Temperature modules

Data sheets

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Order no.: **Temperature modules**

Translation of the original documentation

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1 X20AT2222

1.1 General information

The module is equipped with 2 inputs for PT100/PT1000 resistance temperature measurement.

This module is designed for X20 6-pin terminal blocks. If needed (e.g. for logistical reasons), the 12-pin terminal block can also be used.

- 2 inputs for resistance temperature measurement
- For PT100 and PT1000
- Configurable sensor type per channel
- Direct resistance measurement
- Configurable 2- or 3- wire connections per module
- Configurable filter time

1.1.1 Other applicable documents

For additional and supplementary information, see the following documents.

Other applicable documents

Document name	Title
MAX20	X20 System user's manual
MAEMV	Installation / EMC guide

1.2 Order data

Order number	Short description	Figure
	Temperature measurement	
X20AT2222	X20 temperature input module, 2 resistance measurement inputs, Pt100, Pt1000, resolution 0.1°C, 3-wire connections	
	Required accessories	
	Bus modules	
X20BM11	X20 bus module, 24 VDC keyed, internal I/O power supply connected through	
X20BM15	X20 bus module, with node number switch, 24 VDC keyed, internal I/O power supply connected through	
	Terminal blocks	
X20TB06	X20 terminal block, 6-pin, 24 VDC keyed	
X20TB12	X20 terminal block, 12-pin, 24 VDC keyed	

Table 1: X20AT2222 - Order data

1.3 Technical description

1.3.1 Technical data

Order number	X20AT2222
Short description	
I/O module	2 inputs for Pt100 or Pt1000 resistance temperature measurement
General information	
B&R ID code	0x1BA6
Status indicators	I/O function per channel, operating state, module status
Diagnostics	
Module run/error	Yes, using LED status indicator and software
Inputs	Yes, using LED status indicator and software
Power consumption	
Bus	0.01 W
Internal I/O	1.1 W
Additional power dissipation caused by actuators (resistive) [W]	-
Certifications	
CE	Yes
UKCA	Yes
ATEX	Zone 2, II 3G Ex nA nC IIA T5 Gc IP20, Ta (see X20 user's manual) FTZÚ 09 ATEX 0083X
UL	cULus E115267 Industrial control equipment
HazLoc	cCSAus 244665 Process control equipment for hazardous locations Class I, Division 2, Groups ABCD, T5
DNV	Temperature: **B** (0 - 55°C) Humidity: **B** (up to 100%) Vibration: **B** (4 g) EMC: **B** (bridge and open deck)
LR	ENV1
KR	Yes
ABS	Yes
EAC	Yes
KC	Yes
Resistance measurement temperature inputs	
Input	Resistance measurement with constant current supply for 2- or 3-wire connections
Digital converter resolution	16-bit
Filter time	Configurable between 1 ms and 66.7 ms
Conversion time	
1 channel	20 ms with 50 Hz filter
2 channels	80 ms with 50 Hz filter
Conversion procedure	Sigma-delta
Output format	INT or UINT for resistance measurement
Sensor	
Sensor type	Configurable per channel
Pt100	-200 to 850°C
Pt1000	-200 to 850°C
Resistance measurement range	0.1 to 4500 Ω / 0.05 to 2250 Ω
Input filter	First-order low-pass filter / cutoff frequency 500 Hz
Sensor standard	EN 60751
Common-mode range	>0.7 V
Insulation voltage between channel and bus	500 V_{eff}
Linearization method	Internal
Measurement current	250 µA ±1.25%
Reference	4530 Ω ±0.1%
Permissible input signal	Short-term max. ±30 V
Max. error at 25°C	
Gain	0.037% [1]
Offset	0.0015% [2]
Max. gain drift	0.004%/°C [1]
Max. offset drift	0.00015%/°C [2]
Nonlinearity	<0.001% [2]
Crosstalk between channels	<-93 dB
Temperature sensor resolution	
Pt100	1 LSB = 0.1°C
Pt1000	1 LSB = 0.1°C
Resistance measurement resolution	
G = 1	0.1 Ω
G = 2	0.05 Ω

Table 2: X20AT2222 - Technical data

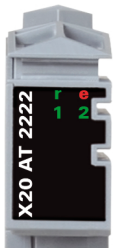
Order number	X20AT2222
Common-mode rejection	
50 Hz	>80 dB
DC	>95 dB
Standardized range of values for resistance measurement	
G = 1	0.1 to 4500 Ω
G = 2	0.05 to 2250 Ω
Temperature sensor normalization	
Pt100	-200.0 to 850.0°C
Pt1000	-200.0 to 850.0°C
Temperature measurement monitoring	
Range undershoot	0x8001
Range overshoot	0x7FFF
Open circuit	0x7FFF
General fault	0x8000
Open inputs	0x7FFF
Resistance measurement monitoring	
Range overshoot	0xFFFF
Open circuit	0xFFFF
General fault	0xFFFF
Open inputs	0xFFFF
Electrical properties	
Electrical isolation	Channel isolated from bus Channel not isolated from channel
Operating conditions	
Mounting orientation	
Horizontal	Yes
Vertical	Yes
Installation elevation above sea level	
0 to 2000 m	No limitation
>2000 m	Reduction of ambient temperature by 0.5°C per 100 m
Degree of protection per EN 60529	IP20
Ambient conditions	
Temperature	
Operation	
Horizontal mounting orientation	-25 to 60°C
Vertical mounting orientation	-25 to 50°C
Derating	-
Storage	-40 to 85°C
Transport	-40 to 85°C
Relative humidity	
Operation	5 to 95%, non-condensing
Storage	5 to 95%, non-condensing
Transport	5 to 95%, non-condensing
Mechanical properties	
Note	Order 1x terminal block X20TB06 or X20TB12 separately. Order 1x bus module X20BM11 separately.
Pitch	$12.5^{+0.2}$ mm

Table 2: X20AT2222 - Technical data

1) Based on the current measured resistance value.
2) Based on the entire resistance measurement range.

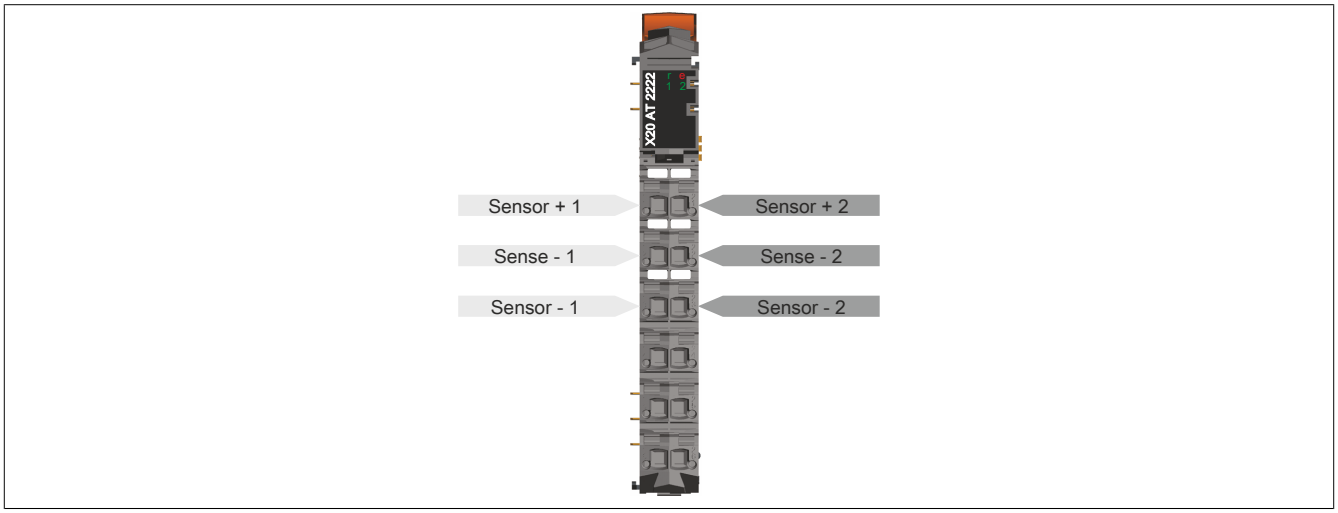
1.3.2 LED status indicators

For a description of the various operating modes, see section "Additional information - Diagnostic LEDs" in the X20 System user's manual.

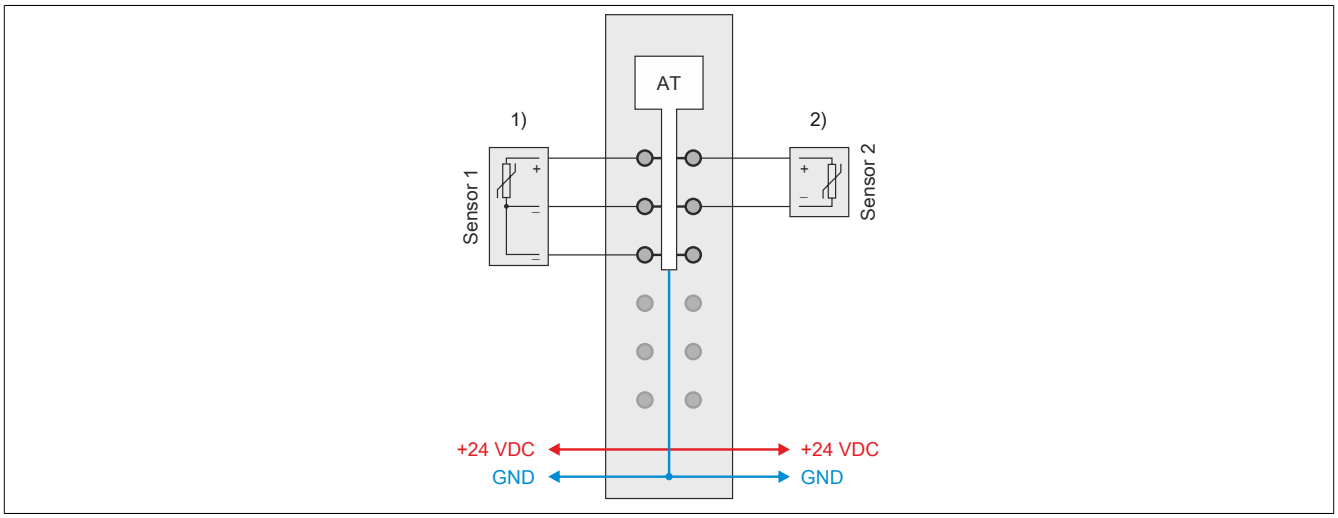
Figure	LED	Color	Status	Description
	r	Green	Off	No power to module
			Single flash	RESET mode
			Blinking	PREOPERATIONAL mode
			On	RUN mode
	e	Red	Off	No power to module or everything OK
			On	Error or reset status
			Single flash	Warning/Error on an I/O channel. Overflow or underflow of the analog inputs.
	e + r	Red on / Green single flash		Invalid firmware
	1 - 2	Green	Off	The input is switched off
			Blinking	Overflow, underflow or open line
			On	Analog/digital converter running, value OK

1.3.3 Pinout

Channels that are not being used should be disabled.



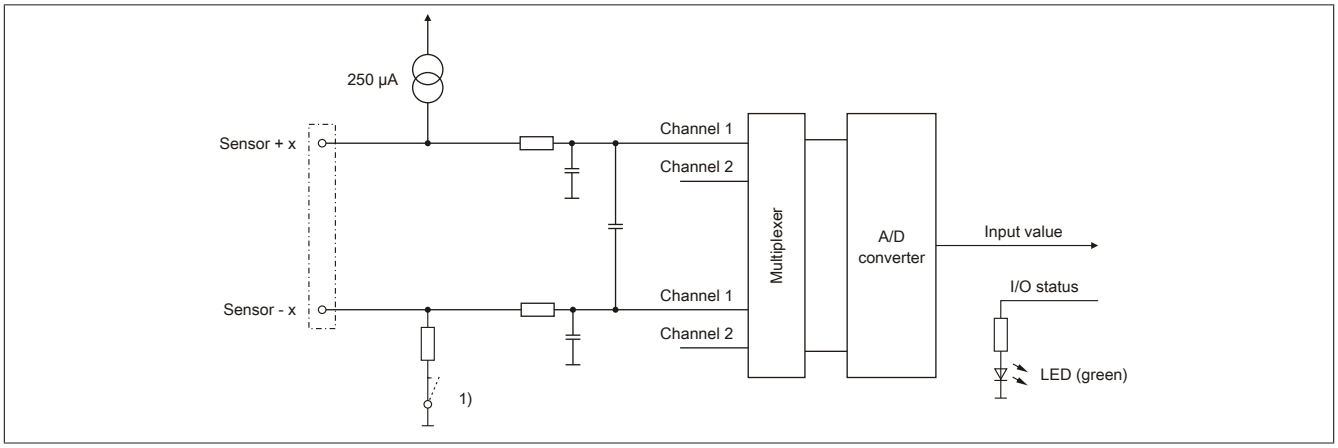
1.3.4 Connection example



1) 3-wire connections
2) 2-wire connections

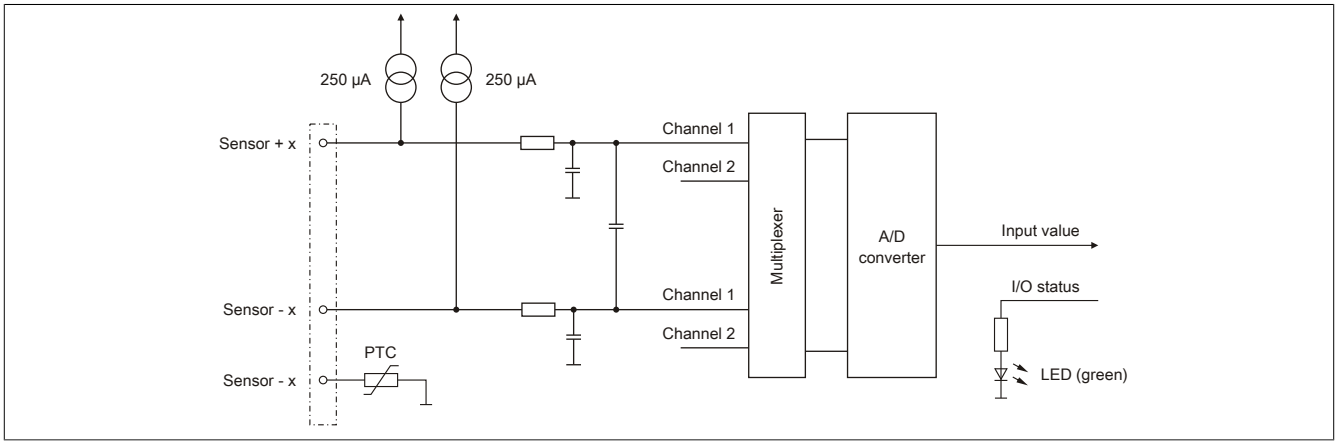
1.3.5 Input circuit diagram

2-wire connections



1) Switch is closed for 2-wire connections.

3-wire connections



1.4 Register description

1.4.1 General data points

In addition to the registers described in the register description, the module has additional general data points. These are not module-specific but contain general information such as serial number and hardware variant.

General data points are described in section "Additional information - General data points" in the X20 System user's manual.

1.4.2 Function model 0 - "3-wire connections" and function model 1 - "2-wire connections"

For this module, the connection type is selected using function models 0 and 1.

Function model	Connection type
0	3-wire connections (standard)
1	2-wire connections

The registers used are identical for both function models:

Register	Name	Data type	Read		Write	
			Cyclic	Acyclic	Cyclic	Acyclic
Configuration						
16	ConfigOutput01 (Input filter)	USINT				•
18	ConfigOutput02 (Sensor configuration)	USINT				•
Communication						
0	Temperature01	INT	•			
	Resistor01	UINT				
2	Temperature02	INT	•			
	Resistor02	UINT				
28	IOCycleCounter	USINT	•			
30	StatusInput01	USINT	•			

1.4.3 Function model 254 - Bus controller

> **Information:**
>
> **Function model 254 (bus controller) only supports 3-wire connections in the default configuration.**

Register	Offset[1)]	Name	Data type	Read		Write	
				Cyclic	Acyclic	Cyclic	Acyclic
Configuration							
16	-	ConfigOutput01 (Input filter)	USINT				•
18	-	ConfigOutput02 (Sensor configuration)	USINT				•
Communication							
0	0	Temperature01	INT	•			
	0	Resistor01	UINT				
2	2	Temperature02	INT	•			
	2	Resistor02	UINT				
28	-	IOCycleCounter	USINT		•		
30	-	StatusInput01	USINT		•		

1) The offset specifies the position of the register within the CAN object.

1.4.3.1 Using the module on the bus controller

Function model 254 "Bus controller" is used by default only by non-configurable bus controllers. All other bus controllers can use other registers and functions depending on the fieldbus used.

For detailed information, see section "Additional information - Using I/O modules on the bus controller" in the X20 user's manual (version 3.50 or later).

1.4.3.2 CAN I/O bus controller

The module occupies 1 analog logical slot on CAN I/O.

1.4.4 General information

1.4.4.1 Analog inputs

The module outputs the converted analog values to the registers. Other ranges of values or data types result depending on resistance or temperature measurement.

> **Information:**
>
> **Operating channels outside specifications can affect neighboring channels.**

1.4.4.2 Timing

The timing for acquiring measured values is controlled by the converter hardware. All switched-on inputs are converted during each conversion cycle and transferred halfway through the X2X Link cycle.

1.4.4.3 Conversion time

The conversion time for the channels depends on their use. For the formulas listed in the table, "n" corresponds to the number of channels that are switched on.

Use of the channels	Conversion time
1 channel	1 · Filter time
n channels with the same sensor type	n · (20 ms + Filter time)
n channels with different sensor types	n · (20 ms + 2 · Filter time)

1.4.4.4 Reduced update time

Any inputs that are not needed can be switched off, which reduces the I/O update time. Inputs can also be only switched off temporarily.

The time saved corresponds to the following:

$$\text{Time saved} = 2 \cdot 20\ \text{ms} + \text{Filter time}$$

The conversion time for the remaining channel corresponds to the filter time.

Examples

Inputs are filtered using a 60 Hz filter.

	Example 1	Example 2
Switched on inputs	1	1 to 2
Conversion time	16.7 ms	73.4 ms

1.4.5 Configuration

1.4.5.1 Input filter

Name:
ConfigOutput01

The filter time of all analog inputs is defined in this register.

Data type	Value	Filter	Filter time
USINT	0	15 Hz	66.7 ms
	1	25 Hz	40 ms
	2	30 Hz	33.3 ms
	3	50 Hz (bus controller default setting)	20 ms
	4	60 Hz	16.7 ms
	5	100 Hz	10 ms
	6	500 Hz	2 ms
	7	1000 Hz	1 ms

1.4.5.2 Sensor configuration

Name:
ConfigOutput02

This register can be used to configure the sensor type for individual channels.

This module is designed for temperature and resistance measurement. The sensor type must be specified because of the different calibration values for temperature and resistance.

The default setting for all channels is ON. To save time, individual channels can be switched off (see "Reduced update time" on page 9).

Data type	Values	Bus controller default setting
USINT	See bit structure.	34

Bit structure:

Bit	Name	Value	Information
0 - 3	Channel 1	0000 - 0001	Reserved
		0010	Sensor type PT100 (bus controller default setting)
		0011	PT1000 sensor type
		0100	Reserved (channel switched off)
		0101	Resistance measurement 0.1 to 4500 Ω
		0110	Resistance measurement 0.05 to 2250 Ω
		0111	Channel switched off
		1000 - 1111	Reserved
4 - 7	Channel 2	0000 - 0001	Reserved
		0010	Sensor type PT100 (bus controller default setting)
		0011	PT1000 sensor type
		0100	Reserved (channel switched off)
		0101	Resistance measurement 0.1 to 4500 Ω
		0110	Resistance measurement 0.05 to 2250 Ω
		0111	Channel switched off
		1000 - 1111	Reserved

1.4.6 Communication

1.4.6.1 Input values of analog inputs

Name:
Temperature01 to Temperature02
Resistor01 to Resistor02

This register contains the analog input values depending on the configured operating mode.

Data type	Digital value	Input signal
INT	-2000 to 8500 (for -200.0 to 850.0°C)	Pt100 sensor type
	-2000 to 8500 (for -200.0 to 850.0°C)	Pt1000 sensor type
UINT	1 to 45000 (resolution 0.1 Ω)	Resistance measurement 0.1 to 4500 Ω
	1 to 45000 (resolution 0.05 Ω)	Resistance measurement 0.05 to 2250 Ω

In order for the user to always be supplied with a defined output value, the following must be taken into consideration:

- Up to the first conversion, 0x8000 is output.
- After switching the operating mode until the first conversion:
  - From "Resistance measurement" to "Sensor type PTxx": 0x8000
  - From "Sensor type PTxx" to "Resistance measurement": 0xFFFF
- If the input is not switched on, 0x8000 is output.

1.4.6.2 I/O cycle counter

Name:
IOCycleCounter

The cyclic counter increases after all input data has been updated.

Data type	Values	Information
USINT	0 to 255	Repeating counter

1.4.6.3 Input status

Name:
StatusInput01

The module's inputs are monitored. A change in the monitoring status generates an error message.

Data type	Values
USINT	See the bit structure.

Bit structure:

Bit	Description	Value	Information
0 - 1	Channel 1	00	No error
		01	Lower limit value exceeded
		10	Upper limit value exceeded
		11	Open line
2 - 3	Channel 2	00	No error
		01	Lower limit value exceeded
		10	Upper limit value exceeded
		11	Open line
4 - 7		0	

Limiting the analog value

In addition to the status information, the analog value is set to the values listed below by default when an error occurs.

Error status	Temperature measurement Digital value for error	Resistance measurement Digital value for error
Open line	32767 (0x7FFF)	65535 (0xFFFF)
Upper limit value exceeded	32767 (0x7FFF)	65535 (0xFFFF)
Lower limit value exceeded	-32767 (0x8001)	0 (0x0000)
Invalid value	-32768 (0x8000)[1)] 32767 (0x7FFF)[2)] 65535 (0xFFFF)[3)]	65535 (0xFFFF)

1) Default value or channel was disabled in the I/O configuration.
2) After switching off the channel during operation.
3) Value in function model 254 - Bus controller.

1.4.7 Minimum cycle time

The minimum cycle time specifies how far the bus cycle can be reduced without communication errors occurring. It is important to note that very fast cycles reduce the idle time available for handling monitoring, diagnostics and acyclic commands.

Minimum cycle time
100 µs

1.4.8 Minimum I/O update time

The minimum I/O update time specifies how far the bus cycle can be reduced so that an I/O update is performed in each cycle.

Minimum I/O update time	
1 input	Equal to the filter time
2 inputs	2 · 20 ms + filter time

2 X20(c)AT2311

2.1 General information

2.1.1 Other applicable documents

For additional and supplementary information, see the following documents.

Other applicable documents

Document name	Title
MAX20	X20 System user's manual
MAEMV	Installation / EMC guide

2.1.2 Coated modules

Coated modules are X20 modules with a protective coating for the electronics component. This coating protects X20c modules from condensation and corrosive gases.
The modules' electronics are fully compatible with the corresponding X20 modules.

For simplification purposes, only images and module IDs of uncoated modules are used in this data sheet.

The coating has been certified according to the following standards:

- Condensation: BMW GS 95011-4, 2x 1 cycle
- Corrosive gas: EN 60068-2-60, method 4, exposure 21 days

2.1.3 Order data

Order number	Short description	Figure
	Temperature measurement	
X20AT2311	X20 temperature input module, 2 resistance measurement inputs, PT100, resolution 0.001°C, 4-wire connections	
X20cAT2311	X20 temperature input module, coated, 2 resistance measurement inputs, Pt100, resolution 0.001°C, 4-wire connections	
	Required accessories	
	Bus modules	
X20BM11	X20 bus module, 24 VDC keyed, internal I/O power supply connected through	
X20BM15	X20 bus module, with node number switch, 24 VDC keyed, internal I/O power supply connected through	
X20cBM11	X20 bus module, coated, 24 VDC keyed, internal I/O power supply connected through	
	Terminal blocks	
X20TB12	X20 terminal block, 12-pin, 24 VDC keyed	

Table 3: X20AT2311, X20cAT2311 - Order data

2.1.4 Module description

The module is equipped with 2 inputs for PT100 4-line resistance temperature measurement.

- 2 inputs for resistance temperature measurement
- PT100 sensor
- Direct resistance measurement
- 4-wire measurement
- Configurable filter time

2.2 Technical description

2.2.1 Technical data

Order number	X20AT2311	X20cAT2311
Short description		
I/O module	2 inputs for PT100 resistance temperature measurement	2 inputs for Pt100 resistance temperature measurement
General information		
B&R ID code	0xA4AA	0xF3B6
Status indicators	I/O function per channel, operating state, module status	
Diagnostics		
Module run/error	Yes, using LED status indicator and software	
Inputs	Yes, using LED status indicator and software	
Power consumption		
Bus	0.35 W	
Internal I/O	0.85 W	
Additional power dissipation caused by actuators (resistive) [W]	-	
Certifications		
CE	Yes	
UKCA	Yes	
ATEX	Zone 2, II 3G Ex nA nC IIA T5 Gc IP20, Ta (see X20 user's manual) FTZÚ 09 ATEX 0083X	
UL	cULus E115267 Industrial control equipment	
HazLoc	cCSAus 244665 Process control equipment for hazardous locations Class I, Division 2, Groups ABCD, T5	-
DNV	Temperature: **B** (0 - 55°C) Humidity: **B** (up to 100%) Vibration: **B** (4 g) EMC: **B** (bridge and open deck)	
LR	ENV1	
KR	Yes	
ABS	Yes	
EAC	Yes	
KC	Yes	-
Resistance measurement temperature inputs		
Input	Resistance measurement with constant current supply for 4-wire connections	
Digital converter resolution	24-bit	
Filter time	Configurable between 1 ms and 400 ms	
Conversion time		
1000 Hz filter	1 ms for all inputs	
50 Hz filter	20 ms for all inputs	
Conversion procedure	Sigma-delta	
Output format	DINT or UDINT for resistance measurement	
Temperature measurement range	-200 to 850°C	
Resistance measurement range	0.5 to 390 Ω	
Temperature sensor resolution	1 LSB = 0.001°C	
Resistance measurement resolution	0.001 Ω	
Input filter	First-order low-pass filter / cutoff frequency 1050 Hz	
Sensor standard	EN 60751	
Insulation voltage between channel and bus	500 V_{eff}	
Insulation voltage between channel and channel	500 V_{eff}	
Linearization method	Internal	
Measurement current	1 mA	
Temperature sensor normalization	-200.0 to 850.0°C	
Reference	1568 Ω ±0.1%	
Permissible input signal	Short-term max. 28.8 V	
Max. error at 25°C [1]		
Gain	0.0059% [2]	
Offset	0.0015% [3]	
Max. gain drift	<0.00065%/°C [2]	
Max. offset drift	<0.000025%/°C [3]	
Nonlinearity	<0.001% [3]	
Standardized range of values for resistance measurement	0.5 Ω to 390 Ω	

Table 4: X20AT2311, X20cAT2311 - Technical data

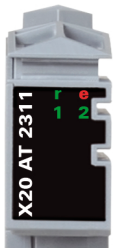
Order number	X20AT2311	X20cAT2311
Temperature measurement monitoring		
Range undershoot	0x80000001	
Range overshoot	0x7FFFFFFF	
Open circuit	0x7FFFFFFF	
General fault	0x80000000	
Open inputs	0x7FFFFFFF	
Resistance measurement monitoring		
Range undershoot	0x80000001	
Range overshoot	0xFFFFFFFF	
Open circuit	0xFFFFFFFF	
General fault	0x80000000	
Electrical properties		
Electrical isolation	Channel isolated from channel and bus	
Operating conditions		
Mounting orientation		
Horizontal	Yes	
Vertical	Yes	
Installation elevation above sea level		
0 to 2000 m	No limitation	
>2000 m	Reduction of ambient temperature by 0.5°C per 100 m	
Degree of protection per EN 60529	IP20	
Ambient conditions		
Temperature		
Operation		
Horizontal mounting orientation	-25 to 60°C	
Vertical mounting orientation	-25 to 50°C	
Derating	-	
Storage	-40 to 85°C	
Transport	-40 to 85°C	
Relative humidity		
Operation	5 to 95%, non-condensing	Up to 100%, condensing
Storage	5 to 95%, non-condensing	
Transport	5 to 95%, non-condensing	
Mechanical properties		
Note	Order 1x terminal block X20TB12 separately. Order 1x bus module X20BM11 separately.	Order 1x terminal block X20TB12 separately. Order 1x bus module X20cBM11 separately.
Pitch	12.5$^{+0.2}$ mm	

Table 4: X20AT2311, X20cAT2311 - Technical data

1) To guarantee accuracy, dummy module ZF0000 must be connected to the left and right of module AT2311.
2) Based on the current measured resistance value.
3) Based on the entire resistance measurement range.

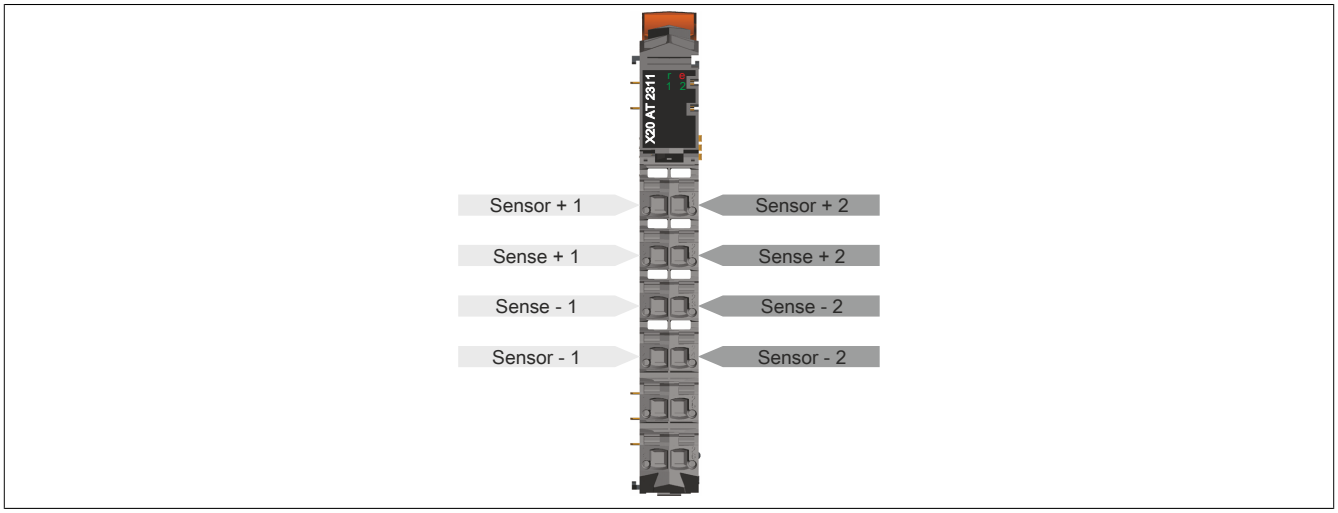
2.2.2 LED status indicators

For a description of the various operating modes, see section "Additional information - Diagnostic LEDs" in the X20 System user's manual.

Figure	LED	Color	Status	Description
	r	Green	Off	No power to module
			Single flash	RESET mode
			Double flash	BOOT mode (during firmware update)[1]
			Blinking	Mode PREOPERATIONAL
			On	RUN mode
	e	Red	Off	No power to module or everything OK
			On	Error or reset status
			Single flash	Warning/Error on an I/O channel. Overflow or underflow of the analog inputs.
	e + r	Red on / Green single flash		Invalid firmware
	1 - 2	Green	Off	The input is switched off
			Blinking	Overflow, underflow or open line
			On	Analog/digital converter running, value OK

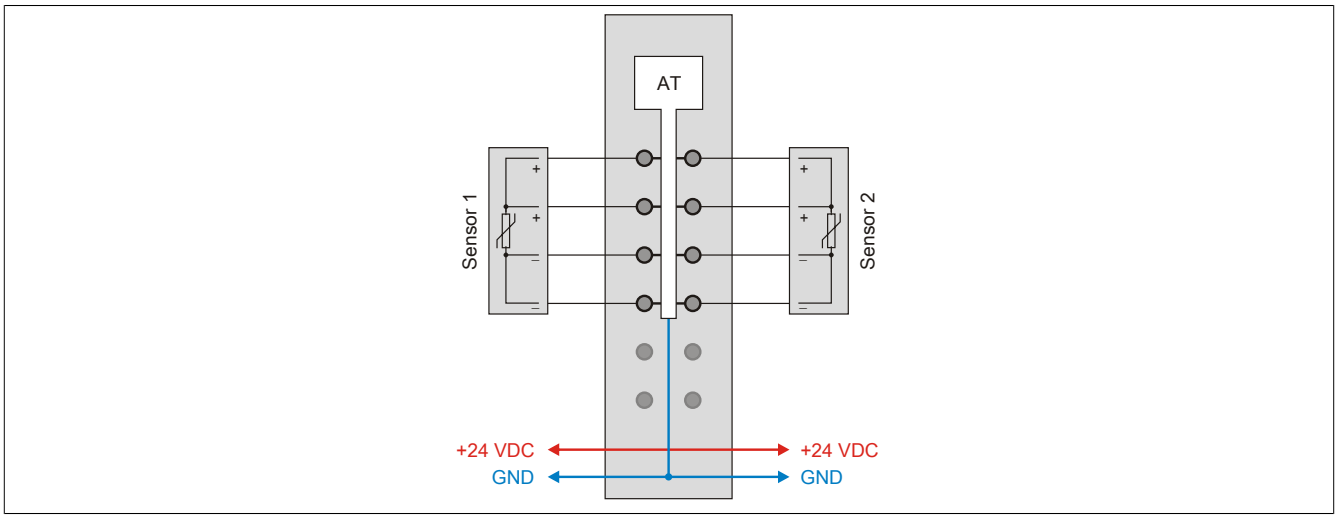
1) Depending on the configuration, a firmware update can take up to several minutes.

2.2.3 Pinout

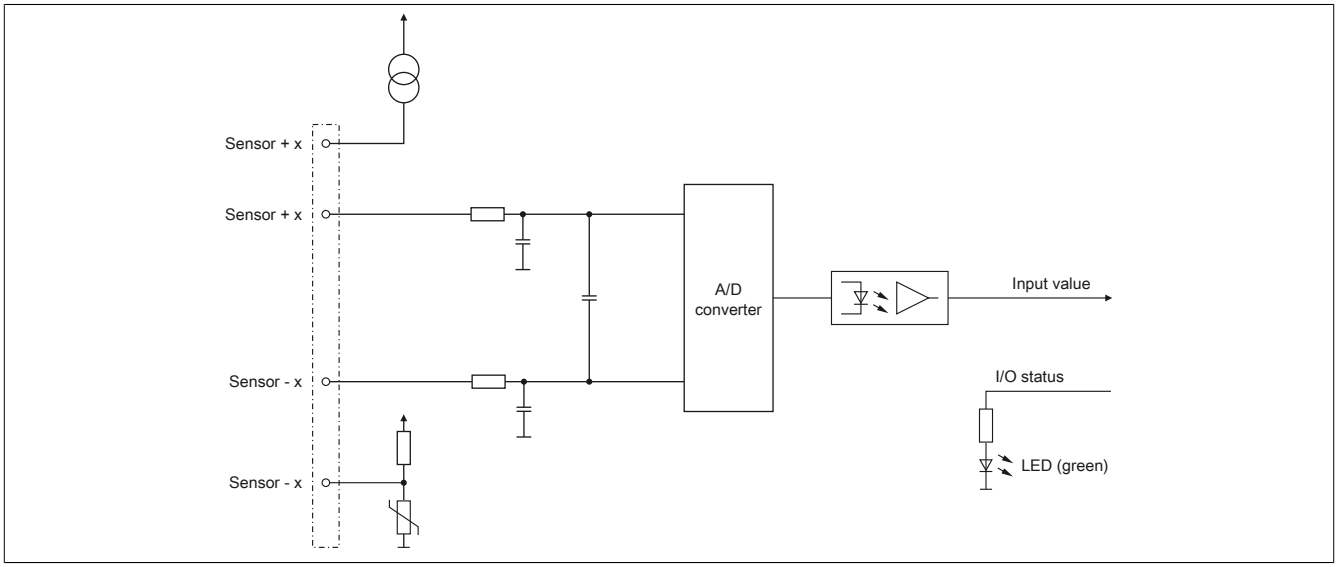


2.2.4 Connection example

To guarantee accuracy, a ZF dummy module must be connected to the left and right of the module.



2.2.5 Input circuit diagram



2.3 Register description

2.3.1 General data points

In addition to the registers described in the register description, the module has additional general data points. These are not module-specific but contain general information such as serial number and hardware variant.

General data points are described in section "Additional information - General data points" in the X20 System user's manual.

2.3.2 Function model 0 - Standard

Register	Name	Data type	Read		Write	
			Cyclic	Acyclic	Cyclic	Acyclic
Configuration						
2049	ConfigOutput01 (input filter)	USINT				•
2051	ConfigOutput02 (sensor type and channel disabling)	USINT				•
Communication						
2308	Temperature01	DINT	•			
	Resistor01	UDINT				
2316	Temperature02	DINT	•			
	Resistor02	UDINT				
2337	IOCycleCounter	USINT	•			
2345	StatusInput01	USINT	•			

2.3.3 Function model 254 - Bus controller

Register	Offset[1)]	Name	Data type	Read		Write	
				Cyclic	Acyclic	Cyclic	Acyclic
Configuration							
2049	-	ConfigOutput01 (input filter)	USINT				•
2051	-	ConfigOutput02 (sensor type and channel disabling)	USINT				•
Communication							
0	0	Temperature01	DINT	•			
		Resistor01	UDINT				
4	4	Temperature02	DINT	•			
		Resistor02	UDINT				
30	-	StatusInput01	USINT	•			

1) The offset specifies the position of the register within the CAN object.

2.3.3.1 Using the module on the bus controller

Function model 254 "Bus controller" is used by default only by non-configurable bus controllers. All other bus controllers can use other registers and functions depending on the fieldbus used.

For detailed information, see section "Additional information - Using I/O modules on the bus controller" in the X20 user's manual (version 3.50 or later).

2.3.3.2 CAN I/O bus controller

The module occupies 1 analog logical slot on CAN I/O.

2.3.4 General information

2.3.4.1 Timing

The timing for acquiring measured values is controlled by the converter hardware. All switched-on inputs are converted during each conversion cycle and transferred halfway through the X2X Link cycle.

2.3.4.2 Conversion time

The conversion time for the channels depends on the filter time set in register "ConfigOutput1" on page 18.

Use of the channels	Conversion time
All channels regardless of configuration	1 x Filter time

2.3.4.3 Ratio of filter time to resolution

The following table shows the maximum frequency with which the specified resolution can be achieved.

Filter / Filter time	Resolution
5 Hz / 200 ms	0.001°C
50 Hz / 20 ms	0.01°C
1000 Hz / 1 ms	0.1°C

2.3.5 Configuration

2.3.5.1 Input filter

Name:
ConfigOutput01

The filter time of all analog inputs is defined in this register.

Data type	Value	Filter	Filter time
USINT	0	15 Hz	66.7 ms
	1	25 Hz	40 ms
	2	30 Hz	33.3 ms
	3	50 Hz	20 ms
	4	60 Hz	16.7 ms
	5	100 Hz	10 ms
	6	500 Hz	2 ms
	7	1000 Hz	1 ms
	8	10 Hz (bus controller default setting)	100 ms
	9	5 Hz	200 ms
	10	2.5 Hz	400 ms

2.3.5.2 Sensor type and channel disabling

Name:
ConfigOutput02

This register can be used to configure the sensor type for individual channels.

This module is designed for temperature and resistance measurement. The sensor type must be specified because of the different calibration values for temperature and resistance.

The default setting for all channels is ON.

Data type	Value	Bus controller default setting
USINT	See bit structure.	17

Bit structure:

Bit	Name	Value	Information
0 - 3	Channel 1	0000	Reserved
		0001	Sensor type PT100 resolution 1mK (bus controller default setting)
		0010	Resistance measurement 0.5 Ω to 390 Ω, resolution 1 mΩ
		0011 to 0110	Reserved
		0111	Channel disabled
		1xxx	Reserved
4 - 7	Channel 2	0000	Reserved
		0001	Sensor type PT100 resolution 1mK (bus controller default setting)
		0010	Resistance measurement 0.5 Ω to 390 Ω, resolution 1 mΩ
		0011 to 0110	Reserved
		0111	Channel disabled
		1xxx	Reserved

2.3.6 Communication

2.3.6.1 Analog measurement inputs

Name:
Temperature01 to Temperature02
Resistor01 to Resistor02

These registers are used to indicate the analog input values depending on the configured operating mode. Different resistance or temperature measurements will result in different value ranges and data types.

Name	Data type	Input signal	Digital value
Temperature01 to Temperature02	DINT	PT100 sensor type	-200000 to +850000 (for -200 to +850°C)
Resistor01 to Resistor02	UDINT	Resistance measurement 0.5 to 390 Ω	500 to 390000 (resolution 0.001 Ω)

In order for the user to always be supplied with a defined output value, the following must be taken into consideration:

- Up to the first conversion, 0x80000000 is output.
- After switching the sensor type, 0x80000000 is output until the first conversion.
- If the input is not switched on, 0x80000000 is output.

2.3.6.2 I/O cycle counter

Name:
IOCycleCounter

The cyclic counter increases after all input data has been updated.

Data type	Values	Information
USINT	0 to 255	Repeating counter

2.3.6.3 Status of the inputs

Name:
StatusInput01

The module's inputs are monitored. A change in the monitoring status is actively transmitted as an error message.

After an error, it takes about 15 filter times until a valid value is available again.

Data type	Values
USINT	See the bit structure.

Bit structure:

Bit	Name	Value	Information
0 - 1	Channel 1	00	No error
		01	Lower limit value undershot
		10	Upper limit value overshot
		11	Open circuit
2 - 3	Channel 2	00	No error
		01	Lower limit value undershot
		10	Upper limit value overshot
		11	Open circuit
4 - 7	Reserved	0	

Analog value in the event of error

In addition to the status information, the analog value is permanently defined to the following value in an error state:

Error state	Temperature measure-ment digital value on error	Resistance measurement digital value on error
Open circuit	+2147483647 (0x7FFFFFFF)	+4294967295 (0xFFFFFFFF)
Upper limit value overshot	+2147483647 (0x7FFFFFFF)	+4294967295 (0xFFFFFFFF)
Lower limit value undershot	-2147483647 (0x80000001)	-2147483647 (0x80000001)
Invalid value	-2147483648 (0x80000000)	-2147483648 (0x80000000)

2.3.7 Minimum cycle time

The minimum cycle time specifies how far the bus cycle can be reduced without communication errors occurring. It is important to note that very fast cycles reduce the idle time available for handling monitoring, diagnostics and acyclic commands.

Minimum cycle time
200 µs

2.3.8 Minimum I/O update time

The minimum I/O update time specifies how far the bus cycle can be reduced so that an I/O update is performed in each cycle.

Minimum I/O update time
1 x Filter time

3 X20AT2402

3.1 General information

3.1.1 Other applicable documents

For additional and supplementary information, see the following documents.

Other applicable documents

Document name	Title
MAX20	X20 System user's manual
MAEMV	Installation / EMC guide

3.1.2 Order data

Order number	Short description	Figure
	Temperature measurement	
X20AT2402	X20 temperature input module, 2 thermocouple inputs, type J, K, N, S, B, R, resolution 0.1/0.01°C	
	Required accessories	
	Bus modules	
X20BM11	X20 bus module, 24 VDC keyed, internal I/O power supply connected through	
X20BM15	X20 bus module, with node number switch, 24 VDC keyed, internal I/O power supply connected through	
	Terminal blocks	
X20TB06	X20 terminal block, 6-pin, 24 VDC keyed	
X20TB12	X20 terminal block, 12-pin, 24 VDC keyed	

Table 5: X20AT2402 - Order data

3.1.3 Module description

The module is equipped with 2 inputs for J, K, N, S, B and R thermocouple sensors. The module has an integrated terminal temperature compensation.

This module is designed for X20 6-pin terminal blocks. If needed (e.g. for logistical reasons), the 12-pin terminal block can also be used.

- 2 inputs for thermocouples
- For sensor types J, K, N, S, B, R
- Additional direct raw value measurement
- Integrated terminal temperature compensation
- Configurable filter time
- Configurable resolution

Functions:

- Sensor type and measurement range
- Input filter
- Monitoring the input signal

Sensor type and measurement range

The module is used with a thermocouple sensor. For sensor types not supported by the module, the module is equipped with raw value measurement.

Input filter

One input filter can be configured for all analog inputs together.

Monitoring the input signal

The input signal of the analog inputs is monitored against the upper and lower limit values as well as for open circuit.

3.2 Technical description

3.2.1 Technical data

Order number	X20AT2402
Short description	
I/O module	2 inputs for thermocouples
General information	
B&R ID code	0x1BA8
Status indicators	I/O function per channel, operating state, module status
Diagnostics	
Module run/error	Yes, using LED status indicator and software
Inputs	Yes, using LED status indicator and software
Power consumption	
Bus	0.01 W
Internal I/O	0.72 W
Additional power dissipation caused by actuators (resistive) [W]	-
Certifications	
CE	Yes
UKCA	Yes
ATEX	Zone 2, II 3G Ex nA nC IIA T5 Gc IP20, Ta (see X20 user's manual) FTZÚ 09 ATEX 0083X
UL	cULus E115267 Industrial control equipment
HazLoc	cCSAus 244665 Process control equipment for hazardous locations Class I, Division 2, Groups ABCD, T5
DNV	Temperature: **B** (0 to 55°C) Humidity: **B** (up to 100%) Vibration: **B** (4 g) EMC: **B** (bridge and open deck)
LR	ENV1
KR	Yes
ABS	Yes
BV	**EC33B** Temperature: 5 - 55°C Vibration: 4 g EMC: Bridge and open deck
EAC	Yes
KC	Yes
Thermocouple temperature inputs	
Input	Thermocouple
Digital converter resolution	16-bit
Filter time	Configurable between 1 ms and 66.7 ms
Conversion time	
1 channel	80.4 ms with 50 Hz filter
2 channels	120.6 ms with 50 Hz filter
Output format	INT
Measurement range	
Sensor temperature	
Type J: Fe-CuNi	-210 to 1200°C
Type K: NiCr-Ni	-270 to 1372°C
Type N: NiCrSi-NiSi	-270 to 1300°C (Rev. ≥D0)
Type S: PtRh10-Pt	-50 to 1768°C
Type B: PtRh30-PtRh6	0 to 1820°C
Type R: PtRh13-Pt	-50 to 1664°C
Terminal temperature	-25 to 85°C
Raw value	±65.534 mV
Terminal temperature compensation	Internal
Sensor standard	EN 60584
Resolution	
Sensor temperature	1 LSB = 0.1°C or 0.01°C
Terminal temperature	1 LSB = 0.1°C
Raw value output with respect to gain	1 LSB = 1 µV or 2 µV

Table 6: X20AT2402 - Technical data

Order number	X20AT2402
Normalization	
Type J: Fe-CuNi	-210.0 to 1200.0°C or -210.00 to 1200.00°C
Type K: NiCr-Ni	-270.0 to 1372.0°C or -270.00 to 1372.00°C
Type N (Rev. ≥D0)	-270.0 to 1300.0°C or -270.00 to 1300.00°C
Type S: PtRh10-Pt	-50.0 to 1768.0°C or -50.00 to 1768.00°C
Type B: PtRh30-PtRh6	0 to 1820.0°C or 0 to 1820.00°C
Type R: PtRh13-Pt	-50.0 to 1664.0°C or -50.00 to 1664.00°C
Terminal temperature	-25.0 to 85.0°C or -25.00 to 85.00°C
Monitoring	
Range undershoot	0x8001
Range overshoot	0x7FFF
Open circuit	0x7FFF
Open inputs	0x7FFF
General fault	0x8000
Conversion procedure	Sigma-delta
Linearization method	Internal
Permissible input signal	Max. ±5 V
Input filter	First-order low-pass filter / cutoff frequency 500 Hz
Max. error at 25°C	
Gain	0.06% [1]
Offset	
Type J: Fe-CuNi	0.04% [2]
Type K: NiCr-Ni	0.05% [2]
Type N (Rev. ≥D0)	0.05% [2]
Type S: PtRh10-Pt	0.11% [2]
Type B: PtRh30-PtRh6	0.13% [2]
Type R: PtRh13-Pt	0.09% [2]
Max. gain drift	0.01%/°C [1]
Max. offset drift	
Type J: Fe-CuNi	0.0019 %/°C [2]
Type K: NiCr-Ni	0.0024% / °C [2]
Type N (Rev. ≥D0)	0.0029 %/°C [2]
Type S: PtRh10-Pt	0.0079 %/°C [2]
Type B: PtRh30-PtRh6	0.0114 %/°C [2]
Type R: PtRh13-Pt	0.0074 %/°C [2]
Nonlinearity	±0.001% [2]
Common-mode rejection	
DC	>70 dB
50 Hz	>70 dB
Common-mode range	±15 V
Crosstalk between channels	<-70 dB
Insulation voltage	
Between channel and bus	500 V_{eff}
Terminal temperature compensation precision	
With artificial convection	±4°C after 10 min
With natural convection	±2°C after 10 min
Electrical properties	
Electrical isolation	Channel isolated from bus Channel not isolated from channel
Operating conditions	
Mounting orientation	
Horizontal	Yes
Vertical	Yes
Installation elevation above sea level	
0 to 2000 m	No limitation
>2000 m	Reduction of ambient temperature by 0.5°C per 100 m
Degree of protection per EN 60529	IP20
Ambient conditions	
Temperature	
Operation	
Horizontal mounting orientation	0 to 55°C
Vertical mounting orientation	0 to 50°C
Derating	-
Storage	-40 to 85°C
Transport	-40 to 85°C

Table 6: X20AT2402 - Technical data

Order number	X20AT2402
Relative humidity	
Operation	5 to 95%, non-condensing
Storage	5 to 95%, non-condensing
Transport	5 to 95%, non-condensing
Mechanical properties	
Note	Order 1x terminal block X20TB06 or X20TB12 separately. Order 1x bus module X20BM11 separately.
Pitch	$12.5^{+0.2}$ mm

Table 6: X20AT2402 - Technical data

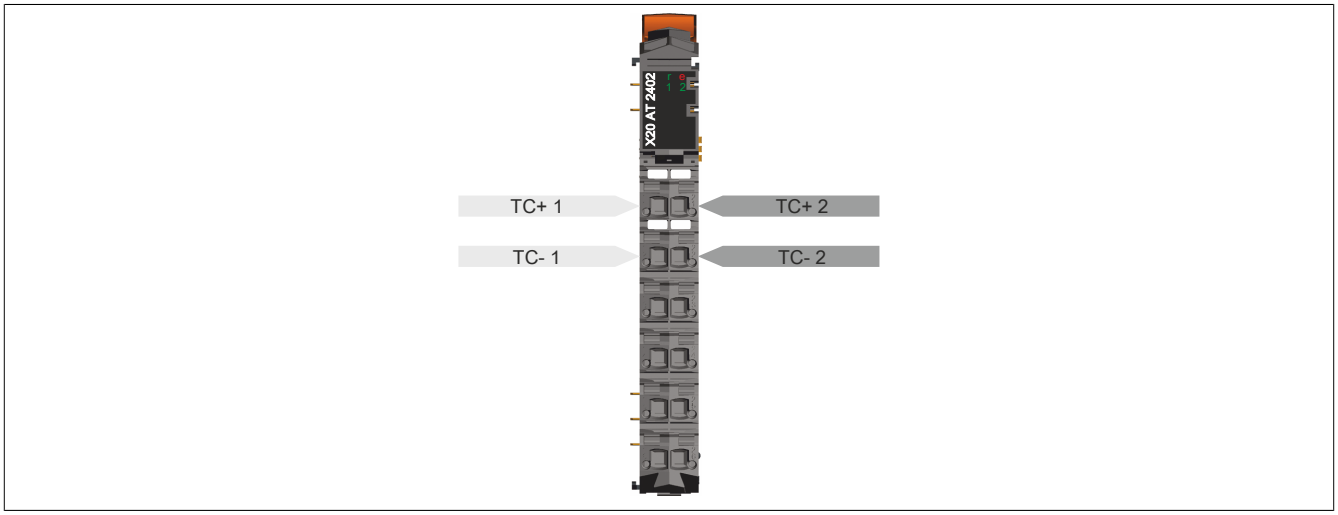
1) Based on the current measured value.
2) Based on the entire measurement range.

