X67AT1402

Data sheet
3.20 (July 2024)

Translation of the original documentation

Publishing information

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Disclaimer

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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).

Version	Date	Comment[1)]
3.20	July 2024	Added title page. Section "Connection example / Without terminal compensation": Corrected diagram. Added section "Function description". Added section "Commissioning".

1) Editorial corrections are not listed.

1 General information

1.1 Other applicable documents

For additional and supplementary information, see the following documents.

Other applicable documents

Document name	Title
MAX67	X67 System user's manual
MAEMV	Installation / EMC guide

1.2 Order data

Order number	Short description	Figure
	Temperature modules	
X67AT1402	X67 temperature input module, 4 thermocouple inputs, type J, K, N, R, S, resolution 0.1 K	

Table 1: X67AT1402 - Order data

Required accessories
For a general overview, see section "Accessories - General overview" in the X67 System user's manual.

1.3 Module description

The module is a temperature module for type J, K, N, R and S thermocouple sensors. The selected sensor type is used for all 4 inputs.

Functions:

- Sensor type and measurement range
- Terminal temperature compensation
- Input filter
- Monitoring the input signal
- Monitoring the operating limits

Sensor type and measurement range

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

Terminal temperature compensation

The module is equipped with integrated terminal temperature compensation.

Input filter

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

An input filter can be configured for each individual analog input.

Monitoring the input signal

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

Monitoring operating limits

The voltage of the I/O power supply is monitored for voltage overshoot or undershoot.

2 Technical description

2.1 Technical data

Order number	X67AT1402
Short description	
I/O module	4 inputs for thermocouple sensors
General information	
B&R ID code	0x1486
Status indicators	I/O function per channel, supply voltage, bus function
Diagnostics	
Inputs	Yes, using LED status indicator and software
I/O power supply	Yes, using LED status indicator and software
Connection type	
X2X Link	M12, B-coded
Inputs	4x M12, A-coded
I/O power supply	M8, 4-pin
Power consumption	
Internal I/O	2.6 W
X2X Link power supply	0.75 W
Certifications	
CE	Yes
UKCA	Yes
ATEX	Zone 2, II 3G Ex nA IIA T5 Gc IP67, Ta = 0 - Max. 60°C TÜV 05 ATEX 7201X
UL	cULus E115267 Industrial control equipment
HazLoc	cCSAus 244665 Process control equipment for hazardous locations Class I, Division 2, Groups ABCD, T5
KC	Yes
I/O power supply	
Nominal voltage	24 VDC
Voltage range	18 to 30 VDC
Integrated protection	Reverse polarity protection
Thermocouple temperature inputs	
Input	Thermocouple
Digital converter resolution	16-bit
Filter time	Configurable between 2 and 20 ms
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
Type S: PtRh10-Pt	-50 to 1768°C
Type R: PtRh13-Pt	-50 to 1768°C
Terminal temperature	-25 to 85°C
Raw value	±65.534 mV
Terminal temperature compensation	Using thermocouple connector X67AC9A02 (accessory) [1)]
Sensor standard	IEC 60584-1
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: Fe-CuNi	-210.0 to 1200.0°C
Type K: NiCr-Ni	-270.0 to 1372.0°C
Type N: NiCrSi-NiSi	-270.0 to 1300.0°C
Type S: PtRh10-Pt	-50.0 to 1768.0°C
Type R: PtRh13-Pt	-50.0 to 1768.0°C

