X67AI2744

This data sheet describes 2 module revisions. The module revision is marked on the side of the module. Select the desired module revision from the following table to view its description.

Module	Revision	Page
X67AI2744	≥BB	1
X67AI2744	<BB	34

> ## Information:
> **The following requirements must be met to be able to use the full range of functions of the module.**
> - **Automation Studio ≥4.0**
> - **Module revision ≥BB**

1 X67AI2744 with Rev. ≥BB

1.1 General information

This module is equipped with 2 inputs for evaluating full-bridge strain gauges and works with both 4-wire and 6-wire strain gauge load cells. The concept applied by the module requires compensation in the measurement system. This compensation eliminates the absolute uncertainty in the measurement circuit, such as component tolerances, effective bridge voltage or zero point offset. The measurement precision refers to the absolute (compensated) value, which will only change as a result of changes in the operating temperature.

- 2 full-bridge strain gauge inputs
- Data output rate configurable from 2.5 Hz to 7.5 kHz
- Special operating modes (synchronous mode and multisampling)
- Configurable filter level
- Can be used with a SafeLOGIC controller

1.2 Order data

Model number	Short description	Figure
	Analog input modules	
X67AI2744	X67 analog input module, 2 full-bridge strain gauge inputs, 10 V, 24-bit converter resolution	

Table 1: X67AI2744 - Order data

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

1.3 Technical data

Model number	**X67AI2744**
Short description	
I/O module	2 full-bridge strain gauge inputs
General information	
B&R ID code	0x8820
Status indicators	Channel status, operating state, module status
Diagnostics	
Module run/error	Yes, using LED status indicator and software
Open circuit	Yes, using LED status indicator and software
Input	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	
Bus	0.75 W
Internal I/O	2.4 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
Full-bridge strain gauge	
Strain gauge factor	2 to 256 mV/V, configurable using software
Connection	4- or 6-wire connections [1)]
Input type	Differential, used to evaluate a full-bridge strain gauge
Digital converter resolution	24-bit
Conversion time	Depends on the configured data output rate
Data output rate	2.5 to 7,500 samples per second, configurable using software (f_{DATA})
Input filter	
Cutoff frequency	5 kHz
Order	3
Slope	60 dB
ADC filter characteristics	Sigma-delta, see section "Filter characteristics of the sigma-delta A/D converter"
Operating range / Measurement sensor	85 to 5,000 Ω
Influence of cable length [2)]	See section "Calculation example", sensor cable length: Max. 30 m
Input protection	RC protection
Common-mode range	0 to 3 VDC Permissible input voltage range (with regard to the poten- tial strain gauge GND) on inputs "Input +" and "Input -"
Isolation voltage between input and bus	500 V_{eff}
Conversion procedure	Sigma-delta
Output of digital value	
Broken bridge supply line	Value approaching 0
Broken sensor line	Value approaching ±end value (status bit "Line status monitoring" is set in register "Module status")
Valid range of values	0xFF800001 to 0x007FFFFF (-8,388,607 to 8,388,607)
Strain gauge supply	
Voltage	5.5 VDC / Max. 65 mA
Short-circuit and overload resistant	Yes
Voltage drop for short-circuit protection	Max. 0.2 VDC at 65 mA and 25°C

Table 2: X67AI2744 - Technical data

Model number	X67AI2744
Quantization [3]	
LSB value (16-bit)	
2 mV/V	336 nV
4 mV/V	671 nV
8 mV/V	1.343 µV
16 mV/V	2.686 µV
32 mV/V	5.371 µV
64 mV/V	10.74 µV
128 mV/V	21.48 µV
256 mV/V	42.97 µV
LSB value (24-bit)	
2 mV/V	1.31 nV
4 mV/V	2.62 nV
8 mV/V	5.25 nV
16 mV/V	10.49 nV
32 mV/V	20.98 nV
64 mV/V	41.96 nV
128 mV/V	83.92 nV
256 mV/V	167.85 nV
Max. gain drift	12 ppm/°C [4]
Max. offset drift	2 ppm/°C [5]
Nonlinearity	<10 ppm [5]
Electrical properties	
Electrical isolation	Bus isolated from analog input and strain gauge supply voltage Channel not isolated from I/O power supply
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	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	190 g
Torque for connections	
M8	Max. 0.4 Nm
M12	Max. 0.6 Nm

Table 2: X67AI2744 - Technical data

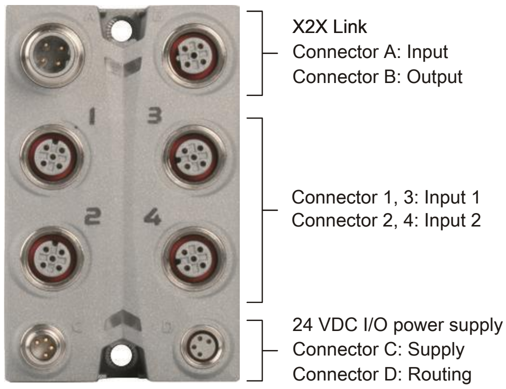
1) With 6-wire connections, line compensation does not function (see section "Connection examples").
2) Sensor cable with twisted and shielded conductors, cable length as short as possible, cable routing separate from load circuits, without intermediate terminal to the sensor.
3) Quantization depends on the strain gauge factor.
4) Based on the current measured value.
5) Based on the entire measurement range.

1.4 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 - 2	Status indicator per input		
		LED	Status	Description
		Green	On	A/D converter running, value OK
			Off	Possible causes: • Open circuit • Sensor disconnected • Converter busy
	3 - 4	These two LEDs are not used.		
	Status indicator 2	Status indicator for module function		
		LED	Status	Description
		Green	Off	No power to module
			Single flash	Mode RESET
			Double flash	Mode BOOT (during firmware update)[1]
			Blinking	Mode PREOPERATIONAL
			On	Mode RUN
		Red	Off	Module not supplied with power or everything OK
			On	Error or reset state

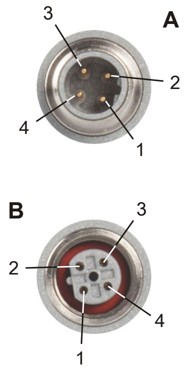
1) Depending on the configuration, a firmware update can take up to several minutes.

1.5 Connection elements



1.6 X2X Link

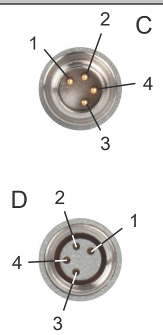
This module is connected to X2X Link using pre-assembled cables. The connection is made using M12 circular connectors.

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	

1.7 24 VDC I/O power supply

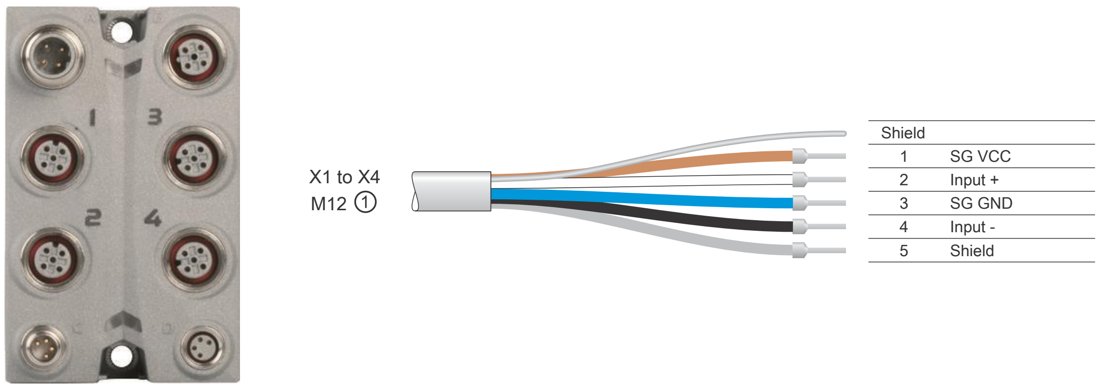
The I/O power supply is connected via M8 connectors C and D. The I/O power supply is connected via connector C (male). Connector D (female) is used to route the I/O power supply to other modules.

> **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	

1.8 Pinout

The maximum length of the sensor cable is 30 m.



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

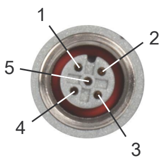
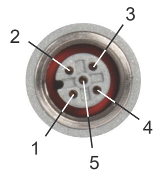
1.8.1 Connections X1 to X4

The module is equipped with 2 channels for the connection of strain gauge load cells.

- X1 and X3: Channel 1 (connected internally)
- X2 and X4: Channel 2 (connected internally)

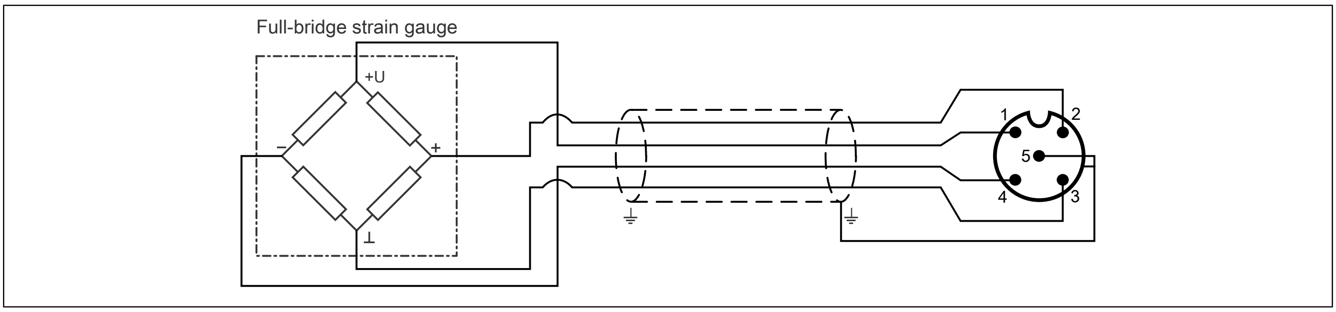
Information:

Connections 1 and 3 as well as 2 and 4 are connected to each other internally. This allows 2 strain gauge load cells to be switched in parallel and connected to the respective channel via these connections.

M12, 5-pin	Pinout		
Connection 1/2	**Pin**	**Description**	**Description**
	1	SG VCC	Strain gauge supply +
	2	Input +	Differential input +
	3	SG GND	Strain gauge supply GND
	4	Input -	Differential input -
	5	Shield[1)]	Shield
	1) Shielding also provided by threaded insert in the module. X1 to X4 → A-keyed (female), input		
Connection 3/4			

1.9 Connection examples

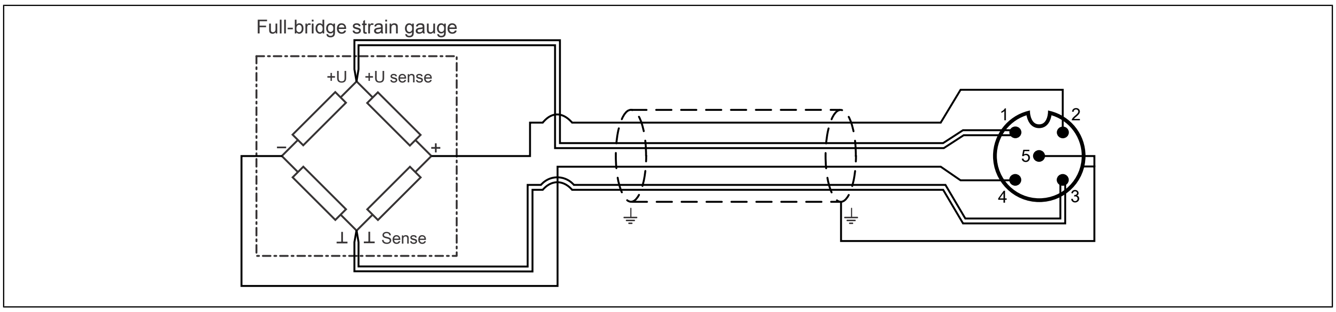
Full-bridge strain gauge with 4-wire connections



Full-bridge strain gauge with 6-wire connections

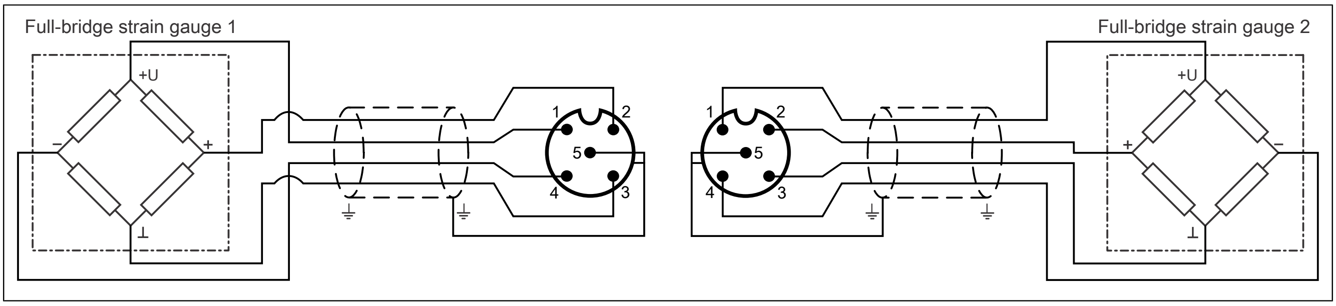
Full-bridge strain gauges can be connected to this module with 6-wire connections. Line compensation is not supported by the module, however. The respective sense line can be connected to the strain gauge VCC or strain gauge GND connection. The measurement precision is therefore affected by changes in operating temperature. Longer cable lengths and smaller cable cross sections also increase the potential for errors in the measurement system.

