X90AISG0.02-00

1 General information

The modular X90 mobile control and I/O system opens up a wide range of possibilities in mobile automation. With the X90 mobile system, flexible automation concepts can be implemented based on a standardized complete system.

Option board X90AISG0.02-00 is integrated in the X90 mobile system and extends the functionality of the entire system.

This module is equipped with 2 inputs for evaluating full-bridge strain gauges and works with 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 offset. The measurement precision refers to the absolute (compensated) value, which will only change as a result of changes in the operating temperature. Communication to the mainboard is made possible via X2X Link.

- 9 to 32 VDC
- 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

2 Order data

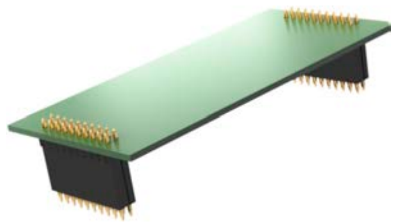
Model number	Short description	Figure
	Analog inputs	
X90AISG0.02-00	X90 mobile option board, strain gauge module for 2 DMS full-bridge strain gauges, 24-bit converter resolution, 5 kHz input filter	

Table 1: X90AISG0.02-00 - Order data

Optional accessories

Order number	Short description
X67CA0A41.xxxx	M12 sensor cable
X67CA0A51.xxxx	M12 sensor cable, angled

Inputs and outputs - Overview

X90AISG0.02-00		Output				Input			
Multifunction I/O	Quantity	PWM	Digital	Analog	PWM signal	Temperature	Analog	Countable	Digital
MF-AI	2						X		

3 Technical data

Model number	X90AISG0.02-00
Short description	
I/O module	2 full-bridge strain gauge inputs
General information	
B&R ID code	0xF79D
Status indicators	-
Certifications	
UN ECE-R10	Yes
CE	Yes
Multi-function inputs	
Multifunction analog inputs (MF-AI)	
Quantity	2
Functions	Analog input, 24-bit digital converter resolution
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	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 electric potential strain gauge GND) on inputs "Input +" and "Input -"
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 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-proof	Yes
Voltage drop for short-circuit protection	Max. 0.2 VDC at 65 mA and 25°C
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
Max. gain drift	12 ppm/°C [3]
Max. offset drift	2 ppm/°C [4]
Nonlinearity	<10 ppm [4]
Operating conditions	
Mounting orientation	
Any	Yes
Chemical resistance	Not guaranteed [5]
Degree of protection per EN 60529	Up to IP66 [6]

Table 2: X90AISG0.02-00 - Technical data

Model number	X90AISG0.02-00
Ambient conditions	
Temperature	
Operation	
Horizontal mounting orientation	-40 to 85°C housing surface 6)
Vertical mounting orientation	-40 to 85°C housing surface 6)
Storage	-40 to 85°C
Transport	-40 to 85°C
Relative humidity	
Operation	5 to 100%, condensing
Storage	5 to 100%, condensing
Transport	5 to 100%, condensing
Shock	
Operation	For shock test 50 g, 11 ms analog values out of tolerance 7)
Mechanical properties	
Dimensions	
Width	47 mm
Length	95 mm
Torque for connections	
M12	0.6 Nm

Table 2: X90AISG0.02-00 - Technical data

1) With 6-wire connections, line compensation does not function (see section "Connection examples").
2) Quantization depends on the strain gauge factor.
3) Based on the current measured value.
4) Based on the entire measurement range.
5) Chemical resistance per ISO 15003 has not been tested. See section "Standards and certifications - Requirements for vehicles - Chemical resistance" in the X90 user's manual.
6) Depends on the mainboard. For additional details, see the data sheet for the mainboard.
7) Shock (50 g, 11 ms) testing performed per EN 60068-2-27 type I per ISO 15003 level 3.
See "X90 user's manual - International and national certifications - Vehicle requirements - Mechanical conditions - Shock".

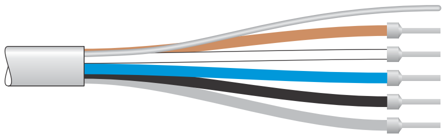
4 Operating and connection elements

4.1 X2X Link interface

Communication between the option board and mainboard is implemented using X2X Link.

5 Pinout

The maximum length of the sensor cable is 30 m.

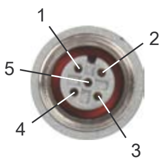


Shield	
1	SG VCC
2	Input +
3	SG GND
4	Input -
5	NC.

