

# X20SM1446-1

Data sheet  
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## **Publishing information**

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## **Version history**

B&R makes every effort to keep documents as current as possible. The most current versions are available for download on the B&R website ([www.br-automation.com](http://www.br-automation.com)).

# 1 General information

## 1.1 Other applicable documents

For additional and supplementary information, see the following documents.

### Other applicable documents

| Document name | Title                                     |
|---------------|-------------------------------------------|
| MAX20         | <a href="#">X20 System user's manual</a>  |
| MAEMV         | <a href="#">Installations / EMV guide</a> |

## 1.2 Order data

| Order number | Short description                                                                                                                                                                                                                                                                                    | Figure                                                                               |
|--------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------|
|              | <b>Motor controllers</b>                                                                                                                                                                                                                                                                             |  |
| X20SM1446-1  | X20 stepper motor module, module power supply 24 to 48 VDC $\pm 25\%$ , with current reduction function, 1 motor connection, 5 A continuous current, 10 A peak current, 4 digital inputs 24 VDC, sink, push-pull circuit, configurable as incremental encoder, NetTime function, double-width module |                                                                                      |
|              | <b>Required accessories</b>                                                                                                                                                                                                                                                                          |                                                                                      |
|              | <b>Bus modules</b>                                                                                                                                                                                                                                                                                   |                                                                                      |
| X20BM31      | X20 bus module, for double-width modules, 24 VDC keyed, internal I/O power supply connected through                                                                                                                                                                                                  |                                                                                      |
|              | <b>Terminal blocks</b>                                                                                                                                                                                                                                                                               |                                                                                      |
| X20TB12      | X20 terminal block, 12-pin, 24 VDC keyed                                                                                                                                                                                                                                                             |                                                                                      |

Table 1: X20SM1446-1 - Order data

## 1.3 Module description

This module is used to control stepper motors with a nominal voltage of 24 to 48 VDC ( $\pm 25\%$ ) at a motor current up to 5 A (10 A peak).

Functions:

- [Integrated motor detection](#)
- [Currents independently configurable](#)
- [Load-dependent current control](#)
- [Stall detection](#)
- [Homing](#)
- [Limitations](#)
- [Motion generator](#)
- [Counters](#)
- [ABR interface and digital inputs](#)
- [Automatic shutdown](#)
- [NetTime Technology](#)

### Integrated motor detection

Due to the integrated motor detection, the connected motors can be identified by their coil characteristics and feedback in the form of an analog value can be generated. This makes it possible to detect not only wiring errors, but also incorrect motor types being used.

### Currents independently configurable

With individual adjustment of the coil currents, the motor is only operated with the current it actually needs. This prevents unnecessary heating of the motor. This lower heating has a positive effect on the energy consumption, thermal load and thus on the service life of the complete system.

### Load-dependent current control

The module contains a sensorless, load-dependent current control. Depending on the operating situation and load, the module controls the current downwards. This results in energy savings of up to 75%.

### Stall detection

Stall detection is integrated to analyze the motor load. Motor stall detection is defined by a configurable threshold. This allows an overload or motor stall to be detected sufficiently accurately in many applications.

### Homing

A large selection of homing procedures allows a wide range of applications for the module. In addition to procedures triggered by limit switches, stop-controlled and immediate homing procedures can also be defined.

For end stop-controlled homing, a delay time can also be defined for stall detection. Homing is only performed after the delay time has elapsed. This prevents unwanted homing due to accidental, brief stoppage of the motor.

### Limitations

Software limitations and/or hardware limit switches allow precise control of the maximum range of movement. This prevents limit transgressions that could result in damage to the machine.

### Motion generator

Movements can be generated directly by the module. Homing or exact positioning procedures can be implemented with minimal application effort using a specified target position and acceleration as well as several other parameters.

### Counter functions

The exact position of the motor can be determined either by an AB(R) encoder or by internal calculations in the module. This allows a large number of motors to be used that are precisely adapted to the machine requirements.

### Inputs/Outputs

The module is equipped with digital inputs that can additionally be used as homing inputs, limit switches or AB(R) encoder inputs.

**Automatic shutdown**

The voltage of the module power supply and the module temperature are monitored. If a value overshoots the predefined limit value, the module is automatically shut down. The outputs are automatically started up again as soon as the value is within the limit value again.

In addition, SDC life sign monitoring can be used to monitor the communication between the controller and module. An interruption of the communication triggers an automatic shutdown of the motor by the module.

The module current, the voltage of the module power supply and the module temperature are monitored. If a value overshoots the predefined limit value, the module is automatically shut down.

**NetTime timestamp of the position and trigger time**

It is not just the position value that is important for highly dynamic positioning tasks, but also the exact time the position is measured. The module is equipped with a NetTime function for this that supplies a timestamp for the recorded position and trigger time with microsecond accuracy.

