X20ATC402

Data sheet
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Translation of the original documentation

Publishing information

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Version history

B&R makes every effort to keep documents as current as possible. The most current versions are available for download on the B&R website (www.br-automation.com).

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

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 1: X20ATC402 - Order data

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.

2 Technical description

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)
CCS	Yes
LR	ENV1
ABS	Yes
BV	**EC33B** Temperature: 5 - 55°C Vibration: 4 g EMC: Bridge and open deck
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

Table 2: X20ATC402 - Technical data

Order number	X20ATC402
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
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}

Table 2: X20ATC402 - Technical data

Order number	X20ATC402
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 X20TB1E for internal/re- mote 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 2: 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.

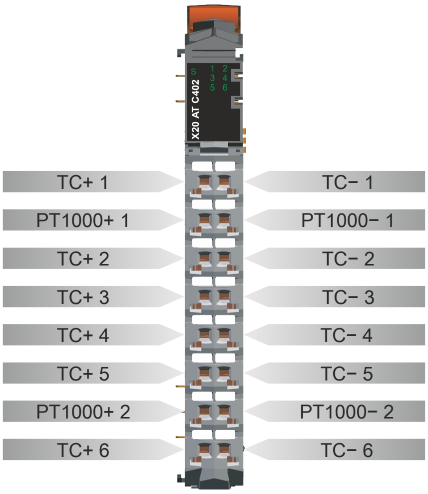
2.2 LED status indicators

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.

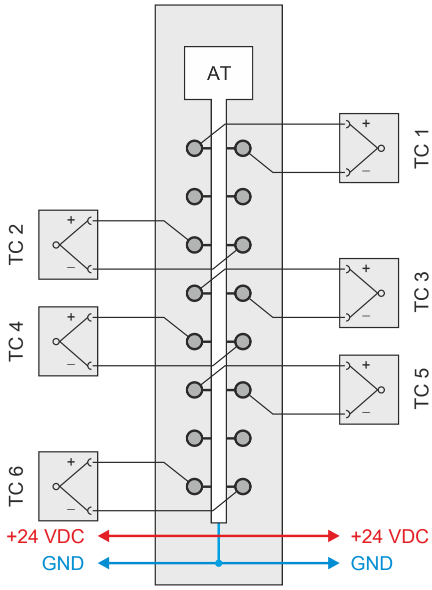
2.3 Pinout



2.4 Connection examples

Internal temperature compensation

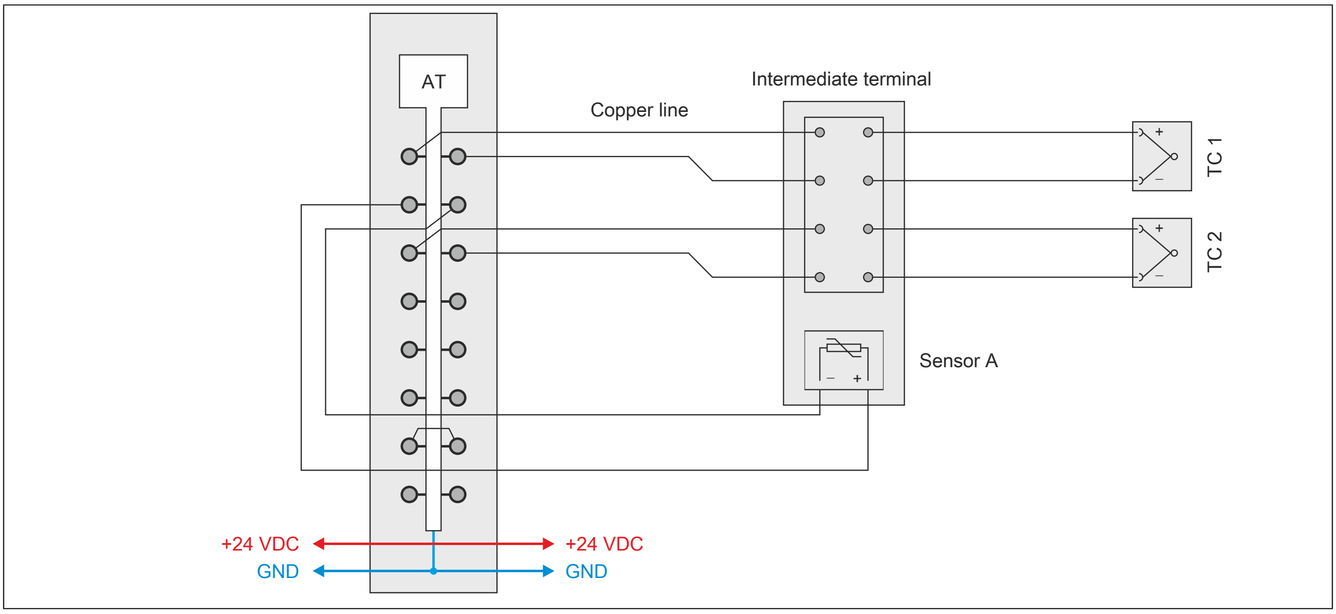
The thermocouple terminal X20TB1E with integrated PT1000 sensors is used for internal temperature compensation.



