X20AIA744

Data sheet
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Translation of the original documentation

Publishing information

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Disclaimer

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1 General information

1.1 Other applicable documents

For additional and supplementary information, see the following documents.

Other applicable documents

Document name	Title
MAX20	X20 System user's manual

1.2 Order data

Order number	Short description	Figure
	Analog input modules	
X20AIA744	X20 analog input module, 2 full-bridge strain inputs, 24-bit converter resolution, 2.5 kHz input filter	
	Required accessories	
	Bus modules	
X20BM11	X20 bus module, 24 VDC keyed, internal I/O power supply connected through	
X20BM15	X20 bus module, with node number switch, 24 VDC keyed, internal I/O power supply connected through	
	Terminal blocks	
X20TB1F	X20 terminal block, 16-pin, 24 VDC keyed	

Table 1: X20AIA744 - Order data

1.3 Module description

The module is equipped with 2 analog inputs that are designed as 4-wire strain gauge load cells.

Functions:

- Full-bridge strain gauge
- Software filters
- Module status
- Timestamp of the channel

Full-bridge strain gauge

The module has 2 connections for force transducers using a full-bridge strain gauge.

Software filters

The module is equipped with 3 switchable and configurable software filters:

- The IIR low-pass filter is used to generally smooth and increase the resolution of the analog value.
- The moving average is used to generally smooth and increase the resolution of the analog value. Individual interference frequencies can also be specifically filtered out.
- The IIR notch filter is used for narrowband interference suppression.

Monitoring the module

The status of the module, such as voltage supply, analog input values and filter states are monitored.

Timestamp

The last channel converted is provided with a timestamp.

2 Technical description

2.1 Technical data

Order number	X20AIA744
Short description	
I/O module	2 full-bridge strain gauge inputs
General information	
B&R ID code	0xE50C
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
Power consumption	
Bus	0.01 W
Internal I/O	0.7 W
Additional power dissipation caused by actuators (resistive) [W]	+0.72 [1)]
Certifications	
CE	Yes
UKCA	Yes
ATEX	Zone 2, II 3G Ex nA nC IIA T5 Gc IP20, Ta (see X20 user's manual) FTZÚ 09 ATEX 0083X
UL	cULus E115267 Industrial control equipment
Full-bridge strain gauge	
Strain gauge factor	2 to 256 mV/V, configurable using software
Connection	4-wire connections
Input type	Differential, used to evaluate a full-bridge strain gauge
Digital converter resolution	24-bit
Conversion time	200 µs
Data output rate	5000 samples per second and per channel (f_{DATA})
Input filter	
Cutoff frequency	2.5 kHz
Order	3
Slope	60 dB
ADC filter characteristics	Sigma-delta, see section "Filter"
Operating range / Measurement sensor	85 to 5000 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	0.6 to 3.8 VDC Permissible input voltage range (with regard to the electric potential strain gauge GND) on inputs "Input +" and "Input -"
Insulation 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 per channel
Short-circuit and overload-proof	Yes
Quantization [2)]	
LSB value	
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	35 ppm/°C [3)]
Max. offset drift	15 ppm/°C [4)]
Nonlinearity	<10 ppm [4)]

Table 2: X20AIA744 - Technical data

Order number	X20AIA744
Electrical properties	
Electrical isolation	Bus isolated from analog input and strain gauge supply voltage Channel not isolated from channel and 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	IP20
Ambient conditions	
Temperature	
Operation	
Horizontal mounting orientation	-25 to 60°C
Vertical mounting orientation	-25 to 50°C
Derating	See section "Hardware configuration"
Storage	-40 to 85°C
Transport	-40 to 85°C
Relative humidity	
Operation	5 to 95%, non-condensing
Storage	5 to 95%, non-condensing
Transport	5 to 95%, non-condensing
Mechanical properties	
Note	Order 1x terminal block X20TB1F separately. Order 1x bus module X20BM11 separately.
Pitch	12.5$^{+0.2}$ mm

Table 2: X20AIA744 - Technical data

1) Depends on the full-bridge strain gauge being used.
2) Quantization depends on the strain gauge factor.
3) Based on the current measured value.
4) Based on the entire measurement range.

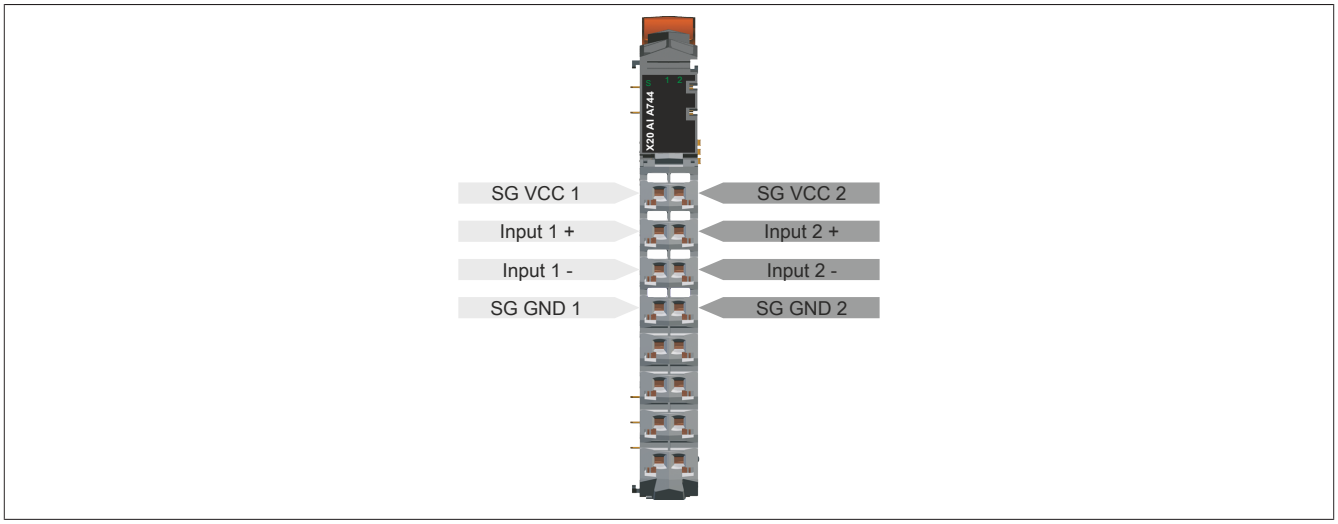
2.2 LED status indicators

For a description of the various operating modes, see section "Additional information - Diagnostic LEDs" in the X20 system user's manual.

