X20AT2402

1 General information

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	
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 1: X20AT2402 - Order data

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.

2 Technical description

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 2: 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 2: 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 2: X20AT2402 - Technical data

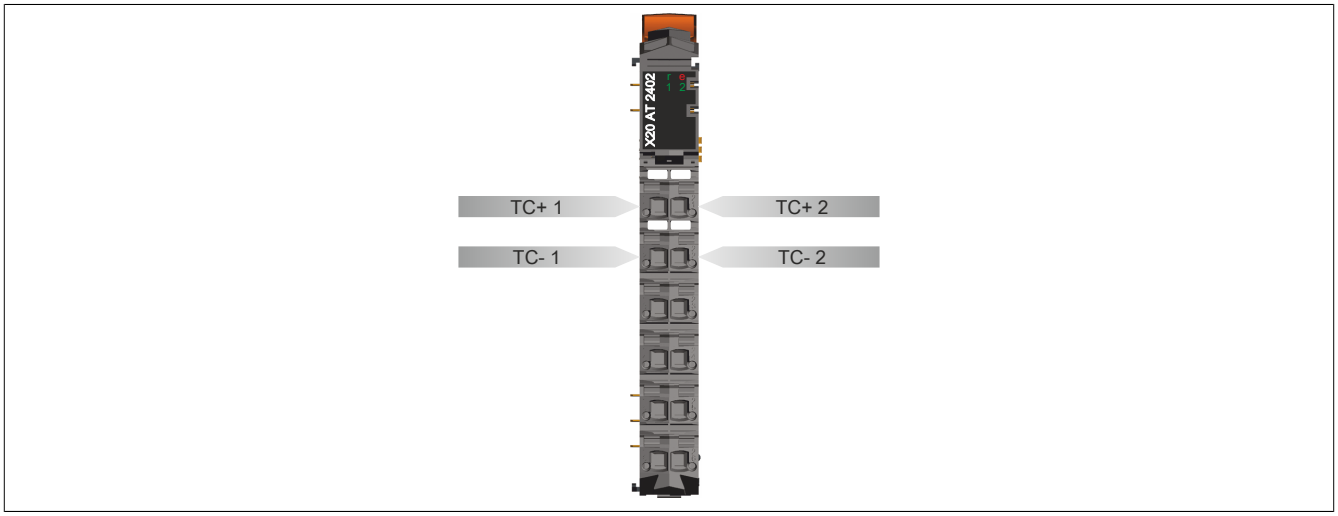
1) Based on the current measured value.
2) Based on the entire measurement range.

2.2 LED status indicators

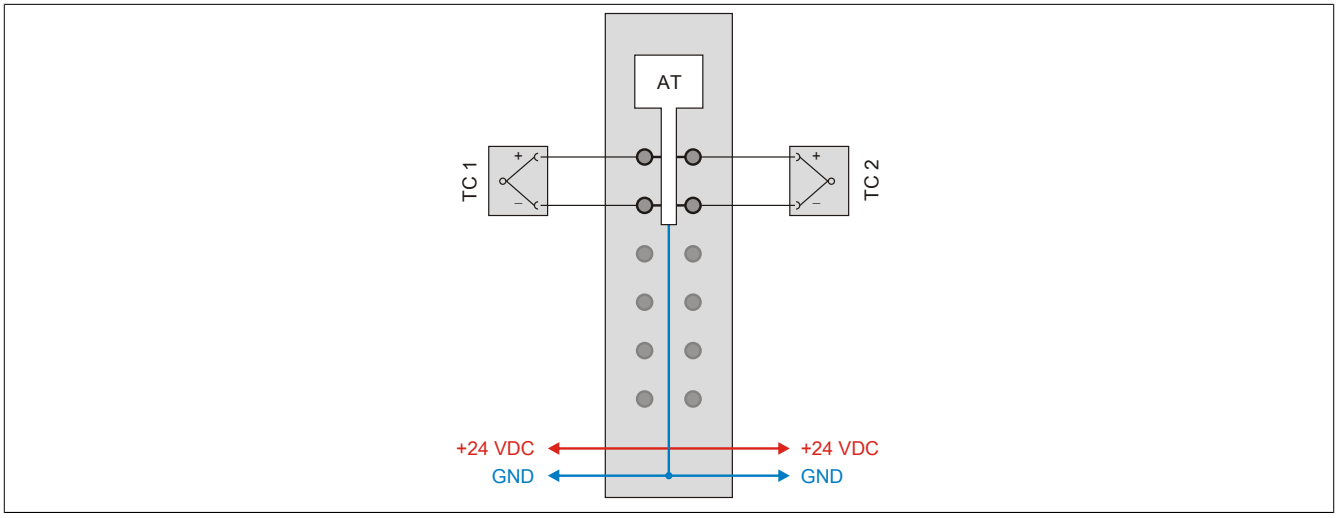
For a description of the various operating modes, see section "Additional information - Diagnostic LEDs" in the X20 System user's manual.

