X20ATA492

Data sheet
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Translation of the original documentation

Publishing information

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Disclaimer

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	
X20ATA492	X20 temperature input module, 2 thermocouple inputs, type J, K, N, S, B, R, E, C, T, single-channel galvanically isolated, 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: X20ATA492 - Order data

1.3 Module description

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

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	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
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 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

Table 2: X20ATA492 - Technical data

Technical description

Order number	X20ATA492
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
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 J: Fe-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: WRe5-WRe26	±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

Table 2: X20ATA492 - Technical data

Order number	X20ATA492
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 2: 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.

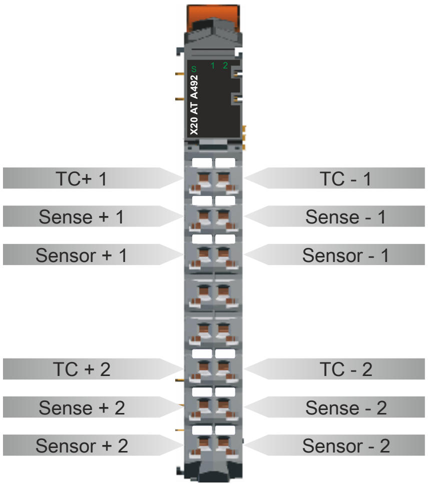
2.2 LED status indicators

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	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.

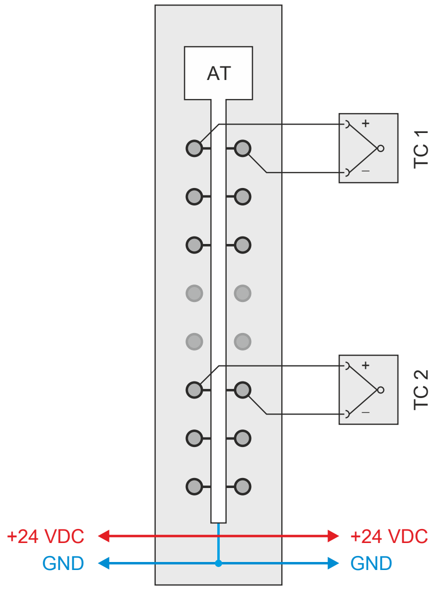
2.3 Pinout



2.4 Connection examples

Internal temperature compensation

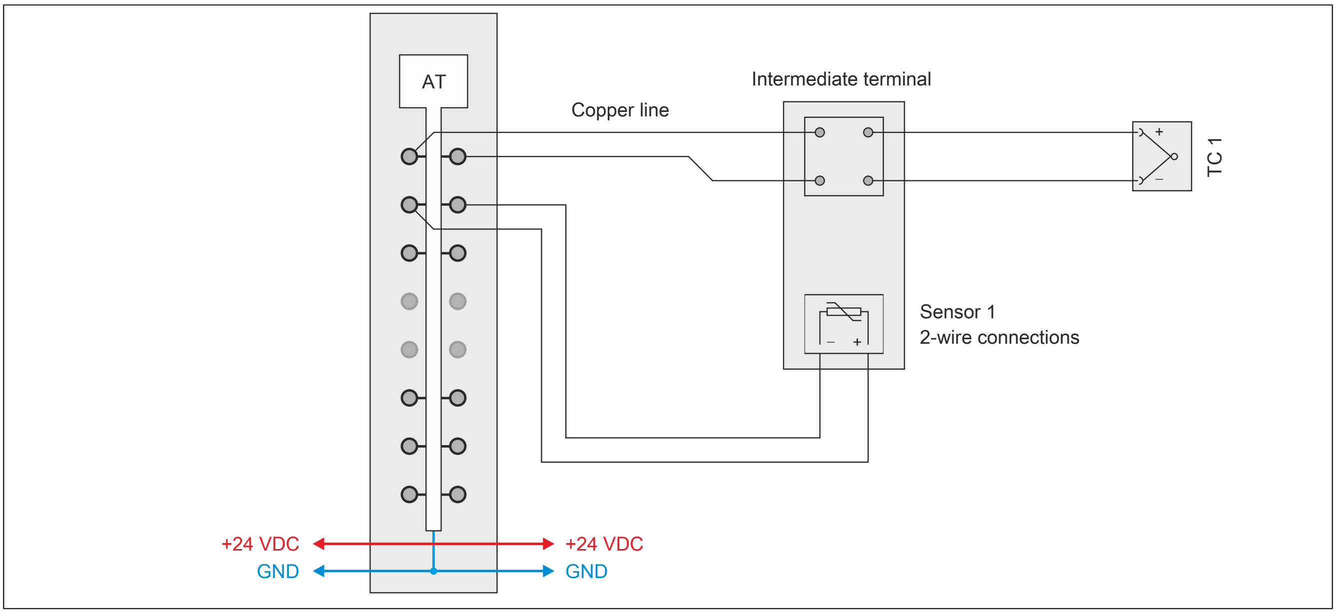
The thermocouple terminal block X20TB1E with integrated PT1000 sensors is used for internal temperature compensation.