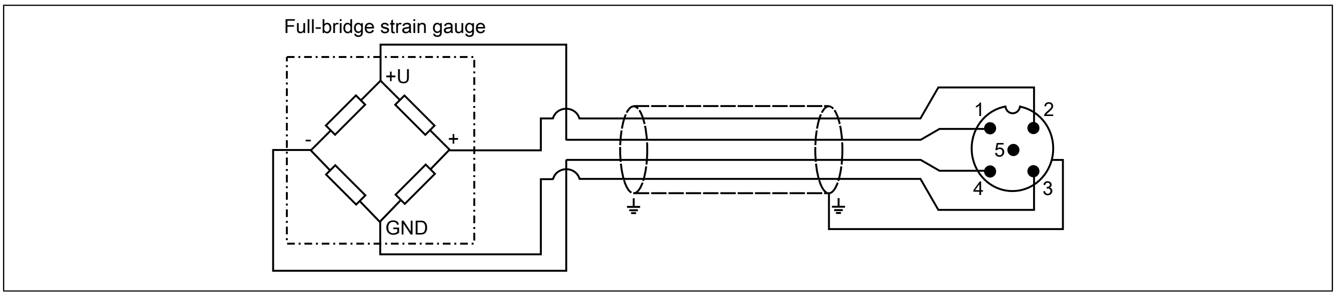
5.1 Connections DMS1 and DMS2

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

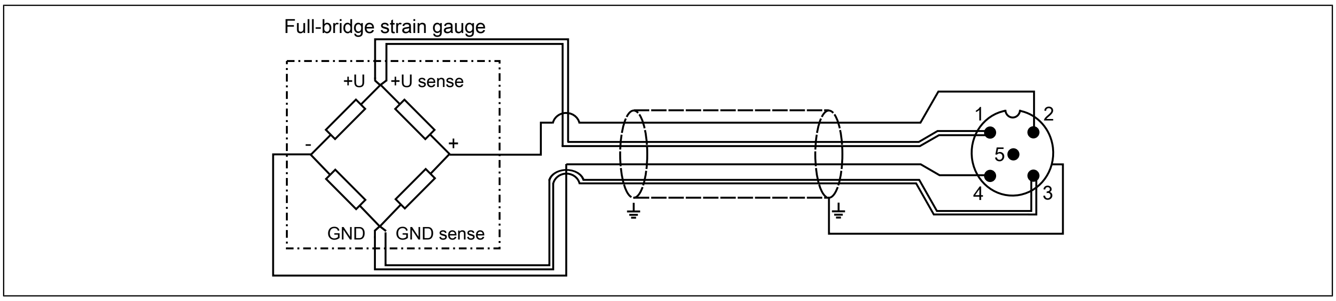
- DMS1
- DMS2

M12, 5-pin	Pinout		
Connection DMS1	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	NC.	NC.
Connection DMS2	1) Shield connection made via threaded insert in the module. DMS1 and DMS2 → A-coded (female), input		