3.2.2 LED status indicators

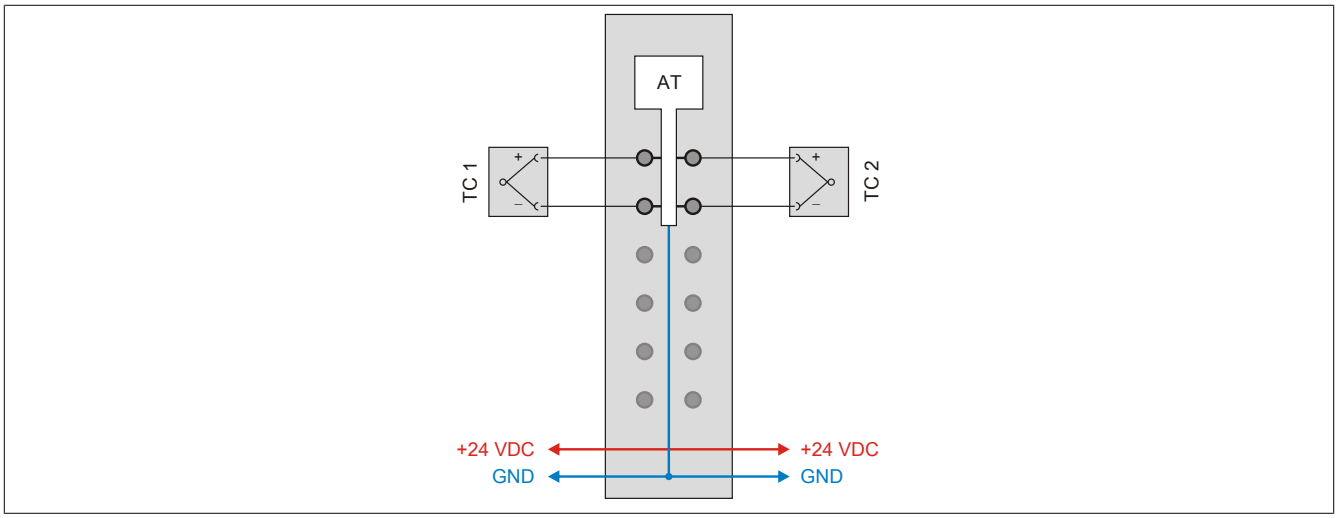
For a description of the various operating modes, see section "Additional information - Diagnostic LEDs" in the X20 System user's manual.

Figure	LED	Color	Status	Description
	r	Green	Off	No power to module
			Single flash	RESET mode
			Blinking	PREOPERATIONAL mode
			On	RUN mode
	e	Red	Off	No power to module or everything OK
			On	Error or reset status
			Single flash	Warning/Error on an I/O channel. Overflow or underflow of the analog inputs.
	e + r	Red on / Green single flash		Invalid firmware
	1 - 2	Green	Off	The input is switched off
			Blinking	Overflow, underflow or open line
			On	Analog/digital converter running, value OK

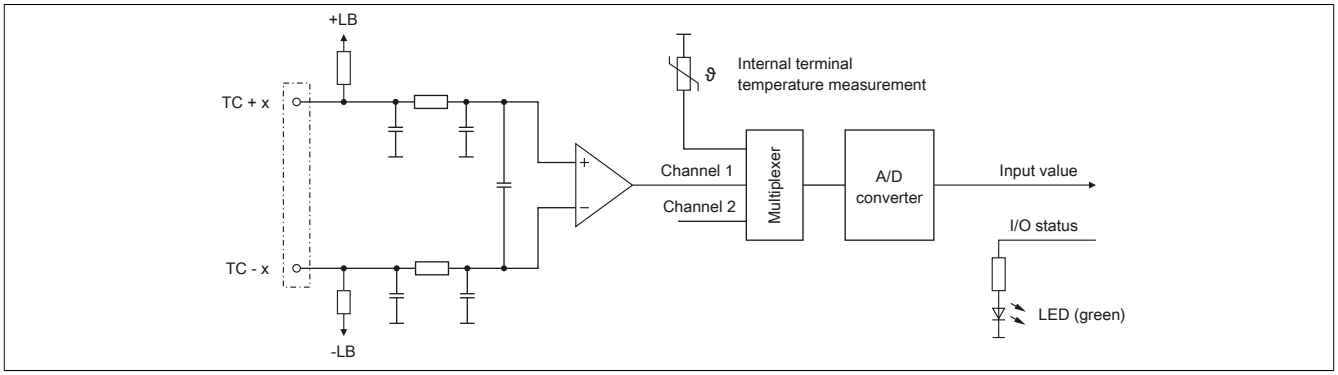
3.2.3 Pinout



3.2.4 Connection example

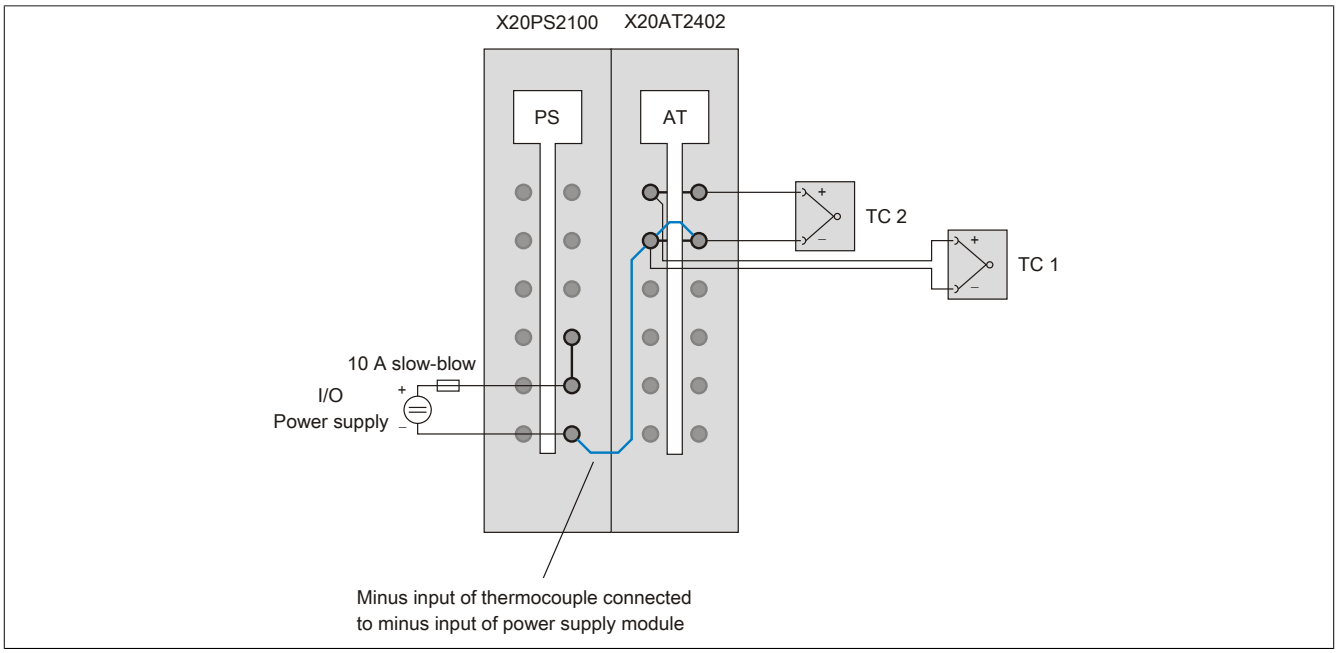


3.2.5 Input circuit diagram



3.2.6 Ceramic heating element with integrated thermo elements

We recommend connecting the minus input of the thermo element to the minus input of the supply feed module. This prevents potential measurement errors caused by ripple voltage effects in the measurement signal.



3.2.7 External cold junction

General information

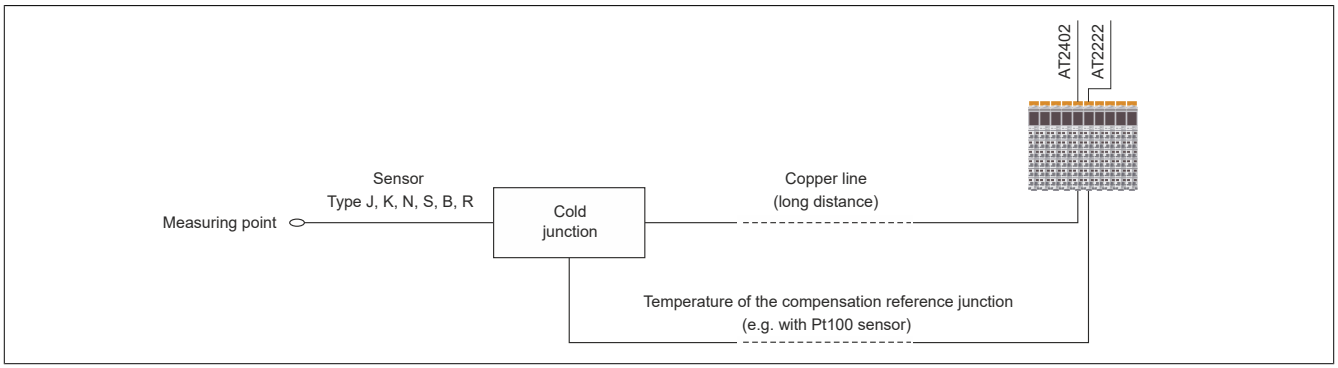
An external cold junction temperature value can be predefined for the module for measurement value correction. This makes it possible to set up an external cold junction. The same external cold junction temperature is used for measurement value correction on all channels.

An external cold junction makes sense in the following applications and situations:

- Large distances between the controller and measurement point
- To increase precision

To bridge large distances

Setting up an external cold junction is recommended when there are large distances between the controller and the measurement point. The thermocouple voltage is routed from the external cold junction to the terminal on the X20AT2402 via copper wires. The temperature measured at the external cold junction (e.g. with PT100 - X20AT2222) is stored in the I/O area of the X20AT2402 module. The X20AT2402 uses the measured voltage and the cold junction temperature to internally calculate the needed thermocouple temperature.



Increased precision

Setting up an external cold junction is recommended to increase precision. The external cold junction is set up as described above. The installation of an external cold junction is especially helpful in the following cases:

- A module consuming more power than 1 W is connected in addition to the X20AT2402.
- No modules but the X20AT2402 are connected
- With strongly fluctuating ambient conditions (draft, temperature)

3.3 Function description

3.3.1 Sensor type and measurement range

The module is designed for different sensor types. The sensor type must be set due to the different calibration values.

Values	Information
1	Sensor type J
2	Sensor type K
3	Sensor type S
4	Sensor type N
6	Raw value without linearization and terminal temperature compensation: 1.0625 µV resolution for a measurement range of ±35 mV
7	Raw value without linearization and terminal temperature compensation: 2.125 µV resolution for a measurement range of ±70 mV
64	Sensor type R
72	Sensor type B

In order for the user to always be supplied with a defined output value, the following must be taken into consideration:

- 0x8000 or 0x80000000 is output until the first conversion depending on the resolution.
- After switching the sensor type, 0x8000 or 0x80000000 is output until the first conversion depending on the resolution.
- If the input is not switched on, 0x8000 or 0x80000000 is output depending on the resolution.

Information:

The register is described in "Sensor type" on page 33.

3.3.2 Input filter

Input filter

The filter time for all analog inputs is defined using the input filter parameter.

Value	Filter	Filter time	Digital converter resolution
0	15 Hz	66.7 ms	16-bit
1	25 Hz	40 ms	16-bit
2	30 Hz	33.3 ms	16-bit
3	50 Hz	20 ms	16-bit
4	60 Hz	16.7 ms	16-bit
5	100 Hz	10 ms	16-bit
6	500 Hz	2 ms	16-bit
7	1000 Hz	1 ms	16-bit

Information:

The register is described in "Input filter and ambient conditions" on page 33.

3.3.3 Monitoring the input signal

The module's inputs are monitored. A change in the monitoring status is actively transmitted as an error message.

Bit value	Information
00	No error
01	Lower limit value undershot
10	Upper limit value overshot
11	Open circuit

Limiting the analog value

In addition to the status information, the analog value is permanently defined to the following value in an error state:

Error state	Digital value on error
Open circuit	0.1°C resolution: +32767 (0x7FFF)
	0.01°C resolution: +2,147,483,647 (0x7FFFFFFF)
Upper limit value overshot	0.1°C resolution: +32767 (0x7FFF)
	0.01°C resolution: +2,147,483,647 (0x7FFFFFFF)
Lower limit value undershot	0.1°C resolution: -32767 (0x8001)
	0.01°C resolution: -2,147,483,647 (0x80000001)
Invalid value	0.1°C resolution: -32768 (0x8000)
	0.01°C resolution: -2,147,483,648 (0x80000000)

Information:

The register is described in "Input status" on page 35.

3.4 Commissioning

3.4.1 Using the module on the bus controller

Function model 254 "Bus controller" is used by default only by non-configurable bus controllers. All other bus controllers can use other registers and functions depending on the fieldbus used.

For detailed information, see section "Additional information - Using I/O modules on the bus controller" in the X20 user's manual (version 3.50 or later).

3.4.1.1 CAN I/O bus controller

The module occupies 1 analog logical slot on CAN I/O.

3.4.2 Raw value measurement

If a sensor type other than J, K, N, S, B or R is used, the terminal temperature must be measured on at least one input. The user must use this value to perform terminal temperature compensation.

3.4.3 Ambient conditions

The ambient conditions setting is used to adapt the internal terminal temperature characteristics to the type and amount of heat radiated onto the module.

The power consumption of the modules connected directly to the left and right in the X2X Link network serves as the characteristic value for the selection. For the power consumption, see the technical data of the corresponding module. The higher value is used for the setting.

3.4.4 Configuring the conversion cycle

The timing for acquiring measurement values is determined by the converter hardware. All enabled inputs are converted during each conversion cycle. In addition, the terminal temperature is measured (not in function model 1).

Any inputs that are not needed can be switched off, which reduces the I/O update time. Inputs can also be only switched off temporarily. Measuring the terminal temperature is switched off in function model 1.

3.4.4.1 Conversion time

The conversion time depends on the number of channels and the function model. For the formulas listed in the table, "n" corresponds to the number of channels that are switched on.

Function model	Conversion time
Model 0 - n channels	(n + 1) · (2 · Filter time + 200 µs)
Model 1 - n channels	n · (2 · Filter time + 200 µs)
Model 1 - 1 channel	Equal to the filter time

Examples

Inputs are filtered using a 50 Hz filter.

	Example 1		Example 2	
	Function model 0	Function model 1	Function model 0	Function model 1
Switched on inputs	1	1	1 - 2	1 - 2
Input conversion times	40.2 ms	20 ms	80.4 ms	80.4 ms
Conversion time for the terminal temperature	40.2 ms	-	40.2 ms	-
Total conversion time	80.4 ms	20 ms	120.6 ms	80.4 ms

3.5 Register description

3.5.1 General data points

In addition to the registers described in the register description, the module has additional general data points. These are not module-specific but contain general information such as serial number and hardware variant.

General data points are described in section "Additional information - General data points" in the X20 System user's manual.

3.5.2 Function model 0 - default

The resolution of 0.1 or 0.01°C can be set in the configuration.

Register	Name	Data type	Read		Write	
			Cyclic	Acyclic	Cyclic	Acyclic
Configuration						
24	ConfigOutput01 (Input filter / ambient conditions)	USINT				•
26	ConfigOutput02 (Sensor type)	USINT				•
27	ConfigOutput03 (Channel disabling)	USINT				•
Communication						
0	Temperature01	INT	•			
2	Temperature02	INT	•			
28	IOCycleCounter	USINT	•			
30	StatusInput01	USINT	•			
14	CompensationTemperature	INT		•		
40	Temperature01_H_Res	DINT	•			
44	Temperature02_H_Res	DINT	•			

3.5.3 Function model 1 - External cold junction temperature

The resolution of 0.1 or 0.01°C can be set in the configuration.

Register	Name	Data type	Read		Write	
			Cyclic	Acyclic	Cyclic	Acyclic
Configuration						
24	ConfigOutput01 (Input filter / ambient conditions)	USINT				•
26	ConfigOutput02 (Sensor type)	USINT				•
27	ConfigOutput03 (Channel disabling)	USINT				•
Communication						
12	ExternalCompensationTemperature	INT			•	
0	Temperature01	INT	•			
2	Temperature02	INT	•			
28	IOCycleCounter	USINT	•			
30	StatusInput01	USINT	•			
40	Temperature01_H_Res	DINT	•			
44	Temperature02_H_Res	DINT	•			

3.5.4 Function model 254 - Bus controller

Register	Offset[1)]	Name	Data type	Read		Write	
				Cyclic	Acyclic	Cyclic	Acyclic
Configuration							
24	-	ConfigOutput01 (Input filter / ambient conditions)	USINT				•
26	-	ConfigOutput02 (Sensor type)	USINT				•
27	-	ConfigOutput03 (Channel disabling)	USINT				•
Communication							
0	0	Temperature01	INT	•			
2	2	Temperature02	INT	•			
28	-	IOCycleCounter	USINT		•		
30	-	StatusInput01	USINT		•		
14	-	CompensationTemperature	INT		•		

1) The offset specifies the position of the register within the CAN object.

3.5.5 Configuration

3.5.5.1 Input filter and ambient conditions

Name:
ConfigOutput01

This register is used to configure input filters and ambient conditions. For details, see "Input filter" on page 29 and "Ambient conditions" on page 31.

Data type	Values	Bus controller default setting
USINT	See bit structure.	3

Bit structure:

Bit	Description	Value	Information
0 - 3	Input filter	0000	15 Hz
		0001	25 Hz
		0010	30 Hz
		0011	50 Hz (bus controller default setting)
		0100	60 Hz
		0101	100 Hz
		0110	500 Hz
		0111	1000 Hz
		1000 to 1111	Not permitted
4 - 7	Ambient conditions	0000	Default, no calculation for adjustment (bus controller default setting)
		0001	Power dissipation less than 0.2 W
		0010	Power dissipation less than 1 W
		0011	Power dissipation more than 1 W
		0100 to 1111	Not permitted

3.5.5.2 Sensor type

Name:
ConfigOutput02

This module is designed for a wide range of sensor types. The sensor type must be configured because of the different alignment values.

Data type	Value	Information
USINT	0	Conversion switched off
	1	Sensor type J (bus controller default setting)
	2	Sensor type K
	3	Sensor type S
	4	Sensor type N
	5	Conversion switched off
	6	Raw value without linearization and terminal temperature compensation: Resolution 1.0625 µV for a measurement range of ±35 mV
	7	Raw value without linearization and terminal temperature compensation: Resolution 2.125 µV for a measurement range of ±70 mV
	8 - 63	Conversion switched off
	64	Sensor type R
	65 - 71	Conversion switched off
	72	Sensor type B
	73 - 255	Conversion switched off

3.5.5.3 Channel disabling

Name:
ConfigOutput03

By default, all channels are switched on. To save time, individual channels can be switched off (see "Conversion time" on page 31).

Data type	Values	Bus controller default setting
USINT	See bit structure.	3

Bit structure:

Bit	Description	Value	Information
0	Channel 1	0	Off
		1	Switched on (bus controller default setting)
1	Channel 2	0	Off
		1	Switched on (bus controller default setting)
2 - 7	Reserved	0	

3.5.6 Communication

3.5.6.1 Analog inputs (resolution = 0.1°C)

Name:
Temperature01 to Temperature02

With a resolution of 0.1°C, these registers contain the analog input value depending on the set sensor type:

Data type	Values	Input signal
INT	-2100 to +12000 (for -210.0°C to +1200.0°C)	Type J (FeCuNi)
	-2700 to +13720 (for -270.0°C to +1372.0°C)	Type K (NiCrNi)
	-2700 to +13000 (for -270.0°C to +1300.0°C)	Type N (NiCrSi)
	-500 to +17680 (for -50.0°C to +1768.0°C)	Type S (PtRhPt)
	0 to +18200 (for 0°C to +1820.0°C)	Type B (PtRhPt)
	-500 to +16640 (for -50.0°C to +1664.0°C)	Type R (PtRhPt)
	-32,768 to +32,767	Raw value without linearization and terminal temperature compensation: Resolution 1.0625 µV for a measurement range of ±35 mV
	-32,768 to +32,767	Raw value without linearization and terminal temperature compensation: Resolution 2.125 µV for a measurement range of ±70 mV

3.5.6.2 Analog inputs (resolution = 0.01°C)

Name:
Temperature01_H_Res to Temperature02_H_Res

With a resolution of 0.01°C, these registers contain the analog input value depending on the set sensor type:

Data type	Values	Input signal
DINT	-21000 to +120000 (for -210.00°C to +1200.00°C)	Type J (FeCuNi)
	-27000 to +137200 (for -270.00°C to +1372.00°C)	Type K (NiCrNi)
	-27000 to +130000 (for -270.00°C to +1300.00°C)	Type N (NiCrSi)
	-5000 to +176800 (for -50.00°C to +1768.00°C)	Type S (PtRhPt)
	0 to +182000 (for 0°C to +1820.00°C)	Type B (PtRhPt)
	-5000 to +166400 (for -50.00°C to +1664.00°C)	Type R (PtRhPt)
	-2,147,483,648 to 2,147,483,647	Raw value without linearization and terminal temperature compensation: 0.10625 µV resolution for a measurement range of ±35 mV
	-2,147,483,648 to 2,147,483,647	Raw value without linearization and terminal temperature compensation: 0.2125 µV resolution for a measurement range of ±70 mV

3.5.6.3 I/O cycle counter

Name:
IOCycleCounter

The cyclic counter increases after all input data has been updated.

Data type	Values	Information
USINT	0 to 255	Repeating counter

3.5.6.4 Input status

Name:
StatusInput01

The module's inputs are monitored. A change in the monitoring status is actively issued as an error message and, in the event of an error, the analog value is fixed at defined values. For details, see "Monitoring the input signal" on page 30.

Data type	Values
USINT	See the bit structure.

Bit structure:

Bit	Description	Value	Information
0 - 1	Channel 1	00	No error
		01	Lower limit value undershot
		10	Upper limit value overshot
		11	Open circuit
2 - 3	Channel 2	00	No error
		01	Lower limit value undershot
		10	Upper limit value overshot
		11	Open circuit
4 - 7	Reserved	0	

3.5.6.5 Reads the internal cold junction temperature

Name:
CompensationTemperature

The internal cold junction temperature is stored in this register.

Data type	Value	Information
INT	-250 to 850	Internal cold junction temperature (PT1000): -25.0 to 85.0°C

3.5.6.6 Defines the external cold junction temperature

Name:
ExternalCompensationTemperature

The external cold junction temperature is defined in this register.

Data type	Value	Information
INT	-250 to 850	External cold junction temperature: -25.0 to 85.0°C

3.5.7 Minimum cycle time

The minimum cycle time specifies how far the bus cycle can be reduced without communication errors occurring. It is important to note that very fast cycles reduce the idle time available for handling monitoring, diagnostics and acyclic commands.

Minimum cycle time
150 µs

3.5.8 Minimum I/O update time

The minimum I/O update time specifies how far the bus cycle can be reduced so that an I/O update is performed in each cycle.

For the formulas listed in the table, 'n' corresponds to the number of channels that are switched on.

Function model 0	
n inputs	(n + 1) · (2 x Filter time + 200 µs)

Function model 1	
1 input	Equal to the filter time
n inputs	n · (2 x Filter time + 200 µs)

4 X20(c)AT4222

4.1 General information

The module is equipped with 4 inputs for PT100/PT1000 resistance temperature measurement.

- 4 inputs for resistance temperature measurement
- For PT100 and PT1000
- Configurable sensor type per channel
- Direct resistance measurement
- Configurable 2- or 3- wire connections per module
- Configurable filter time

4.1.1 Coated modules

Coated modules are X20 modules with a protective coating for the electronics component. This coating protects X20c modules from condensation and corrosive gases.
The modules' electronics are fully compatible with the corresponding X20 modules.

For simplification purposes, only images and module IDs of uncoated modules are used in this data sheet.

The coating has been certified according to the following standards:

- Condensation: BMW GS 95011-4, 2x 1 cycle
- Corrosive gas: EN 60068-2-60, method 4, exposure 21 days

4.1.1.1 Starting temperature

The starting temperature describes the minimum permissible ambient temperature in a voltage-free state at the time the coated module is switched on. This is permitted to be as low as -40°C. During operation, the conditions as specified in the technical data continue to apply.

Information:

It is important to absolutely ensure that there is no forced cooling by air currents in the closed control cabinet, e.g. due to the use of a fan or ventilation slots.

4.1.2 Other applicable documents

For additional and supplementary information, see the following documents.

Other applicable documents

Document name	Title
MAX20	X20 System user's manual
MAEMV	Installation / EMC guide

4.2 Order data

Order number	Short description	Figure
	Temperature measurement	
X20AT4222	X20 temperature input module, 4 resistance measurement inputs, Pt100, Pt1000, resolution 0.1°C, 3-wire connections	
X20cAT4222	X20 temperature input module, coated, 4 resistance measurement inputs, Pt100, Pt1000, resolution 0.1°C, 3-wire connections	
	Required accessories	
	Bus modules	
X20BM11	X20 bus module, 24 VDC keyed, internal I/O power supply connected through	
X20BM15	X20 bus module, with node number switch, 24 VDC keyed, internal I/O power supply connected through	
X20cBM11	X20 bus module, coated, 24 VDC keyed, internal I/O power supply connected through	
	Terminal blocks	
X20TB12	X20 terminal block, 12-pin, 24 VDC keyed	

Table 7: X20AT4222, X20cAT4222 - Order data

4.3 Technical description

4.3.1 Technical data

Order number	X20AT4222	X20cAT4222
Short description		
I/O module	4 inputs for Pt100 or Pt1000 resistance temperature measurement	
General information		
B&R ID code	0x1BA7	0xE215
Status indicators	I/O function per channel, operating state, module status	
Diagnostics		
Module run/error	Yes, using LED status indicator and software	
Inputs	Yes, using LED status indicator and software	
Power consumption		
Bus	0.01 W	
Internal I/O	1.1 W	
Additional power dissipation caused by actuators (resistive) [W]	-	
Certifications		
CE	Yes	
UKCA	Yes	
ATEX	Zone 2, II 3G Ex nA nC IIA T5 Gc IP20, Ta (see X20 user's manual) FTZÚ 09 ATEX 0083X	
UL	cULus E115267 Industrial control equipment	
HazLoc	cCSAus 244665 Process control equipment for hazardous locations Class I, Division 2, Groups ABCD, T5	
DNV	Temperature: **B** (0 - 55°C) Humidity: **B** (up to 100%) Vibration: **B** (4 g) EMC: **B** (bridge and open deck)	
LR	ENV1	
KR	Yes	
ABS	Yes	
EAC	Yes	
KC	Yes	-
Resistance measurement temperature inputs		
Input	Resistance measurement with constant current supply for 2- or 3-wire connections	
Digital converter resolution	16-bit	
Filter time	Configurable between 1 ms and 66.7 ms	
Conversion time		
1 channel	20 ms with 50 Hz filter	
2 - 4 channels	40 ms per channel with 50 Hz filter	
Conversion procedure	Sigma-delta	
Output format	INT or UINT for resistance measurement	

Table 8: X20AT4222, X20cAT4222 - Technical data

Order number	X20AT4222	X20cAT4222
Sensor		
Sensor type	Configurable per channel	
Pt100	-200 to 850°C	
Pt1000	-200 to 850°C	
Resistance measurement range	0.1 to 4500 Ω / 0.05 to 2250 Ω	
Input filter	First-order low-pass filter / cutoff frequency 500 Hz	
Sensor standard	EN 60751	
Common-mode range	>0.7 V	
Insulation voltage between channel and bus	500 V_{eff}	
Linearization method	Internal	
Measurement current	250 µA ±1.25%	
Reference	4530 Ω ±0.1%	
Permissible input signal	Short-term max. ±30 V	
Max. error at 25°C		
Gain	0.037% 1)	
Offset	0.0015% 2)	
Max. gain drift	0.004%/°C 1)	
Max. offset drift	0.00015%/°C 2)	
Nonlinearity	<0.001% 2)	
Crosstalk between channels	<-93 dB	
Temperature sensor resolution		
Pt100	1 LSB = 0.1°C	
Pt1000	1 LSB = 0.1°C	
Resistance measurement resolution		
G = 1	0.1 Ω	
G = 2	0.05 Ω	
Common-mode rejection		
50 Hz	>80 dB	
DC	>95 dB	
Standardized range of values for resistance measurement		
G = 1	0.1 to 4500 Ω	
G = 2	0.05 to 2250 Ω	
Temperature sensor normalization		
Pt100	-200.0 to 850.0°C	
Pt1000	-200.0 to 850.0°C	
Temperature measurement monitoring		
Range undershoot	0x8001	
Range overshoot	0x7FFF	
Open circuit	0x7FFF	
General fault	0x8000	
Open inputs	0x7FFF	
Resistance measurement monitoring		
Range overshoot	0xFFFF	
Open circuit	0xFFFF	
General fault	0xFFFF	
Open inputs	0xFFFF	
Electrical properties		
Electrical isolation	Channel isolated from bus Channel not isolated from channel	
Operating conditions		
Mounting orientation		
Horizontal	Yes	
Vertical	Yes	
Installation elevation above sea level		
0 to 2000 m	No limitation	
>2000 m	Reduction of ambient temperature by 0.5°C per 100 m	
Degree of protection per EN 60529	IP20	
Ambient conditions		
Temperature		
Operation		
Horizontal mounting orientation	-25 to 60°C	
Vertical mounting orientation	-25 to 50°C	
Derating	-	
Starting temperature	-	Yes, -40°C
Storage	-40 to 85°C	
Transport	-40 to 85°C	

Table 8: X20AT4222, X20cAT4222 - Technical data

Order number	X20AT4222	X20cAT4222
Relative humidity		
Operation	5 to 95%, non-condensing	Up to 100%, condensing
Storage	5 to 95%, non-condensing	
Transport	5 to 95%, non-condensing	
Mechanical properties		
Note	Order 1x terminal block X20TB12 separately. Order 1x bus module X20BM11 separately.	Order 1x terminal block X20TB12 separately. Order 1x bus module X20cBM11 separately.
Pitch	$12.5^{+0.2}$ mm	

Table 8: X20AT4222, X20cAT4222 - Technical data

1) Based on the current measured resistance value.
2) Based on the entire resistance measurement range.

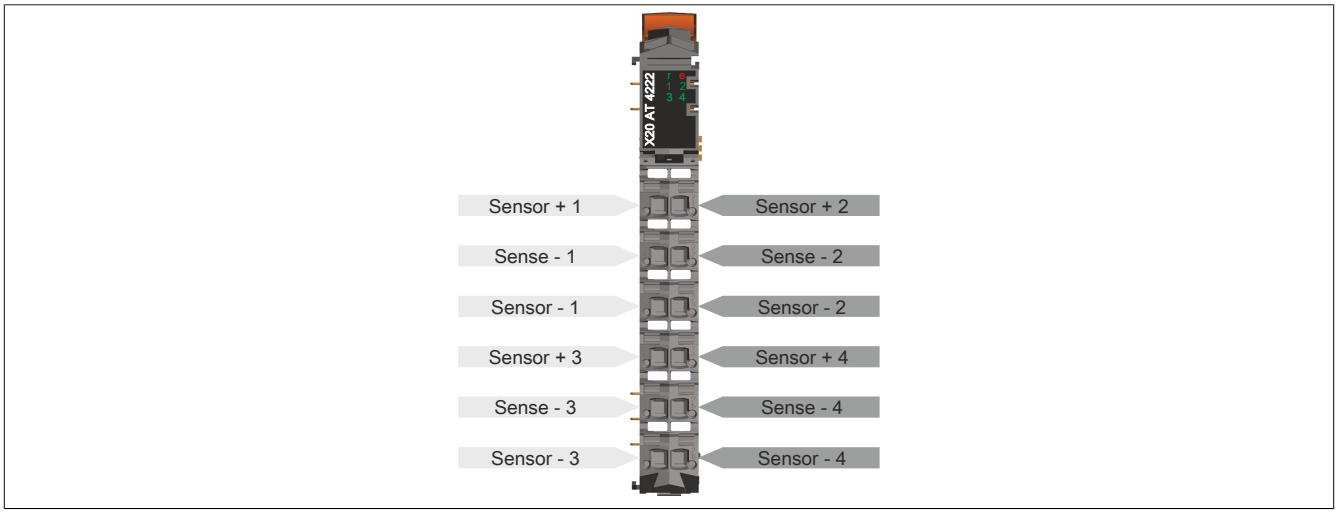
4.3.2 LED status indicators

For a description of the various operating modes, see section "Additional information - Diagnostic LEDs" in the X20 System user's manual.

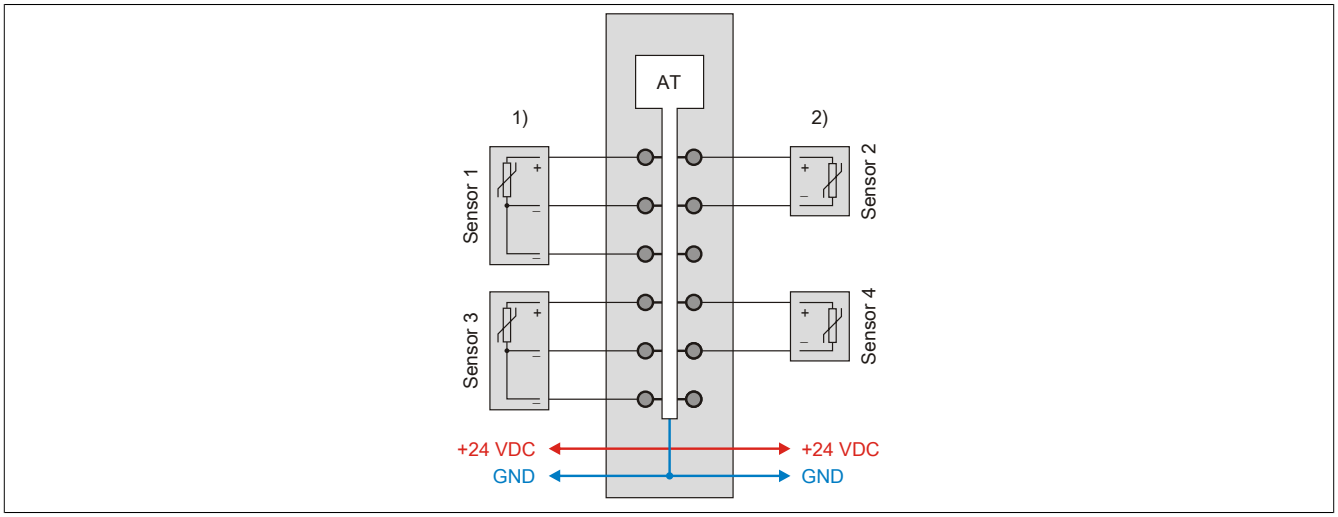
Figure	LED	Color	Status	Description
	r	Green	Off	No power to module
			Single flash	RESET mode
			Blinking	PREOPERATIONAL mode
			On	RUN mode
	e	Red	Off	No power to module or everything OK
			On	Error or reset status
			Single flash	Warning/Error on an I/O channel. Overflow or underflow of the analog inputs.
	e + r	Red on / Green single flash		Invalid firmware
	1 - 4	Green	Off	The input is switched off
			Blinking	Overflow, underflow or open line
			On	Analog/digital converter running, value OK

4.3.3 Pinout

Channels that are not being used should be disabled.



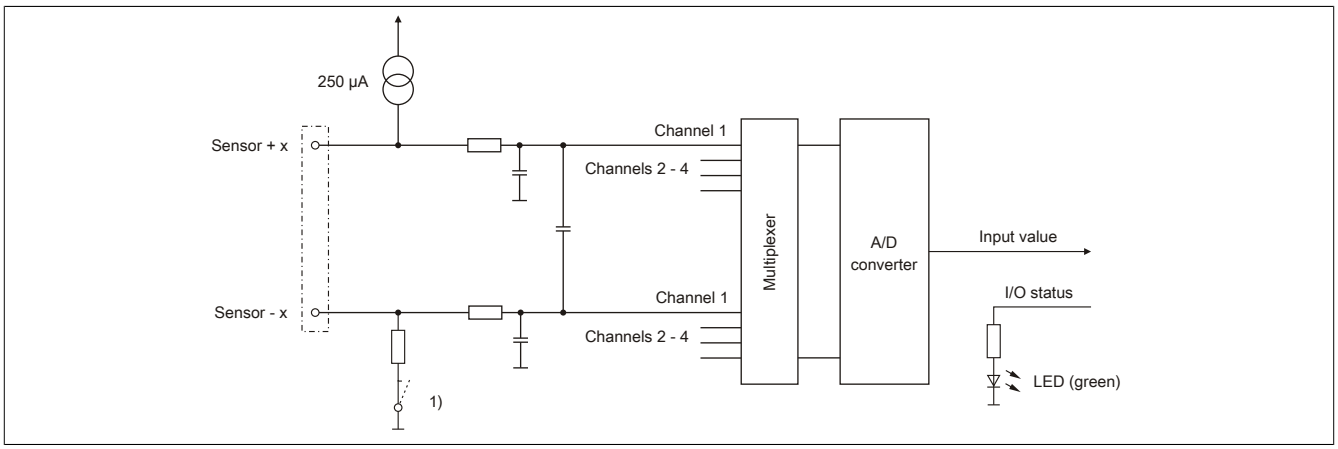
4.3.4 Connection example



1) 3-wire connections
2) 2-wire connections

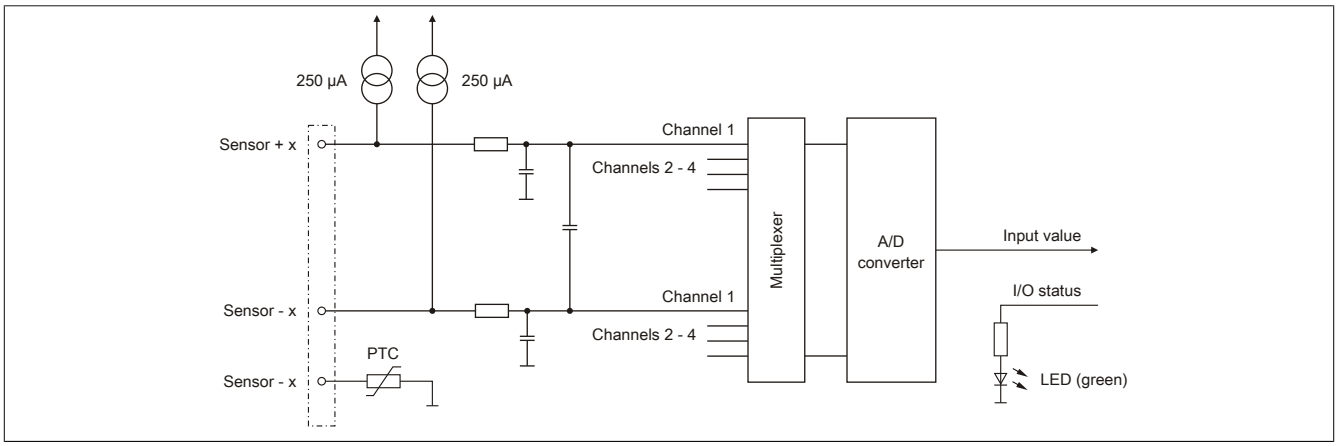
4.3.5 Input circuit diagram

2-wire connections



1) Switch is closed for 2-wire connections.

3-wire connections



4.4 Register description

4.4.1 General data points

In addition to the registers described in the register description, the module has additional general data points. These are not module-specific but contain general information such as serial number and hardware variant.

General data points are described in section "Additional information - General data points" in the X20 System user's manual.

4.4.2 Function model 0 - "3-wire connections" and function model 1 - "2-wire connections"

With this module, the type of connection is selected using function models 0 and 1.

Function model	Connection type
0	3-wire connections (standard)
1	2-wire connections

The registers applied are identical for both function models:

Register	Name	Data type	Read		Write	
			Cyclic	Acyclic	Cyclic	Acyclic
Configuration						
16	ConfigOutput01 (input filter)	USINT				•
18	ConfigOutput02 (sensor configuration)	UINT				•
Communication						
0	Temperature01	INT	•			
	Resistor01	UINT				
2	Temperature02	INT	•			
	Resistor02	UINT				
4	Temperature03	INT	•			
	Resistor03	UINT				
6	Temperature04	INT	•			
	Resistor04	UINT				
28	IOCycleCounter	USINT	•			
30	StatusInput01	USINT	•			

4.4.3 Function model 254 - Bus controller

> **Information:**
>
> **Function model 254 (bus controller) only supports 3-wire connections in the default configuration.**

Register	Offset[1)]	Name	Data type	Read		Write	
				Cyclic	Acyclic	Cyclic	Acyclic
Configuration							
16	-	ConfigOutput01 (input filter)	USINT				•
18	-	ConfigOutput02 (sensor configuration)	UINT				•
Communication							
0	0	Temperature01	INT	•			
	0	Resistor01	UINT				
2	2	Temperature02	INT	•			
	2	Resistor02	UINT				
4	4	Temperature03	INT	•			
	4	Resistor03	UINT				
6	6	Temperature04	INT	•			
	6	Resistor04	UINT				
28	-	IOCycleCounter	USINT		•		
30	-	StatusInput01	USINT		•		

1) The offset specifies the position of the register within the CAN object.

4.4.3.1 Using the module on the bus controller

Function model 254 "Bus controller" is used by default only by non-configurable bus controllers. All other bus controllers can use other registers and functions depending on the fieldbus used.

For detailed information, see section "Additional information - Using I/O modules on the bus controller" in the X20 user's manual (version 3.50 or later).

4.4.3.2 CAN I/O bus controller

The module occupies 1 analog logical slot on CAN I/O.

4.4.4 General information

4.4.4.1 Analog inputs

The module outputs the converted analog values to the registers. Other ranges of values or data types result depending on resistance or temperature measurement.

> **Information:**
>
> **Operating channels outside specifications can affect neighboring channels.**

4.4.4.2 Timing

The timing for acquiring measured values is controlled by the converter hardware. All switched-on inputs are converted during each conversion cycle and transferred halfway through the X2X Link cycle.

4.4.4.3 Conversion time

The conversion time for the channels depends on their use. For the formulas listed in the table, "n" corresponds to the number of channels that are switched on.

Use of the channels	Conversion time
1 channel	1 · Filter time
n channels with the same sensor type	n · (20 ms + Filter time)
n channels with different sensor types	n · (20 ms + 2 · Filter time)

4.4.4.4 Reduced update time

Any inputs that are not needed can be switched off, which reduces the I/O update time. Inputs can also be only switched off temporarily.

Calculating the time saved

The amount of time saved can be calculated with the following formula. And "n" corresponds to the number of inputs that are switched off.

$$\text{Time saved} = n \cdot (20\ \text{ms} + \text{filter time})$$

Examples

Inputs are filtered using a 60 Hz filter.

	Example 1	Example 2	Example 3
Switched on inputs	1	1 and 3	1 to 4
Conversion time	16.7 ms	73.4 ms	146.8 ms

4.4.5 Configuration

4.4.5.1 Input filter

Name:
ConfigOutput01

The filter time of all analog inputs is defined in this register.

Data type	Value	Filter	Filter time
USINT	0	15 Hz	66.7 ms
	1	25 Hz	40 ms
	2	30 Hz	33.3 ms
	3	50 Hz (bus controller default setting)	20 ms
	4	60 Hz	16.7 ms
	5	100 Hz	10 ms
	6	500 Hz	2 ms
	7	1000 Hz	1 ms

4.4.5.2 Sensor configuration

Name:
ConfigOutput02

The sensor type of the individual channels is configured in this register.

This module is designed for temperature and resistance measurement. Due to different adjustment values for temperature and resistance, the sensor type must be selected.

By default, all channels are switched on. To save time, individual channels can be switched off (see "Reduced update time" on page 43).

Data type	Values	Bus controller default setting
UINT	See the bit structure.	8738

Bit structure:

Bit	Description	Value	Information
0 - 3	Channel 1	0000 - 0001	Reserved
		0010	Sensor type PT100 (bus controller default setting)
		0011	PT1000 sensor type
		0100	Reserved (channel switched off)
		0101	Resistance measurement 0.1 to 4500 Ω
		0110	Resistance measurement 0.05 to 2250 Ω
		0111	Channel switched off
		1000 - 1111	Reserved
...		...	
12 - 15	Channel 4	0000 - 0001	Reserved
		0010	Sensor type PT100 (bus controller default setting)
		0011	PT1000 sensor type
		0100	Reserved (channel switched off)
		0101	Resistance measurement 0.1 to 4500 Ω
		0110	Resistance measurement 0.05 to 2250 Ω
		0111	Channel switched off
		1000 - 1111	Reserved

4.4.6 Communication

4.4.6.1 Input values of analog inputs

Name:
Temperature01 to Temperature04
Resistor01 to Resistor04

This register contains the analog input values depending on the configured operating mode.

Data type	Digital value	Input signal
INT	-2000 to 8500 (for -200.0 to 850.0°C)	Pt100 sensor type
	-2000 to 8500 (for -200.0 to 850.0°C)	Pt1000 sensor type
UINT	1 to 45000 (resolution 0.1 Ω)	Resistance measurement 0.1 to 4500 Ω
	1 to 45000 (resolution 0.05 Ω)	Resistance measurement 0.05 to 2250 Ω

In order for the user to always be supplied with a defined output value, the following must be taken into consideration:

- Up to the first conversion, 0x8000 is output.
- After switching the operating mode until the first conversion:
  - From "Resistance measurement" to "Sensor type PTxx": 0x8000
  - From "Sensor type PTxx" to "Resistance measurement": 0xFFFF
- If the input is not switched on, 0x8000 is output.

