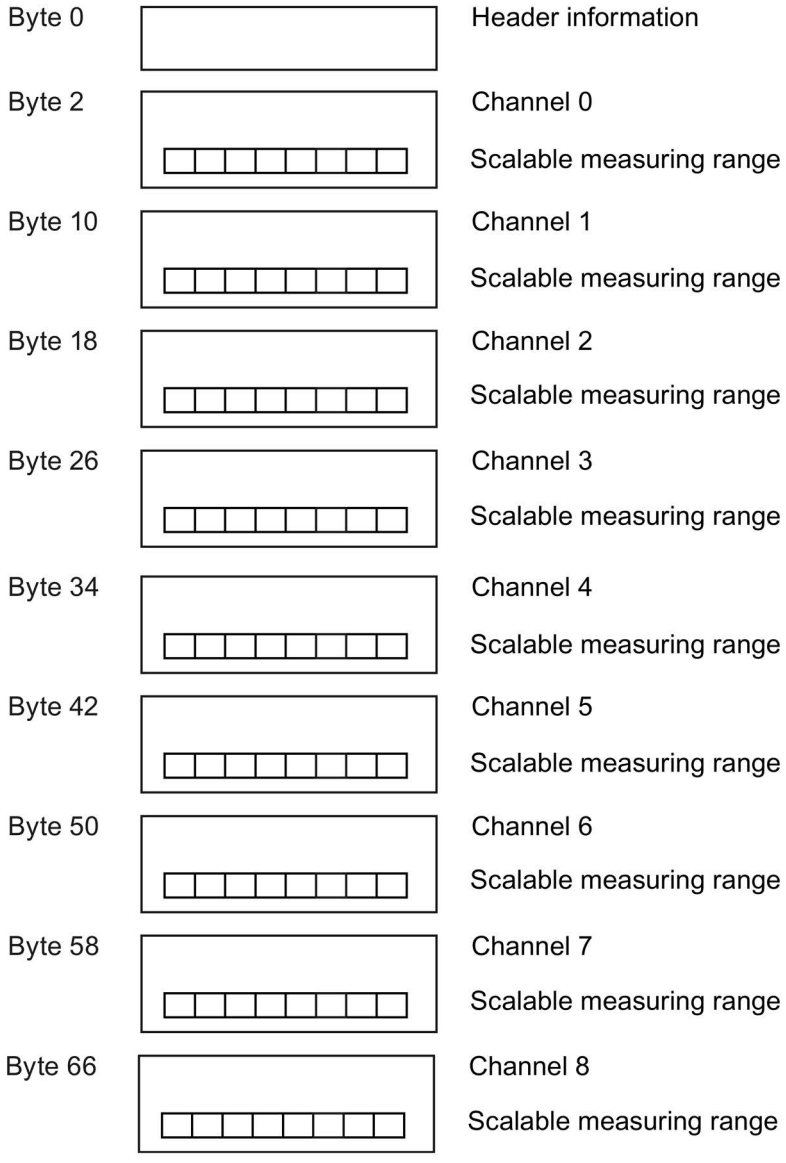


Figure B-5 Structure of data record 235

Header information

The figure below shows the structure of the header information.

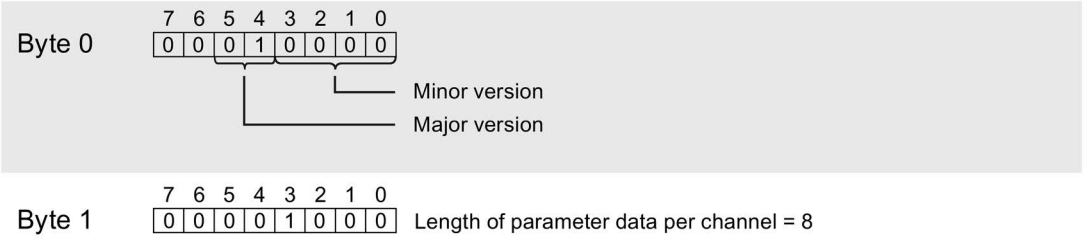


Figure B-6 Structure header information of data record 235

Parameters

The figure below shows the structure of the parameter.

If the corresponding bit is set to "1", the parameter is activated.

