X20(c)AT6402

1 General information

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

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

2 Coated modules

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

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

The coating has been certified according to the following standards:

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

3 Order data

Model number	Short description	Figure
	Temperature measurement	
X20AT6402	X20 temperature input module, 6 thermocouple inputs, Type J, K, N, S, B, R, resolution 0.1°C	
X20cAT6402	X20 temperature input module, coated, 6 thermocouple inputs, Type J, K, N, S, B, R, resolution 0.1°C	
	Required accessories	
	Bus modules	
X20BM11	X20 bus module, 24 VDC keyed, internal I/O supply continuous	
X20cBM11	X20 bus module, coated, 24 VDC keyed, internal I/O supply continuous	
	Terminal blocks	
X20TB12	X20 terminal block, 12-pin, 24 VDC keyed	

Table 1: X20AT6402, X20cAT6402 - Order data

4 Technical data

Product ID	X20AT6402	X20cAT6402
Short description		
I/O module	6 inputs for thermocouples	
General information		
B&R ID code	0x1BA9	0xDD57
Status indicators	I/O function per channel, operating state, module status	
Diagnostics		
Module run/error	Yes, using status LED and software	
Inputs	Yes, using status LED and software	
Power consumption		
Bus	0.01 W	
Internal I/O	0.91 W	
Additional power dissipation caused by the actuators (resistive) [W]	-	
Electrical isolation		
Channel - Bus	Yes	
Channel - Channel	No	
Certification		
CE	Yes	
cULus	Yes	
cCSAus HazLoc Class 1 Division 2	Yes	-
ATEX Zone 2 [1]	Yes	
KC	Yes	-
GL	Yes	
LR	Yes	
GOST-R	Yes	
Thermocouple temperature inputs		
Input	Thermocouple	
Digital converter resolution	16-bit	
Filter time	Configurable between 1 ms and 66.7 ms	
Conversion time		
1 channel	80.4 ms with 50 Hz filter	
n channels	(n + 1) x 40.2 ms at 50 Hz filter	
Output format	INT	
Measurement range		
Sensor temperature		
Type J: Fe-CuNi	-210 to 1200°C	
Type K: NiCr-Ni	-270 to 1372°C	
Type N: NiCrSi-NiSi	-270 to 1300°C (Rev. ≥D0)	
Type S: PtRh10-Pt	-50 to 1768°C	
Type B: PtRh30-PtRh6	0 to 1820°C	
Type R: PtRh13-Pt	-50 to 1664°C	
Terminal temperature	-25 to 85°C	
Raw value	±65.534 mV	
Terminal temperature compensation	Internal	
Sensor standard	EN 60584	
Resolution		
Sensor temperature	1 LSB = 0.1°C	
Terminal temperature	1 LSB = 0.1°C	
Raw value output with respect to gain	1 LSB = 1 µV or 2 µV	
Normalization		
Type J	-210.0 to 1200.0°C	
Type K	-270.0 to 1372.0°C	
Type N (Rev. ≥ D0)	-270.0 to 1300.0°C	
Type S	-50.0 to 1768.0°C	
Type B	0 to 1820.0°C	
Type R	-50.0 to 1664.0°C	
Terminal temperature	-25.0 to 85.0°C	
Monitoring		
Range exceeded (neg.)	0x8001	
Above upper range limit	0x7FFF	
Open line	0x7FFF	
Open inputs	0x7FFF	
General error	0x8000	
Conversion procedure	Sigma-delta	
Linearization method	Internal	
Permitted input signal	Max. ±5 V	
Input filter	1st-order low pass / cutoff frequency 500 Hz	