4.4.6.2 I/O cycle counter

Name:
IOCycleCounter

The cyclic counter increases after all input data has been updated.

Data type	Values	Information
USINT	0 to 255	Repeating counter

4.4.6.3 Status of the inputs

Name:
StatusInput01

The module's inputs are monitored. A change in the monitoring status is actively transmitted as an error message.

Data type	Values
USINT	See the bit structure.

Bit structure:

Bit	Description	Value	Information
0 - 1	Channel 1	00	No error
		01	Lower limit value undershot
		10	Upper limit value overshot
		11	Open circuit
...		...	
6 - 7	Channel 4	00	No error
		01	Lower limit value undershot
		10	Upper limit value overshot
		11	Open circuit

Limiting the analog value

In addition to the status information, the analog value is fixed to the values listed below by default in an error state.

Error state	Temperature measurement Digital value on error	Resistance measurement Digital value on error
Open circuit	32767 (0x7FFF)	65535 (0xFFFF)
Upper limit value overshot	32767 (0x7FFF)	65535 (0xFFFF)
Lower limit value undershot	-32767 (0x8001)	0 (0x0000)
Invalid value	-32768 (0x8000)[1)] 32767 (0x7FFF)[2)] 65535 (0xFFFF)[3)]	65535 (0xFFFF)

1) Default value or channel was disabled in the I/O configuration.
2) After switching off the channel during operation.
3) Value in function model 254 - Bus controller.

4.4.7 Minimum cycle time

The minimum cycle time specifies how far the bus cycle can be reduced without communication errors occurring. It is important to note that very fast cycles reduce the idle time available for handling monitoring, diagnostics and acyclic commands.

Minimum cycle time
100 µs

4.4.8 Minimum I/O update time

The minimum I/O update time specifies how far the bus cycle can be reduced so that an I/O update is performed in each cycle.

Minimum I/O update time	
1 input	Equal to the filter time
n inputs	n · (20 ms + filter time)

5 X20AT4232

5.1 General information

This module is equipped with 4 inputs for NTC resistance temperature measurement (10 kΩ at 25°C). In addition, this module can measure resistance from 0 to 200 kΩ.

- 4 inputs for resistance temperature measurement
- For NTC resistance type 10 kΩ
- Resistance measurement 0 to 200 kΩ
- Configurable measurement type per channel
- 2-wire measurement
- Configurable filter time

5.2 Order data

Order number	Short description	Figure
	Temperature measurement	
X20AT4232	X20 temperature input module, 4 inputs for resistance measurement, NTC 10 kΩ, resolution 0.1°C, 2-wire connections	
	Required accessories	
	Bus modules	
X20BM11	X20 bus module, 24 VDC keyed, internal I/O power supply connected through	
X20BM15	X20 bus module, with node number switch, 24 VDC keyed, internal I/O power supply connected through	
	Terminal blocks	
X20TB12	X20 terminal block, 12-pin, 24 VDC keyed	

Table 9: X20AT4232 - Order data

5.3 Technical data

Order number	X20AT4232
Short description	
I/O module	4 inputs for NTC (10 kΩ) resistance temperature measurement
General information	
B&R ID code	0xEA85
Status indicators	I/O function per channel, operating state, module status
Diagnostics	
Module run/error	Yes, using status LED and software
Inputs	Yes, using status LED and software
Cable specification	
Cable type	Shielded twisted pair cable
Line capacitance	Max. 1 nF
Power consumption	
Bus	0.01 W
Internal I/O	0.72 W
Additional power dissipation caused by actuators (resistive) [W]	-
Certifications	
CE	Yes
EAC	Yes
UL	cULus E115267 Industrial control equipment
HazLoc	cCSAus 244665 Process control equipment for hazardous locations Class I, Division 2, Groups ABCD, T5
ATEX	Zone 2, II 3G Ex nA nC IIA T5 Gc IP20, Ta (see X20 user's manual) FTZÚ 09 ATEX 0083X
Resistance measurement temperature inputs	
Input	Resistance measurement with constant current supply for 2-wire connections
Digital converter resolution	16-bit
Filter time	Configurable between 16.7 and 66.7 ms
Conversion time	
1 channel	20 ms with 50 Hz filter
2 - 4 channels	40 ms per channel with 50 Hz filter
Conversion procedure	Sigma-delta
Output format	INT or UINT for resistance measurement
Sensor	
Sensor type	Configurable per channel
NTC10K type 1	Vishay: NTCLE100E3103GB0, $B_{25/85}$ = 3977
NTC10K type 2	Vishay: NTCLE413E2103F400L, $B_{25/85}$ = 3435
Temperature measurement range	-30 to 100°C for NTC with 10 kΩ [1]
Resistance measurement range	0 to 200 kΩ
Temperature sensor resolution	1 LSB = 0.1°C for NTC with 10 kΩ [1]
Resistance measurement resolution	5 Ω
Input filter	1st-order low pass / cutoff frequency 1.35 kHz
Isolation voltage between channel and bus	500 V_{eff}
Linearization method	Internal
Measurement current	9.1 µA ±1.5%
Reference	103,125 Ω ±0.1%
Permissible input signal	Short-term max. ±30 V
Max. error at 25°C	
Gain	0.35% [2]
Offset	0.004% [3]
Max. gain drift	0.006 %/°C [2]
Max. offset drift	0.00009 %/°C [3]
Nonlinearity	<0.15% [3]
Standardized range of values for resistance measurement	0 to 200,000 Ω
Crosstalk between channels	<-70 dB
Temperature sensor normalization	
NTC10K type 1	-30.0 to 100.0°C
NTC10K type 2	-30.0 to 100.0°C
Temperature measurement monitoring	
Range undershoot	0x8001
Range overshoot	0x7FFF
Open circuit	0x7FFF
General fault	0x8000
Open inputs	0x7FFF

Table 10: X20AT4232 - Technical data

Order number	X20AT4232
Resistance measurement monitoring	
Range overshoot	0xFFFF
Open circuit	0xFFFF
General fault	0xFFFF
Open inputs	0xFFFF
Electrical properties	
Electrical isolation	Channel isolated from bus Channel not isolated from channel
Operating conditions	
Mounting orientation	
Horizontal	Yes
Vertical	Yes
Installation elevation above sea level	
0 to 2000 m	No limitations
>2000 m	Reduction of ambient temperature by 0.5°C per 100 m
Degree of protection per EN 60529	IP20
Ambient conditions	
Temperature	
Operation	
Horizontal mounting orientation	-25 to 60°C
Vertical mounting orientation	-25 to 50°C
Derating	-
Storage	-40 to 85°C
Transport	-40 to 85°C
Relative humidity	
Operation	5 to 95%, non-condensing
Storage	5 to 95%, non-condensing
Transport	5 to 95%, non-condensing
Mechanical properties	
Note	Order 1x X20TB12 terminal block separately Order 1x X20BM11 bus module separately
Spacing	$12.5^{+0.2}$ mm

Table 10: X20AT4232 - Technical data

1) Depends on the temperature sensor. This value applies when using Vishay sensor NTCLE100E3103GB0 $B_{25/85}$ = 3977 and Vishay sensor NTCLE413E2103F400L $B_{25/85}$ = 3435.
2) Based on the current resistance value.
3) Based on the entire resistance measurement range.

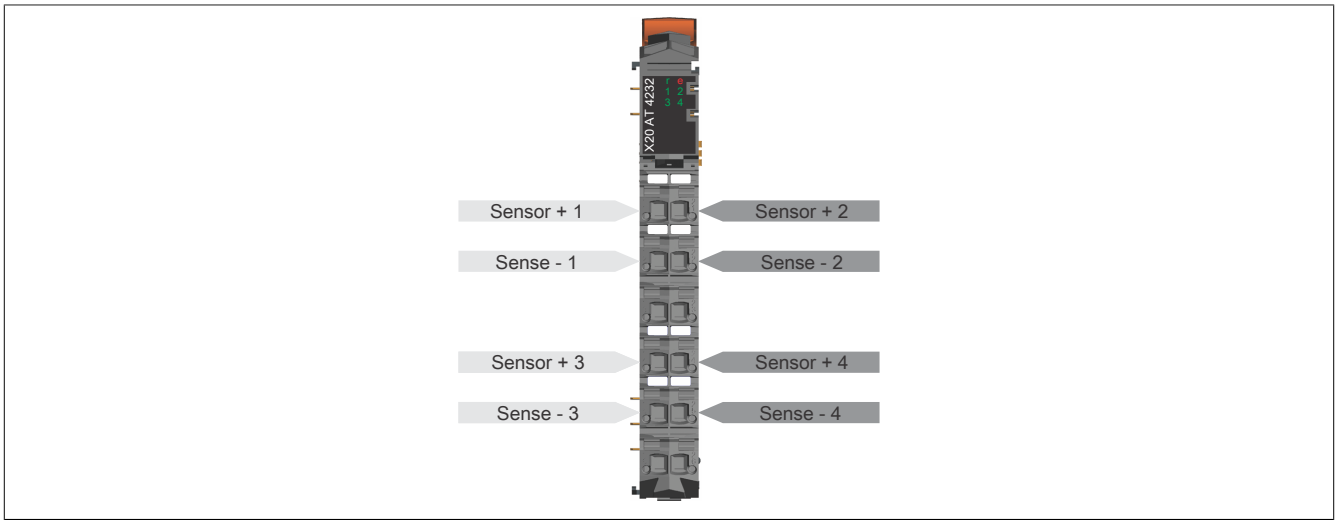
5.4 LED status indicators

For a description of the various operating modes, see section "Additional information - Diagnostic LEDs" in the X20 system user's manual.

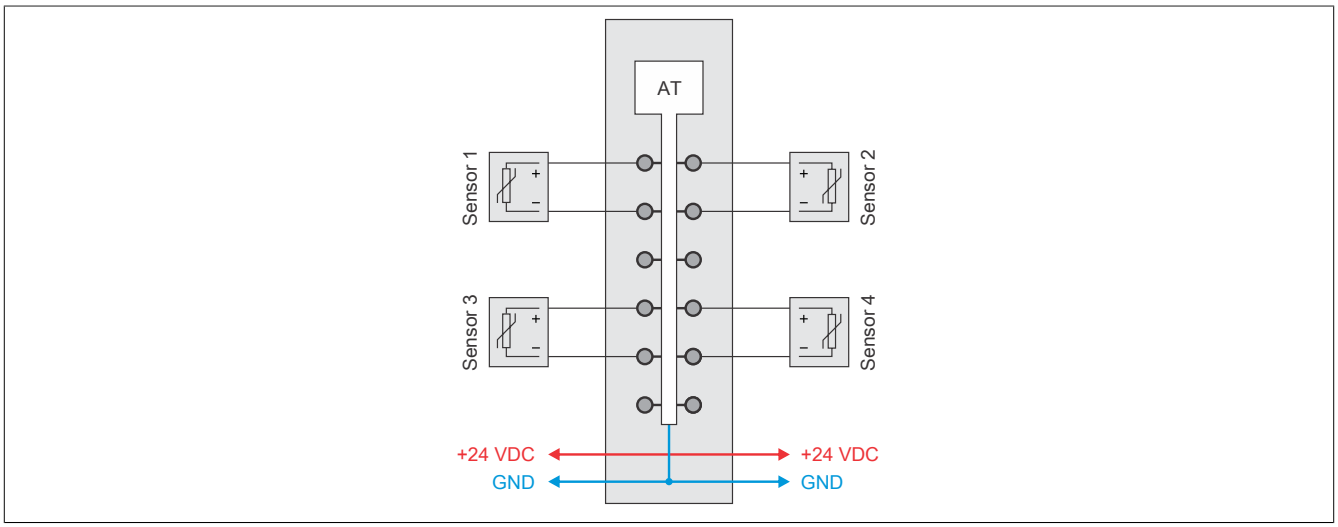
Figure	LED	Color	Status	Description
	r	Green	Off	No power to module
			Single flash	RESET mode
			Blinking	PREOPERATIONAL mode
			On	RUN mode
	e	Red	Off	No power to module or everything OK
			On	Error or reset status
			Single flash	Warning/Error on an I/O channel. Overflow or underflow of the analog inputs.
	e + r	Solid red / Single green flash		Invalid firmware
	1 - 4	Green	Off	The input is switched off
			Blinking	Overflow, underflow or open circuit
			On	Analog/digital converter running, value OK

5.5 Pinout

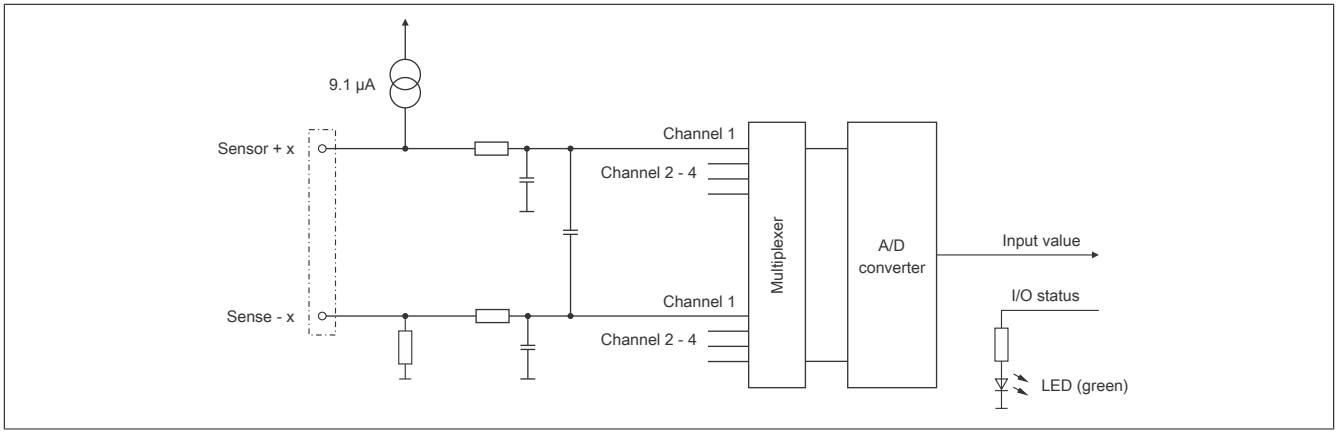
Channels that are not being used should be disabled.



5.6 Connection example



5.7 Input circuit diagram



5.8 Register description

5.8.1 General data points

In addition to the registers described in the register description, the module has additional general data points. These are not module-specific but contain general information such as serial number and hardware variant.

General data points are described in section "Additional information - General data points" in the X20 system user's manual.

5.8.2 Function model 0 - Standard

Register	Name	Data type	Read		Write	
			Cyclic	Acyclic	Cyclic	Acyclic
Configuration						
16	ConfigOutput01 (Input filter)	USINT				•
18	ConfigOutput02 (Sensor configuration)	UINT				•
Communication						
0	Temperature01	INT	•			
	Resistor01	UINT				
2	Temperature02	INT	•			
	Resistor02	UINT				
4	Temperature03	INT	•			
	Resistor03	UINT				
6	Temperature04	INT	•			
	Resistor04	UINT				
28	IOCycleCounter	USINT	•			
30	StatusInput01	USINT	•			

5.8.3 Function model 254 - Bus controller

Register	Offset[1)]	Name	Data type	Read		Write	
				Cyclic	Acyclic	Cyclic	Acyclic
Configuration							
16	-	ConfigOutput01 (Input filter)	USINT				•
18	-	ConfigOutput02 (Sensor configuration)	UINT				•
Communication							
0	0	Temperature01	INT	•			
	0	Resistor01	UINT				
2	2	Temperature02	INT	•			
	2	Resistor02	UINT				
4	4	Temperature03	INT	•			
	4	Resistor03	UINT				
6	6	Temperature04	INT	•			
	6	Resistor04	UINT				
28	-	IOCycleCounter	USINT		•		
30	-	StatusInput01	USINT		•		

1) The offset specifies the position of the register within the CAN object.

5.8.3.1 Using the module on the bus controller

Function model 254 "Bus controller" is used by default only by non-configurable bus controllers. All other bus controllers can use other registers and functions depending on the fieldbus used.

For detailed information, see section "Additional information - Using I/O modules on the bus controller" in the X20 user's manual (version 3.50 or later).

5.8.3.2 CAN I/O bus controller

The module occupies 1 analog logical slot on CAN I/O.

5.8.4 General information

5.8.4.1 Analog inputs

The module outputs the converted analog values to the registers. Other ranges of values or data types result depending on resistance or temperature measurement.

> **Information:**
>
> **Operating channels outside specifications can affect neighboring channels.**

5.8.4.2 Timing

The timing for acquiring measured values is controlled by the converter hardware. All switched-on inputs are converted during each conversion cycle and transferred halfway through the X2X Link cycle.

5.8.4.3 Conversion time

The conversion time for the channels depends on their use. For the formulas listed in the table, "n" corresponds to the number of channels that are switched on.

Use of the channels	Conversion time
1 channel	1 · Filter time
n channels with the same sensor type	n · (20 ms + Filter time)
n channels with different sensor types	n · (20 ms + 2 · Filter time)

5.8.4.4 Reduced update time

Any inputs that are not needed can be switched off, which reduces the I/O update time. Inputs can also be only switched off temporarily.

Calculating the time saved

The amount of time saved can be calculated with the following formula. And "n" corresponds to the number of inputs that are switched off.

$$\text{Time saved} = n \cdot (20\ \text{ms} + \text{filter time})$$

Examples

Inputs are filtered using a 60 Hz filter.

	Example 1	Example 2	Example 3
Switched on inputs	1	1 and 3	1 to 4
Conversion time	16.7 ms	73.4 ms	146.8 ms

5.8.5 Configuration

5.8.5.1 Input filter

Name:
ConfigOutput01

The filter time of all analog inputs is defined in this register.

Data type	Value	Filter	Filter time
USINT	0	15 Hz	66.7 ms
	1	25 Hz	40 ms
	2	30 Hz	33.3 ms
	3	50 Hz (bus controller default setting)	20 ms
	4	60 Hz	16.7 ms

5.8.5.2 Sensor configuration

Name:
ConfigOutput02

This register can be used to configure the sensor type for individual channels.

This module is designed for temperature and resistance measurement. The sensor type must be specified because of the different calibration values for temperature and resistance.

The default setting for all channels is ON. To save time, individual channels can be switched off (see "Reduced update time" on page 52).

Data type	Values	Bus controller default setting
UINT	See the bit structure.	0

Bit structure:

Bit	Name	Value	Information
0 - 3	Channel 1	0000	Sensor: NTC10K type 1 (bus controller default setting) [1]
		0001	Sensor: NTC10K type 2 [2]
		0010	Reserved
		0011	Reserved
		0100	Channel switched off
		0101	Resistance measurement 0 to 200 kΩ
		0110	Reserved
		0111	Channel switched off
		1000 - 1111	Reserved
...		...	
12 - 15	Channel 4	0000	Sensor: NTC10K type 1 (bus controller default setting) [1]
		0001	Sensor: NTC10K type 2 [2]
		0010	Reserved
		0011	Reserved
		0100	Channel switched off
		0101	Resistance measurement 0 to 200 kΩ
		0110	Reserved
		0111	Channel switched off
		1000 - 1111	Reserved

1) Sensor NTC10K type 1: Vishay NTCLE100E3103GB0, $B_{25/85}$ = 3977
2) Sensor NTC10K type 2: Vishay NTCLE413E2103F400L, $B_{25/85}$ = 3435

5.8.6 Communication

5.8.6.1 Input values of analog inputs

Name:
Temperature01 to Temperature04
Resistor01 to Resistor04

This register is used to indicate the analog input values depending on the configured operating mode.

Data type	Digital value	Input signal
INT	-300 to 1000 (for -30.0 to 100.0°C)	Sensor NTC10K type 1
	-300 to 1000 (for -30.0 to 100.0°C)	Sensor NTC10K type 2
UINT	0 to 40000 (resolution 5 Ω)	Resistance measurement 0 to 200 kΩ

In order for the user to always be supplied with a defined output value, the following must be taken into consideration:

- Up to the first conversion, 0x8000 is output.
- After switching the sensor type, 0x8000 is output until the first conversion.
- If the input is not switched on, 0xFFFF is output.

5.8.6.2 I/O cycle counter

Name:
IOCycleCounter

The cyclic counter increases after all input data has been updated.

Data type	Values	Information
USINT	0 to 255	Repeating counter

5.8.6.3 Status of the inputs

Name:
StatusInput01

The module's inputs are monitored. A change in the monitoring status is actively transmitted as an error message.

Data type	Values
USINT	See the bit structure.

Bit structure:

Bit	Description	Value	Information
0 - 1	Channel 1	00	No error
		01	Lower limit value undershot
		10	Upper limit value overshot
		11	Open circuit
...		...	
6 - 7	Channel 4	00	No error
		01	Lower limit value undershot
		10	Upper limit value overshot
		11	Open circuit

Limiting the analog value

In addition to the status information, the analog value is fixed to the values listed below by default in an error state.

Error state	Temperature measurement Digital value on error	Resistance measurement Digital value on error
Open circuit	32767 (0x7FFF)	65535 (0xFFFF)
Upper limit value overshot	32767 (0x7FFF)	65535 (0xFFFF)
Lower limit value undershot	-32767 (0x8001)	0 (0x0000)
Invalid value	-32768 (0x8000)[1)] 32767 (0x7FFF)[2)] 65535 (0xFFFF)[3)]	65535 (0xFFFF)

1) Default value or channel was disabled in the I/O configuration.
2) After switching off the channel during operation.
3) Value in function model 254 - Bus controller.

5.8.7 Minimum cycle time

The minimum cycle time specifies how far the bus cycle can be reduced without communication errors occurring. It is important to note that very fast cycles reduce the idle time available for handling monitoring, diagnostics and acyclic commands.

Minimum cycle time
100 µs

5.8.8 Minimum I/O update time

The minimum I/O update time specifies how far the bus cycle can be reduced so that an I/O update is performed in each cycle.

Minimum I/O update time	
1 input	Equal to the filter time
n inputs	n · (20 ms + filter time)

6 X20(c)AT6402

6.1 General information

6.1.1 Other applicable documents

For additional and supplementary information, see the following documents.

Other applicable documents

Document name	Title
MAX20	X20 System user's manual
MAEMV	Installation / EMC guide

6.1.2 Coated modules

Coated modules are X20 modules with a protective coating for the electronics component. This coating protects X20c modules from condensation and corrosive gases.
The modules' electronics are fully compatible with the corresponding X20 modules.

For simplification purposes, only images and module IDs of uncoated modules are used in this data sheet.

The coating has been certified according to the following standards:

- Condensation: BMW GS 95011-4, 2x 1 cycle
- Corrosive gas: EN 60068-2-60, method 4, exposure 21 days

6.1.2.1 Starting temperature

The starting temperature describes the minimum permissible ambient temperature in a voltage-free state at the time the coated module is switched on. This is permitted to be as low as -40°C. During operation, the conditions as specified in the technical data continue to apply.

Information:

It is important to absolutely ensure that there is no forced cooling by air currents in the closed control cabinet, e.g. due to the use of a fan or ventilation slots.

6.1.3 Order data

Order number	Short description	Figure
	Temperature measurement	
X20AT6402	X20 temperature input module, 6 thermocouple inputs, type J, K, N, S, B, R, resolution 0.1/0.01°C	
X20cAT6402	X20 temperature input module, coated, 6 thermocouple inputs, type J, K, N, S, B, R, resolution 0.1/0.01°C	
	Required accessories	
	Bus modules	
X20BM11	X20 bus module, 24 VDC keyed, internal I/O power supply connected through	
X20BM15	X20 bus module, with node number switch, 24 VDC keyed, internal I/O power supply connected through	
X20cBM11	X20 bus module, coated, 24 VDC keyed, internal I/O power supply connected through	
	Terminal blocks	
X20TB12	X20 terminal block, 12-pin, 24 VDC keyed	

Table 11: X20AT6402, X20cAT6402 - Order data

6.1.4 Module description

The module is equipped with 6 inputs for J, K, N, S, B and R thermocouple sensors. The module has an integrated terminal temperature compensation.

- 6 inputs for thermocouples
- For sensor types J, K, N, S, B, R
- Additional direct raw value measurement
- Integrated terminal temperature compensation
- Configurable filter time
- Configurable resolution

Functions:

- Sensor type and measurement range
- Input filter
- Monitoring the input signal

Sensor type and measurement range

The module is used with a thermocouple sensor. For sensor types not supported by the module, the module is equipped with raw value measurement.

Input filter

One input filter can be configured for all analog inputs together.

Monitoring the input signal

The input signal of the analog inputs is monitored against the upper and lower limit values as well as for open circuit.

6.2 Technical description

6.2.1 Technical data

Order number	X20AT6402	X20cAT6402
Short description		
I/O module	6 inputs for thermocouples	
General information		
B&R ID code	0x1BA9	0xDD57
Status indicators	I/O function per channel, operating state, module status	
Diagnostics		
Module run/error	Yes, using LED status indicator and software	
Inputs	Yes, using LED status indicator and software	
Power consumption		
Bus	0.01 W	
Internal I/O	0.91 W	
Additional power dissipation caused by actuators (resistive) [W]	-	
Certifications		
CE	Yes	
UKCA	Yes	
ATEX	Zone 2, II 3G Ex nA nC IIA T5 Gc IP20, Ta (see X20 user's manual) FTZÚ 09 ATEX 0083X	
UL	cULus E115267 Industrial control equipment	
HazLoc	cCSAus 244665 Process control equipment for hazardous locations Class I, Division 2, Groups ABCD, T5	
DNV	Temperature: **B** (0 to 55°C) Humidity: **B** (up to 100%) Vibration: **B** (4 g) EMC: **B** (bridge and open deck)	
LR	ENV1	
KR	Yes	
ABS	Yes	
BV	**EC33B** Temperature: 5 - 55°C Vibration: 4 g EMC: Bridge and open deck	
EAC	Yes	
KC	Yes	-
Thermocouple temperature inputs		
Input	Thermocouple	
Digital converter resolution	16-bit	
Filter time	Configurable between 1 ms and 66.7 ms	
Conversion time		
1 channel	80.4 ms with 50 Hz filter	
N channels	(n + 1) x 40.2 ms with 50 Hz filter	
Output format	INT	
Measurement range		
Sensor temperature		
Type J: Fe-CuNi	-210 to 1200°C	
Type K: NiCr-Ni	-270 to 1372°C	
Type N: NiCrSi-NiSi	-270 to 1300°C (Rev. ≥D0)	
Type S: PtRh10-Pt	-50 to 1768°C	
Type B: PtRh30-PtRh6	0 to 1820°C	
Type R: PtRh13-Pt	-50 to 1664°C	
Terminal temperature	-25 to 85°C	
Raw value	±65.534 mV	
Terminal temperature compensation	Internal	
Sensor standard	EN 60584	
Resolution		
Sensor temperature	1 LSB = 0.1°C or 0.01°C	
Terminal temperature	1 LSB = 0.1°C	
Raw value output with respect to gain	1 LSB = 1 µV or 2 µV	

Table 12: X20AT6402, X20cAT6402 - Technical data

Order number	X20AT6402	X20cAT6402
Normalization		
Type J: Fe-CuNi	-210.0 to 1200.0°C or -210.00 to 1200.00°C	
Type K: NiCr-Ni	-270.0 to 1372.0°C or -270.00 to 1372.00°C	
Type N (Rev. ≥D0)	-270.0 to 1300.0°C or -270.00 to 1300.00°C	
Type S: PtRh10-Pt	-50.0 to 1768.0°C or -50.00 to 1768.00°C	
Type B: PtRh30-PtRh6	0 to 1820.0°C or 0 to 1820.00°C	
Type R: PtRh13-Pt	-50.0 to 1664.0°C or -50.00 to 1664.00°C	
Terminal temperature	-25.0 to 85.0°C or -25.00 to 85.00°C	
Monitoring		
Range undershoot	0x8001	
Range overshoot	0x7FFF	
Open circuit	0x7FFF	
Open inputs	0x7FFF	
General fault	0x8000	
Conversion procedure	Sigma-delta	
Linearization method	Internal	
Permissible input signal	Max. ±5 V	
Input filter	First-order low-pass filter / cutoff frequency 500 Hz	
Max. error at 25°C		
Gain	0.06% 1)	
Offset		
Type J: Fe-CuNi	0.04% 2)	
Type K: NiCr-Ni	0.05% 2)	
Type N (Rev. ≥D0)	0.05% 2)	
Type S: PtRh10-Pt	0.11% 2)	
Type B: PtRh30-PtRh6	0.13% 2)	
Type R: PtRh13-Pt	0.09% 2)	
Max. gain drift	0.01%/°C 1)	
Max. offset drift		
Type J: Fe-CuNi	0.0019 %/°C 2)	
Type K: NiCr-Ni	0.0024% / °C 2)	
Type N (Rev. ≥D0)	0.0029 %/°C 2)	
Type S: PtRh10-Pt	0.0079 %/°C 2)	
Type B: PtRh30-PtRh6	0.0114 %/°C 2)	
Type R: PtRh13-Pt	0.0074 %/°C 2)	
Nonlinearity	±0.001% 2)	
Common-mode rejection		
DC	>70 dB	
50 Hz	>70 dB	
Common-mode range	±15 V	
Crosstalk between channels	<-70 dB	
Insulation voltage		
Between channel and bus	500 V_{eff}	
Terminal temperature compensation precision		
With artificial convection	±4°C after 10 min	
With natural convection	±2°C after 10 min	
Electrical properties		
Electrical isolation	Channel isolated from bus Channel not isolated from channel	
Operating conditions		
Mounting orientation		
Horizontal	Yes	
Vertical	Yes	
Installation elevation above sea level		
0 to 2000 m	No limitation	
>2000 m	Reduction of ambient temperature by 0.5°C per 100 m	
Degree of protection per EN 60529	IP20	
Ambient conditions		
Temperature		
Operation		
Horizontal mounting orientation	0 to 55°C	-25 to 60°C
Vertical mounting orientation	0 to 50°C	-25 to 50°C
Derating	-	
Starting temperature	-	Yes, -40°C
Storage	-40 to 85°C	
Transport	-40 to 85°C	

Table 12: X20AT6402, X20cAT6402 - Technical data

Order number	X20AT6402	X20cAT6402
Relative humidity		
Operation	5 to 95%, non-condensing	Up to 100%, condensing
Storage	5 to 95%, non-condensing	
Transport	5 to 95%, non-condensing	
Mechanical properties		
Note	Order 1x terminal block X20TB12 separately. Order 1x bus module X20BM11 separately.	Order 1x terminal block X20TB12 separately. Order 1x bus module X20cBM11 separately.
Pitch	$12.5^{+0.2}$ mm	

Table 12: X20AT6402, X20cAT6402 - Technical data

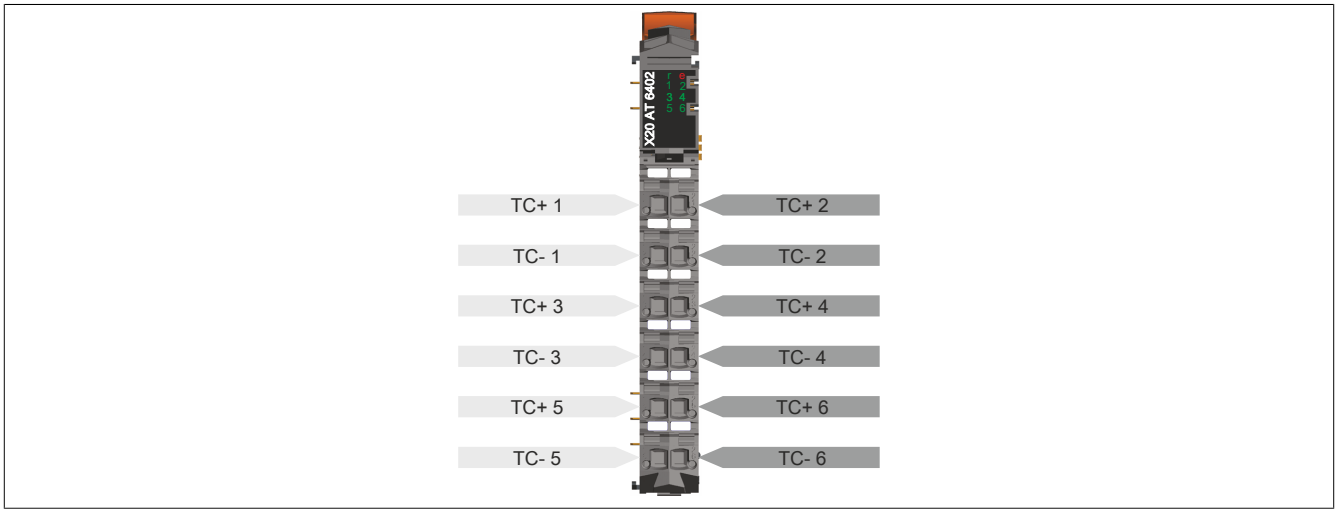
1) Based on the current measured value.
2) Based on the entire measurement range.

6.2.2 LED status indicators

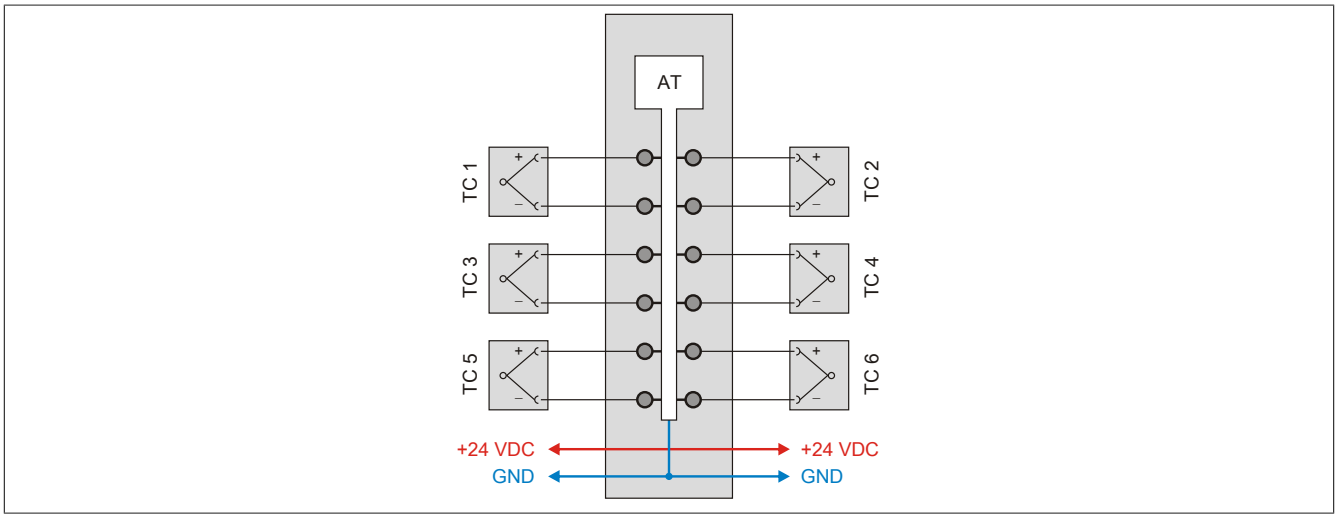
For a description of the various operating modes, see section "Additional information - Diagnostic LEDs" in the X20 System user's manual.

Figure	LED	Color	Status	Description
	r	Green	Off	No power to module
			Single flash	RESET mode
			Blinking	PREOPERATIONAL mode
			On	RUN mode
	e	Red	Off	No power to module or everything OK
			On	Error or reset status
			Single flash	Warning/Error on an I/O channel. Overflow or underflow of the analog inputs.
	e + r	Red on / Green single flash		Invalid firmware
	1 - 6	Green	Off	The input is switched off
			Blinking	Overflow, underflow or open line
			On	Analog/digital converter running, value OK

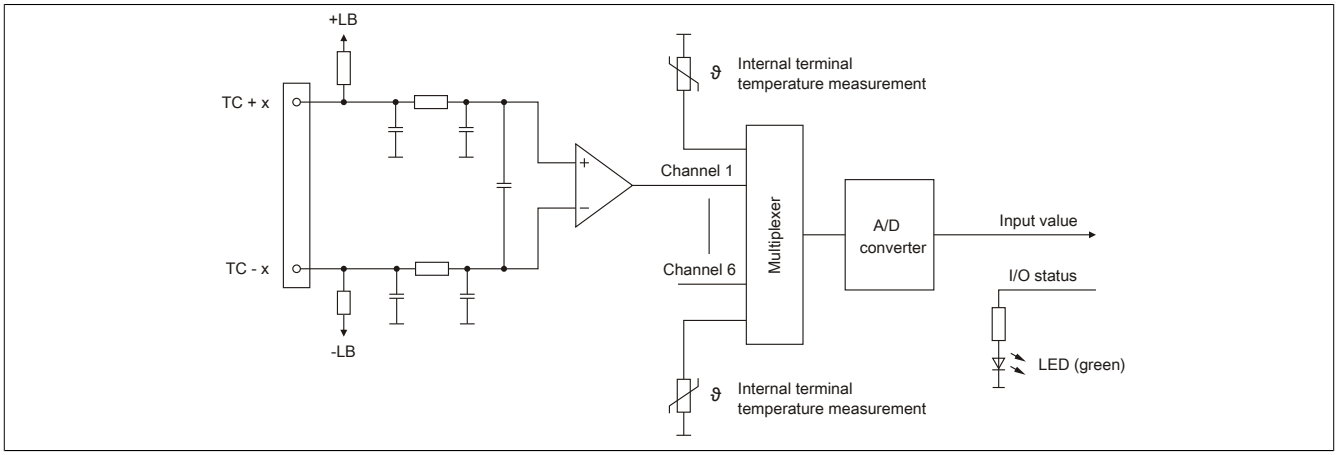
6.2.3 Pinout



6.2.4 Connection example

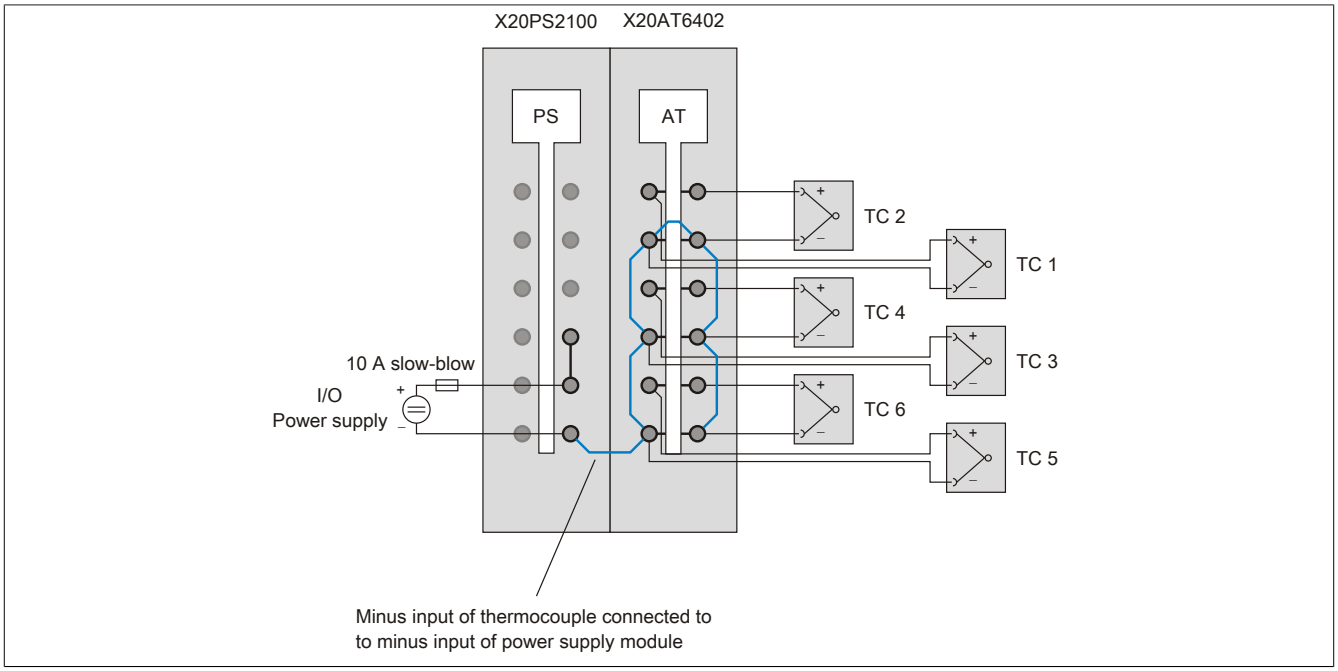


6.2.5 Input circuit diagram



6.2.6 Ceramic heating element with integrated thermo elements

We recommend connecting the minus input of the thermo element to the minus input of the supply feed module. This prevents potential measurement errors caused by ripple voltage effects in the measurement signal.



6.2.7 External cold junction

General information

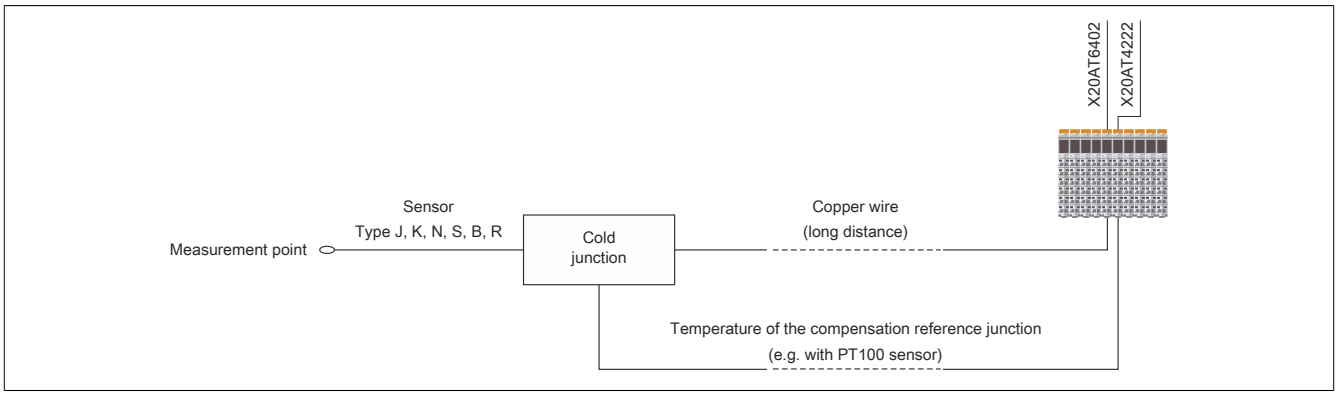
An external cold junction temperature value can be predefined for the module for measurement value correction. This makes it possible to set up an external cold junction. The same external cold junction temperature is used for measurement value correction on all channels.

An external cold junction makes sense in the following applications and situations:

- Large distances between the controller and measurement point
- To increase precision

To bridge large distances

Setting up an external cold junction is recommended when there are large distances between the controller and the measurement point. The thermocouple voltage is routed from the external cold junction to the terminal on the X20AT6402 via copper wires. The temperature measured at the external cold junction (e.g. with PT100 - X20AT4222) is stored in the I/O area of the X20AT6402 module. The X20AT6402 uses the measured voltage and the cold junction temperature to internally calculate the needed thermocouple temperature.



Increased precision

Setting up an external cold junction is recommended to increase precision. The external cold junction is set up as described above. The installation of an external cold junction is especially helpful in the following cases:

- A module consuming more power than 1 W is connected in addition to the X20AT6402.
- No modules but the X20AT6402 are connected
- With strongly fluctuating ambient conditions (draft, temperature)

6.3 Function description

6.3.1 Sensor type and measurement range

The module is designed for different sensor types. The sensor type must be set due to the different calibration values.

Values	Information
1	Sensor type J
2	Sensor type K
3	Sensor type S
4	Sensor type N
6	Raw value without linearization and terminal temperature compensation: 1.0625 µV resolution for a measurement range of ±35 mV
7	Raw value without linearization and terminal temperature compensation: 2.125 µV resolution for a measurement range of ±70 mV
64	Sensor type R
72	Sensor type B

In order for the user to always be supplied with a defined output value, the following must be taken into consideration:

- 0x8000 or 0x80000000 is output until the first conversion depending on the resolution.
- After switching the sensor type, 0x8000 or 0x80000000 is output until the first conversion depending on the resolution.
- After switching the sensor type from raw value to "Type x" measurement, 0x7FFF or 0x7FFFFFFF is output depending on the resolution until the internal terminal temperature measurements have been performed (see "Input circuit diagram" on page 62). In addition, StatusInput bit "Upper limit value exceeded" associated with the channel is set.
- If the input is not switched on, 0x8000 or 0x80000000 is output depending on the resolution.

Information:

The register is described in "Sensor type" on page 69.

6.3.2 Input filter

Input filter

The filter time for all analog inputs is defined using the input filter parameter.

Value	Filter	Filter time	Digital converter resolution
0	15 Hz	66.7 ms	16-bit
1	25 Hz	40 ms	16-bit
2	30 Hz	33.3 ms	16-bit
3	50 Hz	20 ms	16-bit
4	60 Hz	16.7 ms	16-bit
5	100 Hz	10 ms	16-bit
6	500 Hz	2 ms	16-bit
7	1000 Hz	1 ms	16-bit

Information:

The register is described in "Input filter and ambient conditions" on page 68.

6.3.3 Monitoring the input signal

The module's inputs are monitored. A change in the monitoring status is actively transmitted as an error message.

Bit value	Information
00	No error
01	Lower limit value undershot
10	Upper limit value overshot
11	Open circuit

Limiting the analog value

In addition to the status information, the analog value is permanently defined to the following value in an error state:

Error state	Digital value on error
Open circuit	0.1°C resolution: +32767 (0x7FFF)
	0.01°C resolution: +2,147,483,647 (0x7FFFFFFF)
Upper limit value overshot	0.1°C resolution: +32767 (0x7FFF)
	0.01°C resolution: +2,147,483,647 (0x7FFFFFFF)
Lower limit value undershot	0.1°C resolution: -32767 (0x8001)
	0.01°C resolution: -2,147,483,647 (0x80000001)
Invalid value	0.1°C resolution: -32768 (0x8000)
	0.01°C resolution: -2,147,483,648 (0x80000000)

Information:

The register is described in "Input status" on page 70.

6.4 Commissioning

6.4.1 Using the module on the bus controller

Function model 254 "Bus controller" is used by default only by non-configurable bus controllers. All other bus controllers can use other registers and functions depending on the fieldbus used.

For detailed information, see section "Additional information - Using I/O modules on the bus controller" in the X20 user's manual (version 3.50 or later).

6.4.1.1 CAN I/O bus controller

The module occupies 2 analog logical slots on CAN I/O.

6.4.2 Raw value measurement

If a sensor type other than J, K, N, S, B or R is used, the terminal temperature must be measured on at least one input. The user must use this value to perform terminal temperature compensation.

6.4.3 Ambient conditions

The ambient conditions setting is used to adapt the internal terminal temperature characteristics to the type and amount of heat radiated onto the module.

The power consumption of the modules connected directly to the left and right in the X2X Link network serves as the characteristic value for the selection. For the power consumption, see the technical data of the corresponding module. The higher value is used for the setting.

6.4.4 Configuring the conversion cycle

The timing for acquiring measurement values is determined by the converter hardware. All enabled inputs are converted during each conversion cycle. In addition, the terminal temperature is measured (not in function model 1).

Any inputs that are not needed can be switched off, which reduces the I/O update time. Inputs can also be only switched off temporarily. Measuring the terminal temperature is switched off in function model 1.

6.4.4.1 Conversion time

The conversion time depends on the number of channels and the function model. For the formulas listed in the table, "n" corresponds to the number of channels that are switched on.

Function model	Conversion time
Model 0 - n channels	(n + 1) · (2 · Filter time + 200 µs)
Model 1 - n channels	n · (2 · Filter time + 200 µs)
Model 1 - 1 channel	Equal to the filter time

Examples

Inputs are filtered using a 50 Hz filter.

	Example 1		Example 2	
	Function model 0	Function model 1	Function model 0	Function model 1
Switched on inputs	1	1	1 - 6	1 - 6
Input conversion times	40.2 ms	20 ms	241.2 ms	241.2 ms
Conversion time for the terminal temperature	40.2 ms	-	40.2 ms	-
Total conversion time	80.4 ms	20 ms	281.4 ms	241.2 ms

6.5 Register description

6.5.1 General data points

In addition to the registers described in the register description, the module has additional general data points. These are not module-specific but contain general information such as serial number and hardware variant.

General data points are described in section "Additional information - General data points" in the X20 System user's manual.

6.5.2 Function model 0 - Standard

The resolution of 0.1 or 0.01°C can be set in the configuration.