* x = 2 + (channel number x 8)

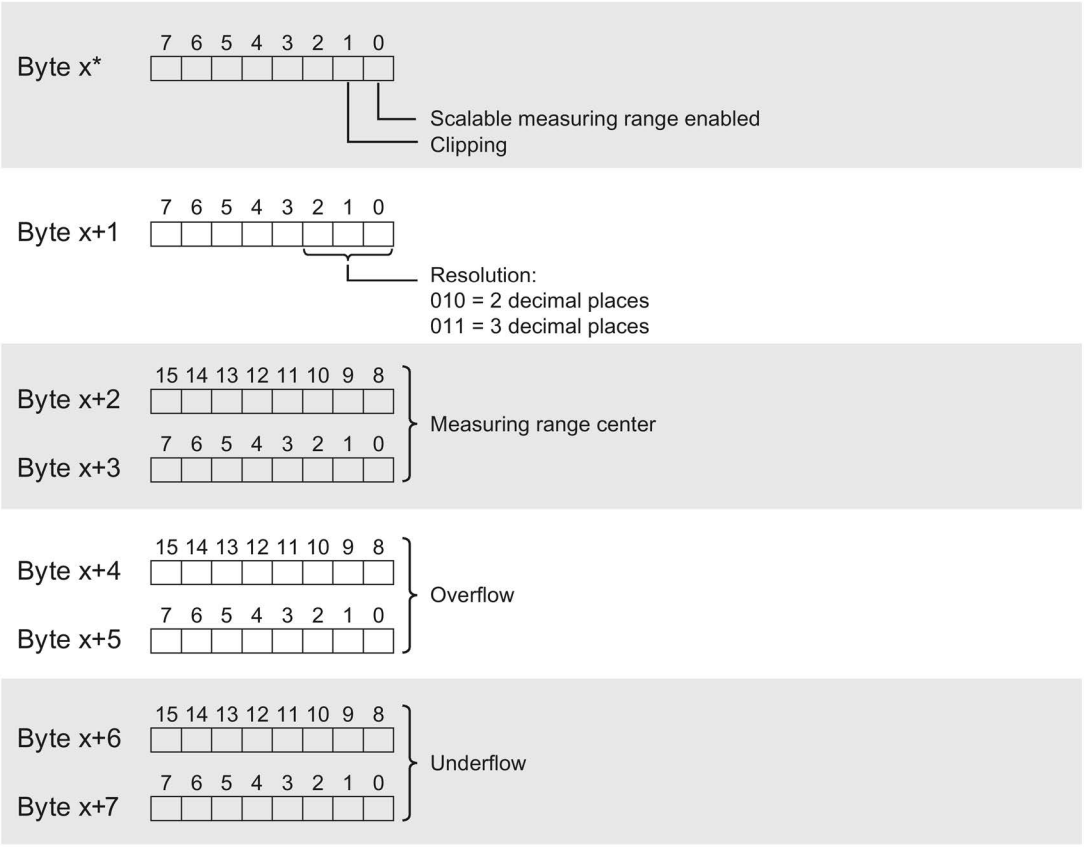


Figure B-7 Structure of data record 235 - channel parameter byte x to x+7

Description of the parameters from data record 235

Table B- 16 **Description of the parameters from data record 235**

Parameter	Description
Scalable measuring range enabled	1 = Function is active for this channel.
Clipping	1 = Scalable measuring range cut off at the over-flow/underflow of the underlying measuring range.
Resolution	2 or 3 decimal places
Measuring range center	Temperature in whole °C / °F / K ("working point" for the scaling)
Overflow/underflow	Limits of the scalable measuring range

Example

The following example shows the values for a thermal resistor Pt 100 Standard, °C:

Table B- 17 Example of a thermal resistor Pt 100 Standard

Hex. value	Dec. value	Evaluation of data record 235
10_H	16	V1.0
08_H	8	8 bytes
03_H	3	Scalable measuring range active and clipped (clipping)
02_H	2	Resolution: 2 decimal places
$02EE_H$	750	Measuring range center: 750 °C
$61A8_H$	25000	Overflow (Maximum): 250.**00** + 750 = 1000.00 °C Scalable measuring range is clipped at the overflow.
8100_H	-32512	Underflow (Minimum): -325.**12** + 750 = 424.88 °C

Representation of analog values

C

Introduction

This appendix shows the analog values for all measuring ranges supported by the AI 8xU/R/RTD/TC HF 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	
	Decimal	Hexadecimal	High byte	Low byte
16	1	1_H	Sign 0 0 0 0 0 0 0	0 0 0 0 0 0 0 1