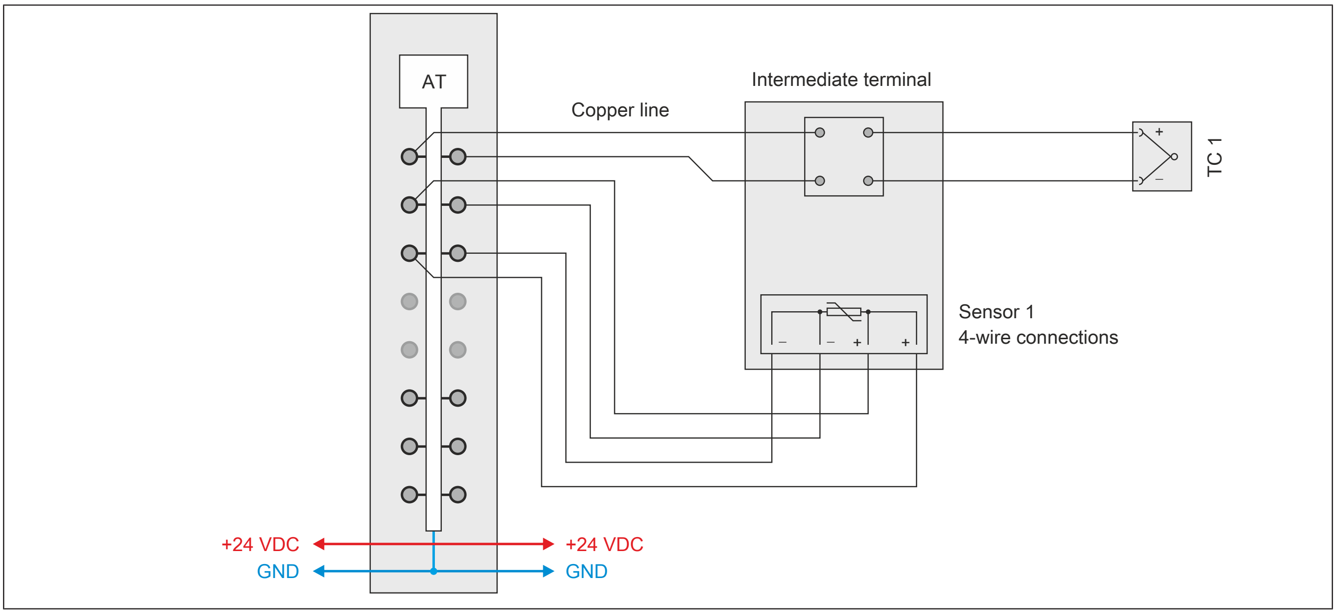
Remote temperature compensation

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



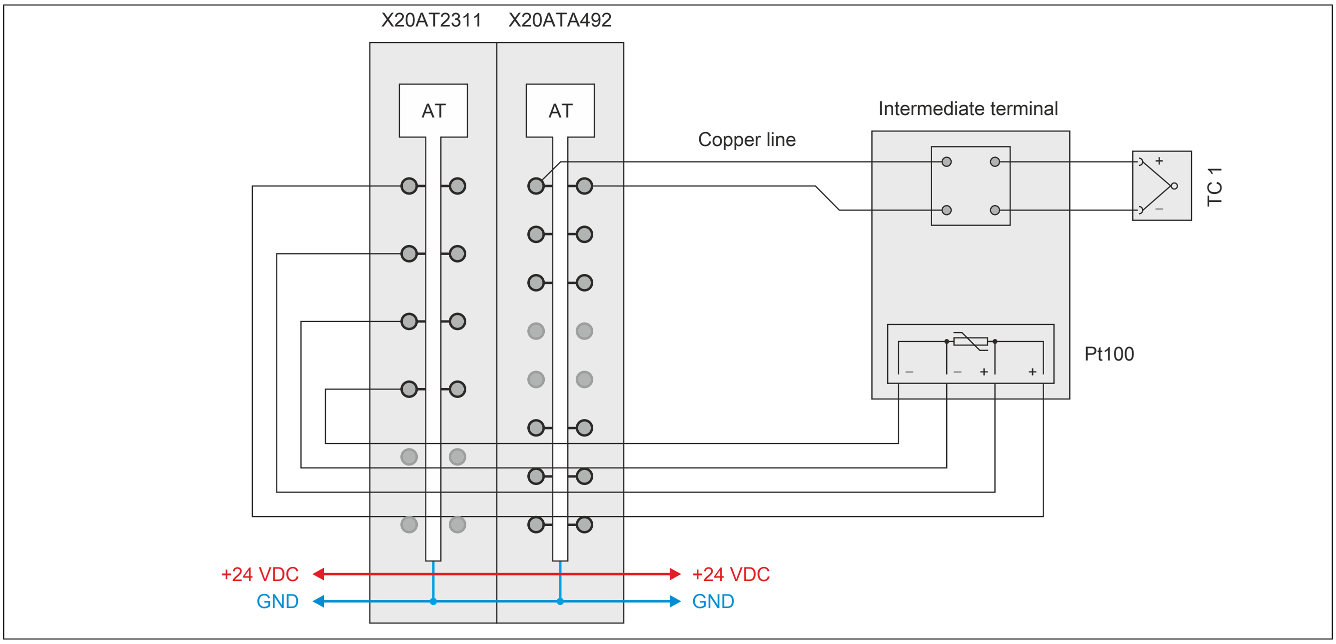
4-wire connections



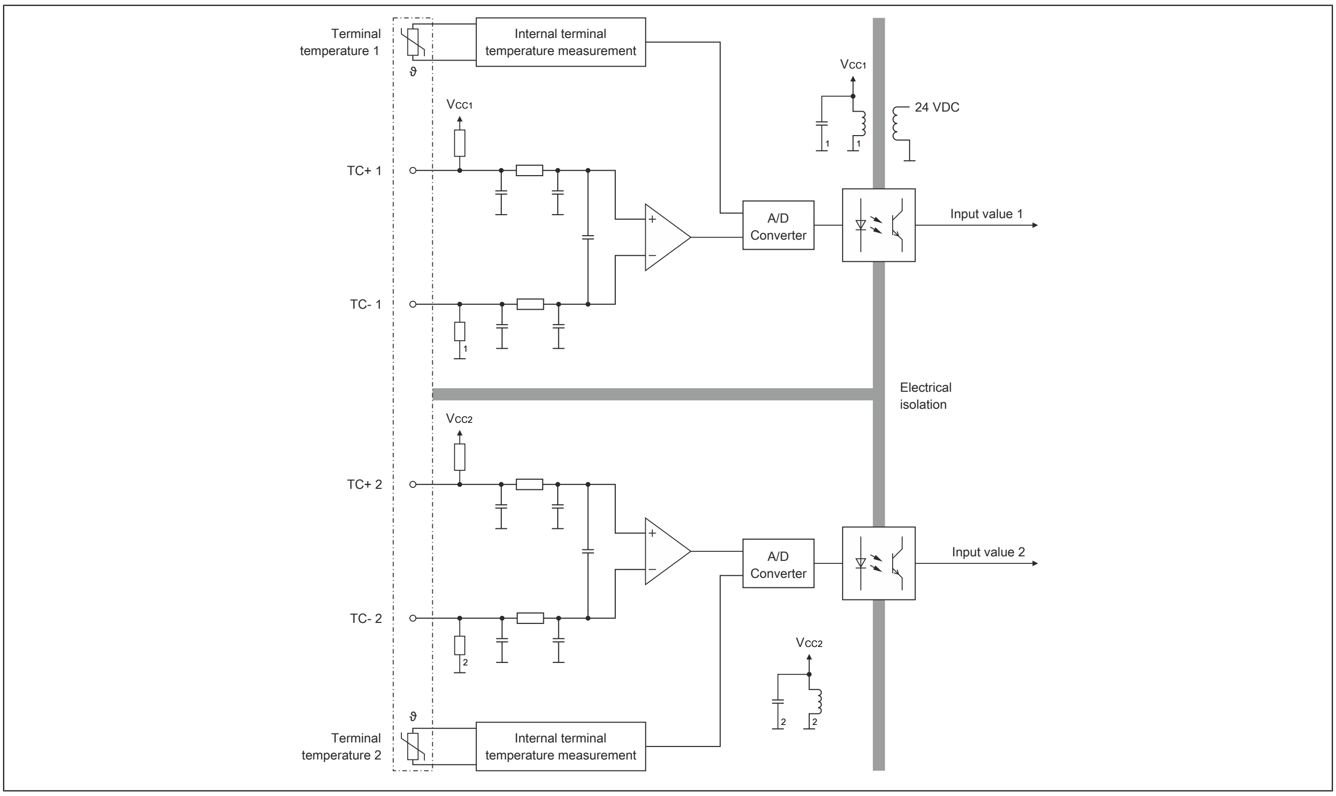
External temperature compensation

External compensation does not require the Pt1000 values to be converted internally in the module. Instead, the reference temperatures 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 X20ATA492 module via the corresponding I/O data points.