Register	Name	Data type	Read		Write	
			Cyclic	Acyclic	Cyclic	Acyclic
Configuration						
24	ConfigOutput01 (input filter / ambient conditions)	USINT				•
26	ConfigOutput02 (sensor type)	USINT				•
27	ConfigOutput03 (channel disabling)	USINT				•
Communication						
0	Temperature01	INT	•			
2	Temperature02	INT	•			
4	Temperature03	INT	•			
6	Temperature04	INT	•			
8	Temperature05	INT	•			
10	Temperature06	INT	•			
28	IOCycleCounter	USINT	•			
30	StatusInput01	USINT	•			
31	StatusInput02	USINT	•			
22	CompensationTemperature	INT		•		
40	Temperature01_H_Res	DINT	•			
44	Temperature02_H_Res	DINT	•			
48	Temperature03_H_Res	DINT	•			
52	Temperature04_H_Res	DINT	•			
56	Temperature05_H_Res	DINT	•			
60	Temperature06_H_Res	DINT	•			

6.5.3 Function model 1 - External cold junction temperature

The resolution of 0.1 or 0.01°C can be set in the configuration.

Register	Name	Data type	Read		Write	
			Cyclic	Acyclic	Cyclic	Acyclic
Configuration						
24	ConfigOutput01 (input filter / ambient conditions)	USINT				•
26	ConfigOutput02 (sensor type)	USINT				•
27	ConfigOutput03 (channel disabling)	USINT				•
Communication						
12	ExternalCompensationTemperature	INT			•	
0	Temperature01	INT	•			
2	Temperature02	INT	•			
4	Temperature03	INT	•			
6	Temperature04	INT	•			
8	Temperature05	INT	•			
10	Temperature06	INT	•			
28	IOCycleCounter	USINT	•			
30	StatusInput01	USINT	•			
31	StatusInput02	USINT	•			
40	Temperature01_H_Res	DINT	•			
44	Temperature02_H_Res	DINT	•			
48	Temperature03_H_Res	DINT	•			
52	Temperature04_H_Res	DINT	•			
56	Temperature05_H_Res	DINT	•			
60	Temperature06_H_Res	DINT	•			

6.5.4 Function model 254 - Bus controller

Register	Offset[1)]	Name	Data type	Read		Write	
				Cyclic	Acyclic	Cyclic	Acyclic
Configuration							
24	-	ConfigOutput01 (Input filter / ambient conditions)	USINT				•
26	-	ConfigOutput02 (Sensor type)	USINT				•
27	-	ConfigOutput03 (Channel disabling)	USINT				•
Communication							
0	0	Temperature01	INT	•			
2	2	Temperature02	INT	•			
4	4	Temperature03	INT	•			
6	8	Temperature04	INT	•			
8	10	Temperature05	INT	•			
10	12	Temperature06	INT	•			
28	-	IOCycleCounter	USINT		•		
30	-	StatusInput01	USINT		•		
31	-	StatusInput02	USINT		•		
22	-	CompensationTemperature	INT		•		

1) The offset specifies the position of the register within the CAN object.

6.5.5 Configuration

6.5.5.1 Input filter and ambient conditions

Name:
ConfigOutput01

This register is used to configure input filters and ambient conditions. For details, see "Input filter" on page 64 and "Ambient conditions" on page 66.

Data type	Values	Bus controller default setting
USINT	See bit structure.	3

Bit structure:

Bit	Description	Value	Information
0 - 3	Input filter	0000	15 Hz
		0001	25 Hz
		0010	30 Hz
		0011	50 Hz (bus controller default setting)
		0100	60 Hz
		0101	100 Hz
		0110	500 Hz
		0111	1000 Hz
		1000 to 1111	Not permitted
4 - 7	Ambient conditions	0000	Default, no calculation for adjustment (bus controller default setting)
		0001	Power dissipation less than 0.2 W
		0010	Power dissipation less than 1 W
		0011	Power dissipation more than 1 W
		0100 to 1111	Not permitted

6.5.5.2 Sensor type

Name:
ConfigOutput02

This module is designed for a wide range of sensor types. The sensor type must be configured because of the different alignment values.

Data type	Value	Information
USINT	0	Conversion switched off
	1	Sensor type J (bus controller default setting)
	2	Sensor type K
	3	Sensor type S
	4	Sensor type N
	5	Conversion switched off
	6	Raw value without linearization and terminal temperature compensation: Resolution 1.0625 µV for a measurement range of ±35 mV
	7	Raw value without linearization and terminal temperature compensation: Resolution 2.125 µV for a measurement range of ±70 mV
	8 - 63	Conversion switched off
	64	Sensor type R
	65 - 71	Conversion switched off
	72	Sensor type B
	73 - 255	Conversion switched off

6.5.5.3 Channel disabling

Name:
ConfigOutput03

By default, all channels are switched on. To save time, individual channels can be switched off (see "Conversion time" on page 66).

Data type	Values	Bus controller default setting
USINT	See bit structure.	63

Bit structure:

Bit	Description	Value	Information
0	Channel 1	0	Off
		1	Switched on (bus controller default setting)
	...	...	
5	Channel 6	0	Off
		1	Switched on (bus controller default setting)
6 - 7	Reserved	0	

6.5.6 Communication

6.5.6.1 Analog inputs (resolution = 0.1°C)

Name:
Temperature01 to Temperature06

With a resolution of 0.1°C, these registers contain the analog input value depending on the set sensor type:

Data type	Values	Input signal
INT	-2100 to +12000 (for -210.0°C to +1200.0°C)	Type J (FeCuNi)
	-2700 to +13720 (for -270.0°C to +1372.0°C)	Type K (NiCrNi)
	-2700 to +13000 (for -270.0°C to +1300.0°C)	Type N (NiCrSi)
	-500 to +17680 (for -50.0°C to +1768.0°C)	Type S (PtRhPt)
	0 to +18200 (for 0°C to +1820.0°C)	Type B (PtRhPt)
	-500 to +16640 (for -50.0°C to +1664.0°C)	Type R (PtRhPt)
	-32768 to +32767	Raw value without linearization and terminal temperature compensation: Resolution 1.0625 µV for a measurement range of ±35 mV
	-32768 to +32767	Raw value without linearization and terminal temperature compensation: Resolution 2.125 µV for a measurement range of ±70 mV

6.5.6.2 Analog inputs (resolution = 0.01°C)

Name:
Temperature01_H_Res to Temperature06_H_Res

With a resolution of 0.01°C, these registers contain the analog input value depending on the set sensor type:

Data type	Values	Input signal
DINT	-21000 to +120000 (for -210.00°C to +1200.00°C)	Type J (FeCuNi)
	-27000 to +137200 (for -270.00°C to +1372.00°C)	Type K (NiCrNi)
	-27000 to +130000 (for -270.00°C to +1300.00°C)	Type N (NiCrSi)
	-5000 to +176800 (for -50.00°C to +1768.00°C)	Type S (PtRhPt)
	0 to +182000 (for 0°C to +1820.00°C)	Type B (PtRhPt)
	-5000 to +166400 (for -50.00°C to +1664.00°C)	Type R (PtRhPt)
	-2,147,483,648 to 2,147,483,647	Raw value without linearization and terminal temperature compensation: 0.10625 µV resolution for a measurement range of ±35 mV
	-2,147,483,648 to 2,147,483,647	Raw value without linearization and terminal temperature compensation: 0.2125 µV resolution for a measurement range of ±70 mV

6.5.6.3 I/O cycle counter

Name:
IOCycleCounter

The cyclic counter increases after all input data has been updated.

Data type	Values	Information
USINT	0 to 255	Repeating counter

6.5.6.4 Input status

The module's inputs are monitored. A change in the monitoring status is actively issued as an error message and, in the event of an error, the analog value is fixed at defined values. For details, see "Monitoring the input signal" on page 65.

6.5.6.4.1 Status of inputs 1 to 4

Name:
StatusInput01

The state of analog inputs 1 to 4 is represented in this register.

Data type	Values
USINT	See the bit structure.

Bit structure:

Bit	Description	Value	Information
0 - 1	Channel 1	00	No error
		01	Lower limit value undershot
		10	Upper limit value overshot
		11	Open circuit
2 - 3	Channel 2	x	Values: See channel 1.
4 - 5	Channel 3	x	Values: See channel 1.
6 - 7	Channel 4	x	Values: See channel 1.

6.5.6.4.2 Status of inputs 5 to 6

Name:
StatusInput02

The state of analog inputs 5 to 6 is represented in this register.

Data type	Values
USINT	See the bit structure.

Bit structure:

Bit	Description	Value	Information
0 - 1	Channel 5	00	No error
		01	Lower limit value undershot
		10	Upper limit value overshot
		11	Open circuit
2 - 3	Channel 6	x	Values: See channel 5.
4 - 7	Reserved	0	

6.5.6.5 Reads the internal cold junction temperature

Name:
CompensationTemperature

The internal cold junction temperature is stored in this register.

Data type	Value	Information
INT	-250 to 850	Internal cold junction temperature (PT1000): -25.0 to 85.0°C

6.5.6.6 Defines the external cold junction temperature

Name:
ExternalCompensationTemperature

The external cold junction temperature is defined in this register.

Data type	Value	Information
INT	-250 to 850	External cold junction temperature: -25.0 to 85.0°C

6.5.7 Minimum cycle time

The minimum cycle time specifies how far the bus cycle can be reduced without communication errors occurring. It is important to note that very fast cycles reduce the idle time available for handling monitoring, diagnostics and acyclic commands.

Minimum cycle time
150 µs

6.5.8 Minimum I/O update time

The minimum I/O update time specifies how far the bus cycle can be reduced so that an I/O update is performed in each cycle.

For the formulas listed in the table, 'n' corresponds to the number of channels that are switched on.

Function model 0	
n inputs	(n + 1) · (2 x Filter time + 200 µs)

Function model 1	
1 input	Equal to the filter time
n inputs	n · (2 x Filter time + 200 µs)

7 X20ATA312

7.1 General information

The module is equipped with 2 inputs for PT100 4-line resistance temperature measurement.

- 2 inputs for resistance temperature measurement
- PT100 sensor
- Direct resistance measurement as well
- 4-wire measurement
- Filter time can be configured
- NetTime timestamp: Moment of measurement

NetTime timestamp of the measurement

For many applications, not only the measured value is important, but also the exact time of the measurement. The module is equipped with a NetTime timestamp function for this that supplies a timestamp for the recorded position and trigger time with microsecond accuracy.

The timestamp function is based on synchronized timers. If a timestamp event occurs, the module immediately saves the current NetTime. After the respective data is transferred to the CPU, including this precise moment, the CPU can then evaluate the data using its own NetTime (or system time), if necessary.

7.2 Order data

Order number	Short description	Figure
	Temperature measurement	
X20ATA312	X20 temperature input module, 2 inputs for resistance measurement, PT100, resolution 0.01°C, 4-wire connections, NetTime function	
	Required accessories	
	Bus modules	
X20BM11	X20 bus module, 24 VDC keyed, internal I/O power supply connected through	
X20BM15	X20 bus module, with node number switch, 24 VDC keyed, internal I/O power supply connected through	
	Terminal blocks	
X20TB1F	X20 terminal block, 16-pin, 24 VDC keyed	

Table 13: X20ATA312 - Order data

7.3 Technical data

Order number	X20ATA312
Short description	
I/O module	2 inputs for PT100 resistance temperature measurement
General information	
B&R ID code	0xE0E4
Status indicators	I/O function per channel, operating state, module status
Diagnostics	
Module run/error	Yes, using LED status indicator and software
Inputs	Yes, using LED status indicator and software
Power consumption	
Bus	0.01 W
Internal I/O	0.4 W
Additional power dissipation caused by actuators (resistive) [W]	-
Certifications	
CE	Yes
ATEX	Zone 2, II 3G Ex nA nC IIA T5 Gc IP20, Ta (see X20 user's manual) FTZÚ 09 ATEX 0083X
UL	cULus E115267 Industrial control equipment
HazLoc	cCSAus 244665 Process control equipment for hazardous locations Class I, Division 2, Groups ABCD, T5
EAC	Yes
Resistance measurement temperature inputs	
Input	Resistance measurement with constant current supply for 4-wire connections
Digital converter resolution	24-bit
Filter time	Configurable between 1 and 200 ms
Conversion time	
1 channel	20 ms with 50 Hz filter
2 channels	40 ms per channel with 50 Hz filter
Conversion procedure	Sigma-delta
Output format	DINT or UDINT for resistance measurement
Temperature measurement range	-200 to 850°C
Resistance measurement range	0.5 to 390 Ω
Temperature sensor resolution	1 LSB = 0.01°C
Resistance measurement resolution	0.001 Ω
Input filter	First-order low-pass filter / cutoff frequency 1050 Hz
Sensor standard	EN 60751
Isolation voltage between channel and bus	500 V_{eff}
Linearization method	Internal
Measurement current	1 mA
Temperature sensor normalization	-200.0 to 850.0°C
Reference	1568 Ω ±0.1%
Permissible input signal	Short-term max. 28.8 V
Max. error at 25°C [1]	
Gain	0.0059% [2]
Offset	0.0015% [3]
Max. gain drift	<0.00065 %/°C [2]
Max. offset drift	<0.000025 %/°C [3]
Nonlinearity	<0.001% [3]
Standardized range of values for resistance measurement	19 to 390 Ω
Temperature measurement monitoring	
Range undershoot	0x80000001
Range overshoot	0x7FFFFFFF
Open circuit	0x7FFFFFFF
General fault	0x80000000
Open inputs	0x7FFFFFFF
Resistance measurement monitoring	
Range undershoot	0x80000001
Range overshoot	0xFFFFFFFF
Open circuit	0xFFFFFFFF
General fault	0x80000000
Electrical properties	
Electrical isolation	Channel isolated from bus Channel not isolated from channel

Table 14: X20ATA312 - Technical data

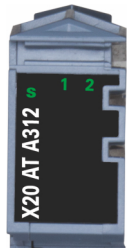
Order number	X20ATA312
Operating conditions	
Mounting orientation	
Horizontal	Yes
Vertical	Yes
Installation elevation above sea level	
0 to 2000 m	No limitation
>2000 m	Reduction of ambient temperature by 0.5°C per 100 m
Degree of protection per EN 60529	IP20
Ambient conditions	
Temperature	
Operation	
Horizontal mounting orientation	-25 to 60°C
Vertical mounting orientation	-25 to 50°C
Derating	-
Storage	-40 to 85°C
Transport	-40 to 85°C
Relative humidity	
Operation	5 to 95%, non-condensing
Storage	5 to 95%, non-condensing
Transport	5 to 95%, non-condensing
Mechanical properties	
Note	Order 1x terminal block X20TB1F separately. Order 1x bus module X20BM11 separately.
Pitch	12.5 $^{+0.2}$ mm

Table 14: X20ATA312 - Technical data

1) To guarantee accuracy, modules with a power dissipation < 1.2 W must be connected to the left and right of this module.
2) Based on the current resistance value.
3) Based on the entire resistance measurement range.

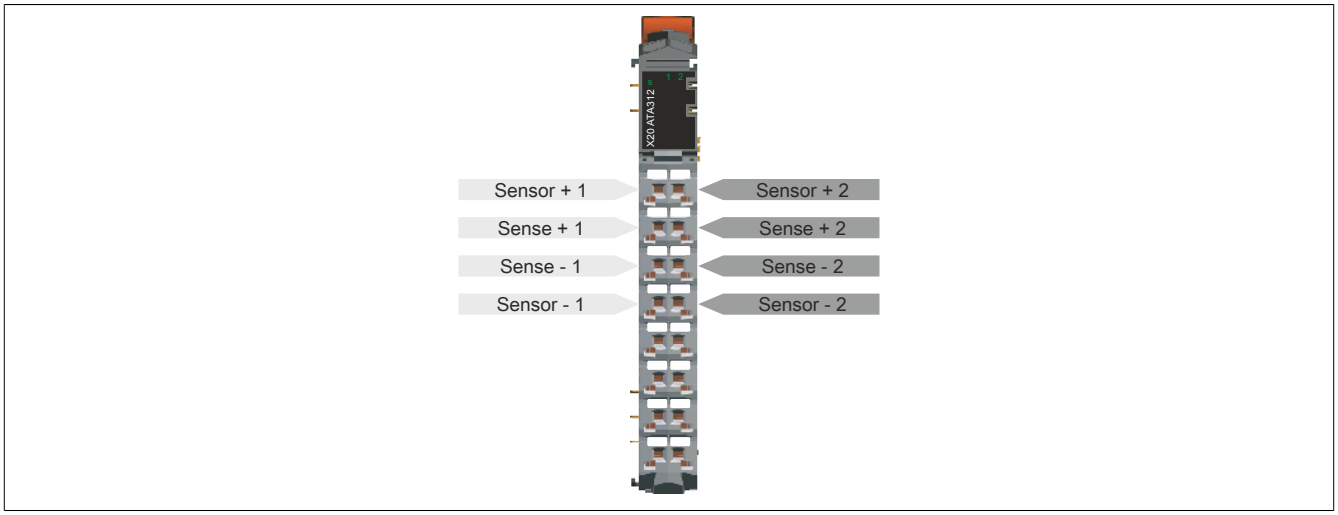
7.4 Status LEDs

For a description of the various operating modes, see section "Additional information - Diagnostic LEDs" in the X20 system user's manual.

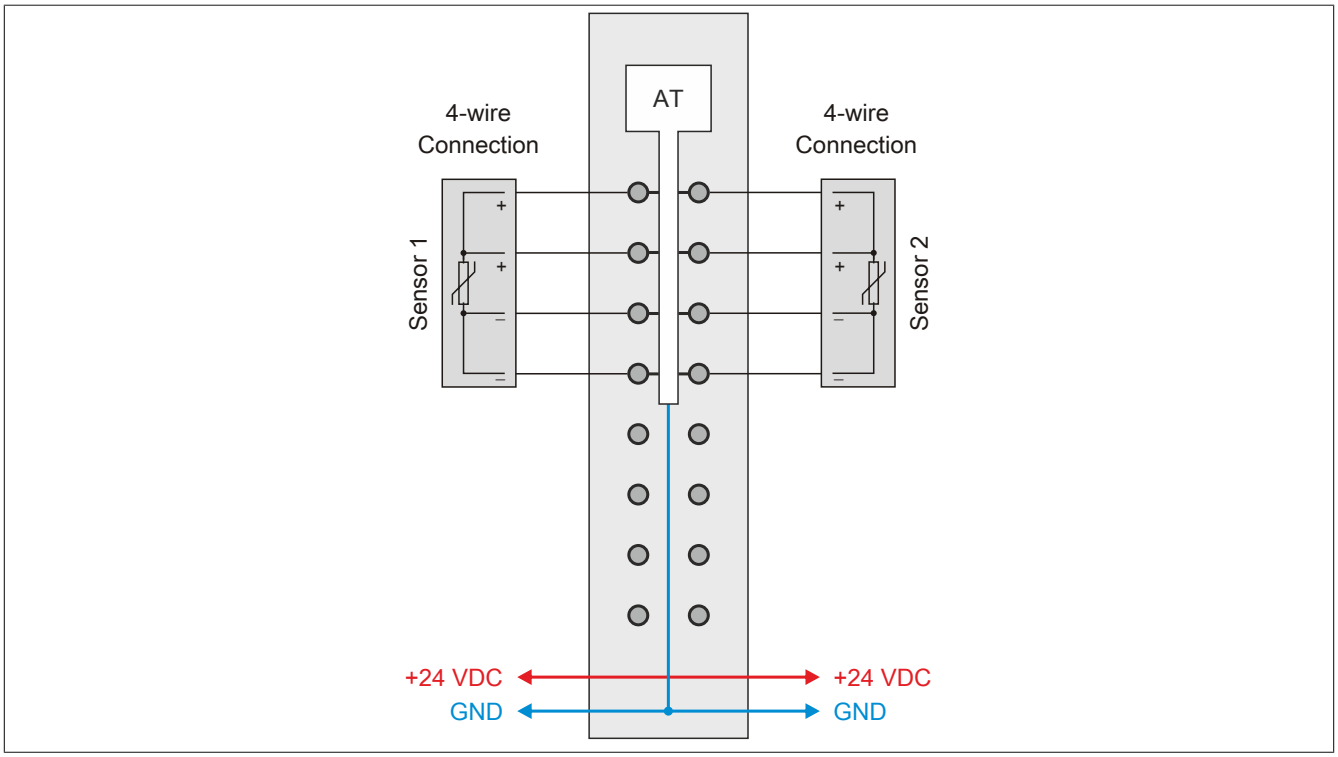
Image	LED	Color	Status	Description
	s	Green	Off	Module supply not connected
			Single flash	Reset mode
			Double flash	Mode BOOT (during firmware update)[1]
			Blinking	PREOPERATIONAL mode
			On	RUN mode
		Red	Off	Module supply not connected or everything OK
			On	Error or reset status
			Single flash	Parameter or conversion error[2]
		Red on / Green single flash		Invalid firmware
	1 - 2	Green	Off	Input turned off or not supplied
			Single flash	Parameter error[2]
			Double flash	Conversion error[2]
			Blinking	Overflow, underflow or open line
			On	A/D converter running, value OK

1) Depending on the configuration, a firmware update can take up to several minutes.
2) Parameter or converter errors are indicated simultaneously on the red "s" LED and the channel LED of the respective output.

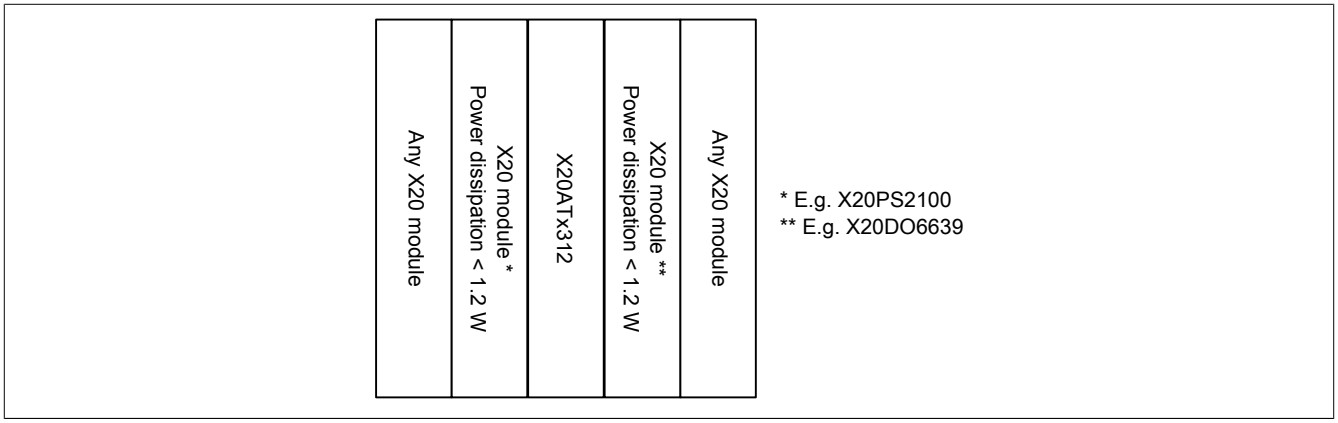
7.5 Pinout



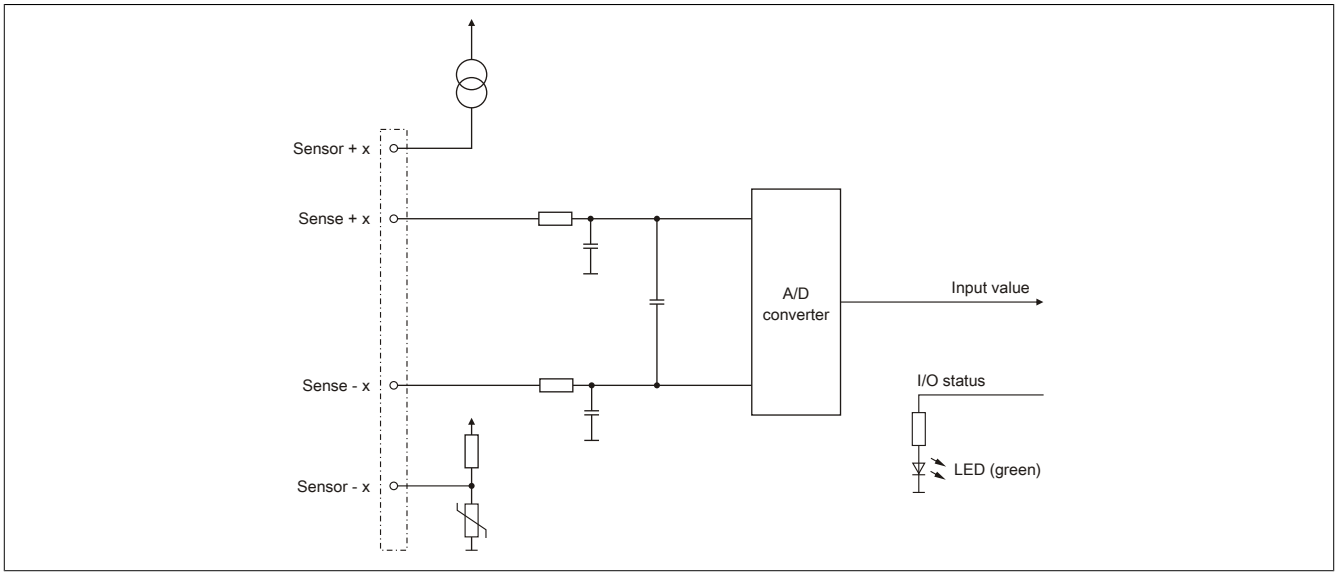
7.6 Connection example



To ensure accuracy, modules with a power consumption <1.2 W must be inserted to the left and right of this modules.



7.7 Input circuit diagram



7.8 Register description

7.8.1 General data points

In addition to the registers described in the register description, the module has additional general data points. These are not module-specific but contain general information such as serial number and hardware variant.

General data points are described in section "Additional information - General data points" in the X20 system user's manual.

7.8.2 Function model 0 - Standard

Register	Name	Data type	Read		Write	
			Cyclic	Acyclic	Cyclic	Acyclic
Configuration						
130	InputFilter	UINT				•
134	ModeADC	UINT				•
514	SensorType01	UINT				•
578	SensorType02					
566	PreparationInterval01	UINT				•
630	PreparationInterval02					
548	ReplaceUpper01	DINT				•
612	ReplaceUpper02					
540	ReplaceLower01	DINT				•
604	ReplaceLower02					
532	UpperLimit01	DINT				•
596	UpperLimit02					
524	LowerLimit01	DINT				•
588	LowerLimit02					
554	Hysteresis01	UINT				•
618	Hysteresis02					
558	ErrorDelay01	UINT				•
622	ErrorDelay02					
562	SumErrorDelay01	UINT				•
626	SumErrorDelay02					
Communication						
0	Temperature01	DINT	•			
	Resistor01	UDINT				
4	Temperature02	DINT	•			
	Restistor02	UDINT				
260	Measurand01	DINT		•		
324	Measurand02					
281	IOCycleCounter01	USINT	•			
345	IOCycleCounter02					
282	IOCycleCounter01	UINT	•			
346	IOCycleCounter02					
274	Sampletime01	INT	•			
338	Sampletime02					
276	Sampletime01	DINT	•			
340	Sampletime02					
297	Status01	USINT	•			
	Underrun01	Bit 0				
	Overrun01	Bit 1				
	OpenLine01	Bit 2				
	ConverterFault01	Bit 4				
	SumFault01	Bit 5				
	ParameterFault01	Bit 6				
	IoSupplyFault01	Bit 7				
361	Status02	USINT	•			
	Underrun02	Bit 0				
	Overrun02	Bit 1				
	OpenLine02	Bit 2				
	ConverterFault02	Bit 4				
	SumFault02	Bit 5				
	ParameterFault02	Bit 6				
	IoSupplyFault02	Bit 7				

7.8.3 Function model 254 - Bus Controller

Register	Offset[1)]	Name	Data type	Read		Write	
				Cyclic	Acyclic	Cyclic	Acyclic
Configuration							
130	-	InputFilter	UINT				•
134	-	ModeADC	UINT				•
514	-	SensorType01	UINT				•
578	-	SensorType02					
566	-	PreparationInterval01	UINT				•
630	-	PreparationInterval02					
548	-	ReplaceUpper01	DINT				•
612	-	ReplaceUpper02					
540	-	ReplaceLower01	DINT				•
604	-	ReplaceLower02					
532	-	UpperLimit01	DINT				•
596	-	UpperLimit02					
524	-	LowerLimit01	DINT				•
588	-	LowerLimit02					
554	-	Hysteresis01	UINT				•
618	-	Hysteresis02					
558	-	ErrorDelay01	UINT				•
622	-	ErrorDelay02					
562	-	SumErrorDelay01	UINT				•
626	-	SumErrorDelay02					
Communication							
0	0	Temperature01	DINT	•			
		Resistor01	UDINT				
4	4	Temperature02	DINT	•			
		Restistor02	UDINT				
281	-	IOCycleCounter01	USINT		•		
345	-	IOCycleCounter02					
30	-	Status01To02	USINT		•		

1) The offset specifies where the register is within the CAN object.

7.8.3.1 Using the module on the bus controller

Function model 254 "Bus controller" is used by default only by non-configurable bus controllers. All other bus controllers can use other registers and functions depending on the fieldbus used.

For detailed information, see section "Additional information - Using I/O modules on the bus controller" in the X20 user's manual (version 3.50 or later).

7.8.3.2 CAN I/O bus controller

The module occupies 1 analog logical slot on CAN I/O.

7.8.4 Configuration of the A/D converter

7.8.4.1 Setting the conversion rate

Name:
InputFilter

Mit Hilfe dieses Registers wird die Abtastzeit des A/D-Wandlers konfiguriert.

Datentyp	Werte	Filterzeit in ms	Wandelrate in s^{-1}
UINT	4	1	1000
	9	2	500
	48	10	100
	80	16,7	60
	96	20 (Bus Controller Default)	50
	160	33,3	30
	192	40	25
	320	66,7	15
	480	100	10
	960	200	5

Information:

Je geringer die Wandelrate konfiguriert wird, desto genauer kann der Wert gewandelt werden. Allerdings wird dadurch auch die I/O-Updatezeit erhöht.

7.8.4.2 Operating mode of the A/D converter

Name:
ModeADC

The operating mode for the A/D converter can be configured in this register.

The individual options allow faster digitalization of the analog values, but this also reduces the precision of the measured values.

Data type	Values	Bus controller default setting
UINT	See the bit structure.	0

Bit structure:

Bit	Description	Value	Information
0	Chopper mode	0	Alternating gain of the analog value (bus controller default setting)
		1	Chopper mode off
1	Order of the SINC filter	0	SINC4 (bus controller default setting)
		1	SINC3
2 - 15	Reserved	-	-

The following applies:

ConversionTime(SINC3) = ConversionTime(SINC4) - 1 x ConversionCycle
ConversionTime(without Chop) = 0.5 x ConversionTime(Chop)

7.8.5 Configuring the measurement channels

Each temperature measurement channel can be configured independently. All the registers required for this purpose by each channel are arranged separately.

7.8.5.1 General channel configuration

Name:
SensorType01 to SensorType02

This register defines the basic behavior of the channel.

Data type	Values	Bus controller default setting
UINT	See the bit structure.	129

Bit structure:

Bit	Description	Value	Information
0 - 2	Sensor type with unit and resolution	001	PT100 [10 mK/bit] - Temperature measurement (bus controller default setting)
		010	PT100 [1 mΩ/bit] - Resistance measurement
		011 to 111	Reserved
3 - 4	Reserved	-	
5	Replacement value strategy	0	Replace statically
		1	Retain last valid value
6	Monitoring the user-defined limit values	0	Switch off additional limits
		1	Switch on additional limits
7	Channel (on/off)	0	Switch off the entire channel
		1	Switch on channel (bus controller default setting)
8 - 15	Reserved	-	

7.8.6 Configuring the replacement value strategy

If a measured value is detected that is outside the permitted value range, the behavior of the input register must still remain clearly defined. The module provides the user two different options for this purpose.

Retain last valid value

With this strategy, the determined measured value is stored temporarily for a specific time and written to the input register after a delay. If an invalid measured value is detected, this value and all values that have been stored temporarily are discarded. The last valid input register value is retained. To update the value in the input register, there must be enough valid values stored in the temporary buffer. The number needed is determined by the time period specified in "PreparationInterval0x".

Replace with static value

With this strategy, the measured value is written to the input register without delay. If an invalid value occurs, it is replaced by a static value that has been predefined by the user.

7.8.6.1 Preparation interval

Name:
PreparationInterval01 to PreparationInterval02

This register defines the time interval in which the measured value is checked before being passed on.

Data type	Value	Information
UINT	0 to 65,535	Unit in 0.1 ms. Bus controller default setting: 0

Information:

This register only needs to be defined if replacement value strategy "Retain last valid value" was selected in register "SensorType0x" on page 80.

7.8.6.2 Static replacement value for upper limit

Name:
ReplaceUpper01 to ReplaceUpper02

This register is used to defined a replacement value that is output in place of the invalid measured value if the upper limit is violated.

Data type	Values	Information
DINT	-2,147,483,648 to 2,147,483,647	Bus controller default setting: 2,147,483,647

Information:

This register must be defined if the replacement value strategy "Replace with static value" was selected in register "SensorType0x" on page 80.

7.8.6.3 Static replacement value for lower limit

Name:
ReplaceLower01 to ReplaceLower02

This register is used to defined a replacement value that is output in place of the invalid measured value if the lower limit is violated.

Data type	Values	Information
DINT	-2,147,483,648 to 2,147,483,647	Bus controller default setting: -2,147,483,647

Information:

This register must be defined if the replacement value strategy "Replace with static value" was selected in register "SensorType0x" on page 80.

7.8.7 Configuring the user-defined limit values

This module provides the user the option to specify user-defined limits. If the valid measurement range is reduced in this way, the behavior of the replacement value strategy is more likely to be applied.

Valid measurement range

The valid range is derived from the properties of the sensor being used or the hardware and firmware of the respective B&R module. These values cannot be changed by the user.

Valid range of values

The range of values is always within the valid measurement range. The range of values can be adapted to the requirements of the application by specifying the upper and lower limit value.

7.8.7.1 Upper limit value

Name:
UpperLimit01 to UpperLimit02

This register specifies the upper limit value. The values entered should be within the valid measurement range.

Data type	Values	Information
DINT	-2,147,483,648 to 2,147,483,647	Bus controller default setting: 2,147,483,647

7.8.7.2 Lower limit value

Name:
LowerLimit01 to LowerLimit02

This register specifies the lower limit value. The values entered should be within the valid measurement range.

Data type	Values	Information
DINT	-2,147,483,648 to 2,147,483,647	Bus controller default setting: -2,147,483,647

7.8.7.3 Hysteresis

Name
Hysteresis01 to Hysteresis02

A hysteresis can be set in order to avoid frequent status changes in the measurement range close to the limit value. Here, a small section is defined at the edge of the valid range of values where the measured values retain the status (valid or invalid) of the previous measured value.

Data type	Values	Information
UINT	0 to 65,535	Bus controller default setting: 16

7.8.8 Configuring status messages

Errors are detected by the module and sent to the application. When using Function model 0 - Standard, the trigger behavior of these error messages can be influenced by the "Delay" register.

In Automation Studio, an error message can be read either packed as the entire register or individually as bits.

7.8.8.1 Delaying error messages

Name:
ErrorDelay01 to ErrorDelay02

In order to avoid false alarms due to short-term measurement variations, the status messages transmitted to the PLC can be delayed. This register determines the number of A/D conversions in which an error must exist before an error message is transmitted.

Data type	Values	Information
UINT	0 to 65,535	AD conversions. Bus controller default setting: 2

7.8.8.2 Delaying the sum error message

Name:
SumErrorDelay01 to SumErrorDelay02

This register can be used to set the delay used when sending bit 5 of the "Status0x" on page 84 register to the PLC independent of the other status messages.

Data type	Values	Information
UINT	0 to 65,535	Bus controller default setting: 4000

7.8.9 Communication

The received temperature data is stored with a timestamp and, depending on the configuration, is made available under various register names and data types.

7.8.9.1 Measured value – Temperature

Name:
Temperature01 to Temperature02

If the channel is configured for resistance measurement, the current temperature value is made available in this register.

Data type	Values
DINT	-2,147,483,648 to 2,147,483,647

7.8.9.2 Measured value – Resistance

Name:
Resistor01 to Resistor02

If the channel is configured for resistance measurement, the current resistance value is made available in this register.

Data type	Values
UDINT	0 to 4,294,967,295

7.8.9.3 Measured value – Unweighted

Name:
Measurand01 to Measurand02

When using the AsIoAcc library, the unweighted measurement can be accessed via this register. This refers to a measured value that is within the valid measurement range and has not yet been compared with the user-defined limits.

Data type	Values
DINT	-2,147,483,648 to 2,147,483,647

Information:

If no user-defined limits are configured, the value of this register does not differ from the temperature or resistance value.

7.8.9.4 Cycle counter

Name:
IOCycleCounter01 to IOCycleCounter02

This register is used to provide a continuous counter for the application that is incremented each time a temperature value is read.

Data type	Value	Information
USINT	0 to 32,767	AD conversion.
UINT	0 to 65,535	AD conversion.

7.8.9.5 Sampling time - Timestamp

Name:
Sampletime01 to Sampletime02

This register provides the application with the NetTime at the time of temperature recording.

For additional information about NetTime and timestamps, see "NetTime Technology" on page 85.

Data type	Value	Information
INT	-32,768 to 32,767	NetTime timestamp in µs
DINT	-2,147,483,648 to 2,147,483,647	NetTime timestamp in µs

Information:

The SDC library requires a 16-bit value for the sampling time. It is therefore also prepared as a 16-bit value.

7.8.9.6 Status messages

Name:
Status01 to Status02

The register bits are set if an error has been diagnosed and the error remains longer than the delay configured in the "ErrorDelay0x" on page 82 register.

Data type	Values
USINT	See the bit structure.

Bit structure:

Bit	Name	Value	Information
0	Underrun01 to Underrun02	0	No error
		1	Value below the permitted range
1	Overrun01 to Overrun02	0	No error
		1	Value above the permitted range
2	OpenLine01 to OpenLine02	0	No error
		1	Sensor is not connected correctly
3	Reserved	-	
4	ConverterFault01 to ConverterFault02	0	No error
		1	Invalid A/D converter output
5	SumFault01 to SumFault02	0	No error
		1	Composite error
6	ParameterFault01 to ParameterFault02	0	No error
		1	The "SensorType0x" on page 80 register is faulty
7	IoSupplyFault01 to IoSupplyFault02	0	No error
		1	The I/O supply voltage is faulty

7.8.9.7 Status messages for function model 254

Name:
Status01To02

The bits in this register are set if an error has been detected.

Data type	Values
USINT	See the bit structure.

Bit structure:

Bit	Name	Value	Information
0	Underrun on channel 01	0	No error
		1	Value below the permitted range
1	Overrun on channel 01	0	No error
		1	Value above the permitted range
2	Underrun on channel 02	0	No error
		1	Value below the permitted range
3	Overrun on channel 02	0	No error
		1	Value above the permitted range
4 - 7	Reserved	-	

Information:

If an open line is detected on a channel, then both error messages will be displayed at the same time.

7.8.10 NetTime Technology

NetTime refers to the ability to precisely synchronize and transfer system times between individual components of the controller or network (CPU, I/O modules, X2X Link, POWERLINK, etc.).

This allows the moment that events occur to be determined system-wide with microsecond precision. Upcoming events can also be executed precisely at a specified moment.

7.8.10.1 Time information

Various time information is available in the controller or on the network:

- System time (on the PLC, Automation PC, etc.)
- X2X Link time (for each X2X Link network)
- POWERLINK time (for each POWERLINK network)
- Time data points of I/O modules

The NetTime is based on 32-bit counters, which are increased with microsecond resolution. The sign of the time information changes after 35 min, 47 s, 483 ms and 648 µs; an overflow occurs after 71 min, 34 s, 967 ms and 296 µs.

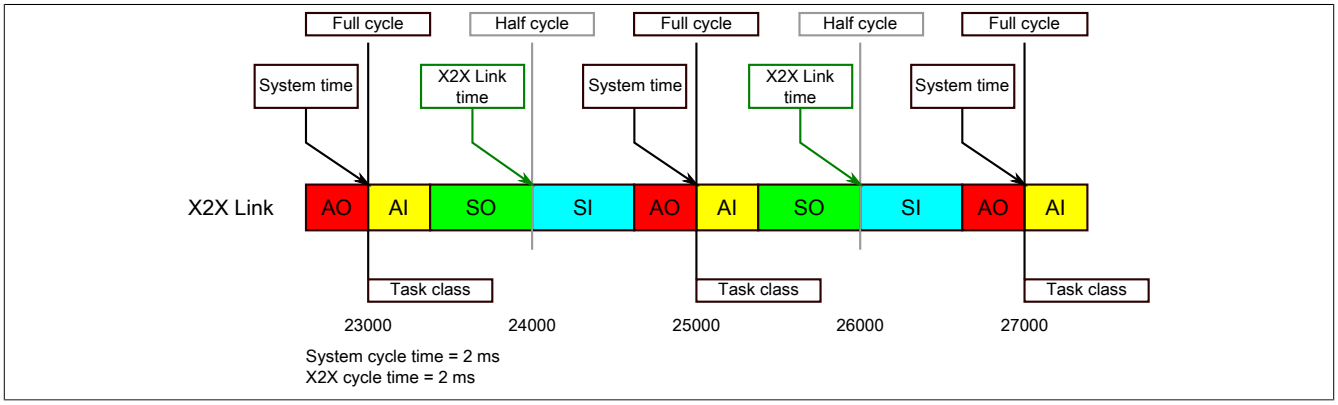
The initialization of the times is based on the system time during the startup of the X2X Link, the I/O modules or the POWERLINK interface.

Current time information in the application can also be determined via library AsIOTime.

7.8.10.1.1 PLC/Controller data points

The NetTime I/O data points of the PLC or the controller are latched to each system clock and made available.

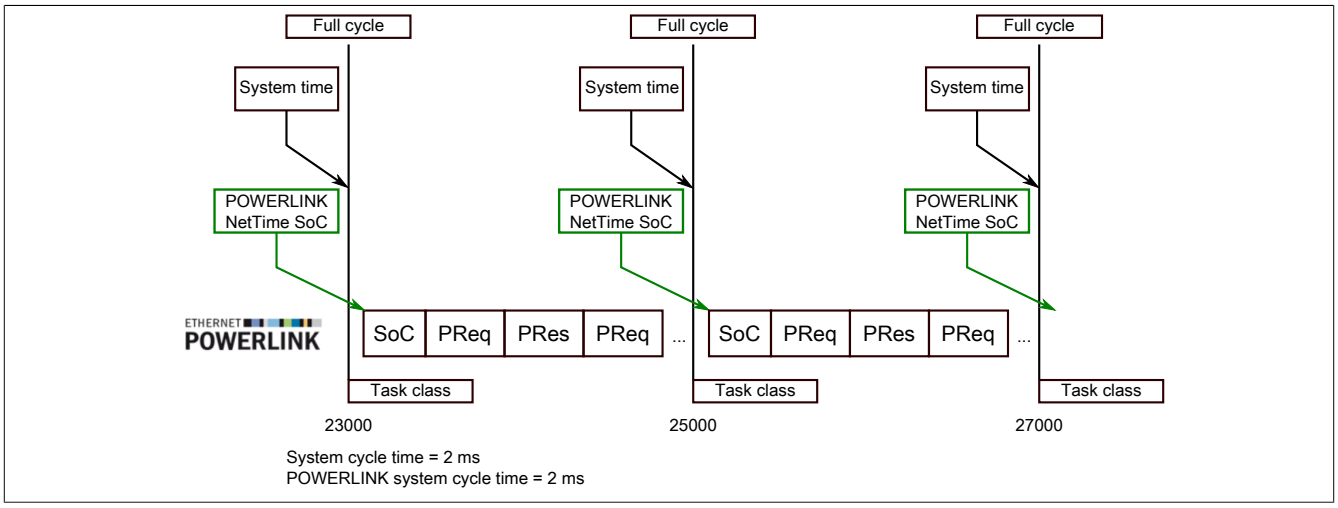
7.8.10.1.2 X2X Link reference moment



The reference moment on the X2X Link network is always calculated at the half cycle of the X2X Link cycle. This results in a difference between the system time and the X2X Link reference moment when the reference time is read out.

In the example above, this results in a difference of 1 ms, i.e. if the system time and X2X Link reference moment are compared at time 25000 in the task, then the system time returns the value 25000 and the X2X Link reference moment returns the value 24000.

7.8.10.1.3 POWERLINK - Reference time point

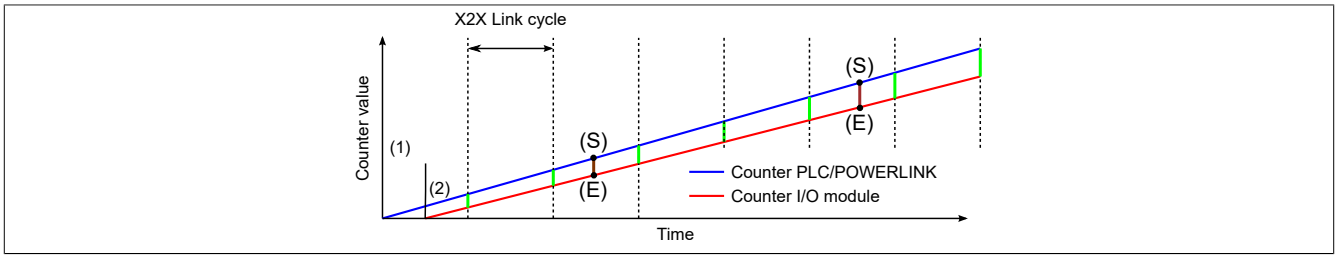


The reference time point on the POWERLINK network is always calculated at the start of cycle (SoC) of the POWERLINK network. The SoC starts 20 µs after the system clock due to the system. This results in the following difference between the system time and the POWERLINK reference time:

POWERLINK reference time = System time - POWERLINK cycle time + 20 µs.

In the example above, this means a difference of 1980 µs, i.e. if the system time and POWERLINK reference time are compared at time 25000 in the task, then the system time returns the value 25000 and the POWERLINK reference time returns the value 23020.

7.8.10.1.4 Synchronization of system time/POWERLINK time and I/O module



At startup, the internal counters for the PLC/POWERLINK (1) and the I/O module (2) start at different times and increase the values with microsecond resolution.

At the beginning of each X2X Link cycle, the PLC or the POWERLINK network sends time information to the I/O module. The I/O module compares this time information with the module's internal time and forms a difference (green line) between the two times and stores it.

When a NetTime event (E) occurs, the internal module time is read out and corrected with the stored difference value (brown line). This means that the exact system moment (S) of an event can always be determined, even if the counters are not absolutely synchronous.

Note

The deviation from the clock signal is strongly exaggerated in the picture as a red line.

7.8.10.2 Timestamp functions

NetTime-capable modules provide various timestamp functions depending on the scope of functions. If a timestamp event occurs, the module immediately saves the current NetTime. After the respective data is transferred to the CPU, including this precise moment, the CPU can then evaluate the data using its own NetTime (or system time), if necessary.

7.8.10.2.1 Time-based inputs

NetTime Technology can be used to determine the exact moment of a rising edge at an input. The rising and falling edges can also be detected and the duration between 2 events can be determined.

Information:

The determined moment always lies in the past.

7.8.10.2.2 Time-based outputs

NetTime Technology can be used to specify the exact moment of a rising edge on an output. The rising and falling edges can also be specified and a pulse pattern generated from them.

Information:

The specified time must always be in the future, and the set X2X Link cycle time must be taken into account for the definition of the moment.

7.8.10.2.3 Time-based measurements

NetTime Technology can be used to determine the exact moment of a measurement that has taken place. Both the starting and end moment of the measurement can be transmitted.

7.8.11 Minimum cycle time

The minimum cycle time defines how far the bus cycle can be reduced without causing a communication error or impaired functionality. It should be noted that very fast cycles decrease the idle time available for handling monitoring, diagnostics and acyclic commands.

Minimum cycle time
200 µs

7.8.12 Minimum I/O update time

The minimum I/O update time defines how far the bus cycle can be reduced while still allowing an I/O update to take place in each cycle.

Minimum I/O update time
1 ms

8 X20ATA492

8.1 General information

The module is equipped with 2 inputs for J, K, N, S, B, R, E, C and T thermocouple sensors. The 2 measurement channels are electrically isolated from each other.

This module can also be equipped with the X20TB1E thermocouple terminal block with integrated PT1000 temperature sensors. This makes it possible to achieve optimal terminal temperature compensation.

- Single-channel electrical isolation
- Integrated terminal temperature compensation
- 2x PT1000 sensor integrated in the terminal
- 2x external PT1000 sensor can be connected, 2-wire or 4-wire connections
- NetTime timestamp: Moment of measurement

NetTime timestamp of the measurement

For many applications, not only the measured value is important, but also the exact time of the measurement. The module is equipped with a NetTime timestamp function for this that supplies a timestamp for the recorded position and trigger time with microsecond accuracy.

The timestamp function is based on synchronized timers. If a timestamp event occurs, the module immediately saves the current NetTime. After the respective data is transferred to the CPU, including this precise moment, the CPU can then evaluate the data using its own NetTime (or system time), if necessary.

8.1.1 Other applicable documents

For additional and supplementary information, see the following documents.