4-wire strain gauge connection - Connection example

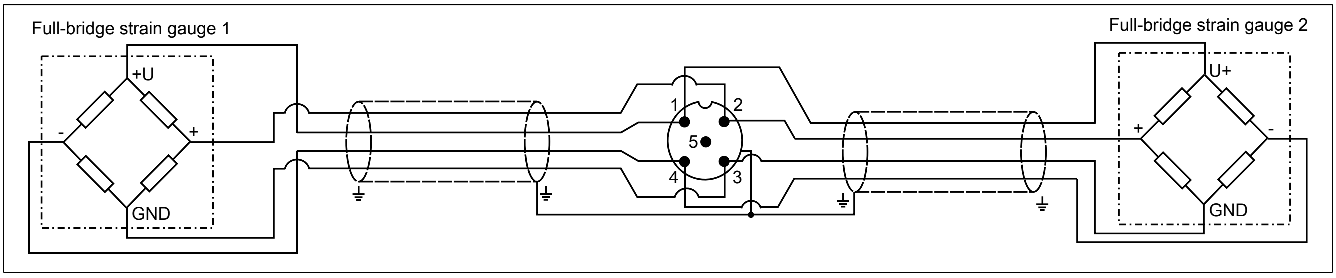


6-wire strain gauge connection - Connection example

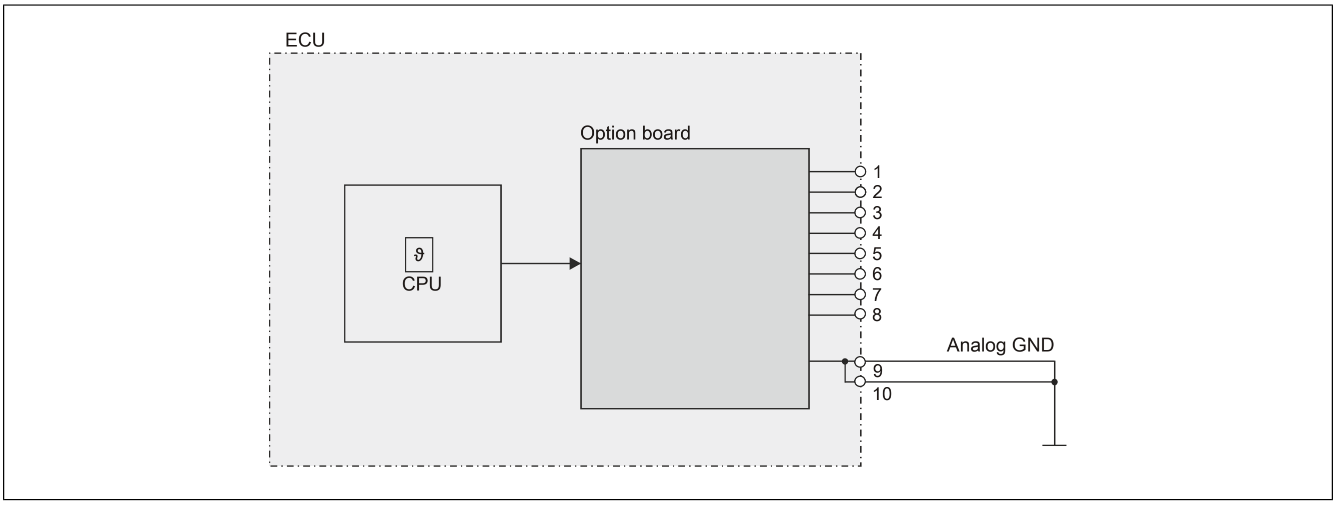


Parallel connection - Connection example

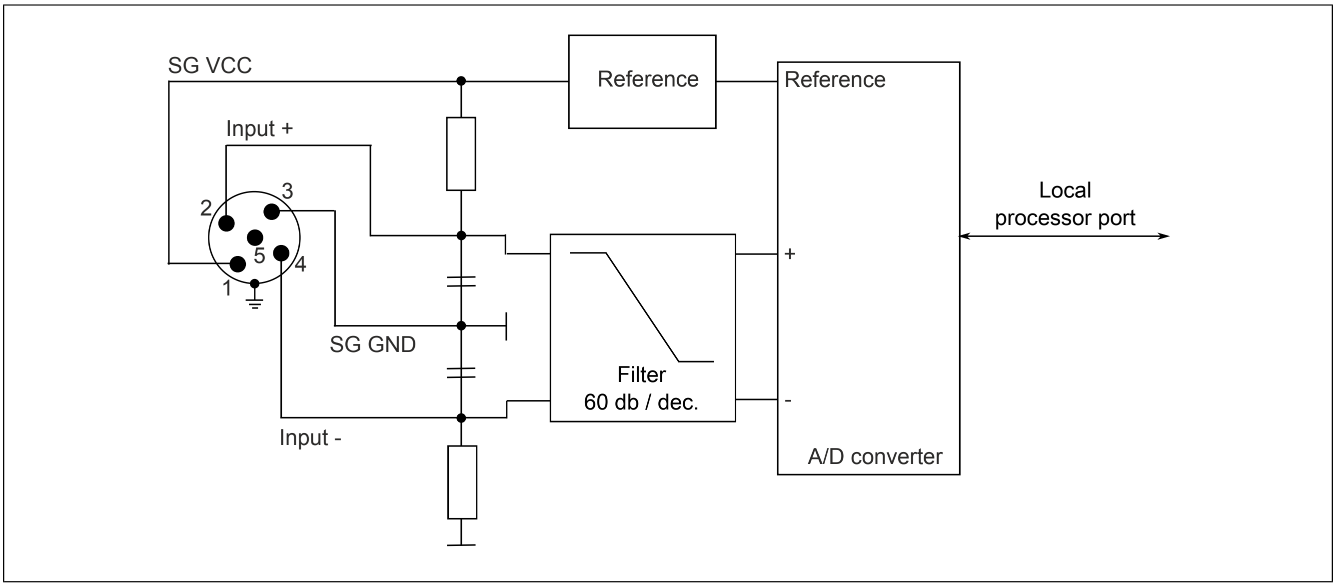
When connecting 2 or more full-bridge strain gauges in parallel, 2 lines must be consolidated in one connector.