Table 2: X20AT6402, X20cAT6402 - Technical data

Product ID	X20AT6402	X20cAT6402
Max. error at 25°C		
Gain	0.06% 2)	
Offset		
Type J	0.04% 3)	
Type K	0.05% 3)	
Type N (Rev. ≥ D0)	0.05% 3)	
Type S	0.11% 3)	
Type B	0.13% 3)	
Type R	0.09% 3)	
Max. gain drift	0.01 %/°C 2)	
Max. offset drift		
Type J	0.0019 %/°C 3)	
Type K	0.0024 %/°C 3)	
Type N (Rev. ≥ D0)	0.0029 %/°C 3)	
Type S	0.0079 %/°C 3)	
Type B	0.0114 %/°C 3)	
Type R	0.0074 %/°C 3)	
Nonlinearity	±0.001% 3)	
Common-mode rejection		
DC	>70 dB	
50 Hz	>70 dB	
Common-mode range	±15 V	
Crosstalk between channels	<-70 dB	
Isolation voltage		
Between channel and bus	500 V_{eff}	
Terminal temperature compensation precision		
With artificial convection	±4°C after 10 min	
With natural convection	±2°C after 10 min	
Operating conditions		
Mounting orientation		
Horizontal	Yes	
Vertical	Yes	
Installation at elevations above sea level		
0 to 2000 m	No limitations	
>2000 m	Reduction of ambient temperature by 0.5°C per 100 m	
EN 60529 protection	IP20	
Environmental conditions		
Temperature		
Operation		
Horizontal installation	0 to 55°C	-25 to 60°C
Vertical installation	0 to 50°C	-25 to 50°C
Derating	-	
Storage	-40 to 85°C	
Transport	-40 to 85°C	
Relative humidity		
Operation	5 to 95%, non-condensing	Up to 100%, condensing
Storage	5 to 95%, non-condensing	
Transport	5 to 95%, non-condensing	
Mechanical characteristics		
Note	Order 1x X20TB12 terminal block separately Order 1x X20BM11 bus module separately	Order 1x X20TB12 terminal block separately Order 1x X20cBM11 bus module separately
Spacing	$12.5^{+0.2}$ mm	

Table 2: X20AT6402, X20cAT6402 - Technical data

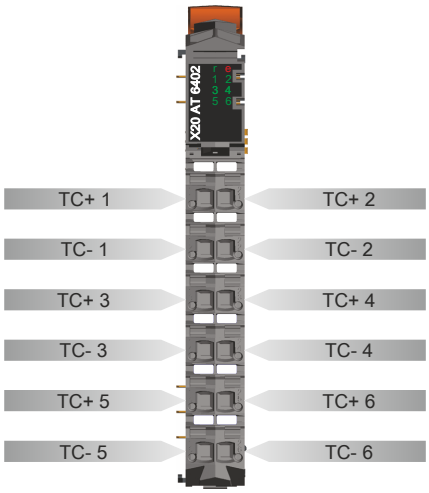
1) Ta min.: 0°C
   Ta max.: See environmental conditions
2) Based on the current measured value.
3) Based on the entire measurement range.

5 LED status indicators

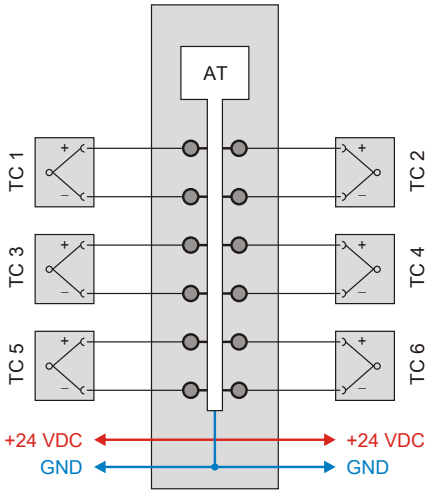
For a description of the various operating modes, see section "re LEDs" in chapter 2 "System characteristics" of the X20 system user's manual.