Other applicable documents

Document name	Title
MAX20	X20 System user's manual
MAEMV	Installation / EMC guide

8.2 Order data

Order number	Short description	Figure
	Temperature measurement	
X20ATA492	X20 temperature input module, 2 thermocouple inputs, type J, K, N, S, B, R, E, C, T, single-channel isolation, NetTime function, 2x PT1000 integrated in terminal block X20TB1E for temperature compensation, order terminal block separately.	
	Required accessories	
	Bus modules	
X20BM11	X20 bus module, 24 VDC keyed, internal I/O power supply connected through	
X20BM15	X20 bus module, with node number switch, 24 VDC keyed, internal I/O power supply connected through	
	Terminal blocks	
X20TB1E	X20 terminal block, 12-pin, 24 VDC keyed, 2x Pt1000 integrated for terminal temperature compensation	
X20TB1F	X20 terminal block, 16-pin, 24 VDC keyed	

Table 15: X20ATA492 - Order data

8.3 Technical description

8.3.1 Technical data

Order number	X20ATA492
Short description	
I/O module	2 inputs for thermocouples
General information	
B&R ID code	0xBB98
Status indicators	I/O function per channel, operating state, module status
Diagnostics	
Module run/error	Yes, using LED status indicator and software
Inputs	Yes, using LED status indicator and software
Power consumption	
Bus	0.35 W
Internal I/O	0.5 W
Additional power dissipation caused by actuators (resistive) [W]	-
Certifications	
CE	Yes
ATEX	Zone 2, II 3G Ex nA nC IIA T5 Gc IP20, Ta (see X20 user's manual) FTZÚ 09 ATEX 0083X
UL	cULus E115267 Industrial control equipment
HazLoc	cCSAus 244665 Process control equipment for hazardous locations Class I, Division 2, Groups ABCD, T5
DNV	Temperature: **B** (0 - 55°C) Humidity: **B** (up to 100%) Vibration: **B** (4 g) EMC: **B** (bridge and open deck)
EAC	Yes
KC	Yes
Thermocouple temperature inputs	
Input	Thermocouple
Digital converter resolution	16-bit
Filter time	Configurable between 1 ms and 200 ms
Conversion time	
Internal terminal temperature comp.	2 * 4 * x ms [1)]
External terminal temperature comp.	x ms [1)]
Remote temperature comp.	2 * 4 * x ms [1)]
Output format	INT
Measurement range	
Sensor temperature	
Type J: Fe-CuNi	-210 to 1200°C
Type K: NiCr-Ni	-270 to 1372°C
Type N: NiCrSi-NiSi	-270 to 1298°C
Type S: PtRh10-Pt	-50 to 1768°C
Type B: PtRh30-PtRh6	0 to 1820°C
Type R: PtRh13-Pt	-50 to 1760°C
Type E: NiCr-CuNi	-270 to 997°C
Type C: WRe5-WRe26	0 to 2310°C
Type T: Cu-CuNi	-270 to 400°C
Terminal temperature	-40 to 130°C
Voltage	±65.534 mV
Sensor standard	EN 60584
Resolution	
Sensor temperature	1 LSB = 0.1°C
Terminal temperature	1 LSB = 0.1°C
Voltage	Depending on gain, 1 LSB = 1 µV or 2 µV
Normalization	
Type J: Fe-CuNi	-210.0 to 1200.0°C
Type K: NiCr-Ni	-270.0 to 1372.0°C
Type N: NiCrSi-NiSi	-270.0 to 1298.0°C
Type S: PtRh10-Pt	-50.0 to 1768.0°C
Type B: PtRh30-PtRh6	0 to 1820.0°C
Type R: PtRh13-Pt	-50.0 to 1760.0°C
Type E: NiCr-CuNi	-270.0 to 997.0°C
Type C: WRe5-WRe26	0 to 2310.0°C
Type T: Cu-CuNi	-270.0 to 400.0°C
Terminal temperature (Pt1000)	-40.0 to 130.0°C
Voltage	Depending on gain ±32.767 mV or ±65.534 mV

Table 16: X20ATA492 - Technical data

Order number	X20ATA492
Monitoring	
Range undershoot	0x8001
Range overshoot	0x7FFF
Open circuit	0x7FFF
Open inputs	0x7FFF
General fault	0x8000
Conversion procedure	Sigma-delta
Linearization method	Internal
Permissible input signal	Max. ±5 V
Input filter	First-order low-pass filter / cutoff frequency 500 Hz
Max. error at 25°C	
Gain	0.07% 2)
Offset	
Type T: Cu-CuNi	0.03% 3)
Type K: NiCr-Ni	0.04% 3)
Type N: NiCrSi-NiSi	0.04% 3)
Type S: PtRh10-Pt	0.1% 3)
Type B: PtRh30-PtRh6	0.12% 3)
Type R: PtRh13-Pt	0.08% 3)
Type E: NiCr-CuNi	0.03% 3)
Type C	0.05% 3)
Type T: Cu-CuNi	0.08% 3)
Voltage	0.017% 3)
Max. gain drift	
Channel	0.01%/°C 2)
Terminal temperature (Pt1000)	0.003 %/°C 2)
Max. offset drift	
Type J: Fe-CuNi	0.0019 %/°C 3)
Type K: NiCr-Ni	0.0025 %/°C 3)
Type N: NiCrSi-NiSi	0.003 %/°C 3)
Type S: PtRh10-Pt	0.0081 %/°C 3)
Type B: PtRh30-PtRh6	0.0111 %/°C 3)
Type R: PtRh13-Pt	0.0072 %/°C 3)
Type E: NiCr-CuNi	0.0017 %/°C 3)
Type C: WRe5-WRe26	0.0039 %/°C 3)
Type T: Cu-CuNi	0.0072 %/°C 3)
Terminal temperature (Pt1000)	0.005 %/°C 3)
Voltage	0.001%/°C 3)
Nonlinearity	
Channel	±0.004% 3)
Terminal temperature	±0.004% 2)
Terminal temperature compensation	
Operating modes	Internal/remote or external
Basic accuracy at 25°C not taking Pt1000 sensor into account	±0.06%
Accuracy of internal terminal temperature	
With natural convection	±1.5°C after 20 min
With artificial convection	±3°C after 20 min
Common-mode rejection	
DC	>110 dB
50 Hz	>110 dB
60 Hz	>110 dB
Common-mode range	±50 V
Crosstalk between channels	<-70 dB
Insulation voltage	
Between channel and bus	500 V_{eff}
Between channel and channel	500 V_{eff}
Electrical properties	
Electrical isolation	Channel isolated from channel and bus
Operating conditions	
Mounting orientation	
Horizontal	Yes
Vertical	Yes
Installation elevation above sea level	
0 to 2000 m	No limitation
>2000 m	Reduction of ambient temperature by 0.5°C per 100 m
Degree of protection per EN 60529	IP20

Table 16: X20ATA492 - Technical data

Order number	X20ATA492
Ambient conditions	
Temperature	
Operation	
Horizontal mounting orientation	-25 to 60°C
Vertical mounting orientation	-25 to 50°C
Derating	-
Storage	-40 to 85°C
Transport	-40 to 85°C
Relative humidity	
Operation	5 to 95%, non-condensing
Storage	5 to 95%, non-condensing
Transport	5 to 95%, non-condensing
Mechanical properties	
Note	Order 1x terminal block X20TB1E for internal/remote terminal temperature compensation separately. Order 1x terminal block X20TB1F for external terminal temperature compensation separately. Order 1x bus module X20BM11 separately.
Pitch	12.5$^{+0.2}$ mm

Table 16: X20ATA492 - Technical data

1) With a 50 Hz filter, x = 20 ms (1 / 50 Hz = 20 ms)
2) Based on the current measured value.
3) Based on the entire measurement range.

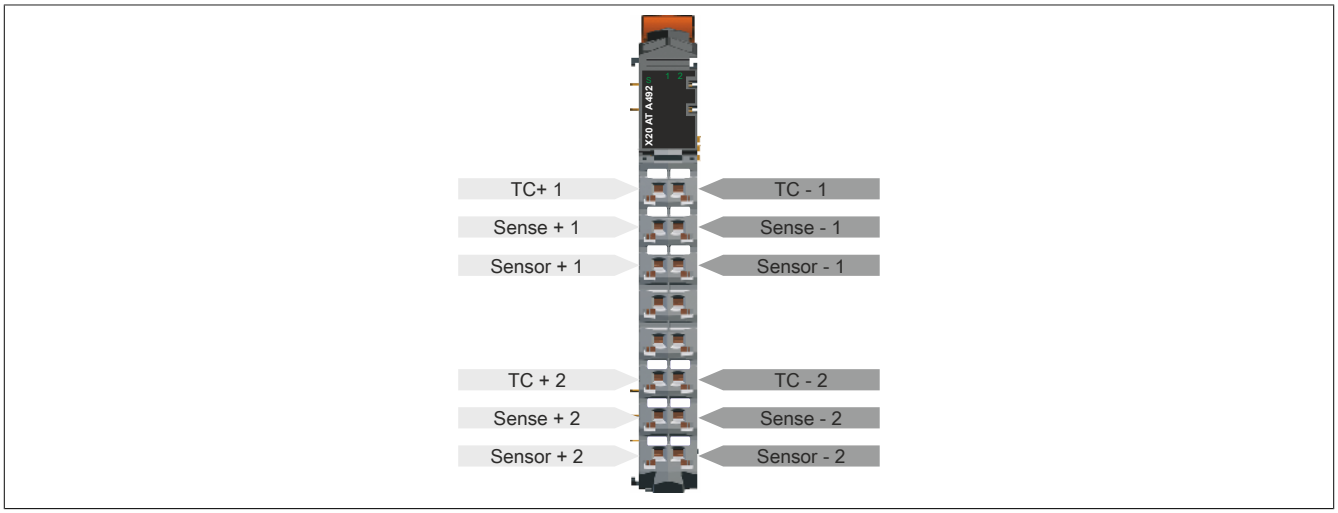
8.3.2 LED status indicators

For a description of the various operating modes, see section "Additional information - Diagnostic LEDs" in the X20 System user's manual.

Figure	LED	Color	Status	Description
	S	Green	Off	No power to module
			Single flash	RESET mode
			Double flash	BOOT mode (during firmware update)[1]
			Blinking	Mode PREOPERATIONAL
			On	RUN mode
		Red	Off	No power to module or everything OK
			On	Error or reset status
			Single flash	A parameter or conversion error has occurred. This status is output in addition to a single/double flash on the channel LED of the analog input where the error occurs.
		Solid red / Single green flash		Invalid firmware
	1 - 2	Green	Off	Input turned off or not supplied
			Single flash	A parameter error has occurred. A single flash is output on the red "s" module status LED.
			Double flash	A conversion error has occurred. A single flash is output on the red "s" module status LED.
			Blinking	Overflow, underflow or open line
			On	Analog/digital converter running, value OK

1) Depending on the configuration, a firmware update can take up to several minutes.

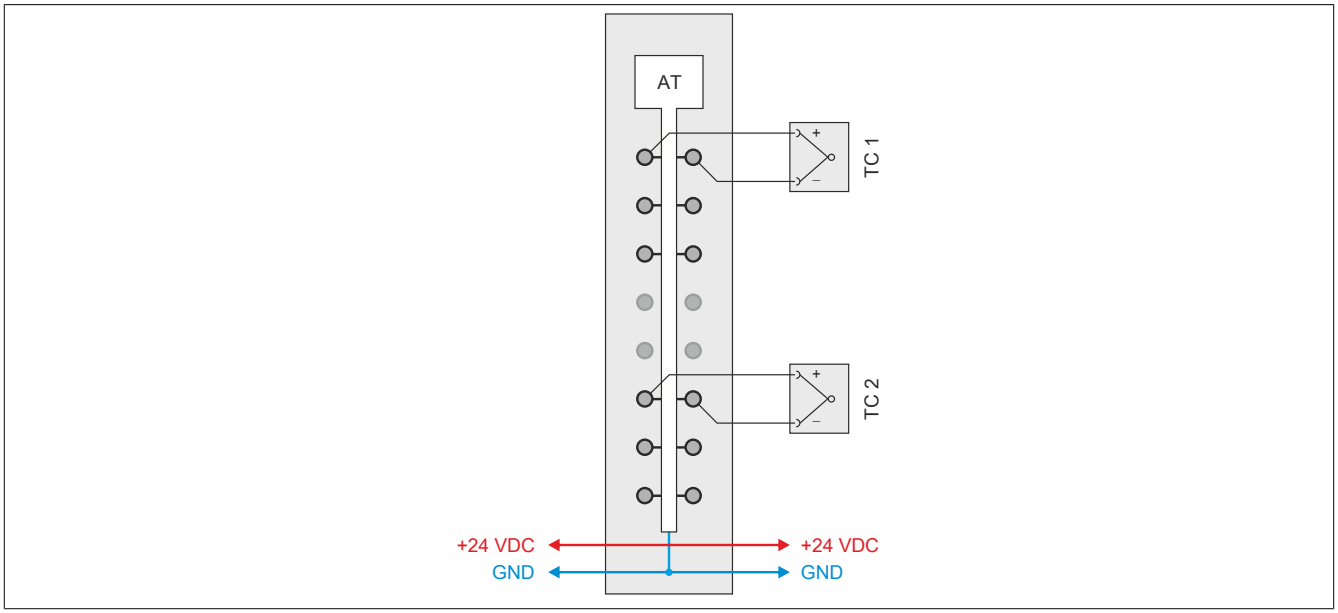
8.3.3 Pinout



8.3.4 Connection examples

Internal temperature compensation

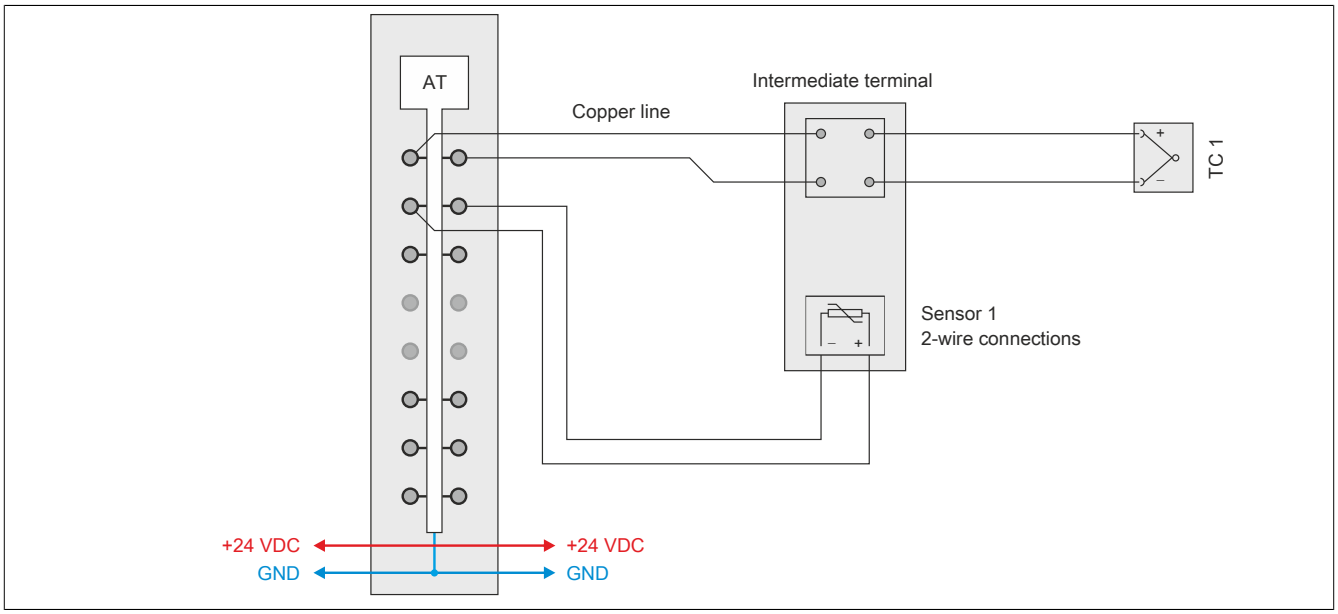
The thermocouple terminal block X20TB1E with integrated PT1000 sensors is used for internal temperature compensation.



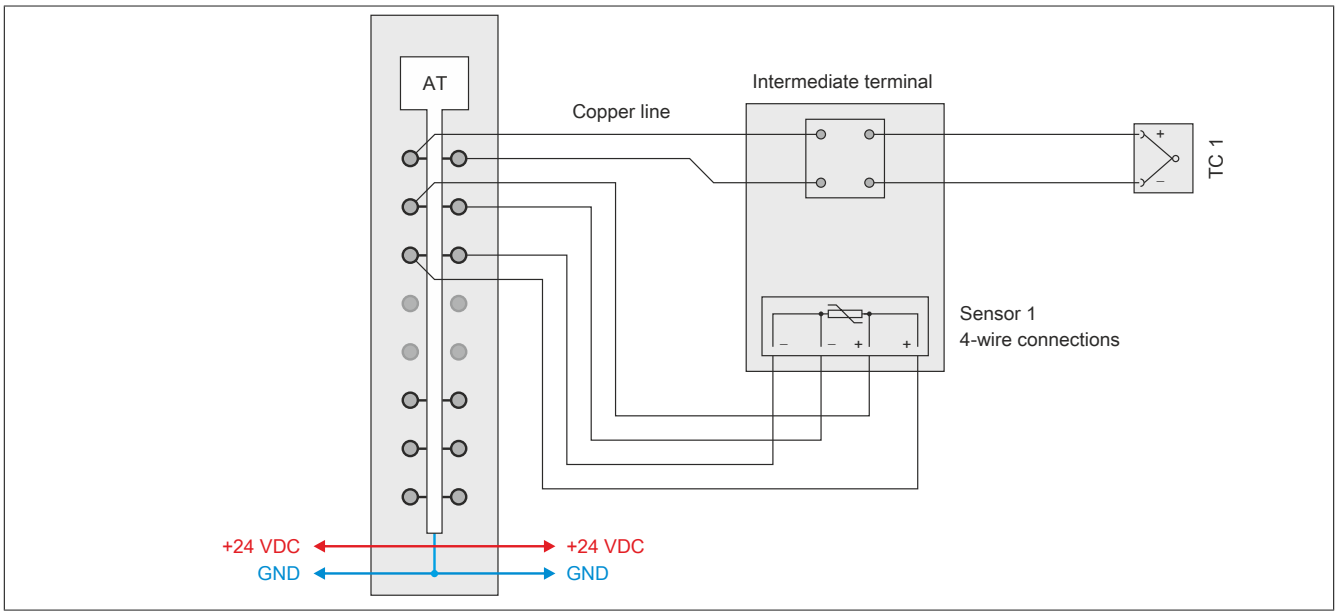
Remote temperature compensation

The 16-pin X20TB1F standard terminal block is used for remote temperature compensation. The external PT1000 sensors are connected to the module using 2-wire or 4-wire connections.

2-wire connections



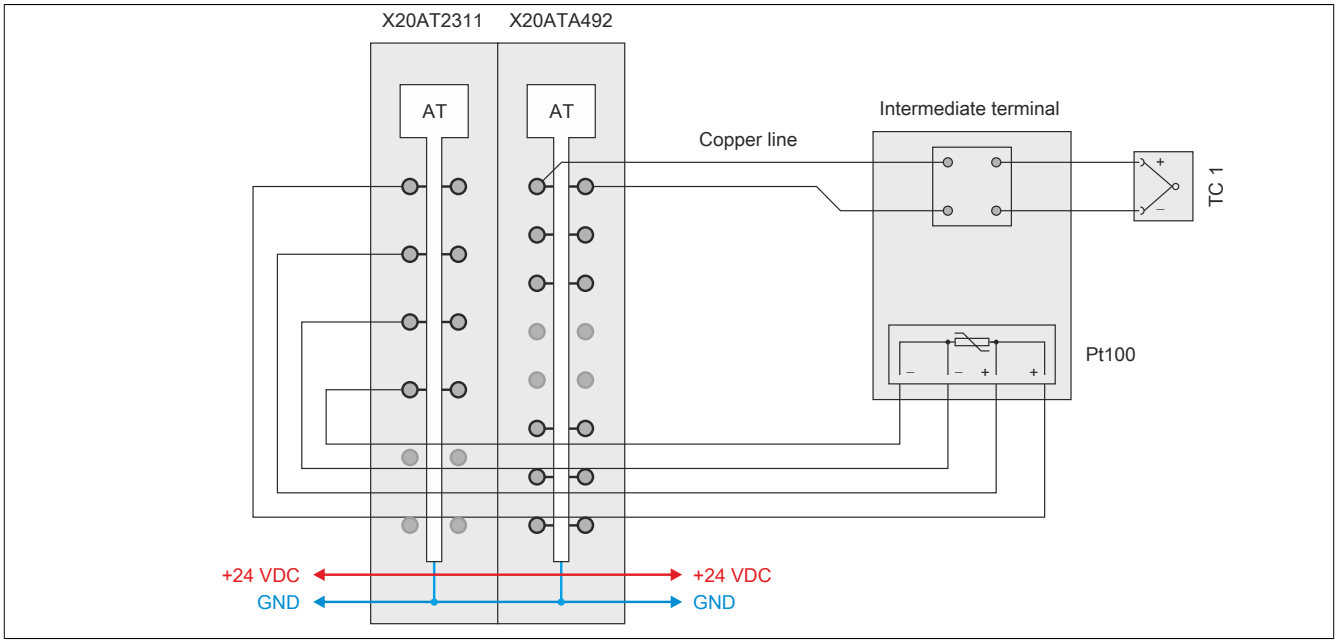
4-wire connections



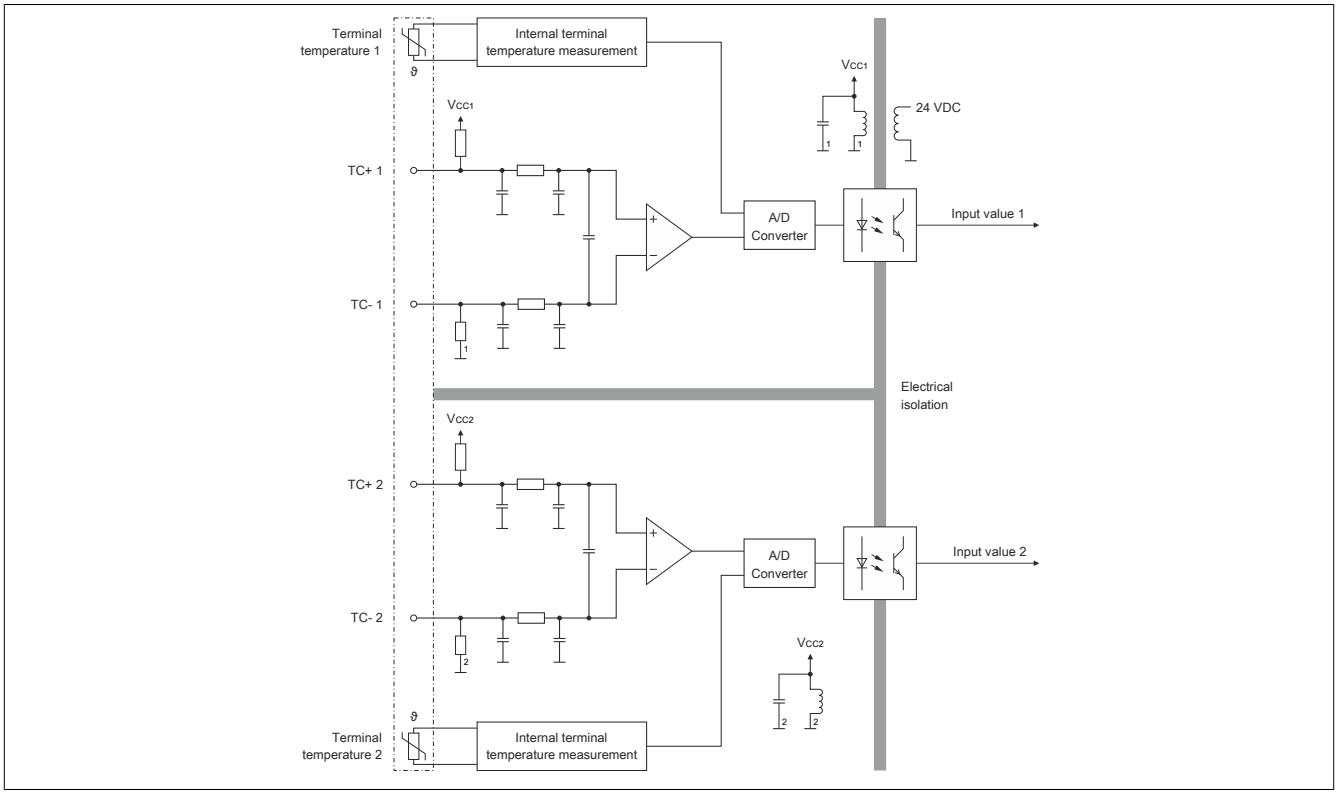
External temperature compensation

External compensation does not require the PT1000 values to be converted internally in the module. Instead, the reference temperatures have to be pre-processed in the program before being stored in the module. A separate register is available for each temperature channel to transfer an externally pre-processed compensation value.

In the following example, the compensation value is determined using the X20AT2311 temperature input module and a PT100 sensor on the intermediate terminal. The cold junction temperature determined externally is then made available to the X20ATA492 module via the respective I/O data points.



8.3.5 Input circuit diagram



8.3.6 Increased precision

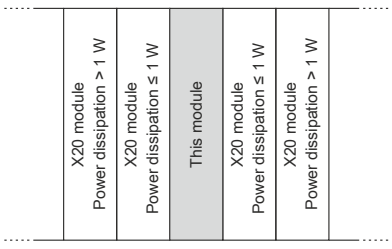
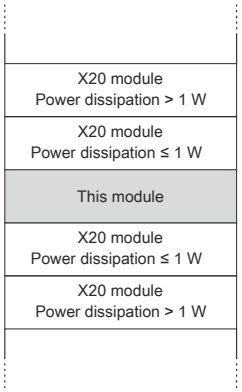
8.3.6.1 Internal temperature compensation

When using internal terminal temperature compensation, a temperature model must be defined in order to increase precision. A temperature model should be selected according to the following criteria:

- Thermal power loss of neighboring modules
- X20 system - Mounting orientation

8.3.6.1.1 Neighboring modules with low thermal power loss

The temperature model listed in the table must be configured according to the mounting orientation.

Horizontal installation	Vertical installation
	

The following temperature model must be set in the "Cfo_SensorTypeCh0x" on page 101 register.

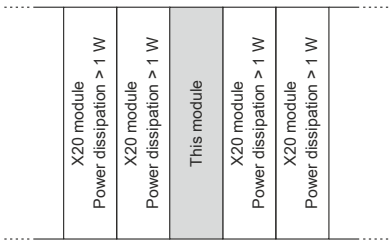
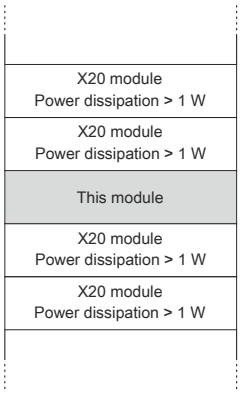
Bit 6 and 7	Temperature model	Bit 6 and 7	Temperature model
00	Horizontal installation, low thermal radiance <1W	10	Vertical installation, low thermal radiance <1W

Information:

The best results are achieved by placing a dummy module on both sides.

8.3.6.1.2 Neighboring modules with higher thermal power loss

The temperature model listed in the table must be configured according to the mounting orientation.

Horizontal installation	Vertical installation
	

The following temperature model must be set in the "Cfo_SensorTypeCh0x" on page 101 register.

Bit 6 and 7	Temperature model	Bit 6 and 7	Temperature model
01	Horizontal installation, high thermal radiance >1 W	11	Vertical installation, high thermal radiance >1 W

8.3.6.2 Remote or external terminal temperature compensation

Setting up a remote or external cold junction can provide the most accurate temperature measurement in a machine or system.

The installation of a remote or external cold junction is especially helpful in the following cases.

- There is no module next to the temperature module
- With strongly fluctuating environmental conditions (draft, temperature)
- External fan is used in the control cabinet

8.4 Register description

8.4.1 General data points

In addition to the registers described in the register description, the module has additional general data points. These are not module-specific but contain general information such as serial number and hardware variant.

General data points are described in section "Additional information - General data points" in the X20 system user's manual.

8.4.2 Function model 0 - Standard

Register	Name	Data type	Read		Write	
			Cyclic	Acyclic	Cyclic	Acyclic
Module configuration						
390 430	Cfo_InputFilterCh01 Cfo_InputFilterCh02	UINT				•
Compensation						
4 6	CompensationValue01 CompensationValue02	INT	•			
285 287	CompensationStatus01 CompensationStatus02	USINT		•		
	CompUnderflow0x	Bit 0				
	CompOverflow0x	Bit 1				
	CompOpenLine0x	Bit 2				
	CompConversionError0x	Bit 3				
	CompSumError0x	Bit 4				
	CompParameterError0x	Bit 5				
	CompIoSuppError0x	Bit 6				
514 518	ExternalCompensationTemperature01 ExternalCompensationTemperature02	INT			•	
Temperature measurement - Configuration						
386 426	Cfo_SensorTypeCh01 Cfo_SensorTypeCh02	UINT				•
466 482	Cfo_PreparationInterval01 Cfo_PreparationInterval02	UINT				•
410 450	Cfo_ReplaceUpperCh01 Cfo_ReplaceUpperCh02	INT				•
406 446	Cfo_ReplaceLowerCh01 Cfo_ReplaceLowerCh02	INT				•
398 438	Cfo_UpperLimitCh01 Cfo_UpperLimitCh02	INT				•
394 434	Cfo_LowerLimitCh01 Cfo_LowerLimitCh02	INT				•
402 442	Cfo_HysteresisCh01 Cfo_HysteresisCh02	INT				•
414 454	Cfo_ErrorDelayCh01 Cfo_ErrorDelayCh02	UINT				•
418 458	Cfo_SumErrorDelayCh01 Cfo_SumErrorDelayCh02	UINT				•
Temperature measurement						
0 2	Temperature01 Temperature02	INT	•			
258 262	Measurand01 Measurand02	INT		•		
292 300	SampleTime01 SampleTime02	DINT		•		
290 298	SampleTime01 SampleTime02	INT		•		
305 313	IOCycleCount01 IOCycleCount02	SINT		•		
306 314	IOCycleCount01 IOCycleCount02	INT		•		
281 283	StatusInput01 StatusInput02	USINT		•		
	Underflow0x	Bit 0				
	Overflow0x	Bit 1				
	OpenLine0x	Bit 2				
	CompTemperaturError0x	Bit 3				
	ConversionError0x	Bit 4				
	SumError0x	Bit 5				
	ParameterError0x	Bit 6				
	IoSuppError0x	Bit 7				

8.4.3 Function model 254 - Bus controller

Register	Offset[1)]	Name	Data type	Read		Write	
				Cyclic	Acyclic	Cyclic	Acyclic
Module configuration							
390 430	- -	Cfo_InputFilterCh01 Cfo_InputFilterCh02	UINT				•
Compensation							
4 6	4 6	CompensationValue01 CompensationValue02	INT	•			
285 287	- -	CompensationStatus01 CompensationStatus02	USINT		•		
		CompUnderflow0x	Bit 0				
		CompOverflow0x	Bit 1				
		CompOpenLine0x	Bit 2				
		CompConversionError0x	Bit 3				
		CompSumError0x	Bit 4				
		CompParameterError0x	Bit 5				
		CompIoSuppError0x	Bit 6				
514 518	- -	ExternalCompensationTemperature01 ExternalCompensationTemperature02	INT				•
Temperature measurement - Configuration							
386 426	- -	Cfo_SensorTypeCh01 Cfo_SensorTypeCh02	UINT				•
466 482	- -	Cfo_PreparationInterval01 Cfo_PreparationInterval02	UINT				•
410 450	- -	Cfo_ReplaceUpperCh01 Cfo_ReplaceUpperCh02	INT				•
406 446	- -	Cfo_ReplaceLowerCh01 Cfo_ReplaceLowerCh02	INT				•
398 438	- -	Cfo_UpperLimitCh01 Cfo_UpperLimitCh02	INT				•
394 434	- -	Cfo_LowerLimitCh01 Cfo_LowerLimitCh02	INT				•
402 442	- -	Cfo_HysteresisCh01 Cfo_HysteresisCh02	INT				•
414 454	- -	Cfo_ErrorDelayCh01 Cfo_ErrorDelayCh02	UINT				•
418 458	- -	Cfo_SumErrorDelayCh01 Cfo_SumErrorDelayCh02	UINT				•
Temperature measurement							
0 2	0 2	Temperature01 Temperature02	INT	•			
258 262	- -	Measurand01 Measurand02	INT		•		
292 300	- -	SampleTime01 SampleTime02	DINT		•		
290 298	- -	SampleTime01 SampleTime02	INT		•		
305 313	- -	IOCycleCount01 IOCycleCount02	SINT		•		
306 314	- -	IOCycleCount01 IOCycleCount02	INT		•		
281 283	- -	StatusInput01 StatusInput02	USINT		•		
		Underflow0x	Bit 0				
		Overflow0x	Bit 1				
		OpenLine0x	Bit 2				
		CompTemperaturError0x	Bit 3				
		ConversionError0x	Bit 4				
		SumError0x	Bit 5				
		ParameterError0x	Bit 6				
		IoSuppError0x	Bit 7				

1) The offset specifies the position of the register within the CAN object.

8.4.3.1 Using the module on the bus controller

Function model 254 "Bus controller" is used by default only by non-configurable bus controllers. All other bus controllers can use other registers and functions depending on the fieldbus used.

For detailed information, see section "Additional information - Using I/O modules on the bus controller" in the X20 user's manual (version 3.50 or later).

8.4.3.2 CAN I/O bus controller

The module occupies 1 analog logical slot on CAN I/O.

8.4.4 Module configuration

The module is an I/O module for temperature measurement and requires a 16-pin standard terminal block or the 12-pin terminal block with 2 integrated PT1000 inputs for temperature compensation.
2 measuring resistors (PT1000) can be connected via pin pairs 12/22 and 17/27 to record the absolute compensation temperature. This comparative value is used as a reference for the actual temperature measurement.

8.4.4.1 Input filter

Name:
Cfo_InputFilterCh01 bis Cfo_InputFilterCh02

Mit Hilfe dieser Register wird die Abtastzeit des A/D-Wandlers konfiguriert. Die eingestellte Filter-/Abtastzeit gilt gleichermaßen für die Eingänge der Thermoelemente als auch des Temperaturwiderstandes.

Datentyp	Werte	Filterzeit in ms	Wandelrate in s^{-1}
UINT	4	1	1000
	9	2	500
	48	10	100
	80	16,7	60
	96	20 (Bus Controller Default)	50
	160	33,3	30
	192	40	25
	320	66,7	15
	480	100	10
	960	200	5

Information:

Je geringer die Wandelrate konfiguriert wird, desto genauer kann der Wert gewandelt werden. Allerdings wird dadurch auch die I/O-Updatezeit erhöht.

8.4.5 Compensation

The measurement process is based on the interaction between the temperature sensors and the thermocouples. The converted voltage value of a thermocouple has a linear relationship with the difference in temperature between the measurement point and the transition point. To calculate the absolute temperature at the measurement point, the measured value must then be placed in relation to an absolute reference temperature.

The compensation value required for this can be determined as follows:

- Value determined directly on the module using a PT1000 temperature sensor. ("Internal compensation" on page 99)
- Value provided via a cyclic data point. ("External compensation" on page 101)

8.4.5.1 Internal compensation

The inputs of the temperature resistors are used for internal compensation. The module can be used with the 12-pin terminal block (X20TB1E), which has 2 PT1000 temperature sensors.
When operating the module with the X20TB1E, the temperature distribution on the terminal block must be taken into account. To do this, various models for calculating the temperature distribution have been implemented on the module. They account for both the ambient temperature in the control cabinet, as well as the mounting orientation of the module. This helps minimize measurement error.

Alternatively, the module can be operated with the standard 16-pin terminal block (X20TB1F). For a detailed description of this procedure, see "Remote terminal block" on page 100.

Information:

To avoid unnecessary traffic on the X2X Link network, the compensation registers should only be transferred cyclically during the fine-tuning process and for service and maintenance purposes. The information is generally not required during normal operation.

8.4.5.1.1 Compensation value

Name:
CompensationValue01 to CompensationValue02

These registers can be used to read the compensation value. Depending on how the "Cfo_SensorType" on page 101 register is set, it is output as either a temperature or resistance value.

Data type	Value	Information
INT	-32767 to 32767	in 0.1°C or 0.1 Ω

In order for the user to always be supplied with a defined output value, the following must be taken into consideration:

- Up to the first conversion, 0x8000 is output.
- After switching the sensor type, 0x8000 is output until the first conversion.
- If the input is switched off, 0x8000 is output.
- If an I/O voltage supply failure occurs, 0x8001 is output.

8.4.5.1.2 Status of the compensation value

Name:
CompensationStatus01 to CompensationStatus02
CompUnderflow01 to CompUnderflow02
CompOverflow01 to CompOverflow02
CompOpenLine01 to CompOpenLine02
CompConversionError01 to CompConversionError02
CompSumError01 to CompSumError02
CompParameterError01 to CompParameterError02
CompIoSuppError01 to CompIoSuppError02

These registers provide information about the current status of the respective compensation value. The structure is based on the "StatusInput" on page 105 register.

Data type	Value
USINT	See bit structure

Bit structure:

Bit	Name	Value	Information
0	CompUnderflow0x	0	No error
		1	Value below the permitted range
1	CompOverflow0x	0	No error
		1	Value above the permitted range
2	CompOpenLine0x	0	No error
		1	Open line
3	Reserved	-	
4	CompConversionError0x	0	No error
		1	Conversion error
5	CompSumError0x	0	No error
		1	Composite error (undelayed)
6	CompParameterError0x	0	No error
		1	Configuration not permitted
7	CompIoSuppError0x	0	No error
		1	I/O power supply error

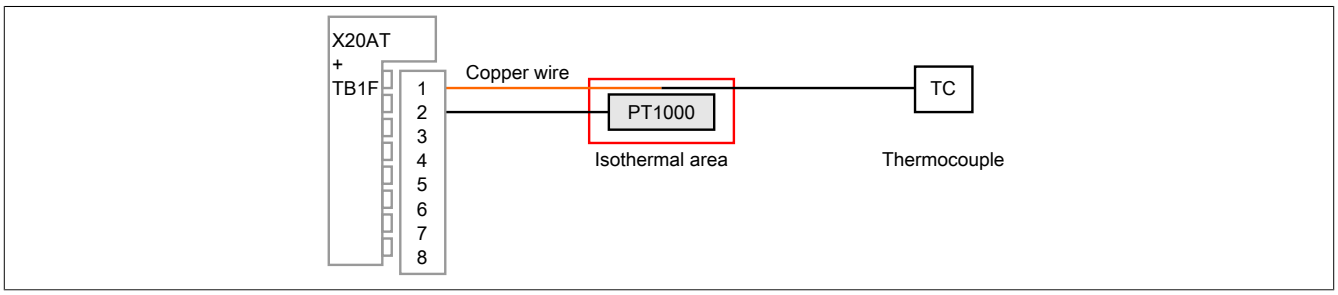
In addition to the status info, the error type also sets the analog value as follows:

Error status	Digital value for error
Open line	32767 (0x7FFF)
Above upper limit value	32767 (0x7FFF)
Below lower limit value	-32767 (0x8001)
Invalid value or I/O power supply error	-32767 (0x8001)

8.4.5.1.3 Remote terminal block

The 16-pin standard terminal block (X20TB1F) is used. The reference point for temperature measurements can be moved from the terminal to a more thermally stable location. This can help to minimize measurement error and increase accuracy.

Principle of remote terminal block



The thermocouple provides $V_{(\Delta T)}$ between the end of the thermocouple and the transition to the copper wire.

The PT1000 sensor provides the absolute temperature of the isothermal area.

Calculation: T(TC) = T(PT1000) + ΔT

8.4.5.2 External compensation

For external compensation, the reference temperatures must be prepared in the application and transferred to the module via X2X Link. There is no need for internal conversion of the PT1000 values in the module.

8.4.5.2.1 External compensation value

Name:
ExternalCompensationTemperature01 to ExternalCompensationTemperature02

These registers can be used to send an externally generated compensation value to the module.

Data type	Value	Information
INT	-32767 to 32767	in 0.1°C

8.4.6 Temperature measurement - Configuration

The temperature measurement channels can be configured independently of each other. The "Cfo_SensorTypeCh" on page 101 register needs to be adjusted in order to enable a temperature channel. The rest of the registers complement this configuration and only need to be defined if required in the application.

8.4.6.1 Configuring temperature measurement

Name:
Cfo_SensorTypeCh01 to Cfo_SensorTypeCh02

These registers control the basic functionality of a temperature channel.

Data type	Value	Information
UINT	See bit structure	Bus controller default setting: 36864

Bit structure:

Bit	Name	Value	Information
0 - 5	Sensor type	0	Sensor J (Fe-CuNi) (bus controller default setting)
		1	Sensor K (NiCr-Ni)
		2	Sensor N (NiCrSi-NiSi)
		3	Sensor S (PtRh10-Pt)
		4	Sensor R (PtRh13-Pt)
		5	Sensor C (WRe5-WRe26)
		6	Sensor T (Cu-CuNi)
		7	Sensor B (PtRh30-PtRh6)
		8	Sensor E (NiCr-CuNi)
		9 to 60	Reserved
	Raw value (Voltage without linearization and terminal temperature compensation)	61	Resolution 1.0625 µV; measurement range ±35 mV
		62	Resolution 2.125 µV; measurement range ±70 mV
		63	Reserved
6 - 7	Temperature model for X20TB1E[1)]	00	Horizontal mounting orientation, low thermal radiation ≤1 W (bus controller default setting)
		01	Horizontal installation, high thermal radiance >1 W
		10	Vertical installation, low thermal radiance ≤1W
		11	Vertical installation, high thermal radiance >1 W
8 - 9	Reference method	00	PT1000 sensor (bus controller default setting)
		01 to 10	Not permitted
		11	External compensation
10	Unit for cold junction value	0	0.1°C (bus controller default setting)
		1	0.1 Ω
11	Method of compensation	0	Internal compensation (bus controller default setting)
		1	External compensation
12	Temperature model for X20TB1E[2)]	0	Disabled
		1	Enabled according to bits 6 and 7 (bus controller default setting)
13	Replacement value strategy	0	Replace with static default value (bus controller default setting)
		1	Retain last valid value
14	Additional user-defined limits for permitted range of values	0	Permissible range of values of the thermocouple (bus controller default setting)
		1	Range of values as configured[3)]
15	Temperature channel	0	Channel not converted by the AD converter
		1	Channel registered on the AD converter (bus controller default setting)

1) This setting is used to adjust the internal terminal temperature characteristic curve to the type and amount of generated heat dissipated to the module. This selection is based on the power consumption of the modules connected immediately to the left and right on the X2X Link. This data can be found in the modules' data sheet. The higher value is used for the configuration.
2) To enable the temperature model, both PT1000 cold junction sensors must be connected.
3) The user-defined limit values can further reduce the permissible range of values for the sensor, depending on the requirements of the application. It is not permitted to define a measurement range larger than the range supported by the sensor.

8.4.6.2 Defining the preparation interval

Name:
Cfo_PreparationInterval01 to Cfo_PreparationInterval02

If the last valid measured value should be kept when violating the limit value, then PreparationInterval must be defined. The measured values continue to be acquired and converted according to the configured I/O update time. They are then checked and discarded if they do not meet the specifications. When an error does not occur, therefore, the measured value acquired 2 preparation intervals ago is constantly output.

Data type	Value	Information
UINT	0 to 65535	In 0.1 ms. Bus controller default setting: 0

Functionality:
Measured values are continuously converted and stored to measured value memory depending on the configured input filter. The current contents of the measured value memory are checked within the configured interval. If a permissible value is present, then the contents of the buffer memory are passed to output memory and the contents of the measured value memory are passed to the buffer.
If the check turns up an impermissible value, then the contents of the measured value memory are discarded. The copy direction between the output and buffer memory reverses and the last valid value continues to be output.

Information:

If configured to keep the last valid value, the delay time from measuring to outputting the value will be at least twice the preparation interval. In the worst case scenario, this can also take twice the interval time plus the configured conversion rate of the A/D converter.

"Application" Value being measured (analog)	
↓	Condition: - Conversion interval (A/D converter) elapsed
"Measured value memory" Measured value (digital)	
↓	Condition: - PreparationInterval elapsed - Measured value permissible
"Buffer" Last valid value	
↓	Condition: - PreparationInterval elapsed - Measured value permissible
"Output memory" Next-to-last valid/ displayed value	

Information:

The registers are only set for the channel when bit 13 is set in the "Cfo_SensorType" on page 101 register.

8.4.6.3 Upper replacement value

Name:
Cfo_ReplaceUpper01 to Cfo_ReplaceUpper02

This register is used to define the static values to be displayed instead of the current measured value when the limit is violated.

Data type	Value	Information
INT	-32767 to 32767	Bus controller default setting: 32767

Information:

The registers are only set for the channel when bit 13 is not set in the "Cfo_SensorType" on page 101 register.

8.4.6.4 Lower replacement value

Name:
Cfo_ReplaceLower01 to Cfo_ReplaceLower02

This register is used to define the lower static values to be displayed instead of the current measured value when the limit is violated.

Data type	Value	Information
INT	-32767 to 32767	Bus controller default setting: -32767

Information:

The registers are only set for the channel when bit 13 is not set in the "Cfo_SensorType" on page 101 register.

8.4.6.5 Upper limit value

Name:
Cfo_UpperLimit01 to Cfo_UpperLimit02

If the value range needs to be restricted further, these registers can be used to enter new user-specific upper limit values.

Data type	Value	Information
INT	-32767 to 32767	Bus controller default setting: 32767

8.4.6.6 Lower limit value

Name:
Cfo_LowerLimit01 to Cfo_LowerLimit02

If the value range needs to be restricted further, these registers can be used to enter new user-specific lower limit values.

Data type	Value	Information
INT	-32767 to 32767	Bus controller default setting: -32767

8.4.6.7 Hysteresis

Name:
Cfo_Hysteresis01 to Cfo_Hysteresis02

If the user-specific limit values are being used, then a hysteresis range should also be defined. These registers configure how far a limit value can be exceeded before a response is triggered.

Data type	Value	Information
INT	-32767 to 32767	Bus controller default setting: 16

8.4.6.8 Error delay

Name:
Cfo_ErrorDelay01 to Cfo_ErrorDelay02

This register specifies the number of consecutive conversion procedures where an error is pending until the corresponding individual error status bit is set. The delay applies to underflow, overflow and open circuit errors. This delay can be used to hide temporary measured value deviations, for example.

Data type	Values	Information
UINT	0 to 65,535	Bus controller default setting: 2

8.4.6.9 Error delay for composite error bit

Name:
Cfo_SumErrorDelay01 to Cfo_SumErrorDelay02

These registers can be used to set the time that an error must remain pending before the composite error bit is set.

Data type	Values	Information
UINT	0 to 65,535	Bus controller default setting: 4000

8.4.7 Temperature measurement

The received temperature data is prepared in 2 different formats and given a timestamp. For each channel there are 2 separate registers for transmitting the measured values to the PLC.

8.4.7.1 Temperature measurements

Name:
Temperature01 to Temperature02
Measurand01 to Measurand02

These registers contain the analog input values according to the sensor type set in the "Cfo_SensorType" on page 101 register:

Data type	Value	Information	Sensor type
INT	-2,100 to 12,000	(for -210.0 to 1200.0°C)	Type J (Fe-CuNi)
	-2,700 to 13,720	(for -270.0 to 1372.0 °C)	Type K (NiCr-Ni)
	-2,700 to 12,980	(for -270.0 to 1298.0 °C)	Type N (NiCrSi-NiSi)
	-500 to 17,680	(for -50.0 to 1768.0 °C)	Type S (PtRh10-Pt)
	-500 to 17,600	(for -50.0 to 1760.0 °C)	Type R (PtRh13-Pt)
	0 to 23,100	(for 0 to 2310.0 °C)	Type C (WRe5-WRe26)
	-2,700 to 4,000	(for -270.0 to 400.0 °C)	Type T (Cu-CuNi)
	0 to 18,200	(for 0 to 1820.0 °C)	Type B (PtRh30-PtRh6)
	-2,700 to 9,970	(for -270.0 to 997.0 °C)	Type E (NiCr-CuNi)
	-32,768 to 32767	Voltage without linearization and terminal temperature compensation Resolution 1.0625 µV for a measurement range of ±35 mV	
	-32,768 to 32767	Voltage without linearization and terminal temperature compensation Resolution 2.125 µV for a measurement range of ±70 mV	

In order for the user to always be supplied with a defined output value, the following must be taken into consideration:

- Up to the first conversion, 0x8000 is output.
- After switching the sensor type, 0x8000 is output until the first conversion.
- If the input is switched off, 0x8000 is output.
- If an I/O voltage supply failure occurs, 0x8001 is output.

8.4.7.2 Sample time

Name:
SampleTime01 to SampleTime02

These registers return the timestamp for when the module reads the current channel mapping. The values are provided as signed 2-byte or 4-byte values.

For additional information about NetTime and timestamps, see "NetTime Technology" on page 106.

