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	
X20AI2437	X20 analog input module, 2 inputs, 4 to 20 mA, 16-bit converter resolution, single-channel galvanically isolated and with own sensor power supply, NetTime function	
	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	
X20TB12	X20 terminal block, 12-pin, 24 VDC keyed	

Table 1: X20AI2437 - Order data

1.3 Module description

The module is equipped with 2 current measurement inputs with 16-bit digital converter resolution.

Each current measurement input has its own sensor supply. The two channels with their respective sensor supplies are electrically isolated from each other. The user can select between the two measurement ranges 4 to 20 mA and 0 to 25 mA.

Functions:

- Configurable conversion rate / filter time
- Monitoring the input signal
- NetTime Technology

Conversion rate and filter time

The sampling time of the A/D converter can be configured individually for each channel together with the filter time.

Monitoring the input signal

The input signal is monitored for upper and lower limit values, open circuit and the status of the power supply. In addition to the status information, user-defined limit values can be defined as well as replacement values that are output if the limit values are overshot or undershot.

NetTime timestamp of the measurement

Not only is the measured value important for many applications, but also the exact time when the measurement takes place. The module is equipped with a NetTime timestamp function for this that supplies a timestamp for the recorded measurement with microsecond accuracy.

2 Technical description

2.1 Technical data

Order number	X20AI2437
Short description	
I/O module	2 analog inputs 4 to 20 mA or 0 to 25 mA
General information	
B&R ID code	0xB784
Status indicators	I/O function per channel, operating state, module status, sensor power supply per channel
Diagnostics	
Module run/error	Yes, using LED status indicator and software
Inputs	Yes, using LED status indicator and software
Sensor power supply	Yes, using LED status indicator and software
Power consumption	
Bus	0.05 W
Internal I/O	1.15 W [1]
Additional power dissipation caused by actuators (resistive) [W]	-
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
HazLoc	cCSAus 244665 Process control equipment for hazardous locations Class I, Division 2, Groups ABCD, T5
DNV	Temperature: **B** (0 to 55°C) Humidity: **B** (up to 100%) Vibration: **B** (4 g) EMC: **B** (bridge and open deck)
CCS	Yes
LR	ENV1
KR	Yes
ABS	Yes
BV	**EC33B** Temperature: 5 - 55°C Vibration: 4 g EMC: Bridge and open deck
KC	Yes
Analog inputs	
Input	4 to 20 mA or 0 to 25 mA configurable using software
Input type	Differential input
Digital converter resolution	16-bit
Data output rate	4.7 to 960 samples per second, configurable using software
Output format	INT
Output format	
4 to 20 mA	INT 0x0000 - 0x7FFF / 1 LSB = 0x0001 = 488.281 nA
0 to 25 mA	INT 0x0000 - 0x7FFF / 1 LSB = 0x0001 = 762.939 nA
0 to 25000 µA	INT 0x0000 - 0x61A8 / 1 LSB = 0x0001 = 1000 nA
Load	I_IN ≥ 0.1 mA: R < 8000 Ω I_IN ≥ 1 mA: R < 1100 Ω I_IN ≥ 4 mA: R < 510 Ω
Input protection	Up to 30 VDC, reverse polarity protection (max. 0.1 A)
Open-circuit detection	Yes, using software
Permissible input signal	0 to 25 mA
Output of digital value during overload	Configurable
Conversion procedure	Sigma-delta
Max. error	
Gain	
0 to 25 mA	<0.046% [2]
4 to 20 mA	<0.046% [2]
Offset	
0 to 25 mA	<0.004% [3]
4 to 20 mA	<0.013% [3]