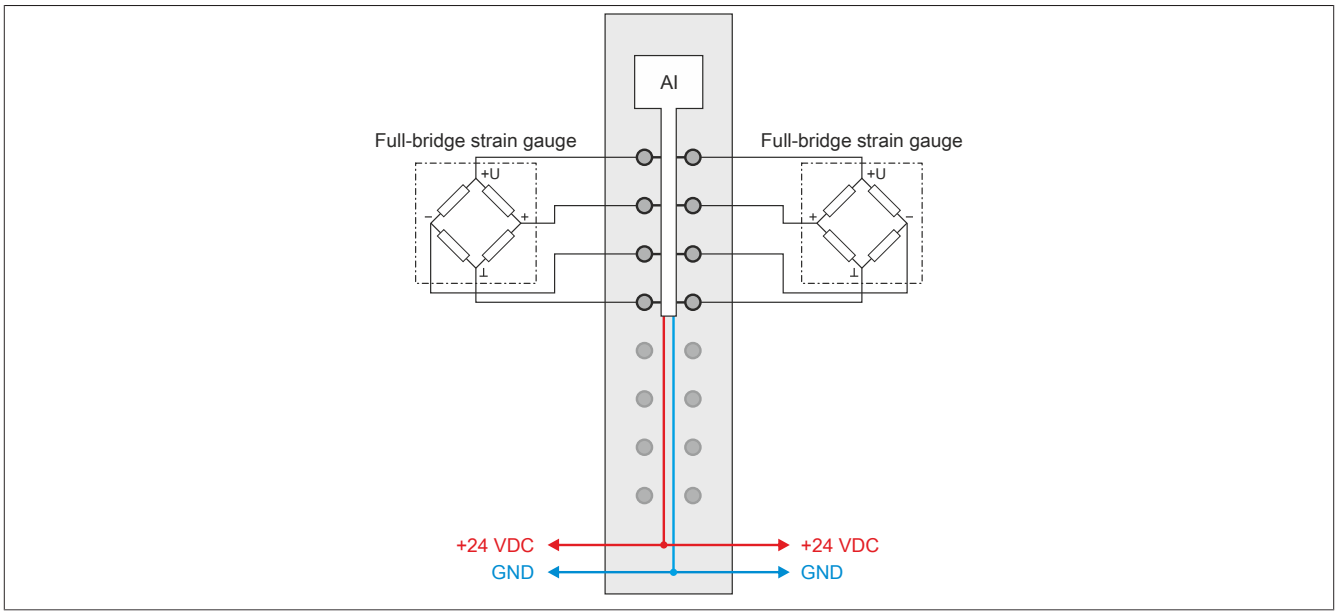
Figure	LED	Color	Status	Description
	S	Green	Off	No power to module
			Single flash	RESET mode
			Double flash	BOOT mode (during firmware update)[1]
			Blinking	PREOPERATIONAL mode
			On	RUN mode
		Red	Off	No power to module or everything OK
			Double flash	I/O supply outside limits
			On	Error or reset status
	1 - 2	Green	Off	Possible causes: • Supply error • Channel not yet configured
			Blinking	Possible causes: • Open line • Overvoltage • Undervoltage
			On	Analog/digital converter running, value OK

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

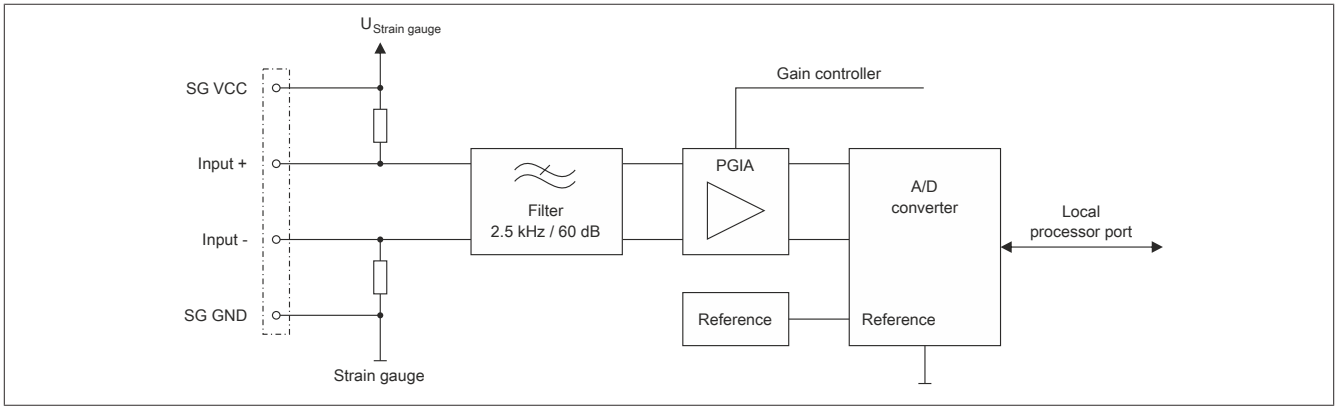
2.3 Pinout



2.4 Connection example



2.5 Input circuit diagram

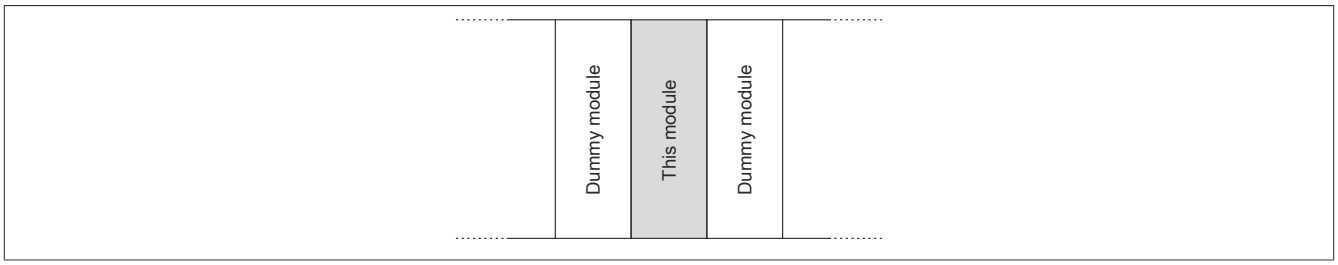


2.6 Hardware configuration

2.6.1 Hardware configuration for horizontal installation starting at 55°C ambient temperature

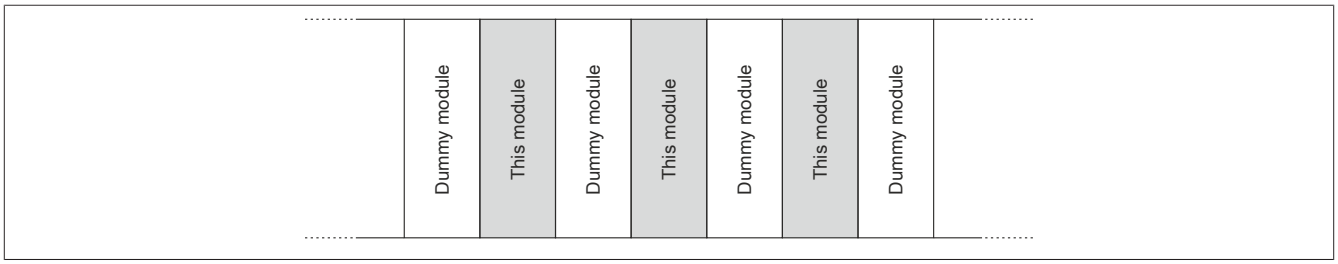
Operating a strain gauge module

Starting at an ambient temperature of 55°C, a dummy module must be connected to the left and right of the strain gauge module in a horizontal mounting orientation.



Operating multiple strain gauge modules side by side

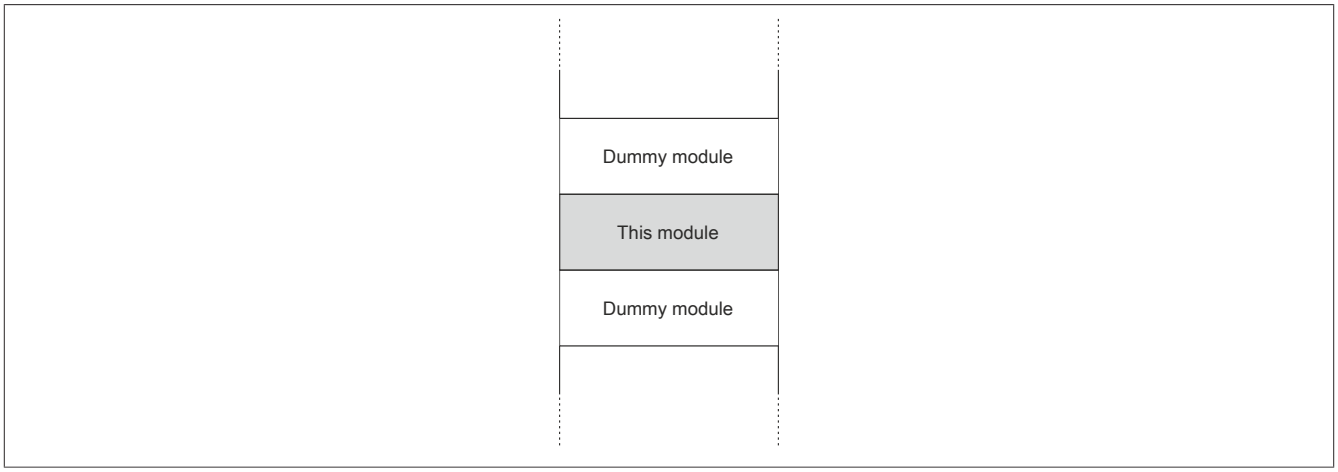
If 2 or more horizontal strain gauge modules are being operated in a cluster, the following arrangement of modules must be observed.