Table 2: X67AT1402 - Technical data

Technical description

Order number	X67AT1402
Monitoring	
Range undershoot	0x8001
Range overshoot	0x7FFF
Open circuit	0x7FFF
Open inputs	0x7FFF
General fault	0x8000
Conversion procedure	Sigma-delta
Linearization method	Software
Permissible input signal	Short-term ±30 VDC
Max. error at 25°C	
Gain	±0.040% 2)
Offset	
Type J: Fe-CuNi	±0.024% 3)
Type K: NiCr-Ni	±0.030% 3)
Type N: NiCrSi-NiSi	±0.035% 3)
Type S: PtRh10-Pt	±0.088% 3)
Type R: PtRh13-Pt	±0.078% 3)
Max. gain drift	0.0123%/°C 2)
Max. offset drift	
Type J: Fe-CuNi	0.0024%/°C 3)
Type K: NiCr-Ni	0.0030%/°C 3)
Type N: NiCrSi-NiSi	0.0035%/°C 3)
Type S: PtRh10-Pt	0.0089%/°C 3)
Type R: PtRh13-Pt	0.0079%/°C 3)
Nonlinearity	<0.002% 4)
Common-mode rejection	
DC	>70 dB
50 Hz	>70 dB
Common-mode range	±12 VDC
Crosstalk between channels	<-70 dB
Terminal temperature error	Typ. ±2°C after 10 min. 5)
Insulation voltage between channel and bus	500 V_{eff}
Conversion time	62 ms per channel with 50 Hz filter + 62 ms per cycle for terminal temperature measurement with 50 Hz filter
Input filter	
Cutoff frequency	4 Hz / First-order filter
Slope	-20 dB
Electrical properties	
Electrical isolation	Channel isolated from bus Channel not isolated from channel
Operating conditions	
Mounting orientation	
Any	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	IP67
Ambient conditions	
Temperature	
Operation	-25 to 60°C
Derating	-
Storage	-40 to 85°C
Transport	-40 to 85°C
Mechanical properties	
Dimensions	
Width	53 mm
Height	85 mm
Depth	42 mm
Weight	205 g
Torque for connections	
M8	Max. 0.4 Nm
M12	Max. 0.6 Nm

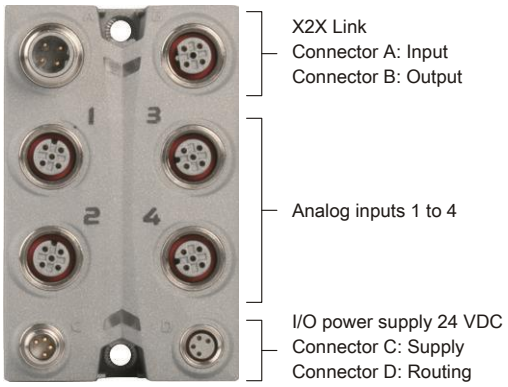
Table 2: X67AT1402 - Technical data

1) At least one terminal temperature sensor is required to determine the temperature measured at the J, K and S thermocouple sensors.
2) Refers to the current measurement without consideration of the reference junction measurement error.
3) Based on the entire measurement range without consideration of the cold junction measurement error.
4) Based on the entire measurement range
5) For slight temperature differences between environment and module mounting area.

2.2 LED status indicators

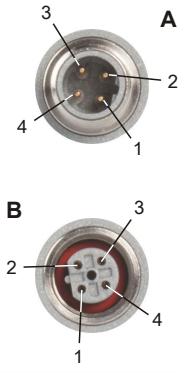
Figure	LED	Description		
	Status indicator 1	Status indicator for X2X Link.		
		Green	Red	Description
		Off	Off	No power supply via X2X Link
		On	Off	X2X Link supplied, communication OK
		Off	On	X2X Link supplied but no X2X Link communication
		On	On	PREOPERATIONAL: X2X Link supplied, module not initialized
	1 - 4	Status indicator of the corresponding analog input.		
		LED	Status	Description
		Green	On	The A/D converter is supplying valid values.
			Blinking	Overflow, underflow or open circuit
			Off	The input is switched off.
	Status indicator 2	Status indicator for module functionality.		
		LED	Status	Description
		Green	Off	No power to module
			Single flash	Mode RESET
			Blinking	Mode PREOPERATIONAL
			On	Mode RUN
		Red	Off	Module not supplied with power or everything OK
			On	Error or reset state
			Single flash	Warning/Error on an I/O channel. Overflow or underflow of the analog inputs.
			Double flash	Supply voltage not within the valid range

2.3 Connection elements

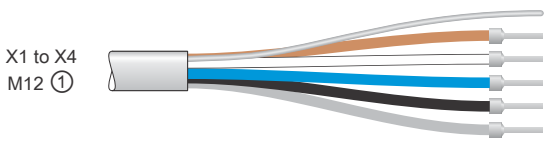


2.3.1 X2X Link

The module is connected to the X2X Link network using pre-assembled cables. The connection is made using M12 circular connectors.