C.1 Representation of input ranges

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

Table C- 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 ±25 mV and ±1 V,

Values		Voltage measuring range		Range
dec	hex	±25 mV	±1 V	
32767	7FFF	>29.4 mV	> 1.176 V	Overflow
32511	7EFF	29.4 mV	1.176 V	Overshoot range
27649	6C01			
27648	6C00	25 mV	1 V	Rated range
20736	5100	18.75 mV	0.75 V	
1	1	904.2 µV	36.17 µV	
0	0	0 V	0 V	
-1	FFFF			
-20736	AF00	-18.75 mV	-0.75 V	
-27648	9400	-25 mV	-1 V	
-27649	93FF			Undershoot range
-32512	8100	-29.4 mV	-1.176 V	
-32768	8000	<-29.40 mV	< -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

C.3 Analog value representation for resistance-type transmitters / resistance thermometers

C.3.1 Resistance-type transmitters 150, 300, 600, 6000 Ohm

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

Table C- 6 Resistance-based sensors of 150 Ω, 300 Ω, 600 Ω, and 6000 Ω

Values		Resistive transmitter 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	

C.3.2 Thermal resistor Pt 10, 50, 100, 200, 500, 1000 Standard/GOST

Thermal resistor Pt x0 Standard and Pt x0 GOST Standard

Table C- 7 Thermal resistor Pt x0 Standard (0.003851, 0.003916, 0.003902, 0.003920) and Pt x0 GOST Standard (0.003910)

Pt x0 Standard in °C (1 digit = 0.1°C)	Units		Pt x0 Standard in °F (1 digit = 0.1 °F)	Units		Pt x00 Standard in K (1 digit = 0.1 K)	Units		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

Thermal resistor Pt x0 and Pt x0 GOST Climatic

Table C- 8 Thermal resistor Pt x0 Standard (0.003851, 0.003916, 0.003902, 0.003920) and Pt x0 GOST Climatic (0.003910)

Pt x0 Climatic in °C (1 digit = 0.01 °C)	Units		Pt x0 Climatic in °F (1 digit = 0.01 °F)	Units		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

C.3.3 Thermal resistor Ni 10, 100, 120, 200, 500, 1000, LG-Ni 1000 Standard

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

Table C- 9 Thermal resistor Ni x0, LG-Ni 1000 Standard (0.00500, 0.006180, 0.006720)

Ni x0 Standard in °C (1 digit = 0.1 °C)	Units		Ni x0 Standard in °F (1 digit = 0.1 °F)	Units		Ni x0 Standard in K (1 digit = 0.1 K)	Units		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

C.3.4 Thermal resistor Ni 10, 100, 120, 200, 500, 1000, LG-Ni 1000 Climatic

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

Table C- 10 Thermal resistor Ni x0 and LG-Ni 1000 Climatic (0.00500. 0.006180. 0.006720) and Ni x0 GOST Climatic (0.006170)

Ni x0 Climatic in °C (1 digit = 0.01 °C)	Units		Ni x0 Climatic in °F (1 digit = 0.01 °F)	Units		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.3.5 Thermal resistor Ni 10, 100, 120, 200, 500, 1000 GOST Standard

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

Table C- 11 Thermal resistor Ni x0 GOST Standard (0.006170)

Ni x0 GOST Standard in °C (1 digit = 0.1 °C)	Units		Ni x0 GOST Standard in °F (1 digit = 0.1 °F)	Units		Ni x0 GOST Standard in K (1 digit = 0.1 K)	Units		Range
	dec.	hex.		dec.	hex.		dec.	hex.	
> 212.4	32767	7FFF	> 414.3	32767	7FFF	> 485.6	32767	7FFF	Overflow
212.4 : 180.1	2124 : 1801	084C : 0709	414.3 : 356.1	4143 : 3561	102F : 0DE9	486.6 : 453.3	4856 : 4533	12F8 : 11B5	Overrange
180.0 : -60.0	1800 : -600	0708 : FDA8	356.0 : -76.0	3560 : -760	0DE8 : FD08	453.2 : 213.2	4532 : 2132	11B4 : 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	Underrange
< -105.0	-32768	8000	< -157.0	-32768	8000	< 168.2	32768	8000	Underflow

C.3.6 Thermal resistor Cu 10, 50, 100 Standard/Climatic/GOST

Thermal resistor Cu 10, 50, 100 Standard (0.00427)

Table C- 12 Thermal resistor Cu 10, 50, 100 Standard (0.00427)