2.6.2 Hardware configuration for vertical installation starting at 45°C ambient temperature

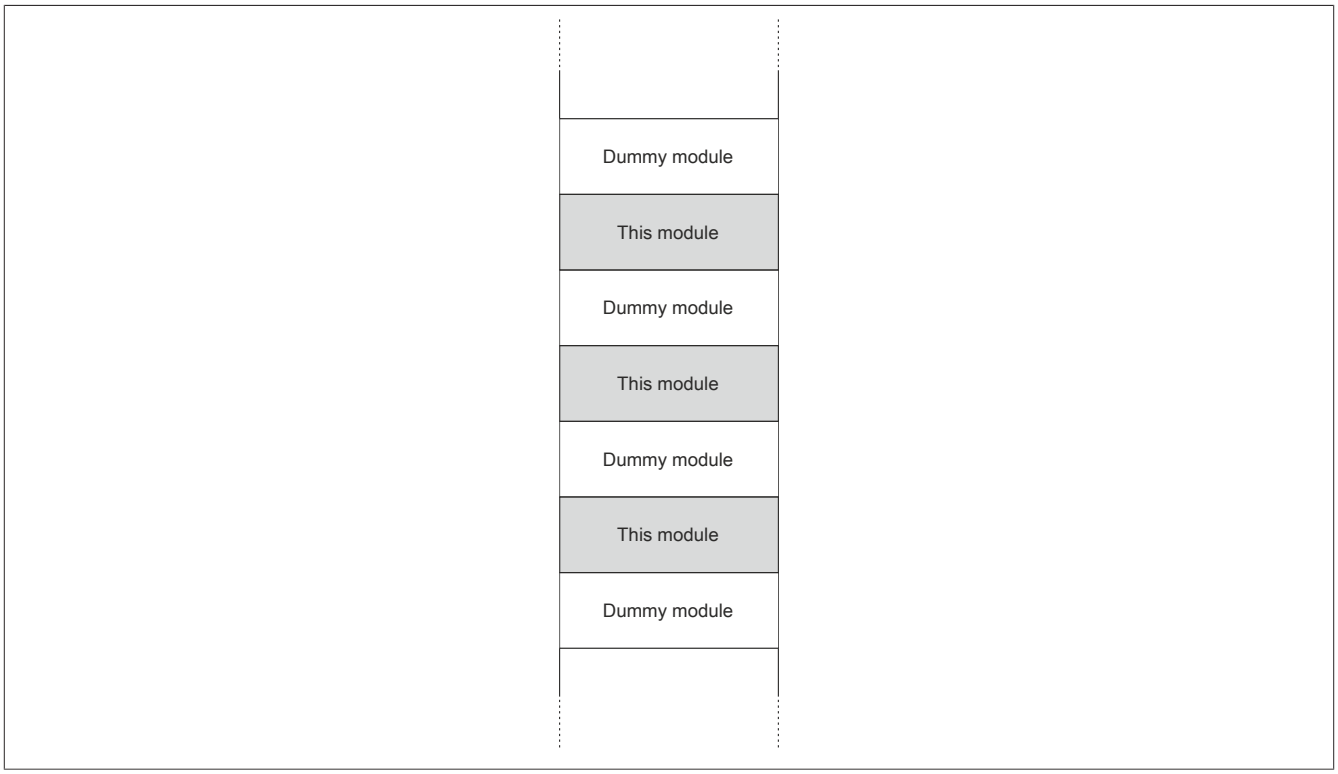
Operating a strain gauge module

Starting at an ambient temperature of 45°C, a dummy module must be connected to the left and right of the strain gauge module in a vertical mounting orientation.



Operating multiple strain gauge modules side by side

If 2 or more vertical strain gauge modules are being operated in a cluster, the following arrangement of modules must be observed.



3 Function description

3.1 Full-bridge strain gauge

The module is equipped with 2 full-bridge strain gauges that are designed as 4-wire strain gauge load cells. The concept applied by the module requires calibration in the measurement system. This calibration compensates or eliminates the absolute inaccuracies in the measurement circuit (e.g. component tolerances, effective bridge voltage or zero offset). The measurement accuracy related to an absolute (calibrated) value only changes due to the negative influence of a change in the operating temperature.

Information:

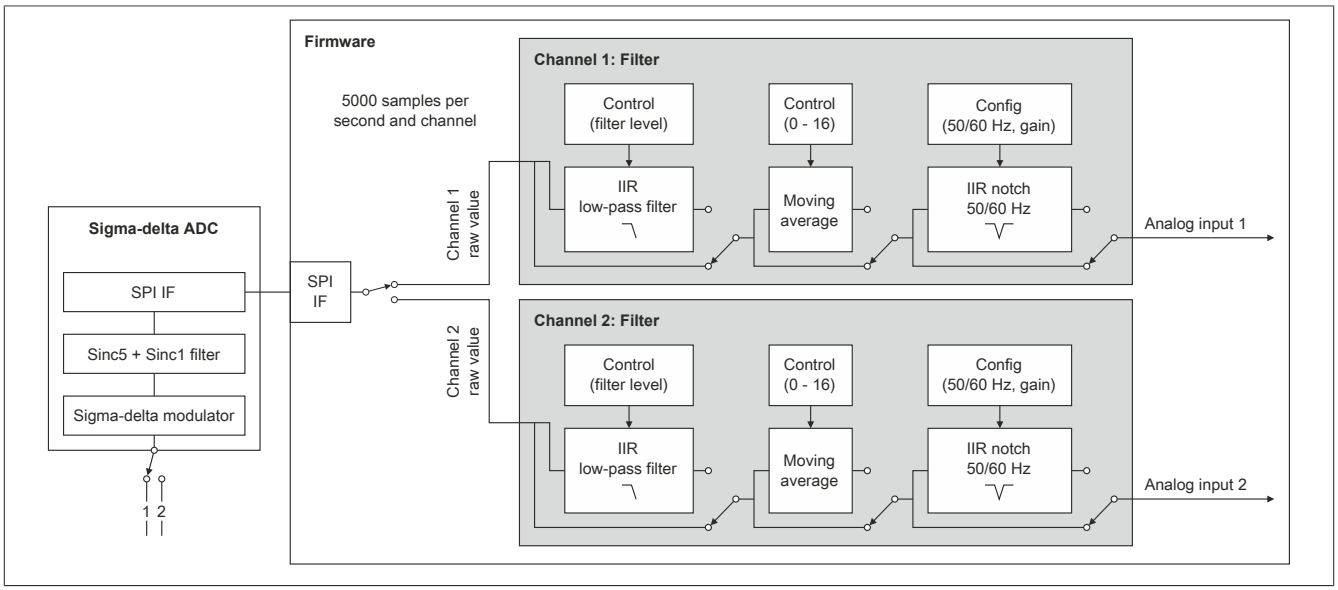
The register is described in "Configuration of strain gauge inputs" on page 21.

3.2 Software filters

An independent cascade of filters is available for each channel. They can be individually enabled and configured at runtime. By default, all filters are disabled when the device is switched on. Filters are controlled and configured using the "ControlPacked0N" on page 21 and "ConfigChannel0N" on page 22 (N = 1 to 2) registers.

