X67AI1333

1 General information

The module is equipped with 4 inputs with 16-bit digital converter resolution. The input signal range is 0 to 20 mA or 4 to 20 mA depending on the selection.

- 4 analog inputs 0 to 20 mA or 4 to 20 mA
- 16-bit digital converter resolution
- Limit detection
- Configurable digital input filters
- Very short cycle times
- Optimal shield grounding on all channels

2 Order data

Model number	Short description	Figure
	Analog input modules	
X67AI1333	X67 analog input module, 4 inputs, 0 to 20 mA or 4 to 20 mA, 16-bit converter resolution, configurable input filter	

Table 1: X67AI1333 - 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	X67AI1333
Short description	
I/O module	4 analog inputs 0 to 20 mA or 4 to 20 mA
General information	
B&R ID code	0xAB1C
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	3 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
Power consumption	
Sensor power supply	Max. 12 W [1]
Analog inputs	
Input	0 to 20 mA or 4 to 20 mA
Input type	Differential input
Digital converter resolution	16-bit
Conversion time	400 µs for all inputs
Output format	INT
Output format	
Current	INT 0x0000 - 0x7FFFF / 1 LSB = 0x001 = 610.4 nA
Load	<300 Ω
Input protection	Protection against wiring with supply voltage
Permissible input signal	Max. ±30 mA
Output of digital value during overload	
Undershoot	0x0000
Overshoot	0x7FFF
Conversion procedure	Successive approximation
Max. error at 25°C	
Gain	
0 to 20 mA	0.13% [2]
4 to 20 mA	0.14% [2]
Offset	
0 to 20 mA	0.04% [3]
4 to 20 mA	0.11% [3]
Max. gain drift	0 to 20 mA = 0.013 %/°C 4 to 20 mA = 0.0165 %/°C [2]
Max. offset drift	0 to 20 mA = 0.004 %/°C 4 to 20 mA = 0.005 %/°C [3]
Common-mode rejection	
DC	>50 dB
50 Hz	>50 dB
Common-mode range	±11 V
Crosstalk between channels	<-70 dB
Nonlinearity	<0.0092% [3]
Isolation voltage between input and bus	500 V_{Eff}
Voltage drop at 20 mA	Typically 4.5 V

Table 2: X67AI1333 - Technical data

Model number	X67AI1333
Input filter	
Cutoff frequency	1 kHz
Slope	40 dB
Sensor power supply	
Voltage	I/O power supply minus voltage drop for short circuit protection
Voltage drop for short-circuit protection at 500 mA	Max. 2 VDC
Summation current	Max. 0.5 A
Short-circuit proof	Yes
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

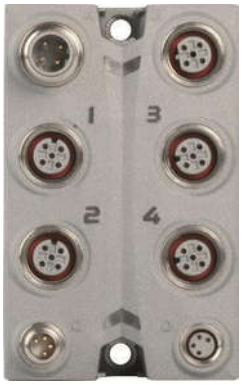
Table 2: X67AI1333 - Technical data

1) The power consumption of the sensors connected to the module is not permitted to exceed 12 W.
2) Based on the current measured value.
3) Based on the entire measurement range.

4 LED status indicators

Figure	LED	Color/Status		Description
	**Status indicator 1:** Status indicator for X2X Link			
	Left/Right	**Green (left)**	**Red (right)**	**Description**
		Off	Off	No supply via X2X Link
		On	Off	X2X Link supplied, communication OK
		Off	On	X2X Link supplied, but X2X Link communication is not functioning
		On	On	PREOPERATIONAL: X2X Link supplied, module not initialized
	I/O LEDs: Status indicator for the corresponding analog input			
	1 - 4	**Color**	**Status**	**Description**
		Green	On	A/D converter running
			Blinking	Input signal overflow or underflow
			Off	Module not in RUN mode
	Status indicator 2: Status indicator for module function			
	Left	**Color**	**Status**	**Description**
		Green	Off	No power to module
			Single flash	RESET mode
			Blinking	PREOPERATIONAL mode
			On	RUN mode
	Right	**Color**	**Status**	**Description**
		Red	Off	No power to module or everything OK
			On	Error or reset status
			Double flash	Supply voltage not in the valid range