Connection	Pinout	
	**Pin**	**Name**
	1	X2X+
	2	X2X
	3	X2X⊥
	4	X2X\
	Shield connection made via threaded insert in the module. A → B-coded (male), input B → B-coded (female), output	

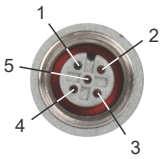
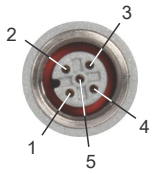
2.3.2 Pinout



Shield	
1	Compensation
2	AI +
3	GND
4	AI -
5	Shield

① X67CA0A41.xxxx: M12 sensor cable, straight
X67CA0A51.xxxx: M12 sensor cable, angled

2.3.2.1 Connections X1 to X4

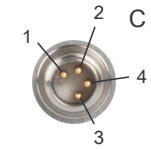
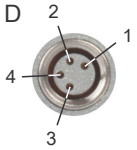
M12, 5-pin	Pinout	
Connection 1/2	**Pin**	**Name**
	1	Compensation input
	2	Input +
	3	GND
	4	Input -
	5	Shield[1)]
	1) Shielding also provided by threaded insert in the module.	
Connection 3/4	X1 to X4 → A-coded (female), input	

2.3.3 I/O power supply 24 VDC

The I/O power supply is connected via M8 connectors C and D. The I/O power supply is connected via connector C (male). Connector D (female) is used to route the I/O power supply to other modules.

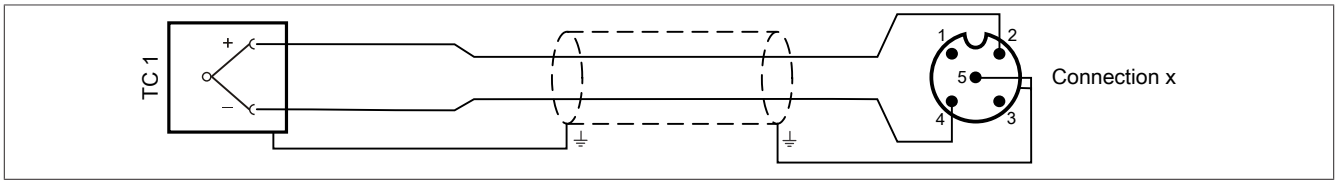
Information:

The maximum permissible current for the I/O power supply is 8 A (4 A per connection pin)!

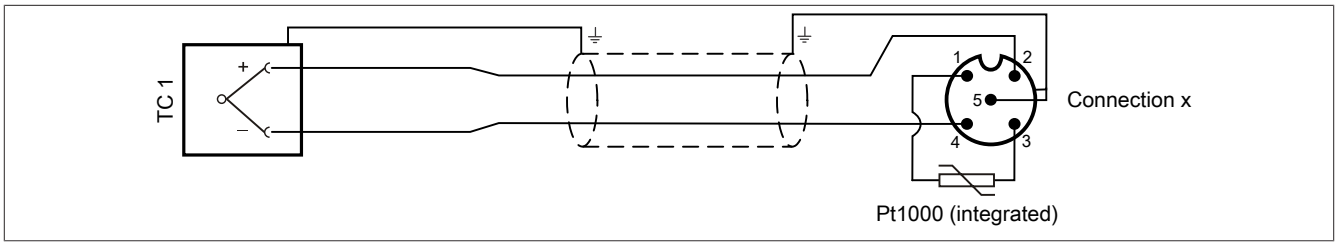
Connection	Pinout	
	**Pin**	**Name**
	1	24 VDC
	2	24 VDC
	3	GND
	4	GND
	C → Connector (male) in module, supply for I/O power supply D → Connector (female) in module, routing of I/O power supply	