To further reduce line resistance, it is recommended to connect the sense lines in parallel with the strain gauge supply lines. Optimal signal quality can be obtained by using a shielded twisted pair cable. The connections for the strain gauge supply lines, the sensor lines and the bridge differential voltage lines should each use one twisted pair cable.



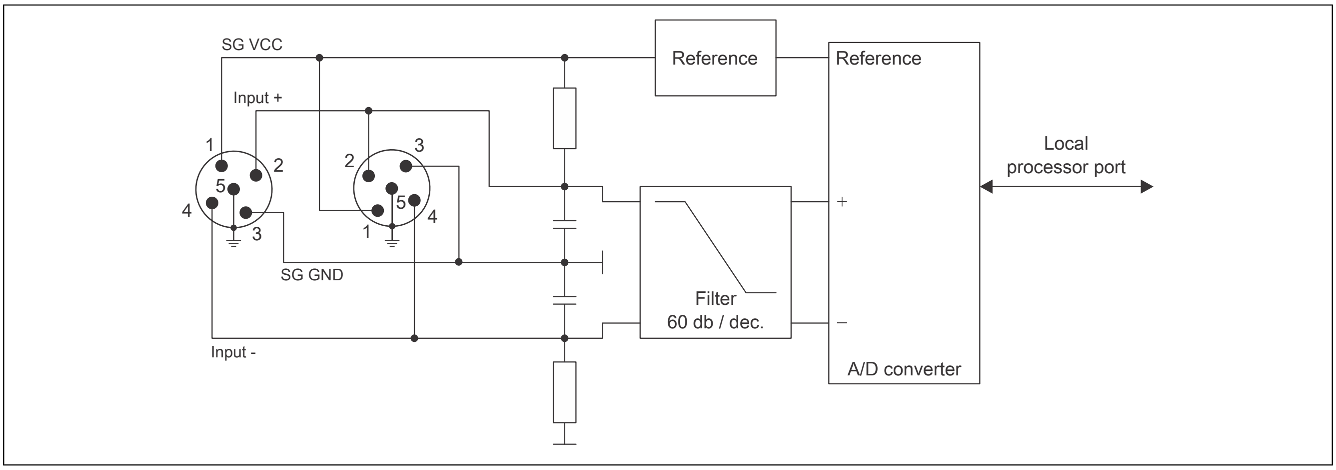
Parallel connection of 2 full-bridge strain gauges (4-wire connections)

If connecting the full-bridge strain gauges in parallel, the manufacturer's guidelines must be observed.



When connecting 3 or more full-bridge strain gauges in parallel, 2 lines must be consolidated in one connector.

1.10 Input circuit diagram

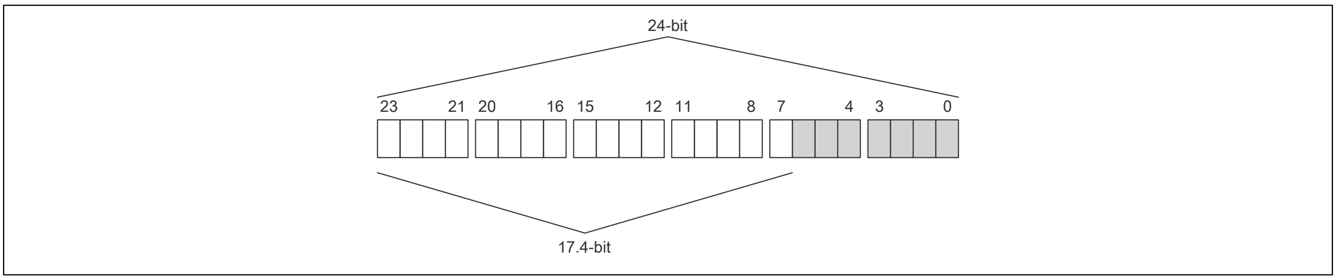


1.11 Effective resolution of the A/D converter

The A/D converter for the module provides a 24-bit measured value. The actual attainable noise-free resolution is always less than 24-bit, however. This "effective resolution" depends on the data rate and measurement range.

Example:

Because of the conversion method, a data rate of 2.5 Hz and a specified measurement area of 2 mV/V result in an effective resolution of 17.4 bits:



The low-order bits (grayed out) contain only noise instead of valid values and are therefore not permitted to be evaluated.

With "Function model 1 - Multisampling", only the highest 16 bits are made available.

1.12 Calculation example

The following example shows the influence of the length of the measuring cable on the bridge voltage of the module and the quantization calculated with it.

1.12.1 Bridge voltage

Although the measuring bridge must be adjusted with the module, the cable length has an influence on the accuracy of the measurement. The reason for this is the voltage drop on the power supply lines of the measuring bridge. As a result, the strain gauge supply voltage at the measuring bridge no longer amounts to the full 5.5 V. The reduced bridge voltage also has an effect on the quantization.

Example

Characteristics of the measuring device used:

- Full-bridge strain gauge with 4-wire connections
- Material-dependent conductivity of the cable (copper: $12\frac{m}{\Omega \cdot mm^2}$)
- Cross section of the cable: 22 AWG = 0.34 mm²
- Length of the cable: 5 m
- Nominal current of the measuring bridge: 15 mA
- Bridge voltage of the module: 5.5 V

Actual bridge voltage taking the voltage drop on the measuring line into account:

$$5.5V - \frac{2 \cdot 5m}{12\frac{m}{\Omega \cdot mm^2} \cdot 0.34mm^2} \cdot 0.015A = 5.463\ V$$

The quantization must be calculated using the actual calculated bridge voltage (see "Quantization" on page 10).

1.12.2 Quantization

In a weighing application, the corresponding weight located on the connected load cell should be determined from the value derived from the module.

Example

The characteristics of the strain gauge load cell are as follows:

- Rated load: 1000 kg
- Strain gauge factor: 4 mV/V
- Actual bridge voltage: 5.463 V

Maximum quantization:
Multiplying the bridge factor of the strain gauge load cell with the bridge supply voltage from the module results in the value for the positive full-scale deflection at a specified rated load of 1000 kg:

4 mV/V · 5.5 V = 22 mV

Actual quantization:
Taking the voltage drop on the measuring line into account, the actual bridge voltage is 5.463 V (for the calculation, see section "Bridge voltage" on page 9). If this voltage is multiplied by the strain gauge factor of 4 mV/V, the following actual quantization results:

4 mV/V · 5.463 V = 21.85 mV

These 21.85 mVcorrespond to 99.3% of the maximum possible measuring range.

Information:

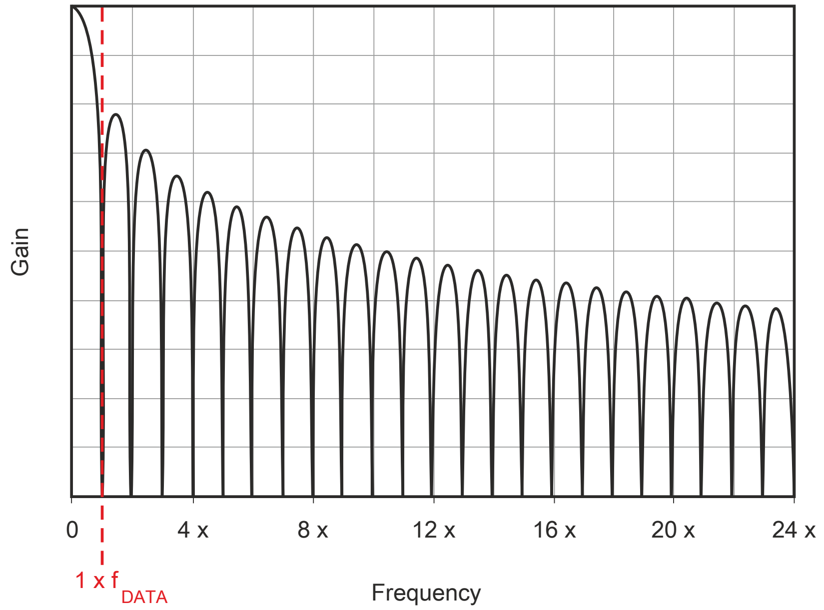
If the quantization decreases, the maximum possible effective resolution also decreases (see "Effective resolution of the A/D converter" on page 8).

With a simple Rule of Three calculation, the corresponding value can be calculated (as seen in the table) from weight to the converter value and vice versa. This simplified theoretical approach is only valid for an ideal measurement system. Calibration of the entire measurement system is recommended because not only the module, but particularly the strain gauge bridges exhibit tolerances (offset, gain). When taring, the gradient offset is recalculated and the gain of the linear equation is determined when normalized. In addition to the calculation displayed in the table, these calculations must also be carried out in the application.

24-bit value of the module		Quantization	Corresponding weight
0x007F FFFF	8,388,607	21.85 mV	1000 kg
0x0000 0001	1	2.61 nV	0.119 g
0x0000 20C3	8387	21.85 µV	1 kg
0x0001 0000	65536	170.7 µV	7.81 kg

The values for 1 LSB are also included in the module's technical data under item "Quantization" (1 LSB each for 16 bits and 24 bits).

1.13 Filter characteristics of the sigma-delta A/D converter

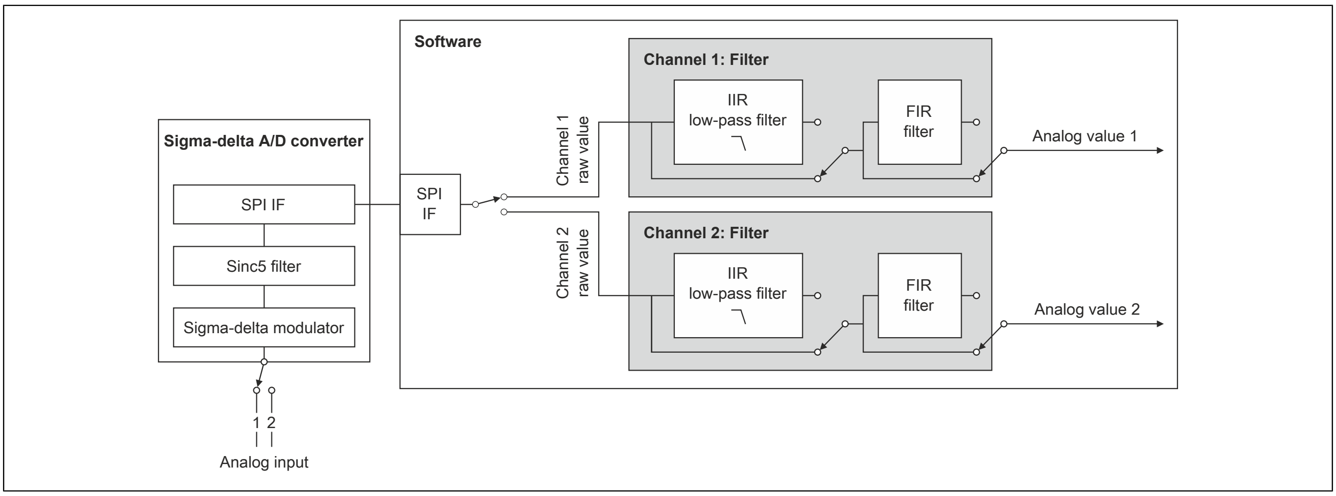


1.14 Software filters

2 filters are available for the analog input. They can be individually enabled and configured at runtime. By default, both filters are disabled when the device is switched on. The filters are controlled and configured using "Function model 2 - Extended filter".

In order to allow the filter behavior to be adapted to the measuring situation or machine cycle (high dynamics and low precision or low dynamics and high precision), the filter characteristics of both the IIR low-pass filter as well as the FIR filter can be changed synchronously at any time.

Filter diagram



1.14.1 IIR low-pass filter

1.14.1.1 General information

The IIR low-pass filter is used to generally smooth and increase the resolution of the analog value. The filter works according to the following formula:

$$y = y_{Old} + \frac{x - y_{Old}}{2^{\text{Filter level}}}$$

x ... Current filter input value
y_{Old} ... Old filter output value
y ... New filter output value

Parameter "Filter level" in the formula above is configured using register "ConfigCommonOutput0x" on page 29. "Filter level" = 0 if the IIR low-pass filter is disabled.