5 Connection elements



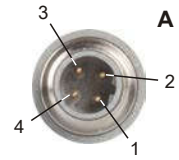
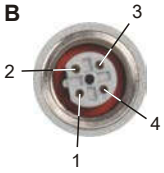
X2X Link
Connection A: Input
Connection B: Output

Analog inputs 1 to 4

24 VDC I/O power supply
Connection C: Supply
Connection D: Routing

6 X2X Link

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

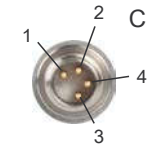
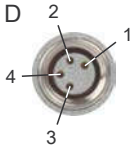
Connection	Pinout	
	**Pin**	**Description**
	1	X2X+
	2	X2X
	3	X2X⊥
	4	X2X\
	Shield connection made via threaded insert in the module.	
	A → B-keyed (male), input B → B-keyed (female), output	

7 24 VDC I/O power supply

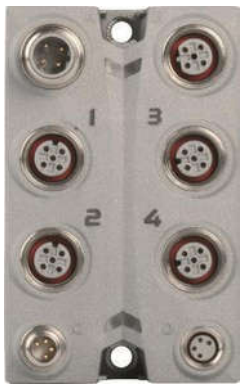
The I/O power supply is connected via M8 connectors C and D. The I/O power supply is connected via connector C (male). Connector D (female) is used to route the I/O power supply to other modules.

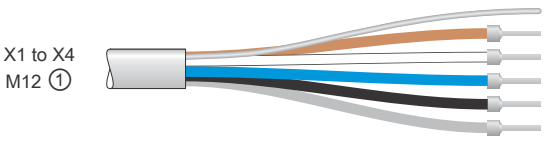
Information:

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

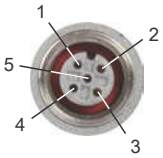




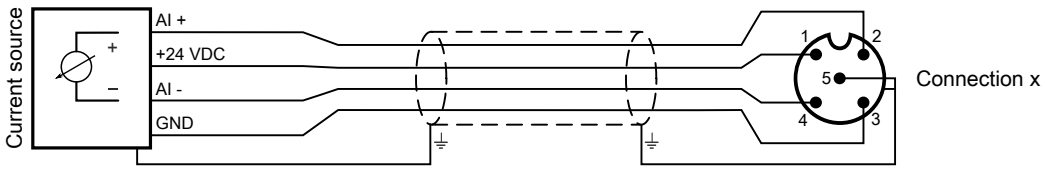
Shield	
1	+24 VDC
2	AI +
3	GND
4	AI -
5	Shield