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 moving average filter can be changed synchronously at any time.

Filter diagram



Information:

The register is described in "Configuration of strain gauge inputs" on page 21.

3.2.1 IIR low-pass filter

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:

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

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

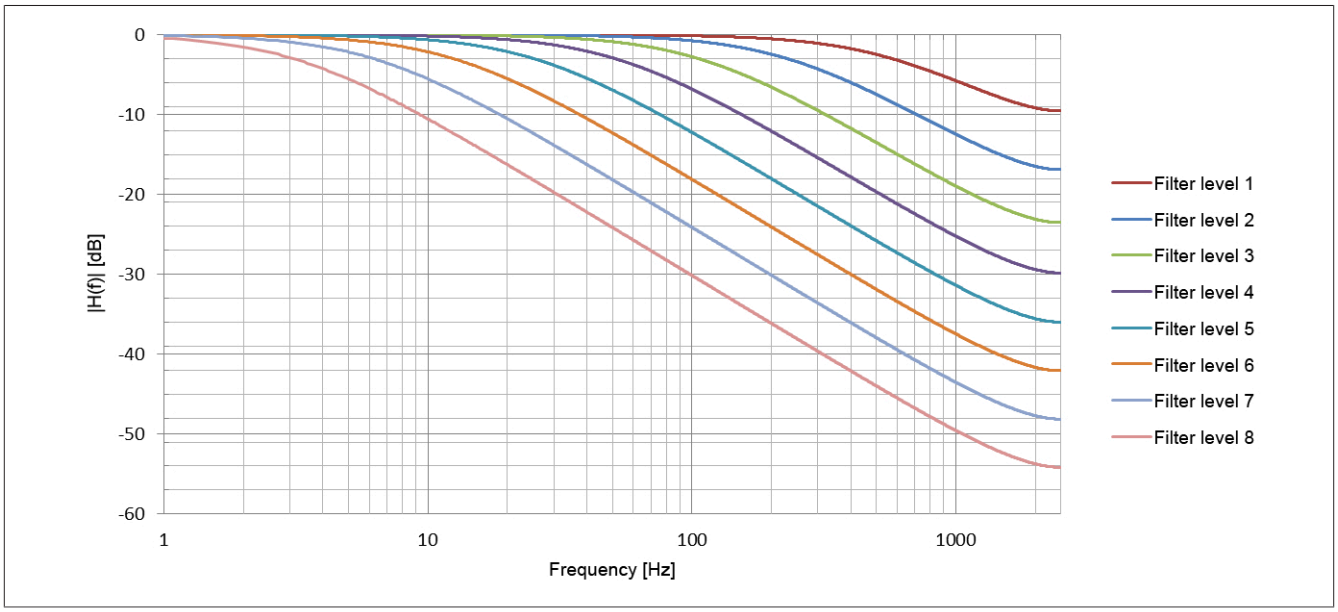
3.2.1.1 Filter characteristics of the 1st-order IIR low-pass filter

Limit frequency f_c

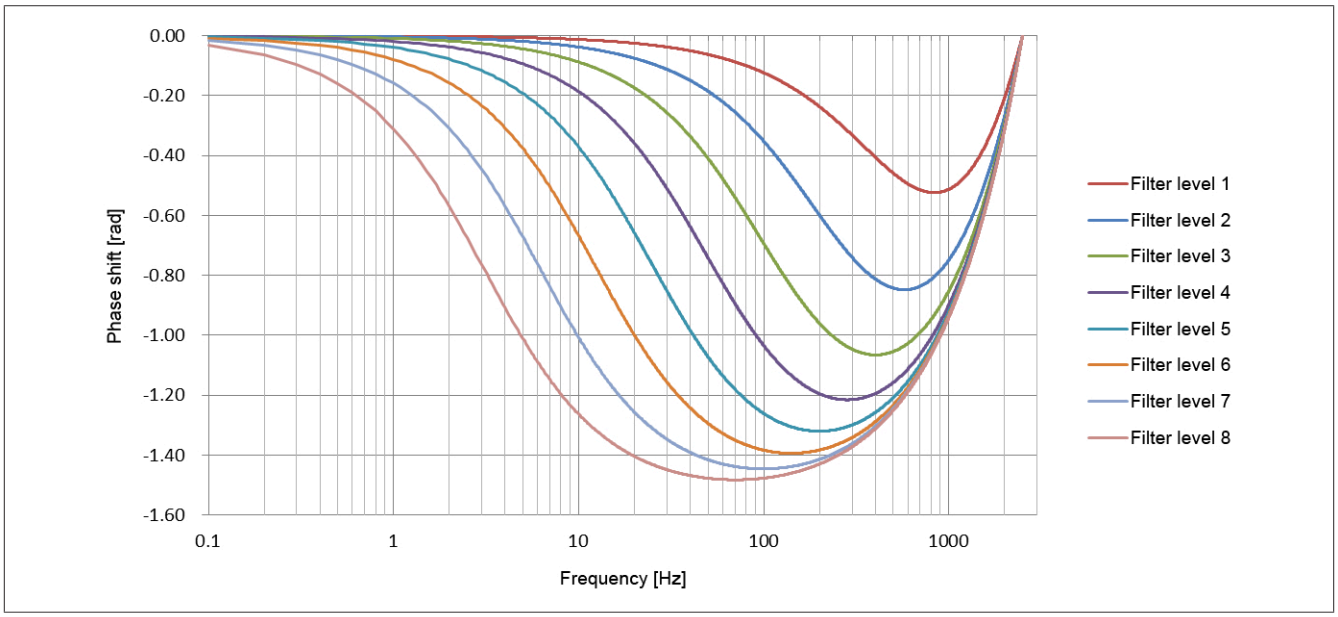
The following table provides an overview of the -3 dB limit frequency f_c depending on the configured filter level.

IIR low-pass filter level	f_c [Hz]
1	575
2	230
3	106
4	51
5	25
6	12.5
7	6.2
8	3.1