Data type	Values	Information
INT	-32,768 to 32767	NetTime timestamp of the current input value in µs
DINT	-2147483648 to 2147483647	NetTime timestamp of the current input value in µs

8.4.7.3 I/O cycle counter

Name:
IOCycleCount01 to IOCycleCount02

This register is a cyclic counter that is incremented each time a value is converted. It can be used as either a 1-byte or 2-byte counter.

Data type	Value
USINT	0 to 255
UINT	0 to 65535

8.4.7.4 Status messages

Name:
StatusInput01 to StatusInput02
Underflow01 to Underflow02
Overflow01 to Overflow02
OpenLine01 to OpenLine02
CompTemperaturError01 to CompTemperaturError02
ConversionError01 to ConversionError02
SumError01 to SumError02
ParameterError01 to ParameterError02
IoSuppError01 to IoSuppError02

The current error status of the module channels is displayed in these registers, regardless of the configured replacement value strategy. Some error information may be delayed according to the conditions configured previously in the "Cfo_ErrorDelay" on page 103 and "Cfo_SumErrorDelay" on page 103 registers.

Data type	Value
USINT	See bit structure.

Bit structure:

Bit	Name	Value	Information
0	Underflow0x	0	No error
		1	Value below the permitted range
1	Overflow0x	0	No error
		1	Value above the permitted range
2	OpenLine0x	0	No error
		1	Open line
3	CompTemperaturError0x	0	Reference temperature is OK
		1	Compensation error; See "CompensationStatus" on page 100 register for a detailed error description
4	ConversionError0x	0	No error
		1	Converter error
5	SumError0x	0	No error
		1	Undelayed composite error
6	ParameterError0x	0	No error
		1	Invalid setting for "Cfo_SensorType" on page 101 register
7	IoSuppError0x[1)]	0	No error
		1	I/O power supply error

1) If the supply falls below 20 VDC, then the I/O power supply error is reported in these bits for the respective temperature channel. The following actions also take place:

- Channel LEDs are turned off
- Temperature values are set to an invalid value = 0x8001
- "IOCycleCount" on page 104 and "SampleTime" on page 104 stop changing

In addition to the status information, the analog value is permanently defined to the following value in an error state:

Fehlerzustand	Digital value for error
Drahtbruch	32767 (0x7FFF)
Above upper limit value	32767 (0x7FFF)
Unterer Grenzwert unterschritten	-32767 (0x8001)
Ungültiger Wert oder I/O-Versorgungsfehler	-32767 (0x8001)

8.4.8 NetTime Technology

NetTime refers to the ability to precisely synchronize and transfer system times between individual components of the controller or network (CPU, I/O modules, X2X Link, POWERLINK, etc.).

This allows the moment that events occur to be determined system-wide with microsecond precision. Upcoming events can also be executed precisely at a specified moment.

8.4.8.1 Time information

Various time information is available in the controller or on the network:

- System time (on the PLC, Automation PC, etc.)
- X2X Link time (for each X2X Link network)
- POWERLINK time (for each POWERLINK network)
- Time data points of I/O modules

The NetTime is based on 32-bit counters, which are increased with microsecond resolution. The sign of the time information changes after 35 min, 47 s, 483 ms and 648 µs; an overflow occurs after 71 min, 34 s, 967 ms and 296 µs.

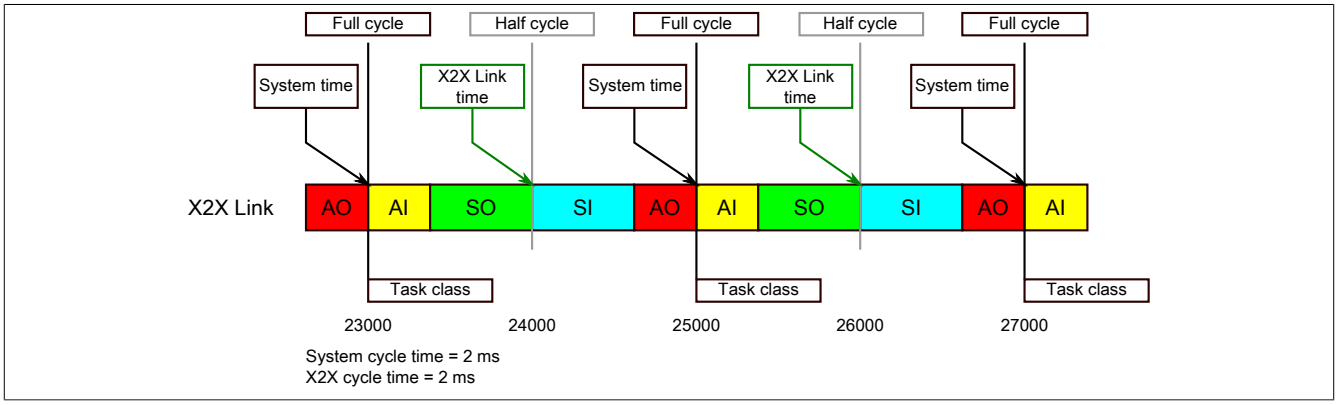
The initialization of the times is based on the system time during the startup of the X2X Link, the I/O modules or the POWERLINK interface.

Current time information in the application can also be determined via library AsIOTime.

8.4.8.1.1 PLC/Controller data points

The NetTime I/O data points of the PLC or the controller are latched to each system clock and made available.

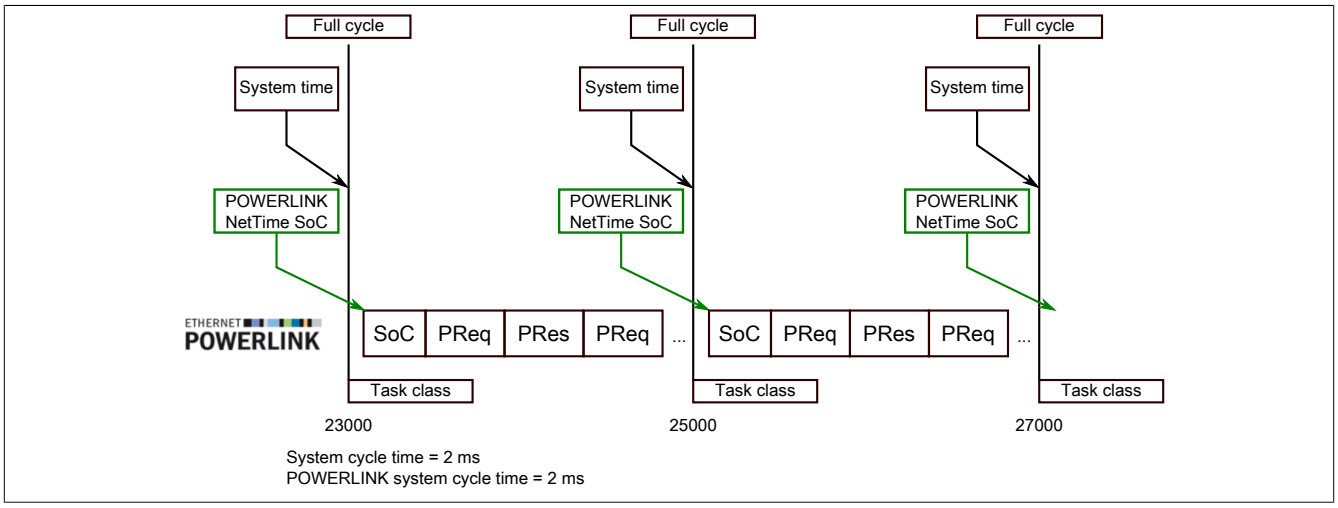
8.4.8.1.2 X2X Link - Reference time point



The reference time point on the X2X Link network is always calculated at the half cycle of the X2X Link cycle. This results in a difference between the system time and the X2X Link reference time point when the reference time is read out.

In the example above, this results in a difference of 1 ms, i.e. if the system time and X2X Link reference time are compared at time 25000 in the task, then the system time returns the value 25000 and the X2X Link reference time returns the value 24000.

8.4.8.1.3 POWERLINK - Reference time point

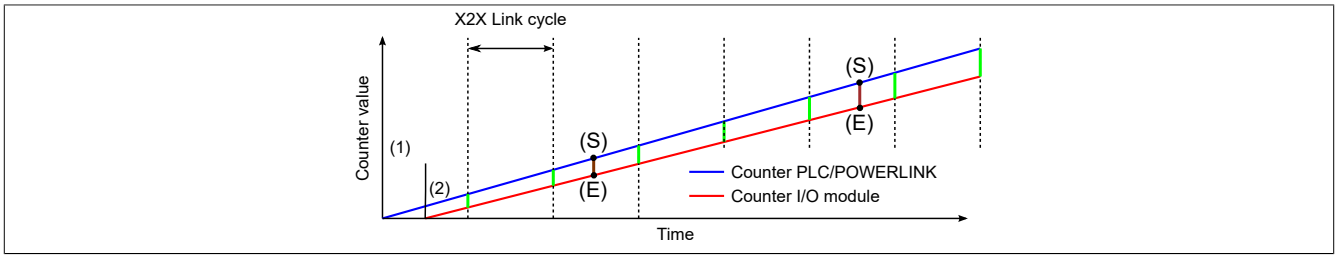


The reference time point on the POWERLINK network is always calculated at the start of cycle (SoC) of the POWERLINK network. The SoC starts 20 µs after the system clock due to the system. This results in the following difference between the system time and the POWERLINK reference time:

POWERLINK reference time = System time - POWERLINK cycle time + 20 µs.

In the example above, this means a difference of 1980 µs, i.e. if the system time and POWERLINK reference time are compared at time 25000 in the task, then the system time returns the value 25000 and the POWERLINK reference time returns the value 23020.

8.4.8.1.4 Synchronization of system time/POWERLINK time and I/O module



At startup, the internal counters for the PLC/POWERLINK (1) and the I/O module (2) start at different times and increase the values with microsecond resolution.

At the beginning of each X2X Link cycle, the PLC or the POWERLINK network sends time information to the I/O module. The I/O module compares this time information with the module's internal time and forms a difference (green line) between the two times and stores it.

When a NetTime event (E) occurs, the internal module time is read out and corrected with the stored difference value (brown line). This means that the exact system moment (S) of an event can always be determined, even if the counters are not absolutely synchronous.

Note

The deviation from the clock signal is strongly exaggerated in the picture as a red line.

8.4.8.2 Timestamp functions

NetTime-capable modules provide various timestamp functions depending on the scope of functions. If a timestamp event occurs, the module immediately saves the current NetTime. After the respective data is transferred to the CPU, including this precise moment, the CPU can then evaluate the data using its own NetTime (or system time), if necessary.

8.4.8.2.1 Time-based inputs

NetTime Technology can be used to determine the exact moment of a rising edge at an input. The rising and falling edges can also be detected and the duration between 2 events can be determined.

> **Information:**
>
> **The determined moment always lies in the past.**

8.4.8.2.2 Time-based outputs

NetTime Technology can be used to specify the exact moment of a rising edge on an output. The rising and falling edges can also be specified and a pulse pattern generated from them.

> **Information:**
>
> **The specified time must always be in the future, and the set X2X Link cycle time must be taken into account for the definition of the moment.**

8.4.8.2.3 Time-based measurements

NetTime Technology can be used to determine the exact moment of a measurement that has taken place. Both the starting and end moment of the measurement can be transmitted.

8.4.9 Minimum cycle time

The minimum cycle time specifies how far the bus cycle can be reduced without communication errors occurring. It is important to note that very fast cycles reduce the idle time available for handling monitoring, diagnostics and acyclic commands.

Minimum cycle time
200 µs

8.4.10 Minimum I/O update time

The minimum I/O update time specifies how far the bus cycle can be reduced so that an I/O update is performed in each cycle.

The A/D converter must convert multiple values. After switching between 2 inputs there are 4 measurements in order to obtain a meaningful value. Since not all inputs need to be used, the actual I/O update time may vary.

The following formulas can be used to calculate the minimum required I/O update time:

I/O update time = 4 * Conversions * Filter time
Filter time = (1024 / 4920000) * Cfo_InputFilter
Conversions = Number of thermocouples + Number of temperature resistors

9 X20ATB312

9.1 General information

The module is equipped with 4 inputs for PT100 4-line resistance temperature measurement.

- 4 inputs for resistance temperature measurement
- PT100 sensor
- Direct resistance measurement as well
- 4-wire measurement
- Filter time can be configured
- NetTime timestamp: Moment of measurement

NetTime timestamp of the measurement

For many applications, not only the measured value is important, but also the exact time of the measurement. The module is equipped with a NetTime timestamp function for this that supplies a timestamp for the recorded position and trigger time with microsecond accuracy.

The timestamp function is based on synchronized timers. If a timestamp event occurs, the module immediately saves the current NetTime. After the respective data is transferred to the CPU, including this precise moment, the CPU can then evaluate the data using its own NetTime (or system time), if necessary.

9.2 Order data

Order number	Short description	Figure
	Temperature measurement	
X20ATB312	X20 temperature input module, 4 inputs for resistance measurement, PT100, resolution 0.01°C, 4-wire connections, NetTime function	
	Required accessories	
	Bus modules	
X20BM11	X20 bus module, 24 VDC keyed, internal I/O power supply connected through	
X20BM15	X20 bus module, with node number switch, 24 VDC keyed, internal I/O power supply connected through	
	Terminal blocks	
X20TB1F	X20 terminal block, 16-pin, 24 VDC keyed	

Table 17: X20ATB312 - Order data

9.3 Technical data

Order number	X20ATB312
Short description	
I/O module	4 inputs for PT100 resistance temperature measurement
General information	
B&R ID code	0xE0EF
Status indicators	I/O function per channel, operating state, module status
Diagnostics	
Module run/error	Yes, using LED status indicator and software
Inputs	Yes, using LED status indicator and software
Power consumption	
Bus	0.01 W
Internal I/O	0.5 W (Rev. ≥ D0), 0.6 W (Rev. < D0)
Additional power dissipation caused by actuators (resistive) [W]	-
Certifications	
CE	Yes
ATEX	Zone 2, II 3G Ex nA nC IIA T5 Gc IP20, Ta (see X20 user's manual) FTZÚ 09 ATEX 0083X
UL	cULus E115267 Industrial control equipment
HazLoc	cCSAus 244665 Process control equipment for hazardous locations Class I, Division 2, Groups ABCD, T5
EAC	Yes
Resistance measurement temperature inputs	
Input	Resistance measurement with constant current supply for 4-wire connections
Digital converter resolution	24-bit
Filter time	Configurable between 1 and 200 ms
Conversion time [1]	
1 channel	20 ms with 50 Hz filter
2 channels	40 ms per channel with 50 Hz filter
Conversion procedure	Sigma-delta
Output format	DINT or UDINT for resistance measurement
Temperature measurement range	-200 to 850°C
Resistance measurement range	0.5 to 390 Ω
Temperature sensor resolution	1 LSB = 0.01°C
Resistance measurement resolution	0.001 Ω
Input filter	First-order low-pass filter / cutoff frequency 1050 Hz
Sensor standard	EN 60751
Isolation voltage between channel and bus	500 V_{eff}
Linearization method	Internal
Measurement current	1 mA
Temperature sensor normalization	-200.0 to 850.0°C
Reference	1568 Ω ±0.1%
Permissible input signal	Short-term max. 28.8 V
Max. error at 25°C [2]	
Gain	0.0059% [3]
Offset	0.0015% [4]
Max. gain drift	<0.00065 %/°C [3]
Max. offset drift	<0.000025 %/°C [4]
Nonlinearity	<0.001% [4]
Standardized range of values for resistance measurement	19 to 390 Ω
Temperature measurement monitoring	
Range undershoot	0x80000001
Range overshoot	0x7FFFFFFF
Open circuit	0x7FFFFFFF
General fault	0x80000000
Open inputs	0x7FFFFFFF
Resistance measurement monitoring	
Range undershoot	0x80000001
Range overshoot	0xFFFFFFFF
Open circuit	0xFFFFFFFF
General fault	0x80000000
Electrical properties	
Electrical isolation	Channel isolated from bus Channel not isolated from channel

Table 18: X20ATB312 - Technical data

Order number	X20ATB312
Operating conditions	
Mounting orientation	
Horizontal	Yes
Vertical	Yes
Installation elevation above sea level	
0 to 2000 m	No limitation
>2000 m	Reduction of ambient temperature by 0.5°C per 100 m
Degree of protection per EN 60529	IP20
Ambient conditions	
Temperature	
Operation	
Horizontal mounting orientation	-25 to 60°C
Vertical mounting orientation	-25 to 50°C
Derating	-
Storage	-40 to 85°C
Transport	-40 to 85°C
Relative humidity	
Operation	5 to 95%, non-condensing
Storage	5 to 95%, non-condensing
Transport	5 to 95%, non-condensing
Mechanical properties	
Note	Order 1x terminal block X20TB1F separately. Order 1x bus module X20BM11 separately.
Pitch	12.5 $^{+0.2}$ mm

Table 18: X20ATB312 - Technical data

1) The module is equipped with two independent converters (sensors 1 and 2, sensors 3 and 4). The conversion time applies to the number of channels connected to the respective converter.
2) To guarantee accuracy, modules with a power dissipation < 1.2 W must be connected to the left and right of this module.
3) Based on the current resistance value.
4) Based on the entire resistance measurement range.

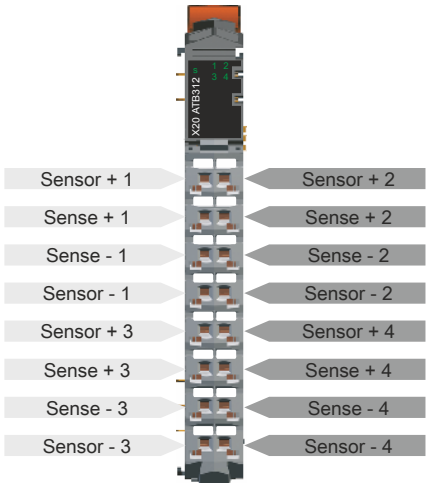
9.4 Status LEDs

For a description of the various operating modes, see section "Additional information - Diagnostic LEDs" in the X20 system user's manual.

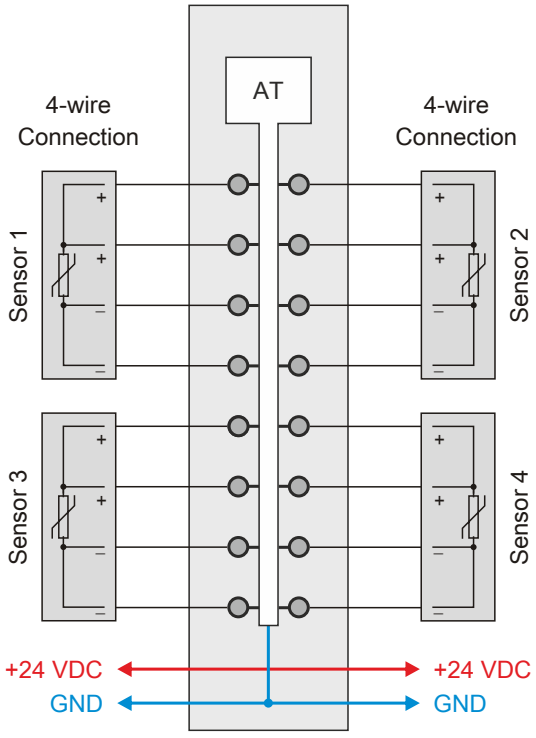
Image	LED	Color	Status	Description
	s	Green	Off	Module supply not connected
			Single flash	Reset mode
			Double flash	Mode BOOT (during firmware update)[1]
			Blinking	PREOPERATIONAL mode
			On	RUN mode
		Red	Off	Module supply not connected or everything OK
			On	Error or reset status
			Single flash	Parameter or conversion error[2]
		Red on / Green single flash		Invalid firmware
	1 - 4	Green	Off	Input turned off or not supplied
			Single flash	Parameter error[2]
			Double flash	Conversion error[2]
			Blinking	Overflow, underflow or open line
			On	A/D converter running, value OK

1) Depending on the configuration, a firmware update can take up to several minutes.
2) Parameter or converter errors are indicated simultaneously on the red "s" LED and the channel LED of the respective output.

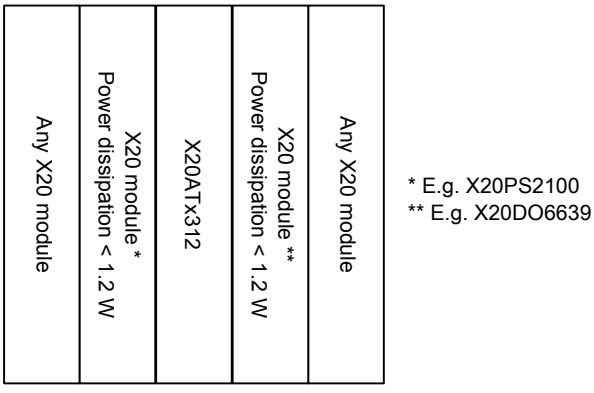
9.5 Pinout



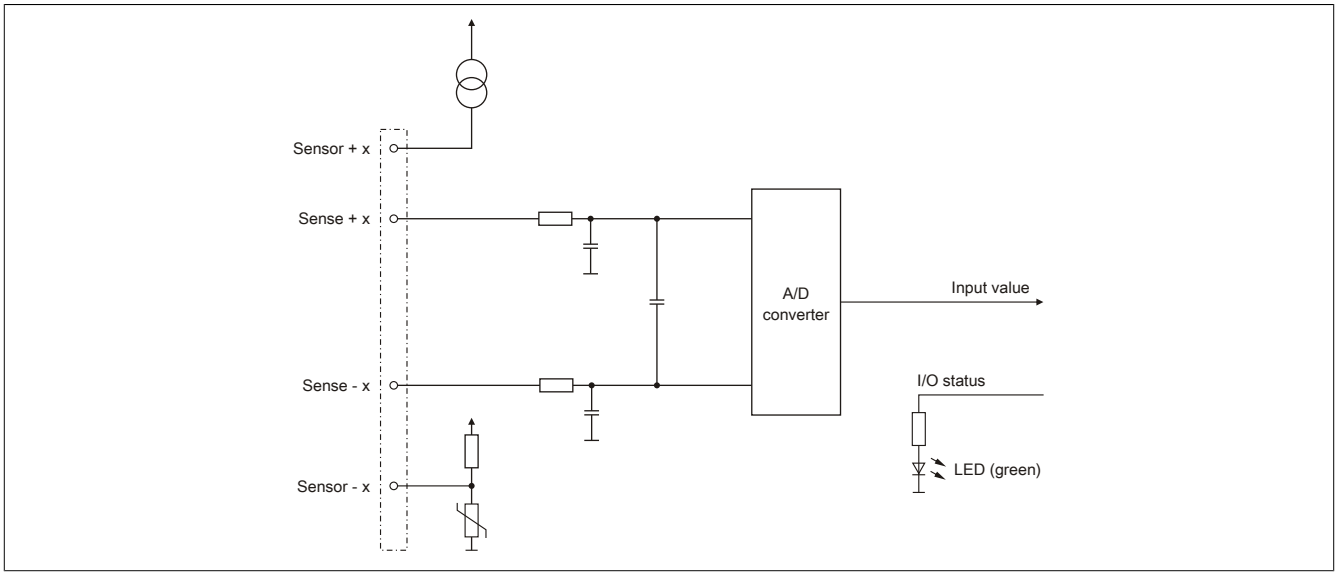
9.6 Connection example



To ensure accuracy, modules with a power consumption <1.2 W must be inserted to the left and right of this modules.



9.7 Input circuit diagram



9.8 Register description

9.8.1 General data points

In addition to the registers described in the register description, the module has additional general data points. These are not module-specific but contain general information such as serial number and hardware variant.

General data points are described in section "Additional information - General data points" in the X20 system user's manual.

9.8.2 Function model 0 - Standard

Register	Name	Data type	Read		Write	
			Cyclic	Acyclic	Cyclic	Acyclic
Configuration						
130	InputFilter	UINT				•
134	ModeADC	UINT				•
Index * 64 + 450	SensorType0x (Index x = 1 to 4)	UINT				•
Index * 64 + 502	PreparationInterval0x (Index x = 1 to 4)	UINT				•
Index * 64 + 484	ReplaceUpper0x (Index x = 1 to 4)	DINT				•
Index * 64 + 476	ReplaceLower0x (Index x = 1 to 4)	DINT				•
Index * 64 + 468	UpperLimit0x (Index x = 1 to 4)	DINT				•
Index * 64 + 460	LowerLimit0x (Index x = 1 to 4)	DINT				•
Index * 64 + 490	Hysteresis0x (Index x = 1 to 4)	UINT				•
Index * 64 + 494	ErrorDelay0x (Index x = 1 to 4)	UINT				•
Index * 64 + 498	SumErrorDelay0x (Index x = 1 to 4)	UINT				•
Communication						
Index * 4 - 4	Temperature0x (Index x = 1 to 4)	DINT	•			
	Resistor0x (Index x = 1 to 4)	UDINT				
Index * 64 + 196	Measurand0x (Index x = 1 to 4)	DINT		•		
Index * 64 + 217	IOCycleCounter0x (Index x = 1 to 4)	USINT	•			
Index * 64 + 218	IOCycleCounter0x (Index x = 1 to 4)	UINT	•			
Index * 64 + 210	Sampletime0x (Index x = 1 to 4)	INT	•			
Index * 64 + 212	Sampletime0x (Index x = 1 to 4)	DINT	•			
Index * 64 + 233	Status0x (Index x = 1 to 4)	USINT	•			
	Underrun0x	Bit 0				
	Overrun0x	Bit 1				
	OpenLine0x	Bit 2				
	ConverterFault0x	Bit 4				
	SumFault0x	Bit 5				
	ParameterFault0x	Bit 6				
	IoSupplyFault0x	Bit 7				

9.8.3 Function model 254 - Bus Controller

Register	Offset[1)]	Name	Data type	Read		Write	
				Cyclic	Acyclic	Cyclic	Acyclic
Configuration							
130	-	InputFilter	UINT				•
134	-	ModeADC	UINT				•
Index * 64 + 450	-	SensorType0x (Index x = 1 to 4)	UINT				•
Index * 64 + 502	-	PreparationInterval0x (Index x = 1 to 4)	UINT				•
Index * 64 + 484	-	ReplaceUpper0x (Index x = 1 to 4)	DINT				•
Index * 64 + 476	-	ReplaceLower0x (Index x = 1 to 4)	DINT				•
Index * 64 + 468	-	UpperLimit0x (Index x = 1 to 4)	DINT				•
Index * 64 + 460	-	LowerLimit0x (Index x = 1 to 4)	DINT				•
Index * 64 + 490	-	Hysteresis0x (Index x = 1 to 4)	UINT				•
Index * 64 + 494	-	ErrorDelay0x (Index x = 1 to 4)	UINT				•
Index * 64 + 498	-	SumErrorDelay0x (Index x = 1 to 4)	UINT				•
Communication							
Index * 4 - 4	Index * 4 - 4	Temperature0x (Index x = 1 to 4)	DINT	•			
		Resistor0x (Index x = 1 to 4)	UDINT				
Index * 64 + 217	-	IOCycleCounter0x (Index x = 1 to 4)	USINT		•		
30	-	Status01To04	USINT		•		

1) The offset specifies where the register is within the CAN object.

9.8.3.1 Using the module on the bus controller

Function model 254 "Bus controller" is used by default only by non-configurable bus controllers. All other bus controllers can use other registers and functions depending on the fieldbus used.

For detailed information, see section "Additional information - Using I/O modules on the bus controller" in the X20 user's manual (version 3.50 or later).

9.8.3.2 CAN I/O bus controller

The module occupies the following analog logical slots on CAN I/O.

- Upgrade version <1.1.3.0: 1
- Upgrade version ≥1.1.3.0: 2

9.8.4 Configuration of the A/D converter

9.8.4.1 Setting the conversion rate

Name:
InputFilter

Mit Hilfe dieses Registers wird die Abtastzeit des A/D-Wandlers konfiguriert.

Datentyp	Werte	Filterzeit in ms	Wandelrate in s^{-1}
UINT	4	1	1000
	9	2	500
	48	10	100
	80	16,7	60
	96	20 (Bus Controller Default)	50
	160	33,3	30
	192	40	25
	320	66,7	15
	480	100	10
	960	200	5

Information:

Je geringer die Wandelrate konfiguriert wird, desto genauer kann der Wert gewandelt werden. Allerdings wird dadurch auch die I/O-Updatezeit erhöht.

9.8.4.2 Operating mode of the A/D converter

Name:
ModeADC

The operating mode for the A/D converter can be configured in this register.

The individual options allow faster digitalization of the analog values, but this also reduces the precision of the measured values.

Data type	Values	Bus controller default setting
UINT	See the bit structure.	0

Bit structure:

Bit	Description	Value	Information
0	Chopper mode	0	Alternating gain of the analog value (bus controller default setting)
		1	Chopper mode off
1	Order of the SINC filter	0	SINC4 (bus controller default setting)
		1	SINC3
2 - 15	Reserved	-	-

The following applies:

ConversionTime(SINC3) = ConversionTime(SINC4) - 1 x ConversionCycle
ConversionTime(without Chop) = 0.5 x ConversionTime(Chop)

9.8.5 Configuring the measurement channels

Each temperature measurement channel can be configured independently. All the registers required for this purpose by each channel are arranged separately.

9.8.5.1 Channel parameters

Name:
SensorType01 to SensorType04

This register defines the basic behavior of the channel.

Data type	Values	Bus controller default setting
UINT	See the bit structure.	129

Bit structure:

Bit	Description	Value	Information
0 - 2	Sensor type with unit and resolution	001	PT100 [10 mK/bit] - Temperature measurement (bus controller default setting)
		010	PT100 [1 mΩ/bit] - Resistance measurement
		011 to 111	Reserved
3 - 4	Reserved	-	
5	Replacement value strategy	0	Replace statically
		1	Retain last valid value
6	Monitoring the user-defined limit values	0	Switch off additional limits
		1	Switch on additional limits
7	Channel (on/off)	0	Switch off the entire channel
		1	Switch on channel (bus controller default setting)
8 - 15	Reserved	-	

9.8.6 Configuring the replacement value strategy

If a measured value is detected that is outside the permitted value range, the behavior of the input register must still remain clearly defined. The module provides the user two different options for this purpose.

Retain last valid value

With this strategy, the determined measured value is stored temporarily for a specific time and written to the input register after a delay. If an invalid measured value is detected, this value and all values that have been stored temporarily are discarded. The last valid input register value is retained. To update the value in the input register, there must be enough valid values stored in the temporary buffer. The number needed is determined by the time period specified in "PreparationInterval0x".

Replace with static value

With this strategy, the measured value is written to the input register without delay. If an invalid value occurs, it is replaced by a static value that has been predefined by the user.

9.8.6.1 Preparation interval

Name:
PreparationInterval01 to PreparationInterval04

This register defines the time interval in which the measured value is checked before being passed on.

Data type	Value	Information
UINT	0 to 65,535	Unit in 0.1 ms. Bus controller default setting: 0

Information:

This register must be defined if the replacement value strategy "Retain last valid value" was selected in register "SensorType0x" on page 117.

9.8.6.2 Static replacement value when exceeding the upper limit

Name:
ReplaceUpper01 to ReplaceUpper04

This register is used to defined a replacement value that is output in place of the invalid measured value if the upper limit is violated.

Data type	Values	Information
DINT	-2,147,483,648 to 2,147,483,647	Bus controller default setting: 2,147,483,647

Information:

This register must be defined if the replacement value strategy "Replace with static value" was selected in register "SensorType0x" on page 117.

9.8.6.3 Static replacement value when falling below the lower limit

Name:
ReplaceLower01 to ReplaceLower04

This register is used to defined a replacement value that is output in place of the invalid measured value if the lower limit is violated.

Data type	Values	Information
DINT	-2,147,483,648 to 2,147,483,647	Bus controller default setting: -2,147,483,647

Information:

This register must be defined if the replacement value strategy "Replace with static value" was selected in register "SensorType0x" on page 117.

9.8.7 Configuring the user-defined limit values

This module provides the user the option to specify user-defined limits. If the valid measurement range is reduced in this way, the behavior of the replacement value strategy is more likely to be applied.

Valid measurement range

The valid range is derived from the properties of the sensor being used or the hardware and firmware of the respective B&R module. These values cannot be changed by the user.

Valid range of values

The range of values is always within the valid measurement range. The range of values can be adapted to the requirements of the application by specifying the upper and lower limit value.

9.8.7.1 Upper limit value

Name:
UpperLimit01 to UpperLimit04

This register specifies the upper limit value. The values entered should be within the valid measurement range.

Data type	Values	Information
DINT	-2,147,483,648 to 2,147,483,647	Bus controller default setting: 2,147,483,647

9.8.7.2 Lower limit value

Name:
LowerLimit01 to LowerLimit04

This register specifies the lower limit value. The values entered should be within the valid measurement range.

Data type	Values	Information
DINT	-2,147,483,648 to 2,147,483,647	Bus controller default setting: -2,147,483,647

9.8.7.3 Hysteresis

Name
Hysteresis01 to Hysteresis04

A hysteresis can be set in order to avoid frequent status changes in the measurement range close to the limit value. Here, a small section is defined at the edge of the valid range of values where the measured values retain the status (valid or invalid) of the previous measured value.

Data type	Values	Information
UINT	0 to 65,535	Bus controller default setting: 16

9.8.8 Configuring status messages

Errors are detected by the module and sent to the application. When using Function model 0 - Standard, the trigger behavior of these error messages can be influenced by the "Delay" register.

In Automation Studio, an error message can be read either packed as the entire register or individually as bits.

9.8.8.1 Delaying error messages

Name:
ErrorDelay01 to ErrorDelay04

In order to avoid false alarms due to short-term measurement variations, the status messages transmitted to the PLC can be delayed. This register determines the number of A/D conversions in which an error must exist before an error message is transmitted.

Data type	Values	Information
UINT	0 to 65,535	AD conversions. Bus controller default setting: 2

9.8.8.2 Delaying the sum error message

Name:
SumErrorDelay01 to SumErrorDelay04

This register can be used to set the delay used when sending bit 5 of the "Status0x" on page 121 register to the PLC independent of the other status messages.

Data type	Values	Information
UINT	0 to 65,535	Bus controller default setting: 4000

9.8.9 Communication

The received temperature data is stored with a timestamp and, depending on the configuration, is made available under various register names and data types.

9.8.9.1 Measured value – Temperature

Name:
Temperature01 to Temperature04

If the channel is configured for resistance measurement, the current temperature value is made available in this register.

Data type	Values
DINT	-2,147,483,648 to 2,147,483,647

9.8.9.2 Measured value – Resistance

Name:
Resistor01 to Resistor04

If the channel is configured for resistance measurement, the current resistance value is made available in this register.

Data type	Values
UDINT	0 to 4,294,967,295

9.8.9.3 Measured value – Unweighted

Name:
Measurand01 to Measurand04

When using the AsIoAcc library, the unweighted measurement can be accessed via this register. This refers to a measured value that is within the valid measurement range and has not yet been compared with the user-defined limits.

Data type	Values
DINT	-2,147,483,648 to 2,147,483,647

Information:

If no user-defined limits are configured, the value of this register does not differ from the temperature or resistance value.

9.8.9.4 Cycle counter

Name:
IOCycleCounter01 to IOCycleCounter04

This register is used to provide a continuous counter for the application that is incremented each time a temperature value is read.

Data type	Value	Information
USINT	0 to 32,767	AD conversion.
UINT	0 to 65,535	AD conversion.

9.8.9.5 Sampling time

Name:
Sampletime01 to Sampletime04

This register provides the application with the NetTime at the time of temperature recording.

For additional information about NetTime and timestamps, see "NetTime Technology" on page 122.

Data type	Value	Information
INT	-32,768 to 32,767	NetTime timestamp in µs
DINT	-2,147,483,648 to 2,147,483,647	NetTime timestamp in µs

Information:

The SDC library requires a 16-bit value for the sampling time. It is therefore also prepared as a 16-bit value.

9.8.9.6 Status messages

Name:
Status01 to Status04

The register bits are set if an error has been diagnosed and the error remains longer than the delay configured in the "ErrorDelay0x" on page 119 register.

Data type	Values
USINT	See the bit structure.

Bit structure:

Bit	Name	Value	Information
0	Underrun01 to Underrun04	0	No error
		1	Value below the permitted range
1	Overrun01 to Overrun04	0	No error
		1	Value above the permitted range
2	OpenLine01 to OpenLine04	0	No error
		1	Sensor is not connected correctly
3	Reserved	-	
4	ConverterFault01 to ConverterFault04	0	No error
		1	Invalid A/D converter output
5	SumFault01 to SumFault04	0	No error
		1	Composite error
6	ParameterFault01 to ParameterFault04	0	No error
		1	The "SensorType0x" on page 117 register is faulty
7	IoSupplyFault01 to IoSupplyFault04	0	No error
		1	The supply voltage (I/O) is faulty

9.8.9.7 Status messages for function model 254

Name:
Status01To04

The bits in this register are set if an error has been detected.

Data type	Values
USINT	See the bit structure.

Bit structure:

Bit	Name	Value	Information
0	Underrun on channel 01	0	No error
		1	Value below the permitted range
1	Overrun on channel 01	0	No error
		1	Value above the permitted range
...		...	
6	Underrun on channel 04	0	No error
		1	Value below the permitted range
7	Overrun on channel 04	0	No error
		1	Value above the permitted range

Information:

If an open line is detected on a channel, then both error messages will be displayed at the same time.

9.8.10 NetTime Technology

NetTime refers to the ability to precisely synchronize and transfer system times between individual components of the controller or network (CPU, I/O modules, X2X Link, POWERLINK, etc.).

This allows the moment that events occur to be determined system-wide with microsecond precision. Upcoming events can also be executed precisely at a specified moment.

9.8.10.1 Time information

Various time information is available in the controller or on the network:

- System time (on the PLC, Automation PC, etc.)
- X2X Link time (for each X2X Link network)
- POWERLINK time (for each POWERLINK network)
- Time data points of I/O modules

The NetTime is based on 32-bit counters, which are increased with microsecond resolution. The sign of the time information changes after 35 min, 47 s, 483 ms and 648 µs; an overflow occurs after 71 min, 34 s, 967 ms and 296 µs.

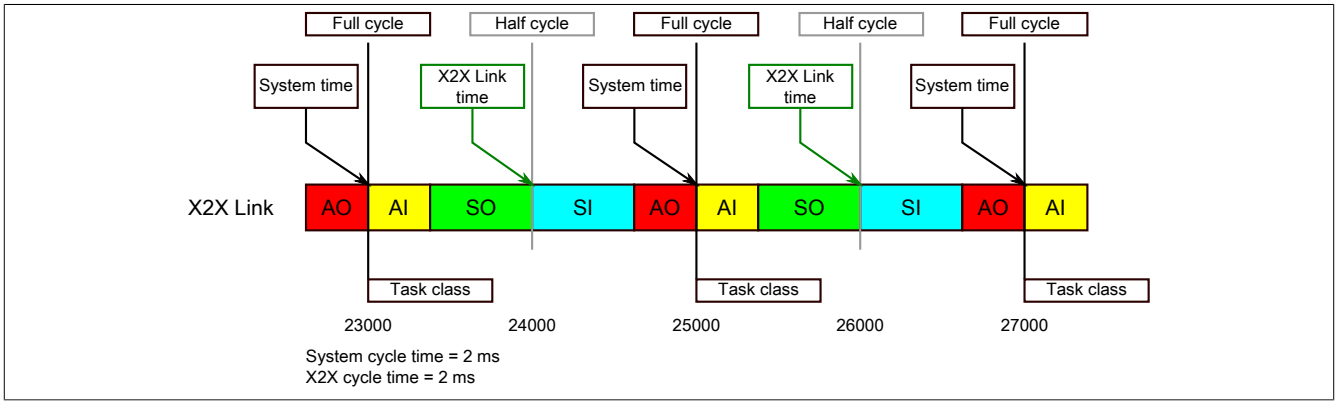
The initialization of the times is based on the system time during the startup of the X2X Link, the I/O modules or the POWERLINK interface.

Current time information in the application can also be determined via library AsIOTime.

9.8.10.1.1 PLC/Controller data points

The NetTime I/O data points of the PLC or the controller are latched to each system clock and made available.

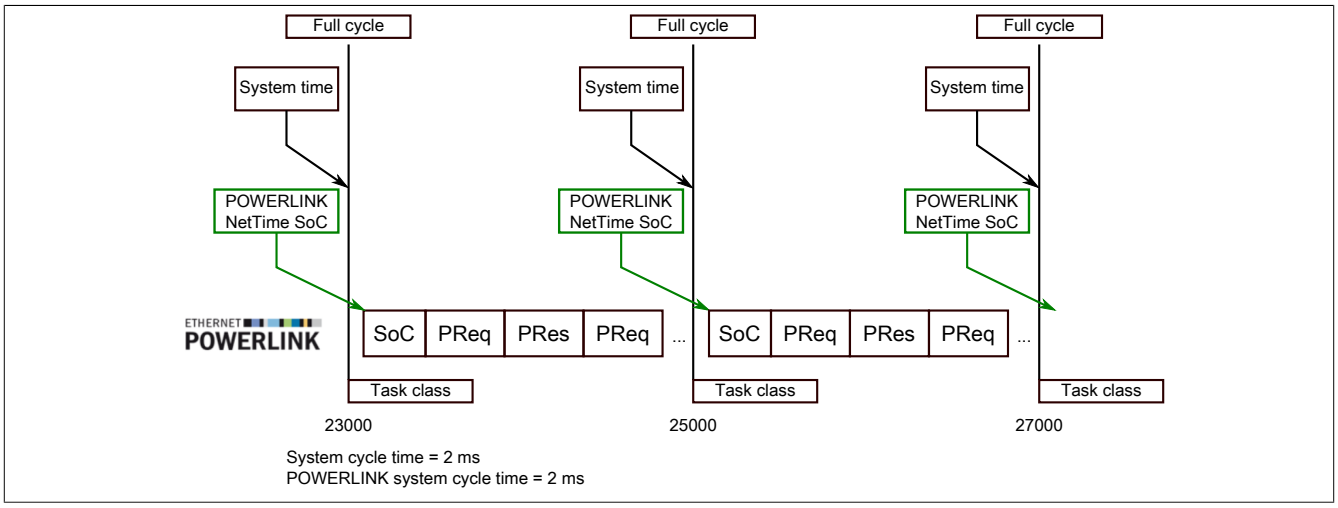
9.8.10.1.2 X2X Link reference moment



The reference moment on the X2X Link network is always calculated at the half cycle of the X2X Link cycle. This results in a difference between the system time and the X2X Link reference moment when the reference time is read out.

In the example above, this results in a difference of 1 ms, i.e. if the system time and X2X Link reference moment are compared at time 25000 in the task, then the system time returns the value 25000 and the X2X Link reference moment returns the value 24000.

9.8.10.1.3 POWERLINK - Reference time point

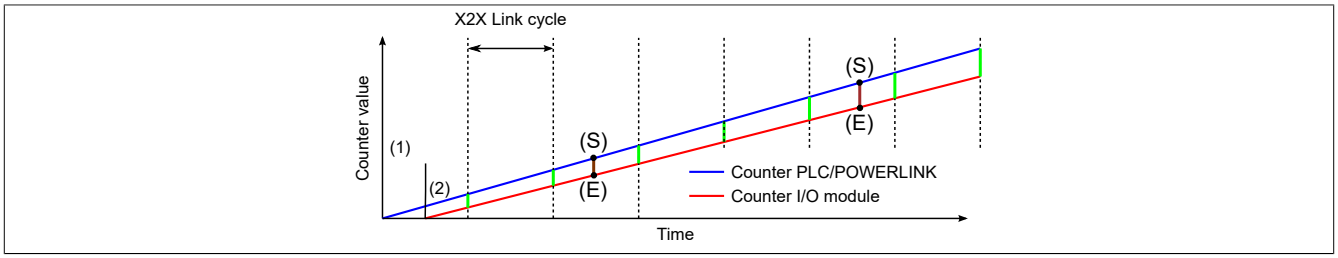


The reference time point on the POWERLINK network is always calculated at the start of cycle (SoC) of the POWERLINK network. The SoC starts 20 µs after the system clock due to the system. This results in the following difference between the system time and the POWERLINK reference time:

POWERLINK reference time = System time - POWERLINK cycle time + 20 µs.

In the example above, this means a difference of 1980 µs, i.e. if the system time and POWERLINK reference time are compared at time 25000 in the task, then the system time returns the value 25000 and the POWERLINK reference time returns the value 23020.

9.8.10.1.4 Synchronization of system time/POWERLINK time and I/O module



At startup, the internal counters for the PLC/POWERLINK (1) and the I/O module (2) start at different times and increase the values with microsecond resolution.

At the beginning of each X2X Link cycle, the PLC or the POWERLINK network sends time information to the I/O module. The I/O module compares this time information with the module's internal time and forms a difference (green line) between the two times and stores it.

When a NetTime event (E) occurs, the internal module time is read out and corrected with the stored difference value (brown line). This means that the exact system moment (S) of an event can always be determined, even if the counters are not absolutely synchronous.

Note

The deviation from the clock signal is strongly exaggerated in the picture as a red line.

9.8.10.2 Timestamp functions

NetTime-capable modules provide various timestamp functions depending on the scope of functions. If a timestamp event occurs, the module immediately saves the current NetTime. After the respective data is transferred to the CPU, including this precise moment, the CPU can then evaluate the data using its own NetTime (or system time), if necessary.

9.8.10.2.1 Time-based inputs

NetTime Technology can be used to determine the exact moment of a rising edge at an input. The rising and falling edges can also be detected and the duration between 2 events can be determined.

Information:

The determined moment always lies in the past.

9.8.10.2.2 Time-based outputs

NetTime Technology can be used to specify the exact moment of a rising edge on an output. The rising and falling edges can also be specified and a pulse pattern generated from them.

Information:

The specified time must always be in the future, and the set X2X Link cycle time must be taken into account for the definition of the moment.

9.8.10.2.3 Time-based measurements

NetTime Technology can be used to determine the exact moment of a measurement that has taken place. Both the starting and end moment of the measurement can be transmitted.

9.8.11 Minimum cycle time

The minimum cycle time defines how far the bus cycle can be reduced without causing a communication error or impaired functionality. It should be noted that very fast cycles decrease the idle time available for handling monitoring, diagnostics and acyclic commands.

Minimum cycle time
200 µs

9.8.12 Minimum I/O update time

The minimum I/O update time defines how far the bus cycle can be reduced while still allowing an I/O update to take place in each cycle.

Minimum I/O update time
1 ms

10 X20ATC402

10.1 General information

10.1.1 Other applicable documents

For additional and supplementary information, see the following documents.

Other applicable documents

Document name	Title
MAX20	X20 System user's manual
MAEMV	Installation / EMC guide

10.1.2 Order data

Order number	Short description	Figure
	Temperature measurement	
X20ATC402	X20 temperature input module, 6 thermocouple inputs, type J, K, N, S, B, R, E, C, T, NetTime function, 2x Pt1000 integrated in terminal block X20TB1E for temperature compensation, order terminal block separately!	
	Required accessories	
	Bus modules	
X20BM11	X20 bus module, 24 VDC keyed, internal I/O power supply connected through	
X20BM15	X20 bus module, with node number switch, 24 VDC keyed, internal I/O power supply connected through	
	Terminal blocks	
X20TB1E	X20 terminal block, 12-pin, 24 VDC keyed, 2x Pt1000 integrated for terminal temperature compensation	
X20TB1F	X20 terminal block, 16-pin, 24 VDC keyed	

Table 19: X20ATC402 - Order data

10.1.3 Module description

The module is equipped with 6 inputs for J, K, N, S, B, R, E, C and T thermocouple sensors.

This module can also be equipped with the X20TB1E thermocouple terminal block with integrated PT1000 temperature sensors. This makes it possible to achieve optimal terminal temperature compensation.

- 6 channels for thermocouples
- For sensor types J, K, N, S, B, R, E, C, T, raw value measurement
- Integrated terminal temperature compensation
- 2x PT1000 sensor integrated in the terminal (X20TB1E)
- 2x external PT1000 sensor can be connected (X20TB1F)
- Configurable filter time
- Configurable resolution
- NetTime timestamp: Moment of measurement

Functions:

- Sensor type and measurement range
- Configurable conversion rate / filter time
- Compensation
- Monitoring the input signal
- NetTime Technology

Sensor type and measurement range

The module can be used for both measurement sensor and resistance measurement. The measurement range varies depending on the operating mode set.

Conversion rate and filter time

The sampling time of the A/D converter can be configured together with the filter time.

Compensation values

A remote or external cold junction can be moved to a more thermally stable location for a precise determination of the temperature. In this way, the measurement error can be minimized or the measurement accuracy increased.

Monitoring the input signal

The input signal is monitored against the upper and lower limit values as well as for open circuit. In addition to the status information, user-defined limit values can be defined as well as replacement values that are output if the limit values are overshot or undershot.

NetTime timestamp of the measurement

For many applications, not only the measured value is important, but also the exact time of the measurement. The module is equipped with a NetTime timestamp function for this that supplies a timestamp for the recorded position and trigger time with microsecond accuracy.

