X20(c)MM2436

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 Coated modules

Coated modules are X20 modules with a protective coating for the electronics component. This coating protects X20c modules from condensation and corrosive gases.
The modules' electronics are fully compatible with the corresponding X20 modules.

For simplification purposes, only images and module IDs of uncoated modules are used in this data sheet.

The coating has been certified according to the following standards:

- Condensation: BMW GS 95011-4, 2x 1 cycle
- Corrosive gas: EN 60068-2-60, method 4, exposure 21 days

1.2.1 Starting temperature

The starting temperature describes the minimum permissible ambient temperature in a voltage-free state at the time the coated module is switched on. This is permitted to be as low as -40°C. During operation, the conditions as specified in the technical data continue to apply.

Information:

It is important to absolutely ensure that there is no forced cooling by air currents in the closed control cabinet, e.g. due to the use of a fan or ventilation slots.

1.3 Order data

Order number	Short description	Figure
	Motor controllers	
X20MM2436	X20 PWM motor module, 24 to 39 VDC ±25%, 2 PWM motor bridges, 3 A continuous current, 3.5 A peak current, 4 digital inputs 24 VDC, sink, configurable as incremental encoder	
X20cMM2436	X20 PWM motor module, coated, 24 to 39 VDC ±25%, 2 PWM motor bridges, 3 A continuous current, 3.5 A peak current, 4 digital inputs 24 VDC, sink, configurable as incremental encoder	
	Required accessories	
	Bus modules	
X20BM31	X20 bus module, for double-width modules, 24 VDC keyed, internal I/O power supply connected through	
X20cBM31	X20 bus module, coated, for double-width modules, 24 VDC keyed, internal I/O power supply connected through	
	Terminal blocks	
X20TB12	X20 terminal block, 12-pin, 24 VDC keyed	

Table 1: X20MM2436, X20cMM2436 - Order data

1.4 Module description

The motor bridge module is used to control 2 DC motors with a nominal voltage of 24 to 39 VDC ±25% at a nominal current up to 3 A.

Functions:

- Counters
- Standard PWM/current mode
- Frequency mode
- SuperVibe mode
- Valve control
- Automatic shutdown

Digital counter inputs

The module is equipped with 4 digital inputs that can additionally be used as incremental counters. In addition to AB(R) and event counters, period duration and gate measurements are also possible.

Operating modes

The PWM outputs of the module can be controlled in 3 different operating modes. In addition to standard PWM mode, a special current operating mode for controlling inductive loads as well as PWM control with reversed edges is available. This allows the module to be adapted to a wide range of applications.

Valve control

This module can be used to control valves. To prevent the valves from sticking, a dither can be configured exactly according to the specifications of the valve manufacturer.

Automatic shutdown

The voltage of the I/O power supply, the motor current and the module temperature are monitored. If a value overshoots the predefined limit value, the module is automatically shut down. The outputs are automatically put into operation by the module as soon as the value is within the limit value again.

2 Technical description

2.1 Technical data

Order number	X20MM2436	X20cMM2436
Short description		
I/O module	2-channel PWM motor bridge, 2 AB incremental encoders	
General information		
B&R ID code	0x26B5	0xE752
Status indicators	I/O function per channel, operating state, module status	
Diagnostics		
Module run/error	Yes, using LED status indicator and software	
Output	Yes, using LED status indicator and software	
I/O power supply	Yes, using software	
Power consumption		
Bus	0.01 W	
Internal I/O	-	
External I/O		
24 VDC	2.45 W	
48 VDC	3.15 W	
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	cURus E225616 Power conversion 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	-
Digital inputs		
Quantity	4	
Nominal voltage	24 VDC	
Input voltage	24 VDC (-15% / +20%)	
Input current at 24 VDC	Approx. 1.3 mA	
Input circuit	Sink	
Input filter		
Hardware	<5 µs	
Software	-	
Connection type	1-wire connections	
Input resistance	Typ. 18 kΩ	
Additional functions	2x AB incremental encoder, 1x ABR counter, 2x event counter, 2x period duration/gate measurement	
Switching threshold		
Low	<5 VDC	
High	>15 VDC	
Insulation voltage between channel and bus	500 V_{eff}	
AB incremental encoder		
Quantity	2	
Encoder inputs	24 V, asymmetrical	
Counter size	16-bit	
Input frequency	Max. 50 kHz	
Evaluation	4x	

Table 2: X20MM2436, X20cMM2436 - Technical data

Technical description

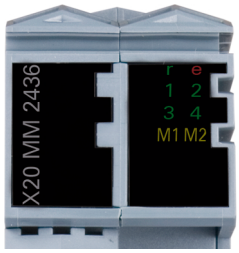
Order number	X20MM2436	X20cMM2436
Signal form	Square wave pulse	
PWM output		
Quantity	2	
Nominal voltage	24 to 39 VDC ±25% [1]	
Nominal current	3 A	
Maximum current	3.5 A (2 s)	
PWM frequency	Standard operating mode: 15 Hz to 50 kHz Frequency operating mode: 1 Hz to 6553.5 Hz SuperVibe operating mode: 1 Hz to 50 kHz	
Actuator power supply		
Supply	External	
Fuse	Required line fuse: Max. 10 A, slow-blow	
Output protection	Thermal shutdown in the event of overcurrent or short circuit	
Variant	H bridge	
Configurable dither	Amplitude, frequency	
Period duration resolution (PWM/current operating mode)	16-bit, min. 20 µs	
Frequency resolution	**Frequency mode** Scaling 0.1 Hz <3000 Hz: 0.1 Hz; 3000 to 6553.5 Hz: 0.1 to 0.4 Hz Scaling 0.01 Hz <300 Hz: 0.01 Hz; 300 to 655.35 Hz: 0.01 to 0.04 Hz **SuperVibe mode** Scaling 1 Hz <10 kHz: 1 Hz; 10 to 50 kHz: 1 to 40 Hz Scaling 0.1 Hz <1000 Hz: 0.1 Hz; 1000 to 6553.5 Hz: 0.1 to 4 Hz	
Phase shift PWM1 to PWM2	180° - if possible (according to operating mode)	
DC bus capacitance	100 µF	
PWM pulse width	15 bits plus sign ≥10 ns	
Frequency mode	15 bits plus sign ≥10 ns	
Insulation voltage between channel and bus	500 V_{eff}	
Electrical properties		
Electrical isolation	Channel isolated from bus Channel not isolated from channel	
Operating conditions		
Mounting orientation		
Horizontal	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 50°C	
Vertical mounting orientation	Not permitted	
Derating	See section "Derating".	
Starting temperature	-	Yes, -40°C
Storage	-40 to 85°C	
Transport	-40 to 85°C	
Relative humidity		
Operation	5 to 95%, non-condensing	Up to 100%, 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 X20BM31 separately.	Order 1x terminal block X20TB12 separately. Order 1x bus module X20cBM31 separately.
Pitch	$25^{+0.2}$ mm	

Table 2: X20MM2436, X20cMM2436 - Technical data

1) The tolerance value is composed of the voltage tolerances and permissible total AC voltage component with a peak value of 5% of the rated voltage.

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
	r	Green	Off	No power to module
			Single flash	RESET mode
			Double flash	BOOT mode (during firmware update)[1)]
			Blinking	PREOPERATIONAL mode
			On	RUN mode
	e	Red	Off	No power to module or everything OK
			On	Error or reset status
	e + r	Red on / Green single flash		Invalid firmware
	1 - 4	Green		Input state of the corresponding digital input
	M1, M2	Orange	On	Output 1 or 2 is active

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

2.3 Pinout

In accordance with the EN 60204-1 standard, a cable cross section of 0.75 mm² or larger must be used for the motor outputs in order to handle the maximum motor current of 3.5 A. To ensure full motor power, voltage drops that could result from the cable length and the electrical connections must also be taken into consideration when selecting the attachment cable.

Warning!

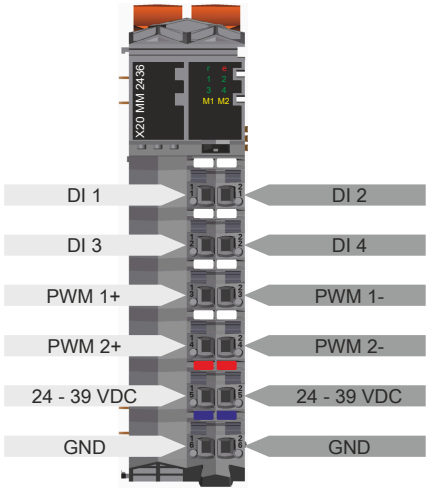
The terminal block is not permitted to be disconnected or connected during operation.

Mise en garde !

Il est interdit de déconnecter le connecteur pendant le fonctionnement.