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

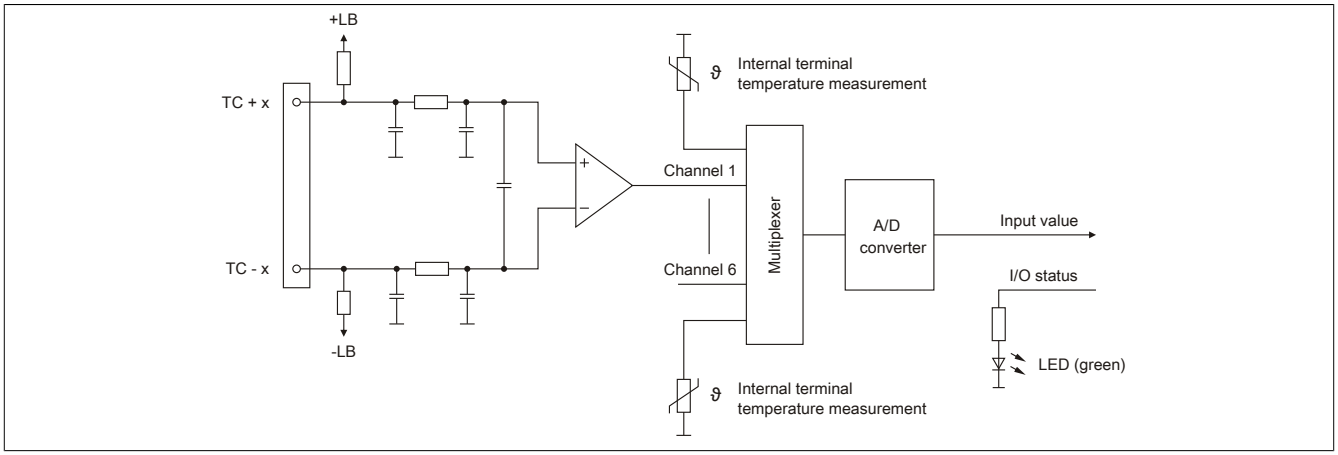
6 Pinout



7 Connection example

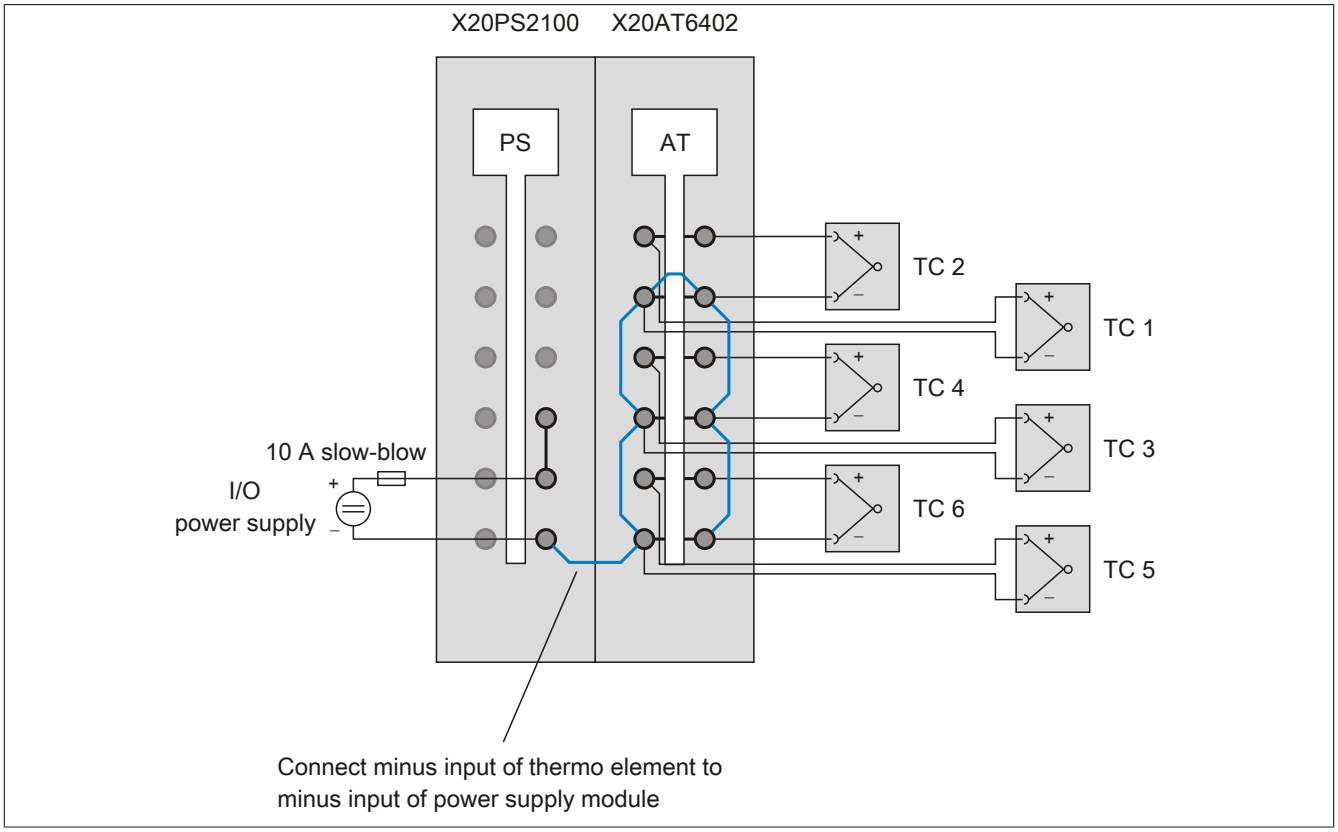


8 Input circuit diagram



9 Ceramic heating element with integrated thermo elements

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



10 External cold junction

General information

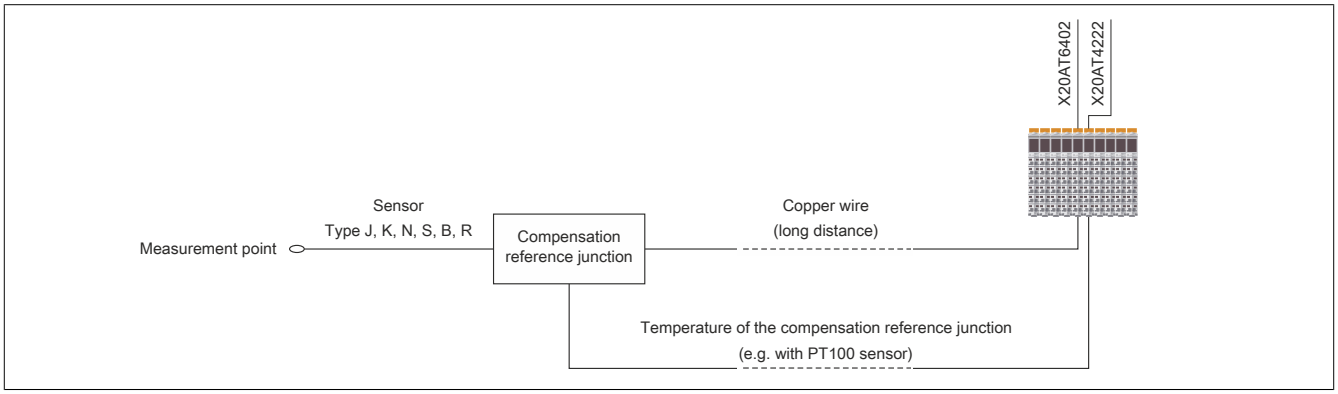
An external cold junction temperature value can be predefined for the module for measurement value correction. This makes it possible to set up an external cold junction. The same external cold junction temperature is used for measurement value correction on all channels.

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

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

To bridge large distances

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



Increased precision

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

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

11 Register description

11.1 General data points

In addition to the registers listed in the register description, the module also has other more general data points. These registers are not specific to the module but contain general information such as serial number and hardware version.

These general data points are listed in the "General data points" section of chapter 4 "X20 system modules" in the X20 system user's manual.

11.2 Function model 0 - default

Register	Name	Data type	Read		Write	
			Cyclic	Acyclic	Cyclic	Acyclic
Configuration						