10.2 Technical description

10.2.1 Technical data

Order number	X20ATC402
Short description	
I/O module	6 inputs for thermocouples
General information	
B&R ID code	0xBB99
Status indicators	I/O function per channel, operating state, module status
Diagnostics	
Module run/error	Yes, using LED status indicator and software
Inputs	Yes, using LED status indicator and software
Power consumption	
Bus	0.01 W
Internal I/O	0.85 W
Additional power dissipation caused by actuators (resistive) [W]	-
Certifications	
CE	Yes
UKCA	Yes
ATEX	Zone 2, II 3G Ex nA nC IIA T5 Gc IP20, Ta (see X20 user's manual) FTZÚ 09 ATEX 0083X
UL	cULus E115267 Industrial control equipment
HazLoc	cCSAus 244665 Process control equipment for hazardous locations Class I, Division 2, Groups ABCD, T5
DNV	Temperature: **B** (0 to 55°C) Humidity: **B** (up to 100%) Vibration: **B** (4 g) EMC: **B** (bridge and open deck)
LR	ENV1
ABS	Yes
BV	**EC33B** Temperature: 5 - 55°C Vibration: 4 g EMC: Bridge and open deck
EAC	Yes
KC	Yes
Thermocouple temperature inputs	
Input	Thermocouple
Digital converter resolution	16-bit
Filter time	Configurable between 1 and 200 ms
Conversion time	
Internal terminal temperature comp.	
N channels	(n + 2) * 4 * x ms [1)]
External terminal temperature comp.	
1 channel	x ms [1)]
N channels	n * 4 * x ms [1)]
Remote temperature comp.	
N channels	(n + 2) * 4 * x ms [1)]
Output format	INT
Measurement range	
Sensor temperature	
Type J: Fe-CuNi	-210 to 1200°C
Type K: NiCr-Ni	-270 to 1372°C
Type N: NiCrSi-NiSi	-270 to 1298°C
Type S: PtRh10-Pt	-50 to 1768°C
Type B: PtRh30-PtRh6	0 to 1820°C
Type R: PtRh13-Pt	-50 to 1760°C
Type E: NiCr-CuNi	-270 to 997°C
Type C: WRe5-WRe26	0 to 2310°C
Type T: Cu-CuNi	-270 to 400°C
Terminal temperature	-40 to 130°C
Voltage	±65.534 mV
Sensor standard	EN 60584
Resolution	
Sensor temperature	1 LSB = 0.1°C or 0.01°C
Terminal temperature	1 LSB = 0.1°C or 0.01°C
Voltage	Depending on gain, 1 LSB = 1 µV or 2 µV

Table 20: X20ATC402 - Technical data

Order number	X20ATC402
Normalization	
Type J: Fe-CuNi	-210.0 to 1200.0°C or -210.00 to 1200.00°C
Type K: NiCr-Ni	-270.0 to 1372.0°C or -270.00 to 1372.00°C
Type N: NiCrSi-NiSi	-270.0 to 1298.0°C or -270.00 to 1298.00°C
Type S: PtRh10-Pt	-50.0 to 1768.0°C or -50.00 to 1768.00°C
Type B: PtRh30-PtRh6	0 to 1820.0°C or 0 to 1820.00°C
Type R: PtRh13-Pt	-50.0 to 1760.0°C or -50.00 to 1760.00°C
Type E: NiCr-CuNi	-270.0 to 997.0°C or -270.00 to 997.00°C
Type C: WRe5-WRe26	0 to 2310.0°C or 0 to 2310.00°C
Type T: Cu-CuNi	-270.0 to 400.0°C or -270.00 to 400.00°C
Terminal temperature	-145.0 to 840.0°C or -145.00 to 840.00°C
Voltage	Depending on gain ±32.767 mV or ±65.534 mV
Monitoring	
Range undershoot	0x8001 or 0x80000001
Range overshoot	0x7FFF or 0x7FFFFFFF
Open circuit	0x7FFF or 0x7FFFFFFF
Open inputs	0x7FFF or 0x7FFFFFFF
General fault	0x8000 or 0x80000000
Conversion procedure	Sigma-delta
Linearization method	Internal
Permissible input signal	Max. ±15 V
Input filter	First-order low-pass filter / cutoff frequency 500 Hz
Max. error at 25°C	
Gain	0.04% 2)
Offset	
Type J: Fe-CuNi	0.06% 3)
Type K: NiCr-Ni	0.07% 3)
Type N: NiCrSi-NiSi	0.07% 3)
Type S: PtRh10-Pt	0.13% 3)
Type B: PtRh30-PtRh6	0.15% 3)
Type R: PtRh13-Pt	0.11% 3)
Type E: NiCr-CuNi	0.06% 3)
Type C: WRe5-WRe26	0.08% 3)
Type T: Cu-CuNi	0.11% 3)
Voltage	0.015% 3)
Max. gain drift	
Channel	0.01%/°C 2)
Terminal temperature	0.03 %/°C 2)
Max. offset drift	
Type J: Fe-CuNi	0.0033 %/°C 3)
Type K: NiCr-Ni	0.0042 %/°C 3)
Type N: NiCrSi-NiSi	0.0048 %/°C 3)
Type S: PtRh10-Pt	0.0123 %/°C 3)
Type B: PtRh30-PtRh6	0.0166 %/°C 3)
Type R: PtRh13-Pt	0.0109 %/°C 3)
Type E: NiCr-CuNi	0.003 %/°C 3)
Type C: WRe5-WRe26	0.0062 %/°C 3)
Type T: Cu-CuNi	0.011%/°C 3)
Terminal temperature	0.005 %/°C 3)
Voltage	0.003 %/°C 3)
Nonlinearity	
Channel	±0.004% 3)
Terminal temperature	±0.004% 2)
Terminal temperature compensation	
Operating modes	Internal/remote or external
Basic accuracy at 25°C not taking Pt1000 sensor into account	±0.06%
Accuracy of internal terminal temperature	
With natural convection	±1.5°C after 20 min
With artificial convection	±3°C after 20 min
Common-mode rejection	
DC	>100 dB
50 Hz	>100 dB
60 Hz	>100 dB
Common-mode range	±14 V
Crosstalk between channels	<-70 dB
Insulation voltage	
Between channel and bus	500 V_{eff}
Electrical properties	
Electrical isolation	Channel isolated from bus Channel not isolated from channel

Table 20: X20ATC402 - Technical data

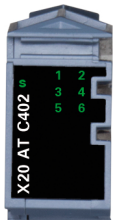
Order number	X20ATC402
Operating conditions	
Mounting orientation	
Horizontal	Yes
Vertical	Yes
Installation elevation above sea level	
0 to 2000 m	No limitation
>2000 m	Reduction of ambient temperature by 0.5°C per 100 m
Degree of protection per EN 60529	IP20
Ambient conditions	
Temperature	
Operation	
Horizontal mounting orientation	-25 to 60°C
Vertical mounting orientation	-25 to 50°C
Derating	-
Storage	-40 to 85°C
Transport	-40 to 85°C
Relative humidity	
Operation	5 to 95%, non-condensing
Storage	5 to 95%, non-condensing
Transport	5 to 95%, non-condensing
Mechanical properties	
Note	Order 1x terminal block X20TB1E for internal/remote terminal temperature compensation separately. Order 1x terminal block X20TB1F for external terminal temperature compensation separately. Order 1x bus module X20BM11 separately.
Pitch	$12.5^{+0.2}$ mm

Table 20: X20ATC402 - Technical data

1) With a 50 Hz filter, x = 20 ms (1 / 50 Hz = 20 ms)
2) Based on the current measured value.
3) Based on the entire measurement range.

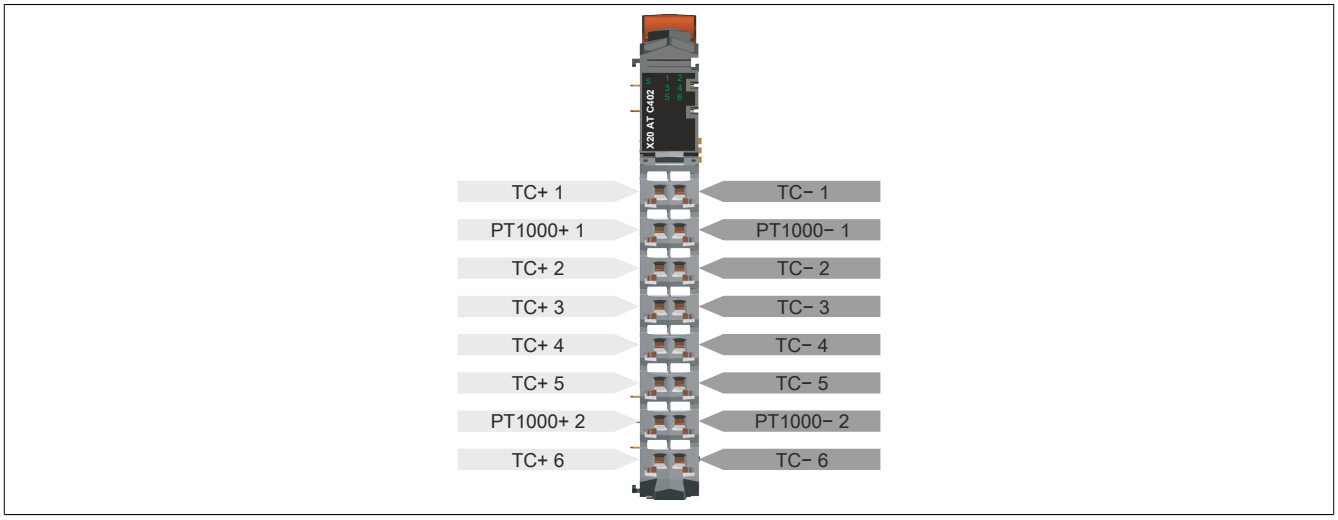
10.2.2 LED status indicators

For a description of the various operating modes, see section "Additional information - Diagnostic LEDs" in the X20 System user's manual.

Figure	LED	Color	Status	Description
	S	Green	Off	No power to module
			Single flash	RESET mode
			Double flash	BOOT mode (during firmware update)[1)]
			Blinking	PREOPERATIONAL mode
			On	RUN mode
		Red	Off	No power to module or everything OK
			On	Error or reset status
			Single flash	A parameter or conversion error has occurred. This status is output in addition to a single/double flash on the channel LED of the analog input where the error occurs.
		Solid red / Single green flash		Invalid firmware
	1 - 6	Green	Off	Input turned off or not supplied
			Single flash	A parameter error has occurred. A single flash is output on the red "s" module status LED.
			Double flash	A conversion error has occurred. A single flash is output on the red "s" module status LED.
			Blinking	Overflow, underflow or open line
			On	Analog/digital converter running, value OK

1) Depending on the configuration, a firmware update can take up to several minutes.

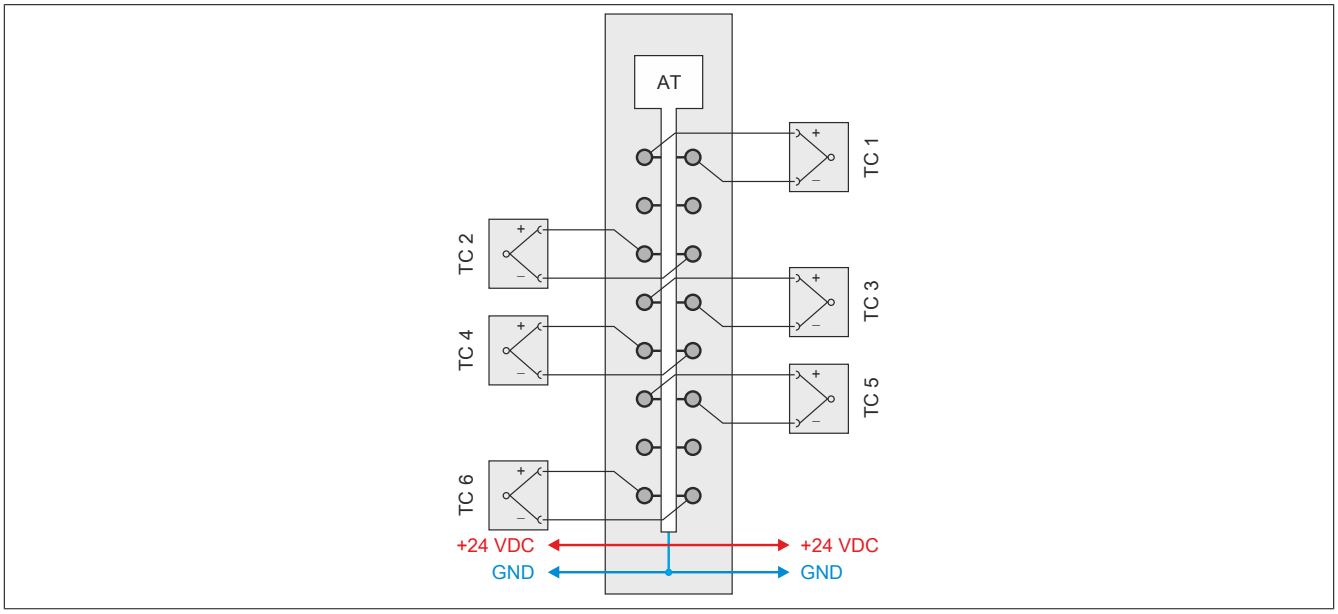
10.2.3 Pinout



10.2.4 Connection examples

Internal temperature compensation

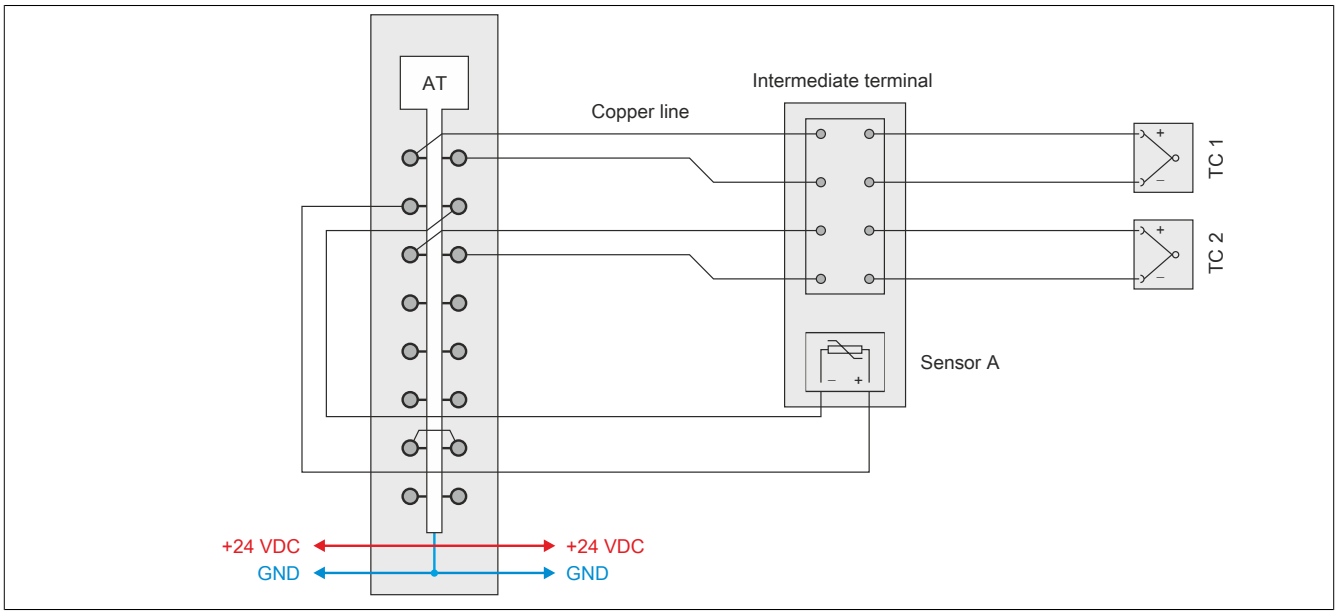
The thermocouple terminal X20TB1E with integrated PT1000 sensors is used for internal temperature compensation.



Remote temperature compensation

The 16-pin X20TB1F standard terminal block is used for remote temperature compensation. The external PT1000 sensors are connected to the module using 2-wire connections.

If Sensor B is not needed for temperature compensation, then the terminal points need to be bypassed.

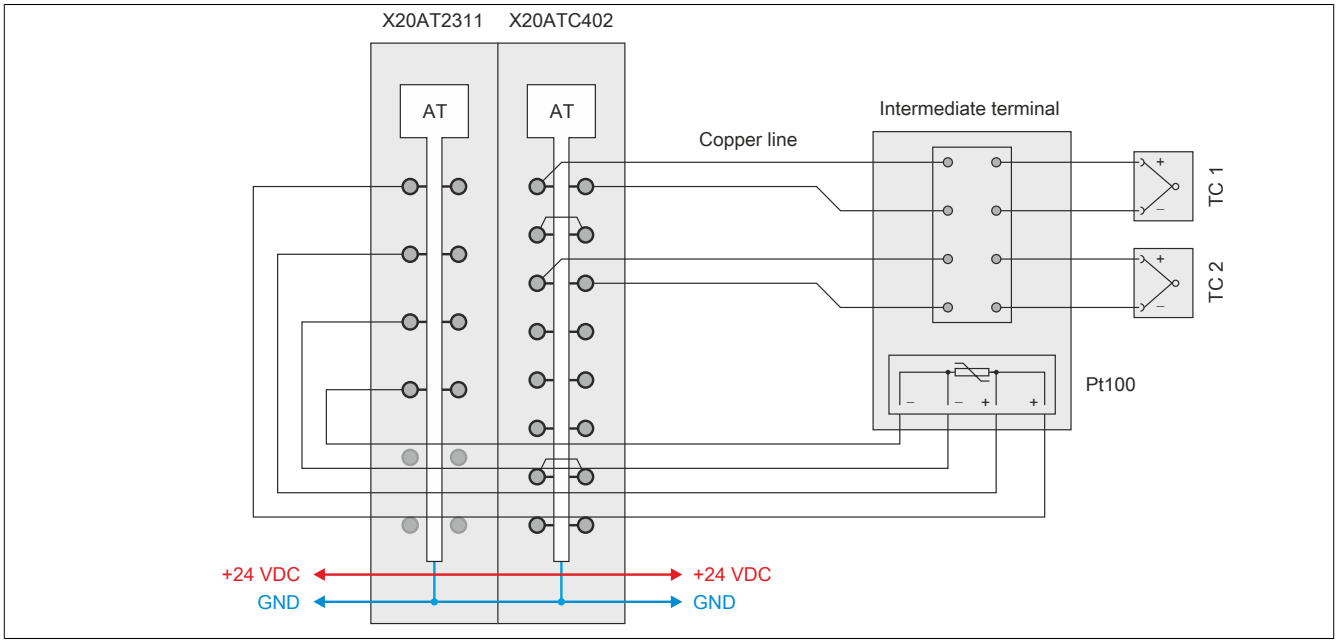


External temperature compensation

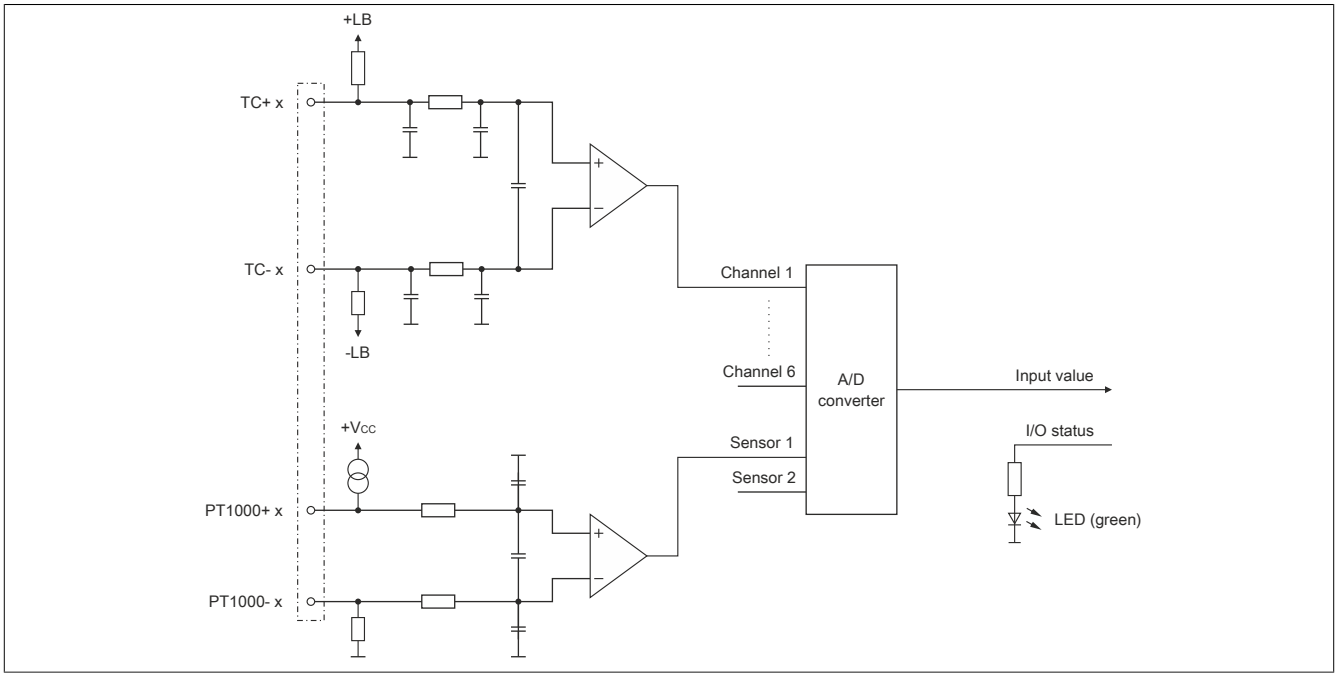
External compensation does not require the Pt1000 values to be converted internally in the module. Instead, the reference temperatures must be prepared in the program sequence and specified to the module. A separate register is available for each temperature channel for transferring an externally prepared compensation value.

In the following example, the compensation value is determined using the X20AT2311 temperature input module and a Pt100 sensor on the intermediate terminal. This externally determined cold junction temperature value is provided to the X20ATC402 module via the corresponding I/O data points.

Since sensors A and B aren't needed for temperature compensation, the respective terminal points need to be bypassed.



10.2.5 Input circuit diagram



10.2.6 Remote or external terminal temperature compensation

Setting up a remote or external cold junction can provide the most accurate temperature measurement in a machine or system.

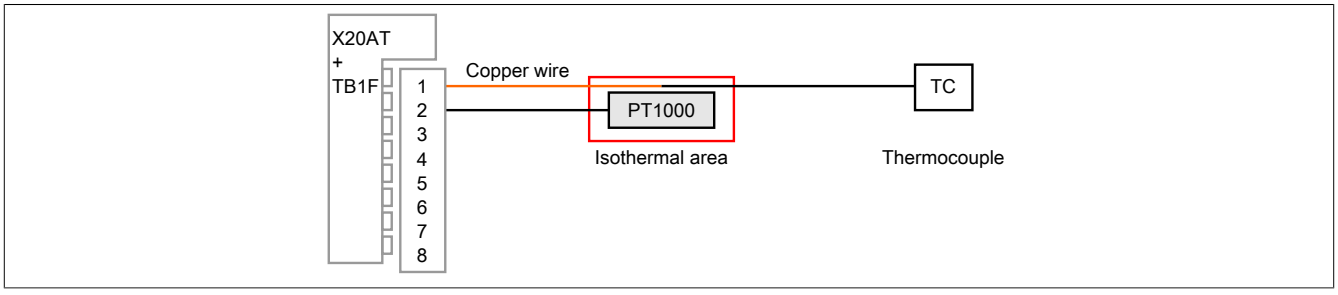
The installation of a remote or external cold junction is especially helpful in the following cases.

- There is no module next to the temperature module
- With strongly fluctuating environmental conditions (draft, temperature)
- External fan is used in the control cabinet

10.2.6.1 Remote terminal block

The 16-pin standard terminal block (X20TB1F) is used. The reference point for temperature measurements can be moved from the terminal to a more thermally stable location. This can help to minimize measurement error and increase accuracy.

Principle of the remote terminal block



The thermocouple provides $V_{(\Delta T)}$ between the end of the thermocouple and the transition to the copper wire.

The PT1000 sensor provides the absolute temperature of the isothermal area.

Calculation: T(TC) = T(PT1000) + ΔT

10.3 Function description

10.3.1 Sensor type and measurement range

The module can be used for both temperature and resistance measurement. The following measurement ranges result depending on the set operating mode:

Sensor type	Measurement range
Type J (Fe-CuNi)	-210 to 1200°C
Type K (NiCr-Ni)	-270 to 1372°C
Type N (NiCrSi-NiSi)	-270 to 1298°C
Type S (PtRh10-Pt)	-50 to 1768°C
Type R (PtRh13-Pt)	-50 to 1760°C
Type C (WRe5-WRe26)	0 to 2310°C
Type T (Cu-CuNi)	-270 to 400°C
Type B (PtRh30-PtRh6)	0 to 1820°C
Type E (NiCr-CuNi)	-270 to 997°C
Raw value (voltage without linearization and terminal temperature compensation)	1.0625 µV resolution with a measurement range of ±35 mV
Raw value (voltage without linearization and terminal temperature compensation)	2.125 µV resolution with a measurement range of ±70 mV

In order for the user to always be supplied with a defined output value, the following must be taken into consideration:

- 0x8000 or 0x80000000 is output until the first conversion depending on the resolution.
- After switching the sensor type, 0x8000 or 0x80000000 is output until the first conversion depending on the resolution.
- If the input is switched off, 0x8000 or 0x80000000 is output depending on the resolution.
- 0x8000 or 0x80000000 is output if an I/O power supply error occurs depending on the resolution.

Information:

The register is described in "Configuring temperature measurement" on page 143.

10.3.2 Configurable conversion rate / filter time

The sampling time of the A/D converter is configured together with the filter time. The set filter/sampling time applies equally to the inputs of the thermocouples and temperature resistor.

Datentyp	Werte	Filterzeit in ms	Wandelrate in s^{-1}
UINT	4	1	1000
	9	2	500
	48	10	100
	80	16,7	60
	96	20 (Bus Controller Default)	50
	160	33,3	30
	192	40	25
	320	66,7	15
	480	100	10
	960	200	5

Information:

Je geringer die Wandelrate konfiguriert wird, desto genauer kann der Wert gewandelt werden. Allerdings wird dadurch auch die I/O-Updatezeit erhöht.

Information:

The register is described in "Input filter" on page 141.

10.3.3 Compensation

The measurement process is based on the interaction between the temperature sensors and the thermocouples. The converted voltage value of a thermocouple has a linear relationship with the difference in temperature between the measurement point and the transition point. To calculate the absolute temperature at the measurement point, the measured value must then be placed in relation to an absolute reference temperature.

The compensation value required for this can be determined as follows:

- The value is determined directly on the module using a Pt1000 temperature sensor (internal compensation).
- The value is provided via a cyclic data point (external compensation).

10.3.3.1 Internal compensation

The inputs of the temperature resistors are used for internal compensation. The module can be used with the 12-pin terminal block (X20TB1E), which has 2 PT1000 temperature sensors.
When operating the module with the X20TB1E, the temperature distribution on the terminal block must be taken into account. To do this, various models for calculating the temperature distribution have been implemented on the module. They account for both the ambient temperature in the control cabinet, as well as the mounting orientation of the module. This helps minimize measurement error.

Alternatively, the module can be operated with the standard 16-pin terminal block (X20TB1F). For a detailed description of this procedure, see "Remote terminal block" on page 132.

Information:

To avoid unnecessary traffic on the X2X Link network, the compensation registers should only be transferred cyclically during the fine-tuning process and for service and maintenance purposes. The information is generally not required during normal operation.

10.3.3.2 External compensation

For external compensation, the reference temperatures must be prepared in the application and transferred to the module via X2X Link. There is no need for internal conversion of the PT1000 values in the module.

10.3.3.3 Status of the compensation value

The compensation value is monitored against the upper and lower limit values as well as for open circuit.

Range of values	Measurement signal
Upper maximum value	+32767 (0x7FFF)
Lower minimum value	-32767 (0x8001)

The results of monitoring are displayed in the compensation status register.

Information:

The registers are described in "Compensation" on page 141 and "Status of the compensation value" on page 142.

10.3.4 Monitoring the input signal

The input signal is monitored against the upper and lower limit values as well as for open circuit.

Information:

The registers are described in "Status messages" on page 146.

10.3.4.1 User-defined limit values

In addition to the status information, user-defined limit values can be defined as well as replacement values that are output if the limit values are overshot or undershot.

If user-specific limit values are used, a hysteresis range should also be defined. This range determines how far the limit values must be exceeded in order to trigger a reaction.

10.3.4.2 Receiving the measured value

If the last valid measured value should be kept when violating the limit value, then PreparationInterval must be defined. The measured values continue to be acquired and converted according to the configured I/O update time. They are then checked and discarded if they do not meet the specifications. When an error does not occur, therefore, the measured value acquired 2 preparation intervals ago is constantly output.

Functionality:
Depending on the configured input filter, measured values are continuously converted and stored in the measured value memory. The current content of the measured value memory is checked within the set interval time. If a permissible value is present, the content of the temporary memory is transferred to the output memory and the content of the measured value memory is transferred to the temporary memory.
If the check results in an impermissible value, the content of the measured value memory is discarded. The copy direction between the output memory and temporary memory is reversed, and the next-to-last valid value is still output.

	"Application" Value being measured (analog)
↓	Condition: - Conversion interval (A/D converter) elapsed
	"Measured value memory" Measured value (digital)
↓	Condition: - PreparationInterval elapsed - Measured value permissible
	"Buffer" Last valid value
↓	Condition: - PreparationInterval elapsed - Measured value permissible
	"Output memory" Next-to-last valid/ displayed value

Information:

With the "Hold last valid value" configuration, the delay from measurement to the output of the value is at least twice the time of the preparation interval. In the worst case, however, it can also take twice the interval time plus the configured conversion cycle of the A/D converter.

Information:

The registers are described in "Configuring the limit values" on page 144.

10.3.5 NetTime Technology

NetTime refers to the ability to precisely synchronize and transfer system times between individual components of the controller or network (controller, I/O modules, X2X Link, POWERLINK, etc.).

This allows the moment that events occur to be determined system-wide with microsecond precision. Upcoming events can also be executed precisely at a specified moment.

10.3.5.1 Time information

Various time information is available in the controller or on the network:

- System time (on the PLC, Automation PC, etc.)
- X2X Link time (for each X2X Link network)
- POWERLINK time (for each POWERLINK network)
- Time data points of I/O modules

The NetTime is based on 32-bit counters, which are increased with microsecond resolution. The sign of the time information changes after 35 min, 47 s, 483 ms and 648 µs; an overflow occurs after 71 min, 34 s, 967 ms and 296 µs.

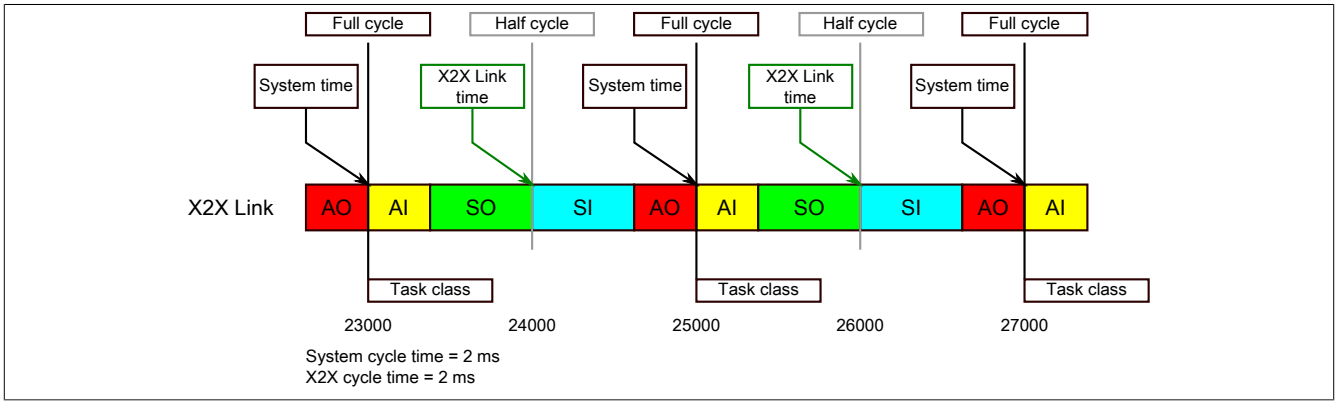
The initialization of the times is based on the system time during the startup of the X2X Link, the I/O modules or the POWERLINK interface.

Current time information in the application can also be determined via library AsIOTime.

10.3.5.1.1 Controller data points

The NetTime I/O data points of the controller are latched to each system clock and made available.

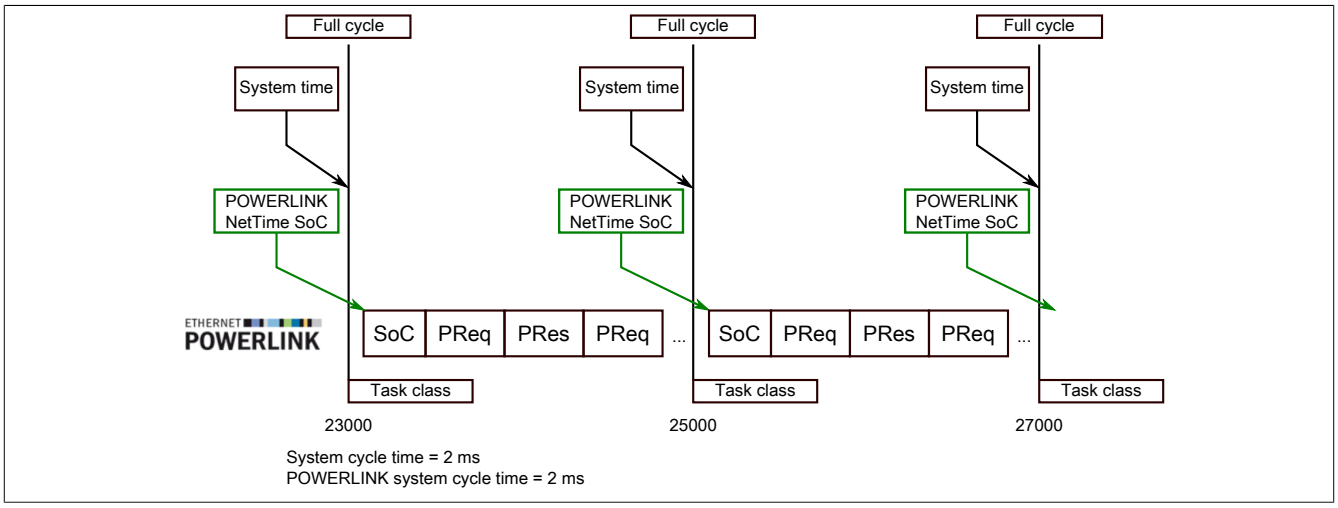
10.3.5.1.2 X2X Link - Reference time point



The reference time point on the X2X Link network is always calculated at the half cycle of the X2X Link cycle. This results in a difference between the system time and the X2X Link reference time point when the reference time is read out.

In the example above, this results in a difference of 1 ms, i.e. if the system time and X2X Link reference time are compared at time 25000 in the task, then the system time returns the value 25000 and the X2X Link reference time returns the value 24000.

10.3.5.1.3 POWERLINK - Reference time point

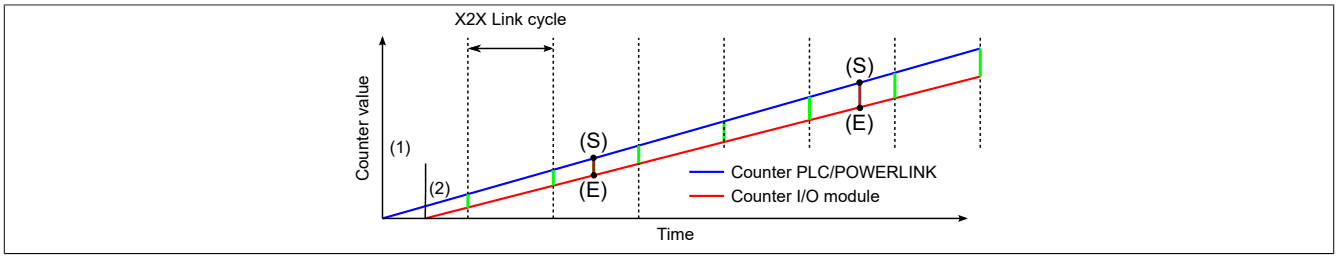


The POWERLINK reference time point is always calculated at the start of cycle (SoC) of the POWERLINK network. The SoC starts 20 µs after the system clock due to the system. This results in the following difference between the system time and the POWERLINK reference time:

POWERLINK reference time = System time - POWERLINK cycle time + 20 µs

In the example above, this means a difference of 1980 µs, i.e. if the system time and POWERLINK reference time are compared at time 25000 in the task, then the system time returns the value 25000 and the POWERLINK reference time returns the value 23020.

10.3.5.1.4 Synchronization of system time/POWERLINK time and I/O module



At startup, the internal counters for the controller/POWERLINK (1) and the I/O module (2) start at different times and increase the values with microsecond resolution.

At the beginning of each X2X Link cycle, the controller or POWERLINK network sends time information to the I/O module. The I/O module compares this time information with the module's internal time and forms a difference (green line) between the two times and stores it.

When a NetTime event (E) occurs, the internal module time is read out and corrected with the stored difference value (brown line). This means that the exact system moment (S) of an event can always be determined, even if the counters are not absolutely synchronous.

Note

The deviation from the clock signal is strongly exaggerated in the picture as a red line.

10.3.5.2 Timestamp functions

NetTime-capable modules provide various timestamp functions depending on the scope of functions. If a timestamp event occurs, the module immediately saves the current NetTime. After the respective data is transferred to the controller, including this precise moment, the controller can then evaluate the data using its own NetTime (or system time), if necessary.
For details, see the respective module documentation.

10.3.5.2.1 Time-based inputs

NetTime Technology can be used to determine the exact moment of a rising edge at an input. The rising and falling edges can also be detected and the duration between 2 events can be determined.

> **Information:**
>
> **The determined moment always lies in the past.**

10.3.5.2.2 Time-based outputs

NetTime Technology can be used to specify the exact moment of a rising edge on an output. The rising and falling edges can also be specified and a pulse pattern generated from them.

> **Information:**
>
> **The specified time must always be in the future, and the set X2X Link cycle time must be taken into account for the definition of the moment.**

10.3.5.2.3 Time-based measurements

NetTime Technology can be used to determine the exact moment of a measurement that has taken place. Both the starting and end moment of the measurement can be transmitted.

10.4 Commissioning

10.4.1 Using the module on the bus controller

Function model 254 "Bus controller" is used by default only by non-configurable bus controllers. All other bus controllers can use other registers and functions depending on the fieldbus used.

For detailed information, see section "Additional information - Using I/O modules on the bus controller" in the X20 user's manual (version 3.50 or later).

10.4.1.1 CAN I/O bus controller

The module occupies 2 analog logical slots on CAN I/O.

10.5 Register description

10.5.1 General data points

In addition to the registers described in the register description, the module has additional general data points. These are not module-specific but contain general information such as serial number and hardware variant.

General data points are described in section "Additional information - General data points" in the X20 System user's manual.

10.5.2 Function model 0 - Standard

Register	Name	Data type	Read		Write	
			Cyclic	Acyclic	Cyclic	Acyclic
Module configuration						
1026	Cfo_InputFilter	UINT				•
Compensation						
1030 1034	Cfo_ClampTypeA Cfo_ClampTypeB	UINT				•
1038 1042	Cfo_ClampOffsetA Cfo_ClampOffsetB	INT				•
266 270	CompensationValueA CompensationValueB	INT		•		
261 263	CompensationStatusA CompensationStatusB	USINT		•		
	UnderrunA, UnderrunB	Bit 0				
	OverrunA, OverrunB	Bit 1				
	OpenLineA, OpenLineB	Bit 2				
	ConverterFaultA, ConverterFaultB	Bit 4				
	SumFaultA, SumFaultB	Bit 5				
	ParameterFaultA, ParameterFaultB	Bit 6				
N * 4 + 766	ExternalCompensation0N (index N = 1 to 6)	INT			•	
Temperature measurement - Configuration						
N * 64 + 1026	Cfo_SensorType0N (index N = 1 to 6)	UINT				•
N * 64 + 1058	Cfo_PreparationInterval0N (index N = 1 to 6)	UINT				•
N * 64 + 1046	Cfo_ReplaceUpper0N (index N = 1 to 6)	INT				•
N * 64 + 1042	Cfo_ReplaceLower0N (index N = 1 to 6)	INT				•
N * 64 + 1034	Cfo_UpperLimit0N (index N = 1 to 6)	INT				•
N * 64 + 1030	Cfo_LowerLimit0N (index N = 1 to 6)	INT				•
N * 64 + 1038	Cfo_Hysteresis0N (index N = 1 to 6)	INT				•
N * 64 + 1050	Cfo_ErrorDelay0N (index N = 1 to 6)	UINT				•
N * 64 + 1054	Cfo_SumErrorDelay0N (index N = 1 to 6)	UINT				•
N * 64 + 4036	Cfo_LowerLimit0NH (index N = 1 to 6)	DINT				•
N * 64 + 4044	Cfo_UpperLimit0NH (index N = 1 to 6)	DINT				•
N * 64 + 4052	Cfo_ReplaceLower0NH (index N = 1 to 6)	DINT				•
N * 64 + 4060	Cfo_ReplaceUpper0NH (index N = 1 to 6)	DINT				•
Temperature measurement						
N * 8 + 60	Temperature0N_H_Res (index N = 1 to 6)	DINT	•			
N * 64 + 262	Temperature0N (index N = 1 to 6)	INT	•			
N * 64 + 258	Measurand0N (index N = 1 to 6)	INT		•		
N * 64 + 274	SampleTime0N (index N = 1 to 6)	INT	•			
N * 64 + 276	SampleTime0N (index N = 1 to 6)	DINT	•			
N * 64 + 281	IOCycleCounter0N (index N = 1 to 6)	USINT		•		
N * 64 + 282	IOCycleCounter0N (index N = 1 to 6)	UINT	•			
N * 64 + 269	Status0N (index N = 1 to 6)	USINT	•			
	Underrun0N	Bit 0				
	Overrun0N	Bit 1				
	OpenLine0N	Bit 2				
	CompensationFault0N	Bit 3				
	ConverterFault0N	Bit 4				
	SumFault0N	Bit 5				
	ParameterFault0N	Bit 6				

10.5.3 Function model 254 - Bus controller

Register	Offset[1)]	Name	Data type	Read		Write	
				Cyclic	Acyclic	Cyclic	Acyclic
Module configuration							
1026	-	Cfo_InputFilter	UINT				•
Compensation							
1030 1034	-	Cfo_ClampTypeA Cfo_ClampTypeB	UINT				•
1038 1042	-	Cfo_ClampOffsetA Cfo_ClampOffsetB	INT				•
266 270	-	CompensationValueA CompensationValueB	INT		•		
261 263	-	CompensationStatusA CompensationStatusB	USINT		•		
		UnderrunA, UnderrunB	Bit 0				
		OverrunA, OverrunB	Bit 1				
		OpenLineA, OpenLineB	Bit 2				
		ConverterFaultA, ConverterFaultB	Bit 4				
		SumFaultA, SumFaultB	Bit 5				
		ParameterFaultA, ParameterFaultB	Bit 6				
N * 4 + 766	-	ExternalCompensation0N (index N = 1 to 6)	INT				•
Temperature measurement - Configuration							
N * 64 + 1026	-	Cfo_SensorType0N (index N = 1 to 6)	UINT				•
N * 64 + 1058	-	Cfo_PreparationInterval0N (index N = 1 to 6)	UINT				•
N * 64 + 1046	-	Cfo_ReplaceUpper0N (index N = 1 to 6)	INT				•
N * 64 + 1042	-	Cfo_ReplaceLower0N (index N = 1 to 6)	INT				•
N * 64 + 1034	-	Cfo_UpperLimit0N (index N = 1 to 6)	INT				•
N * 64 + 1030	-	Cfo_LowerLimit0N (index N = 1 to 6)	INT				•
N * 64 + 1038	-	Cfo_Hysteresis0N (index N = 1 to 6)	INT				•
N * 64 + 1050	-	Cfo_ErrorDelay0N (index N = 1 to 6)	UINT				•
N * 64 + 1054	-	Cfo_SumErrorDelay0N (index N = 1 to 6)	UINT				•
Temperature measurement							
N * 64 + 262	N * 2 - 2	Temperature0N (index N = 1 to 3)	INT	•			
	N * 2	Temperature0N (index N = 4 to 6)					
N * 64 + 258	-	Measurand0N (index N = 1 to 6)	INT		•		
N * 64 + 281	-	IOCycleCounter0N (index N = 1 to 6)	USINT		•		
30 31	-	ModuleStatus01 ModuleStatus02	USINT		•		

1) The offset specifies the position of the register within the CAN object.

10.5.4 Module configuration

10.5.4.1 Input filter

Name:
Cfo_InputFilter

Mit Hilfe dieses Registers wird die Abtastzeit des A/D-Wandlers konfiguriert. Die eingestellte Filter-/Abtastzeit gilt gleichermaßen für die Eingänge der Thermoelemente als auch des Temperaturwiderstandes.

Datentyp	Werte	Filterzeit in ms	Wandelrate in s^{-1}
UINT	4	1	1000
	9	2	500
	48	10	100
	80	16,7	60
	96	20 (Bus Controller Default)	50
	160	33,3	30
	192	40	25
	320	66,7	15
	480	100	10
	960	200	5

Information:

Je geringer die Wandelrate konfiguriert wird, desto genauer kann der Wert gewandelt werden. Allerdings wird dadurch auch die I/O-Updatezeit erhöht.

10.5.5 Compensation

10.5.5.1 Setting the compensation parameters

Name:
Cfo_ClampTypeA, Cfo_ClampTypeB

These registers are used to specify the sensor type and register the conversion of the compensation value on the A/D converter.

Four different temperature distribution models have been built into the module, optimized for the various ways the module can be installed. The respective model is selected using bits 4 (installation parameter) and 5 (thermal radiance).

Data type	Value	Information
UINT	See the bit structure.	Bus controller default setting value: 0

Bit structure:

Bit	Name	Value	Information
0	Sensor type	0	PT1000 (bus controller default setting)
		1	Reserved
1	Compensation channel (on/off)	0	Channel not converted by the AD converter (bus controller default setting)
		1	Channel registered on the AD converter
2	Compensation value (see register "Compensation value" on page 142)	0	Prepare as temperature value (bus controller default setting)
		1	Prepare as resistance value
3	Reserved	-	
4	Installation parameter	0	Horizontal mounting orientation (bus controller default setting)
		1	Vertical mounting orientation
5	Thermal radiance[1)]	0	Low (bus controller default setting)
		1	High
6 - 15	Reserved	-	

1) If an active module that generates additional heat is installed in the immediate vicinity of the temperature module, then this parameter should be set to 1.

10.5.5.2 Compensation offset

Name:
Cfo_ClampOffsetA, Cfo_ClampOffsetB

These registers define the offsets that are deducted from the respective compensation values.

Data type	Value	Information
INT	-32767 to 32767	In 0.1 Ω. Bus controller default setting: 0

10.5.5.3 Compensation value

Name:
CompensationValueA, CompensationValueB

These registers can be used to read the compensation value. Depending on how the "Cfo_ClampType" on page 141 register is set, it is output as either a temperature or resistance value.

Data type	Value	Information
INT	-32767 to 32767	In 0.1°C or 0.1 Ω

10.5.5.4 Status of the compensation value

Name:
CompensationStatusA, CompensationStatusB
UnderrunA, UnderrunB
OverrunA, OverrunB
OpenLineA, OpenLineB
ConverterFaultA, ConverterFaultB
SumFaultA, SumFaultB
ParameterFaultA, ParameterFaultB

These registers provide information about the current state of the respective compensation value. The structure is derived from register "Status" on page 147.

Data type	Value
USINT	See the bit structure.

Bit structure:

Bit	Name	Value	Information
0	UnderrunA UnderrunB	0	No error
		1	Value below the permitted range
1	OverrunA OverrunB	0	No error
		1	Value above the permitted range
2	OpenLineA OpenLineB	0	No error
		1	Open line
3	(Compensation error)	-	No meaning
4	ConverterFaultA ConverterFaultB	0	No error
		1	Converter error
5	SumFaultA SumFaultB	0	No error
		1	Undelayed composite error
6	ParameterFaultA ParameterFaultB	0	No error
		1	Invalid setting for "ClampType" on page 141 register
7	Reserved	-	

10.5.5.5 External compensation value

Name:
ExternalCompensation01 to ExternalCompensation06

These registers can be used to send an externally generated compensation value to the module.

Data type	Value	Information
INT	-32767 to 32767	Resolution in 0.1 or 0.01°C

10.5.6 Temperature measurement - Configuration

The temperature measurement channels can be configured independently of each other. The "Cfo_SensorType" on page 143 register needs to be adjusted in order to enable a temperature channel. The rest of the registers complement this configuration and only need to be defined if required in the application.

10.5.6.1 Configuring temperature measurement

Name:
Cfo_SensorType01 to Cfo_SensorType06

These registers control the basic functionality of a temperature channel.