## 2 Technical description

### 2.1 Technical data

|                                                                  |                                                                         |
|------------------------------------------------------------------|-------------------------------------------------------------------------|
| Order number                                                     | X20SM1446-1                                                             |
| Short description                                                |                                                                         |
| I/O module                                                       | 1 full bridge for controlling stepper motors                            |
| General information                                              |                                                                         |
| B&R ID code                                                      | 0xF3B0                                                                  |
| 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                                                           | 2.4 W                                                                   |
| 48 VDC                                                           | 3.5 W                                                                   |
| Additional power dissipation caused by actuators (resistive) [W] | -                                                                       |
| Input current limiting                                           | Max. 12.5 A                                                             |
| Certifications                                                   |                                                                         |
| CE                                                               | Yes                                                                     |
| UKCA                                                             | Yes                                                                     |
| UL                                                               | cURus E225616<br>Power conversion equipment                             |
| Motor bridge - Power unit                                        |                                                                         |
| Quantity                                                         | 1                                                                       |
| Type                                                             | 2-phase bipolar stepper motor (full bridge)                             |
| Nominal voltage                                                  | 24 to 48 VDC $\pm 25\%$ <sup>1)</sup>                                   |
| Nominal current                                                  | 5 A                                                                     |
| Maximum current                                                  | 10 A for 1 s <sup>2)</sup>                                              |
| DC bus capacitance                                               | 100 $\mu$ F                                                             |
| Step resolution                                                  | Max. 256 microsteps per step                                            |
| Module power supply                                              |                                                                         |
| Supply                                                           | External                                                                |
| Fuse                                                             | Required line fuse: Max. 10 A, slow-blow                                |
| Output protection                                                | Reverse polarity protection on supply voltage                           |
| Digital inputs                                                   |                                                                         |
| Quantity                                                         | 4                                                                       |
| Nominal voltage                                                  | 24 VDC                                                                  |
| Input circuit                                                    | Sink                                                                    |
| Input filter                                                     |                                                                         |
| Hardware                                                         | <5 $\mu$ s                                                              |
| Software                                                         | -                                                                       |
| Connection type                                                  | 1-wire connections                                                      |
| Input resistance                                                 | Typ. 10 k $\Omega$                                                      |
| Additional functions                                             | 1x ABR incremental encoder,<br>open-circuit detection                   |
| Switching threshold                                              |                                                                         |
| Low                                                              | <5 VDC                                                                  |
| High                                                             | >10 VDC                                                                 |
| ABR incremental encoder                                          |                                                                         |
| Quantity                                                         | 1                                                                       |
| Encoder inputs                                                   | 24 V, asymmetrical                                                      |
| Counter size                                                     | 16-bit                                                                  |
| Input frequency                                                  | Max. 50 kHz                                                             |
| Evaluation                                                       | 4x                                                                      |
| Electrical properties                                            |                                                                         |
| Electrical isolation                                             | Channel isolated from bus<br>Channel not isolated from I/O power supply |
| Operating conditions                                             |                                                                         |
| Mounting orientation                                             |                                                                         |
| Horizontal                                                       | Yes                                                                     |
| Vertical                                                         | Yes                                                                     |

Table 2: X20SM1446-1 - Technical data

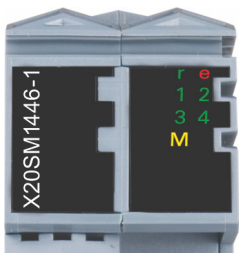
| Order number                           | X20SM1446-1                                                                            |
|----------------------------------------|----------------------------------------------------------------------------------------|
| Installation elevation above sea level |                                                                                        |
| 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          | -25 to 40°C                                                                            |
| Derating                               | See section "Derating".                                                                |
| Storage                                | -25 to 70°C                                                                            |
| Transport                              | -25 to 70°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.<br>Order 1x bus module X20BM31 separately. |
| Pitch                                  | 25 <sup>+0.2</sup> mm                                                                  |

Table 2: X20SM1446-1 - 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) See section "Let-through energy I2T".

## 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 | Mode RESET                                       |
|                                                                                     |       |                                | Double flash | Mode BOOT (during firmware update) <sup>1)</sup> |
|                                                                                     |       |                                | Blinking     | Mode PREOPERATIONAL                              |
|                                                                                     |       |                                | On           | Mode RUN                                         |
|                                                                                     | e     | Red                            | Off          | Module not supplied with power or everything OK  |
|                                                                                     |       |                                | On           | Error or reset status                            |
|                                                                                     | e + r | Solid red / Single green flash |              | Invalid firmware                                 |
|                                                                                     | 1 - 4 | Green                          | On/Off       | Input state of the corresponding digital input   |
|                                                                                     |       |                                | Blinking     | Open circuit or not connected                    |
|                                                                                     | M     | Orange                         | On           | The motor is active.                             |

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

## 2.3 Pinout

To guarantee full motor power, voltage drops that could result from the cable length and the electrical connections must also be taken into account when selecting the attachment cable.



### Warning!

The terminal block is not permitted to be plugged in or unplugged during operation.



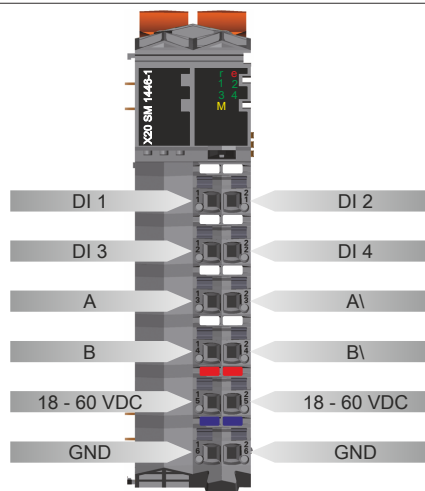
### Information:

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



### Information:

If a boost current of 10 A is required, the motor cables are not permitted to be longer than 2 meters.