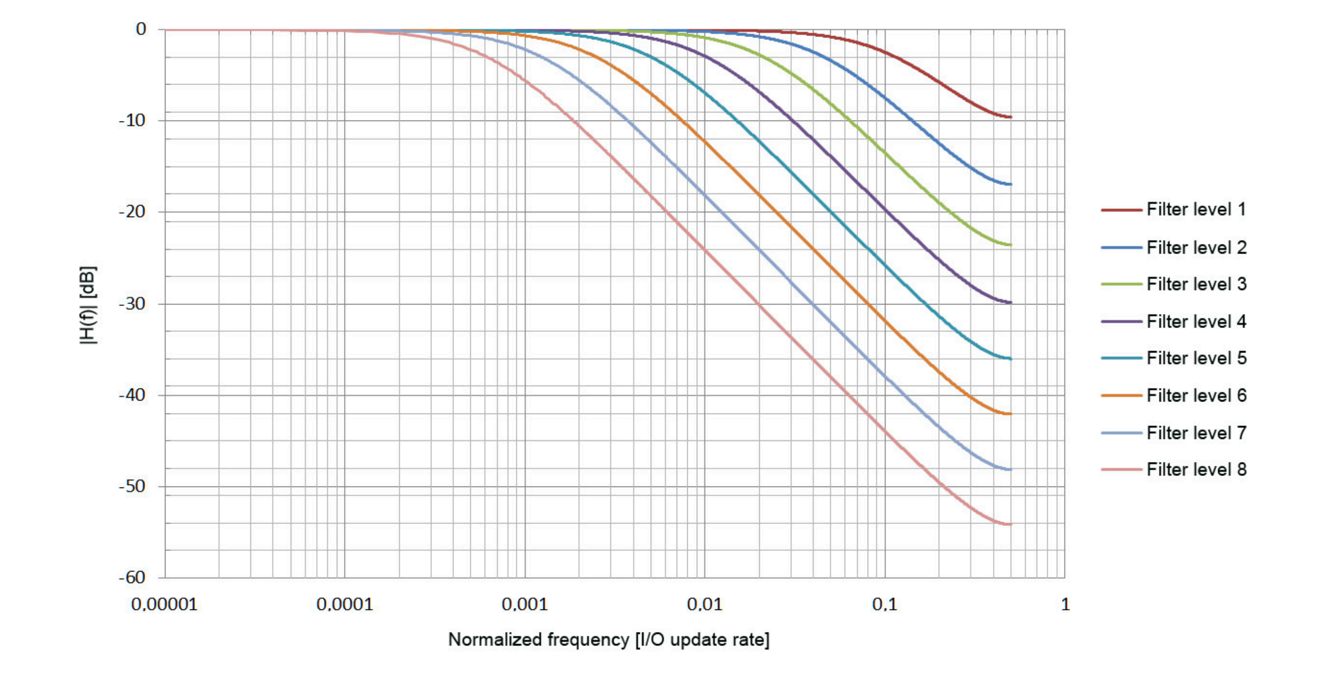
1.14.1.2 Filter characteristics of the 1st-order IIR low-pass filter

Limit frequency f_c

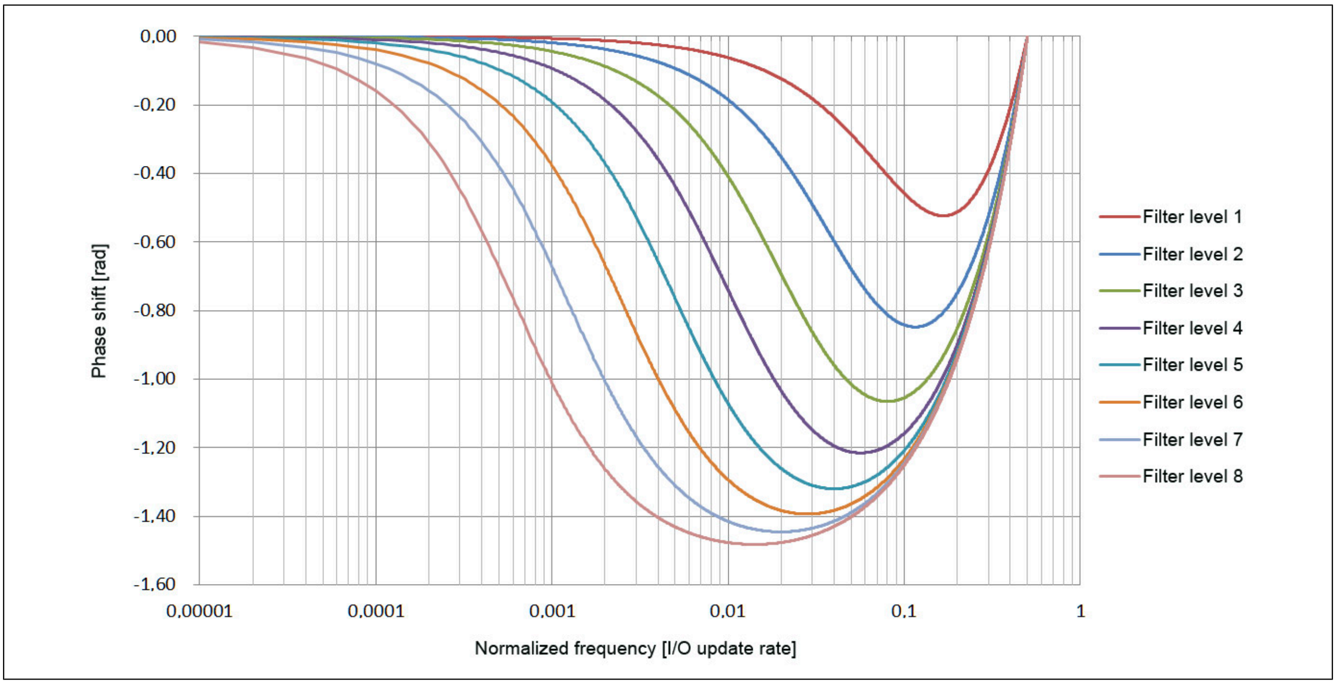
The following table provides an overview of the -3 dB limit frequency f_c depending on the configured filter level.

Filter level	Normalized f_c [I/O update rate]	f_c [Hz] I/O update rate = 7500/s	f_c [Hz] I/O update rate = 10000/s
1	0.11476	860.7	1147.6
2	0.046	345	460
3	0.02124	159.3	212.4
4	0.01026	76.95	102.6
5	0.00504	37.8	50.4
6	0.0025	18.8	25
7	0.00124	9.3	12.4
8	0.00062	4.65	6.2

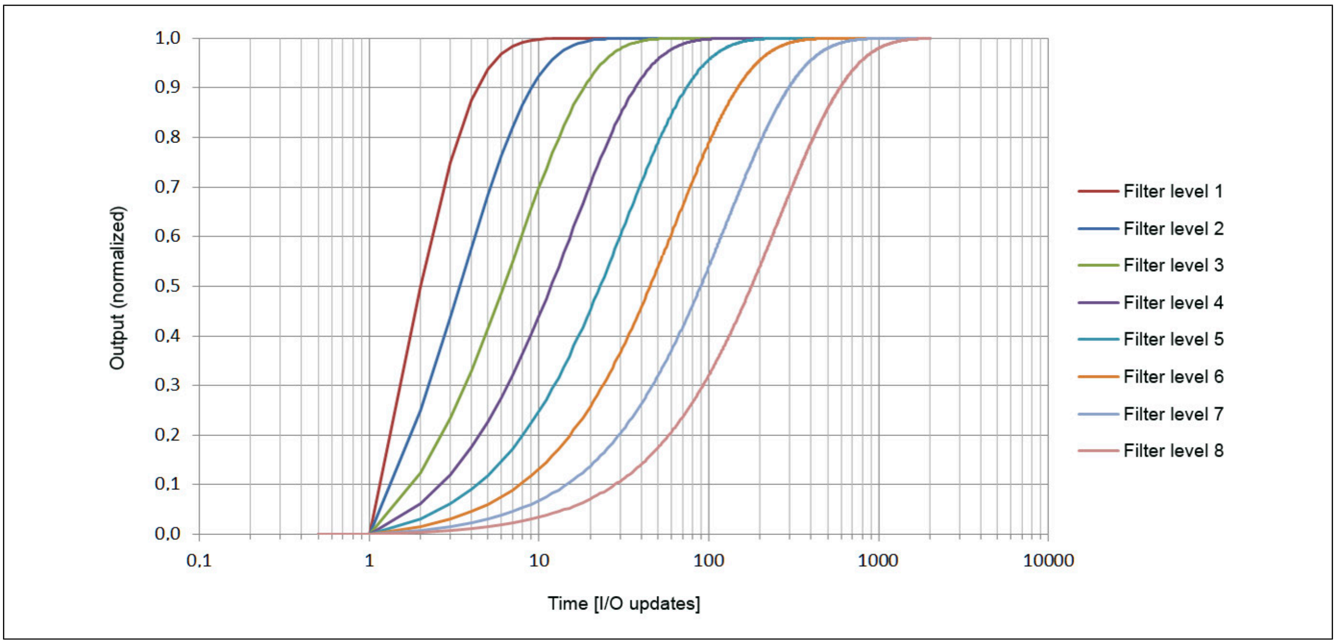
Gain of the IIR low-pass filter



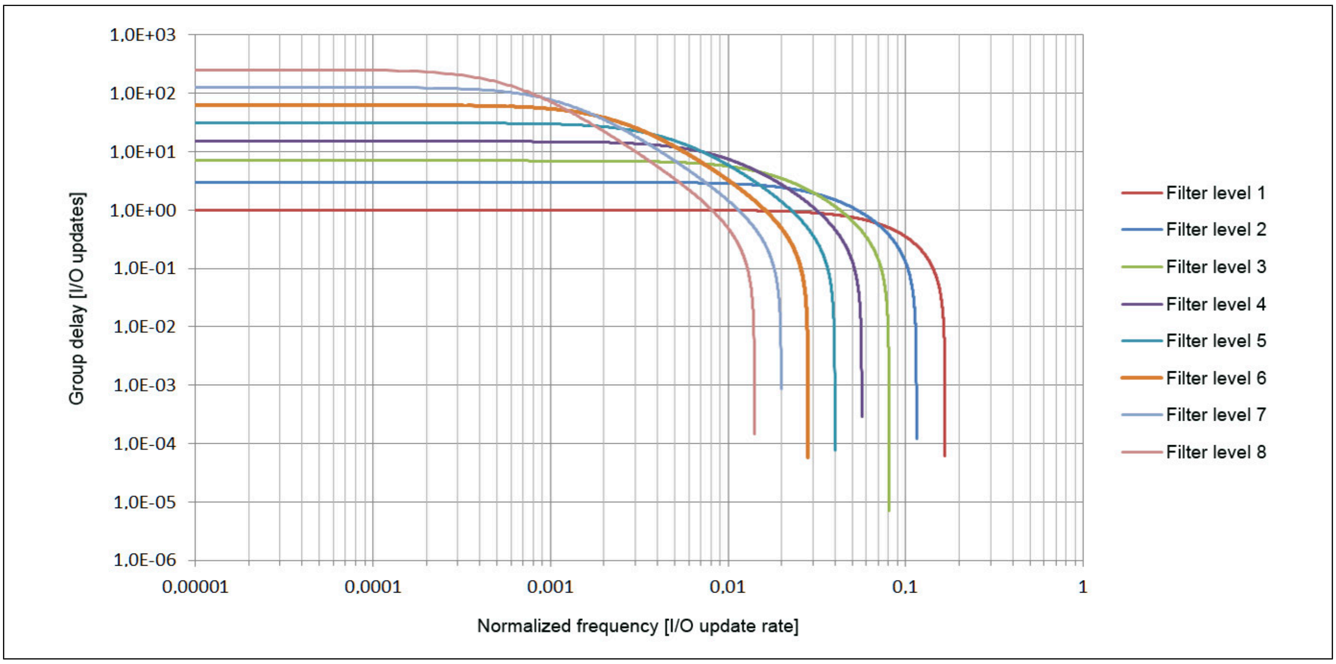
Phase shift of the IIR low-pass filter



Step response of the IIR low-pass filter



Group delay of the IIR low-pass filter



1.14.2 FIR filter

Like the IIR low-pass filter, the FIR filter can also be used to smooth out the signal and increase its resolution. In addition, configuring the filter length accordingly makes it possible to target and efficiently filter out individual interference frequencies. The source of these interference frequencies may be mechanical or electromagnetic. Multiples of these are also filtered out (as long as they are a whole-number factor of the data output rate).

Example:
Data output rate = 10000 samples/s, averaging over 10 values → "Notch" at 1 kHz (2 kHz, etc.)

When reconfiguring the filter, it takes 1/data rate (FIR filter in mode "Selectable data rate") or 1/filter frequency (FIR filter in mode"High-resolution data rate") until the filter is tuned. During tuning, bit 5 is set in register "StatusInput0x" on page 31.

1.14.2.1 Characteristics of the FIR filter in mode "Selectable data rate"

The following table applies to "Function model 0 - Standard" and "Function model 254 - Bus controller" as well as for "Function model 2 - Extended filter" in mode "Selectable data rate".

			I/O update rate [Hz]		I/O update time [ms]	
Set value 1) 2)	**Data rate (f_{Data}) [Hz]** 3) 4)	**f_{Notch} [Hz]**	**Function models 0 and 254**	**Function model 2 (mode "Selectable data rate")**	**Function models 0 and 254**	**Function model 2 (mode "Selectable data rate")**
0000	2.5	2.5	2.5	7500	400	0.133
0001	5	5	5	7500	200	0.133
0010	10	10	10	7500	100	0.133
0011	15	15	15	7500	66.6667	0.133
0100	25	25	25	7500	40	0.133
0101	30	30	30	7500	33.3333	0.133
0110	50	50	50	7500	20	0.133
0111	60	60	60	7500	16.6667	0.133
1000	100	100	100	7500	10	0.133
1001	500	500	500	7500	2	0.133
1010	1000	1000	1000	10000	1	0.1
1011	2000	2000	2000	10000	0.5	0.1
1100	3750	3750	3750	7500	0.2667	0.133
1101	7500	7500	7500	7500	0.1333	0.133
1110	Reserved					
1111	Reserved					

1) Function model 0 and 254: Bits 0 to 3 of registers "ConfigOutput0x" on page 22
2) Function model 2: Bits 0 to 3 of register "ConfigDatarateOutput0x" on page 30
3) Function models 0 and 254: Data rate = 1/Filter length [s] (f_{Notch}) = I/O update rate
4) Function model 2: Data rate = 1/Filter length [s] (f_{Notch})

1.14.2.2 Characteristics of the FIR filter in mode "High-resolution data rate"

The following table applies to "Function model 2 - Extended filter".