Information:

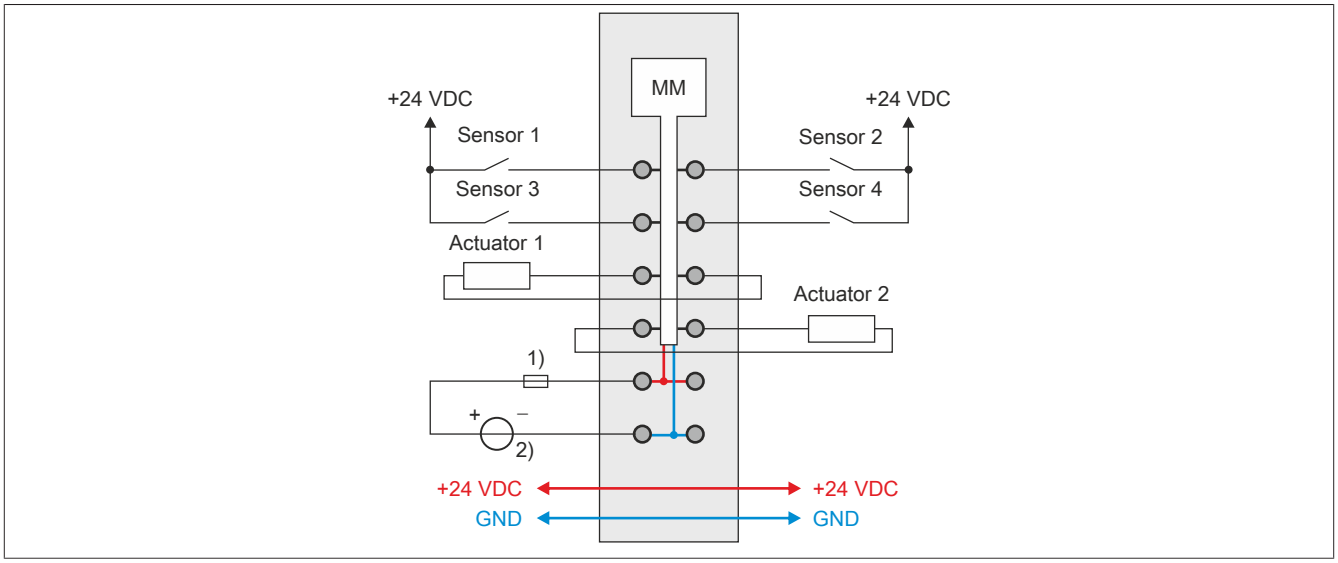
Shielded motor cables must be used in order to meet the limit values per standard EN 55011 (emissions).



2.4 Connection example

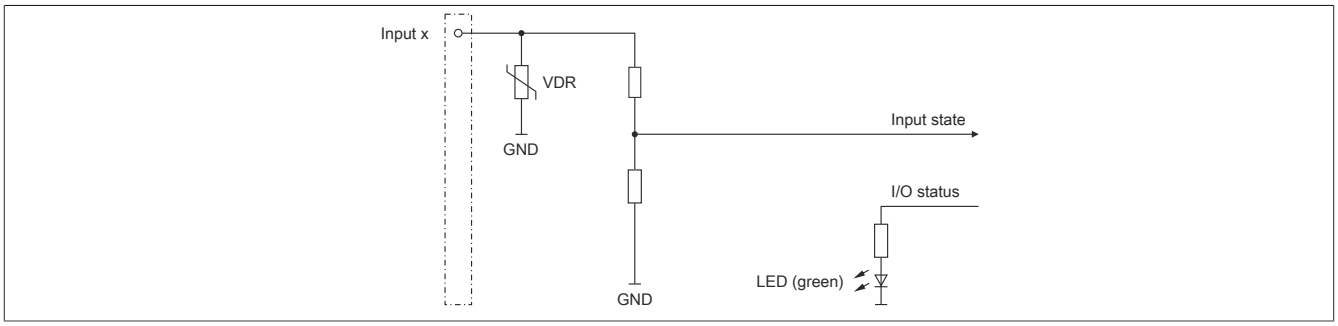
Information:

This module can only be operated if supplied with power via the terminal block.

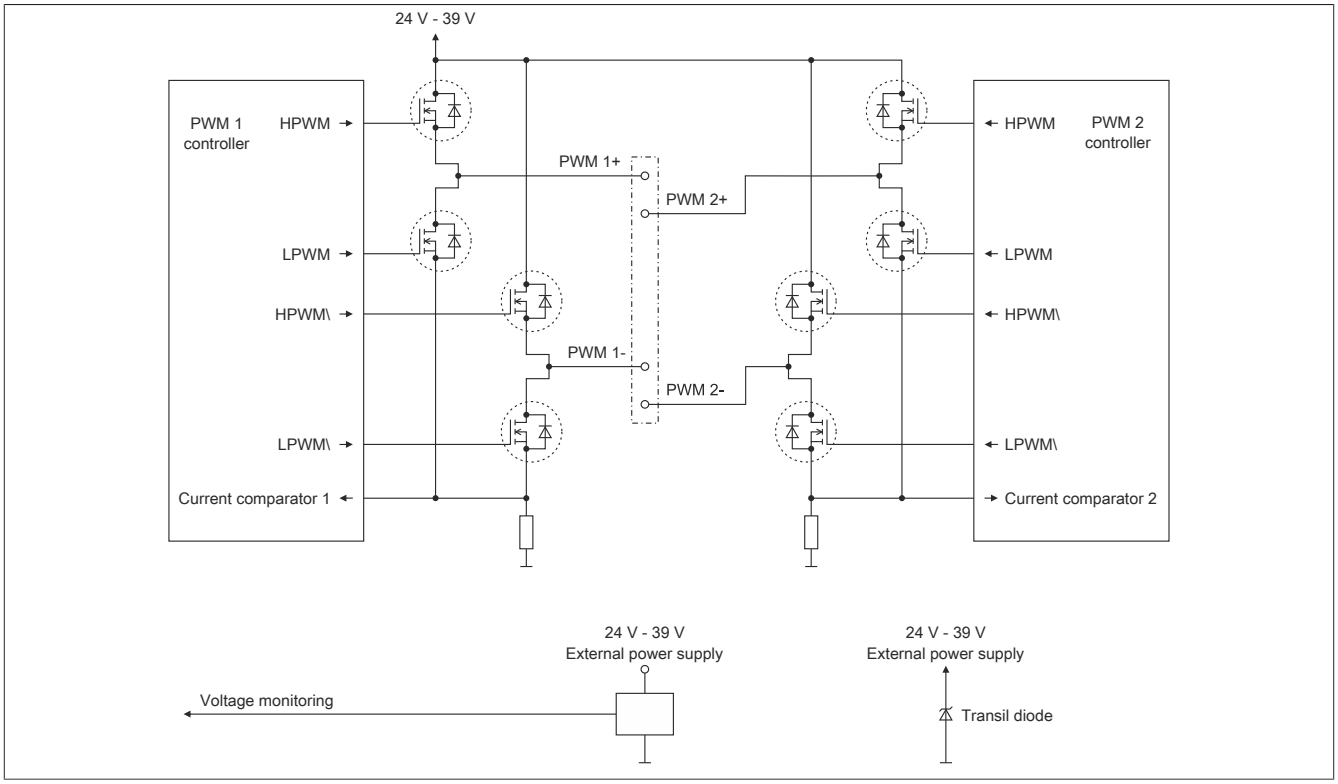


1) Fuse, 10 A slow-blow
2) 24 to 39 VDC supply

2.5 Input circuit diagram



2.6 Output circuit diagram



2.7 Protection

Line protection must be provided in the power supply line via a circuit breaker or fuses. In general, dimensioning the supply line and overcurrent protection depends on the structure of the power supply (modules can be connected individually or in groups).

Information:

The effective current for the power supply depends on the load but is always less than the motor current. Make sure the maximum nominal current of 7 A is not exceeded on the power supply terminals of the power element.

When choosing a suitable fuse, the user must also account for characteristics such as aging effects, temperature derating, overcurrent capacity and the definition of the rated current, which can vary by manufacturer and type. In addition, the fuse that is selected must also be able to handle application-specific characteristics (e.g. overcurrent that occurs in acceleration cycles).

The cross section of the mains power input and the rated current of the used fuse are chosen according to the current-carrying capacity such that the permissible current-carrying capacity of the selected cable cross section (depending on wiring, see table) is greater than or equal to the current load in the mains power input. The rated current of the fuse protection must be less than or equal to the permissible current-carrying capacity of the selected cable cross section (depending on the how it is installed, see table):

$$I_{Mains} \leq I_b \leq I_z$$

Mains ≤ Fuse ≤ Line/Cable

Line cross section [mm²]	Current-carrying capacity of cable cross section I_z / rated current of fuse I_b [A] depending on the to type of wiring at an ambient air temperature of 40°C per EN 60204-1			
	B1	B2	C	E
1.5	13.5 / 13	13.1 / 10	15.2 / 13	16.1 / 16
2.5	18.3 / 16	16.5 / 16	21 / 20	22 / 20

Table 3: Cable cross section of the mains power input depending on the type of wiring

The tripping current of the fuse is not permitted to exceed the rated current of the fuse I_b.

Type of wiring	Description
B1	Wires in conduit or cable duct
B2	Cables in conduit or cable duct
C	Cables or lines on walls
E	Cables or lines on open-ended cable tray

Table 4: Type of wiring used for the mains power input

2.8 Energy regeneration from voltages

Note

The following information must be observed for the module's regenerative mode:

- The module is primarily designed and optimized for motor operation. This means that the module receives energy to generate a movement. In certain applications, "regenerative mode" is necessary or desired. This means that the motor is driven externally, for example by a load or movement, causing the motor to function as a generator and deliver electrical energy in this process.
- It is expressly pointed out that energy is fed back to the module when the motor is in regenerative mode. This can cause the voltage in the module to rise above the supply voltage. Exceeding the maximum permissible voltage in the module (see "Nominal voltage" in section "Technical data" - "Motor bridge - Power section") can result in irreversible damage to the module. This type of damage is caused by an overload of the internal components and is not due to a material or manufacturing defect.
- It is important to ensure that regenerative mode is managed in such a way that the maximum permissible voltage in the module is never exceeded. This can be achieved by suitable protective measures such as braking resistors.
- This also applies to movement of the actuator when it is switched off, for example during maintenance tasks, since voltage is also induced here. Energy regeneration can be avoided by disconnecting the cables, for example.
- No warranty can be provided for damage caused directly or indirectly by exceeding the maximum permissible voltage in the module.

Notice!

Overshoot of the limit values must not be avoided by means of suitable technical measures or by disconnecting cables during maintenance tasks.

Avis !