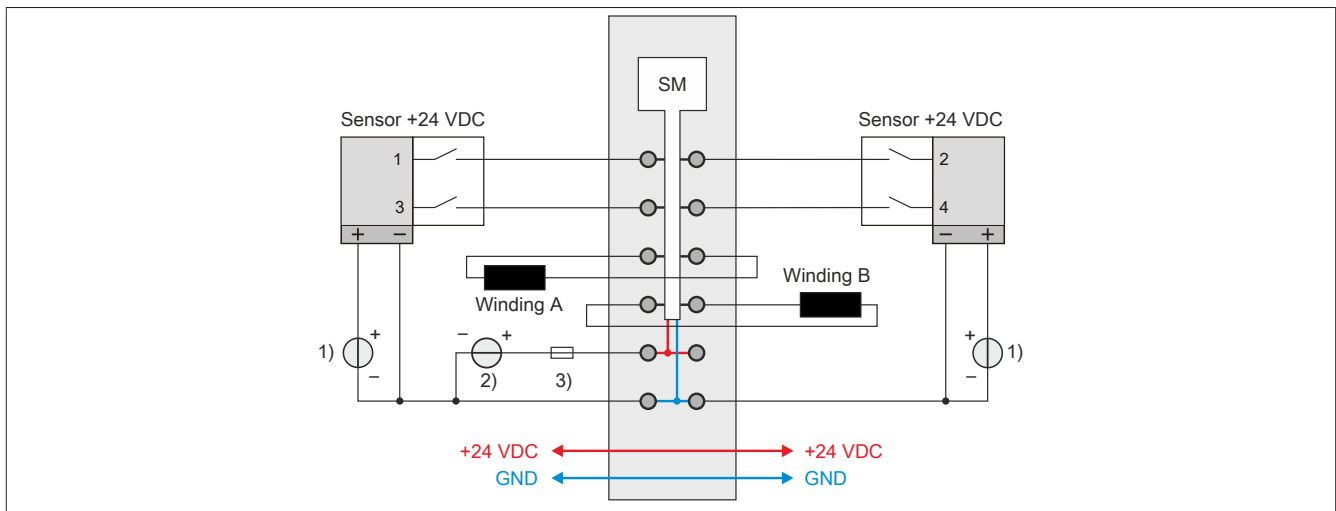


## 2.4 Connection example



### Information:

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



- 1) 24 VDC supply
- 2) 18 to 60 VDC supply
- 3) Fuse, 10 A slow-blow

For the wiring of sensors 1 to 4 see ["Push-pull input circuits" on page 9](#)

### 2.4.1 Push-pull input circuits

The digital inputs of the module are equipped with open-circuit detection and therefore designed for a push-pull circuit.



### Information:

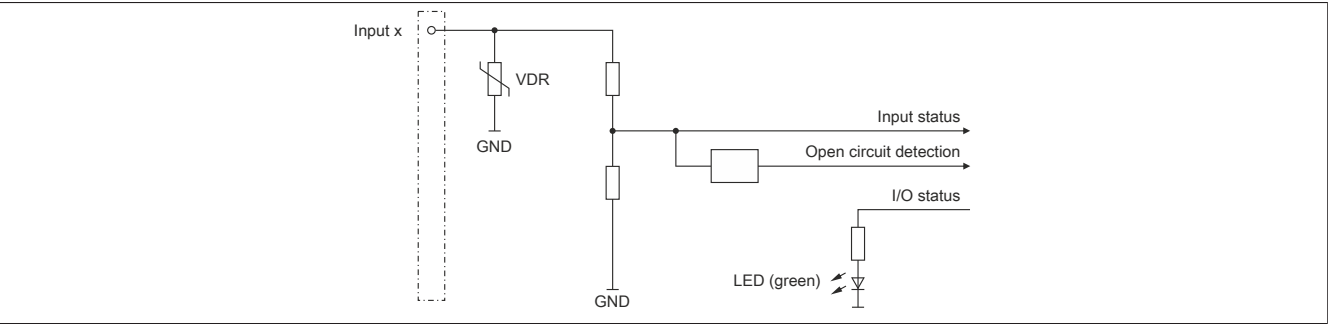
If no push-pull circuit is used, an open sensor contact is interpreted by the module as an open circuit.

#### Circuit variants

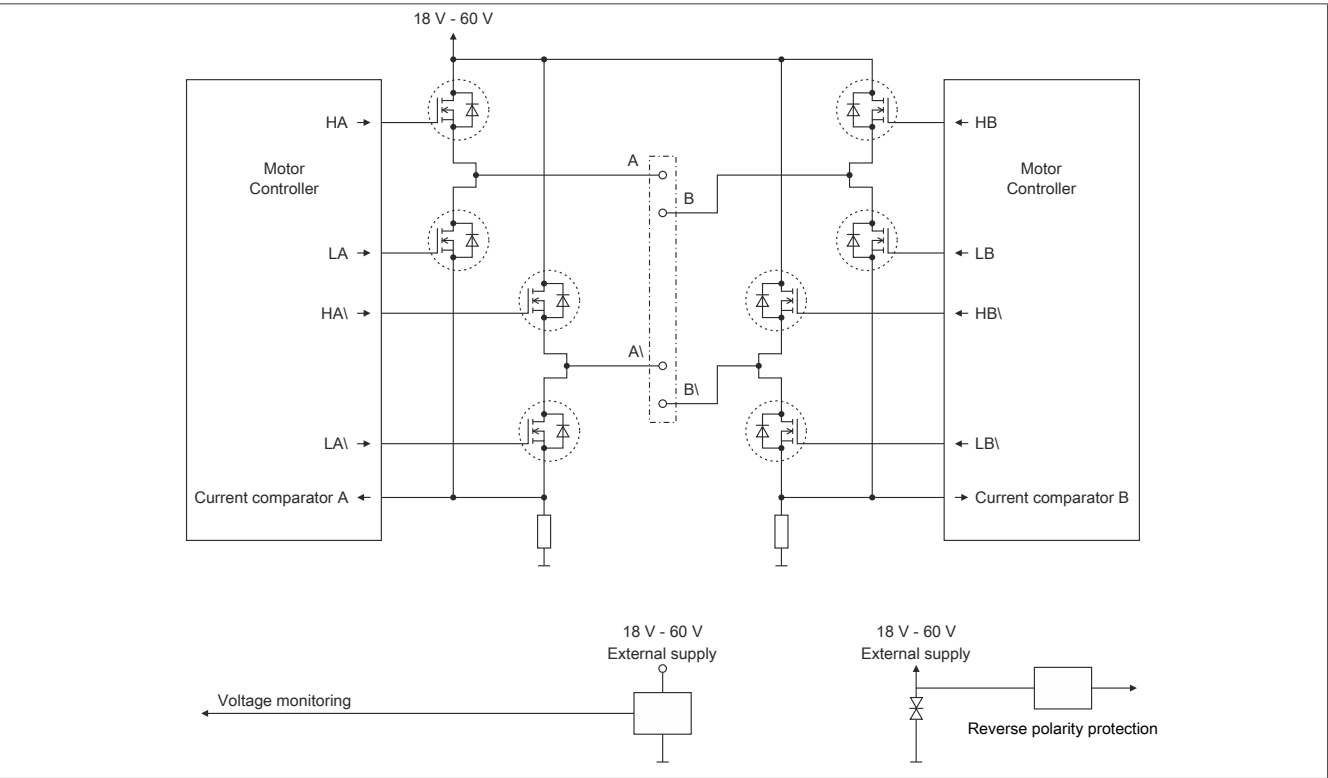
| Push circuit | Pull circuit | Push-pull circuit with toggle switch |
|--------------|--------------|--------------------------------------|
|              |              |                                      |

The size of the resistor depends on the sensor used and must therefore be calculated in each individual case.

