X67AT1402

1 General information

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.

- 4 inputs for thermocouple sensors
- Sensor types J, K, N, R and S
- Additional direct raw value measurement for other sensor types
- Terminal temperature compensation

2 Order data

Model 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" of the X67 system user's manual.

3 Technical data

Model number	X67AT1402
Short description	
I/O module	4 inputs for thermocouple sensors
General information	
B&R ID code	0x1486
Status indicators	I/O function for each channel, supply voltage, bus function
Diagnostics	
Inputs	Yes, using status LED and software
I/O power supply	Yes, using status LED and software
Connection type	
X2X Link	M12, B-keyed
Inputs	4x M12, A-keyed
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
KC	Yes
EAC	Yes
UL	cULus E115267 Industrial control equipment
HazLoc	cCSAus 244665 Process control equipment for hazardous locations Class I, Division 2, Groups ABCD, T5
ATEX	Zone 2, II 3G Ex nA IIA T5 Gc IP67, Ta = 0 - Max. 60°C TÜV 05 ATEX 7201X
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	-210.0 to 1200.0°C
Type K	-270.0 to 1372.0°C
Type N	-270.0 to 1300.0°C
Type S	-50.0 to 1768.0°C
Type R	-50.0 to 1768.0°C
Monitoring	
Range undershoot	0x8001
Range overshoot	0x7FFF
Open circuit	0x7FFF
Open inputs	0x7FFF
General error	0x8000
Conversion procedure	Sigma-delta
Linearization method	Software
Permissible input signal	Short-term ±30 VDC

Table 2: X67AT1402 - Technical data

Model number	X67AT1402
Max. error at 25°C	
Gain	±0.040% 2)
Offset	
Type J	±0.024% 3)
Type K	±0.030% 3)
Type N	±0.035% 3)
Type S	±0.088% 3)
Type R	±0.078% 3)
Max. gain drift	0.0123% / °C 2)
Max. offset drift	
Type J	0.0024% / °C 3)
Type K	0.0030 %/°C 3)
Type N	0.0035 %/°C 3)
Type S	0.0089% / °C 3)
Type R	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)
Isolation 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 / Filter 1st order
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 limitations
>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

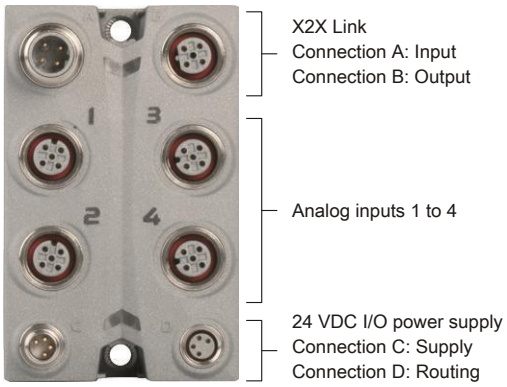
Table 2: X67AT1402 - Technical data

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.

4 LED status indicators

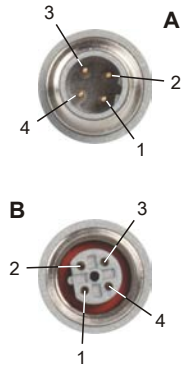
<table>
<tr><th>Figure</th><th>LED</th><th colspan="3">Description</th></tr>
<tr><td rowspan="15"> 
</td><td>Status indicator 1</td><td colspan="3">Status indicator - X2X Link.</td></tr>
<tr><td></td><td>Green</td><td>Red</td><td>Description</td></tr>
<tr><td></td><td>Off</td><td>Off</td><td>No supply via X2X Link</td></tr>
<tr><td></td><td>On</td><td>Off</td><td>X2X Link supplied, communication OK</td></tr>
<tr><td></td><td>Off</td><td>On</td><td>X2X Link supplied, but X2X Link communication is not functioning</td></tr>
<tr><td></td><td>On</td><td>On</td><td>PREOPERATIONAL: X2X Link supplied, module not initialized</td></tr>
<tr><td>1 - 4</td><td colspan="3">Status display of the corresponding analog input</td></tr>
<tr><td></td><td>LED</td><td>Status</td><td>Description</td></tr>
<tr><td></td><td>Green</td><td>On</td><td>The A/D converter returns valid values.</td></tr>
<tr><td></td><td></td><td>Blinking</td><td>Overflow, underflow or open circuit</td></tr>
<tr><td></td><td></td><td>Off</td><td>The input is switched off</td></tr>
<tr><td>Status indicator 2</td><td colspan="3">Status indicator for module function.</td></tr>
<tr><td></td><td>LED</td><td>Status</td><td>Description</td></tr>
<tr><td></td><td>Green</td><td>Off</td><td>No power to module</td></tr>
<tr><td></td><td></td><td>Single flash</td><td>RESET mode</td></tr>
<tr><td></td><td></td><td>Blinking</td><td>PREOPERATIONAL mode</td></tr>
<tr><td></td><td></td><td>On</td><td>RUN mode</td></tr>
<tr><td></td><td>Red</td><td>Off</td><td>No power to module or everything OK</td></tr>
<tr><td></td><td></td><td>On</td><td>Error or reset status</td></tr>
<tr><td></td><td></td><td>Single flash</td><td>Warning/Error on an I/O channel. Overflow or underflow of the analog inputs.</td></tr>
<tr><td></td><td></td><td>Double flash</td><td>Supply voltage not in the valid range</td></tr>
</table>