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.

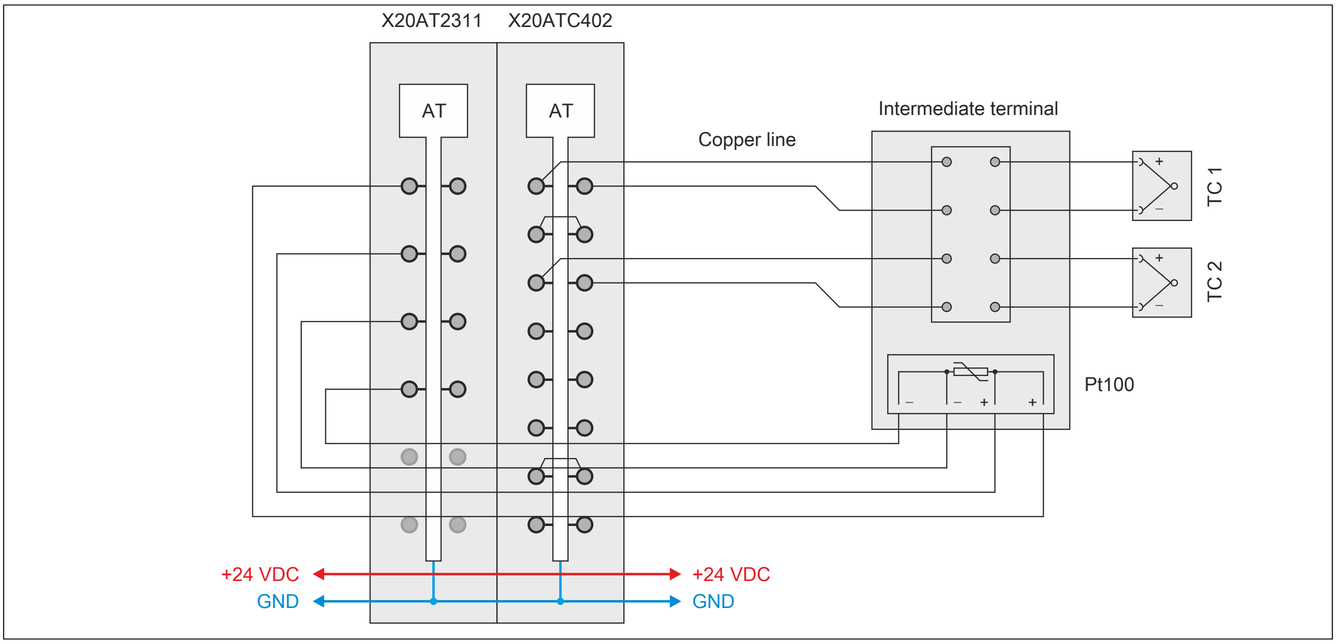


External temperature compensation

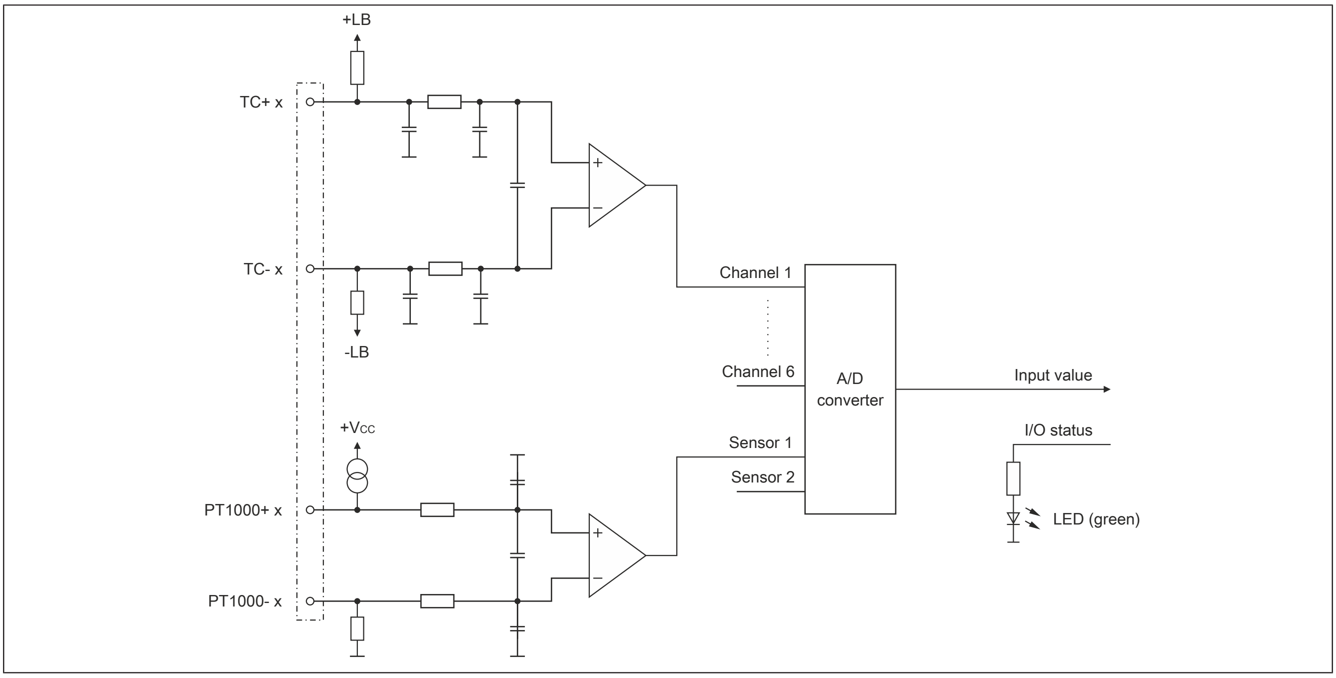
External compensation does not require the Pt1000 values to be converted internally in the module. Instead, the reference temperatures must be prepared in the program sequence and specified to the module. A separate register is available for each temperature channel for transferring an externally prepared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



2.5 Input circuit diagram



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.