Table 2: X20AI2437 - Technical data

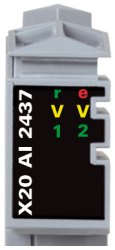
Order number	X20AI2437
Common-mode rejection	
DC	80 dB
50 Hz	Depends on the sampling rate: e.g. >130 dB for 50 samples per second
Common-mode range	0 to 7 V
Nonlinearity	<0.003% 3)
Input filter	
Hardware	First-order low-pass filter / cutoff frequency 2.5 kHz
Software	Sinc4 filter
Max. gain drift	
0 to 25 mA	0.003 %/°C 2)
4 to 20 mA	0.003 %/°C 2)
Max. offset drift	
0 to 25 mA	0.0002 %/°C 3)
4 to 20 mA	0.0007 %/°C 3)
Test voltage	
Channel - Channel	1000 VAC
Channel - Bus	1000 VAC
Channel - Ground	1000 VAC
Sensor power supply	
Power consumption	0.75 W per channel
Nominal voltage	25 V ±2%
Nominal output current	Max. 30 mA
Short-circuit proof	Yes, continuous
Max. voltage ripple	
Up to 100 kHz	≤2.2 mV
Up to 1 MHz	≤22 mV
Higher	≤100 mV
Short-circuit current	
Typical	<50 mA
Maximum	60 mA
Behavior on short circuit	Current limiting
Electrical properties	
Electrical isolation	Channel isolated from channel and bus Sensor power supply isolated from sensor power supply Sensor power supply not isolated from channel
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	-
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 X20TB12 separately. Order 1x bus module X20BM11 separately.
Pitch	$12.5^{+0.2}$ mm

Table 2: X20AI2437 - Technical data

1) To reduce power dissipation, B&R recommends leaving unused inputs open.
2) Based on the current measured value.
3) Based on the 25 mA measurement range.

2.2 LED status indicators

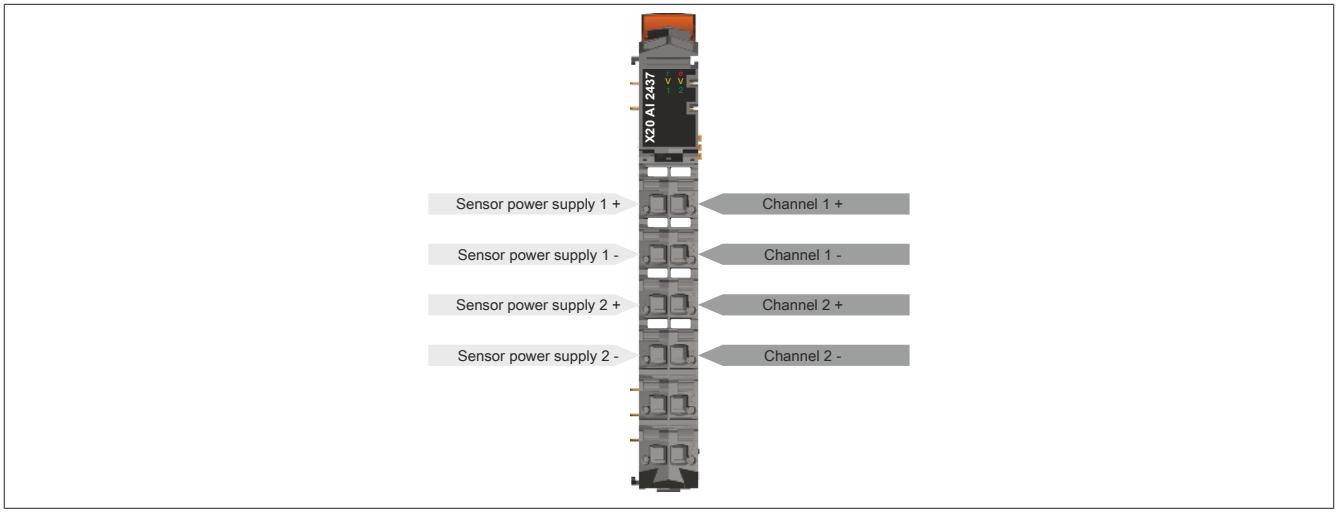
For a description of the various operating modes, see section "Additional information - Diagnostic LEDs" in the X20 system user's manual.