2.5 Input circuit diagram



2.6 Output circuit diagram



## 2.7 Power supply unit dimensioning

The motor's current consumption depends on the defined motor currents, the available power and the actual motor being used.

| Example                                |                   |
|----------------------------------------|-------------------|
| Order number of the motor              | 80MPD5.300S000-01 |
| Configured current in the motor module | 3 A               |
| Supply voltage of the motor module     | 48 VDC            |
| Motor load                             | 1 Nm              |

Table 3: Power supply unit dimensioning example - Basic data

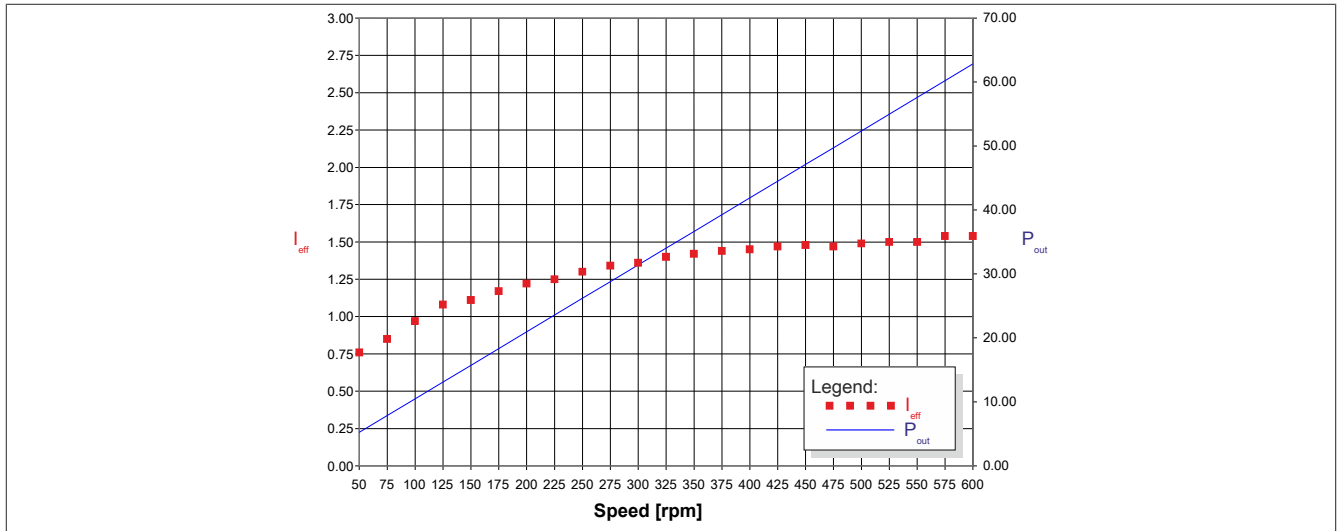


Figure 1: Power supply unit dimensioning example - Power/Speed relationship

The example is based on a constant load throughout the entire speed range.

An increase in the motor load causes an increase in the effective current of the I/O power supply.

## 2.8 Fuse 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 10 A is not exceeded on the power supply terminals of the power unit.**

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):

$$\begin{array}{ccccc} I_{\text{Mains}} & \leq & I_b & \leq & I_z \\ \text{Mains} & \leq & \text{Fuse} & \leq & \text{Line/Cable} \end{array}$$

| Line cross section [mm²] | Current-carrying capacity of cable cross section $I_z$ / rated current of fuse $I_b$ [A] depending on the 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 4: 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 5: Type of wiring used for the mains power input

## 2.9 Let-through energy I2T

The module is designed for a continuous current of 5 A. A higher current can be temporarily drawn, however. The following points must be observed:

- The module is designed for a let-through energy of 825 A<sup>2</sup>s for a period of 30 seconds.



### Information:

Exceeding the maximum let-through energy can result in damage to the module.

- If maximum current  $I_{\text{boost}}$  is drawn for maximum time  $t_{\text{boost}}$ , the continuous current of 5 A can be drawn for the remaining time of 30 seconds.
- If maximum current  $I_{\text{boost}}$  is drawn for more than maximum time  $t_{\text{boost}}$ , the current is not permitted to exceed the calculated residual current for the remaining time of 30 seconds (see example below).
- At the end of a 30 second period with increased current consumption, 5 A continuous current or a higher current can be drawn again.

### Calculating the residual current

$$I_{\text{boost}}^2 \cdot t_{\text{boost}} + I_{\text{residual}}^2 \cdot (30 - t_{\text{boost}}) \leq 825 \text{ A}^2 \text{ s}$$

$$I_{\text{residual}} = \sqrt{\frac{825 \text{ A}^2 \text{ s} - I_{\text{boost}}^2 \cdot t_{\text{boost}}}{30 \text{ s} - t_{\text{boost}}}}$$

### Example

A boost current of 8 A is needed for a duration of 3 seconds. According to the formula, the residual current of 4.84 A is not permitted to be exceeded for the remaining 27 seconds.