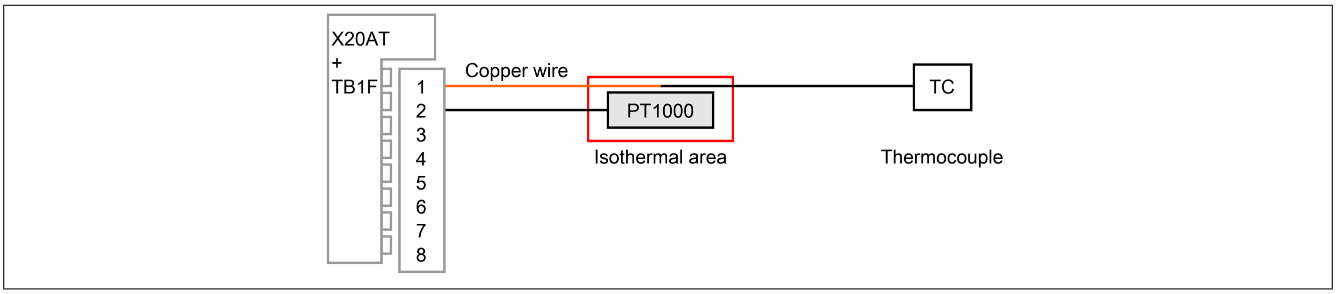
The installation of a remote or external cold junction is especially helpful in the following cases.

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

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

3 Function description

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 22.

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 20.

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).

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 10.

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.

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.

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 20 and "Status of the compensation value" on page 21.

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 25.

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.

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. **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.**	"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 described in "Configuring the limit values" on page 23.

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.

NetTime TECHNOLOGY

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.

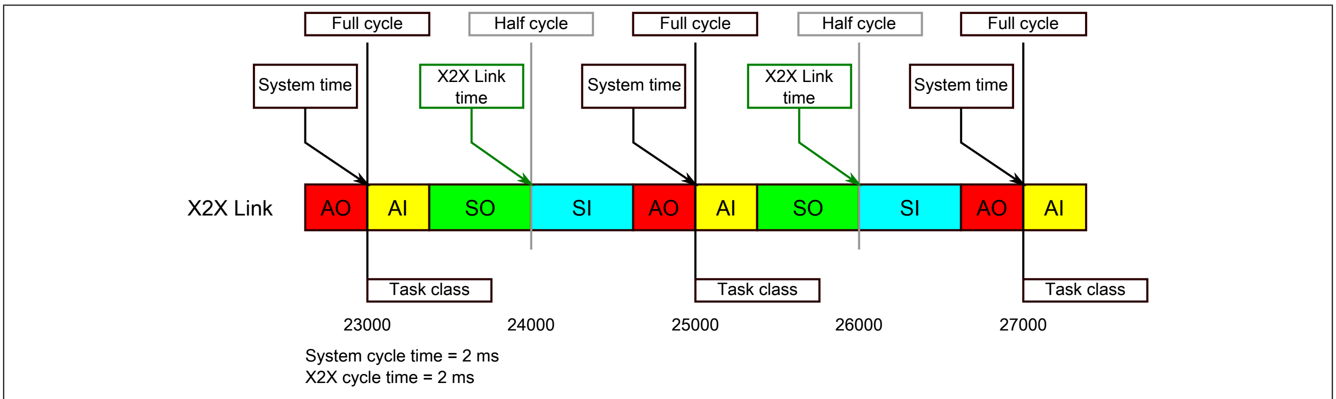
The initialization of the times is based on the system time during the startup of the X2X Link, the I/O modules or the POWERLINK interface.

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

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.