24	ConfigOutput01	USINT				●
26	ConfigOutput02	USINT				●
27	ConfigOutput03	USINT				●
Communication						
0	Temperature01	INT	●			
2	Temperature02	INT	●			
4	Temperature03	INT	●			
6	Temperature04	INT	●			
8	Temperature05	INT	●			
10	Temperature06	INT	●			
28	IOCycleCounter	USINT	●			
30	StatusInput01	USINT	●			
31	StatusInput02	USINT	●			
22	CompensationTemperature	INT		●		

11.3 Function model 1 - External cold junction temperature

Register	Name	Data type	Read		Write	
			Cyclic	Acyclic	Cyclic	Acyclic
Configuration						
24	ConfigOutput01	USINT				●
26	ConfigOutput02	USINT				●
27	ConfigOutput03	USINT				●
Communication						
12	ExternalCompensationTemperature	INT			●	
0	Temperature01	INT	●			
2	Temperature02	INT	●			
4	Temperature03	INT	●			
6	Temperature04	INT	●			
8	Temperature05	INT	●			
10	Temperature06	INT	●			
28	IOCycleCounter	USINT	●			
30	StatusInput01	USINT	●			
31	StatusInput02	USINT	●			

11.4 Function model 254 - Bus controller

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

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

11.4.1 CAN I/O bus controller

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

11.5 General information

11.5.1 Raw value measurement

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

11.5.2 Timing

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

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

11.5.3 Conversion time

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

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

Examples

Inputs are filtered using a 50 Hz filter.