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

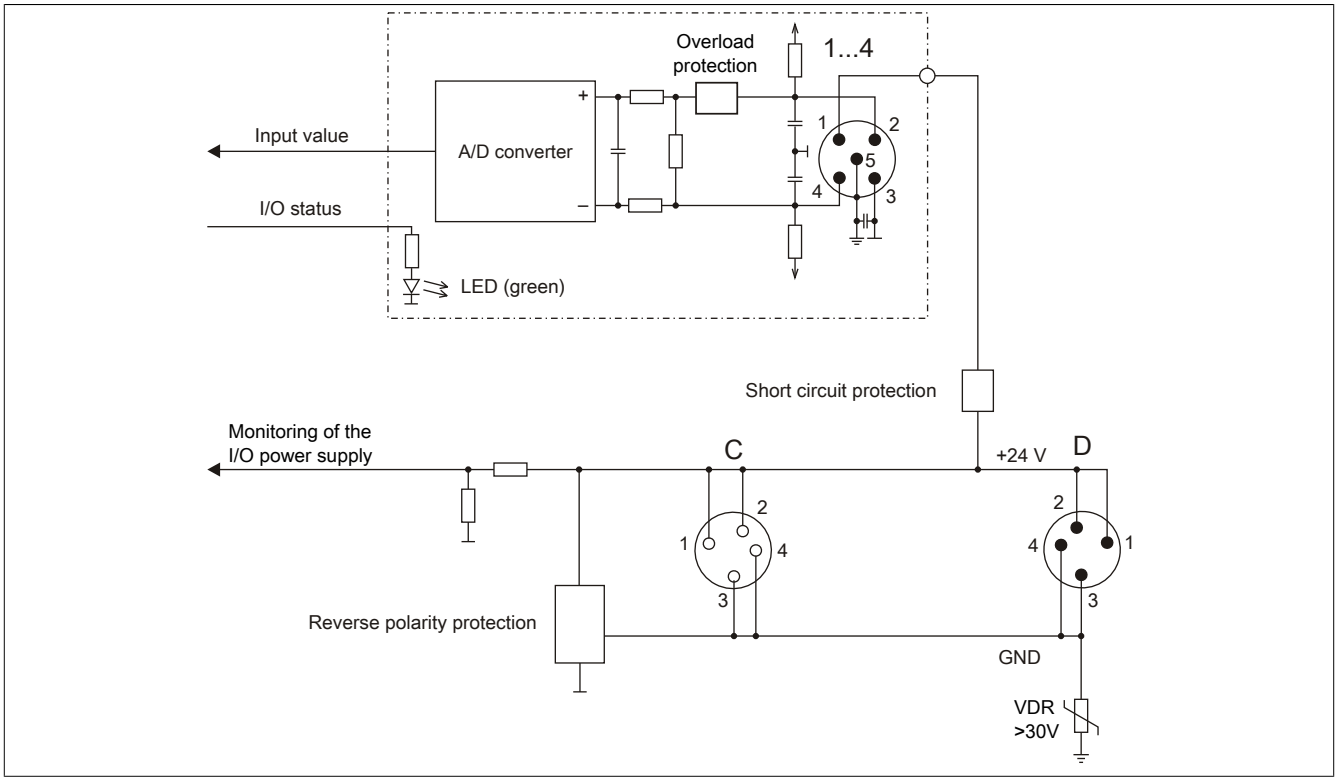
8.1 Connections X1 to X4

M12, 5-pin	Pinout	
Connections 1/2	**Pin**	**Name**
	1	24 VDC sensor supply
	2	Input +
	3	GND
	4	Input -
	5	Shield[1)]
Connections 3/4	1) Shielding also provided by threaded insert in the module.	
	X1 to X4 → A-keyed (female), input	

9 Connection example



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 (channel type)	USINT				•
20	ConfigOutput03 (lower limit value)	INT				•
22	ConfigOutput04 (upper limit value)	INT				•
Communication						
0	AnalogInput01	INT	•			
2	AnalogInput02	INT	•			
4	AnalogInput03	INT	•			
6	AnalogInput04	INT	•			
30	Status of the inputs	USINT	•			
	UnderflowAnalogInput01	Bit 0				
	OverflowAnalogInput01	Bit 1				
	...	...				
	UnderflowAnalogInput04	Bit 6				
	OverflowAnalogInput04	Bit 7				
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 (channel type)	USINT				•
20	-	ConfigOutput03 (lower limit value)	INT				•
22	-	ConfigOutput04 (upper limit value)	INT				•
Communication							
0	0	AnalogInput01	INT	•			
2	2	AnalogInput02	INT	•			
4	4	AnalogInput03	INT	•			
6	6	AnalogInput04	INT	•			
30	-	Status of the inputs	USINT		•		
		UnderflowAnalogInput01	Bit 0				
		OverflowAnalogInput01	Bit 1				
		...	...				
		UnderflowAnalogInput04	Bit 6				
		OverflowAnalogInput04	Bit 7				
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 Analog signal - Configuration

11.4.1 Configuring the input filter

Name:
ConfigOutput01

This register is used to define the filter level and input ramp limitation of the input filter.

Data type	Values	Bus controller default setting
USINT	See bit structure.	0

Bit structure:

Bit	Description	Value	Information
0 - 2	Defines the filter level	000	Filter disabled (bus controller default setting)
		001	Filter level 2
		010	Filter level 4
		011	Filter level 8
		100	Filter level 16
		101	Filter level 32
		110	Filter level 64
		111	Filter level 128
3	Reserved	0	
4 - 6	Defines the input ramp limit	000	The input value is applied without limitation (bus controller default setting)
		001	Limit value = 0x3FFF (16383)
		010	Limit value = 0x1FFF (8191)
		011	Limit value = 0x0FFF (4095)
		100	Limit value = 0x07FF (2047)
		101	Limit value = 0x03FF (1023)
		110	Limit value = 0x01FF (511)
		111	Limit value = 0x00FF (255)
7	Reserved	0	

11.4.2 Channel type

Name:
ConfigOutput02

This register determines the measurement range for the analog input.