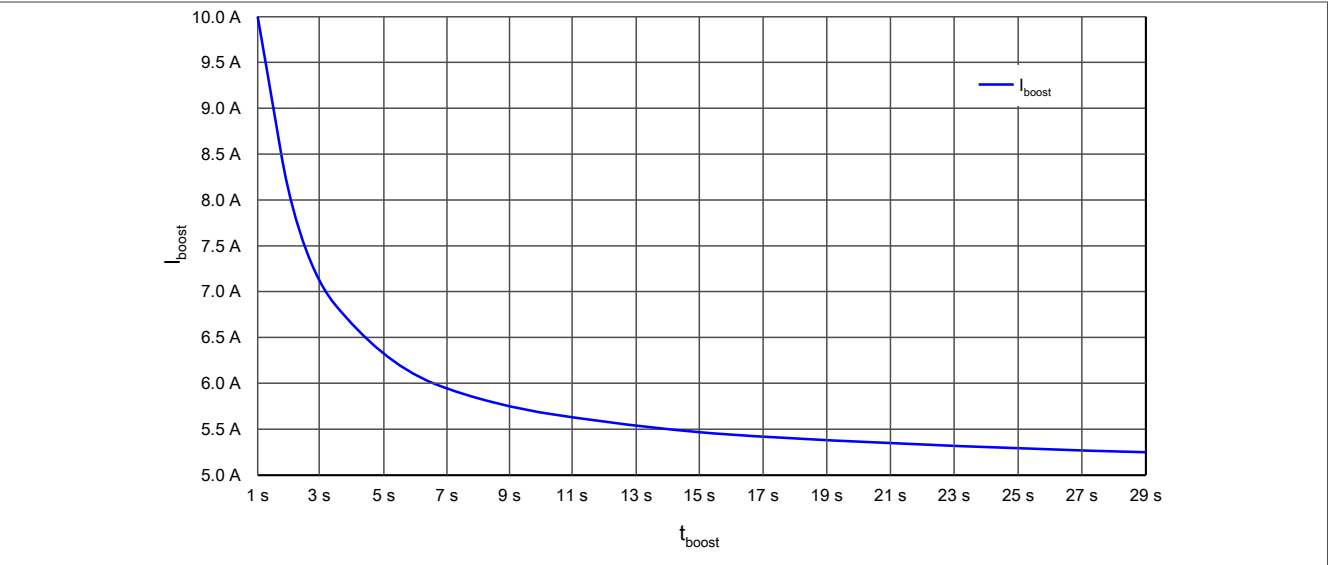
$$I_{\text{residual}} = \sqrt{\frac{825 \text{ A}^2 \text{ s} - 8 \text{ A}^2 \cdot 3 \text{ s}}{30 \text{ s} - 3 \text{ s}}} = 4.84 \text{ A}$$

### $I_{\text{boost}}$ values if $I_2T = 825 \text{ A}^2 \text{ s}$ and $I_{\text{rest}} = 5 \text{ A}$

| $t_{\text{boost}}$<br>s | $I_{\text{boost}}$<br>A | $t_{\text{residual}}$<br>s |  | $t_{\text{boost}}$<br>s | $I_{\text{boost}}$<br>A | $t_{\text{residual}}$<br>s |
|-------------------------|-------------------------|----------------------------|--|-------------------------|-------------------------|----------------------------|
| 1                       | 10.00                   | 29                         |  | 16                      | 5.45                    | 14                         |
| 2                       | 7.91                    | 28                         |  | 17                      | 5.42                    | 13                         |
| 3                       | 7.07                    | 27                         |  | 18                      | 5.40                    | 12                         |
| 4                       | 6.61                    | 26                         |  | 19                      | 5.38                    | 11                         |
| 5                       | 6.32                    | 25                         |  | 20                      | 5.36                    | 10                         |
| 6                       | 6.12                    | 25                         |  | 21                      | 5.35                    | 9                          |
| 7                       | 5.98                    | 23                         |  | 22                      | 5.33                    | 8                          |
| 9                       | 5.77                    | 21                         |  | 23                      | 5.32                    | 7                          |
| 10                      | 5.70                    | 20                         |  | 24                      | 5.30                    | 6                          |
| 11                      | 5.64                    | 19                         |  | 25                      | 5.29                    | 5                          |
| 12                      | 5.59                    | 18                         |  | 26                      | 5.28                    | 4                          |
| 13                      | 5.55                    | 17                         |  | 27                      | 5.27                    | 3                          |
| 14                      | 5.51                    | 16                         |  | 28                      | 5.26                    | 2                          |
| 15                      | 5.48                    | 15                         |  | 29                      | 5.25                    | 1                          |
|                         |                         |                            |  | 30                      | 5.24                    | 0                          |

Technical description

These values correspond to the following curve for let-through current I<sub>2T</sub>:



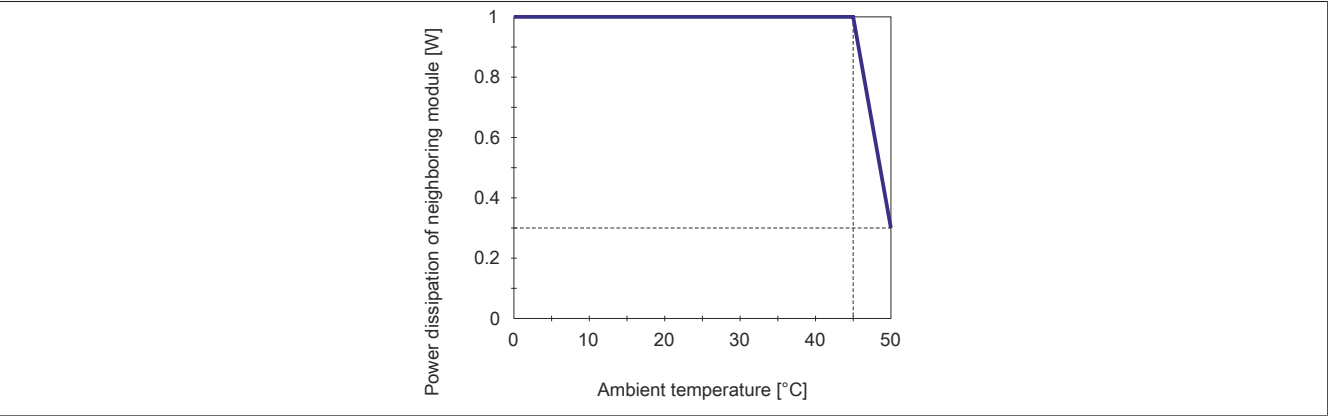
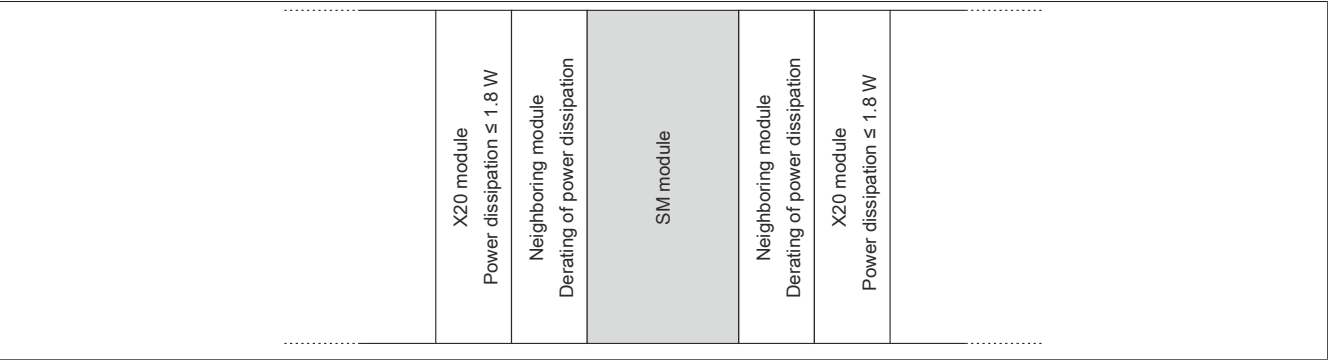
2.10 Derating