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

11.6 Configuration

11.6.1 Input filter and ambient conditions

Name:
ConfigOutput01

This register configures input filters and ambient conditions.

Input filter

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

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

Environmental conditions

Ambient conditions are set in order 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. Power consumption values can also be found in the technical data for the corresponding module. The higher value is used for the configuration.

Data type	Value
USINT	See bit structure.

Bit structure:

Bit	Description	Value	Information
0 - 3	Filter time	0000	15 Hz
		0001	25 Hz
		0010	30 Hz
		0011	50 Hz
		0100	60 Hz
		0101	100 Hz
		0110	500 Hz
		0111	1000 Hz
		1000 to 1111	Not permitted
4 - 7	Environmental conditions	0000	Default, no calculation for adjustment
		0001	Power dissipation less than 0.2 W
		0010	Power dissipation less than 1 W
		0011	Power dissipation more than 1 W
		0100 to 1111	Not permitted

11.6.2 Sensor type

Name:
ConfigOutput02

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

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

11.6.3 Channel disabling

Name:
ConfigOutput03

By default, all channels are switched on. To save time, individual channels can be switched off (see "Conversion time" on page 8).

Data type	Value
USINT	See bit structure.

Bit structure:

Bit	Description	Value	Information
0	Channel 1	0	Off
		1	On
1	Channel 2	0	Off
		1	On
2	Channel 3	0	Off
		1	On
3	Channel 4	0	Off
		1	On
4	Channel 5	0	Off
		1	On
5	Channel 6	0	Off
		1	On
6 - 7	Reserved	0	

11.7 Communication

11.7.1 Analog inputs

Name:
Temperature01 to Temperature06

Analog input value depending on the configured sensor type:

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

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

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

11.7.2 I/O cycle counter

Name:
IOCycleCounter

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

Data type	Value	Information
USINT	0 to 255	Repeating counter

11.7.3 Input status

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

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

Error status	Digital value for error
Open line	+32767 (0x7FFF)
Upper limit value exceeded	+32767 (0x7FFF)
Lower limit value exceeded	-32767 (0x8001)
Invalid value	-32768 (0x8000)

11.7.3.1 Status of inputs 1 to 4

Name:
StatusInput01

Bit structure:

Bit	Description	Value	Information
0 - 1	Channel 1	00	No error
		01	Lower limit value exceeded
		10	Upper limit value exceeded
		11	Open line
2 - 3	Channel 2	00	No error
		01	Lower limit value exceeded
		10	Upper limit value exceeded
		11	Open line
4 - 5	Channel 3	00	No error
		01	Lower limit value exceeded
		10	Upper limit value exceeded
		11	Open line
6 - 7	Channel 4	00	No error
		01	Lower limit value exceeded
		10	Upper limit value exceeded
		11	Open line

11.7.3.2 Status of inputs 5 to 6

Name:
StatusInput02

Bit structure:

Bit	Description	Value	Information
0 - 1	Channel 5	00	No error
		01	Lower limit value exceeded
		10	Upper limit value exceeded
		11	Open line
2 - 3	Channel 6	00	No error
		01	Lower limit value exceeded
		10	Upper limit value exceeded
		11	Open line
4 - 7	Reserved	0	

11.7.4 Reads the internal cold junction temperature

Name:
CompensationTemperature

The internal cold junction temperature is stored in this register.

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

11.7.5 Defines the external cold junction temperature

Name:
ExternalCompensationTemperature

The external cold junction temperature is defined in this register.

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

11.8 Minimum cycle time

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

Minimum cycle time
150 µs

11.9 Minimum I/O update time

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

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

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

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