Cu 10 standard in °C (1 digit = 0.1 °C)	Units		Cu 10 standard in °F (1 digit = 0.1 °F)	Units		Cu 10 standard in K (1 digit = 0.1 K)	Units		Range
	dec.	hex.		dec.	hex.		dec.	hex.	
> 312.0	32767	7FFF	> 593.6	32767	7FFF	> 585.2	32767	7FFF	Overflow
312.0 : 260.1	3120 : 2601	C30 : A29	593.6 : 500.1	5936 : 5001	1730 : 12D5	585.2 : 533.3	5852 : 5333	16DC : 14D5	Overrange
260.0 : -200.0	2600 : -2000	A28 : F830	500.0 : -328.0	5000 : -3280	1389 : F330	533.2 : 73.2	5332 : 732	14D4 : 2DC	Nominal range
-200.1 : -240.0	-2001 : -2400	F82F : F6A0	-328.1 : -400.0	-3281 : -4000	F32F : F060	73.1 : 33.2	731 : 332	2DB : 14C	Underrange
< -240.0	-32768	8000	< -400.0	-32768	8000	< 33.2	32768	8000	Underflow

Thermal resistor Cu 10, 50, 100 GOST Standard (0.00426)

Table C- 13 Thermal resistor Cu 10, 50, 100 GOST Standard (0.00426)

Cu x0 Standard in °C (1 digit = 0.1 °C)	Units		Cu x0 standard in °F (1 digit = 0.1 °F)	Units		Cu x0 standard in K (1 digit = 0.1 K)	Units		Range
	dec.	hex.		dec.	hex.		dec.	hex.	
> 240.0	32767	7FFF	> 464.0	32767	7FFF	> 513.2	32767	7FFF	Overflow
240.0 : 200.1	2400 : 2001	0960 : 07D1	464.0 : 392.1	4640 : 3921	1220 : 0F51	513.2 : 473.3	5132 : 4733	140C : 127D	Overrange
200.0 : -50.0	2000 : -500	07D0 : FE0C	392.0 : -58.0	3920 : -580	0F50 : FDBC	473.2 : 222.2	4732 : 2232	127C : 8B8	Nominal range
-50.1 : -60.0	-501 : -600	FE0B : FDA8	-58.1 : -76.0	-581 : -760	FDBB : FD08	223.1 : 213.2	2231 : 2132	8B7 : 854	Under-range
< - 60.00	-32768	8000	< - 76.0	-32768	8000	< 213.2	32768	8000	Underflow

Thermal resistor Cu 10, 50, 100 GOST Standard (0.00428)

Table C- 14 Thermal resistor Cu 10, 50, 100 GOST Standard (0.00428)

Cu x0 standard in °C (1 digit = 0.1 °C)	Units		Cu x0 standard in °F (1 digit = 0.1 °F)	Units		Cu x0 standard in K (1 digit = 0.1 K)	Units		Range
	dec.	hex.		dec.	hex.		dec.	hex.	
> 240.0	32767	7FFF	> 464.0	32767	7FFF	> 513.2	32767	7FFF	Overflow
240.0 : 200.1	2400 : 2001	0960 : 07D1	464.0 : 392.1	4640 : 3921	1220 : 0F51	513.2 : 473.3	5132 : 4733	140C : 127D	Overrange
200.0 : -180.0	2000 : -1800	07D0 : F8F8	392.0 : -292.0	3920 : -2920	0F50 : F498	473.2 : 93.2	4732 : 932	127C : 3A4	Nominal range
-180.1 : -220.0	-1801 : -2200	F8F7 : F768	-292.1 : -364.0	-2921 : -3640	F497 : F1C8	93.1 : 53.2	931 : 532	3A3 : 214	Under-range
< - 220.0	-32768	8000	< - 364.0	-32768	8000	< 53.2	32768	8000	Underflow

Thermal resistor Cu x0 Climatic (0.00427) and Cu x0 Gost Climatic (0.00426 and 0.00428)

Table C- 15 Thermal resistor Cu 10, 50, 100 Climatic and Cu 10, 50, 100 GOST Climatic

Cu x0 Climatic in °C (1 digit = 0.01 °C)	Units		Cu x0 Climatic in °F (1 digit = 0.01 °F)	Units		Range
	dec.	hex.		dec.	hex.	
> 180.00	32767	7FFF	> 325.11	32767	7FFF	Overflow
180.00 : 150.01	18000 : 15001	4650 : 3A99	327.66 : 280.01	32766 : 28001	7FFE : 6D61	Overrange
150.00 : -50.00	15000 : -5000	3A98 : EC78	280.00 : - 58.00	28000 : -5800	6D60 : I958	Nominal range
-50.01 : -60.00	-5001 : -6000	EC77 : E890	-58.01 : -76.00	-5801 : -7600	E957 : E250	Underrange
< - 60.00	-32768	8000	< - 76.00	-32768	8000	Underflow