Only modules with a maximum power dissipation of 1 W are permitted to be operated next to the SM module. To ensure proper operation, observe the derating values listed below:

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.

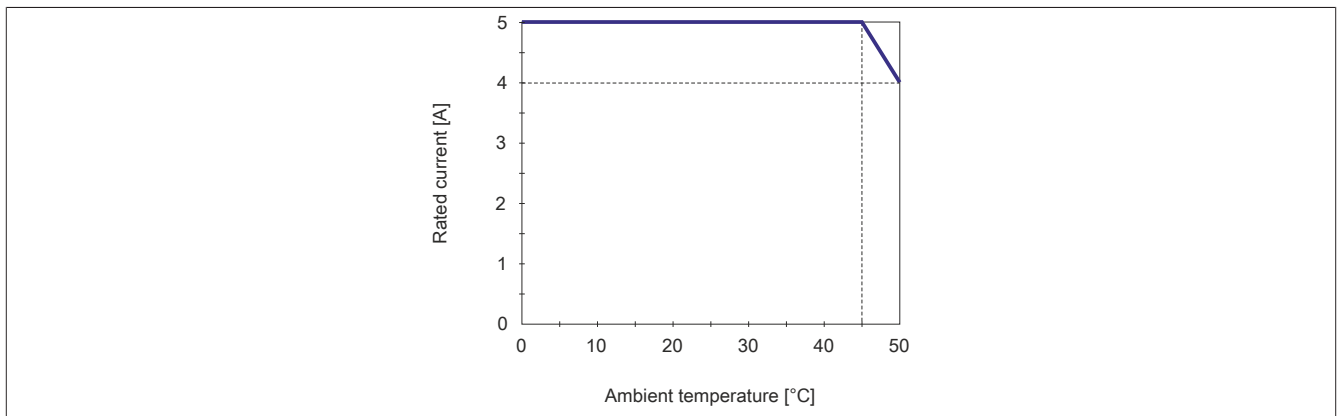
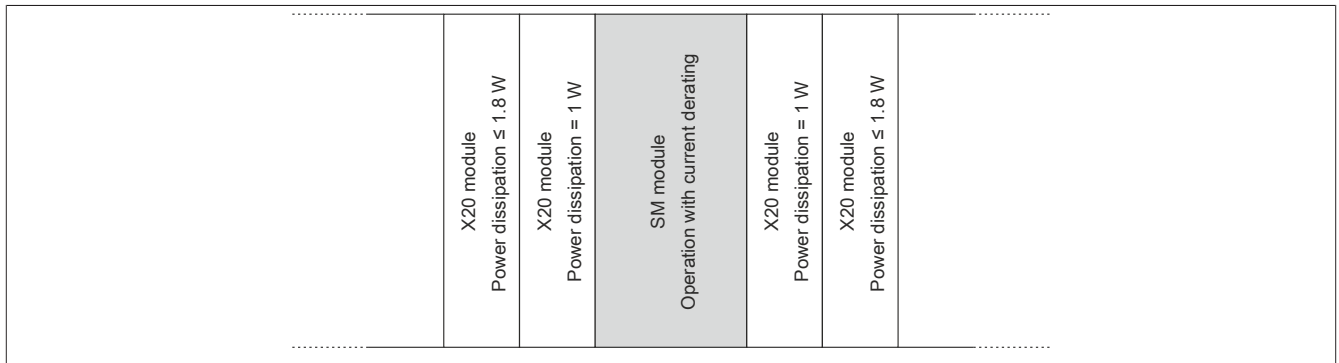
Power dissipation derating for neighboring modules

The power dissipation of immediate neighboring modules of the SM module is permitted to be 1 W. If the SM module is operated at the rated load over the entire temperature range (5 A nominal current), the power dissipation of neighboring modules must be derated starting at 45°C.