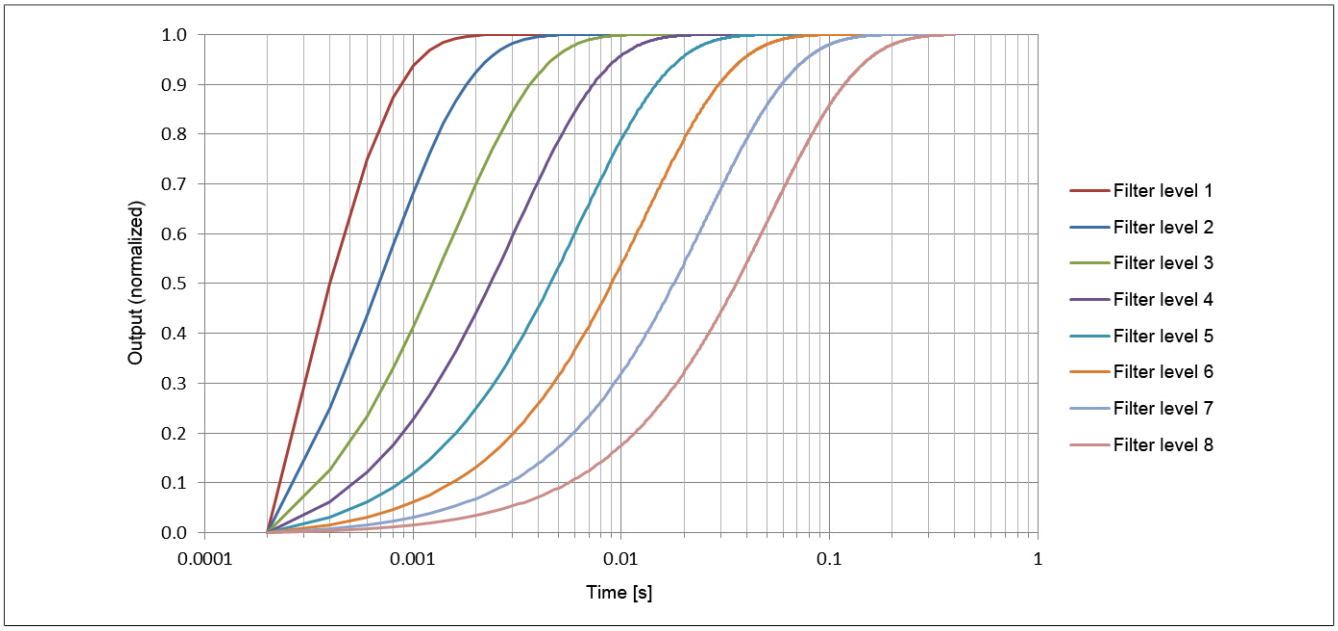
Gain of the IIR low-pass filter



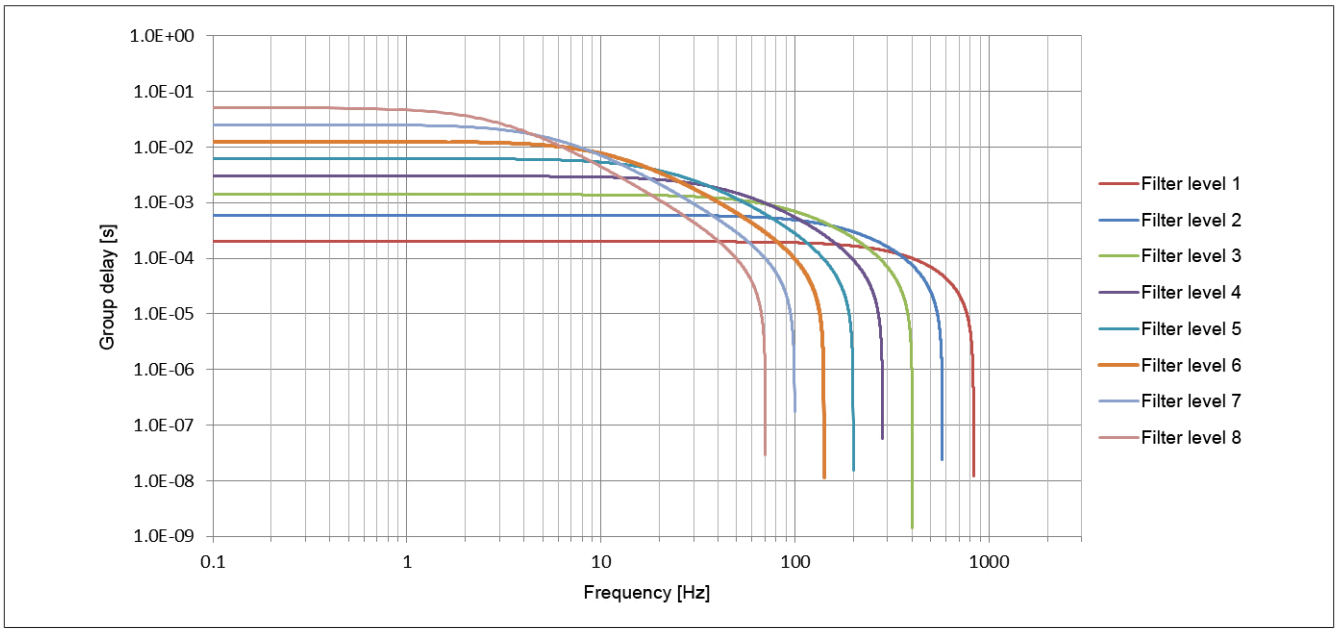
Phase shift of the IIR low-pass filter



Step response of the IIR low-pass filter



Group delay of the IIR low-pass filter



3.2.2 Sinc1 / Moving average filter

Like the low-pass filter, the moving average 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 of 5000 samples per second and channel).

Example:
Data output rate = 5000 samples/s/channel, averaging over 4 values -> "Notch" at 1.25 kHz (and 2.5 kHz)

When reconfiguring the filter length from "n" to "m", it takes |m-n| * 200 µs until the desired filter length setpoint is reached again. As long as the filter length setpoint is not reached, this situation will be indicated by the bit 7 status bit in the "StatusPacked0N" on page 22 register.

3.2.2.1 Filter characteristics of the moving average filter

Filter configuration	Filter length	f_{Notch} [Hz] 1)	f_c [Hz] 2)
0	1		
1	2	2500	1244
2	4	1250	568
3	5	1000	450
4	10	500	222
5	20	250	111
6	25	200	88.4
7	50	100	44.0
8	83	60.24	26.5
9	100	50	21.9
10	125	40	17.5
11	167	29.94	13.0
12	200	25	10.9
13	250	20	8.6
14	300	16.67	7.1
15	500	10	4.3
16	1000	5	2.0

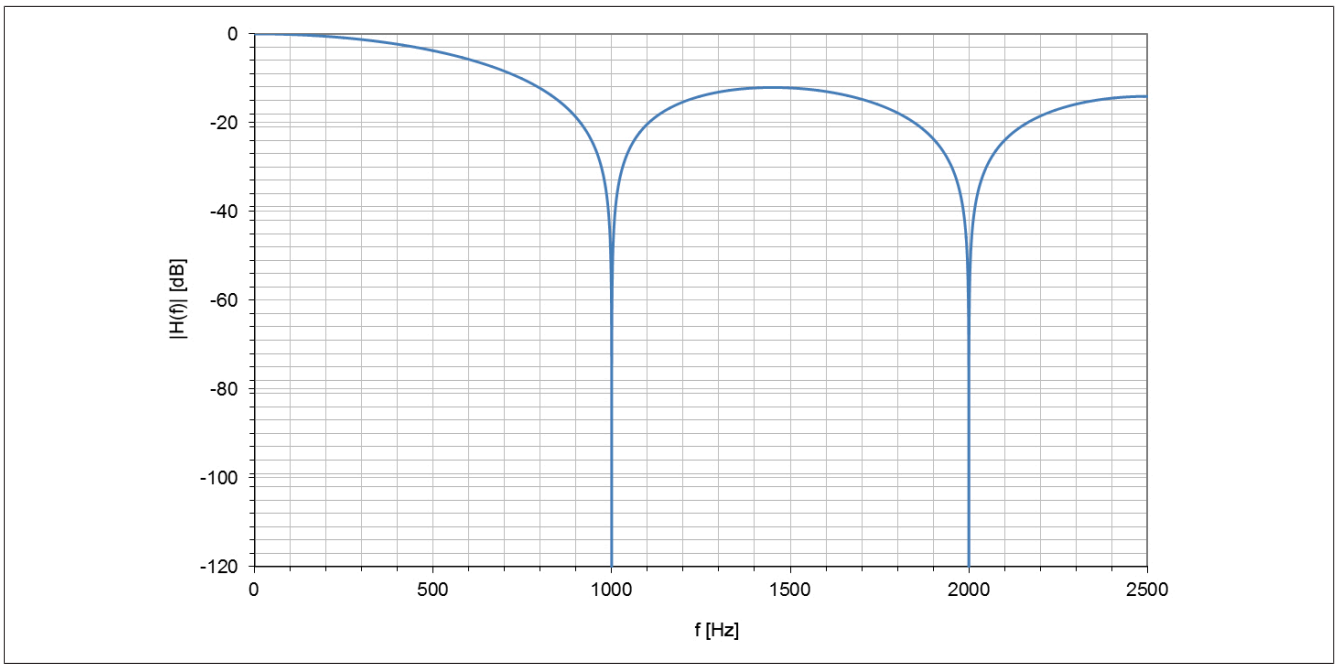
1) Mid-band frequency of the first attenuation maximum.
2) -3 dB limit frequency.