Le dépassement des valeurs limites ne doit pas être évité par des mesures techniques appropriées ou par la déconnexion des câbles lors des opérations de maintenance.

2.9 Derating

To ensure proper operation, the following items must be taken into consideration:

- The sum of the square of both effective currents (I_N , peak value must not exceed 3 A) must not exceed 9 A^2. The boost current of 3.5 A for 2 seconds is an exception.
- Modules next to the motor module can have a maximum power consumption of 1 W.
- The derating values listed below must be taken into consideration

Example calculations

In the following examples, the calculation of I_N^2 is used to check if the current operating state is permitted.

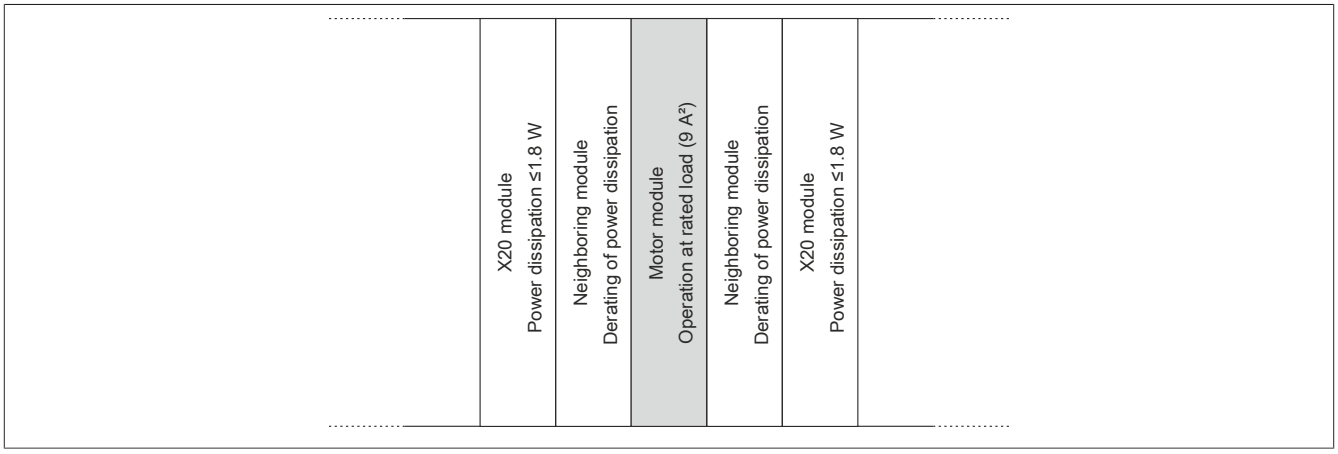
Output current		I_N^2	Operating state permitted
PWM 1	PWM 2		
3 A	0 A	$I_N^2 = 3\ A \cdot 3\ A + 0\ A \cdot 0\ A = 9\ A^2$	Yes
2.1 A	2.1 A	$I_N^2 = 2.1\ A \cdot 2.1\ A + 2.1\ A \cdot 2.1\ A = 8.82\ A^2$	Yes
2.8 A	2 A	$I_N^2 = 2.8\ A \cdot 2.8\ A + 2\ A \cdot 2\ A = 11.84\ A^2$	for max. 2 s[1)]

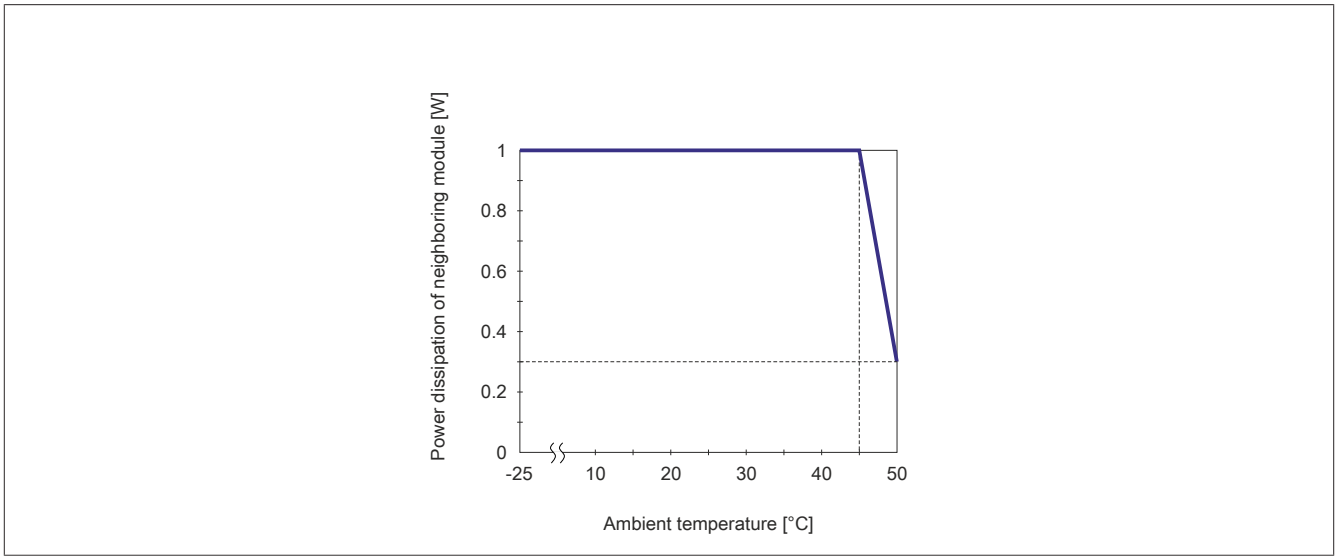
1) The cooling time, which means operation <9 A^2, must be at least 5 times as long as the time of the overload.

Power loss derating for neighboring modules

Modules directly next to the motor module can have a power loss of 1 W. If the motor module is operated with the rated load over the entire temperature range (9 A^2), a derating for power loss of the neighboring modules must be adhered to starting at 45°C.

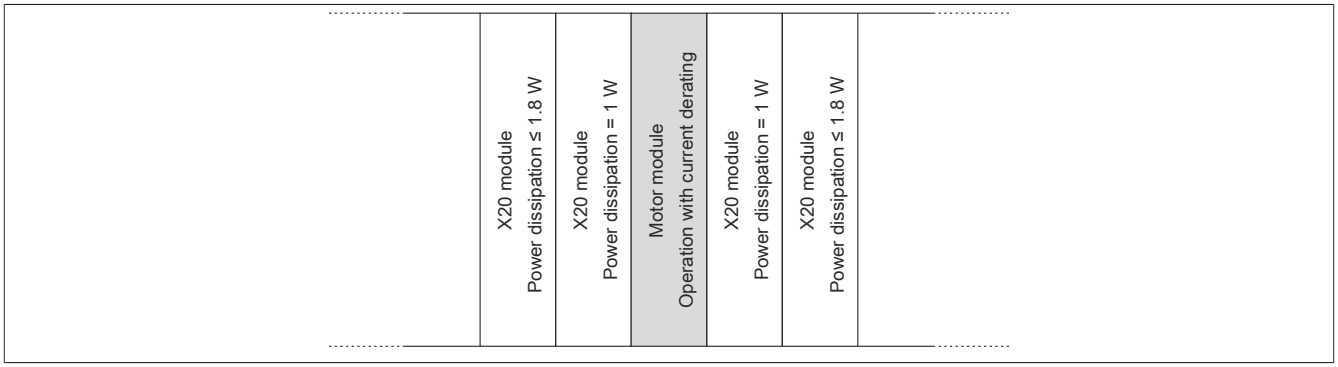
For an example of calculating the power dissipation of I/O modules, see section "Mechanical and electrical configuration - Power dissipation of I/O modules" in the X20 user's manual.