6 Block diagram



6.1 Input circuit diagram

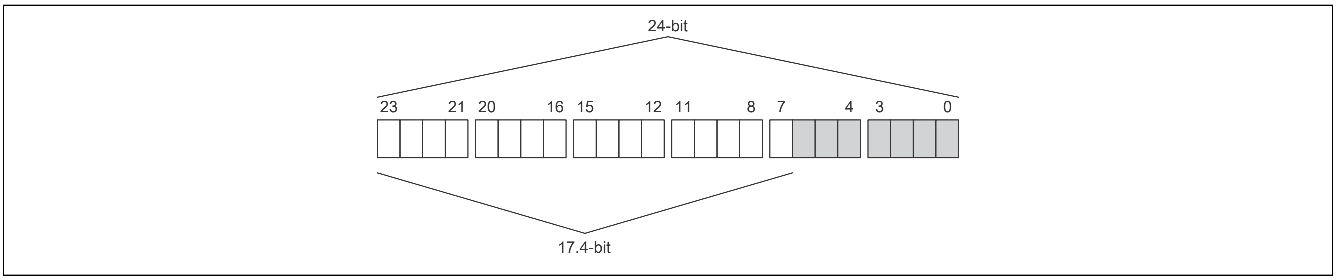


7 Effective resolution of the A/D converter

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 range of 2 mV/V result in an effective resolution of 17.4 bits:



The low-order bits (shown in gray) 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.

8 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.

8.1 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:

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

The quantization must be calculated using the actual calculated bridge voltage (see "Quantization" on page 7).

8.2 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 6). 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

This 21.85 mV corresponds to 99.3% of the maximum possible measurement range.

Information:

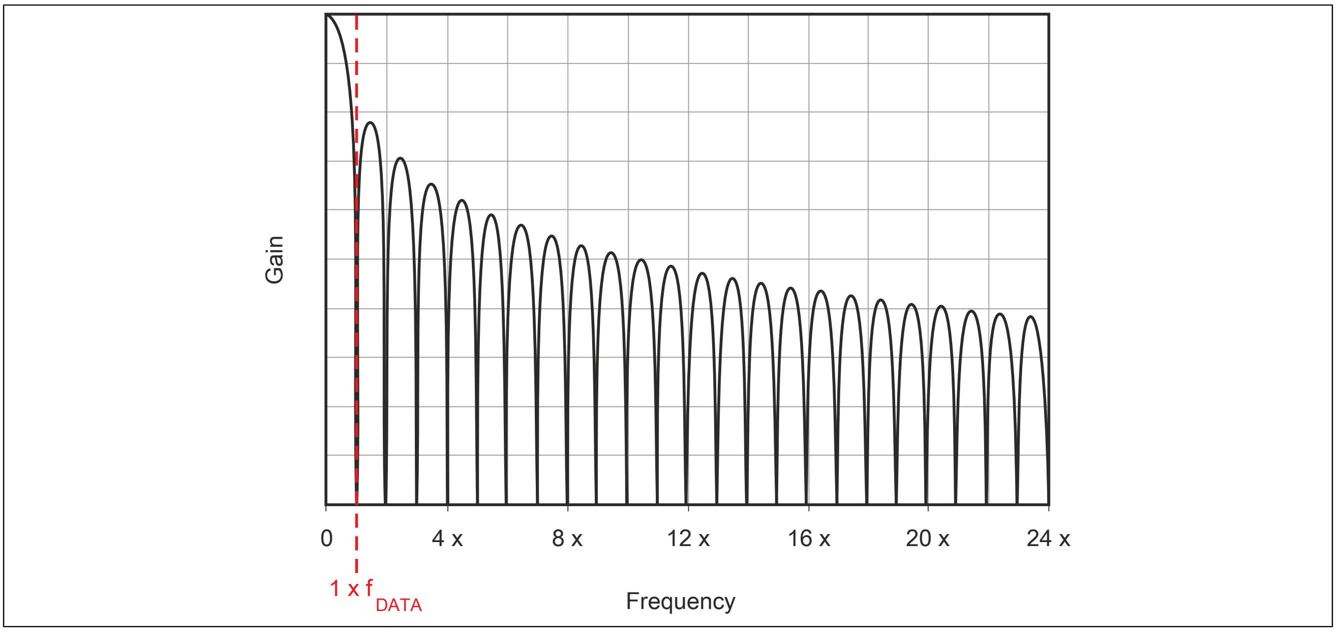
If the quantization decreases, the maximum possible effective resolution also decreases (see "Effective resolution of the A/D converter" on page 5).

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).