3.2.2.2 Examples for the gain of the moving average filter

Example 1

Filter setting = 3:

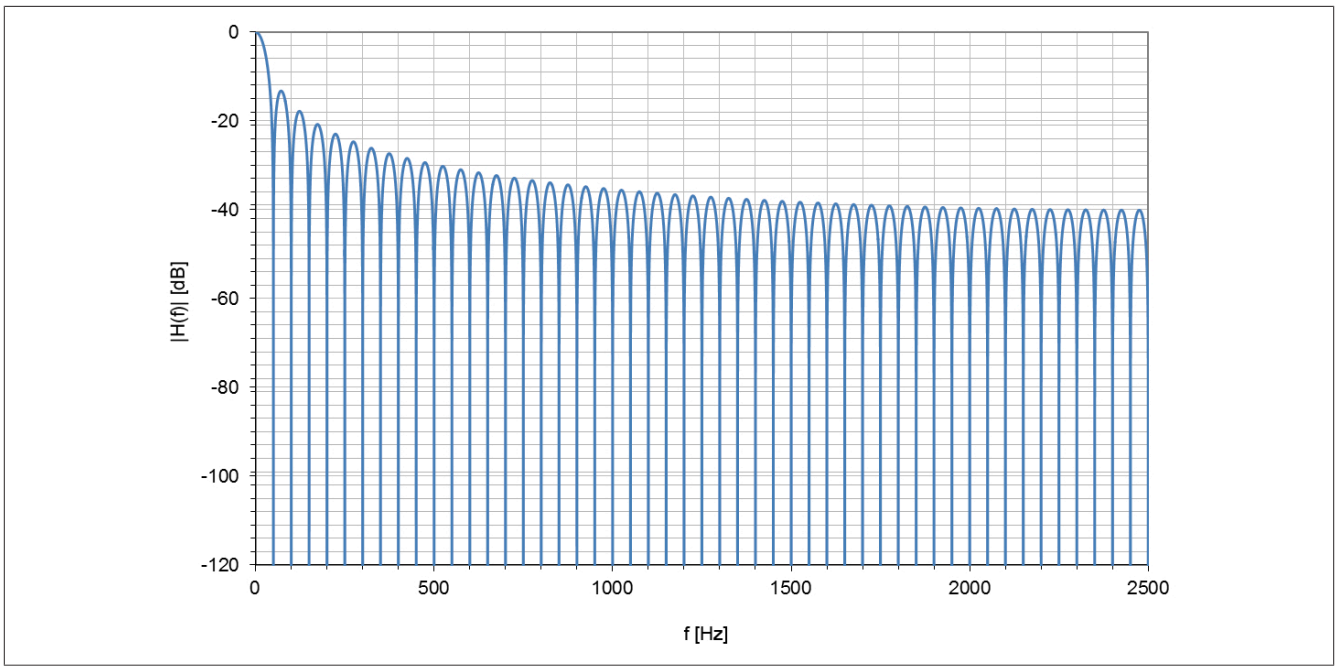
- f_{Notch} = 1000 Hz
- f_c = 449.6 Hz



Example 2

Filter setting = 9:

- f_{Notch} = 50 Hz
- f_c = 21.9 Hz



3.2.3 50/60 Hz IIR notch filter

The IIR notch filter is used for narrow-band suppression of interference caused by the mains frequency.

This is an 8th-order IIR notch filter implemented in the form of a cascade of 4 2nd-order IIR notch filters.

Information:

The IIR notch filter should only be enabled if there is actually interference being caused by the mains frequency. You should always check whether sufficiently low and sufficiently narrow band filtering at 50 Hz / 60 Hz can be implemented using a moving average filter (see "Filter characteristics of the moving average filter" on page 13).

This is because, like every higher-order IIR notch filter, this filter also has a tendency to respond to an input step with an attenuating vibration. The higher the dynamics of the expected measurement signal, the greater the potential interfering effect of this vibration tendency. In extreme cases, the vibration can temporarily be greater than the mains interference that is supposed to be filtered out.

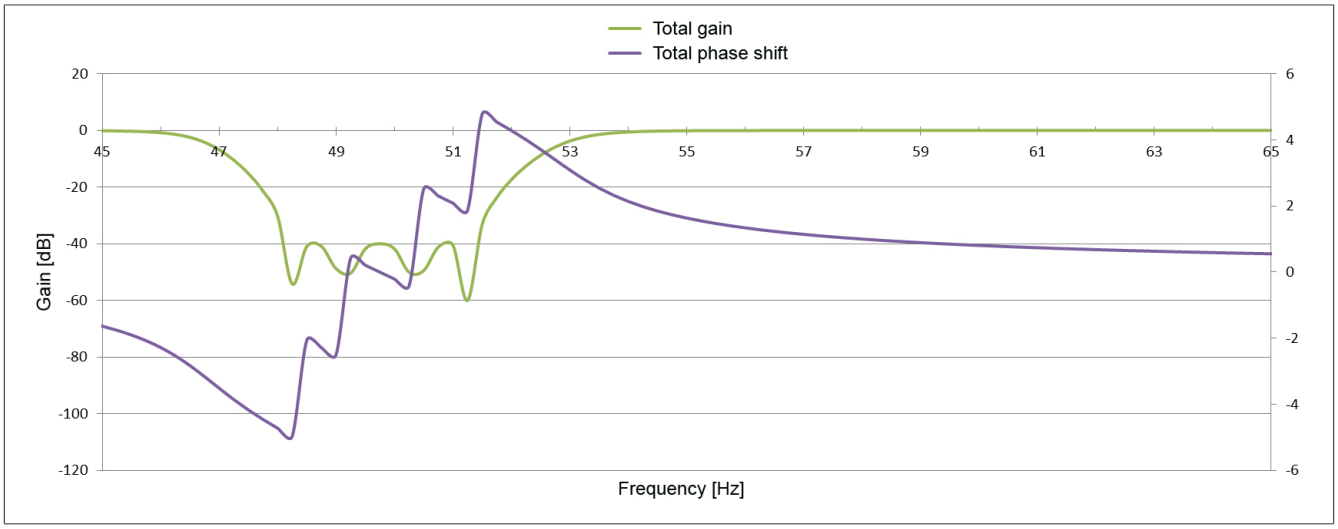
3.2.3.1 Filter characteristics of the IIR notch filter

3 different filter characteristics (-40 dB, -60 dB, -80 dB) can be selected for 50 Hz and 60 Hz. The higher the damping, the narrower the stop band.

Example 1

Filter characteristics for the following settings:

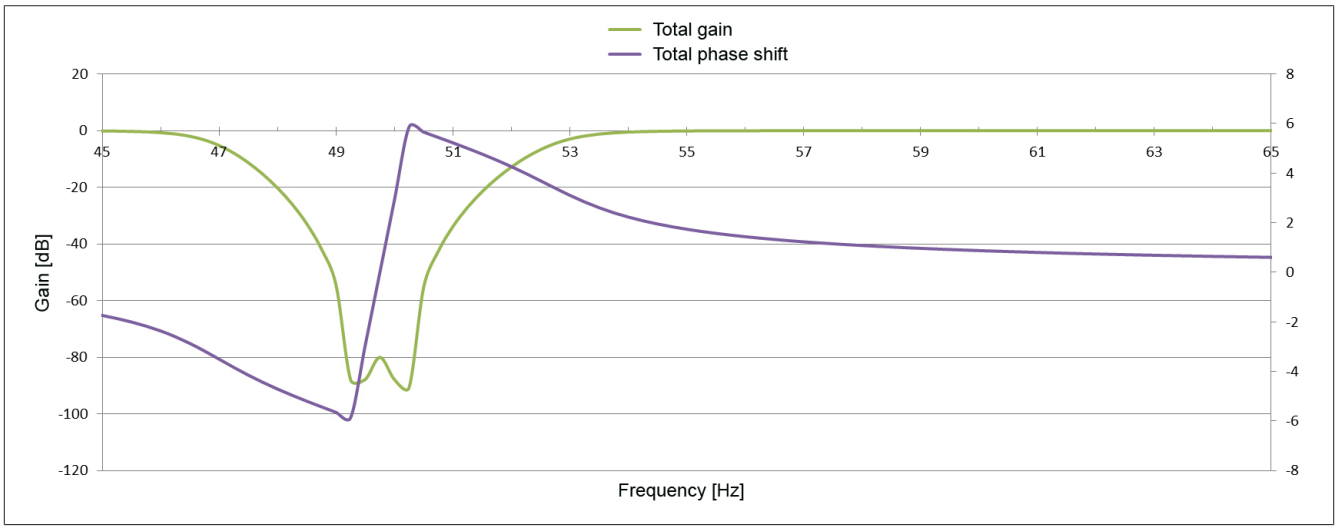
- Gain = -40 dB
- Frequency = 50 Hz
- Passband = 5 Hz
- Stopband = ±1 Hz