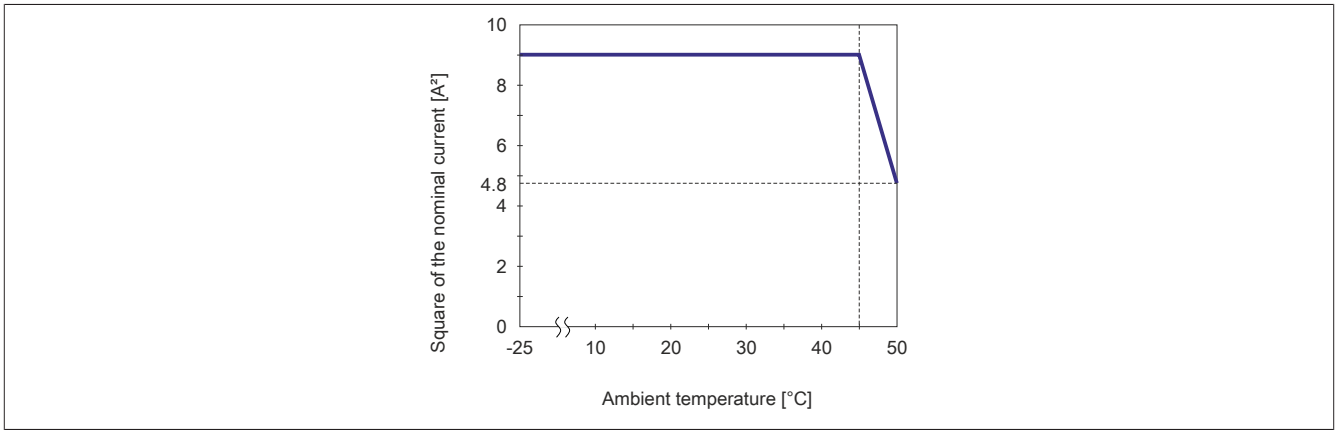




Current derating of the motor module

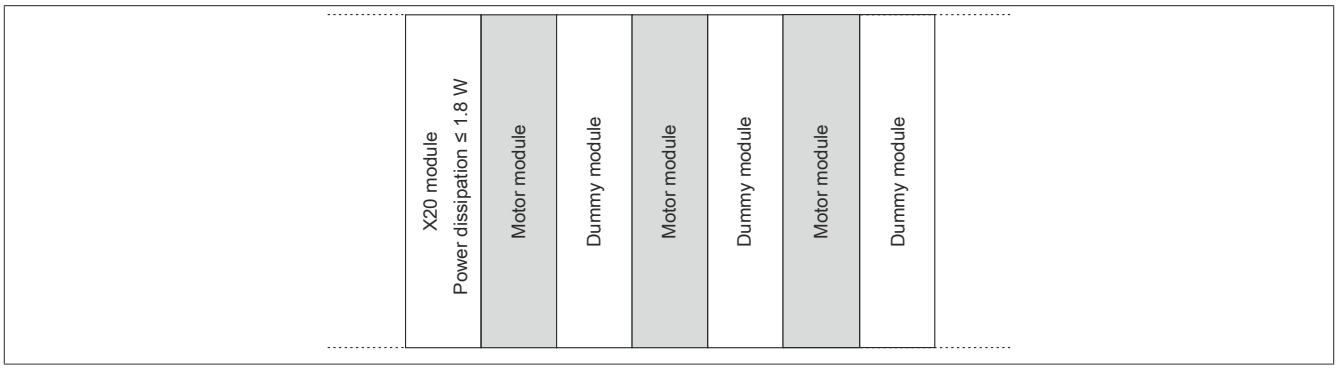
If the power loss of the neighboring modules to the motor module is 1 W, then the current of the motor module must be derated starting at 45°C.





Hardware configuration for multiple motor modules

If 2 or more motor modules (power dissipation ≥1 W) are operated in a cluster, a dummy module must be connected between the motor modules. There is no derating in this arrangement.



3 Function description

3.1 Counters

The following counter types or measurements can be configured on the module:

- AB counters
- ABR counter (only counter 1)
- Event counters
- Period measurement
- Gate measurement

Counter function - Assignment of the digital inputs:

Counter function	Counter number	A	B	R	Enable reference	Counter input	Period duration and gate signal	External measuring frequency
Incremental counter	1	DI 1	DI 2	DI 3	DI 4			
	2	DI 3	DI 4					
Event counters	1					DI 1		
	2					DI 3		
Period duration and gate measurement	1						DI 1	DI 2
	2						DI 3	DI 4

Information:

The registers are described in "Counter configuration 1" on page 26 and "Counter configuration 2" on page 27.

3.2 Operating modes

The outputs of the module can be operated in different modes. The following table lists the differences between the different operating modes:

Operating mode	Standard PWM/ current mode	Frequency mode 1	Frequency mode 2	SuperVibe mode
Operating modes	PWM control Current control	Frequency mode		SuperVibe control PWM control
Starting with firmware version	-	7	7	8.02
Frequency setting	1x period duration in microseconds	2x in 1/10 or 1/100 Hz	1x in 1/10 or 1/100 Hz	2x in 1/10 or 10 Hz
Duty cycle / Current setting	2x -100 to 100%	1x -100 to 100%	2x -100 to 100%	2x -100 to +100%
Dither	Yes	No	No	No
Decay mode setting	Yes	No	No	No
Channel reference	PWM start from channel 2 offset 180° compared to channel 1	A fixed phase relationship between channel 1 and channel 2 is not possible.	PWM start from channel 2 offset 180° compared to channel 1	A fixed phase relationship between channel 1 and channel 2 is not possible.
	3.5 A per channel	1 A per channel	3.5 A per channel	Maximum 1 A per channel

Information:

After switching on or resetting, only a one-time changeover from default mode "Standard PWM/current mode" to "Frequency mode 1" or "Frequency mode 2" is permitted. Later reconfigurations into another mode are ignored by the module's firmware.

Information:

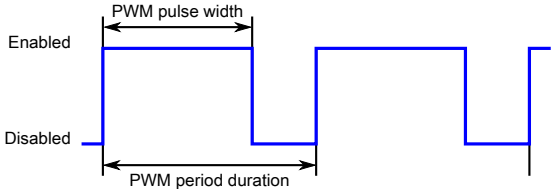
The register is described in "Module configuration" on page 27.

3.2.1 PWM control Standard PWM/current mode

PWM control

The following graphic shows how the current curves of the outputs are affected by registers PWM period duration and PWM pulse width.

At the beginning of each period, the output is switched on for the percentage of time set in the PWM pulse width. The period duration is specified in µs.



Information:

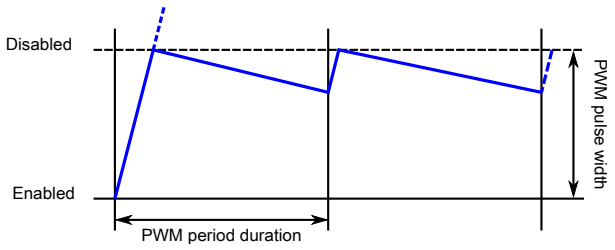
In order to be software-compatible with module X67MM2436, the same pulse width scaling is used for this module. Current values larger than 3.5 A are limited to 3.5 A.

Derating must also be taken into account when using both channels (see "Derating" on page 12).

Current control

The following graphic shows how the current curves of the outputs are affected by registers PWM period duration and PWM pulse width.

The current output is switched on at the beginning of each period. After reaching the value set in PWM pulse width, the output is switched off and the voltage drops according to the decay configuration until switched back on.



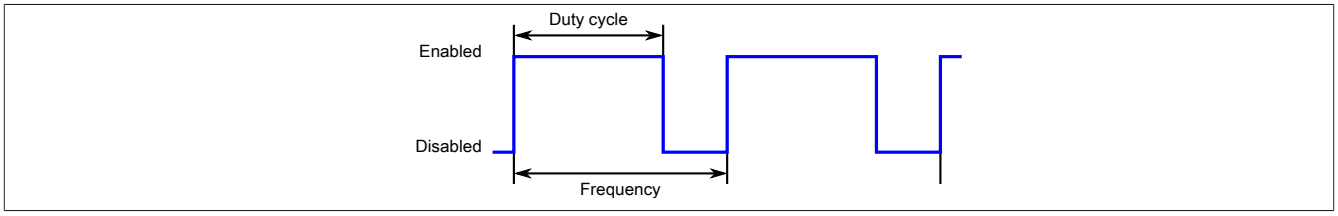
3.2.2 Frequency mode

The following graphic shows how the current curves of the outputs are affected by registers Frequency and Duty cycle.

At the beginning of each period, the output is switched on for the percentage of time set in the duty cycle. The frequency is specified in hertz depending on FrequencyPrescale.

Depending on the operating mode, the following settings are possible:

- Frequency mode 1: Frequency is individually adjustable for PWM outputs; duty cycle is identical for PWM outputs 1 and 2.
- Frequency mode 2: Frequency is identical for PWM outputs 1 and 2; duty cycle can be set individually for PWM outputs.



Notice!

A negative duty cycle can also be configured. In this case, the frequency is output to "PWM1/2" (identical to standard PWM/current mode) instead of the "PWM1/2+" output. It is especially important to take this into account with actuators that are only able to process positive input values.

FrequencyPrescale

The prescaler for the frequency setting is switched using FrequencyPrescale:

- In frequency mode
  Unit in 1/10 Hz, frequency domain: 10 to 6553.5 Hz
  Unit in 1/100 Hz, frequency domain: 1 to 655.35 Hz
- In SuperVibe mode
  Unit in 1 Hz, frequency domain: 10 to 50000 Hz
  Unit in 1/10 Hz, frequency domain: 1 to 6553.5 Hz

In operating mode "Frequency mode 2", both channels are operated at the same frequency.

Information:

Switching the frequency range is possible at any time but results in a frequency jump by a factor of 10. If this frequency jump is out of tolerance in the application, the value set in register "Frequency" on page 29 must be adjusted accordingly.

Information:

The register is described in "Error acknowledgment, dither switch-off and FrequencyPrescale" on page 32.

3.2.3 SuperVibe mode

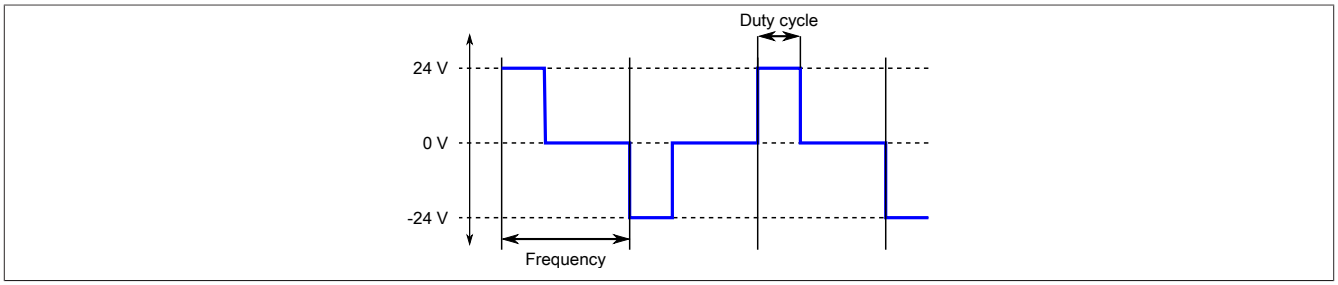
SuperVibe control

Information:

Only available with firmware version 8.02 or later.

SuperVibe (edge polarity reversal) is enabled.

Every second PWM edge is reversed. The following graphic shows how the current curves of the outputs are affected by registers Frequency and Duty cycle.