Setpoint [0.1 Hz] [1]	Data rate (f_{Data}) [Hz]	f_{Notch} [Hz]	I/O update time [µs]
1 to 65535	Setpoint / 10	= Data rate	≈100 µs [2]

1) Setpoint of register ConfigHighResolutionOutput0x (page 30)
2) The value varies between 75 and 125 µs (see also the next section "I/O update time")

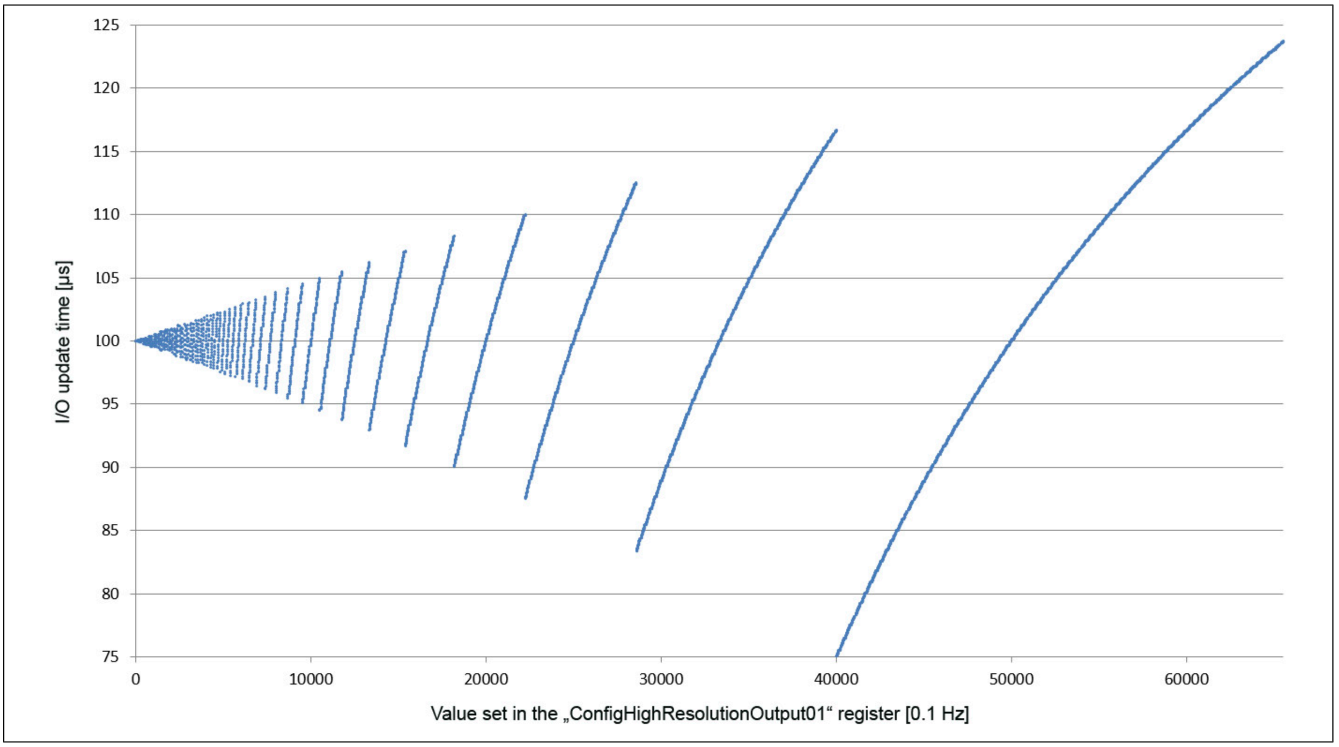
I/O update time

The value of the I/O update time depends on the setpoint and varies between 75 and 125 µs. The following formula can be used to precisely calculate the I/O update time:

I/O update time = 1e6 · (2e-4 - 10 / (Setpoint · [10 / (1e-4 · Setpoint)]))

Legend: The square brackets in the formula above mean that the calculated value must be rounded to a whole number.

The following image shows the I/O update time depending on the setpoint:

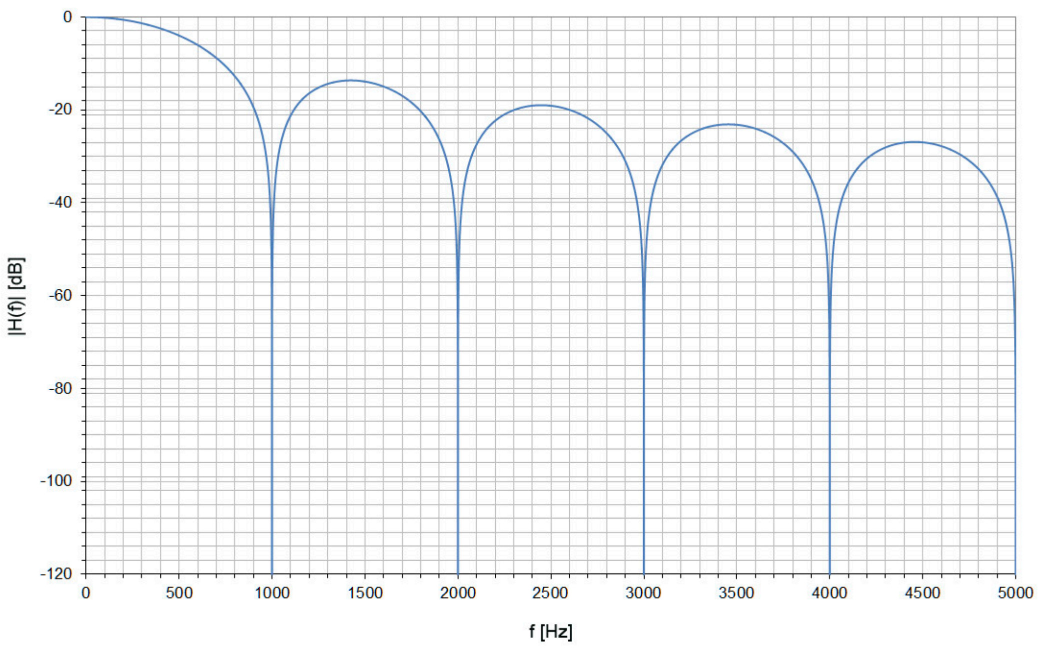


1.14.2.3 Examples for the gain of the FIR filter

Example 1

Filter setting = 10:

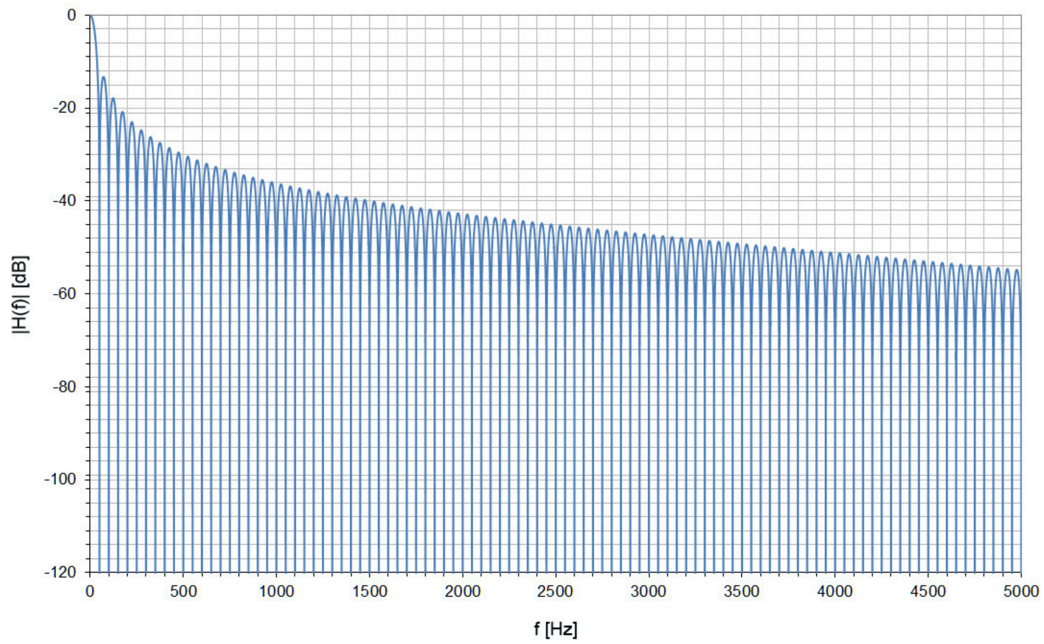
- f_{Notch} = 1000 Hz
- f_c = 439.3 Hz



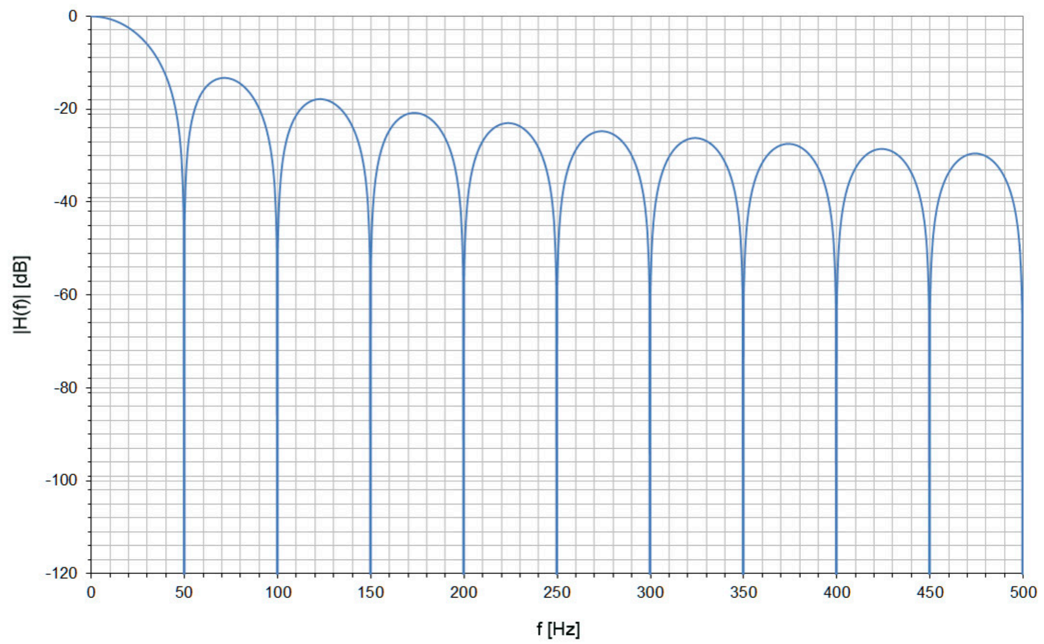
Example 2

Filter setting = 6:

- f_{Notch} = 50 Hz
- f_c = 21.8 Hz



Detailed excerpt from the filter curve shown above:



1.15 Register description

1.15.1 Function model 0 - Standard

Register	Name	Data type	Read		Write	
			Cyclic	Acyclic	Cyclic	Acyclic
Analog signal - Configuration						
16	ConfigOutput01 (A/D converter configuration 1)	USINT			•	
17	ConfigOutput02 (A/D converter configuration 2)	USINT			•	
18	ConfigCycletime01	UINT				•
20	ConfigCycletime02	UINT				•
Analog signal - Communication						
4	AnalogInput01	DINT	•			
8	AnalogInput02	DINT	•			
2	StatusInput01	USINT	•			

1.15.2 Function model 1 - Multisampling

Information:

"Function model 1 - Multisampling" can only be used on channel 1.

In this function model, the A/D converter is operated synchronously to X2X Link with a predefined A/D converter cycle time. The value is configurable as 50 or 100 µs.

The module returns between 3 and 10 measured values per X2X cycle depending on the configuration. With an X2X cycle time of 400 µs and A/D converter cycle time of 50 µs, exactly 8 measurements are performed and the module can return 8 values (strain gauge value 01 to strain gauge value 08).

If a longer cycle time is used, the values returned correspond to the last measurements. If using an X2X cycle time that is not a whole number multiple of the A/D converter cycle time, then the conversion cannot be synchronized with X2X Link. In this case, the module outputs the invalid value 0x8000.

Example 1

If using an X2X cycle time of 800 µs, it is possible to perform 16 measurements per X2X cycle if the A/D converter cycle time equals 50 µs. The first 6 measured values are discarded; the last 10 measured values are provided by the module.

With a shorter X2X cycle time, the number of measured values should not exceed the number of measurements that can actually be made. All other measured values are invalid (0x8000). To minimize the load on the X2X Link network, it is possible to disable these unneeded registers (see "Number of measured values" on page 28).