Example 2

Filter characteristics for the following settings:

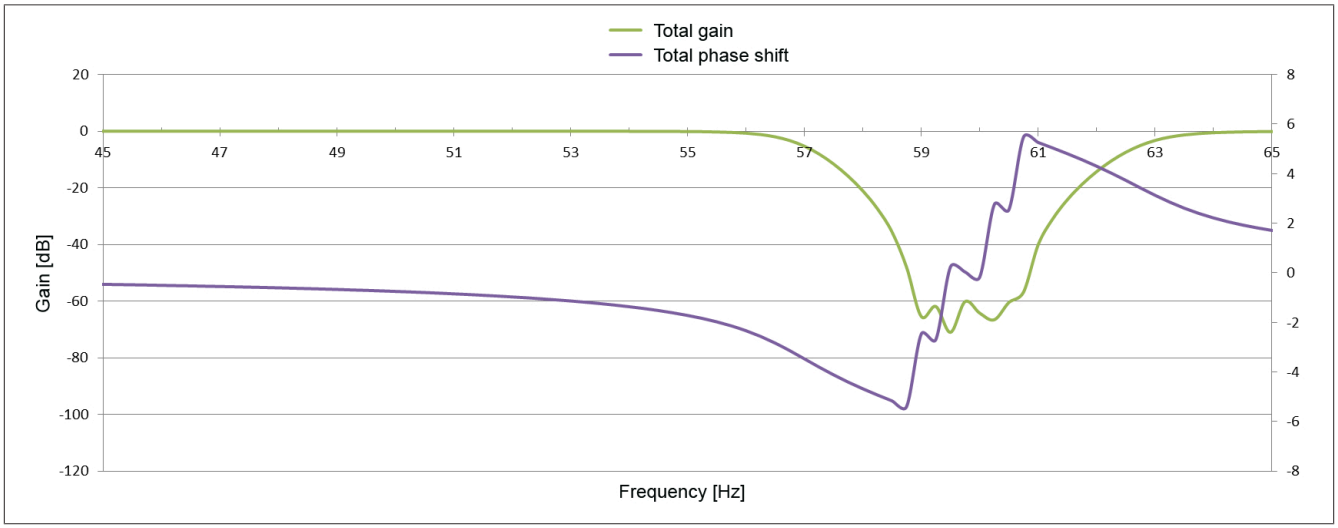
- Gain = -80 dB
- Frequency = 50 Hz
- Passband = 5 Hz
- Stopband = ±0.25 Hz



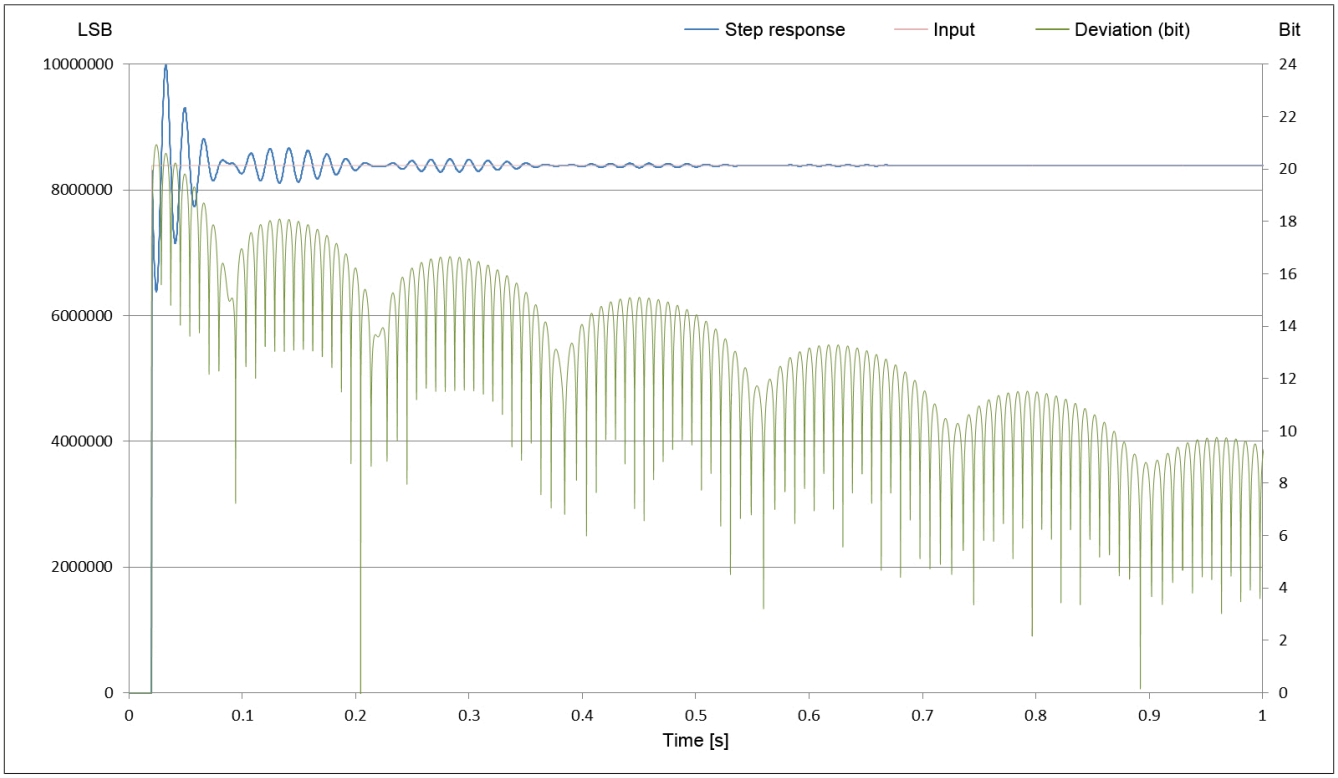
Example 3

Filter characteristics for the following settings:

- Gain = -60 dB
- Frequency = 60 Hz
- Passband = 5 Hz
- Stopband = ±0.5 Hz



Step response of an 8th-order IIR notch filter, including the deviation in bits:



3.3 Module status

The status of the module, analog input values and filter states are monitored. These include:

Description	Value	Information
I/O power supply	0	No error
	1	Error in power supply
Bypass current	0	No error
	1	Overcurrent (sum from all sensors)
A/D converter configuration	0	Already configured
	1	Not yet configured
Analog values	0	Analog value valid
	1	Analog value invalid (analog value = -8,388,608 = 0xFF800000). Possible causes: • Internal transfer error (XOR checksum verification) • Error in strain gauge supply (bit 1) • Error in I/O power supply (bit 0) • A/D converter not (yet) configured
Analog value range overflow	0	Analog value valid
	1	Analog value invalid. Possible causes: • Overflow / Open circuit (analog value = 8,388,607 = 0x007FFFFF) • Underflow (analog value = -8,388,607 = 0xFF800001)
Moving average filter	0	Moving average filter tuned
	1	Moving average filter not tuned. Possible causes: • After changing the filter length • Consequence of the filter being reset by another error

Information:

The register is described in "Module status" on page 22.