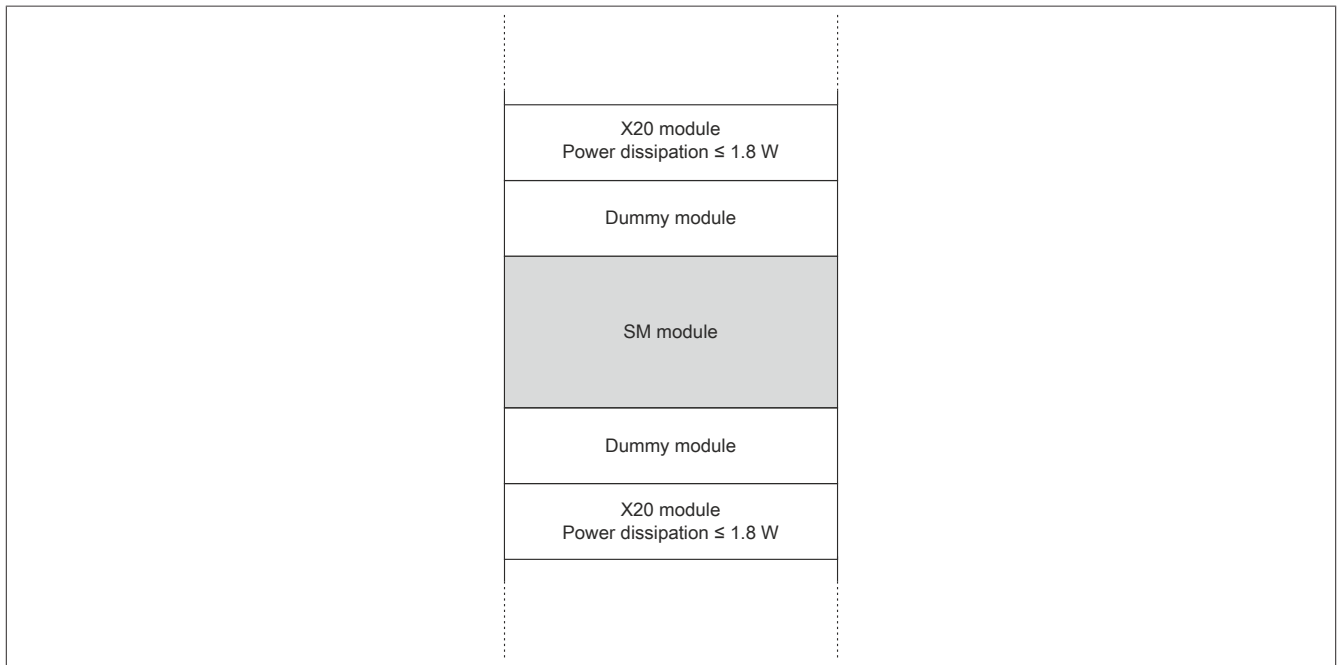
### Current derating of the SM module

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



### Derating for vertical mounting orientation

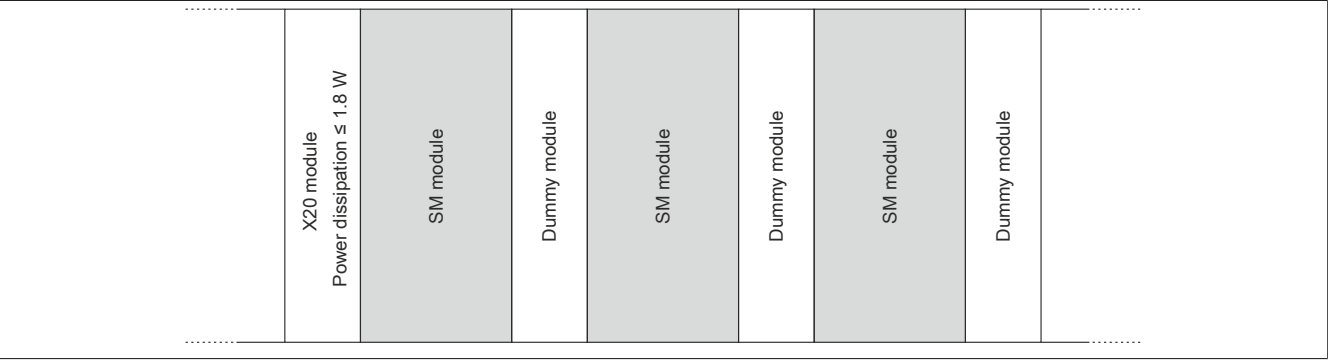
When operating the module in a vertical mounting orientation, dummy modules must be connected as neighboring modules. There is no derating in this configuration.



Technical description

Hardware configuration for multiple SM modules

If three or more SM modules are operated in a cluster, a dummy module must be inserted between the SM modules. There is no derating in this configuration.



## 3 Function description

### 3.1 Integrated motor detection

The stepper motor module can identify the connected motor by the coil characteristics. This makes it possible to detect not only wiring errors, but also incorrect motor types being used mistakenly.

After successful measurement, the time required to apply a current increase of  $\Delta I = 1\text{ A}$  to a motor winding is returned in microseconds.

This depends on:

- Operating voltage
- Inductance and resistance of the motor winding

| Measurement procedure |                                                                                                                                                                                                                                                                                                                                           |
|-----------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 1)                    | To achieve reproducible results, the measurement must be made under the following defined conditions:                                                                                                                                                                                                                                     |
| a)                    | Motor is at standstill.                                                                                                                                                                                                                                                                                                                   |
| b)                    | The motor must be in a half-step position (phase A fully powered, phase B not powered). This means the internal position counter on the SM module must have a value that fulfills the following conditions: <ul style="list-style-type: none"> <li>• Full steps are divisible by 4.</li> <li>• Microsteps = 0</li> </ul>                  |
| 2)                    | Condition 1b) is fulfilled after a the SM module is reset or switched on. Immediately afterwards, when the holding current is applied to the motor for the first time (at standstill), the duration for applying the current is measured. This is therefore a suitable time to read the motor identification register in the application. |
| 3)                    | The current range from approximately 1/3 of the nominal current up to the nominal current is used as operating range for determining the motor identifier.                                                                                                                                                                                |



#### Information:

The registers are described in "[Motor identification](#)" on page 53.

## 3.2 Currents independently configurable

Due to the individual adjustment of the coil currents, the motor is only operated with the current it actually needs. The required motor voltage is automatically set via the constant current control of the module and the provided winding resistance of one phase of the motor.

This simplifies the selection of the available motors and prevents unnecessary heating. Because this affects energy consumption and thermal load, the effects are positive on the service life of the complete system. Complete flexibility is achieved through the use of independently adjustable holding, maximum and nominal current values. The current for microsteps is automatically adjusted to the configured current values.

The holding current, nominal current and maximum current registers are used to configure the desired motor current. The nominal motor current is entered in the nominal current register according to the motor's data sheet.