The 4 to 20 mA measurement range is determined by converting the value from the 0 to 20 mA range. 4 mA equals digital value 0x0000, and 20 mA equals the value 0x7FFF. Due to the conversion, certain digital values never occur (higher value range).

Data type	Value	Bus controller default setting
USINT	See bit structure.	0

Bit structure:

Bit	Description	Value	Information
0	Channel 1	0	0 to 20 mA (bus controller default setting)
		1	4 to 20 mA
...		...	
3	Channel 4	0	0 to 20 mA (bus controller default setting)
		1	4 to 20 mA
4 - 7	Reserved	0	

11.4.3 Limit values

The input signal is monitored at the upper and lower limit values. These must be defined according to the operating mode:

Limit value (default)	Current signal 0 to 20 mA		Current signal 4 to 20 mA	
Upper maximum limit value	20 mA	+32767 (0x7FFF)	20 mA	+32767 (0x7FFF)
Lower minimum limit value	0 mA	0 (0x0000)[1)]	4 mA	0 (0x0000)[2)]

1) The analog value is limited down to 0.
2) The analog value is limited down to 0 at currents <4 mA. The status bit for the lower limit is set.

Other limit values can be defined if necessary. Limit values are valid for all channels and activated automatically by writing to the limit value registers. From this point on, the analog values will be monitored and limited according to the new limits. The results of monitoring are displayed in the status register.

Examples of limit value settings

Application case	Limit value settings
Current signal: 4 to 20 mA	A negative limit value must be configured in order to measure values <4 mA with a current signal of 4 to 20 mA: 0 mA corresponds to the value -8192 (0xE000). When limit values are changed, it is important to note that the configured limit values apply to all channels in mixed operation.

11.4.3.1 Lower limit value

Name:
ConfigOutput03

This register can be used to configure the lower limit for analog values. If the analog value goes below the limit value, it is frozen at this value and the corresponding error status bit is set.

Data type	Value	Information
INT	-32768 to 32767	Bus controller default setting: -32767

Information:

- **When configured as 0 to 20 mA, this value should be set to 0.**
- **When configured as 4 to 20 mA, this value can be set to -8192 (corresponds to 0 mA) in order to display values <4 mA.**

Information:

Keep in mind that this setting applies to all channels!

11.4.3.2 Upper limit value

Name:
ConfigOutput04

This register can be used to configure the upper limit for analog values. If the analog value goes above the limit value, it is frozen at this value and the corresponding error status bit is set.

Data type	Value	Information
INT	-32768 to 32767	Bus controller default setting: 32767

Information:

The default value of 32767 corresponds to the maximum default value at 20 mA.

Information:

Keep in mind that this setting applies to all channels!

11.5 Analog signal - Communication

11.5.1 Analog inputs

The input state is collected with a fixed offset to the network cycle and transferred in the same cycle.

11.5.2 Input values of analog inputs

Name:
AnalogInput01 to AnalogInput04

The analog input value is mapped in this register depending on the configured operating mode.

Data type	Value	Input signal:
INT	-8192 to 32767	Current signal 4 to 20 mA
	0 to 32767	Current signal 0 to 20 mA

11.5.3 Input filter

This module is equipped with a configurable input filter. The minimum cycle time must be >500 µs. Filtering is disabled for shorter cycle times.

If the input filter is active, then the scan rate for the channels is measured in ms. The time offset between the channels is 200 µs. The conversion takes place asynchronously to the network cycle.

11.5.3.1 Input ramp limitation

Input ramp limitation can only take place when a filter is used; the input ramp is limited before filtering takes place.

The amount the input value changes is checked to make sure that specified limits are not exceeded. If the values are exceeded, the adjusted input value is equal to the old value ± the limit value.