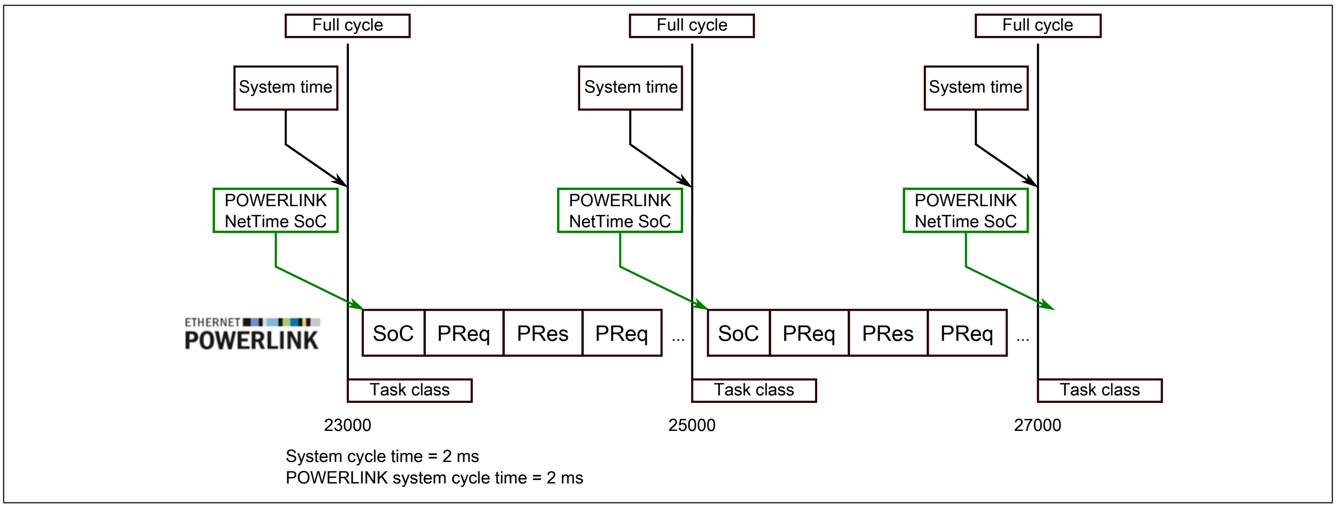
3.5.1.2 X2X Link - Reference time point



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.

3.5.1.3 POWERLINK - Reference time point

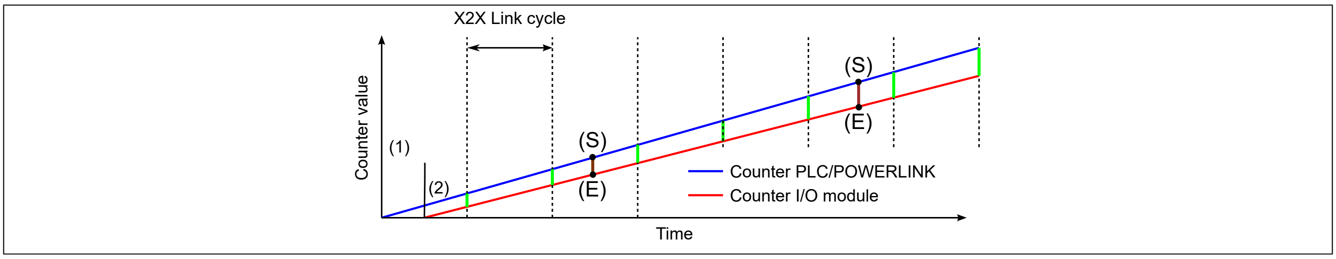


The POWERLINK reference time point is always calculated at the start of cycle (SoC) of the POWERLINK network. The SoC starts 20 µs after the system clock due to the system. This results in the following difference between the system time and the POWERLINK reference time:

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.

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.

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.

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.

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.

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.

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 2 analog logical slots on CAN I/O.

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 - 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				

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.

5.4 Module configuration

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.

5.5 Compensation

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 21)	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.

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

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 20 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

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 26.

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 20 register
7	Reserved	-	

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

5.6 Temperature measurement - Configuration

The temperature measurement channels can be configured independently of each other. The "Cfo_SensorType" on page 22 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.

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.

5.7 Configuring the limit values

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

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

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

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 13.

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 22 register.

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 22.

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 22 register.

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.

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 22:

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	

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 22:

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	

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 14.

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

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

5.9 Status messages

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

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

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 25 and "Cfo_SumErrorDelay" on page 26 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 21 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 20
7	Reserved	-	

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	-	

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

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