PWM control

SuperVibe (edge polarity reversal) is disabled.

The PWM output behaves as described in Frequency mode. Frequency and Duty cycle are configurable for each PWM output, however.

3.3 Valve control

When the position setpoint for valves remains constant for a long period of time, especially in fluids, there is a risk that a valve will stick. This is normally prevented using "dithering". When doing so, the value is permitted to slightly oscillate around the position setpoint.

In the module, this dithering is implemented in the form of a triangle wave.

- In PWM mode, the pulse width (duty cycle) of the PWM signal oscillates.
- In current mode, the current setpoint oscillates.

Concrete values for the dither amplitude and frequency to be set must be either taken from the valve data sheet or determined empirically.

By default, the dither is active for both outputs as soon as the dither amplitude and frequency are set to a value >0. If required, dither can be disabled individually and synchronously for each output (see "Error acknowledgment, dither switch-off and FrequencyPrescale" on page 32).

Information:

The registers are described under "Dither amplitude" on page 30 and "Dither frequency" on page 30.

3.3.1 Dither example

The values specified in the data sheet for a valve should be used to calculate Dither amplitude and Dither frequency.

Data sheet for the valve

The data sheet for a valve manufacturer recommends the following dithering:

Dither height in percent (A_{Dither}): 20 to 35% (peak values) of the nominal valve current of 2 A

Dither frequency in Hertz (F_{Dither}): 40 to 70 Hz

Selected values

These values correspond to the average values on the valve data sheet.

A_{Dither} = 27% of the valve's nominal current (peak values)

F_{Dither} = 56 Hz

Formulas

Dither amplitude = (A_{Dither} / 2) * (Nominal current $_{Valve}$ / Nominal current$_{Module}$) * 10
Info: (A_{Dither} / 2) = Conversion of the peak values to amplitude, " * 10" = Scaling of the dither amplitude to 1/10%

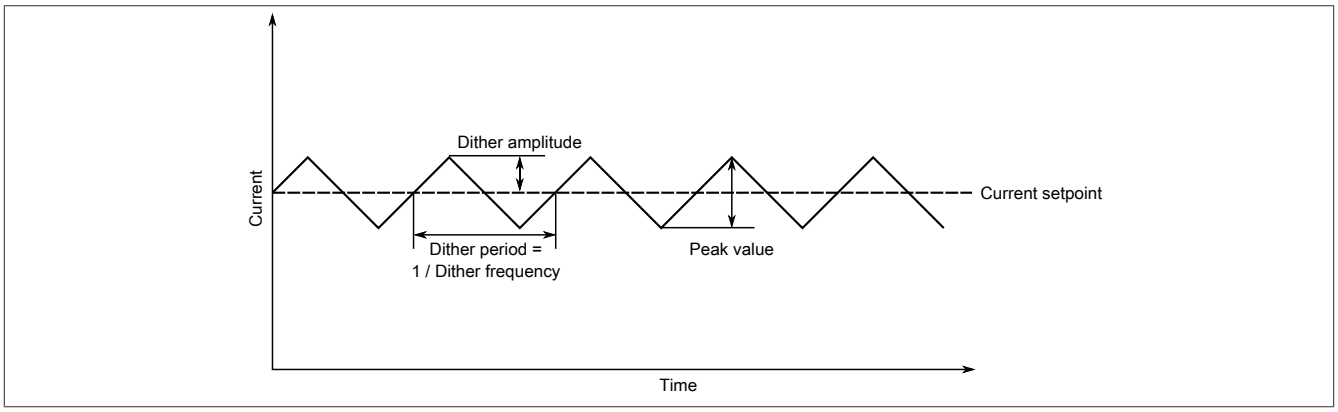
Dither frequency = F_{Dither} / 2 Hz
Info: Dither frequency is configured in 2 Hz steps.

Calculation

By using the selected values in the formulas.

Dither amplitude = 27% / 2 * (2 A / 3 A) * 10 = 90

Dither frequency = 56 Hz / 2 Hz = 28



3.4 Automatic shutdown

To prevent damage to the module or motor, both the voltage and current of the module power supply as well as the module temperature are monitored.

3.4.1 Overvoltage cutoff

The module power supply voltage is monitored. The "error state" on page 31 is returned in the event of a voltage greater or less than the limit values.

If the supply voltage in the module rises above or below the limit values (e.g. due to energy regeneration in regenerative mode), the motor output is switched off.

The outputs are enabled again as soon as the supply voltage is back in the permissible range. In current mode (depending on the current setpoint and inductance of the load), switching on the outputs again can result in an "open-load" error just like any other abrupt change in the current setpoint.

Limit values for the supply voltage

	Drive cut off
Lower limit	<18 V
Upper limit	>50 V

3.4.2 Shutdown in the event of overcurrent

The output current of the PWM outputs is monitored. An overcurrent error is reported in the following cases:

- The maximum output current of a PWM output is exceeded for at least 2 seconds.
  - Standard/PWM mode: ≥3.5 A
  - Frequency mode 1: >1 A
  - SuperVibe mode: Value corresponding to register "MaxCurrentConfig" on page 28
- The output current is ≥5 A for the consecutive PWM cycles set in register "ToleratedShortCyclesConfig" on page 28.

In each case, the pins of the PWM output are short-circuited and the PWM output concerned is disabled. The disabled PWM output can only be started up again by the user after error acknowledgment (see "Error acknowledgment, dither switch-off and FrequencyPrescale" on page 32).

3.4.3 Shutdown in the event of overtemperature

If the module temperature reaches or overshoots the limit value of 85°C, the module performs the following actions:

- Setting error bit "Overtemperature" on page 31.
- The outputs are cut off (short-circuited).

As soon as the temperature sinks below 83°C, the error bit is automatically cleared by the module and the outputs become operational again.

3.5 Decay mode

The decay configuration can be used to determine the method and dynamics of the current reduction of inductive loads or motors.

In default mode "Slow decay", the current is automatically reduced with resistance in the load. No energy is regenerated into the module.

Mode "Mixed decay" is for applications that require a dynamic and linear reduction of current. In this mode, energy is regenerated into the module during part of the PWM cycle (fast decay).

This function is available starting with firmware V3.

Information:

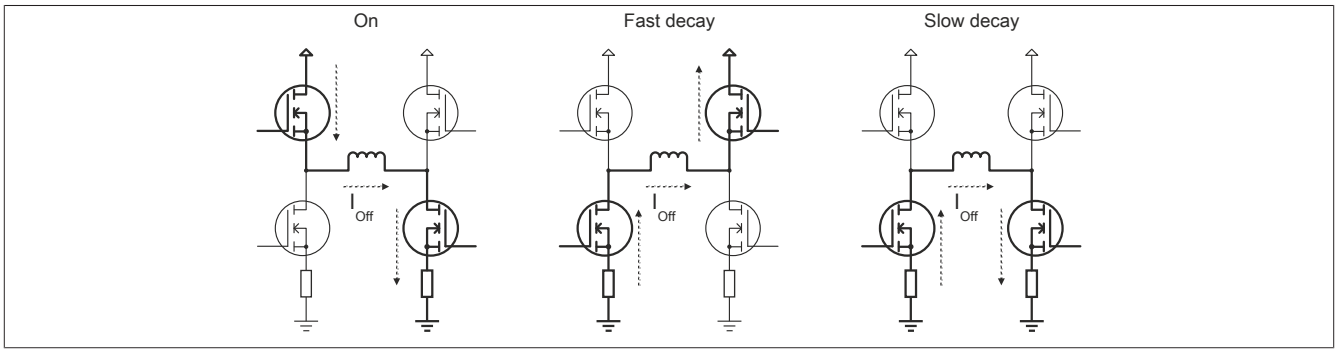
The register is described in "Decay configuration" on page 28.

Mixed decay

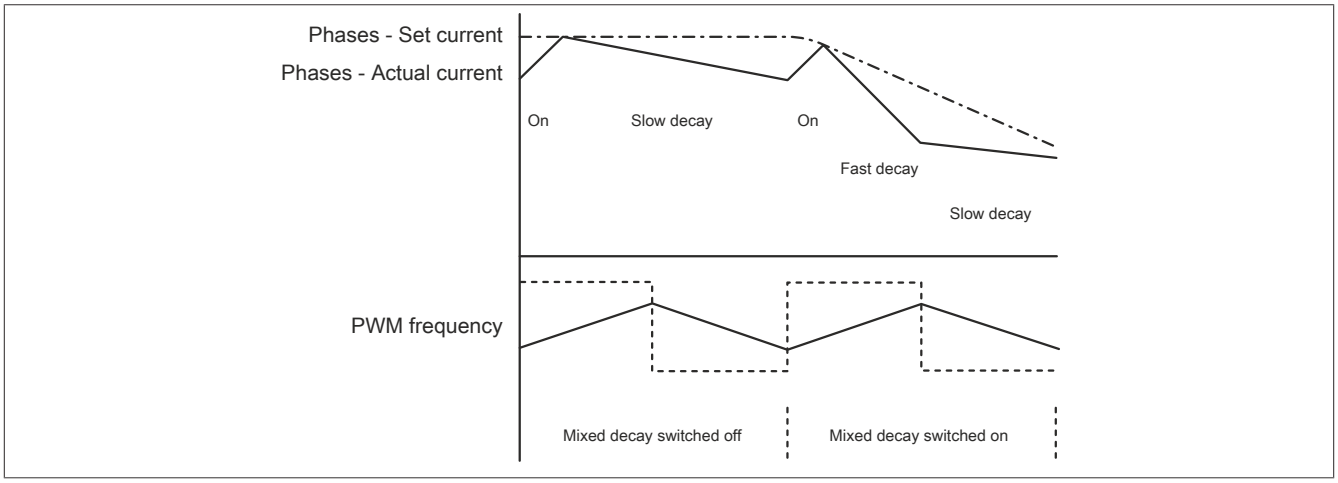
Mixed decay mode is a mix of "slow decay" and "fast decay".