5 Connection elements



6 X2X Link

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

<table>
<tr><th>Connection</th><th colspan="2">Pinout</th></tr>
<tr><td rowspan="7"> 
</td><td>Pin</td><td>Description</td></tr>
<tr><td>1</td><td>X2X+</td></tr>
<tr><td>2</td><td>X2X</td></tr>
<tr><td>3</td><td>X2X⊥</td></tr>
<tr><td>4</td><td>X2X\</td></tr>
<tr><td colspan="2">Shield connection made via threaded insert in the module.

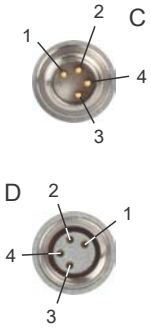
A → B-keyed (male), input
B → B-keyed (female), output</td></tr>
</table>

7 24 VDC I/O power supply

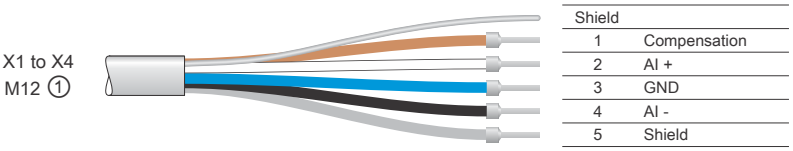
The I/O power supply is connected via M8 connectors C and D. The I/O power supply is connected via connector C (male). Connector D (female) is used to route the I/O power supply to other modules.

Information:

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

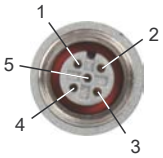
Connection	Pinout	
	**Pin**	**Description**
	1	24 VDC
	2	24 VDC
	3	GND
	4	GND
	C → Connector (male) in module, feed for I/O power supply D → Connection (female) in module, routing of I/O power supply	

8 Pinout



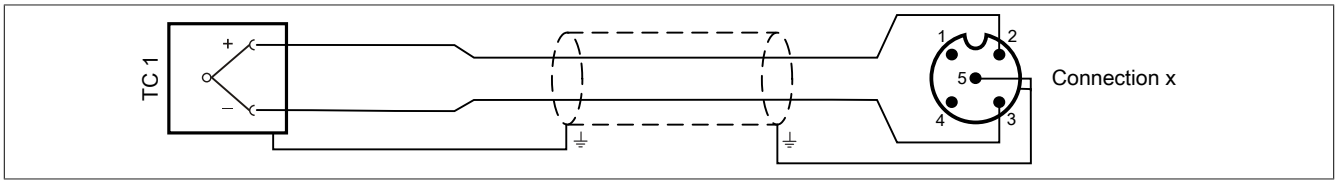
① X67CA0A41.xxxx: M12 sensor cable, straight
X67CA0A51.xxxx: M12 sensor cable, angled