Figure	LED	Color	Status	Description
	**Operating state**			
	r	Green	Off	No power to module
			Single flash	UNLINK mode
			Double flash	BOOT mode (during firmware update)[1)]
			Blinking quickly	SYNC mode
			Blinking slowly	Mode PREOPERATIONAL
			On	RUN mode
	Module status			
	e	Red	Off	No power to module or everything OK
			Single flash	A conversion error has occurred. This status is output along with a double flash on the channel LED of the analog input where the error occurs.
			On	Error or reset status
	Sensor supply			
	V	Yellow	Off	Overload
			On	Sensor supply in its normal operating range
	Analog input			
	1 - 2	Green	Off	Indicates one of the following cases: • No power to module • Channel disabled • Open line
			Single flash	Input signal overflow or underflow
			Double flash	A conversion error has occurred. A single flash is output on the red "e" module status LED.
			On	Analog/digital converter running, value OK

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

2.3 Pinout

Shielded twisted pair cables should be used to minimize coupling disturbances. Use either one cable for each channel or a multiple twisted pair cable for both channels.

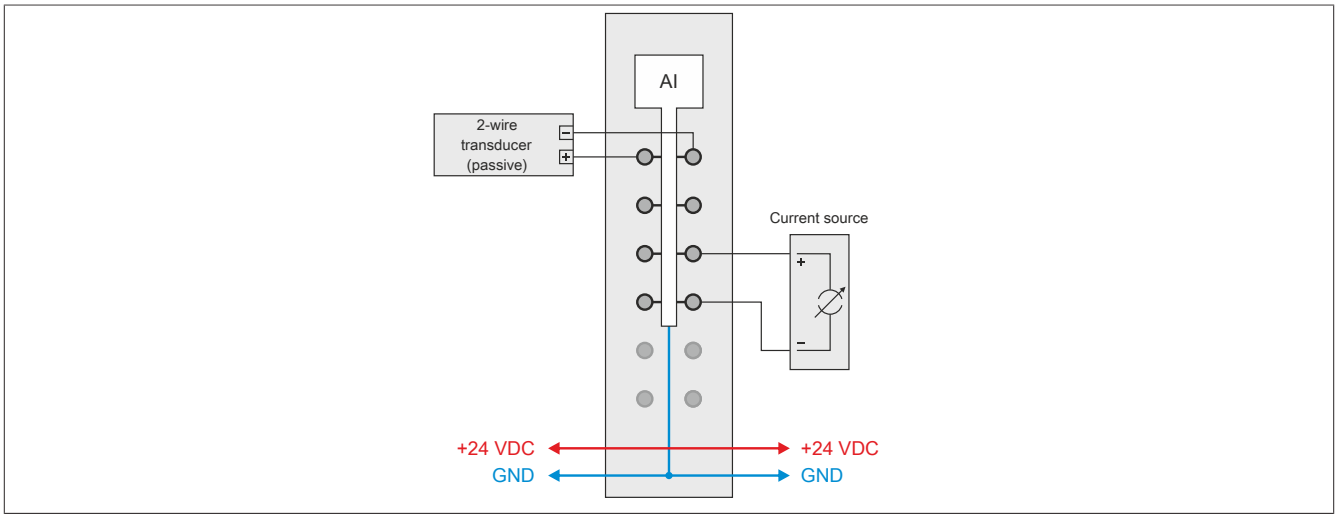


2.4 Connection examples

2-wire connections

A 2-wire connection can be implemented as follows:

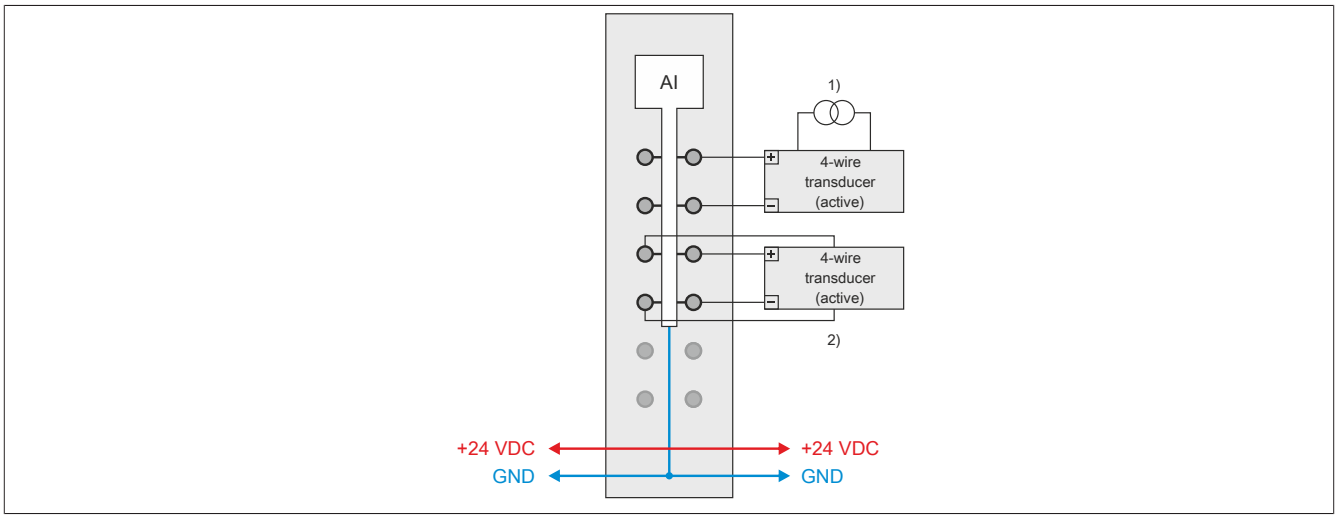
- 2-wire transducer
- Active current source



4-wire connections

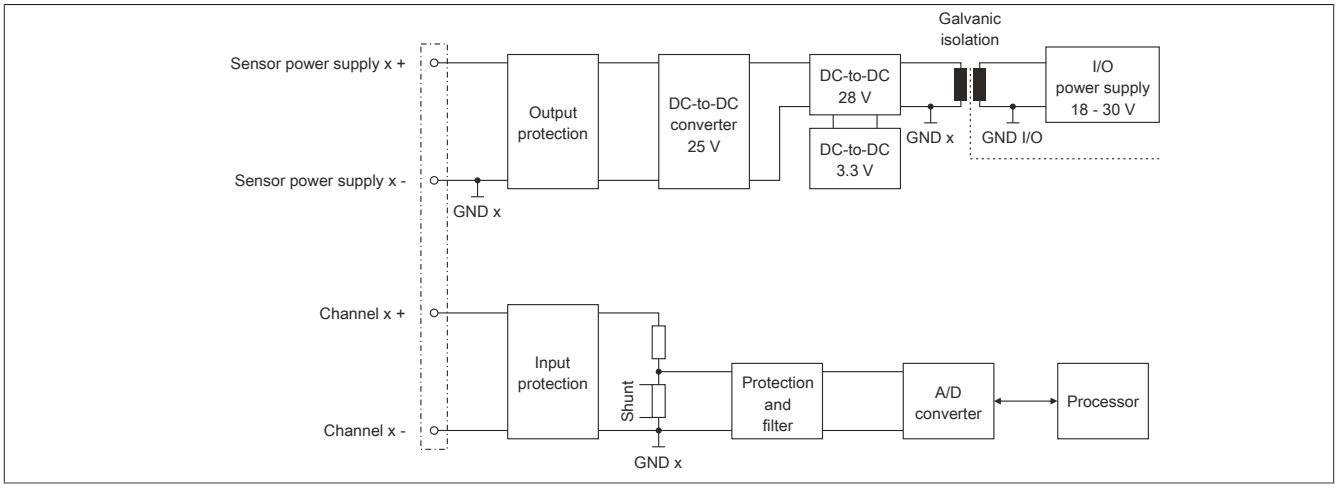
A 4-wire connection can be implemented as follows:

- 4-wire transducer with external supply
- 4-wire transducer supplied by the module