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

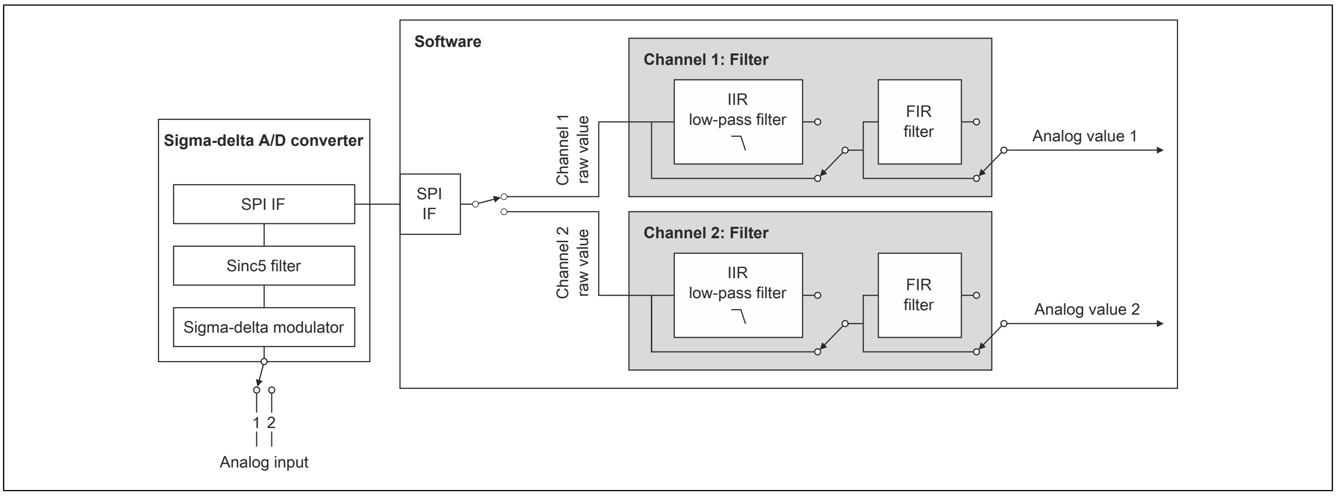


10 Software filters

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



10.1 IIR low-pass filter

10.1.1 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 21. "Filter level" = 0 if the IIR low-pass filter is disabled.

10.1.2 Filter characteristics of the first-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

10.2 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 = 15000 samples/s, averaging over 15 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 "StatusInput01" on page 16.

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

The following table applies to "Function model 0 - Standard" and "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 model 0	Function model 2 ("Selectable data rate" mode)	Function model 0	Function model 2 ("Selectable data rate" mode)
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: Bits 0 to 3 of register "ConfigOutput0x" on page 15
2) Function model 2: Bits 0 to 3 of register "ConfigDatarateOutput0x" on page 22
3) Function model 0: Data rate = 1/Filter length [s] (f_{Notch}) = I/O update rate
4) Function model 2: Data rate = 1/Filter length [s] (f_{Notch})

10.2.2 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 from register ConfigHighResolutionOutput0x (Page 22)
2) The value varies between 75 and 125 µs (see also the next section "I/O update time")