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

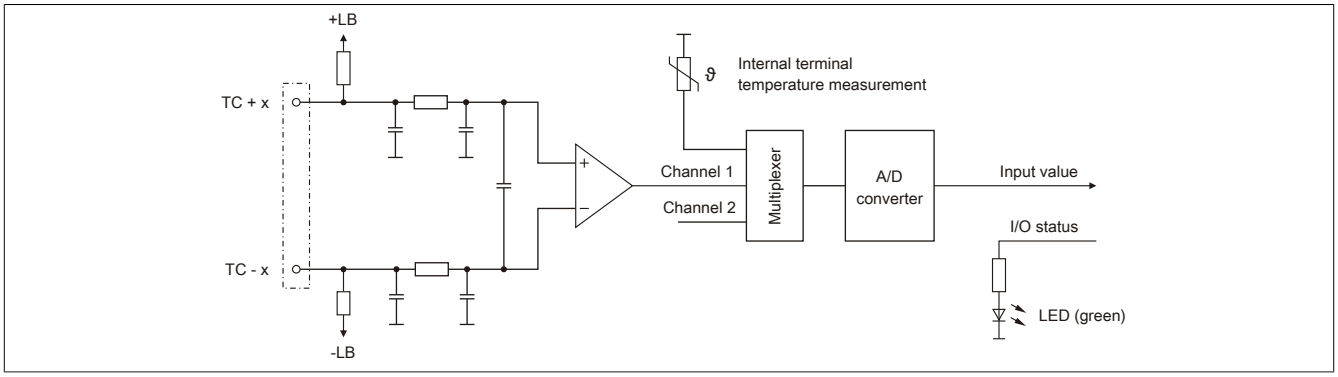
2.3 Pinout



2.4 Connection example

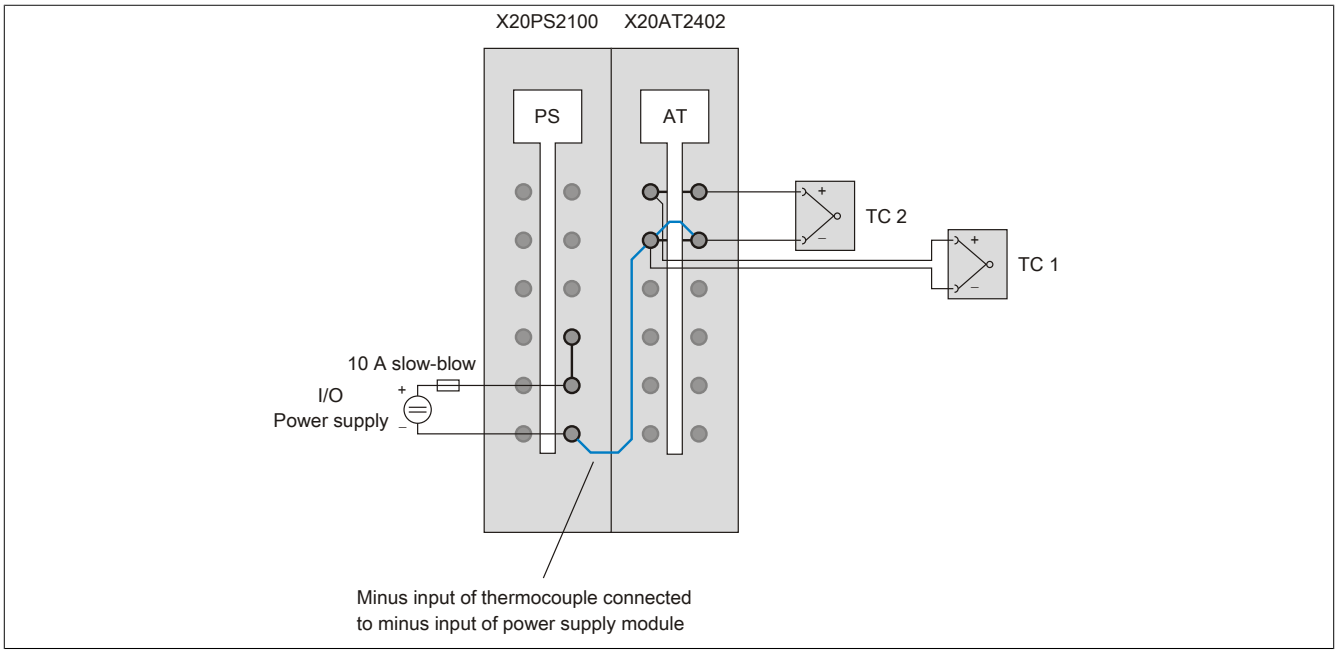


2.5 Input circuit diagram



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.



2.7 External cold junction

General information

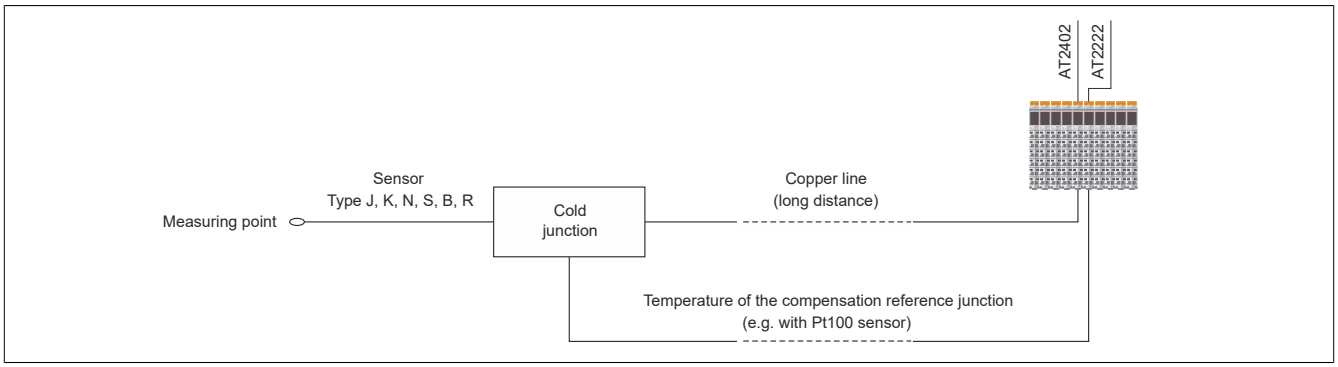
An external cold junction temperature value can be predefined for the module for measurement value correction. This makes it possible to set up an external cold junction. The same external cold junction temperature is used for measurement value correction on all channels.

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 Function description

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 13.

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 13.

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 15.

4 Commissioning

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).

4.1.1 CAN I/O bus controller

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

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.

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.

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.

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

5 Register description

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.

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	•			

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	•			

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.

5.5 Configuration

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 9 and "Ambient conditions" on page 11.

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

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

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 11).

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	

5.6 Communication

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

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

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

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 10.

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	

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

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

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

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)