C.4 Representation of analog values for thermocouples

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

Table C- 16 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	Overrange
1820.0 : 250.0	18200 : 2500	4718 : 09C4	2786.5 : 482.0	27865 : 4820	6CD9 : 12D4	2093.2 : 523.2	20932 : 5232	51C4 : 1470	Nominal 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	Underrange
< 0.0	-32768	8000	< 32.0	-32768	8000	< 273.2	32768	8000	Underflow

Table C- 17 Thermocouple Type C

Type C in °C	Values		Type C in °F	Values		Type C in °K	Values		Range
	dec.	hex.		dec.	hex.		dec.	hex.	
> 2500.0	32767	7FFF	> 3276.6	32767	7FFF	> 2773.2	32767	7FFF	Overflow
2500.0 : 2300.1	25000 : 23001	61A8 : 59D9	3276.6 : 2786.6	32766 : 27866	7FFE : 6CDA	2773.2 : 2573.3	27732 : 25733	6C54 : 6485	Overrange
2300.0 : 0.0	23000 : 0	59D8 : 0000	2786.5 : 32.0	27865 : 320	6CD9 : 0140	2573.2 : 273.2	25732 : 2732	6484 : 0AAC	Nominal range
-0.1 : -120.0	-1 : -1200	FFFF : FB50	31.9 : -184.0	319 : -1840	013F : F8D0	273.1 : 153.2	2731 : 1532	0AAB : 05FC	Underrange
< -120.0	-32768	8000	< -184.0	-32768	8000	< 153.2	32768	8000	Underflow

Table C- 18 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	Overrange
1000.0 : -270.0	10000 : -2700	2710 : F574	1832.0 : -454.0	18320 : -4540	4790 : EE44	1273.2 : 3.2	12732 : 32	31BC : 0020	Nominal range
< -270.0	-32768	8000	< -454.0	-32768	8000	< 3.2	-32768	8000	Underflow

Table C- 19 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	Overrange
1200.0 : -210.0	12000 : -2100	2EE0 : F7CC	2192.0 : -346.0	21920 : -3460	55A0 : F27C	1473.2 : 63.2	14732 : 632	398C : 0278	Nominal range
< -210.0	-32768	8000	< -346.0	-32768	8000	< 63.2	-32768	8000	Underflow

Table C- 20 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	Overrange
1372.0 : -270.0	13720 : -2700	3598 : F574	2501.6 : -454.0	25016 : -4540	61B8 : EE44	1645.2 : 3.2	16452 : 32	4044 : 0020	Nominal range
< -270.0	-32768	8000	< -454.0	-32768	8000	< 3.2	-32768	8000	Underflow

Table C- 21 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	Overrange
1300.0 : -270.0	13000 : -2700	32C8 : F574	2372.0 : -454.0	23720 : -4540	5CA8 : EE44	1573.2 : 3.2	15732 : 32	3D74 : 0020	Nominal range
< -270.0	-32768	8000	< -454.0	-32768	8000	< 3.2	-32768	8000	Underflow

Table C- 22 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	Overrange
1769.0 : -50.0	17690 : -500	451A : FE0C	3216.2 : -58.0	32162 : -580	7DA2 : FDBC	2042.2 : 223.2	20422 : 2232	4FC6 : 08B8	Nominal 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	Underrange
< -170.0	-32768	8000	< -274.0	-32768	8000	< 103.2	< 1032	8000	Underflow

Table C- 23 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	Overrange
400.0 : -270.0	4000 : -2700	0FA0 : F574	752.0 : -454.0	7520 : -4540	1D60 : EE44	673.2 : 3.2	6732 : 32	1AAC : 0020	Nominal range
< -270.0	-32768	8000	< -454.0	-32768	8000	< 3.2	-32768	8000	Underflow

Table C- 24 Thermocouple type TXK/XKL GOST

Type TXK /XKL in °C	Values		Type TXK /XKL in °F	Values		Type TXK/XKL in K	Values		Range
	dec.	hex.		dec.	hex.		dec.	hex.	
> 1050.0	32767	7FFF	> 1922.0	32767	7FFF	> 1323.2	32767	7FFF	Overflow
1050.0 : 800.1	10500 : 8001	2904 : 1FA1	1922.0 : 1472.1	19220 : 14721	4B14 : 3981	1323.2 : 1073.3	13232 : 10733	33B0 : 29ED	Overrange
800.0 : -200.0	8000 : -2000	1F40 : F830	1472.0 : -328.0	14720 : -3280	3980 : F330	1073.2 : 73.2	10732 : 732	29EC : 02DC	Nominal range
< -200.0	-32768	8000	< -328.0	-32768	8000	< 73.2	-32768	8000	Underflow