A check is made at the beginning of each PWM cycle to determine if the actual current for the phases is less than the current setpoint. If this is the case, PWM is enabled (on) until the current setpoint is reached. The system switches to fast decay mode for the rest of the first half of the PWM cycle. If the current setpoint has already been exceeded at the beginning of the PWM cycle (generator operation), the system immediately switches to fast decay mode. The second half of the PWM cycle always takes place in slow decay mode.

This also permits generator operation as long as the valid range for the supply voltage has not been exceeded due to the regeneration into the DC circuit.



Mixed decay - Current setpoint / Actual current, PWM frequency



Operating DC motors

In PWM mode, the motor current is limited to the maximum current (3.5 A), independent of the supply voltage.

However, the motor switches to generator operation when braking. Because of the counter EMF, which is dependent on the rotary speed, a current is generated in the module that is only limited by the internal resistance of the motor. This is not permitted to exceed 7 A (maximum 2 seconds).

The counter EMF closely corresponds to the voltage needed to achieve this speed. The maximum braking current can be calculated with the following formula.

$$I_{Brake} = U_e * \frac{PulseWidth}{100\%} * \frac{1}{R_{Motor}}$$

Example:

Module power supply	38 V
Pulse width	16364 (equal to 50%)
Internal resistance of motor	3.5 Ω

$$I_{Brake} = 38\ V * \frac{50}{100\%} * \frac{1}{3.5\Omega} = 5.4A$$

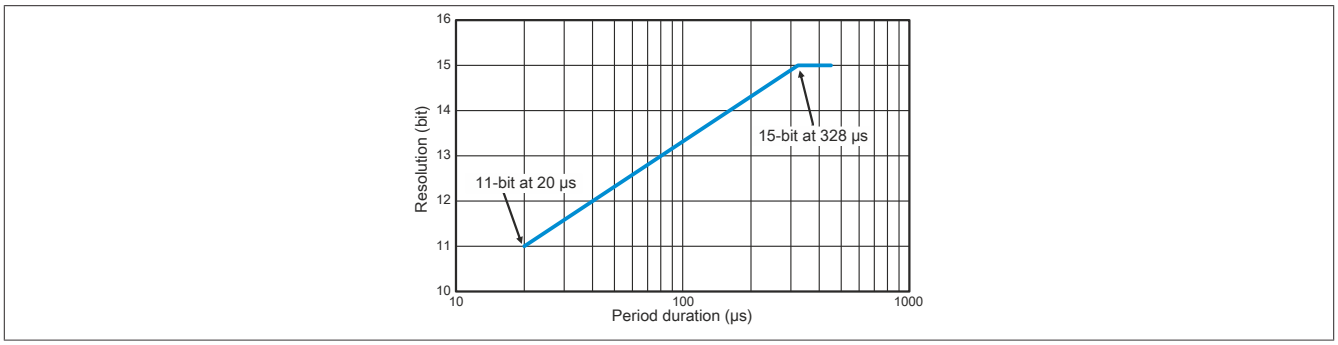
3.6 Bit resolutions of the PWM outputs

The bit resolution of the PWM outputs is 15 bits plus sign. This resolution cannot be maintained in all cases, however.

Resolution in standard PWM/current mode

Depending on the length of the period duration, the bit resolution is subject to derating due to the minimum time resolution of PWM (10 ns).

The bit resolution is 15 bits up to a period duration of 328 µs. With the minimum PWM period duration of 20 µs, the resolution of PWM is only 11 bits.

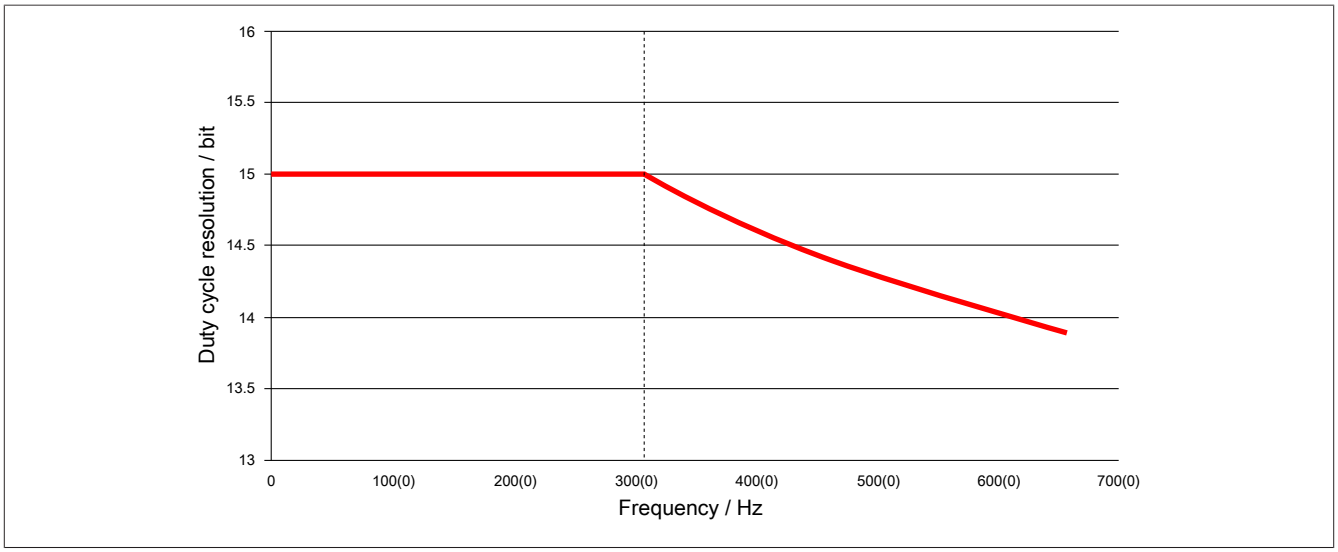


Resolution in frequency and SuperVibe modes

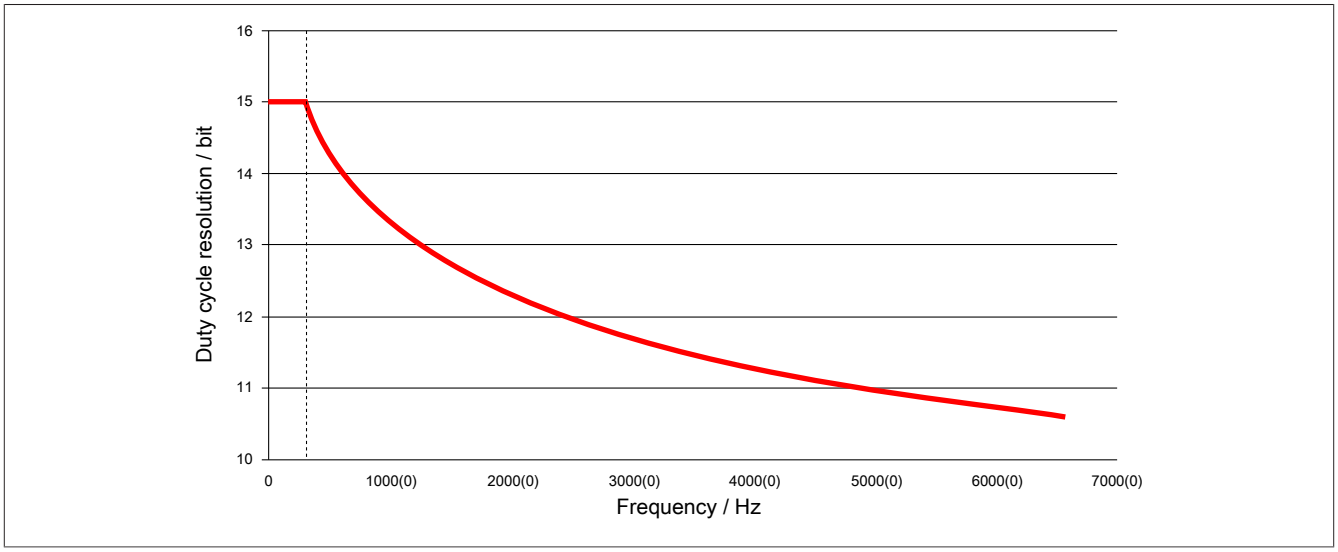
As with standard PWM/current mode, the predefined duty cycle in the frequency and SuperVibe modes cannot be implemented over the entire frequency domain with full 15-bit resolution; instead, it is subject to bit derating.

It is possible to achieve the full 15-bit resolution until about 305 or 3050 Hz (depending on the frequency domain).