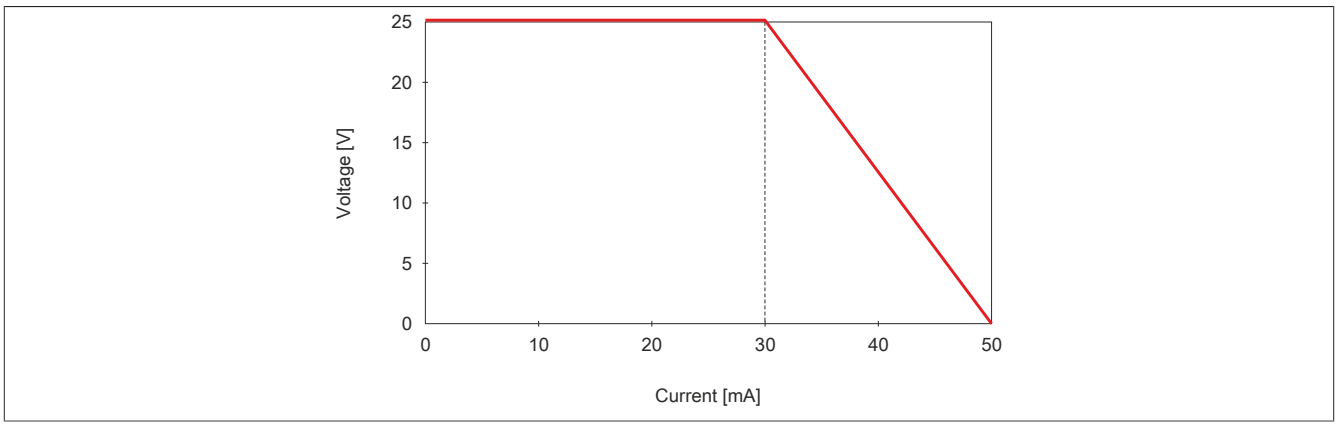
1) With external power supply.
2) With internal power supply. The internal power supply is only permitted to be loaded with max. 30 mA.

2.5 Input circuit diagram



2.6 Behavior in the event of short circuit

In the event of a short circuit, the output current for the sensor supply is limited according to the following diagram.



3 Function description

3.1 Analog inputs

The module is equipped with 2 independent galvanically isolated channels. An analog signal can be read in via both channels. All the necessary registers are duplicated so that the channels can be configured and operated independently of each other.
The current input signals (0 to 25 mA) can be displayed in various formats:

Values	Information
0 to 25000	Normalization option 0 to 25 mA
0 to 32767	Normalization option 0 to 25 mA
-8192 to 32767	Normalization option 4 to 20 mA (value 0 corresponds to 4 mA)
0 to 65535	Normalization option 0 to 25 mA

Predefining values and timing
If a replacement value strategy has been configured, value "0" (zero) is output at the beginning until a valid measured value has been calculated.

The timing of the measured value acquisition is determined by the converter hardware and the set sampling rate. The two channels are converted independently and not synchronized with the X2X Link network.

Conversion time
Sampling rate of channel 0x



Information:

The register is described in "Analog input values" on page 21.

3.1.1 Configurable conversion rate / filter time

The sampling time of the A/D converter is configured together with the filter time. A conversion rate can be configured independently for the two analog inputs. Based on the desired sampling frequency, the following formula results for this parameter:

Conversion rate for A/D converter = (4920000 / 1024) / Sampling frequency

Values	Filter time in milliseconds	Conversion rate in s^{-1}
4	1	1000
9	2	500
48	10	100
80	16.7	60
96	20 (bus controller default setting)	50
160	33.3	30
192	40	25
320	66.7	15
480	100	10
960	200	5



Information:

The register is described in "Sample rate" on page 18.

3.2 Monitoring the input signal

The input signal is monitored against the upper and lower limit values as well as for open circuit. The status of the power supply can also be read out. Some error information is delayed according to the previously set condition.

Packed status information

Setting "Format status information" in Automation Studio makes it possible to specify whether the status information is transferred as USINT or bit by bit.