2.4 Connection example

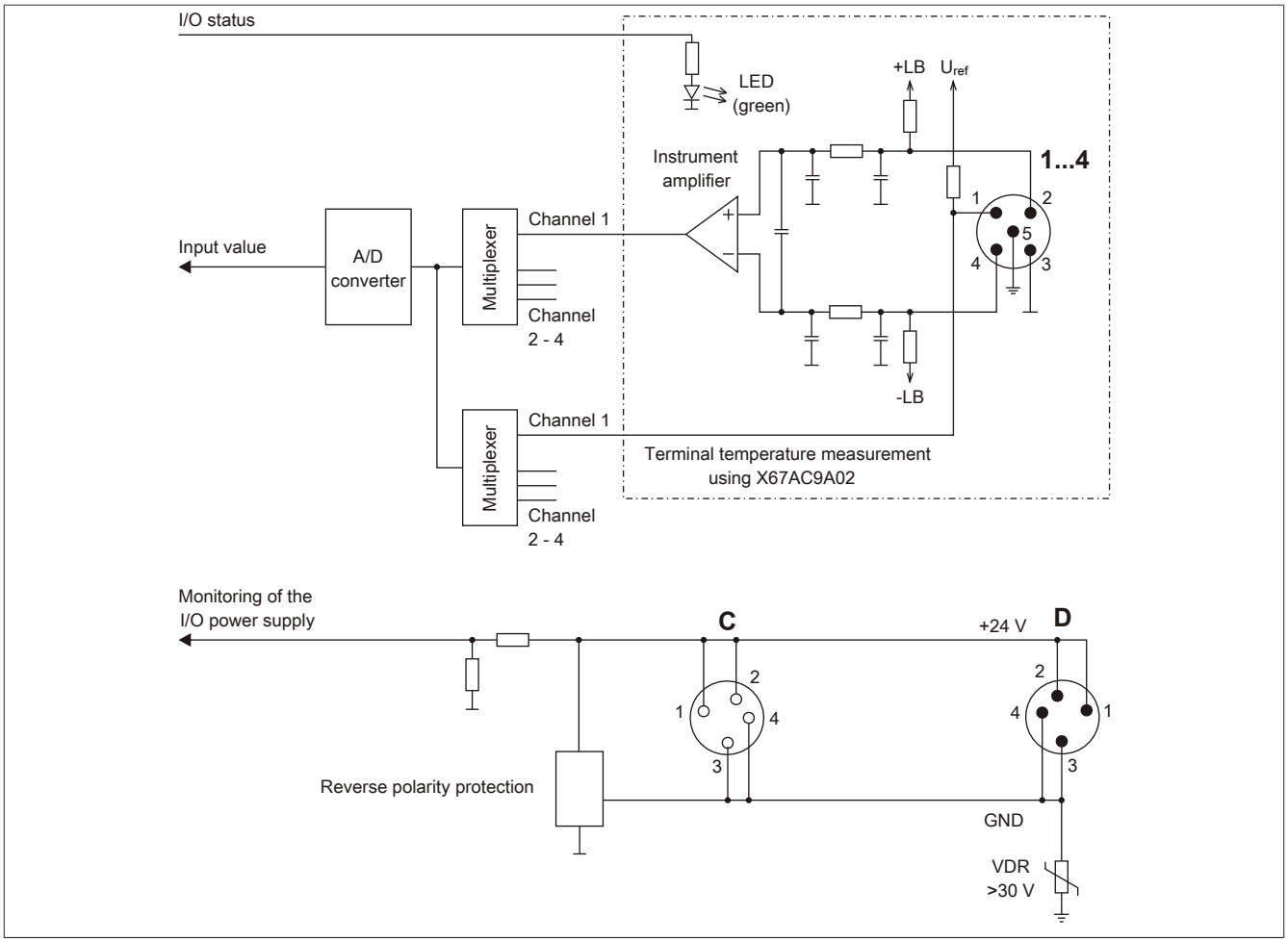
Without terminal compensation



With terminal compensation (Pt1000 sensor is integrated in connector X67AC9A02)



2.5 Input circuit diagram



3 Function description

3.1 Sensor type and measurement range

The module can be used with different measurement sensors. For sensor types not supported by the module, the module is equipped with raw value measurement. Switching off channels that are not needed shortens the conversion time.
The following measurement ranges result depending on the sensor type:

Input signal	Measurement range
Sensor type J	-210.0 to 1200.0°C
Sensor type K	-270.0 to 1372.0°C
Sensor type N	-270.0 to 1300.0°C
Sensor type R	-50.0 to 1768.0°C
Sensor type S	-50.0 to 1768.0°C
Raw value	1 µV for a measurement range of ±32.767 mV
Raw value	2 µV for a measurement range of ±65.534 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 not switched on, 0x8000 is output.
- At least one terminal temperature sensor is required to determine the temperature measured at the J, K, N, R and S thermocouple sensors. Otherwise, 0x7FFF is generally output.

Raw value measurement

Raw value measurement functions with and without terminal temperature measurement. If a sensor type other than J, K or S is used, the terminal temperature must be measured on at least one input. The user must use this value to perform terminal temperature compensation.

Information:

The register is described in "Sensor type and channel selection" on page 14.

3.2 Terminal temperature compensation

The module is equipped with integrated terminal temperature compensation. The following applies:

- Possible for inputs 1 to 4.
- The sensor for measuring the terminal temperature is integrated in the connector housing (X67AC9A02).
- The module recognizes by means of such a connector independently that terminal temperature compensation is desired.
- To determine the measured temperature, at least one terminal temperature sensor is required for J, K and S thermocouple sensors; otherwise, 0x7FFF is generally output.