Resolution in frequency mode



Resolution in SuperVibe mode



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 1 analog logical slot 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 - Standard

Register	Name	Data type	Read		Write	
			Cyclic	Acyclic	Cyclic	Acyclic
Configuration						
Operating mode "Standard PWM/current mode"						
12	PeriodDurationPWM01PWM02	UINT			•	
14	PulseWidthCurrentPWM01	INT			•	
16	PulseWidthCurrentPWM02	INT			•	
18	ConfigOutput01	USINT				•
20	ConfigOutput02	USINT				•
31	DecayConfig[1]	USINT				•
Operating mode "Frequency mode 1 and 2"[2]						
12	FrequencyPWM01PWM02	UINT			•	
	DutyCyclePWM01PWM02	INT				
14	DutyCyclePWM01	INT			•	
	FrequencyPWM01	UINT				
16	DutyCyclePWM02	INT			•	
	FrequencyPWM02	UINT				
Operating mode "SuperVibe"[4]						
12	FrequencyPWM01	UINT			•	
14	DutyCyclePWM01	INT			•	
16	DutyCyclePWM02	INT			•	
22	FrequencyPWM02	UINT			•	
42	MaxCurrentConfig01	UINT				•
44	MaxCurrentConfig02	UINT				•
All operating modes						
30	ConfigOutput03	USINT				•
38	CounterConfig01[3]	USINT				•
39	CounterConfig02[3]	USINT				•
40	ToleratedShortCycles[4]	USINT				•
Communication						
All operating modes						
0	Counter01	INT	•			
2	Counter02	INT	•			
10	Input status[3]	USINT	•			
	StatusInput01	Bit 0				
	...	...				
	StatusInput04	Bit 3				
	CounterOverflow01	Bit 4				
	CounterOverflow02	Bit 5				
	RefToggle01	Bit 6				
32	Error status	USINT	•			
	UnderVoltageError	Bit 0				
	OverVoltageError	Bit 1				
	OvertemperaturError	Bit 2				
	OperatingError	Bit 3				
	CurrentError01	Bit 4				
	OverCurrentError01	Bit 5				
	CurrentError02	Bit 6				
	OverCurrentError02	Bit 7				

Register	Name	Data type	Read		Write	
			Cyclic	Acyclic	Cyclic	Acyclic
34	Error acknowledgment, dither switch-off[3] and FrequencyPrescale[2]	USINT			•	
	ClearError01	Bit 0				
	ClearError02	Bit 1				
	CounterOverflowDetectEnable01	Bit 2				
	CounterOverflowDetectEnable02	Bit 3				
	CounterReset01	Bit 4				
	CounterReset02	Bit 5				
	DitherDisable01 FrequencyPrescale01	Bit 6				
	DitherDisable02 FrequencyPrescale02	Bit 7				
36	Temperature01	SINT		•		

1) Firmware version 3 or later
2) Firmware version 7.00 or later
3) Firmware version 4 or later
4) Firmware version 8.02 or later

5.3 Function model 254 - Bus controller

Register	Offset[1]	Name	Data type	Read		Write	
				Cyclic	Acyclic	Cyclic	Acyclic
Configuration							
Operating mode "Standard PWM/current mode"							
12	0	PeriodDurationPWM01PWM02	UINT			•	
14	2	PulseWidthCurrentPWM01	INT			•	
16	4	PulseWidthCurrentPWM02	INT			•	
18	-	ConfigOutput01	USINT				•
20	-	ConfigOutput02	USINT				•
31	-	DecayConfig[2]	USINT				•
Operating mode "Frequency mode 1 and 2"[3]							
12	0	FrequencyPWM01PWM02	UINT			•	
		DutyCyclePWM01PWM02	INT				
14	2	DutyCyclePWM01	INT			•	
		FrequencyPWM01	UINT				
16	4	DutyCyclePWM02	INT			•	
		FrequencyPWM02	UINT				
All operating modes							
30	-	ConfigOutput03	USINT				•
38	-	CounterConfig01[4]	USINT				•
39	-	CounterConfig02[4]	USINT				•
49	-	ToleratedShortCycles[5]	USINT				•
Communication							
All operating modes							
0	0	Counter01	INT	•			
2	2	Counter02	INT	•			
10	4	Input status[4]	USINT	•			
		StatusInput01	Bit 0				
		...	...				
		StatusInput04	Bit 3				
		CounterOverflow01	Bit 4				
		CounterOverflow02	Bit 5				
		RefToggle01	Bit 6				
32	6	Error status	USINT	•			
		UnderVoltageError	Bit 0				
		OverVoltageError	Bit 1				
		OvertemperaturError	Bit 2				
		OperatingError	Bit 3				
		CurrentError01	Bit 4				
		OverCurrentError01	Bit 5				
		CurrentError02	Bit 6				
		OverCurrentError02	Bit 7				

Register description

Register	Offset[1]	Name	Data type	Read		Write	
				Cyclic	Acyclic	Cyclic	Acyclic
34	6	Error acknowledgment, dither switch-off[4] and FrequencyPrescale[3]	USINT			•	
		ClearError01	Bit 0				
		ClearError02	Bit 1				
		CounterOverflowDetectEnable01	Bit 2				
		CounterOverflowDetectEnable02	Bit 3				
		CounterReset01	Bit 4				
		CounterReset02	Bit 5				
		DitherDisable01 FrequencyPrescaled01	Bit 6				
		DitherDisable02 FrequencyPrescaled02	Bit 7				
36	-	Temperature01	SINT		•		

1) The offset specifies the position of the register within the CAN object.
2) Firmware version 3 or later
3) Firmware version 7.00 or later
4) Firmware version 4 or later
5) Firmware version 8.02 or later

5.4 Configuration

5.4.1 Counter configuration 1

Name:
CounterConfig01

This register can be used to configure counter 1.

This function is available beginning with firmware Version 4.

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

Bit structure:

Bit	Description	Value	Information
0 - 2	Sets the type of counter.	000	AB counter with 4x evaluation (A = DI 1, B = DI 2) (bus controller default setting)
		001	Event counter (DI 1)
		010	Period measurement (DI 1)
		011	Gate measurement (DI 1)
		100	ABR counter with 4x evaluation (A = DI 1, B = DI 2, R = DI 3, reference release = DI 4). When referencing, counter value 1 is copied to counter value 2. Counter 2 is displayed in I/O mapping, even if it is disabled according to counter configuration 2.
		101 to 111	No counter. Counter is disabled and not shown in the I/O mapping.
3	Measurement starts	0	On rising edge of DI 1 Referencing on a rising edge of DI 3 (only for ABR counter) (bus controller default setting)
		1	On falling edge of DI 1 Referencing on a falling edge on DI 3 (only for ABR counter)
4 - 5	Set the counter frequency for gate or period measurement	00	4 MHz (bus controller default setting)
		01	External via DI 2
		10	31.25 kHz
		11	Reserved
6 - 7	Set the reference input	00	Reference input always enabled (DI 3) (bus controller default setting)
		01	Reserved
		10	Enable for reference input (DI 3) if DI 4 = 0
		11	Enable for reference input (DI 3) if DI 4 = 1

5.4.2 Counter configuration 2

Name:
CounterConfig02

This register can be used to configure counter 2. Unlike counter 1, this counter cannot be configured as an ABR counter.

This function is available beginning with firmware Version 4.

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

Bit structure:

Bit	Description	Value	Information
0 - 2	Sets the type of counter.	000	AB counter with 4x evaluation (A = DI 3, B = DI 4) (bus controller default setting)
		001	Event counter (DI 3)
		010	Period measurement (DI 3)
		011	Gate measurement (DI 3)
		100 to 111	No counter. Counter is disabled and not shown in the I/O map.
3	Measurement starts	0	On rising edge of DI 3 (bus controller default setting)
		1	At falling edge on DI 3
4 - 5	Set the counter frequency for gate or period measurement	00	4 MHz (bus controller default setting)
		01	External via DI 4
		10	31.25 kHz
		11	Reserved
6 - 7	Reserved	-	

5.4.3 Module configuration

Name:
ConfigOutput03

The output control for each motor can be configured separately in this register.

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

Bit structure:

Bit	Description	Value	Information
0	Output 1	0	PWM control (bus controller default setting)
		1	Current control or SuperVibe PWM (edge reversal)
1	Output 2	0	PWM control (bus controller default setting)
		1	Current control or SuperVibe PWM (edge reversal)
2 - 3	Operating mode[1)]	00	Standard PWM/current mode (bus controller default setting)
		01	Frequency mode 1 (bit 0 to 1 ignored)
		10	Frequency mode 2 (bit 0 to 1 ignored)
		11	SuperVibe[2)]
4 - 7	Reserved	-	

1) Firmware version 7.00 or later
2) Starting with firmware version 8.02, function model 0 - "Standard" only

5.4.4 Decay configuration

Name:
DecayConfig

The decay configuration determines the method and dynamics of current reduction for inductive loads or motors.

This function is available starting with firmware V3.

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

Bit structure:

Bit	Description	Value	Information
0 - 1	PWM 1	00	Slow decay (bus controller default setting)
		01	Mixed decay
		10 to 11	Reserved
2 - 3	Reserved	0	
4 - 5	PWM 2	00	Slow decay (bus controller default setting)
		01	Mixed decay
		10 to 11	Reserved
6 - 7	Reserved	0	

5.4.5 Overload shutdown

Name:
ToleratedShortCycles

This register can be used to set how many periods in a row overcurrent must be pending until it is recognized as an error.

This function is available starting with firmware version 8.02.

Data type	Values	Information
USINT	2 to 5	Number of periods

5.4.6 Permissible maximum current

Name:
MaxCurrentConfig01 to MaxCurrentConfig02

In these registers, the maximum permissible current for PWM01 and PWM02 can be set individually in mode SuperVibe.

This function is available starting with firmware version 8.02.

Data type	Values	Information
UINT	100 to 1000	Corresponds to 100 mA to 1 A

5.4.7 PWM period duration

Name:
PeriodDurationPWM01PWM02

The period duration can be set from 20 µs (50 kHz) to 65535 µs (15 Hz) in this register. See also "Operating modes" on page 14.

Data type	Values	Information
UINT	20 to 65535	Time in microseconds

5.4.8 PWM pulse width

Name:
PulseWidthCurrentPWM01 to PulseWidthCurrentPWM02

The PWM pulse width (PWM mode) or current setting (in current mode) is specified in this register according to the setting in the module configuration register. (See also "Operating modes" on page 14.) The output polarity is reversed if the value is negative.