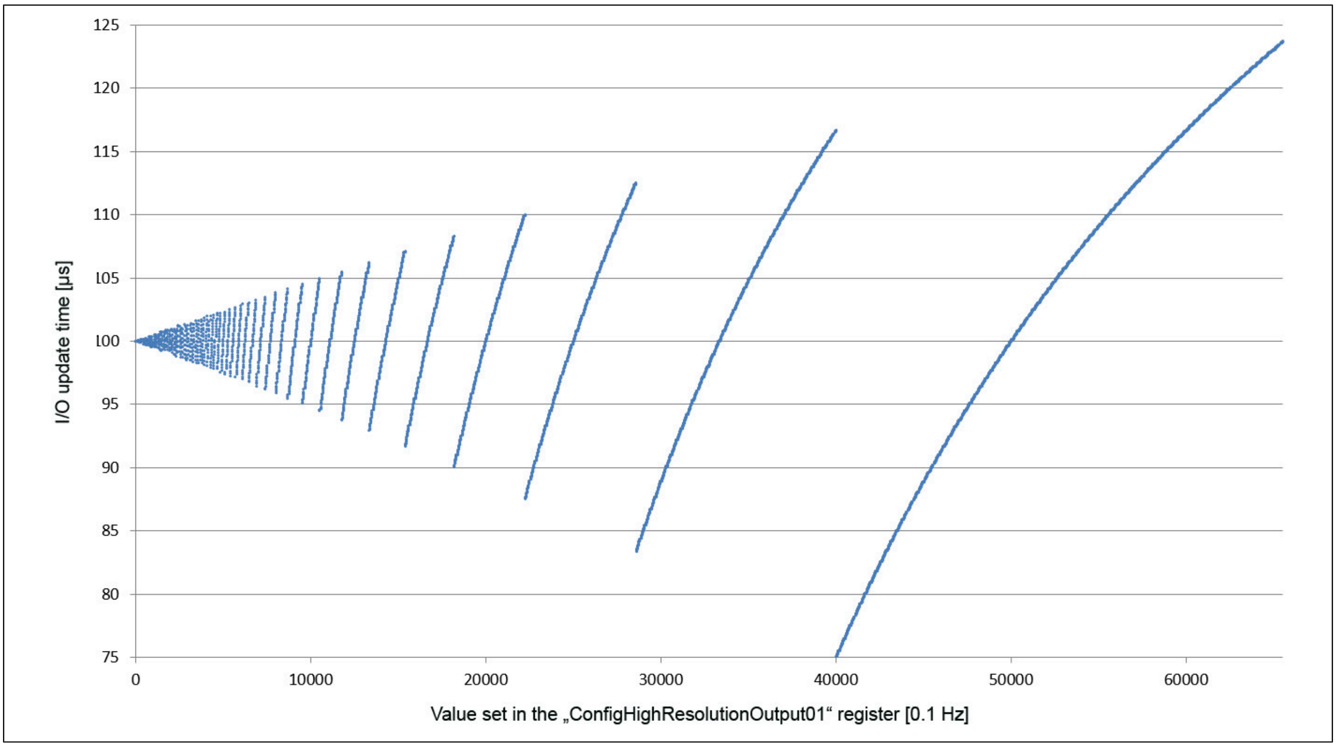
I/O update time

The value of the I/O update time depends on the set value and varies between 42 and 56 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:

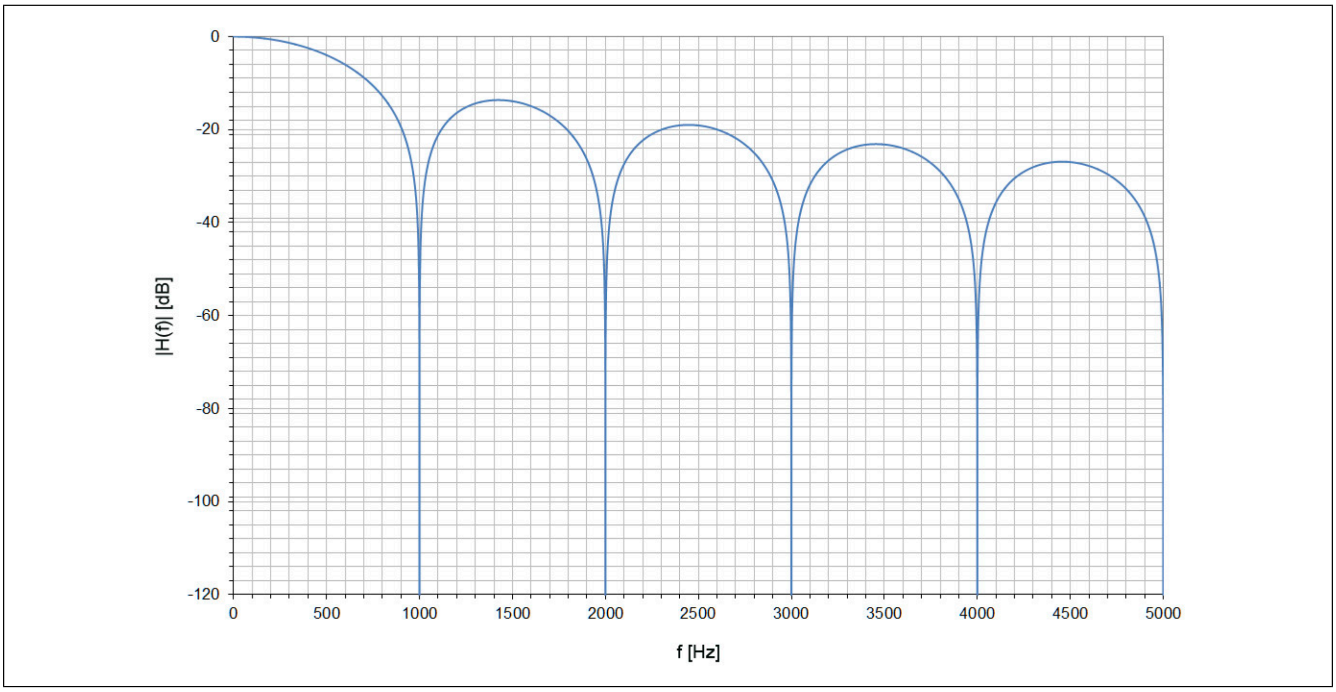


10.2.3 Examples for the gain of the FIR filter

Example 1

Filter setting = 10:

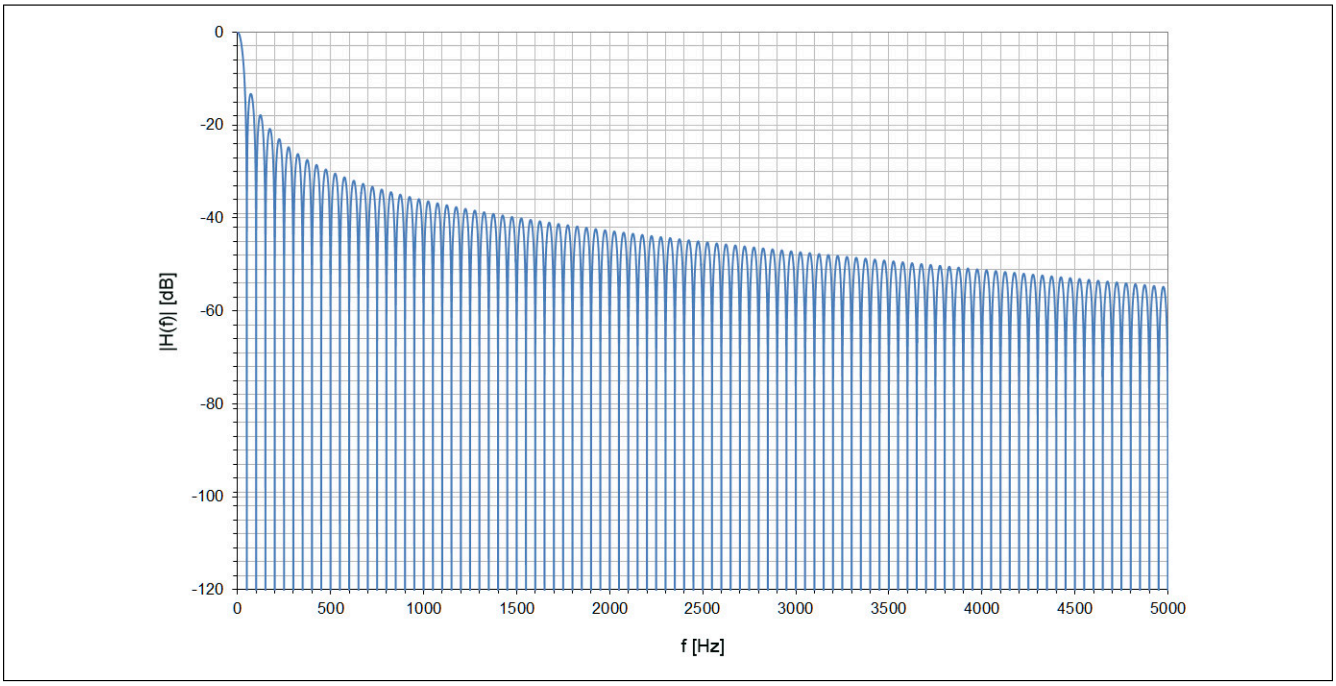
- f_{Notch} = 1000 Hz
- f_c = 439.3 Hz



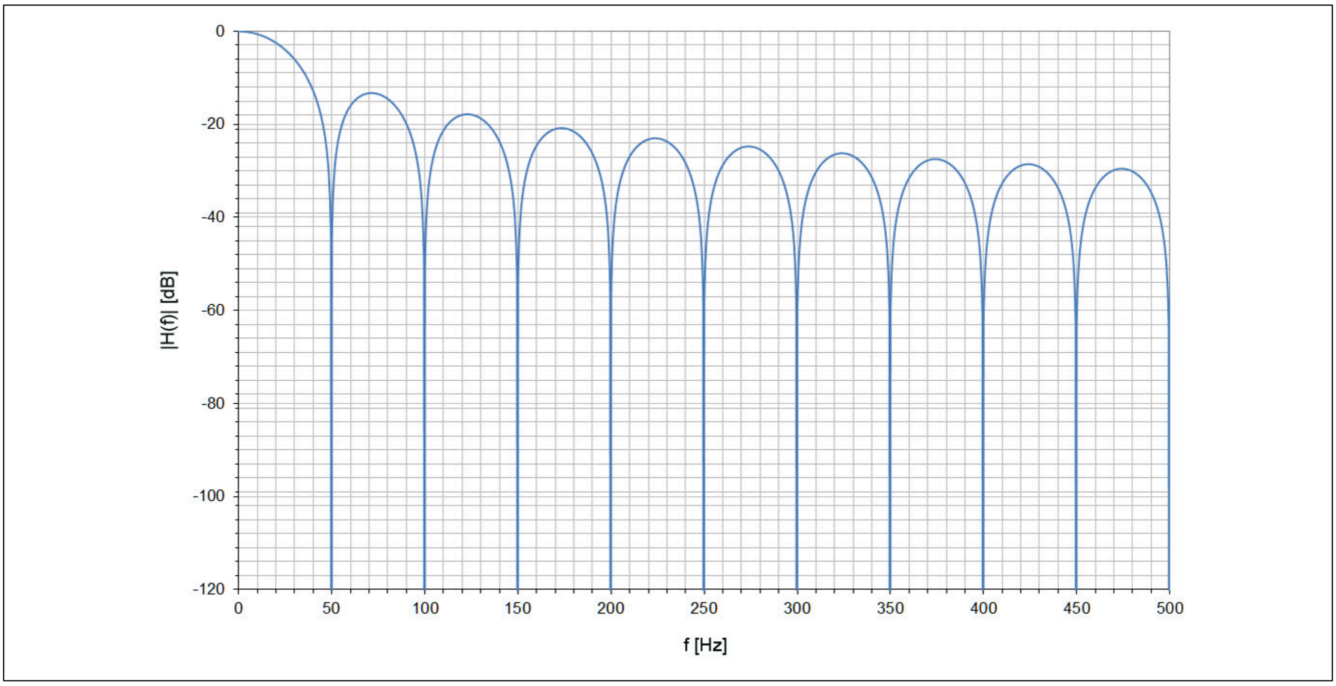
Example 2

Filter setting = 6:

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



Detailed excerpt from the filter curve shown above:



11 Register description

11.1 System requirements

The following minimum versions are recommended to generally be able to use all functions:

- Automation Studio 4.3
- Automation Runtime 4.3

11.2 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	•			

11.3 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 4 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 20).

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	•			

11.4 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	●			

11.5 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	●			

11.6 Registers for function model "0 - Standard"

11.6.1 Analog signal - Configuration

11.6.1.1 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	Default
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 (default)
		1110	Synchronous mode
		1111	Reserved
4 - 6	Standard measurement range (bit 6 = 0)	000	16 mV/V (default)
		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)

11.6.1.1.1 Synchronous mode

The A/D converter on the module can be operated and read out synchronously to the X2X Link network. Synchronous mode is enabled by selecting the respective operating mode in register "ConfigOutput" on page 15. A time between 400 and 2000 μs must also be set in register "ConfigCycletime" on page 16. 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.

11.6.1.2 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 400 to 2000 µs

Data type	Values	Information
UINT	400 to 2000	Default value: 0

11.6.2 Analog signal - Communication

11.6.2.1 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), open-circuit detection does not work reliably (because of the variable input impedance of the amplifier in relation to the set data rate).

11.6.2.2 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 5).

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

	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

11.7 Register for "Function model 1 - Multisampling"

> **Information:**
>
> **"Function model 1 - Multisampling" can only be used on channel 1.**

11.7.1 Analog signal - Configuration

11.7.1.1 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)

11.7.1.2 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

11.7.2 Analog signal - Communication

11.7.2.1 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 4 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 the measurement range (see "Effective resolution of the A/D converter" on page 5).

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

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

11.7.2.2 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	-	

11.7.2.3 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 13).

Example: A/D converter cycle time = 50 µs

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

11.8 Register for "Function model 2 - Extended filter"

11.8.1 Analog signal - Configuration

11.8.1.1 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)

11.8.1.2 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 22.
	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 22.

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

11.8.2 Analog signal - Communication

11.8.2.1 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	-	

11.8.2.2 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

11.9 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 about the calls, see library DATA_to_SafeDATA_SF contained in SafeDESIGNER.

11.9.1 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. See "Strain gauge value" on page 17 for more information.

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

11.9.2 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

11.9.3 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

11.9.4 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

11.9.5 SourceRef address

Name:
CfO_DTS_SourceRef

This register contains the acyclically configurable SourceRef address that is transmitted 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

11.10 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
400 μs

11.11 Minimum I/O update time

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

For the I/O update times for function models "0 - Standard" and "2 - Extended filter", see section "Characteristics of the FIR filter in mode "Selectable data rate"" on page 10.

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