2.5 Input circuit diagram



2.6 Increased precision

2.6.1 Internal temperature compensation

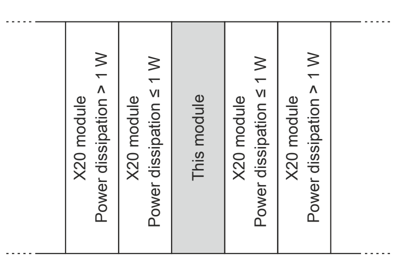
When using internal terminal temperature compensation, a temperature model must be defined in order to increase precision. A temperature model should be selected according to the following criteria:

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

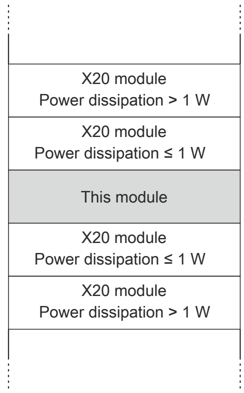
2.6.1.1 Neighboring modules with low thermal power loss

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 25 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

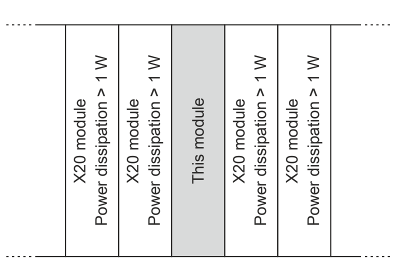
Information:

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

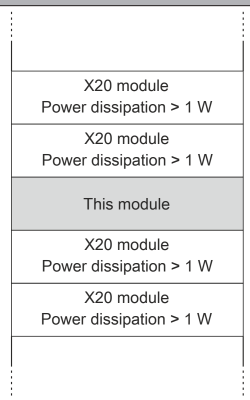
2.6.1.2 Neighboring modules with higher thermal power loss

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 25 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

2.6.2 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.