The following values are monitored:

Name	Value	Information
UnderflowAnalogInput	0	No error
Depending on the configuration, the error state of the signal undershoot is mapped here. [1)]	1	Lower limit value undershot
OverflowAnalogInput	0	No error
Depending on the configuration, the error state of the signal overshoot is mapped here. [1)]	1	Upper limit value overshot
OpenLineAnalogInput	0	No error
Depending on the configuration, the measurement information is checked for <2 mA for the failure signal. Open-circuit detection takes place by means of a configurable hysteresis (default: 100 µA). It is possible to disable open-circuit monitoring in order to suppress alarm generation if hardware is missing. [1)]	1	Open circuit detected
ConversionErrorAnalogInput	0	No error
The error state triggered by a hardware conversion timeout is displayed here.	1	Conversion error detected
SumErrorAnalogInput	0	No error
This error information is derived from the status of the individual errors and is only enabled after a configurable delay time [ms]. Linking this error information in the application makes it possible to hide temporary overshoots or undershoots of the temperature value, for example.	1	Composite error detected
SensorErrorAnalogInput	0	Sensor voltage OK
This error information is derived from the status of the individual errors and is only enabled after a configurable delay time [ms]. Linking this error information in the application makes it possible to hide temporary overshoots or undershoots of the temperature value, for example.	1	Sensor load too high
IoSuppErrorAnalogInput	0	I/O power supply OK
This error is enabled immediately after a supply voltage undershoot (<20 VDC) is detected.	1	I/O power supply error detected

1) This error information is only enabled after a configurable delay as a multiple of the conversion cycles.



Information:

The register is described in "Status of the inputs" on page 22.

3.2.1 Limit and replacement values

3.2.1.1 Limit value monitoring

In addition to the qualitative assessment of the input, the module is also equipped with the function of adjusting the permissible range of values to the requirements of the application. In addition, the permissible upper and lower limits can be further limited. In this case, the set replacement value strategy is applied sooner.

If user-specific limit values are used, a hysteresis range should also be defined. This configures how far the limit value must be overshot in order to trigger a reaction.

3.2.1.2 Replacement value strategy

To ensure the quality of the read-in value, the detected voltage is assessed. If a logically impermissible voltage value or open circuit is detected, for example, limit value monitoring is triggered.

The reaction to this is determined by the user via the replacement value strategy. With option "Use replacement values in the event of error", the user defines two values for the overshoot or undershoot that are used to replace the converted value in the event of a limit value violation. With the alternative "Keep last valid converted value", the last value deemed good is retained. The assessment takes more time, however. Depending on the defined preparation interval, the current read-in value is delayed.



Information:

The registers are described in "Configuring the limit values" on page 19.

3.2.1.3 Receiving the measured value

If the last valid measured value should be kept when violating the limit value, then PreparationInterval must be defined. The measured values continue to be acquired and converted according to the configured I/O update time. They are then checked and discarded if they do not meet the specifications. When an error does not occur, therefore, the measured value acquired 2 preparation intervals ago is constantly output.

<table>
<tr><td rowspan="9">Functionality:
Depending on the configured input filter, measured values are continuously converted and stored in the measured value memory. The current content of the measured value memory is checked within the set interval time. If a permissible value is present, the content of the temporary memory is transferred to the output memory and the content of the measured value memory is transferred to the temporary memory.
If the check results in an impermissible value, the content of the measured value memory is discarded. The copy direction between the output memory and temporary memory is reversed, and the next-to-last valid value is still output.