Examples of possible configurations

Connector with sensor on input	Description
1	Terminal temperature compensation is performed for all 4 inputs with the temperature measured on input 1.
1 and 3	Terminal temperature compensation is performed for inputs 1 and 2 with the temperature measured on input 1. Terminal temperature compensation is performed for inputs 3 and 4 with the temperature measured on input 3.
1 to 4	Terminal temperature compensation is performed with the temperature measured on the respective input.

3.3 Input filter

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

Filter frequency	Filter time	Digital converter resolution
50 Hz	20 ms	16-bit
60 Hz	16.67 ms	16-bit
250 Hz	4 ms	16-bit
500 Hz	2 ms	10-bit

Information:

The register is described in "Input filter" on page 14.

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.

Error state	Temperature measurement Digital value on error
Open circuit or open input	32767 (0x7FFF)
Upper limit value overshot	32767 (0x7FFF)
Lower limit value undershot	-32767 (0x8001)
General fault	-32768 (0x8000)

Information:

The register is described in "Status of the inputs" on page 15.

3.5 Monitoring the operating limits

The status of the I/O power supply can be read out.

Bit	Description
0	I/O power supply within the warning limits (18 to 30 V)
1	I/O power supply outside the warning limits (<18 V or >30 V)

Information:

The register is described in "Operating limit status registers" on page 15.

4 Commissioning

4.1 Using the module on the bus controller

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

For detailed information, see section "Additional information - Using I/O modules on the bus controller" in the X67 user's manual (version 3.30 or later).

4.1.1 CAN I/O bus controller

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

4.2 Configuring the conversion time

All pending signals from enabled inputs are converted to digital values in every conversion cycle. A terminal temperature measurement also takes place.

Disabling inputs that are not needed reduces the I/O update time. The cutoff can also be temporary if inputs are not required for a certain period of time. The measurement of the terminal temperature cannot be switched off.

The conversion time needed for an individual input is calculated using the following formula:

$$3 * \frac{1}{Filter\ frequency} + 2ms$$

The savings per input depends on the filter time:

Filter	Filter time	Amount of time saved per input	Digital converter resolution
50 Hz	20 ms	75 ms	16-bit
60 Hz	16.67 ms	65 ms	16-bit
250 Hz	4 ms	27 ms	13-bit
500 Hz	2 ms	21 ms	10-bit

Example

Inputs are filtered using a 50 Hz filter.

	Example 1	Example 2
Switched on inputs	1 to 4	1, 3
Conversion time for inputs	248 ms	124 ms
Conversion time for terminal temperature	62 ms	62 ms
Conversion time total	310 ms	186 ms

5 Register description

5.1 General data points

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

General data points are described in section "Additional information - General data points" in the X67 System user's manual.

5.2 Function model 0 - Standard

Register	Name	Data type	Read		Write	
			Cyclic	Acyclic	Cyclic	Acyclic
Configuration						
16	ConfigOutput01 (input filter)	USINT				•
18	ConfigOutput02 (measurement range and channel selection)	UINT				•
Communication						
0	Temperature01	INT	•			
2	Temperature02	INT	•			
4	Temperature03	INT	•			
6	Temperature04	INT	•			
8	TerminalTemperature01	INT	•			
10	TerminalTemperature02	INT	•			
12	TerminalTemperature03	INT	•			
14	TerminalTemperature04	INT	•			
30	StatusInput01	USINT	•			
8192	asy_ModulID	UINT		•		
8196	asy_SupplyStatus	USINT		•		
8208	asy_SupplyInput	USINT		•		

5.3 Function model 254 - Bus controller

Register	Offset[1)]	Name	Data type	Read		Write	
				Cyclic	Acyclic	Cyclic	Acyclic
Configuration							
16	-	ConfigOutput01 (input filter)	USINT				•
18	-	ConfigOutput02 (measurement range and channel selection)	UINT				•
Communication							
0	0	Temperature01	INT	•			
2	2	Temperature02	INT	•			
4	4	Temperature03	INT	•			
6	6	Temperature04	INT	•			
8	-	TerminalTemperature01	INT		•		
10	-	TerminalTemperature02	INT		•		
12	-	TerminalTemperature03	INT		•		
14	-	TerminalTemperature04	INT		•		
30	-	StatusInput01	USINT		•		
8192	-	asy_ModulID	UINT		•		
8196	-	asy_SupplyStatus	USINT		•		
8208	-	asy_SupplyInput	USINT		•		

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

5.4 Configuration

5.4.1 Input filter

Name:
ConfigOutput01

This register is used to configure the filtering of all analog inputs.