3.4 Timestamp of the channel

The last channel converted is provided with a timestamp. This is always the point in time in [µs] at which the conversion of the latest A/D converter raw value is completed.

The timestamp of the other channels can be determined by an application using the number of the last channel converted and its timestamp according to the following table.

Channel	Age difference
2 - 1	47 µs
1 - 2	153 µs

Example 1:

- Most current channel (bit 0 - 1 in register "AdcConvCtr01") = 01 (analog input 2):
- Timestamp: Register "AdcConvTimestamp01" = 0 µs

Channel	Timestamp
2	0 µs
1	-47 µs

Example 2:

- Most current channel (bit 0 - 1 in register "AdcConvCtr01") = 00 (analog input 1):
- Timestamp: Register "AdcConvTimestamp01" = 0 µs

Channel	Timestamp
1	0 µs
2	-153 µs

Information:

The register is described in "ADC conversion timestamp" on page 23.

4 Commissioning

4.1 Using the module on the bus controller

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

For detailed information, see section "Additional information - Using I/O modules on the bus controller" in the X20 user's manual (version 3.50 or later).

4.1.1 CAN I/O bus controller

The module occupies 4 analog logical slots on CAN I/O.

5 Register description

5.1 General data points

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

General data points are described in section "Additional information - General data points" in the X20 System user's manual.

5.2 Function model 0 - default

Register	Name	Data type	Read		Write	
			Cyclic	Acyclic	Cyclic	Acyclic
Analog signal - Configuration						
2	ControlPacked01 (configuration of strain gauge inputs)	UINT			•	
6	ControlPacked02 (configuration of strain gauge inputs)	UINT			•	
514	ConfigChannel01 (channel configuration)	UINT				•
578	ConfigChannel02 (channel configuration)	UINT				•
Analog signal - Communication						
4	AnalogInput01	DINT	•			
12	AnalogInput02	DINT	•			
33	StatusPacked01	USINT	•			
35	StatusPacked02	USINT	•			
257	AdcConvCtr01	SINT	•			
268	AdcConvTimeStamp01	DINT	•			

5.3 Function model 254 - Bus controller

Register	Offset[1)]	Name	Data type	Read		Write	
				Cyclic	Acyclic	Cyclic	Acyclic
Analog signal - Configuration							
2	2	ControlPacked01 (configuration of strain gauge inputs)	UINT			•	
6	10	ControlPacked02 (configuration of strain gauge inputs)	UINT			•	
514	514	ConfigChannel01 (channel configuration)	UINT				•
578	578	ConfigChannel02 (channel configuration)	UINT				•
Analog signal - Communication							
4	4	AnalogInput01	DINT	•			
12	12	AnalogInput02	DINT	•			
33	0	StatusPacked01	USINT	•			
35	8	StatusPacked02	USINT	•			

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

5.4 Configuration

5.4.1 Configuration of strain gauge inputs

Name:
ControlPacked01 to ControlPacked02

The strain gauge inputs are configured in these registers:

- Strain gauge factor of strain gauge load cell
- Enabling of filters

Data type	Values
UINT	See the bit structure.

Bit structure:

Bit	Description	Value	Information	
0 - 2	Strain gauge factor	000	Default: 256 mV/V	
		001	128 mV/V	
		010	64 mV/V	
		011	32 mV/V	
		100	16 mV/V	
		101	8 mV/V	
		110	4 mV/V	
		111	2 mV/V	
			Averaging	Notch frequency [Hz]
3 - 7	Moving average	00000	Default: Moving average disabled (bypass)	
		00001	2	2500
		00010	4	1250
		00011	5	1000
		00100	10	500
		00101	20	250
		00110	25	200
		00111	50	100
		01000	83	60
		01001	100	50
		01010	125	40
		01011	167	30
		01100	200	25
		01101	250	20
		01110	300	16.66
		01111	500	10
		10000	1000	5
		10001 to 11111	Reserved (firmware limited to 1000)	
8	Notch filter	0	Default: IIR notch filter disabled (bypass)	
		1	IIR notch filter enabled	
9	Reserved	0		
10 - 11	Low-pass filter mode	00	IIR low-pass filter disabled (bypass)	
		01	1st-order IIR low-pass filter (see "IIR low-pass filter" on page 10)	
		10 - 11	Reserved: No IIR low-pass filter active	
			Filter level	-3 db frequency [Hz]
12 - 14	Low-pass filter level	000	1	575
		001	2	230
		010	3	106
		011	4	51
		100	5	25
		101	6	12.5
		110	7	6.2
		111	8	3.1
15	Reserved	0		

5.4.2 Channel configuration

Name:
ConfigChannel01 to ConfigChannel02

The IIR notch filter is configured individually for each channel in these registers.

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

Bit structure:

Bit	Description	Value	Information
0 - 11	Reserved	0	
12 - 13	Notch filter attenuation	00	Gain: -40 dB Pass: ±5 Hz Stop: ±1 Hz (Bus controller default setting)
		01	Gain: -60 dB Pass: ±5 Hz Stop: ±0.5 Hz
		10	Gain: -80 dB Pass: ±5 Hz Stop: ±0.25 Hz
		11	Reserved
14	Notch filter frequency	0	With 50 Hz (bus controller default setting)
		1	At 60 Hz
15	Reserved	0	

5.5 Communication

5.5.1 Analog input values

Name:
AnalogInput01 to AnalogInput02

The analog input value is mapped in this register.

Data type	Value	Input signal
DINT	-8,388,608	Negative invalid value
	-8,388,607	Negative full-scale deflection / Underflow
	-8,388,606 to 8,388,606	Valid range
	8,388,607	Positive full-scale deflection / Overflow / Open line

5.5.2 Module status

Name:
StatusPacked01 to StatusPacked02

These registers contain the current state of the module.

Data type	Values
USINT	See the bit structure.

Bit structure:

Bit	Description	Value	Information
0	I/O power supply	0	No error
		1	Error in power supply
1	Bypass current	0	No error
		1	Overcurrent (sum from all sensors)
2 - 3	Reserved	0	
4	A/D converter configuration	0	Already configured
		1	Not yet configured
5	Analog values	0	Analog value valid
		1	Analog value invalid (analog value = -8,388,608 = 0xFF800000)
6	Analog value range overrun	0	Analog value valid
		1	Analog value invalid.
7	Moving average filter	0	Moving average filter engaged
		1	Moving average filter not tuned

5.5.3 A/D conversion counter

Name:
AdcConvCtr01

The strain gauge channels of the module are not measured simultaneously, but in multiplex mode. Register "AdcConvTimestamp01" on page 23 contains the timestamp of the last converted channel encoded in register "AdcConvCtr01". This information can then be used to calculate the timestamp for the other channels.

Data type	Values
SINT	See the bit structure.

Bit structure:

Bit	Description	Value	Information
0 - 1	Index of the last converted channel	0	Analog input 1
		1	Analog input 2
		2	Reserved
		3	Reserved
2 - 7	Rotating cycle counter	x	Incremented at the end of a conversion cycle. All channels are converted in a conversion cycle.

5.5.4 ADC conversion timestamp

Name:
AdcConvTimestamp01

The timestamp of the last converted channel is stored in this register (see Bit 0 and 1 in register "AdcConvCtr01" on page 23). 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	Value	Function
DINT	-2147483648 to 2147483647	Timestamp (in µs) of the last converted channel (see bits 0 and 1 in the A/D conversion counter)

5.6 Minimum cycle time

The minimum cycle time specifies how far the bus cycle can be reduced without communication errors occurring. It is important to note that very fast cycles reduce the idle time available for handling monitoring, diagnostics and acyclic commands.

Minimum cycle time
200 µs

5.7 Minimum I/O update time

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

Minimum I/O update time
200 µs