Example 2

If using an X2X cycle time of 300 µs, it is possible to perform 6 measurements per X2X cycle if the A/D converter cycle time equals 50 µs. For this reason, only the first 6 registers are valid. The registers for the 7th through 10th measured value (AnalogInput07 to AnalogInput10) should be disabled by setting Number of measured values to "6 measured values" in the I/O configuration.

Register	Name	Data type	Read		Write	
			Cyclic	Acyclic	Cyclic	Acyclic
Analog signal - Configuration						
1601	ConfigGain01_MultiSample (A/D converter configuration 1)	USINT			•	
1603	ConfigCycletime01_MultiSample	USINT				•
Analog signal - Communication						
1534 + N * 4	AnalogInput0N (N = 1 to 10)	INT	•			
260	StatusInput01	USINT	•			

1.15.3 Function model 2 - Extended filter

This function model allows the IIR low-pass filter and the FIR filter to be enabled.

Register	Name	Data type	Read		Write	
			Cyclic	Acyclic	Cyclic	Acyclic
Analog signal - Configuration						
272	ConfigCommonOutput01 (A/D converter and IIR filter configuration 1)	USINT			•	
400	ConfigCommonOutput02 (A/D converter and IIR filter configuration 2)	USINT			•	
288	ConfigFilterOutput01	UINT				•
416	ConfigFilterOutput02	UINT				•
273	ConfigDatarateOutput01	USINT			•	
401	ConfigDatarateOutput02	USINT			•	
274	ConfigHighResolutionOutput01	UINT			•	
402	ConfigHighResolutionOutput02	UINT			•	
Analog signal - Communication						
4	AnalogInput01	DINT	•			
8	AnalogInput02	DINT	•			
1169	StatusInput01	USINT	•			
1425	StatusInput02	USINT	•			
256	AdcConvTimeStampInput01	DINT	•			
384	AdcConvTimeStampInput02	DINT	•			

1.15.4 Function model 3 - DATA_to_SafeDATA

This functional model differs from "Function model 2 - Advanced filters" in that it has additional registers that allow the module to be used with a SafeLOGIC controller.

Register	Name	Data type	Read		Write	
			Cyclic	Acyclic	Cyclic	Acyclic
Analog signal - Configuration						
272	ConfigCommonOutput01 (A/D converter and IIR filter configuration 1)	USINT			•	
400	ConfigCommonOutput02 (A/D converter and IIR filter configuration 2)	USINT			•	
288	ConfigFilterOutput01	UINT				•
416	ConfigFilterOutput02	UINT				•
273	ConfigDatarateOutput01	USINT			•	
401	ConfigDatarateOutput02	USINT			•	
274	ConfigHighResolutionOutput01	UINT			•	
402	ConfigHighResolutionOutput02	UINT			•	
DataToSaveData - Configuration						
7170	CfO_DTS_SourceRef	INT				•
Analog signal - Communication						
4	AnalogInput01	DINT	•			
8	AnalogInput02	DINT	•			
1169	StatusInput01	USINT	•			
1425	StatusInput02	USINT	•			
256	AdcConvTimeStampInput01	DINT	•			
384	AdcConvTimeStampInput02	DINT	•			
DataToSaveData - Communication						
7188	AnalogInput01	DINT	•			
7196	AdcConvTimeStamp01	DINT	•			
7202	DTS_SourceRef	INT	•			
7206	DTS_CheckSum	INT	•			

1.15.5 Function model 254 - Bus controller

In function model "Bus controller", the module behaves as it does in function model "Standard" with the exception that it is not synchronized to the X2X Link network even if synchronous mode is enabled in register ConfigOutput01. Instead, the module behaves as if the set ADC cycle time is not a factor or multiple of the X2X cycle time and attempts to maintain the set ADC cycle time as precisely as possible.

Register	Offset[1]	Name	Data type	Read		Write	
				Cyclic	Acyclic	Cyclic	Acyclic
Analog signal - Configuration							
16	0	ConfigOutput01 (A/D converter configuration 1)	USINT			•	
17	2	ConfigOutput02 (A/D converter configuration 2)	USINT			•	
18	-	ConfigCycletime01	UINT				•
20	-	ConfigCycletime02	UINT				•
Analog signal - Communication							
4	0	AnalogInput01	DINT	•			
8	4	AnalogInput02	DINT	•			
2	8	StatusInput01	USINT	•			

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

1.15.5.1 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).

1.15.5.2 CAN I/O bus controller

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

1.15.6 Registers for function models "0 - Standard" and "254 - Bus controller"

1.15.6.1 Analog signal - Configuration

1.15.6.1.1 A/D converter configuration

Name:
ConfigOutput01 to ConfigOutput02

The data rate and measurement range of the A/D converter can be configured in this register.

Data type	Values	Bus controller default setting
USINT	See the bit structure.	13

Bit structure:

Bit	Description	Value	Information
0 - 3	Data rate f_{DATA} (samples per second):	0000	2.5
		0001	5
		0010	10
		0011	15
		0100	25
		0101	30
		0110	50
		0111	60
		1000	100
		1001	500
		1010	1000
		1011	2000
		1100	3750
		1101	7500 (bus controller default setting)
		1110	Synchronous mode
		1111	Reserved
4 - 6	Standard measurement range (bit 6 = 0)	000	16 mV/V (bus controller default setting)
		001	8 mV/V
		010	4 mV/V
		011	2 mV/V
	Extended measurement range (bit 6 = 1)	100	256 mV/V
		101	128 mV/V
		110	64 mV/V
		111	32 mV/V
7	Reserved	0	(must be 0)

Synchronous mode

Starting with firmware version 3, the A/D converter on the module can be operated and read synchronously to the X2X Link network. Synchronous mode is enabled by selecting the respective operating mode in register "ConfigOutput" on page 22. A time between 200 and 2000 μs must also be set in register "ConfigCycletime" on page 23. If this time is a whole number factor or multiple of the configured cycle time of X2X Link, then the A/D converter is read synchronously to X2X Link.

Information:

The A/D converter cycle time must be ≥1/4 of the X2X cycle time when using synchronous mode!

Bit 2 in "Module status" is set (i.e. A/D converter not running synchronously)...

- ... If the configured A/D converter cycle time cannot be synchronized with X2X Link.
- ... If the module is still in the settling phase.

Jitter, dead time and settling time:

Jitter A/D converter cycle times <1500 μs A/D converter cycle times >1500 μs	 Max. ±1 μs Max. ±4 μs
X2X Link dead time	$50\ \mu s + \frac{\text{X2X cycle time}}{128}$
Settling time	150 x X2X cycle time

The settling time corresponds to the time needed until the A/D converter can be operated after enabling synchronous mode or following conversion of the A/D converter cycle time.

1.15.6.1.2 A/D converter cycle time

Name:
ConfigCycletime01 to ConfigCycletime02

This register is only used in "Synchronous mode". If synchronous mode is enabled in the A/D converter configuration, then the module attempts to operate the A/D converter as synchronously as possible to the X2X Link network (based on the A/D converter cycle time set in this register). For this it is of course necessary that the cycle time of the X2X Link network and the A/D converter cycle time are in a certain ratio to each other. The following conditions must be observed:

1) A/D converter cycle time ≥ 1/4 X2X cycle time
2) A/D converter cycle time corresponds to a whole number factor or multiple of the X2X cycle time
3) A/D converter cycle time must be in the range 200 to 2000 µs

Data type	Values	Information
UINT	200 to 2000	Bus controller default setting: 0

1.15.6.2 Analog signal - Communication

1.15.6.2.1 Module status

Name:
StatusInput01

This register contains the current state of the module.

Data type	Values
USINT	See the bit structure.

Bit structure:

Bit	Description	Value	Information
0	Channel1: A/D converter values	0	Valid A/D converter value
		1	Invalid A/D converter value (analog value = 0xFF800000). Possible causes: • Strain gauge supply error • ADC not (yet) configured
1	Channel1: Line status monitoring	0	OK
		1	Open circuit
2	Channel1: Only valid in synchronous mode	0	A/D converter runs synchronous to X2X Link
		1	A/D converter does not run synchronous to X2X Link
3	Reserved	-	
4	Channel 2: A/D converter values	0	Valid A/D converter value
		1	Invalid A/D converter value (analog value = 0xFF800000). Possible causes: • Strain gauge supply error • ADC not (yet) configured
5	Channel 2: Line status monitoring	0	OK
		1	Open circuit
6	Channel 2: Only valid in synchronous mode	0	A/D converter runs synchronous to X2X Link
		1	A/D converter does not run synchronous to X2X Link
7	Reserved	-	

1) In the standard measurement range (2 to 16 mV/V), open circuit detection works reliably at all adjustable data rates. In the extended measurement range (32 to 256 mV/V, firmware version 5 and later), open circuit detection does not work reliably (because of the variable input impedance of the amplifier in relation to the set data rate).

1.15.6.2.2 Strain gauge value

Name:
AnalogInput01 to AnalogInput02

This register contains the raw value determined by the A/D converter for the full-bridge strain gauge with 24-bit resolution.

Data type	Values	Information
DINT	-8,388,608	Negative invalid value
	-8,388,607	Negative full-scale deflection / Underflow
	-8,388,606 to 8388606	Valid range
	8,388,607	Positive full-scale deflection / Overflow / Open circuit

Effective resolution

In principle, the effective resolution of the A/D converter is dependent on the data rate and the measurement range (see "Effective resolution of the A/D converter" on page 8).

The following table shows how the effective resolution (in bits), or the RMS value range of the strain gauge value depend on the module configuration (data rate, measurement area).

	Measurement range							
	±16 mV/V		±8 mV/V		±4 mV/V		±2 mV/V	
Data rate f_{DATA} [Hz]	Bits	Range of values	Bits	Range of values	Bits	Range of values	Bits	Range of values
2.5	19.9	±489,000	19.1	±281,000	18.0	±131,000	17.4	±86,500
5	19.4	±346,000	18.2	±151,000	17.5	±92,700	16.4	±43,200
10	18.5	±185,000	17.8	±114,000	16.8	±57,100	15.9	±30,600
15	18.2	±151,000	17.3	±80,700	16.4	±43,200	15.4	±21,600
25	17.8	±114,000	16.9	±61,100	16.0	±32,800	14.9	±15,300
30	17.8	±114,000	16.8	±57,100	15.9	±30,600	14.8	±14,300
50	17.4	±86,500	16.3	±40,300	15.4	±21,600	14.4	±10,800
60	17.4	±86,500	16.2	±37,600	15.3	±20,200	14.1	±8,780
100	16.9	±61,100	15.9	±30,600	14.8	±14,300	13.8	±7,130
500	15.5	±23,200	14.5	±11,600	13.5	±5,790	12.5	±2,900
1000	15.0	±16,400	14.1	±8,780	13.1	±4,390	11.9	±1,910
2000	14.5	±11,600	13.4	±5,400	12.6	±3,100	11.4	±1,350
3750	14.1	±8,780	13.1	±4,390	12.1	±2,190	11.1	±1,100
7500	13.8	±7,130	12.7	±3,330	11.8	±1,780	10.6	±776

Table 3: Effective resolution of the strain gauge value in bits for the measurement range 2 to 16 mV/V

	Measurement range							
	±256 mV/V		±128 mV/V		±64 mV/V		±32 mV/V	
Data rate f_{DATA} [Hz]	Bits	Range of values	Bits	Range of values	Bits	Range of values	Bits	Range of values
2.5	22.0	±2,100,000	22.0	±2,100,000	21.2	±1,200,000	20.5	±741,000
5	21.7	±1,700,000	21.4	±1,380,000	20.8	±913,000	20.3	±645,000
10	20.8	±913,000	20.8	±913,000	20.2	±602,000	19.4	±346,000
15	20.7	±852,000	20.5	±741,000	19.9	±489,000	19.3	±323,000
25	20.1	±562,000	19.9	±489,000	19.7	±426,000	18.9	±245,000
30	19.9	±489,000	19.9	±489,000	19.4	±346,000	18.8	±228,000
50	19.8	±456,000	19.2	±301,000	19.2	±301,000	18.2	±151,000
60	19.5	±371,000	19.2	±301,000	19.0	±262,000	18.2	±151,000
100	19.0	±262,000	18.8	±228,000	18.5	±185,000	17.6	±99,300
500	17.8	±114,000	17.5	±92,700	17.1	±70,200	16.4	±43,200
1000	17.2	±75,300	17.1	±70,200	16.7	±53,200	15.8	±28,500
2000	16.7	±53,200	16.5	±46,300	16.1	±35,100	15.2	±18,800
3750	16.2	±37,600	16.1	±35,100	15.8	±28,500	14.9	±15,300
7500	15.9	±30,600	15.8	±28,500	15.3	±20,200	14.6	±12,400

Table 4: Effective resolution of the strain gauge value in bits for the measurement range 32 to 256 mV/V

1.15.7 Register for "Function model 1 - Multisampling"

Information:

"Function model 1 - Multisampling" can only be used on channel 1.

1.15.7.1 Analog signal - Configuration

1.15.7.1.1 A/D converter configuration

Name:
ConfigGain01_MultiSample

The measurement range for the A/D converter can be configured in this register.

Data type	Values
USINT	See the bit structure.