Data type	Value	Filter frequency	Filter time	Digital converter resolution
USINT	0	50 Hz. Bus controller default setting	20 ms	16-bit
	1	60 Hz	16.67 ms	16-bit
	2	250 Hz	4 ms	13-bit
	3	500 Hz	2 ms	10-bit
	≥4	Values ≥4 are not permitted.		

5.4.2 Sensor type and channel selection

Name:
ConfigOutput02

The sensor type of all channels and the number of channels used are configured in this register.

By default, all channels are switched on. To save time, individual channels can be switched off (see "Configuring the conversion time" on page 12).

Data type	Values	Bus controller default setting
USINT	See the bit structure.	241

Bit structure:

Bit	Description	Value	Information
0 - 2	Defines the sensor type for all channels	000	Conversion switched off
		001	Sensor type J (bus controller default setting)
		010	Sensor type K
		011	Sensor type S
		100	Sensor type N
		101	Sensor type R
		110	Raw value without linearization and terminal temperature compensation, resolution 1 µV with a measurement range of ±32.767 mV
		111	Raw value without linearization and terminal temperature compensation, resolution 2 µV with a measurement range of ±65.534 mV
3	Reserved	0	
4	Input 1	0	Input 1 switched off
		1	Input 1 switched on (bus controller default setting)
...		...	
7	Input 4	0	Input 4 switched off
		1	Input 4 switched on (bus controller default setting)

5.5 Communication

5.5.1 Analog inputs

Name:
Temperature01 to Temperature04

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

Data type	Values	Input signal
INT	-2100 to 12000 (for -210.0 to 1200.0°C)	Sensor type J
	-2700 to 13720 (for -270.0 to 1372.0°C)	Sensor type K
	-2700 to 13000 (for -270.0 to 1300.0°C)	Sensor type N
	-500 to 17680 (for -50.0 to 1768.0°C)	Sensor type R
	-500 to 17680 (for -50.0 to 1768.0°C)	Sensor type S

5.5.2 Terminal temperature

Name:
TerminalTemperature01 to TerminalTemperature04

The terminal temperature is output in 0.1°C steps in these registers. For details, see "Terminal temperature compensation" on page 10.

Data type	Values	Information
INT	-250 to 850	For -25.0 to 85.0°C

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, 0x000 is output.
- If not all terminal temperature sensors are equipped, value 0x7FFF is output on the non-equipped inputs.
- If no terminal temperature sensor is equipped at all, value 0x7FFF is generally output.

5.5.3 Status of the inputs

Name:
StatusInput01

The module's inputs are monitored. A change in the monitoring status is actively issued as an error message and, in the event of an error, the analog value is fixed at defined values. For details, see "Monitoring the input signal" on page 11.

Data type	Values
UINT	See the bit structure.

Bit structure:

Bit	Description	Value	Information
0 - 1	Channel 1	00	No error
		01	Lower limit value undershot
		10	Upper limit value overshot
		11	Open circuit
...		...	
6 - 7	Channel 4	00	No error
		01	Lower limit value undershot
		10	Upper limit value overshot
		11	Open circuit
8 - 15	Number of conversion cycles performed	x	

5.5.4 Reading out the module ID

Name:
asy_ModulID

This register offers the possibility to read the module ID.

Data type	Values
UINT	Module ID

5.5.5 Operating limit status registers

Name:
asy_SupplyStatus

The status of the operating limits can be read out in this register.

Data type	Values
USINT	See the bit structure.

Bit structure:

Bit	Description	Value	Information
0	I/O power supply within/outside warning limits	0	Within the warning limits (18 to 30 V)
		1	Outside the warning limits (<18 V or >30 V)
1 - 7	Reserved	0	

5.5.6 I/O supply voltage

Name:
asy_SupplyInput

This register contains the I/O supply voltage measured by the module.

Data type	Values	Information
USINT	0 to 255	Resolution 1 V

5.6 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

5.7 Minimum I/O update time

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

	Minimum I/O update time
Inputs	$(3 * \frac{1}{Filter\ frequency} + 2ms) * n_{inputs} + 1$