8.1 Connections X1 to X4

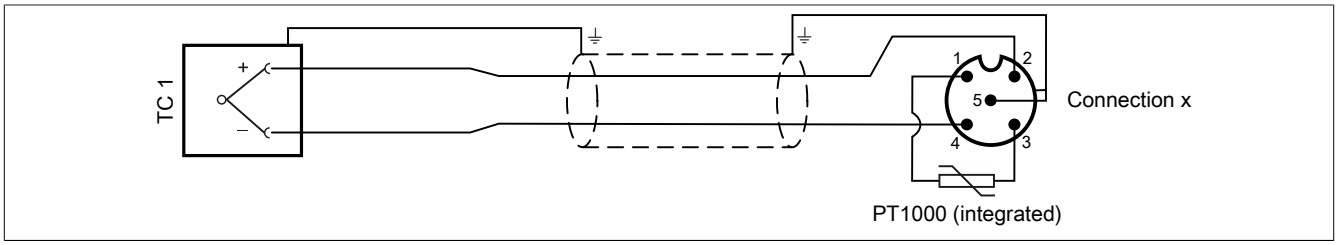
M12, 5-pin	Pinout	
Connections 1/2   Connections 3/4	**Pin**	**Name**
	1	Compensation input
	2	Input +
	3	GND
	4	Input -
	5	Shield[1)]
	1) Shielding also provided by threaded insert in the module. X1 to X4 → A-keyed (female), input	

9 Connection example

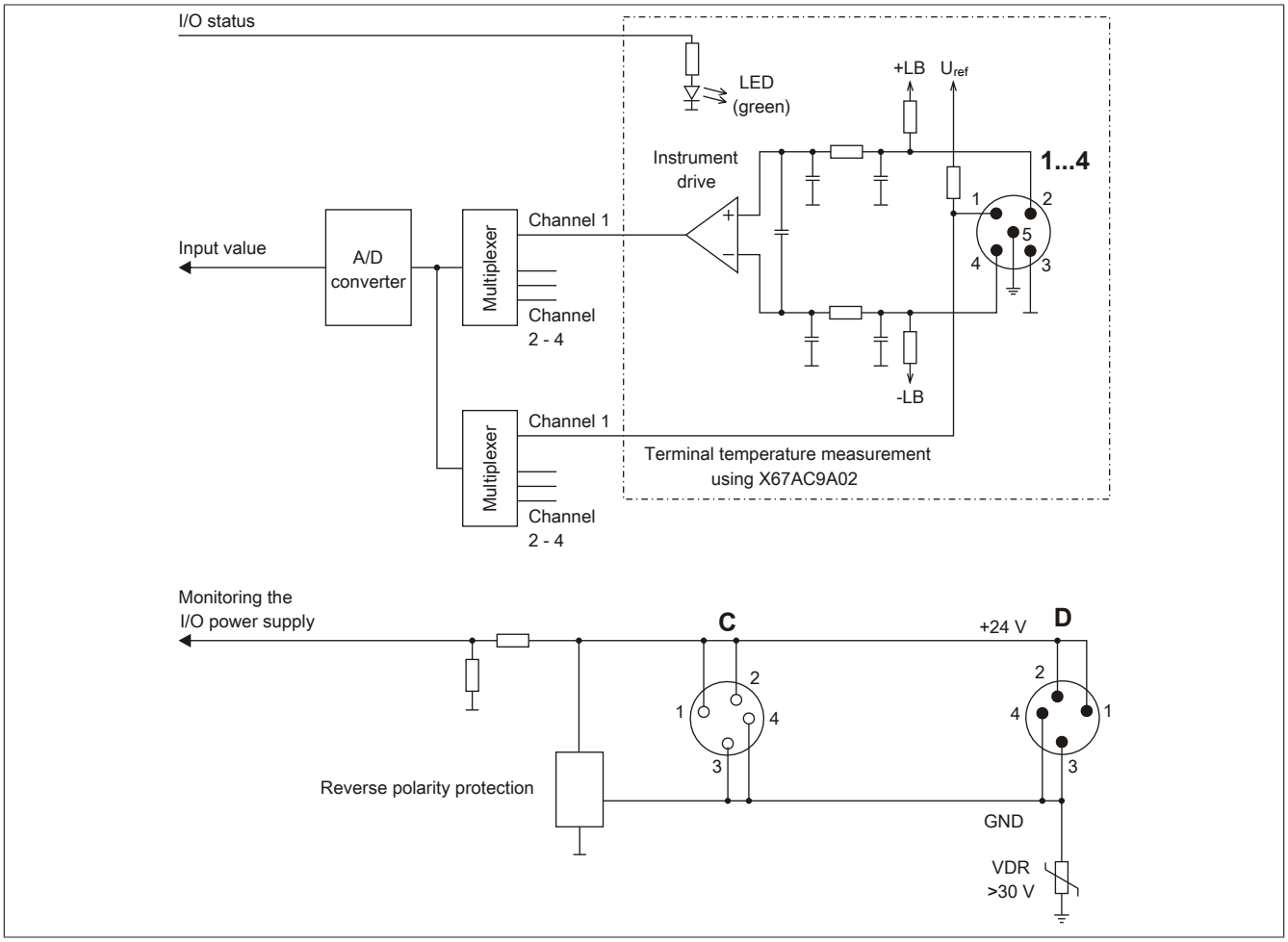
Without temperature compensation



With temperature compensation (Sensor PT1000 is integrated in connector X67AC9A02.)