Bit structure:

Bit	Description	Value	Information
0 - 2	Standard measurement range (bit 2 = 0)	000	16 mV/V
		001	8 mV/V
		010	4 mV/V
		011	2 mV/V
	Extended measurement range (bit 2 = 1)	100	256 mV/V
		101	128 mV/V
		110	64 mV/V
		111	32 mV/V
3 - 7	Reserved	0	(must be 0)

1.15.7.1.2 A/D converter cycle time

Name:
ConfigCycletime01_MultiSample

The A/D converter cycle time can be configured in this register.

In order for multisampling to work, the X2X cycle time must be divisible by the A/D converter cycle time to produce a whole number.

Data type	Value	Information
USINT	0	50 µs (default)
	1	100 µs
	2 to 255	Reserved

1.15.7.2 Analog signal - Communication

1.15.7.2.1 Strain gauge value - Multiple

Name:
AnalogInput01 to AnalogInput10

This register contains the raw value determined by the A/D converter for the full-bridge strain gauge with 16-bit resolution. The module returns between 3 and 10 measured values per X2X cycle depending on the configuration.

Effective resolution

In principle, the effective resolution of the A/D converter is dependent on the data rate and measurement range (see "Effective resolution of the A/D converter" on page 8).

The following table shows how the effective resolution (in bits), or the RMS value range of the strain gauge value depend on the module configuration (data rate, measurement area).

Measurement range							
±16 mV/V		±8 mV/V		±4 mV/V		±2 mV/V	
Bits	Range of values	Bits	Range of values	Bits	Range of values	Bits	Range of values
13.4	±5,240	12.3	±2,510	11.3	±1,300	10.3	±630

Table 5: Effective resolution of the strain gauge value in bits for the measurement range 2 to 16 mV/V

Measurement range							
±256 mV/V		±128 mV/V		±64 mV/V		±32 mV/V	
Bits	Range of values	Bits	Range of values	Bits	Range of values	Bits	Range of values
15.5	±23,200	15.0	±16,400	15.0	±16,400	14.1	±8,490

Table 6: Effective resolution of the strain gauge value in bits for the measurement range 32 to 256 mV/V

1.15.7.2.2 Module status

Name:
StatusInput01

This register contains the current state of the module.

Data type	Values
USINT	See the bit structure.

Bit structure:

Bit	Description	Value	Information
0	A/D converter values	0	Valid A/D converter value
		1	Invalid A/D converter value
1	Line monitoring	0	OK
		1	Open circuit An open circuit was found during at least one measurement in this X2X cycle. This bit is reset if all measurements are OK after correcting this error, i.e. it does not have to be acknowledged.
2	Synchronous mode	0	A/D converter runs synchronous to X2X Link
		1	A/D converter does not run synchronous to X2X Link
3	Reserved	-	
4	Channel 2 is disabled.	1	Channel 2 is disabled in multisampling mode. Bit 4 is set permanently to 1.
5 - 7	Reserved	-	

1.15.7.2.3 Number of measured values

If the X2X cycle time is too short, then not all 10 measurements can be performed. To reduce the load on X2X Link, it makes sense to only transfer as many values as measurements that can be made. This is why it is possible to configure the number of measured values to be transferred (see "Function model 1 - Multisampling" on page 19).

Example: A/D converter cycle time = 50 µs

X2X cycle time	Number of measured values to be transferred
250 µs	5
300 µs	6
350 µs	7
400 µs	8
450 µs	9
≥500 µs	10

Example: A/D converter cycle time = 100 µs

X2X cycle time	Number of measured values to be transferred
300 µs	3
400 µs	4
500 µs	5
600 µs	6
700 µs	7
800 µs	8
900 µs	9
≥1 ms	10

1.15.8 Register for "Function model 2 - Extended filter"

1.15.8.1 Analog signal - Configuration

1.15.8.1.1 A/D converter and IIR filter configuration

Name:
ConfigCommonOutput01 to ConfigCommonOutput02

The IIR low-pass filter and measurement range of the A/D converter can be configured in this register.

Data type	Values
USINT	See the bit structure.

Bit structure:

Bit	Description	Value	Information
			Filter level
0 - 3	IIR low-pass filter	0000	0: IIR low-pass filter switched off
		0001	1
		0010	2
		0011	3
		0100	4
		0101	5
		0110	6
		0111	7
		1000	8
		1001 - 1111	The analog input value indicates an invalid range.
4 - 6	Default measurement range	000	16 mV/V
		001	8 mV/V
		010	4 mV/V
		011	2 mV/V
	Extended measurement range	100	256 mV/V
		101	128 mV/V
		110	64 mV/V
		111	32 mV/V
7	Reserved	0	(must be 0)

1.15.8.1.2 Data rate configuration

Name:
ConfigFilterOutput01 to ConfigFilterOutput02

Whether a selectable data rate or a high-resolution data rate is being used for the FIR filter is configured in this register.

Data type	Values	Information
UINT	0	Mode "Selectable data rate": A selectable data rate is used for the FIR filter (default). Configuration takes place in register "ConfigDatarateOutput0x" on page 30.
	1	Mode "High-resolution data rate": A high-resolution data rate is used for the FIR filter. Configuration takes place in register "ConfigHighResolutionOutput0x" on page 30.

Name:
ConfigDatarateOutput01 to ConfigDatarateOutput02

The data rate of the FIR filter in mode "Selectable data rate" is configured in this register.

Data type	Values
USINT	See the bit structure.

Bit structure:

Bit	Description	Value	Information
0 - 3	Data rate f_{DATA} (samples per second):	0000	2.5
		0001	5
		0010	10
		0011	15
		0100	25
		0101	30
		0110	50
		0111	60
		1000	100
		1001	500
		1010	1000
		1011	2000
		1100	3750
		1101	7500
		1110 - 1111	The analog input value indicates an invalid range.
4 - 7	Reserved	0	(must be 0)

Name:
ConfigHighResolutionOutput01 to ConfigHighResolutionOutput02

The data rate of the FIR filter in 0.1 Hz steps is configured in this register (0.1 to 6553.5 Hz).

Data type	Values	Information
UINT	0	Disables the FIR filter
	1 to 65,535	0.1 to 6553.5 Hz

1.15.8.2 Analog signal - Communication

1.15.8.2.1 Module status

Name:
StatusInput01 to StatusInput02

This register contains the current state of the module. If there is a fault in the module power supply or strain gauge supply, the analog input value indicates an invalid range and the buffer of the enabled filter is reset.

Data type	Values
USINT	See the bit structure.

Bit structure:

Bit	Description	Value	Information
0	A/D converter values	0	Valid A/D converter value
		1	Invalid A/D converter value
1	Line monitoring	0	OK
		1	Open circuit
2 - 3	Reserved	-	
4	Strain gauge supply	0	OK
		1	Error in strain gauge supply
5	FIR filter ready	0	OK
		1	FIR filter not yet ready
6	Module power supply	0	OK
		1	Error in module power supply
7	Reserved	-	

1.15.8.2.2 A/D converter conversion timestamp

Name:
AdcConvTimeStampInput01 to AdcConvTimeStampInput02

This register holds the timestamp of the last analog conversion. This is always the point in time (in µs) at which the conversion of the latest A/D converter raw value is completed.

Data type	Values	Explanation
DINT	-2,147,483,648 to 2,147,483,647	Timestamp [µs] of the last analog conversion

1.15.9 DATA_to_SafeDATA

Function DATA_to_SafeDATA determines a safe signal from 2 independent standard signals. For this purpose, the standard data of 2 I/O modules are transferred to the SafeLOGIC controller and compared with each other there. With the functions provided in SafeDESIGNER, the resulting data can be used for applications up to PL d.

Function DATA_to_SafeDATA is enabled and the register calls take place using SafeDESIGNER. For more detailed information on the calls, see library DATA_to_SafeDATA_SF contained in SafeDESIGNER.

1.15.9.1 Input value

Name:
AnalogInput01

This register contains the raw value determined by the A/D converter for the full-bridge strain gauge with 24-bit resolution. For more information, see "Strain gauge value" on page 25.

The register is only active if function DATA_to_SafeDATA is enabled.

Data type	Values
DINT	-2,147,483,648 to 2,147,483,647

1.15.9.2 NetTime of the input value

Name:
AdcConvTimeStamp01

This register represents the NetTime of the most recent valid input value. The register is only active if function DATA_to_SafeDATA is enabled.

Data type	Values
DINT	-2,147,483,648 to 2,147,483,647

1.15.9.3 Displaying the SourceRef address

Name:
DTS_SourceRef

This register cyclically displays the SourceRef address set in the configuration. The register is only active if function DATA_to_SafeDATA is enabled.

Data type	Values
INT	-32768 to 32767

1.15.9.4 Checksum

Name:
DTS_CheckSum

This register contains a checksum formed from the 3 cyclic data points AnalogInput01, AdcConvTimeStamp01 and DTS_SourceRef. The register is only active if function DATA_to_SafeDATA is enabled.

Data type	Values
INT	-32768 to 32767

1.15.9.5 SourceRef address

Name:
CfO_DTS_SourceRef

This register contains the acyclically configurable SourceRef address that is sent back by the module as a cyclic data point. The register is only active if function DATA_to_SafeDATA is enabled.

Data type	Values
INT	-32768 to 32767

1.15.10 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
250 μs

1.15.11 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 I/O update times for function models "0 - Standard", "2 - Extended filter" and "254 - Bus controller", see section "Characteristics of the FIR filter in mode "Selectable data rate"" on page 15.

Depending on the setting in register ConfigCycletime01_MultiSample, the I/O update time in "Function model 1 - Multisampling" is 50 or 100 μs.

2 X67AI2744 with Rev. <BB

2.1 General information

This module is equipped with 2 inputs for evaluating full-bridge strain gauges and works with both 4-wire and 6-wire strain gauge load cells. The concept applied by the module requires compensation in the measurement system. This compensation eliminates the absolute uncertainty in the measurement circuit, such as component tolerances, effective bridge voltage or zero point offset. The measurement precision refers to the absolute (compensated) value, which will only change as a result of changes in the operating temperature.

- 2 full-bridge strain gauge inputs
- Data output rate configurable from 2.5 Hz to 7.5 kHz

2.2 Order data

Model number	Short description	Figure
	Analog input modules	
X67AI2744	X67 analog input module, 2 full-bridge strain gauge inputs, 10 V, 24-bit converter resolution	

Table 7: X67AI2744 - Order data

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

2.3 Technical data

Model number	X67AI2744
Short description	
I/O module	2 full-bridge strain gauge inputs
General information	
B&R ID code	0x8820
Status indicators	Channel status, operating state, module status
Diagnostics	
Module run/error	Yes, using status LED and software
Open circuit	Yes, using status LED and software
Input	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	
Bus	0.75 W
Internal I/O	2.4 W
Electrical isolation	
Bus - Analog input	Yes
Bus - Bridge supply voltage	Yes
Channel - I/O power supply	No
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
Full-bridge strain gauge	
Strain gauge factor	2 to 256 mV/V, configurable using software
Connection	4- or 6-wire connections [1]
Input type	Differential, used to evaluate a full-bridge strain gauge
Digital converter resolution	24-bit
Conversion time	Depends on the configured data output rate
Data output rate	2.5 to 7,500 samples per second, configurable using software (f_{DATA})
Input filter	
Cutoff frequency	5 kHz
Order	3
Slope	60 dB
ADC filter characteristics	Sigma-delta, see section "Filter characteristics of the sigma-delta A/D converter"
Operating range / Measurement sensor	85 to 5,000 Ω
Influence of cable length	Twisted and shielded conductors, cable length as short as possible, cable routing separate from load circuits, without intermediate terminal to sensor
Input protection	RC protection
Common-mode range	0 to 3 VDC Permissible input voltage range (with regard to the poten- tial strain gauge GND) on inputs "Input +" and "Input -"
Isolation voltage between input and bus	500 V_{eff}
Conversion procedure	Sigma-delta
Output of digital value	
Broken bridge supply line	Value approaching 0
Broken sensor line	Value approaching ±end value (status bit "Open circuit" set in register "Module status")
Valid range of values	0xFF800001 to 0x007FFFFF (-8,388,607 to 8,388,607)
Strain gauge supply	
Voltage	5.5 VDC / Max. 65 mA
Short-circuit and overload resistant	Yes
Voltage drop for short-circuit protection	Max. 0.2 VDC at 65 mA

Table 8: X67AI2744 - Technical data

Model number	X67AI2744
Quantization [2]	
LSB value (16-bit)	
2 mV/V	336 nV
4 mV/V	671 nV
8 mV/V	1.343 µV
16 mV/V	2.686 µV
32 mV/V	5.371 µV
64 mV/V	10.74 µV
128 mV/V	21.48 µV
256 mV/V	42.97 µV
LSB value (24-bit)	
2 mV/V	1.31 nV
4 mV/V	2.62 nV
8 mV/V	5.25 nV
16 mV/V	10.49 nV
32 mV/V	20.98 nV
64 mV/V	41.96 nV
128 mV/V	83.92 nV
256 mV/V	167.85 nV
Temperature coefficient	30 ppm/°C
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	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	190 g
Torque for connections	
M8	Max. 0.4 Nm
M12	Max. 0.6 Nm

Table 8: X67AI2744 - Technical data

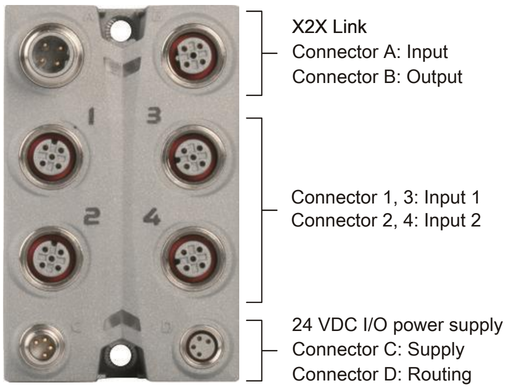
1) With 6-wire connections, line compensation does not function (see section "Connection examples").
2) Quantization depends on the strain gauge factor.