Data type	Value	Bus controller default setting
UINT	See the bit structure.	33792

Bit structure:

Bit	Name	Value	Information
0 - 5	Sensor type	0	Sensor J (Fe-CuNi) (bus controller default setting)
		1	Sensor K (NiCr-Ni)
		2	Sensor N (NiCrSi-NiSi)
		3	Sensor S (PtRh10-Pt)
		4	Sensor R (PtRh13-Pt)
		5	Sensor C (WRe5-WRe26)
		6	Sensor T (Cu-CuNi)
		7	Sensor B (PtRh30-PtRh6)
		8	Sensor E (NiCr-CuNi)
		9 to 60	Reserved
	Raw value (Voltage without linearization and terminal temperature compensation)	61	Resolution 1.0625 µV; measurement range ±35 mV
		62	Resolution 2.125 µV; measurement range ±70 mV
		63	Reserved
6 - 7	Reserved	-	
8 - 9	Reference method	0	PT1000 sensor (bus controller default setting)
		1 to 2	Not permitted
		3	External compensation
10	Temperature model for X20TB1E[1)]	0	Disabled (bus controller default setting)
		1	Enabled
11	Method of compensation	0	Internal compensation (bus controller default setting)
		1	External compensation
12	Resolution of the temperature value	0	Resolution = 0.1°C
		1	Resolution = 0.01°C
13	Replacement value strategy	0	Replace with static default value (bus controller default setting)
		1	Retain last valid value
14	Additional user-defined limits for permitted range of values	0	Permissible range of values of the thermocouple (bus controller default setting)
		1	Range of values as configured[2)]
15	Temperature channel	0	Channel not converted by the AD converter
		1	Channel registered on the AD converter (bus controller default setting)

1) To enable the temperature model, both PT1000 cold junction sensors must be connected.
2) The user-defined limit values can further reduce the permissible range of values for the sensor, depending on the requirements of the application. It is not permitted to define a measurement range larger than the range supported by the sensor.

10.5.7 Configuring the limit values

10.5.7.1 Hysteresis

Name:
Cfo_Hysteresis01 to Cfo_Hysteresis06

If the user-specific limit values are being used, then a hysteresis range should also be defined. These registers configure how far a limit value can be exceeded before a response is triggered.

Data type	Value	Information
INT	-32767 to 32767	Resolution = 0.1°C Bus controller default setting: 16
		Resolution = 0.01°C

10.5.7.2 Upper limit value

Name:
Cfo_UpperLimit01 to Cfo_UpperLimit06
Cfo_UpperLimit01H to Cfo_UpperLimit06H

If the value range needs to be restricted further, these registers can be used to enter new user-specific upper limit values.

Data type	Value	Information
INT	-32767 to 32767	Resolution = 0.1°C Bus controller default setting: 32767
DINT	-2,147,483,648 to 2,147,483,647	Resolution = 0.01°C

10.5.7.3 Lower limit value

Name:
Cfo_LowerLimit01 to Cfo_LowerLimit06
Cfo_LowerLimit01H to Cfo_LowerLimit06H

If the value range needs to be restricted further, these registers can be used to enter new user-specific lower limit values.

Data type	Value	Information
INT	-32767 to 32767	Resolution = 0.1°C Bus controller default setting: -32767
DINT	-2,147,483,648 to 2,147,483,647	Resolution = 0.01°C

10.5.7.4 Defining the preparation interval

Name:
Cfo_PreparationInterval01 to Cfo_PreparationInterval06

If the last valid measured value should be retained in the event of a limit value violation, the preparation interval can be defined in these registers. For details, see "Receiving the measured value" on page 135.

Data type	Value	Information
UINT	0 to 65535	In 0.1 ms. Bus controller default setting: 0

Information:

The registers are only set for the channel when bit 13 is set in the "Cfo_SensorType" on page 143 register.

10.5.7.5 Upper replacement value

Name:
Cfo_ReplaceUpper01 to Cfo_ReplaceUpper06
Cfo_ReplaceUpper01H to Cfo_ReplaceUpper06H

These registers are used to specify the upper static values that are displayed instead of the current measured value when a limit value is violated.

Data type	Value	Information
INT	-32767 to 32767	Resolution = 0.1°C Bus controller default setting: 32767
DINT	-2,147,483,648 to 2,147,483,647	Resolution = 0.01°C

Information:

The registers are only created for the channel if bit 13 is not set in register "Cfo_SensorType" on page 143.

10.5.7.6 Lower replacement value

Name:
Cfo_ReplaceLower01 to Cfo_ReplaceLower06
Cfo_ReplaceLower01H to Cfo_ReplaceLower06H

These registers are used to specify the lower static values that are displayed instead of the current measured value when a limit value is violated.

Data type	Value	Information
INT	-32767 to 32767	Resolution = 0.1°C Bus controller default setting: -32767
DINT	-2,147,483,648 to 2,147,483,647	Resolution = 0.01°C

Information:

The registers are only set for the channel when bit 13 is not set in the "Cfo_SensorType" on page 143 register.

10.5.8 Temperature measurement

The received temperature data is prepared in 2 different formats and given a timestamp. For each channel there are 2 separate registers for transmitting the measured values to the PLC.

10.5.8.1 Temperature measurement values (resolution = 0.1°C)

Name:
Temperature01 to Temperature06
Measurand01 to Measurand06

With a resolution of 0.1°C, these registers contain the analog input values corresponding to the sensor type set in register "Cfo_SensorType" on page 143:

Data type	Value	Information	Sensor type
INT	-2,100 to 12,000	(for -210.0 to 1200.0°C)	Type J (Fe-CuNi)
	-2,700 to 13,720	(for -270.0 to 1372.0 °C)	Type K (NiCr-Ni)
	-2,700 to 12,980	(for -270.0 to 1298.0 °C)	Type N (NiCrSi-NiSi)
	-500 to 17,680	(for -50.0 to 1768.0 °C)	Type S (PtRh10-Pt)
	-500 to 17,600	(for -50.0 to 1760.0 °C)	Type R (PtRh13-Pt)
	0 to 23,100	(for 0 to 2310.0 °C)	Type C (WRe5-WRe26)
	-2,700 to 4,000	(for -270.0 to 400.0 °C)	Type T (Cu-CuNi)
	0 to 18,200	(for 0 to 1820.0 °C)	Type B (PtRh30-PtRh6)
	-2,700 to 9,970	(for -270.0 to 997.0 °C)	Type E (NiCr-CuNi)
	-32,768 to 32767	Voltage without linearization and terminal temperature compensation Resolution 1.0625 µV for a measurement range of ±35 mV	
	-32,768 to 32767	Voltage without linearization and terminal temperature compensation Resolution 2.125 µV for a measurement range of ±70 mV	

10.5.8.2 Temperature measurement values (resolution = 0.01°C)

Name:
Temperature01_H_Res to Temperature06_H_Res

With a resolution of 0.01°C, these registers contain the analog input values corresponding to the sensor type set in register "Cfo_SensorType" on page 143:

Data type	Values	Information	Sensor type
DINT	-21000 to 120000	(for -210.00 to 1200.00°C)	Type J (Fe-CuNi)
	-27000 to 137200	(for -270.00 to 1372.00°C)	Type K (NiCr-Ni)
	-27000 to 129800	(for -270.00 to 1298.00°C)	Type N (NiCrSi-NiSi)
	-5000 to 176800	(for -50.00 to 1768.00°C)	Type S (PtRh10-Pt)
	-5000 to 176000	(for -50.00 to 1760.00°C)	Type R (PtRh13-Pt)
	0 to 231000	(for 0 to 2310.00°C)	Type C (WRe5-WRe26)
	-27000 to 40000	(for -270.00 to 400.00°C)	Type T (Cu-CuNi)
	0 to 182000	(for 0 to 1820.00°C)	Type B (PtRh30-PtRh6)
	-27000 to 99700	(for -270.00 to 997.00°C)	Type E (NiCr-CuNi)
	-2,147,483,648 to 2,147,483,647	Voltage without linearization and terminal temperature compensation 0.010625 µV resolution with a measurement range of ±35 mV	
	-2,147,483,648 to 2,147,483,647	Voltage without linearization and terminal temperature compensation 0.02125 µV resolution with a measurement range of ±70 mV	

10.5.8.3 Sample time

Name:
SampleTime01 to SampleTime06

These registers return the timestamp for when the module reads the current channel mapping. The values are provided as signed 2-byte or 4-byte values.

For additional information about NetTime and timestamps, see "NetTime Technology" on page 136.

Data type	Values	Information
INT	-32,768 to 32767	NetTime timestamp of the current input value in microseconds
DINT	-2147483648 to 2147483647	NetTime timestamp of the current input value in microseconds

10.5.8.4 I/O cycle counter

Name:
IOCycleCounter01 to IOCycleCounter06

These registers are revolving counters that are incremented with each newly converted value. They can be used either as 1-byte or 2-byte counters.

Data type	Value
USINT	0 to 255
UINT	0 to 65535

10.5.9 Status messages

10.5.9.1 Error delay

Name:
Cfo_ErrorDelay01 to Cfo_ErrorDelay06

This register describes the number of consecutive conversion operations for which an error must be pending until the corresponding single error status bit is set. The delay acts on underflow, overflow and open circuit errors. This delay can be used to hide short-term deviations of the measured value, for example.

Data type	Values	Information
UINT	0 to 65535	AD conversions. Bus controller default setting: 2

10.5.9.2 Error delay for composite error bit

Name:
Cfo_SumErrorDelay01 to Cfo_SumErrorDelay06

These registers can be used to set the time that an error must remain pending before the composite error bit is set.

Data type	Values	Information
UINT	0 to 65535	Bus controller default setting: 4000

10.5.9.3 Status messages (Function model 0)

Name:
Status01 to Status06
Underrun01 to Underrun06
Overrun01 to Overrun06
OpenLine01 to OpenLine06
CompensationFault01 to CompensationFault06
ConverterFault01 to ConverterFault06
SumFault01 to SumFault06
ParameterFault01 to ParameterFault06

The current error status of the module channels is displayed in these registers, regardless of the configured replacement value strategy. Some error information may be delayed according to the conditions configured previously in the "Cfo_ErrorDelay" on page 146 and "Cfo_SumErrorDelay" on page 146 registers.

Data type	Value
USINT	See bit structure.

Bit structure:

Bit	Name	Value	Information
0	Underrun0x	0	No error
		1	Value below the permitted range
1	Overrun0x	0	No error
		1	Value above the permitted range
2	OpenLine0x	0	No error
		1	Open line
3	CompensationFault0x	0	No error
		1	Compensation error; See "CompensationStatus" on page 142 register for a detailed error description
4	ConverterFault0x	0	No error
		1	Converter error
5	SumFault0x	0	No error
		1	Undelayed composite error
6	ParameterFault0x	0	No error
		1	Invalid configuration for "Cfo_ClampType" on page 141
7	Reserved	-	

10.5.9.4 Status messages (Function model 254)

Name:
ModuleStatus01 to ModuleStatus06

In function model 254, error detection does not have to be preconfigured. It is enabled at every startup. To streamline the transfer, however, only the 4 basic error messages were implemented.

The bits of these registers are set when one of the implemented error diagnostics is triggered.

Data type	Value
USINT	Channels 1 to 4: see bit structure I
	Channels 5 and 6: see bit structure II

Bit structure I:

Bit	Name	Value	Information
0 - 1	Channel 1	00	No error
		01	Underflow (lower value limit violated)
		10	Overflow (upper value limit violated)
		11	Open line
2 - 3	Channel 2	00 to 11	See channel 1.
4 - 5	Channel 3	00 to 11	See channel 1.
6 - 7	Channel 4	00 to 11	See channel 1.

Bit structure II:

Bit	Name	Value	Information
0 - 1	Channel 5	00	No error
		01	Underflow (lower value limit violated)
		10	Overflow (upper value limit violated)
		11	Open line
2 - 3	Channel 6	00 to 11	See channel 5.
4 - 7	Reserved	-	

10.5.10 Minimum cycle time

The minimum cycle time defines how far the bus cycle can be reduced without causing a communication error or impaired functionality. It should be noted that very fast cycles decrease the idle time available for handling monitoring, diagnostics and acyclic commands.

Minimum cycle time
200 µs

10.5.11 Minimum I/O update time

The minimum I/O update time specifies how far the bus cycle can be reduced so that an I/O update is performed in each cycle.

The A/D converter must convert multiple values. After switching between 2 inputs there are 4 measurements in order to obtain a meaningful value. Since not all inputs need to be used, the actual I/O update time may vary.

The following formulas can be used to calculate the minimum required I/O update time:

I/O update time = 4 * Conversions * Filter time
Filter time = (1024 / 4920000) * Cfo_InputFilter
Conversions = Number of thermocouples + Number of temperature resistors

11 Safety module

11.1 X20ST4492

Information:

B&R makes every effort to keep data sheets as current as possible. From a safety point of view, however, the current version of the data sheet must always be used.
The certified, currently valid data sheet is available for download on the B&R website (www.br-automation.com).

Information:

This data sheet must be used with mapp Safety.
B&R safety technology can still be used in Safety Releases ≤1.10, however. The documentation is available for download on the B&R website (www.br-automation.com).

For additional information about mapp Safety, additional technical descriptions (e.g. connection examples and error detection) as well as generally valid contents (intended use, etc.), see section Safety technology in Automation Help.

Organization of notices

Safety notices

Contain **only** information that warns of dangerous functions or situations.

Signal word	Description
Danger!	Failure to observe these safety guidelines and notices will result in death, severe injury or substantial damage to property.
Warning!	Failure to observe these safety guidelines and notices can result in death, severe injury or substantial damage to property.
Caution!	Failure to observe these safety guidelines and notices can result in minor injury or damage to property.
Notice!	Failure to observe these safety guidelines and notices can result in damage to property.

Table 21: Organization of safety notices

General notices

Contain **useful** information for users and instructions for avoiding malfunctions.

Signal word	Description
Information:	Useful information, application tips and instructions for avoiding malfunctions.

Table 22: Organization of general notices

11.1.1 General information

The module is equipped with 2 safe analog input pairs for J, K, N, S, R, C and T thermocouple sensors and 1 safe analog input pair for PT100/PT1000 resistance temperature measurement.

Thermocouple sensors require a measurement of the terminal temperature. The module's PT100/PT1000 sensors are used for temperature compensation.

The safe temperature module is suitable for safely acquiring temperatures for safety-related applications up to PL e or SIL 3.

This module is designed for X20 16-pin terminal blocks.

- 2 safe analog input pairs for thermocouples
- For sensor types J, K, N, S, R, C, T, raw value measurement
- 1 safe analog input pair for resistance temperature measurement
- For PT100 and PT1000
- Configurable sensor type per channel
- 24-bit digital converter resolution
- Galvanically isolated analog channel pairs
- Input filter configurable
- Integrated terminal temperature compensation
- 2x PT1000 sensor integrated in the terminal (X20TB5E)
- 2x external PT1000 sensor can be connected (X20TB5F)

11.1.2 Coated modules

Coated modules are X20 modules with a protective coating for the electronics component. This coating protects X20c modules from condensation.
The modules' electronics are fully compatible with the corresponding X20 modules.

Information:

For simplification purposes, only images and module IDs of uncoated modules are used in this data sheet.

The coating has been certified according to the following standards:

- Condensation: BMW GS 95011-4, 2x 1 cycle
- Corrosive gas: EN 60068-2-60, Method 4, exposure 21 days

Contrary to the specifications for X20 system modules without safety certification and despite the tests performed, X20 safety modules are **NOT suited for applications with corrosive gases (EN 60068-2-60)!**

11.1.2.1 Starting temperature

The starting temperature describes the minimum permissible ambient temperature in a voltage-free state at the time the coated module is switched on. This is permitted to be as low as -40°C. During operation, the conditions as specified in the technical data continue to apply.

Information:

It is important to absolutely ensure that there is no forced cooling by air currents in the closed control cabinet, e.g. due to the use of a fan or ventilation slots.

11.1.3 Order data

Order number	Short description	Figure
	Analog input modules	
X20ST4492	X20 safe temperature input module, 2x 2 safe analog inputs for thermocouples, Type: J, K, N, S, R, C, T, resolution 0.1°C, 1x 2 safe analog inputs for PT100/PT1000 sensors, channel pairs galvanically isolated, integrated compensation of terminal temperature, integrated temperature sensor in terminal block X20TB5E, configurable input filter and switching thresholds	
	Required accessories	
	Bus modules	
X20BM33	X20 bus module, for X20 SafeIO modules, internal I/O power supply connected through	
X20BM36	X20 bus module, for X20 SafeIO modules, with node number switch, internal I/O power supply connected through	
	Terminal blocks	
X20TB5E	X20 terminal block, 16-pin, safety-keyed, 2x Pt1000 integrated for terminal temperature compensation	
X20TB5F	X20 terminal block, 16-pin, safety-keyed	

Table 23: X20ST4492 - Order data

11.1.4 Technical data

Order number	X20ST4492
Short description	
I/O module	2x 2 safe analog inputs for thermocouples, 1x 2 safe analog inputs for PT100/ PT1000 sensors, channel pairs galvanically isolated, integrated terminal temperature compensation, integrated temperature sensor in terminal block X20TB5E
General information	
B&R ID code	0xB419
System requirements	
Automation Studio	3.0.81.15 or later
Automation Runtime	3.00 or later
SafeDESIGNER	2.81 or later
Safety Release	1.4 or later
mapp Technology Package [1)]	mapp Safety 5.7.0 or later
Status indicators	I/O function per channel, operating state, module status
Diagnostics	
Module run/error	Yes, using LED status indicator and software
Inputs	Yes, using LED status indicator and software
Blackout mode	
Scope	Module
Function	Module functionality
Standalone mode	No
Max. I/O cycle time	2 ms
Power consumption	
Bus	0.25 W
Internal I/O	1.2 W
Additional power dissipation caused by actuators (resistive) [W]	-
Electrical isolation	
Channel - Bus	Yes
Channel - Channel	No
Channel pair - Channel pair	Yes
Certifications	
CE	Yes
Functional safety	cULus FSPC E361559 Energy and industrial systems Certified for functional safety ANSI UL 1998:2013
Functional safety	IEC 61508:2010, SIL 3 EN 62061:2013, SIL 3 EN ISO 13849-1:2015, Cat. 4 / PL e IEC 61511:2004, SIL 3
Functional safety	EN 50156-1:2004
ATEX	Zone 2, II 3G Ex nA nC IIA T5 Gc IP20, Ta (see X20 user's manual) FTZÚ 09 ATEX 0083X
UL	cULus E115267 Industrial control equipment
HazLoc	cCSAus 244665 Process control equipment for hazardous locations Class I, Division 2, Groups ABCD, T5
DNV	Temperature: **A** (0 - 45°C) Humidity: **B** (up to 100%) Vibration: **A** (0.7 g) EMC: **B** (bridge and open deck)
LR	ENV1
KR	Yes
ABS	Yes
EAC	Yes
KC	Yes
Safety characteristics	
Note	The following characteristic values apply only to the use of input channel pairs. Assessing the channels from a safety point of view when they are used individually is not possible. [2)]
EN ISO 13849-1:2015	
Category	Cat. 4
PL	PL e
DC	>94%
MTTFD	2200 years
Mission time	Max. 20 years

Table 24: X20ST4492 - Technical data

Order number	X20ST4492
IEC 61508:2010, IEC 61511:2004, EN 62061:2013	
SIL CL	SIL 3
SFF	>90%
PFH / PFH_d	
Per channel	$<1*10^{-9}$
openSAFETY wired	Negligible
openSAFETY wireless	$<1*10^{-14}$ * Number of openSAFETY packets per hour
PFD	$<1*10^{-4}$
Proof test interval (PT)	20 years
I/O power supply	
Nominal voltage	24 VDC
Voltage range	24 VDC -15% / +20%
Thermocouple temperature inputs	
Quantity	2 safe input channel pairs
Variant	Type thermocouple
Digital converter resolution	24-bit
Filter time	Configurable between 1 and 66.7 ms
Output format	SAFEINT
Measurement range	
Sensor temperature	
Type J: Fe-CuNi	-210.0 to 1200.0°C
Type K: NiCr-Ni	-270.0 to 1372.0°C
Type N: NiCrSi-NiSi	-270.0 to 1300.0°C
Type S: PtRh10-Pt	-50.0 to 1768.0°C
Type R: PtRh13-Pt	-50.0 to 1768.0°C
Type C: WRe5-WRe26	0 to 2320.0°C
Type T: Cu-CuNi	-270.0 to 400.0°C
Voltage	±65 mV
Max. internal resistance of source during voltage measurement	20 Ω
Terminal temperature compensation	Internal / External
Sensor standard	EN 60584
Resolution	
Sensor temperature	1 LSB = 0.1°C
Voltage	1 LSB = 2 µV
Conversion procedure	Sigma-delta
Linearization method	Internal
Permissible input signal	Max. ±1 V
Input filter	First-order low-pass filter / cutoff frequency 500 Hz
Basic accuracy [3]	
Type J: Fe-CuNi	1.41°C
Type K: NiCr-Ni	1.81°C
Type N: NiCrSi-NiSi	1.73°C
Type S: PtRh10-Pt	3.10°C
Type R: PtRh13-Pt	3.10°C
Type C: WRe5-WRe26	3.48°C
Type T: Cu-CuNi	0.74°C
Voltage	78 µV
Max. gain drift [4]	0.013 %/°C
Max. offset drift	
Type J: Fe-CuNi	0.0297°C per °C
Type K: NiCr-Ni	0.0427°C per °C
Type N: NiCrSi-NiSi	0.0471°C per °C
Type S: PtRh10-Pt	0.1637°C per °C
Type R: PtRh13-Pt	0.1455°C per °C
Type C: WRe5-WRe26	0.1068°C per °C
Type T: Cu-CuNi	0.0335°C per °C
Voltage	1.69 µV per °C
Terminal temperature compensation	
Accuracy of internal terminal temperature	15°C at static temperatures and during safe operation
Common-mode rejection	
DC	>70 dB
50 Hz	>70 dB
Common-mode range	±4 V within channel pair, ±50 V between 2 channel pairs
Crosstalk between channels	≤70 dB
Insulation voltage between channel and bus	500 VDC

Table 24: X20ST4492 - Technical data

Order number	X20ST4492
Safety-related accuracy per channel	
Type J: Fe-CuNi	35.25°C
Type K: NiCr-Ni	47.62°C
Type N: NiCrSi-NiSi	51.81°C
Type S: PtRh10-Pt	150.90°C
Type R: PtRh13-Pt	134.54°C
Type C: WRe5-WRe26	111.36°C
Type T: Cu-CuNi	30.82°C
Voltage	2080 µV
Resistance measurement temperature inputs	
Quantity	1 safe input channel pair
Variant	Type PT100/PT1000
Measurement range	
Pt100	-200.0 to 850.0°C
Pt1000	-200.0 to 850.0°C
Basic accuracy [3]	
Pt100	1.89°C
Pt1000	0.53°C
Measurement current	262 µA ±5%
Max. gain drift [4]	0.004 %/°C
Max. offset drift	
Pt100	0.0525°C per °C
Pt1000	0.0053°C per °C
Temperature sensor resolution	
Pt100	1 LSB = 0.1°C
Pt1000	1 LSB = 0.1°C
Input filter	
Cutoff frequency	500 Hz first-order
Max. line length	50 m
Max. line resistance	5 Ω
Safety-related accuracy per channel	
Pt100	12.60°C
Pt1000	8.93°C
Operating conditions	
Mounting orientation	
Horizontal	Yes
Vertical	Yes
Installation elevation above sea level	0 to 2000 m, no limitation
Degree of protection per EN 60529	IP20
Ambient conditions	
Temperature	
Operation	
Horizontal mounting orientation	0 to 60°C
Vertical mounting orientation	0 to 50°C
Derating	See section "Derating".
Storage	-40 to 85°C
Transport	-40 to 85°C
Relative humidity	
Operation	5 to 95%, non-condensing
Storage	5 to 95%, non-condensing
Transport	5 to 95%, non-condensing
Mechanical properties	
Note	Order 1x safety-keyed terminal block separately. Order 1x safety-keyed bus module separately.
Pitch	$25^{+0.2}$ mm

Table 24: X20ST4492 - Technical data

1) The system requirements of the mapp Technology Package must be observed (see Automation Help).
2) In addition, the danger notices in the technical data sheet and section "Safety technology" in Automation Help must be observed.
3) At 25°C
4) Based on the measured value

Derating

Starting at a temperature of 55°C (horizontal mounting orientation), dummy modules must be connected next to the X20ST4492.

Module	X20ST4492
Derating bonus	
Dummy module on the left	+0°C
Dummy module on the right	+2.5°C
Dummy module on the left and right	+5°C

Table 25: Derating bonus

Danger!

Operation outside the technical data is not permitted and can result in dangerous states.

Information:

For additional information about installation, see section "Installation notes for X20 modules" in Automation Help.

11.1.5 LED status indicators

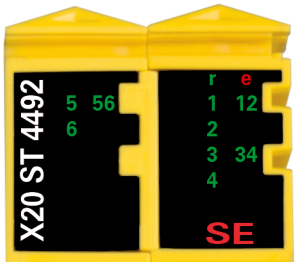
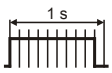
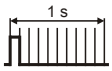
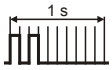
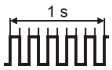
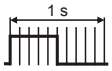
Figure	LED	Color	Status	Description
	r	Green	Off	No power to module
			Single flash	Mode "Reset"
			Double flash	Updating firmware
			Blinking	Mode PREOPERATIONAL
			On	Mode RUN
	e	Red	Off	Module not supplied with power or everything OK
			Pulsating	Bootloader mode
			Triple flash	Updating safety-related firmware
			On	Error or I/O component not provided with voltage
	e + r	Solid red / Single green flash		Invalid firmware
	1 to 6	Input state of the corresponding analog input		
		Red	On	Warning/Error on the input channel
			Blinking	Open circuit on corresponding channel
			All on	Error on all channels, connection to the SafeLOGIC controller not OK or startup not yet completed
		Green	On	Channel being used and signal OK
			Blinking	Channel outside of the limits configured in SafeDESIGNER
			Off	Channel not used
	12, 34, 56	Input state of the corresponding analog input channel pair		
		Red	On	Warning/Error on this channel pair
			All on	Error on all channels, connection to the SafeLOGIC controller not OK or startup not yet completed
		Green	On	Signal on channel pair OK
			Off	Signal on channel pair not OK
	SE	Red	Off	Mode RUN or I/O component not provided with voltage
				Boot phase, missing X2X Link or defective processor
				Safety PREOPERATIONAL state Modules that are not used in the SafeDESIGNER application remain in state PREOPERATIONAL.
				Safe communication channel not OK
				The firmware for this module is a non-certified pilot customer version.
				Boot phase, faulty firmware
			On	Safety state active for the entire module (= state "FailSafe")
		The "SE" LEDs separately indicate the status of safety processor 1 ("S" LED) and safety processor 2 ("E" LED).		

Table 26: Status indicators

Danger!

Constantly lit "SE" LEDs indicate a defective module that must be replaced immediately.
It is your responsibility to ensure that all necessary repair measures are initiated after an error occurs since subsequent errors can result in a hazard!

11.1.6 Pinout

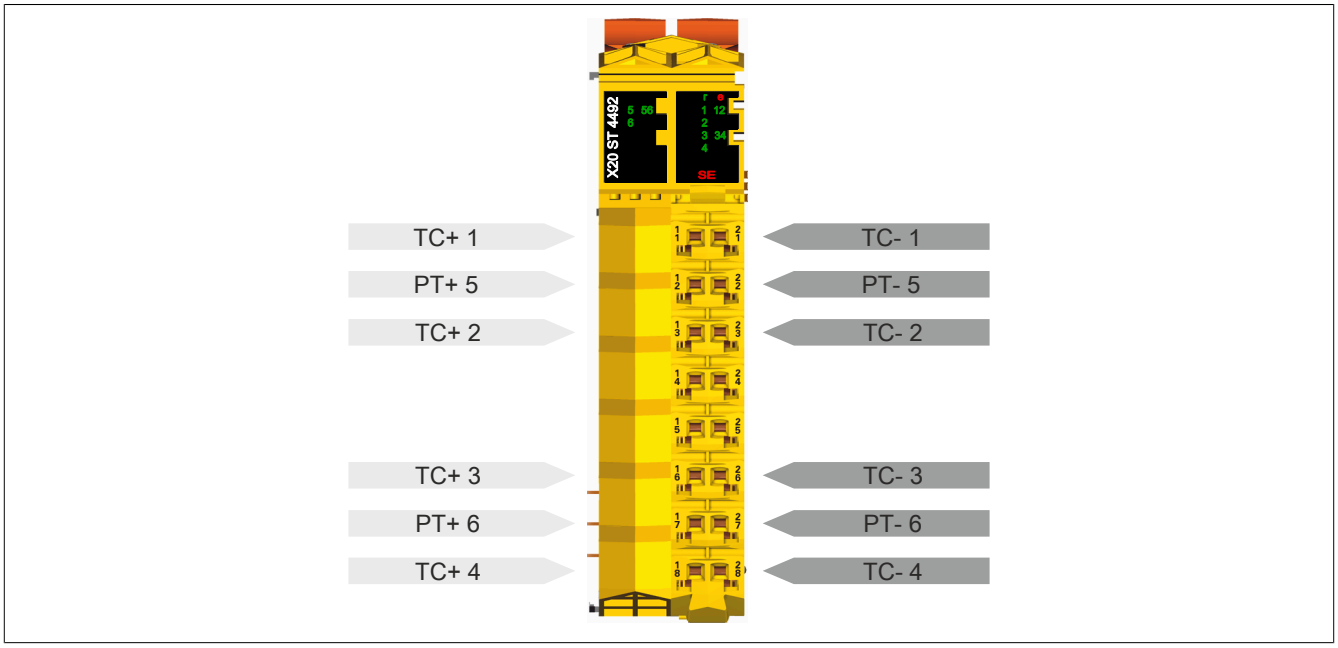


Figure 1: X20ST4492 - Pinout

11.1.7 Input circuit diagram

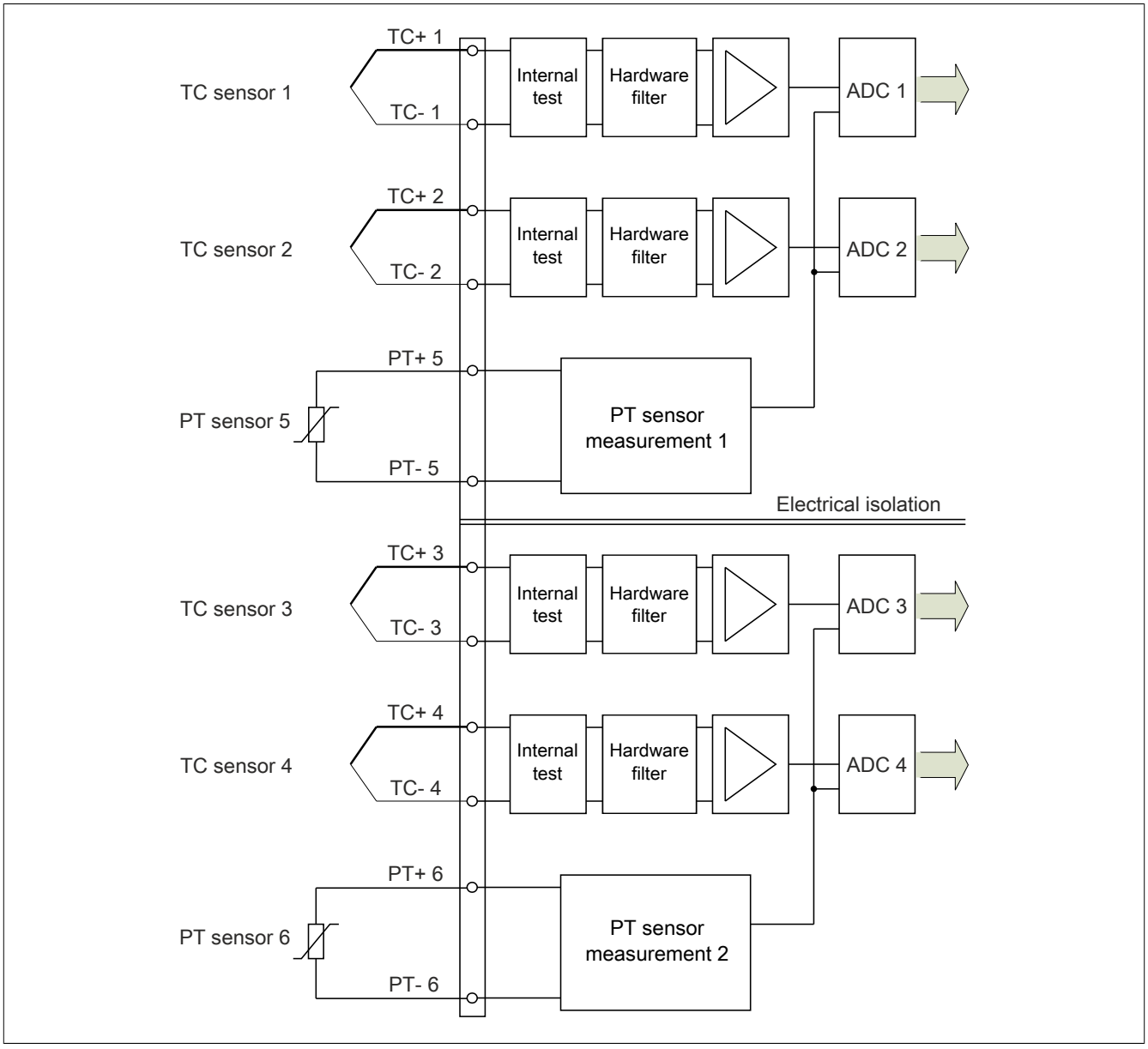


Figure 2: Input circuit diagram

11.1.8 Register description

11.1.8.1 Parameters in the I/O configuration

Group: Function model

Parameter	Description	Default value	Unit
Function model	This parameter is reserved for future functional expansions.	Default	-

Table 27: I/O configuration parameters: Function model

Group: General

Parameter	Description	Default value	Unit
Module supervised	System behavior when a module is missing	On	-
	Parameter value / **Description** On: A missing module triggers service mode. Off: A missing module is ignored.		
Blackout mode	This parameter enables blackout mode (see section Blackout mode in Automation Help under: Hardware → X20 system → Additional information → Blackout mode).	Off	-
	Parameter value / **Description** On: Blackout mode is enabled. Off: Blackout mode is disabled.		
SafeDOMAIN ID	In applications with multiple SafeLOGIC controllers, this parameter defines the module's association with a particular SafeLOGIC controller. • Permissible values: 1 to 1000	Assigned automatically	-
SafeNODE ID	Unique safety address of the module • Permissible values: 2 to 1023	Assigned automatically	-

Table 28: I/O configuration parameters: General

11.1.8.2 Parameters in SafeDESIGNER

Group: Basic

Parameter	Description	Default value	Unit
Min. required firmware revision	This parameter is reserved for future functional expansions.	Basic release	-
Availability	This parameter can be used to configure the module as "optional". Optional modules do not have to be present, i.e. the SafeLOGIC controller will not indicate that these modules are not present. However, this parameter does not influence the module's signal or status data.	Permanent	-

Parameter value	Description
Permanent	This module is mandatory for the application. The module must be in OPERATIONAL mode after startup, and safe communication with the SafeLOGIC controller must be established without errors (SafeModuleOK = SAFETRUE). Processing of the safety application on the SafeLOGIC controller is delayed after startup until this state is achieved for all modules with "Availability = Permanent". After startup, module problems are indicated by a quickly blinking "MXCHG" LED on the SafeLOGIC controller. An entry is also made in the logbook.
Optional	The module is not required for the application. The module is not taken into account during startup, which means the safety application is started regardless of whether the modules with "Availability = Optional" are in OPERATIONAL mode or if safe communication is properly established between these modules and the SafeLOGIC controller. After startup, module problems are NOT indicated by a quickly blinking "MXCHG" LED on the SafeLOGIC controller. An entry is NOT made in the logbook.
Startup	This module is optional. The system determines how the module will proceed during startup. If it is determined that the module is physically present during startup (regardless of whether it is in OPERATIONAL mode or not), then the module behaves as if "Availability = Permanent" is set. If it is determined that the module is not physically present during startup, then the module behaves as if "Availability = Optional" is set.
Never	The module is not required for the application. The module is not taken into account during startup, which means the safety application is started regardless of whether the modules with "Availability = Never" are physically present. Unlike when "Availability = Optional" is configured, the module is not started with "Availability = Never", which optimizes system startup behavior. After startup, module problems are NOT indicated by a quickly blinking "MXCHG" LED on the SafeLOGIC controller. An entry is NOT made in the logbook.

Table 29: SafeDESIGNER parameters: Basic

Group: Safety response time

Parameter	Description	Default value	Unit
Manual configuration	This parameter makes it possible to manually and individually configure the safety response time for the module. The parameters for the safety response time are generally set in the same way for all stations involved in the application. For this reason, these parameters are configured for the SafeLOGIC controller in SafeDESIGNER. For application situations in which individual safety functions require optimal response time behavior, the parameters for the safety response time can be configured individually on the respective module.	No	-
	Parameter value / **Description** Yes: Data from the module's "Safety response time" group is used to calculate the safety response time for the module's signals. No: The parameters for the safety response time are taken from the "Safety response time" group on the SafeLOGIC controller.		
Safe data duration	This parameter specifies the maximum permissible data transmission time between the SafeLOGIC controller and SafeIO module. For additional information about the actual data transmission time, see section Diagnostics and service → Diagnostics tools → Network analyzer → Editor → Calculation of safety runtime in Automation Help. The following formula can be used as the lower limit: "Value of the Network Analyzer" * 2 + SafeLOGIC cycle time * 2 The stability of the system cannot be ensured for smaller values. • Permissible values: 2000 to 10,000,000 µs (corresponds to 2 ms to 10 s)	20000	µs
Additional tolerated packet loss	This parameter specifies the number of additional tolerated lost packets during data transfer. • Permissible values: 0 to 10	1	Packets
Node guarding packets	This parameter specifies the maximum number of packets used for node guarding. • Permissible values: 1 to 255 **Note** • The larger the configured value, the greater the amount of asynchronous data traffic. • This setting is not critical to safety functionality. The time for safely cutting off actuators is determined independently of this.	5	Packets

Table 30: SafeDESIGNER parameters: Safety response time

Group: Module configuration

Parameter	Description	Default value	Unit
Dual-channel mode	This value sets the channels being used for dual-channel evaluation.	Channel 12	-
	Parameter value / **Description** Channel 12: Channels 1 and 2 as well as Channels 3 and 4 are used for dual-channel evaluation. Channel 13: Channels 1 and 3 as well as Channels 2 and 4 are used for dual-channel evaluation.		
Input filter	This parameter sets the filter time of A/D converters. • Permissible values: 1 ms, 2 ms, 10 ms, 16.7 ms, 20 ms, 33.3 ms, 40 ms, 66.7 ms	1	ms

Table 31: SafeDESIGNER parameters: Module configuration

Group: SafeTemperatureInputxx

Parameter	Description	Default value	Unit
Sensor type (for SafeTemperatureInput01-04)	This parameter can be used to specify the type of sensor connected. • Permissible values: Type J, Type K, Type N, Type S, Type R, Type C, Type T, Voltage [µV]	Type J	-
Sensor type (for SafeTemperatureInput05-06)	This parameter can be used to specify the type of sensor connected. • Permissible values: PT100, PT1000	PT1000	-

Table 32: SafeDESIGNER parameters: SafeTemperatureInputxx

Danger!

The use or configuration of an incorrect TC sensor type CANNOT be detected by the module. The temperature value acquired by the module is incorrect.

Make sure during validation that the correct TC sensor type is installed and configured.

Information:

The use or configuration of an incorrect PT sensor type is detected by the module. The module will switch to the FAILSAFE state.

Group: SafeTemperaturexxyy

Parameter	Description	Default value	Unit
Limit threshold equivalent x	This parameter specifies the limit value for the "Dual-channel evaluation" function for the maximum temperature difference between the two channels. • Permissible values during temperature measurement: Corresponds to the thermocouple type • Permissible values during voltage measurement: -2,147,483,648 to +2,147,483,647	1000	0.1°C 2 µV
Discrepancy time x	This parameter specifies the maximum time for the "Dual-channel evaluation" function in which the difference between both analog input values is permitted to exceed the limit value. • Permissible values: 0 to 10,000 ms (corresponds to 0 to 10 s)	0	ms

Table 33: SafeDESIGNER parameters: SafeTemperaturexxyy

Parameters "Limit threshold equivalent x" and "Discrepancy time x" together form a parameter set. Channels "SafeThresholdSelector_xxyy_Bit1" and "SafeThresholdSelector_xxyy_Bit2" are available in the SafeDESIGNER application to determine which parameter set in the module is enabled, i.e. it is possible to change the parameter set at runtime.

11.1.8.3 Channel list

Channel name	Access via Automation Studio	Access via SafeDESIGNER	Data type	Description
ModuleOk	Read	-	BOOL	Indicates whether the module is physically present in the slot and configured
SerialNumber	Read	-	UDINT	Module serial number
ModuleID	Read	-	UINT	Module ID
HardwareVariant	Read	-	UINT	Hardware variant
FirmwareVersion	Read	-	UINT	Firmware version of the module
UDID_low	(Read) [1]	-	UDINT	UDID, lower 4 bytes
UDID_high	(Read) [1]	-	UINT	UDID, upper 2 bytes
SafetyFWversion1	(Read) [1]	-	UINT	Firmware version - Safety processor 1
SafetyFWversion2	(Read) [1]	-	UINT	Firmware version - Safety processor 2
SafetyFWcrc1	(Read) [1]	-	UINT	CRC of the firmware header on safety processor 1
SafetyFWcrc2	(Read) [1]	-	UINT	CRC of the firmware header on safety processor 2
Bootstate	(Read) [1]	-	UINT	Startup state of the module. Notes: • Some of the boot states do not occur during normal startup or are cycled through so quickly that they are not visible externally. • The boot states usually cycle through in ascending order. There are cases, however, in which a previous value is captured. **Value** / **Description** 0x0003: Startup communication processor OK, no communication with the safety processors (check 24 V supply voltage!) 0x0010: FAILSAFE. At least one of the safety processors is in the safe state. 0x0020: Internal communication with safety processors started 0x0024: Firmware update of safety processors 0x0040: Firmware of safety processors started 0x0440: Firmware of safety processors running 0x0840: Waiting for openSAFETY "Operational" (loading the SafeDESIGNER application or no valid application available; waiting for acknowledgments such as module replacement) 0x1040: Evaluating the configuration according to the SafeDESIGNER application 0x3440: Stabilizing cyclic openSAFETY data exchange. **Note:** If the boot state remains here, SafeDESIGNER parameters "(Default) Safe data duration" and "(Default) Additional tolerated packet loss" must be checked. 0x4040: RUN. Final state, startup completed.
Diag1_Temp	(Read) [1]	-	INT	Module temperature in °C
oS_PropDelayStat (hardware upgrade 2.3.0.0 or later)	(Read) [1]	-	UDINT	Propagation delay statistics (average value of the data transmission time). The unit depends on parameter "Process data transfer rate" of the SafeLOGIC controller. • If the value of the parameter is "High", the unit is 100 µs. • If the value of the parameter is "Low", the unit is 1 ms. This value corresponds to the measurement of the forward and return channels and thus twice the theoretical runtime that is determined by the Network Analyzer.
SafeModuleOK	Read	Read	SAFEBOOL	Indicates whether the safe communication channel is OK
SafeTemperatureOKxxyy	Read	Read	SAFEBOOL	Status of dual-channel temperature evaluation xx/yy
TestActive	Read	Read	BOOL	Indication of an active channel test
EquivalentThresholdxxyy	(Read) [1]	-	UINT	Limit value "Limit threshold equivalent" currently in use (see "SafeDESIGNER parameters: SafeTemperaturexxyy")
DiscrepancyTimeThresholdxxyy	(Read) [1]	-	UINT	Limit value "Discrepancy time" currently in use (see "SafeDESIGNER parameters: SafeTemperaturexxyy")
SafeTemperaturexxyy	Read	Read	SAFEINT	(Temperature channel xx + Temperature channel yy)/2
TemperatureOKxx	Read	Read	BOOL	Status of temperature evaluation xx
Temperature_A	Read	-	INT	Temperature of the temperature channel selected with "TempChannel_Select_A"

Table 34: Channel list

<table>
<tr><th>Channel name</th><th>Access via Automation Studio</th><th>Access via SafeDESIGNER</th><th>Data type</th><th>Description</th></tr>
<tr><td>TempChannel_Select_A</td><td>Write</td><td>-</td><td>USINT</td><td>Selection of the temperature to be transferred on channel "Temperature_A".
<table><tr><th>Value</th><th>Description</th></tr><tr><td>0</td><td>The value from channel 2 is transferred.</td></tr><tr><td>1</td><td>The value from channel 1 is transferred.</td></tr><tr><td>2</td><td>The value from channel 2 is transferred.</td></tr><tr><td>3</td><td>The value from channel 3 is transferred.</td></tr><tr><td>4</td><td>The value from channel 4 is transferred.</td></tr><tr><td>5</td><td>The value from channel 5 is transferred.</td></tr><tr><td>6</td><td>The value from channel 6 is transferred.</td></tr><tr><td>≥7</td><td>The value from channel 2 is transferred.</td></tr></table></td></tr>
<tr><td>SafeThresholdSelector_xxyy_Bit1</td><td>-</td><td>Write</td><td>SAFEBOOL</td><td></td></tr>
<tr><td>SafeThresholdSelector_xxyy_Bit2</td><td>-</td><td>Write</td><td>SAFEBOOL</td><td><table><tr><th>**_Bit1</th><th>**_Bit2</th><th>Parameters currently being used</th></tr><tr><td>0</td><td>0</td><td>Parameter set 1</td></tr><tr><td>1</td><td>0</td><td>Parameter set 2</td></tr><tr><td>0</td><td>1</td><td>Parameter set 3</td></tr><tr><td>1</td><td>1</td><td>Parameter set 4</td></tr></table></td></tr>
<tr><td>SafeReleasexxyy</td><td>-</td><td>Write</td><td>SAFEBOOL</td><td>Release signal - Channel xxyy</td></tr>
</table>

Table 34: Channel list

1) This data is accessed in Automation Studio using library ASIOACC.

Danger!

The validity of analog signals is represented by the associated status signals. These binary status signals (data type SAFEBOOL) must also be evaluated each time the analog signals are used. A binary status signal with the status FALSE indicates an invalid value in the analog signal. In these situations, the analog signal is no longer permitted to be used for safety-related assessments.

11.1.9 Minimum cycle time

The minimum cycle time specifies the time up to which the bus cycle can be reduced without communication errors occurring.

Minimum cycle time
200 µs

11.1.10 I/O update time

The time needed by the module to generate a sample is specified by the I/O update time.

Configured filter	Maximum I/O update time
1 ms	32 ms
2 ms	40 ms
10 ms	86 ms
16.7 ms	132 ms
20 ms	152 ms
33.3 ms	240 ms
40 ms	284 ms
66.7 ms	372 ms

11.1.11 Version history

Version	Date	Comment
2.20	February 2024	Updated chapters 11.1.6 "Pinout" and 11.1.7 "Input circuit diagram".
2.14	May 2022	• Chapter 11.1.4 "Technical data": – Safety characteristics: Editorial change for PFH / PFH_d – Updated DNV certification. • Updated chapter 11.1.12 "Declaration of conformity".
2.10	May 2021	Chapter 11.1.4 "Technical data": • Updated display of system requirements. • Safety characteristics: Updated footnote.
2.08	November 2020	• Chapter 11.1.4 "Technical data": – Thermocouple temperature inputs: Added number of channels. – Resistance measurement temperature inputs: Added number of channels. • Editorial changes.
2.07	August 2020	• Chapter 11.1.4 "Technical data": – General information: Added additional power dissipation caused by actuators (resistive) [W]. – Updated certifications. • Editorial changes.
2.06	May 2020	• Chapter 11.1.1 "General information": Updated description. • Chapter 11.1.4 "Technical data": – Added footnote for system requirements. – Updated certifications. – Thermocouple temperature inputs: Added variant. – Resistance measurement temperature inputs: Added variant. • Chapter 11.1.8.3 "Channel list": Added channel "oS_PropDelayStat".
2.05	February 2020	Editorial changes.
2.04	November 2019	• Chapter 11.1.4 "Technical data": – Updated certifications. – Resistance measurement temperature inputs: Updated basic accuracy. – Resistance measurement temperature inputs: Updated max. offset drift. – Resistance measurement temperature inputs: Updated safety-related accuracy per channel. • Editorial changes.
2.03	August 2019	Chapter 11.1.8.3 "Channel list": Updated description of channel "TempChannel_Select_A".
2.02	May 2019	First edition for mapp Safety

Table 35: Version history

11.1.12 Declaration of conformity

This document was originally written in the German language. The German edition therefore represents the original documentation in accordance with Machinery Directive 2006/42/EC. Documents in other languages should be interpreted as translations of the original documentation.

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Declarations of conformity for B&R products are available for download on the B&R website (www.br-automation.com).