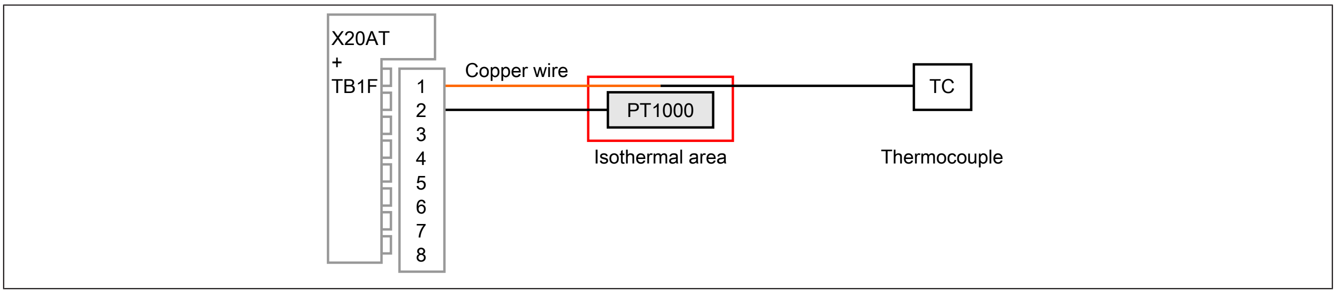
The installation of a remote or external cold junction is especially helpful in the following cases.

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

2.6.2.1 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:

- 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.
- 0x8001 is output if an I/O power supply error occurs.

Information:

The register is described in "Configuring temperature measurement" on page 25.

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 23.

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 Compensation value

Depending on the configuration, the compensation value is output as a temperature or resistance value.

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.
- 0x8001 is output if an I/O power supply error occurs.

3.3.2 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 12.

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.

3.3.3 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.

3.3.4 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.

Limiting the value

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

Error state	Value on error (default values)
Open circuit	+32767 (0x7FFF)
Upper limit value overshot	+32767 (0x7FFF)
Lower limit value undershot	-32767 (0x8001)
Invalid value or I/O power supply error	-32767 (0x8001)

Information:

The registers are described in "Compensation" on page 24 and "Status of the compensation value" on page 24.

3.4 Monitoring the input signal

The input signal is monitored against the upper and lower limit values as well as for 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. The analog value is limited to the new values if the limit values were changed.

Error state	Digital value on error (default values)
Open circuit	+32767 (0x7FFF)
Upper limit value overshot	+32767 (0x7FFF)
Lower limit value undershot	-32767 (0x8001)
Invalid value or I/O power supply error	-32767 (0x8001)

Information:

The registers are described in "Status messages" on page 28.

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.

<table>
<tr><td rowspan="7">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.</td><td colspan="2">"Application"
Value being measured (analog)</td></tr>
<tr><td>↓</td><td>Condition:
- Conversion interval (A/D converter) elapsed</td></tr>
<tr><td colspan="2">"Measured value memory"
Measured value (digital)</td></tr>
<tr><td>↓</td><td>Condition:
- PreparationInterval elapsed
- Measured value permissible</td></tr>
<tr><td colspan="2">"Buffer"
Last valid value</td></tr>
<tr><td>↓</td><td>Condition:
- PreparationInterval elapsed
- Measured value permissible</td></tr>
<tr><td colspan="2">"Output memory"
Next-to-last valid/
displayed value</td></tr>
</table>

Information:

The registers are described in "Configuring the limit values" on page 26.

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.