2.4 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 - 2	Status indicator per input		
		LED	Status	Description
		Green	On	A/D converter running, value OK
			Off	Possible causes: • Open circuit • Sensor disconnected • Converter busy
	3 - 4	These two LEDs are not used.		
	Status indicator 2	Status indicator for module function		
		LED	Status	Description
		Green	Off	No power to module
			Single flash	Mode RESET
			Double flash	Mode BOOT (during firmware update)[1]
			Blinking	Mode PREOPERATIONAL
			On	Mode RUN
		Red	Off	Module not supplied with power or everything OK
			On	Error or reset state

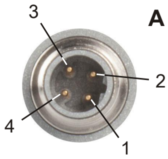
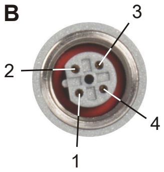
1) Depending on the configuration, a firmware update can take up to several minutes.

2.5 Connection elements



2.6 X2X Link

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

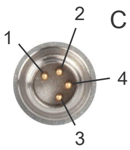
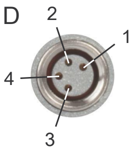
Connection	Pinout	
	Pin	Description
 	1	X2X+
	2	X2X
	3	X2X⊥
	4	X2X\
	Shield connection made via threaded insert in the module. A → B-keyed (male), input B → B-keyed (female), output	

2.7 24 VDC I/O power supply

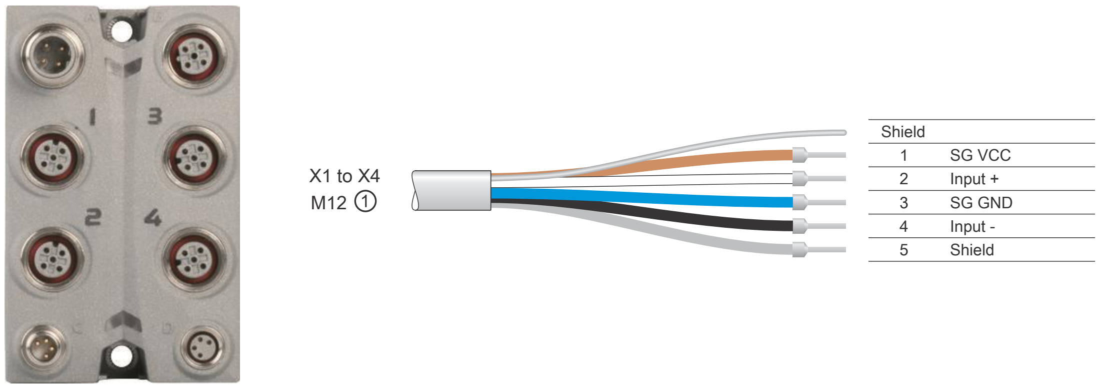
The I/O power supply is connected via M8 connectors C and D. The I/O power supply is connected via connector C (male). Connector D (female) is used to route the I/O power supply to other modules.

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	

2.8 Pinout



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

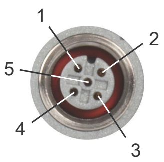
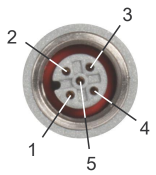
2.8.1 Connections X1 to X4

The module is equipped with 2 channels for the connection of strain gauge load cells.

- X1 and X3: Channel 1 (connected internally)
- X2 and X4: Channel 2 (connected internally)

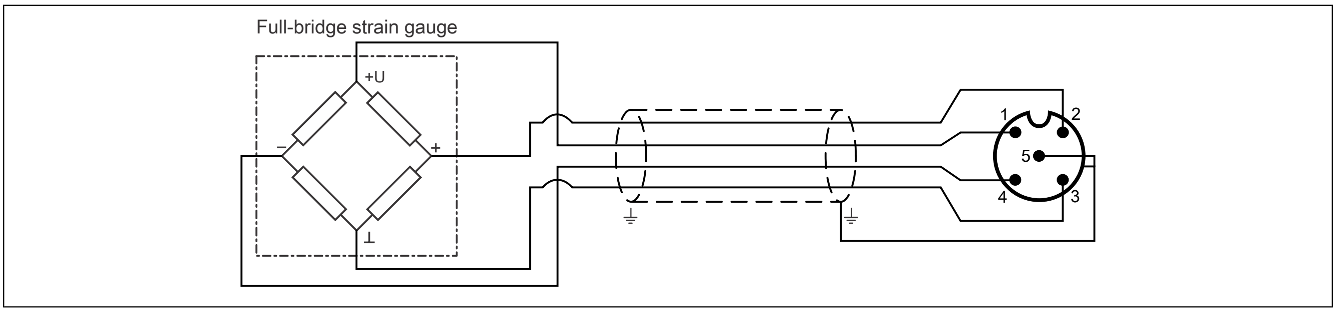
Information:

Connections 1 and 3 as well as 2 and 4 are connected to each other internally. This allows 2 strain gauge load cells to be switched in parallel and connected to the respective channel via these connections.

M12, 5-pin	Pinout		
Connection 1/2	**Pin**	**Description**	**Description**
	1	SG VCC	Strain gauge supply +
	2	Input +	Differential input +
	3	SG GND	Strain gauge supply GND
	4	Input -	Differential input -
	5	Shield[1)]	Shield
 Connection 3/4	1) Shielding also provided by threaded insert in the module. X1 to X4 → A-keyed (female), input		

2.9 Connection examples

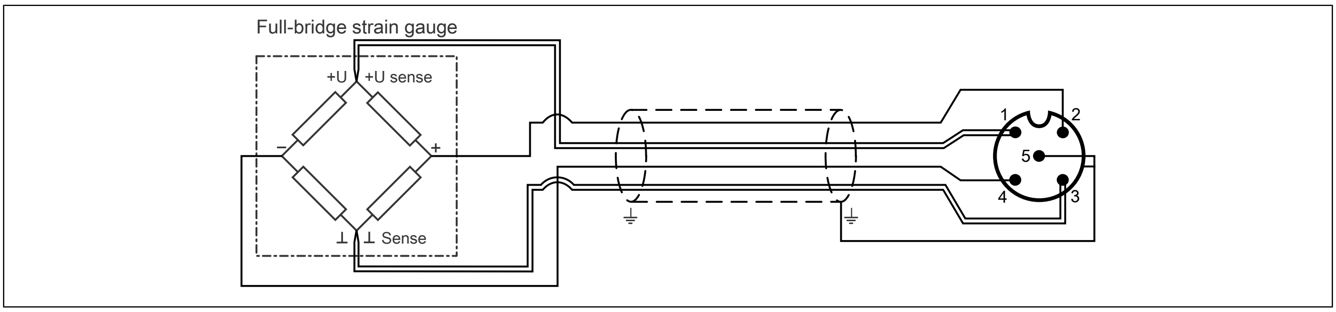
Full-bridge strain gauge with 4-wire connections



Full-bridge strain gauge with 6-wire connections

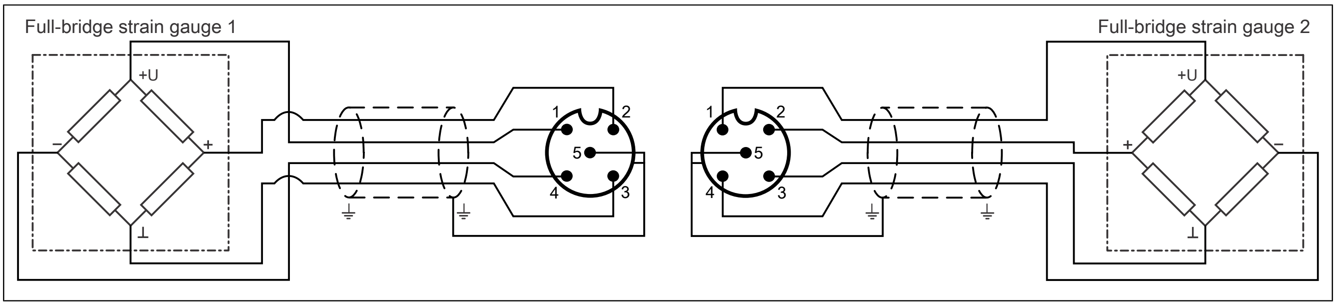
Full-bridge strain gauges can be connected to this module with 6-wire connections. Line compensation is not supported by the module, however. The respective sense line can be connected to the strain gauge VCC or strain gauge GND connection. The measurement precision is therefore affected by changes in operating temperature. Longer cable lengths and smaller cable cross sections also increase the potential for errors in the measurement system.

To further reduce line resistance, it is recommended to connect the sense lines in parallel with the strain gauge supply lines. Optimal signal quality can be obtained by using a shielded twisted pair cable. The connections for the strain gauge supply lines, the sensor lines and the bridge differential voltage lines should each use one twisted pair cable.



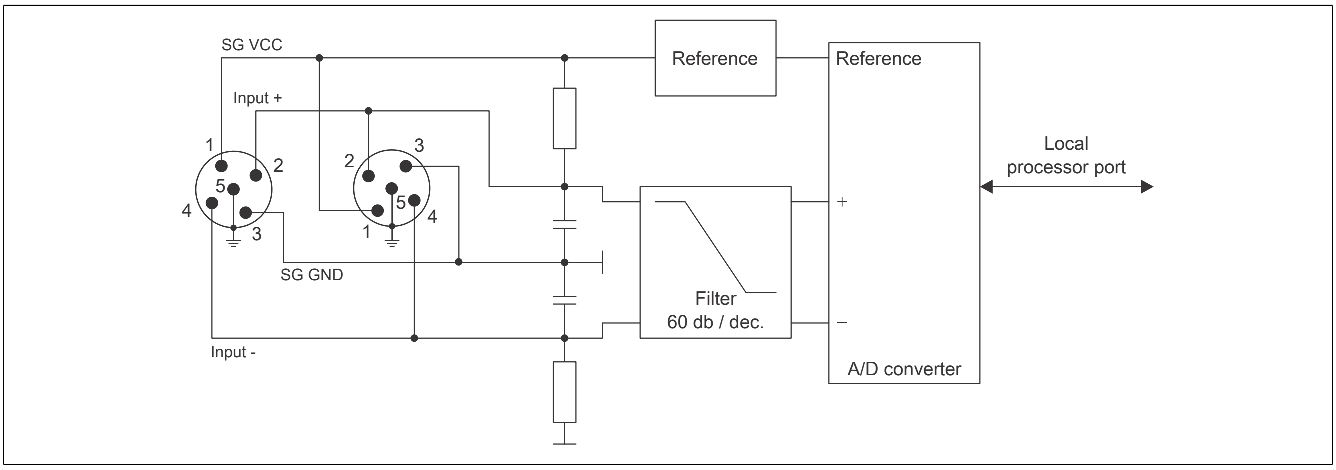
Parallel connection of 2 full-bridge strain gauges (4-wire connections)

If connecting the full-bridge strain gauges in parallel, the manufacturer's guidelines must be observed.



When connecting 3 or more full-bridge strain gauges in parallel, 2 lines must be consolidated in one connector.

2.10 Input circuit diagram

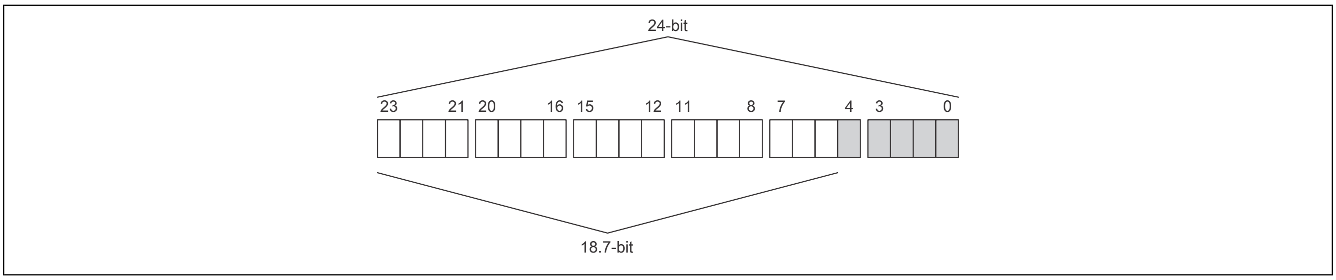


2.11 Effective resolution of the A/D converter

The A/D converter for the module provides a 24-bit measured value. The actual attainable noise-free resolution is always less than 24-bit, however. This "effective resolution" depends on the data rate and measurement range.

Example:

Because of the conversion method, a data rate of 2.5 Hz and a specified measurement area of 2 mV/V result in an effective resolution of 18.7 bits:



The low-order bits (grayed out) contain only noise instead of valid values and must therefore not be evaluated.