Information:
With the "Hold last valid value" configuration, the delay from measurement to the output of the value is at least twice the time of the preparation interval. In the worst case, however, it can also take twice the interval time plus the configured conversion cycle of the A/D converter.</td><td colspan="2">"Application"
Value being measured (analog)</td></tr>
<tr><td>↓</td><td>Condition:
- Conversion interval (A/D converter) elapsed</td></tr>
<tr><td colspan="2">"Measured value memory"
Measured value (digital)</td></tr>
<tr><td>↓</td><td>Condition:
- PreparationInterval elapsed
- Measured value permissible</td></tr>
<tr><td colspan="2">"Buffer"
Last valid value</td></tr>
<tr><td>↓</td><td>Condition:
- PreparationInterval elapsed
- Measured value permissible</td></tr>
<tr><td colspan="2">"Output memory"
Next-to-last valid/
displayed value</td></tr>
</table>

Information:

With the "Hold last valid value" configuration, the delay from measurement to the output of the value is at least twice the time of the preparation interval. In the worst case, however, it can also take twice the interval time plus the configured conversion cycle of the A/D converter.



Information:

The register is described in "Preparation time for the measured values" on page 21.

3.3 NetTime Technology

NetTime refers to the ability to precisely synchronize and transfer system times between individual components of the controller or network (controller, I/O modules, X2X Link, POWERLINK, etc.).

This allows the moment that events occur to be determined system-wide with microsecond precision. Upcoming events can also be executed precisely at a specified moment.

3.3.1 Time information

Various time information is available in the controller or on the network:

- System time (on the PLC, Automation PC, etc.)
- X2X Link time (for each X2X Link network)
- POWERLINK time (for each POWERLINK network)
- Time data points of I/O modules

The NetTime is based on 32-bit counters, which are increased with microsecond resolution. The sign of the time information changes after 35 min, 47 s, 483 ms and 648 µs; an overflow occurs after 71 min, 34 s, 967 ms and 296 µs.

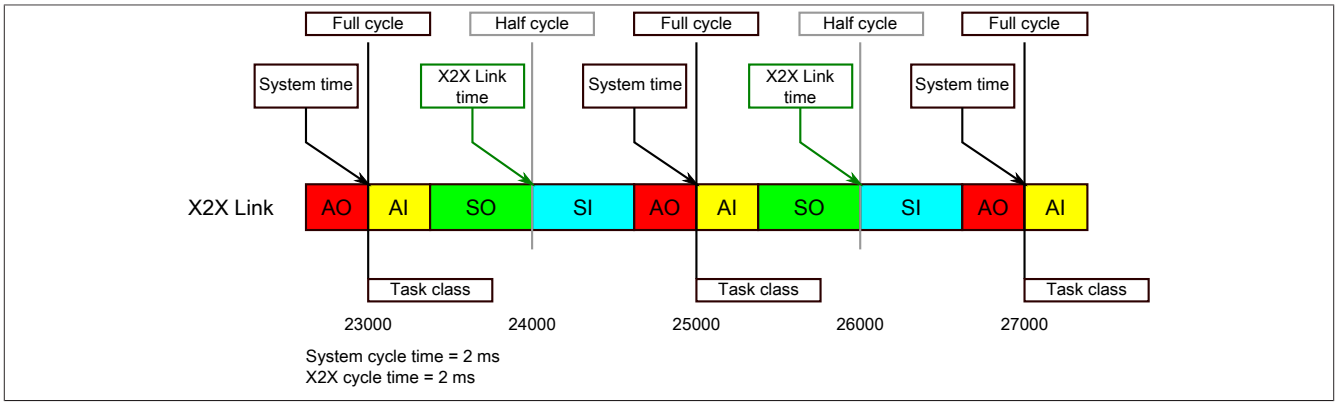
The initialization of the times is based on the system time during the startup of the X2X Link, the I/O modules or the POWERLINK interface.

Current time information in the application can also be determined via library AsIOTime.

3.3.1.1 Controller data points

The NetTime I/O data points of the controller are latched to each system clock and made available.

3.3.1.2 X2X Link - Reference time point



The reference time point on the X2X Link network is always calculated at the half cycle of the X2X Link cycle. This results in a difference between the system time and the X2X Link reference time point when the reference time is read out.

In the example above, this results in a difference of 1 ms, i.e. if the system time and X2X Link reference time are compared at time 25000 in the task, then the system time returns the value 25000 and the X2X Link reference time returns the value 24000.