PWM mode

Data type	Values	Output +	Output -
INT	32767	High	Low
	16384	PWM 50/50	Low
	0	Low (bus controller default setting)	Low (bus controller default setting)
	-16384	Low	PWM 50/50
	-32767	Low	High

Current mode

Data type	Values	Current mode	Note
INT	22937 to 32767	+3.5 A (max. 2 s)	Limited internally, check derating
	22936	3.5 A (max. 2 s)	Derating must be taken into account.
	19660	+3 A	
	0	0 A (bus controller default setting)	
	-19660	-3 A	
	-22936	-3.5 A (max. 2 s)	Derating must be taken into account.
	-22937 to -32767	-3.5 A (max. 2 s)	Limited internally, check derating

5.4.9 Frequency

Name:
FrequencyPWM01 to FrequencyPWM02 (frequency mode 1 and SuperVibe)
FrequencyPWM01PWM02 (frequency mode 2)

The frequency for PWM01 or PWM02 (depends on the mode) can be set individually or together in these registers. For more information, see registers "Error acknowledgment, dither switch-off and FrequencyPrescale" on page 32.

Mode FrequencyPrescale

The unit is 1/10 or 1/100 Hz depending on how the "FrequencyPrescale" settings are configured.

Data type	Value	Information
UINT	0	Disabled
	1 to 99	FrequencyPrescale 1/10: 10 Hz FrequencyPrescale 1/100: 1 Hz
	100 to 65535	FrequencyPrescale 1/10: 1/10 * Value = 10 to 6553.5 Hz FrequencyPrescale 1/100: 1/100 * Value = 1 to 655.35 Hz

Mode SuperVibe

The unit is 1 Hz or 1/10 Hz depending on how the "FrequencyPrescale" settings are configured.

Data type	Values	Information
UINT	0	Disabled
	1 to 9	FrequencyPrescale 1: 10 Hz FrequencyPrescale 1/10: 1 Hz
	10 to 50000 10 to 65535	FrequencyPrescale 1: 10 to 50000 Hz FrequencyPrescale 1/10: 1 to 6553.5 Hz

5.4.10 Duty cycle

Name:
DutyCyclePWM01PWM02 (frequency mode 1)
DutyCyclePWM01 to DutyCyclePWM02 (frequency mode 2 and SuperVibe)

The duty cycle for the PWM outputs is set individually or separately in these registers depending on the frequency or SuperVibe mode.

For information about scaling, derating, etc. see the "PWM pulse width" on page 29 registers (PWM mode).

Data type	Values
INT	-32768 to 32767

5.4.11 Dither amplitude

Name:
ConfigOutput01

The amplitude value or the pulse width can be set in this register.

Data type	Values	Information
USINT	0 to 255	Current operation: 0 to 25.5% of the nominal module current[1)] PWM mode: 0 to 25.5% of the period duration. Bus controller default setting: 0

1) See the technical data of the module.

5.4.12 Dither frequency

Name:
ConfigOutput02

The frequency can be specified in steps of 2 Hz in this register.

Data type	Values	Information
USINT	0 to 255	Corresponds to 0 to 510 Hz. Bus controller default setting: 0

5.5 Communication

5.5.1 Counters

Name:
Counter01 to Counter02

This register indicates the status of counters 1 and 2. If counter 1 is configured as an ABR counter, the register for counter 2 is written with the current value of counter 1 when the reference pulse occurs.

Data type	Values
INT	-32768 to 32767

5.5.2 Input status

Name:
StatusInput01 to StatusInput04
CounterOverflow01 to CounterOverflow02
RefToggle01

The status of the inputs and counters is mapped in this register.

This function is available beginning with firmware Version 4.

Data type	Values
USINT	See the bit structure.

Bit structure:

Bit	Description	Value	Information
0	StatusInput01	0 or 1	Logical state of input 1
...		...	
3	StatusInput04	0 or 1	Logical state of input 4
4	CounterOverflow01	0	Period duration or gate time measurement of counter 1 is within the valid range (0x0 - 0xFFFF). This bit is only valid if overflow detection is enabled (bit 2 = 1 in register "Error acknowledgment, dither switch-off and FrequencyPrescale" on page 32).
		1	Overflow during period duration or gate measurement (reset with bit 2 = 0 in the "Error acknowledgment, dither switch-off and FrequencyPrescale" on page 32 register).
5	CounterOverflow02	0	Period duration or gate time measurement of counter 2 is within the valid range (0x0 - 0xFFFF). This bit is only valid if overflow detection is enabled (bit 3 = 1 in register "Error acknowledgment, dither switch-off and FrequencyPrescale" on page 32).
		1	Overflow during period duration or gate measurement (reset with bit 3 = 0 in the "Error acknowledgment, dither switch-off and FrequencyPrescale" on page 32 register).
6	RefToggle01	x	Bit 6 changes value each time the counter state is latched from counter 1 to counter 2. After the module boots, bit 6 = 0.
7	Reserved	-	

5.5.3 Temperature

Name:
Temperature01

The module temperature is indicated in this register.

Data type	Values	Information
SINT	-40 to 125	Module temperature in °C

5.5.4 Error status

Name:
UnderVoltageError
OverVoltageError
OvertemperatureError
OperatingError
CurrentError01 to CurrentError02
OverCurrentError01 to OverCurrentError02

If an error is detected, the corresponding error bit remains set in this register until the error is acknowledged (see "Error acknowledgment, dither switch-off and FrequencyPrescale" on page 32).

Data type	Values
USINT	See the bit structure.

Bit structure:

Bit	Description	Value	Information
0	UnderVoltageError	0	No error
		1	Module supply lower limit <18 V
1	OverVoltageError	0	No error
		1	Module supply upper limit >50 V
2	OvertemperatureError	0	No error
		1	Overtemperature
3	OperatingError[1)]	0	No error
		1	Faulty operation
4	CurrentError01	0	No error
		1	Open load error Output 1
5	OverCurrentError01	0	No error
		1	Overcurrent error Output 1
6	CurrentError02	0	No error
		1	Open load error Output 2
7	OverCurrentError02	0	No error
		1	Overcurrent error Output 2

1) Firmware version 7.00 or higher.

Faulty operation

This warning indicates faulty operation of the module. The following table lists possible causes, the module's reaction and how to correct/acknowledge the error.

Cause	Reaction	Correction/Acknowledgment
Default value for "PeriodDuration" on page 28 or "Frequency" on page 29 outside of specified range	Limiting the default value to the specified range	Automatic acknowledgment as soon as the default value is back within specifications
Later reconfiguration of the operating mode (see bits 2 to 3 of the "Module configuration" on page 27 register)	The new configuration is ignored. The module continues to work in the original operating mode.	The original configuration is restored.

Overcurrent error

An overcurrent error is reported when the current at the PWM output exceeds the set limit. For details, see "Shutdown in the event of overcurrent" on page 19.

Open load error

An open load error is only registered in current control mode (see "configuration register" on page 27) if the current setpoint is not reached. In some cases this can be caused by an open line, although usually the impedance of the load is too high.

5.5.5 Error acknowledgment, dither switch-off and FrequencyPrescale

Name:
ClearError01 to ClearError02
CounterOverflowDetectEnable01 to CounterOverflowDetectEnable02
CounterReset01 to CounterReset02
DitherDisable01 to DitherDisable02
FrequencyPrescale01 to FrequencyPrescale02

This register can be used to acknowledge errors; to enable/disable overflow detection, counters and dither; and to set a prescaler for the frequency domains.

This function is available beginning with firmware Version 4.

Data type	Values
USINT	See the bit structure.

Bit structure:

Bit	Description	Value	Information
0	ClearError01	0	No effect
		1	Error acknowledgment on output 1 (overcurrent or open load) or acknowledgment from limit switch 1
1	ClearError02	0	No effect
		1	Error acknowledgment on output 2 (overcurrent or open load) or acknowledgment from limit switch 2
2	CounterOverflowDetectEnable01	0	Overflow detection disabled. Bit 4 in the counter status register is reset (see "Input status" on page 30)
		1	Counter 1: Overflow detection enabled.
3	CounterOverflowDetectEnable02	0	Overflow detection disabled. Bit 5 in the counter status register is reset (see "Input status" on page 30)
		1	Counter 2: Overflow detection enabled.
4	CounterReset01	0	Counter 1 is enabled (default).
		1	Counter 1 is set to 0 and disabled. If counter 1 is configured as an ABR counter (see "Counter configuration 1" on page 26), then latch 2 is also set to 0. In this mode, the latched value from counter 1 is stored in counter 2.
5	CounterReset02	0	Counter 2 is enabled (default).
		1	Counter 2 is set to 0 and disabled (no effects if counter 1 is configured as an ABR counter)
6	DitherDisable01	0	Dither for PWM output 1 is enabled (default). The dither frequency and dither amplitude must be >0 (see "Valve control" on page 17).
		1	Dither for PWM output 1 is disabled.
	FrequencyPrescale01[1)]	0	Unit in 1/10 or 1 Hz, depends on the operating mode
		1	Unit in 1/100 or 1/10 Hz, depends on the operating mode
7	DitherDisable02	0	Dither for PWM output 2 is enabled (default). The dither frequency and dither amplitude must be >0 (see "Valve control" on page 17).
		1	Dither for PWM output 2 is disabled.
	FrequencyPrescale02[1)]	0	Unit in 1/10 or 1 Hz, depends on the operating mode
		1	Unit in 1/100 or 1/10 Hz, depends on the operating mode

1) Firmware version 7.00 or higher.

FrequencyPrescale

Beginning with firmware version 7.00, bits 6 to 7 in the "Frequency mode 1 and 2" operating mode have a different meaning.

Instead of enabling/disabling dithering for channel 1 or channel 2, the prescaler for the frequency setting is switched over. For details, see "FrequencyPrescale" on page 16.

In "Frequency mode 2" operating mode, only bit 6 (FrequencyPrescale01) is used since both channels are operated with the same frequency.

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
250 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
250 µs