2.12 Calculation example / Quantization

In a weighing application, the corresponding weight located on the connected load cell should be determined from the value derived from the module.

The characteristics of the strain gauge load cell are as follows:

- Rated load: 1000 kg
- Strain gauge factor: 4 mV/V

The value for the positive full-scale deflection at a specified rated load of 1000 kg is derived from the bridge factor of the strain gauge load cell (multiplication with the bridge supply voltage from the module):

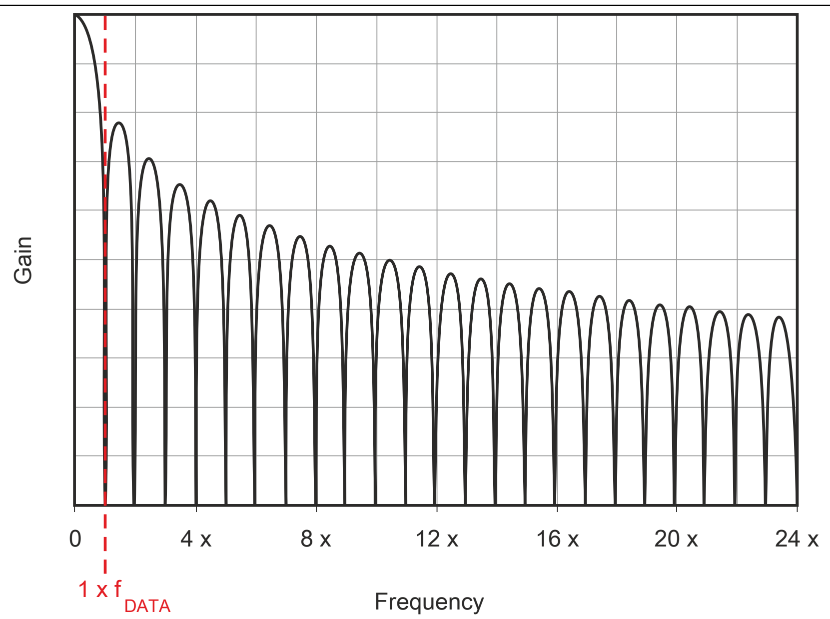
4 mV/V × 5.5 V = 22 mV

With a simple Rule of Three calculation, the corresponding value can be calculated (as seen in the table) from weight to the converter value and vice versa. This simplified theoretical approach is only valid for an ideal measurement system. Calibration of the entire measurement system is recommended because not only the module, but particularly the strain gauge bridges exhibit tolerances (offset, gain). When taring, the gradient offset is recalculated and the gain of the linear equation is determined when normalized. In addition to the calculation displayed in the table, these calculations must also be carried out in the application.

24-bit value of the module		Quantization	Corresponding weight
0x007F FFFF	8,388,607	22.0 mV	1000 kg
0x0000 0001	1	2.62 nV	0.119 g
0x0000 20C3	8387	22.0 µV	1 kg
0x0001 0000	65536	171.9 µV	7.81 kg

The values for each LSB can be found in the technical data of the module under "Quantization" (1 LSB in reference to 16-bit and 1 LSB in reference to 24-bit).

2.13 Filter characteristics of the sigma-delta A/D converter



2.14 Register description

2.14.1 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.

2.14.2 Function model 0 - Standard

Register	Name	Data type	Read		Write	
			Cyclic	Acyclic	Cyclic	Acyclic
Analog signal - Configuration						
16	ConfigOutput01 (A/D converter configuration 1)	USINT			●	
17	ConfigOutput02 (A/D converter configuration 2)	USINT			●	
18	ConfigCycletime01	UINT				●
20	ConfigCycletime02	UINT				●
Analog signal - Communication						
4	AnalogInput01	DINT	●			
8	AnalogInput02	DINT	●			
2	StatusInput01	USINT	●			

2.14.3 Function model 254 - Bus controller

Register	Offset[1]	Name	Data type	Read		Write	
				Cyclic	Acyclic	Cyclic	Acyclic
Analog signal - Configuration							
16	0	ConfigOutput01 (A/D converter configuration 1)	USINT			●	
17	2	ConfigOutput02 (A/D converter configuration 2)	USINT			●	
18	-	ConfigCycletime01	UINT				●
20	-	ConfigCycletime02	UINT				●
Analog signal - Communication							
4	0	AnalogInput01	DINT	●			
8	4	AnalogInput02	DINT	●			
2	8	StatusInput01	USINT	●			

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

2.14.3.1 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).

2.14.3.2 CAN I/O bus controller

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

2.14.4 Analog signal - Configuration

2.14.4.1 A/D converter configuration

Name:
ConfigOutput01 to ConfigOutput02

The data rate and measurement range of the A/D converter can be configured in this register.

Data type	Values
USINT	See the bit structure.

Bit structure:

Bit	Description	Value	Information
0 - 3	Data rate f_{DATA} (samples per second):	0000	2.5
		0001	5
		0010	10
		0011	15
		0100	25
		0101	30
		0110	50
		0111	60
		1000	100
		1001	500
		1010	1000
		1011	2000
		1100	3750
		1101	7500
		1110	Synchronous mode[1)]
		1111	Reserved
4 - 6	Standard measurement range (bit 6 = 0)	000	16 mV/V
		001	8 mV/V
		010	4 mV/V
		011	2 mV/V
	Extended measurement range (bit 6 = 1)[2)]	100	256 mV/V
		101	128 mV/V
		110	64 mV/V
		111	32 mV/V
7	Reserved	0	(must be 0)

1) A/D converter is operated synchronously with X2X Link if possible; beginning with firmware 3
2) Firmware V5 or later. In the standard measurement range (2 to 16 mV/V), open circuit detection works reliably at all adjustable data rates. In the extended measurement range (32 to 256 mV/V), open circuit detection does not work reliably (because of the variable input impedance of the amplifier in relation to the set data rate).

2.14.4.1.1 Synchronous mode

Starting with firmware version 3, the A/D converter on the module can be operated and read synchronously to the X2X Link network. Synchronous mode is enabled by selecting the respective operating mode in register "ConfigOutput" on page 44. A time between 200 and 2000 µs must also be set in register "ConfigCycletime" on page 45. If this time is a whole number factor or multiple of the configured cycle time of X2X Link, then the A/D converter is read synchronously to X2X Link.

Information:

The A/D converter cycle time must be ≥1/4 of the X2X cycle time when using synchronous mode!

Bit 2 in "Module status" is set (i.e. A/D converter not running synchronously)...

- ... If the configured A/D converter cycle time cannot be synchronized with X2X Link.
- ... If the module is still in the settling phase.

Jitter, dead time and settling time:

Jitter A/D converter cycle times <1500 µs A/D converter cycle times >1500 µs	 Max. ±1 µs Max. ±4 µs
X2X Link dead time	$50\ \mu s + \frac{\text{X2X cycle time}}{128}$
Settling time Firmware version ≤4 Firmware version ≥5	 Max. 150 x A/D converter cycle time 150 x X2X cycle time

The settling time corresponds to the time needed until the A/D converter can be operated after enabling synchronous mode or following conversion of the A/D converter cycle time.

2.14.4.2 A/D converter cycle time

Name:
ConfigCycletime01 to ConfigCycletime02

This register is only used in "Synchronous mode". If synchronous mode is enabled in the A/D converter configuration, then the module attempts to operate the A/D converter as synchronously as possible to the X2X Link network (based on the A/D converter cycle time set in this register). For this it is of course necessary that the cycle time of the X2X Link network and the A/D converter cycle time are in a certain ratio to each other. The following conditions must be observed:

1) A/D converter cycle time ≥ 1/4 X2X cycle time
2) A/D converter cycle time corresponds to a whole number factor or multiple of the X2X cycle time
3) A/D converter cycle time must be in the range 200 to 2000 µs

Data type	Values	Information
UINT	200 to 2000	Bus controller default setting: 0

2.14.5 Analog signal - Communication

2.14.5.1 Module status

Name:
StatusInput01

This register contains the current state of the module.

Data type	Values
USINT	See the bit structure.

Bit structure:

Bit	Description	Value	Information
0	Channel1: A/D converter values	0	Valid A/D converter value
		1	Invalid A/D converter value (analog value = 0xFF800000). Possible causes: • Strain gauge supply error • ADC not (yet) configured
1	Channel1: Line status monitoring	0	OK
		1	Open circuit
2	Channel1: Only valid in synchronous mode	0	A/D converter runs synchronous to X2X Link
		1	A/D converter does not run synchronous to X2X Link
3	Reserved	-	
4	Channel 2: A/D converter values	0	Valid A/D converter value
		1	Invalid A/D converter value (analog value = 0xFF800000). Possible causes: • Strain gauge supply error • ADC not (yet) configured
5	Channel 2: Line status monitoring	0	OK
		1	Open circuit
6	Channel 2: Only valid in synchronous mode	0	A/D converter runs synchronous to X2X Link
		1	A/D converter does not run synchronous to X2X Link
7	Reserved	-	

1) In the standard measurement range (2 to 16 mV/V), open circuit detection works reliably at all adjustable data rates. In the extended measurement range (32 to 256 mV/V, firmware version 5 and later), open circuit detection does not work reliably (because of the variable input impedance of the amplifier in relation to the set data rate).

2.14.5.2 Strain gauge value

Name:
AnalogInput01 to AnalogInput02

This register contains the raw value determined by the A/D converter for the full-bridge strain gauge with 24-bit resolution.

Data type	Values	Information
DINT	0xFF800001 to 0x007FFFFF	Valid range of values
	0x007FFFFF	Overflow
	0xFF800001	Underflow
	0xFF800000	Invalid value

Effective resolution

In principle, the effective resolution of the A/D converter is dependent on the data rate and the measurement range (see "Effective resolution of the A/D converter" on page 41).

The following table shows how the effective resolution (in bits), or the RMS value range of the strain gauge value depend on the module configuration (data rate, measurement area).

	Measurement range							
	±16 mV/V		±8 mV/V		±4 mV/V		±2 mV/V	
Data rate f_{DATA} [Hz]	Bits	Range of values	Bits	Range of values	Bits	Range of values	Bits	Range of values
2.5	21.3	±1,290,000	20.8	±912,000	19.7	±425,000	18.7	±212,000
5	20.7	±851,000	20.3	±645,000	19.3	±322,000	18.3	±161,000
10	20.4	±691,000	19.9	±490,000	18.9	±244,000	17.9	±122,000
15	20.1	±562,000	19.3	±320,000	18.7	±212,000	17.7	±106,000
25	19.7	±425,000	19.2	±301,000	18.5	±185,000	17.5	±92,000
30	19.6	±397,000	19.0	±262,000	18.1	±140,000	17.1	±72,000
50	19.4	±346,000	18.8	±230,000	17.9	±122,000	16.9	±61,000
60	19.3	±320,000	18.8	±230,000	17.8	±114,000	16.8	±57,000
100	19.1	±280,000	18.5	±185,000	17.4	±86,000	16.4	±43,000
500	18.0	±130,000	17.3	±80,000	16.3	±40,000	15.3	±20,000
1000	17.2	±75,000	16.5	±46,000	15.6	±25,000	14.6	±12,000
2000	16.6	±49,600	16.1	±35,000	15.3	±20,000	14.3	±10,000
3750	16.2	±37,600	15.7	±26,600	14.7	±13,000	13.7	±6,600
7500	15.8	±28,500	15.3	±20,200	14.4	±10,800	13.4	±5,400

Table 9: Effective resolution of the strain gauge value in bits for the measurement range 2 to 16 mV/V

	Measurement range							
	±256 mV/V		±128 mV/V		±64 mV/V		±32 mV/V	
Data rate f_{DATA} [Hz]	Bits	Range of values	Bits	Range of values	Bits	Range of values	Bits	Range of values
2.5	23	±4,194,000	22.6	±3,179,000	22.1	±2,248,000	21.7	±1,703,000
5	22.3	±2,582,000	22.4	±2,767,000	21.9	±1,957,000	21.3	±1,291,000
10	22.3	±2,582,000	22	±2,097,000	21.6	±1,589,000	21	±1,049,000
15	22	±2,097,000	21.7	±1,703,000	21.3	±1,291,000	20.7	±852,000
25	21.7	±1,703,000	21.4	±1,384,000	21.1	±1,124,000	20.5	±741,000
30	21.8	±1,826,000	21.3	±1,291,000	20.8	±913,000	20.4	±692,000
50	21.3	±1,291,000	21.1	±1,124,000	20.4	±692,000	19.9	±489,000
60	21.3	±1,291,000	20.9	±978,000	20.5	±741,000	19.8	±456,000
100	20.9	±978,000	20.7	±852,000	20.2	±602,000	19.6	±397,000
500	20.1	±562,000	19.6	±397,000	19.1	±281,000	18.6	±199,000
1000	19	±262,000	18.6	±199,000	18.1	±140,000	17.5	±93,000
2000	18.5	±185,000	18.1	±140,000	17.8	±114,000	17	±66,000
3750	18.1	±140,000	17.8	±114,000	17.3	±81,000	16.6	±50,000
7500	17.7	±106,000	17.3	±81,000	16.9	±61,000	16.2	±38,000

Table 10: Effective resolution of the strain gauge value in bits for the measurement range 32 to 256 mV/V

2.14.6 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
250 μs

2.14.7 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
133 to 400 μs depending on the data rate