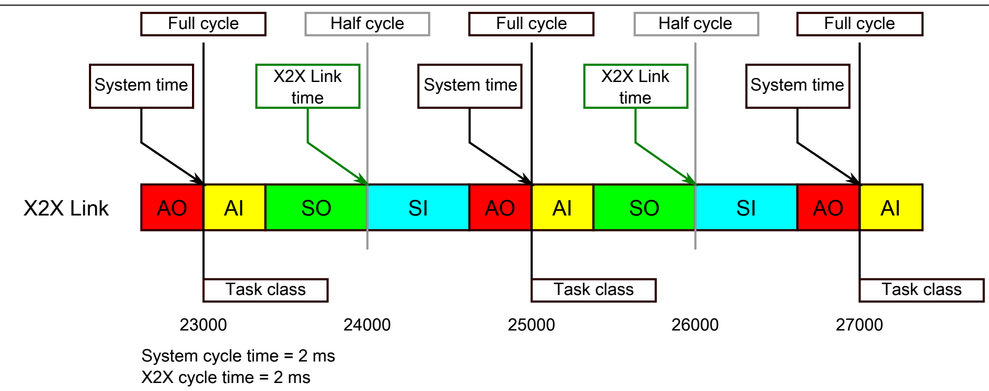
The initialization of the times is based on the system time during the startup of the X2X Link, the I/O modules or the POWERLINK interface.

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.

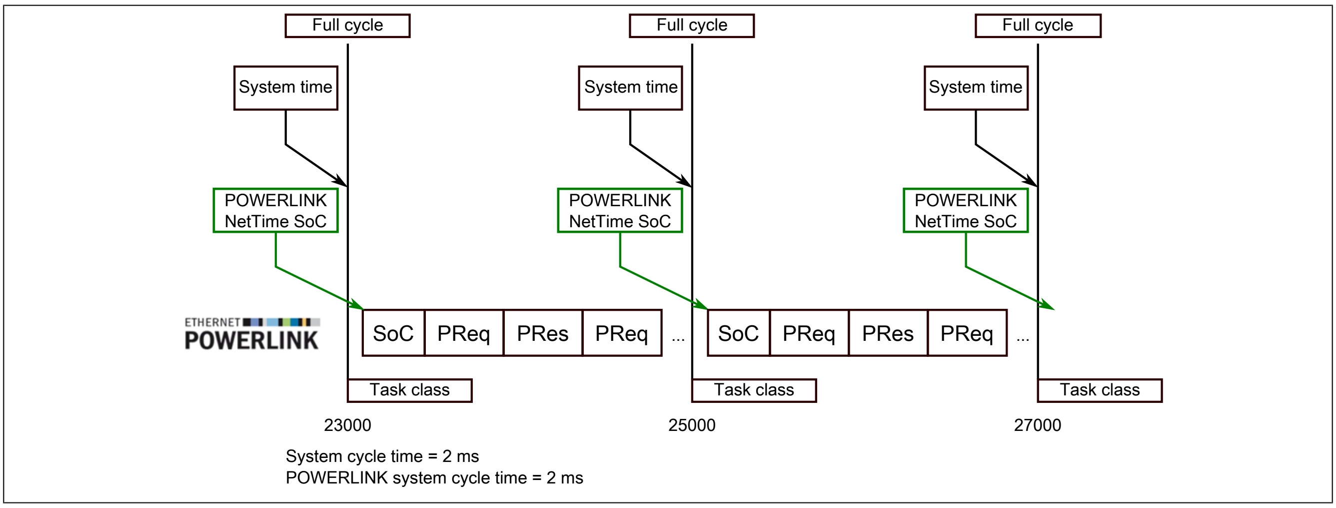
3.5.1.2 X2X Link - Reference time point



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

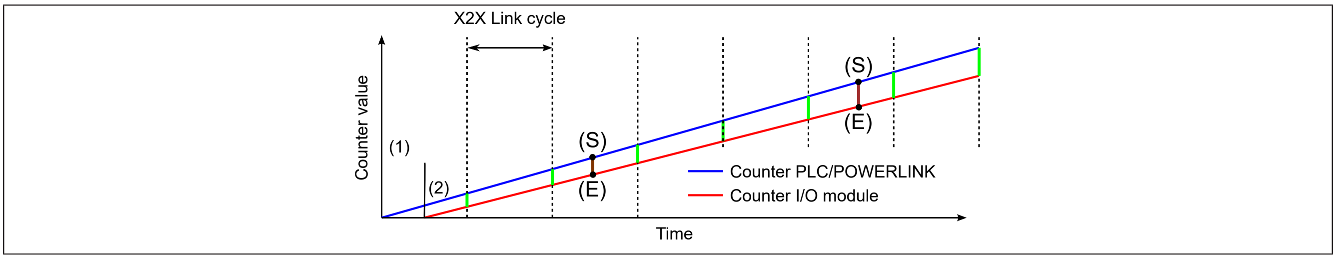


The POWERLINK reference time point is always calculated at the start of cycle (SoC) of the POWERLINK network. The SoC starts 20 µs after the system clock due to the system. This results in the following difference between the system time and the POWERLINK reference time:

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 1 analog logical slot 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						
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		•		

Register description

Register	Name	Data type	Read		Write	
			Cyclic	Acyclic	Cyclic	Acyclic
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				

5.3 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		•		

Register	Offset[1]	Name	Data type	Read		Write	
				Cyclic	Acyclic	Cyclic	Acyclic
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.

5.4 Module configuration

5.4.1 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.

5.5 Compensation

5.5.1 Compensation value

Name:
CompensationValue01 to CompensationValue02

These registers can be used to read the compensation value. Depending on how the "Cfo_SensorType" on page 25 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

5.5.2 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 state of the respective compensation value. The structure is derived from register "StatusInput" on page 28.

Data type	Value
USINT	See the 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

5.5.3 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	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_SensorTypeCh" on page 25 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_SensorTypeCh01 to Cfo_SensorTypeCh02

These registers control the basic functionality of a temperature channel.

Data type	Value	Information
UINT	See the 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.

5.7 Configuring the limit values

5.7.1 Hysteresis

Name:
Cfo_Hysteresis01 to Cfo_Hysteresis02

If user-specific limit values are used, a hysteresis range should also be defined. These registers configure how far the limit value must be overshot in order to trigger a reaction.

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

5.7.2 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

5.7.3 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

5.7.4 Defining the preparation interval

Name:
Cfo_PreparationInterval01 to Cfo_PreparationInterval02

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 16.

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 25 register.

5.7.5 Upper replacement value

Name:
Cfo_ReplaceUpper01 to Cfo_ReplaceUpper02

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	Bus controller default setting: 32767

Information:

The registers are only created for the channel if bit 13 is not set in register "Cfo_SensorType" on page 25.

5.7.6 Lower replacement value

Name:
Cfo_ReplaceLower01 to Cfo_ReplaceLower02

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	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 25 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 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 25 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	

5.8.2 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 17.

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

5.8.3 I/O cycle counter

Name:
IOCycleCount01 to IOCycleCount02

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

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_ErrorDelay02

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	Bus controller default setting: 2

5.9.2 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 65535	Bus controller default setting: 4000

5.9.3 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

Regardless of the configured replacement value strategy, the current error state of the module channels is indicated in these registers. Some error information is delayed according to conditions previously set in registers "Cfo_ErrorDelay" on page 28 and "Cfo_SumErrorDelay" on page 28.

Data type	Values
USINT	See the bit structure.

Bit structure:

Bit	Name	Value	Information
0	Underflow0x	0	No error
		1	Permissible range of values is undershot.
1	Overflow0x	0	No error
		1	Permissible range of values is overshot.
2	OpenLine0x	0	No error
		1	Open circuit
3	CompTemperaturError0x	0	Reference temperature OK
		1	Faulty compensation. For error details, see register "CompensationStatus" on page 24
4	ConversionError0x	0	No error
		1	Converter error
5	SumError0x	0	No error
		1	Undelayed composite error
6	ParameterError0x	0	No error
		1	Register "Cfo_SensorType" on page 25 configured incorrectly
7	IoSuppError0x[1]	0	No error
		1	I/O power supply error

1) If the power supply falls below 20 VDC, the I/O power supply error of the respective temperature channel is mapped in this bit. The following actions are also performed:

- Channel LEDs are switched off.
- Temperature values are set to invalid value = 0x8001.
- "IOCycleCount" on page 27 and "SampleTime" on page 27 are no longer changed.

5.10 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

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