10 Input circuit diagram



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 section "Additional information - General data points" of the X67 system user's manual.

11.2 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		•		

11.3 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.

11.3.1 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 additional registers and functions depending on the fieldbus used.

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

11.3.2 CAN I/O bus controller

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

11.4 General information

11.4.1 Terminal temperature compensation

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

- Possible for inputs 1 to 4.
- The sensor for measuring the terminal temperature is integrated in the plug housing (X67AC9A02).
- The module independently recognizes that a terminal temperature compensation is necessary using this type of plug.
- At least one terminal temperature sensor is required to determine the temperature measured at the J, K and S thermocouple sensors; otherwise, 0x7FFF is generally output.

Examples of possible configurations

Plug with sensor on the input	Description
1	The terminal temperature compensation for all 4 inputs is performed using the temperature measured on input 1.
1 and 3	The terminal temperature compensation for inputs 1 and 2 is performed using the temperature measured on input 1. The terminal temperature compensation for inputs 3 and 4 is performed using the temperature measured on input 3.
1 to 4	The terminal temperature compensation is performed using the temperature measured on the respective input.

11.4.2 Raw value measurement

Raw value measurement functions with and without terminal temperature measurement. If another sensor type is used as J, K and S, then the terminal temperature must be measured on at least one input. Based on this value, the user must then implement terminal temperature compensation.

11.4.3 Conversion time

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

Unnecessary inputs can be disabled to reduce the I/O update time. Inputs can also be disabled temporarily if they are not needed for a certain amount 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 amount of time saved per channel 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

11.5 Configuration

11.5.1 Input filter

Name:
ConfigOutput01

Filtering for all analog inputs can be configured via this register.

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.		

11.5.2 Sensor type and channel selection

Name:
ConfigOutput02

The sensor type of the individual 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 "Conversion time" on page 8).

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

Bit structure:

Bit	Description	Value	Information
0 - 2	Defines sensor	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 for a measurement range of ±32.767 mV
		111	Raw value without linearization and terminal temperature compensation; Resolution 2 µV for 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)

11.6 Communication

11.6.1 Analog inputs

Name:
Temperature01 to Temperature04

This register is used to indicate the analog input values depending on the configured operating mode.

Data type	Value	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

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.

11.6.2 Terminal temperature

Name:
TerminalTemperature01 to TerminalTemperature04

These registers output the terminal temperature in 0.1°C steps.

Data type	Value	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 some of the terminal temperature sensors are not installed, then the value 0x7FFF is output on the inputs which are not installed.
- If there is no terminal temperature sensor installed at all, then the value 0x7FFF is generally output.

11.6.3 Status of the inputs

Name:
StatusInput01

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

Data type	Values
UINT	See the bit structure.

Bit structure:

Bit	Description	Value	Information
0 - 1	Channel 1	00	No error
		01	Below lower limit value
		10	Above upper limit value
		11	Open circuit
...		...	
6 - 7	Channel 4	00	No error
		01	Below lower limit value
		10	Above upper limit value
		11	Open circuit
8 - 15	Number of conversion cycles performed	x	

Limiting the analog value

In addition to the status information, the analog value is set to the values listed below by default when an error occurs.

Error status	Digital value for error
Open circuit or open input	32767 (0x7FFF)
Above upper limit value	32767 (0x7FFF)
Below lower limit value	-32767 (0x8001)
General error	-32768 (0x8000)

11.6.4 Reading the module ID

Name:
asy_ModulID

This register offers the possibility to read the module ID.

Data type	Values
UINT	Module ID

11.6.5 Operating limit status registers

Name:
asy_SupplyStatus

This register can be used to read the status of the operating limits.

Data type	Values
USINT	See 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 of the warning limits (<18 V or >30 V)
1 - 7	Reserved	0	

11.6.6 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

11.7 Minimum cycle time

The minimum cycle time specifies the time up to which 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

11.8 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.

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