Configurable limit values:

Value	Limit value
0	The input value is used without limitation.
1	0x3FFF = 16383
2	0x1FFF = 8191
3	0x0FFF = 4095
4	0x07FF = 2047
5	0x03FF = 1023
6	0x01FF = 511
7	0x00FF = 255

Input ramp limitation is well suited for suppressing disturbances (spikes). The following examples show the function of the input ramp limitation based on an input jump and a disturbance.

Example 1

The input value jumps from 8000 to 17000. The diagram shows the adjusted input value with the following settings:

Input ramp limitation = 4 = 0x07FF = 2047

Filter level = 2

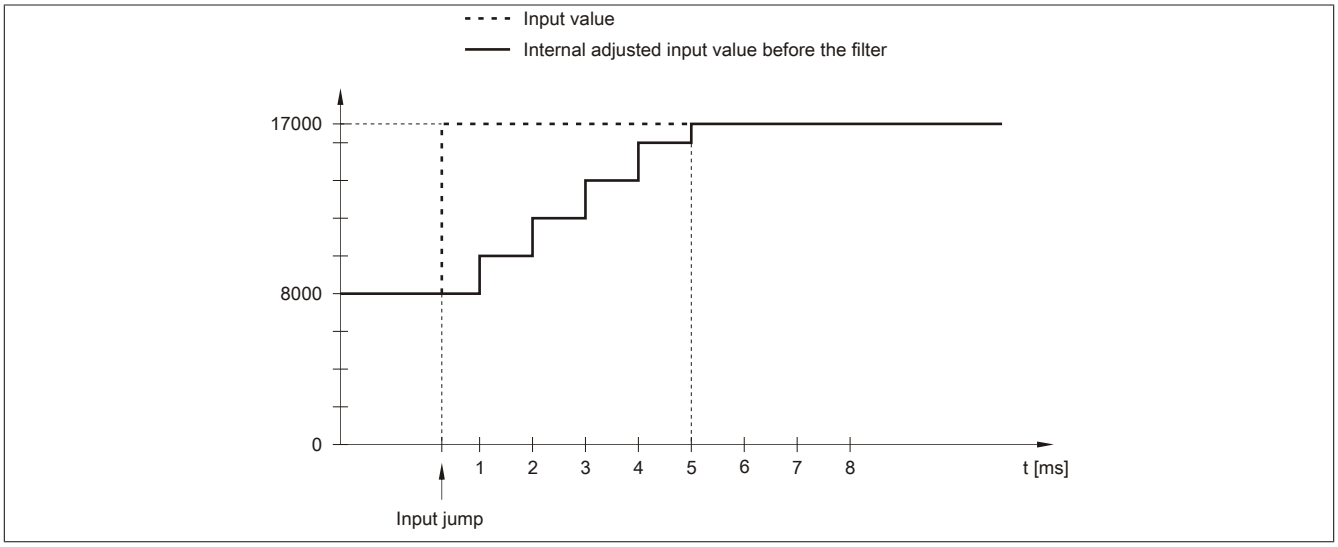


Figure 1: Tracked input value for input jump

Example 2

A disturbance interferes with the input value. The diagram shows the adjusted input value with the following settings:

Input ramp limitation = 4 = 0x07FF = 2047

Filter level = 2

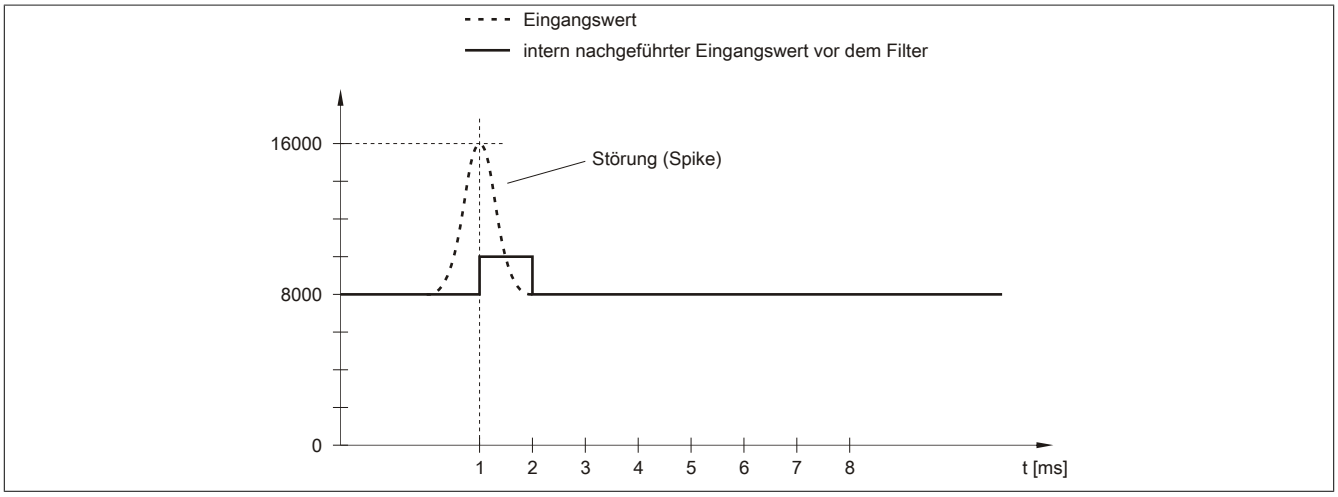


Figure 2: Adjusted input value for disturbance

11.5.3.2 Filter level

A filter can be defined to prevent large input jumps. This filter is used to bring the input value closer to the actual analog value over a period of several bus cycles.
Filtering takes place after input ramp limitation.

Formula for calculating the input value:

$$\text{Value}_{\text{New}} = \text{Value}_{\text{Old}} - \frac{\text{Value}_{\text{Old}}}{\text{Filter level}} + \frac{\text{Input value}}{\text{Filter level}}$$

Adjustable filter levels:

Value	Filter level
0	Filter switched off
1	Filter level 2
2	Filter level 4
3	Filter level 8
4	Filter level 16
5	Filter level 32
6	Filter level 64
7	Filter level 128

The following examples show how filtering works in the event of an input jump or disturbance.

Example 1

The input value jumps from 8000 to 16000. The diagram shows the calculated value with the following settings:

Input ramp limitation = 0

Filter level = 2 or 4

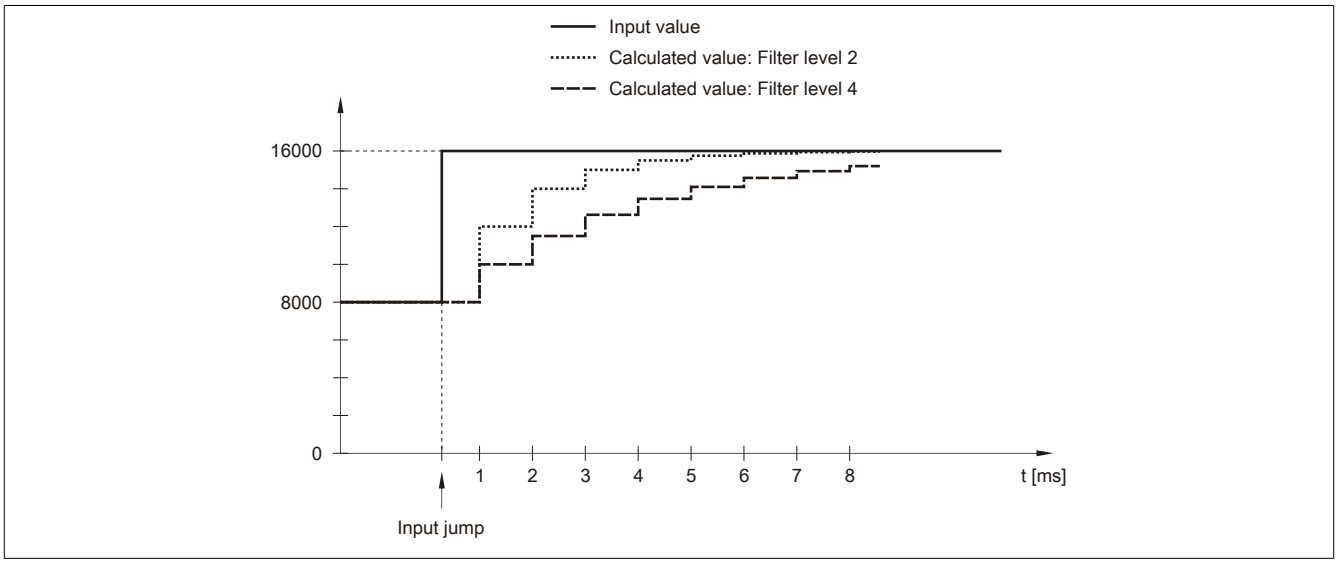


Figure 3: Calculated value during input jump

Example 2

A disturbance interferes with the input value. The diagram shows the calculated value with the following settings:

Input ramp limitation = 0

Filter level = 2 or 4

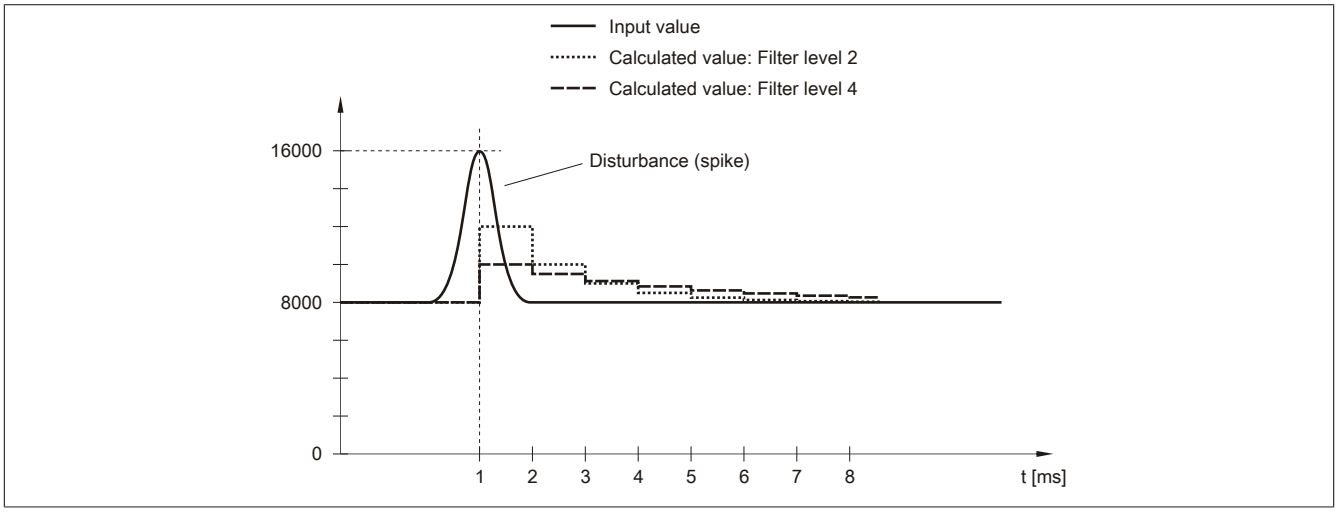


Figure 4: Calculated value during disturbance

11.5.4 Status of the inputs

Name:
UnderflowAnalogInput01 to UnderflowAnalogInput04
OverflowAnalogInput01 to OverflowAnalogInput04

This register is used to monitor the module inputs. A change in the monitoring status generates an error message. The following states are monitored depending on the settings:

Data type	Values
USINT	See the bit structure.

Bit structure:

Bit	Description	Value	Information
0	UnderflowAnalogInput01	0	No error
		1	Below lower limit value
1	OverflowAnalogInput01	0	No error
		1	Above upper limit value
...		...	
6	UnderflowAnalogInput04	0	No error
		1	Below lower limit value
7	OverflowAnalogInput04	0	No error
		1	Above upper limit value

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. The analog value is limited to the new values if the limit values were changed.

Error status	Digital value for error (default values)
Above upper limit value	+32767 (0x7FFF)
Below lower limit value	0 (0x0000)

11.6 Reading the module ID

Name:
asy_ModulID

This register offers the possibility to read the module ID.

Data type	Values
UINT	Module ID

11.7 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	

11.8 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

11.9 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
Inputs without filtering	250 µs
Inputs with filtering	>500 µs

11.10 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 without filtering	400 µs for all inputs
Inputs with filtering	1 ms