Reasonable values:

- Holding current < Nominal current < Maximum current



### Information:

**The maximum current must always be configured greater than or equal to the nominal current.**

| Register        | Description                                                                                                                                                                                         |
|-----------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Nominal current | Current during operation at constant speed                                                                                                                                                          |
| Maximum current | Current during short acceleration phases if a higher motor torque is required.<br>In mode "Homing", the nominal current is always used instead of the maximum current, even in acceleration phases. |
| Holding current | Current consumption for phases in which less torque is required (e.g. at standstill). This reduces the amount of heat generated by the motor.                                                       |

When the current changes to a weaker value (e.g. when transitioning from the acceleration phase to the constant speed mode), the stronger current is maintained for an additional 100 ms. The following priority applies regardless of the values actually set: Maximum current before nominal current before holding current.



### Information:

**The registers are described in "Configuring currents (function model 0)" on page 47 and "Configuring currents (function models 3 and 254)" on page 47.**

## 3.3 Load-dependent current control

Load-dependent current control uses the motor load value to reduce the current for the motor when the motor is only slightly loaded. In addition to saving energy, this also reduces the noise level of the motor. The motor is also not heated as much. If a heavier load is again placed on the motor, the motor current is increased and thus more torque can be provided.

To set the load-dependent current control, the upper and lower limits of the motor load must be set so that they can be increased or decreased as needed.

Due to the dependence of the motor load value on motor-specific properties and application-specific load and speed requirements, the operating conditions should be matched to the actual application.

For the configuration, see [Stall detection](#).



### Information:

**The registers are described in "Measuring the motor load" on page 53 and "Configuring current control" on page 43.**

### 3.4 Stall detection

To reliably detect a standstill of the motor, the stall threshold must be determined. The stall threshold should be a value within the operating limits and slightly higher than the minimum value before an actual motor standstill occurs.

- The SGT correction values are used to compensate for an offset that results from the back EMF of the motor. For this purpose, the maximum load that the motor can run without blocking must be determined. Ideally, the motor load value should drop to 0 before a step loss due to overload causes the motor to stop.

If the SGT correction value is set so that a value of 0 is displayed at maximum motor load, then the stall is precisely detected and the stall error bit is set correctly.

For some motors, however, stall detection is very difficult to use or cannot be used at all. With these motors, no settings can be determined where the motor stops without slipping, e.g. due to electrical parameters or too little magnetic field feedback from the motor.

- The SCT speed values set the threshold value from which speed the determined SCT correction value becomes active. These include:

**Threshold value 1** From 0 to SGT\_Speed01a

**Threshold value 2** From SGT\_Speed01b to maximum

Since the motor load value drops to 0 during acceleration from standstill, this would be incorrectly detected as a stall and the motor would stop again immediately. A minimum speed can therefore be set at which stall detection is enabled.



#### Information:

- At very low motor speeds (<1 revolution/second), stall detection cannot be carried out reliably due to low back EMF values.
- At very high motor speeds, at which the sinusoidal motor current can no longer be impressed into the motor coil, poor responsiveness can also occur.



#### Information:

The registers are described in "[Stall detection \(function model 0\)](#)" on page 48 and "[Stall detection \(function models 3 and 254\)](#)" on page 48.

## 3.5 Homing

Homing can be carried out in forward and reverse direction.

Before homing can be performed, the motor must be at a standstill.

If the homing condition occurs, the motor stops and the values of the position counter that are valid at the moment when the homing condition occurs are applied as the homed zero position.

Whether homing should take place via low/high level on the digital input, stall or unconditionally must be set in the homing configuration.

### Homing via digital input

**Case 1:** Active homing level not yet reached → Motor not yet at end position:

Movement continues at the homing speed in the homing direction until the active level for "Stop homing" is on the input.

**Case 2:** Active homing level already reached → Motor at end position:

Movement continues at the homing speed against the homing direction until the active level for "Stop homing" is no longer on the digital input. Movement continues at the homing speed in the homing direction until the active level for "Stop homing" is on the digital input again.

### Homing during stall

Movement continues in the homing direction until a stall is detected. When a stall is detected, the value of the position counter is applied as the homed zero position within one millisecond. The motor is then stopped abruptly (not using the deceleration ramp). However, it can take up to 25 ms to stop the motor because the ramp generator runs with a configurable internal cycle of up to 25 ms.

In order to prevent unwanted homing due to brief stalling, an additional delay time can be defined for stall detection. Homing is only performed after the delay time has elapsed.

In this mode, the nominal current is always used instead of the maximum current, even in acceleration phases.

To test the responsiveness of this homing mode, the motor load value used for identifying a stall can be made visible in the status word.

### Immediate homing

The current values of the position counter are immediately applied as the homed zero position (no motor movement).



#### Information:

Registers are described in ["Homing" on page 52](#).

### 3.6 Limitations

Limitations can be implemented both in hardware using limit switches and in software using software limits.

#### Negative/Positive limit switch:

When one of the limit switches is reached, a warning is triggered and the speed is decelerated to 0. There is no state change of "Device control state machine". This keeps current flowing to the motor.

The error that occurred can be read from the error code register. Normal operation can be resumed through acknowledgment of the warning. This will not restrict motor movement to a specific direction and the limit switch will not be triggered until the next active edge.

#### Overshooting the limit switch while braking

The limit switches are not linked with the corresponding direction of movement. If the limit switch is traversed, another error will be triggered when reversing after acknowledging the initial error.

#### Direction monitoring

If this function is enabled, then the two limit switches will be linked with the respective direction of movement. This means that the negative limit switch is only triggered in the negative and the positive limit switch only in the positive direction of movement (specified direction).

This prevents specifying a movement in the incorrect direction when direction monitoring is enabled and limit switches are active.



#### Warning!

**If the motor is wired incorrectly with this configuration (incorrect direction of movement), then the limit switch will not be triggered and the actual correct direction of movement will be denied. This will also be the case when the limit switch connections are reversed.**

#### Monitoring software limits

This function is enabled if at least one of the two software limit registers is not equal to zero.

This limit monitoring is effective in all positioning modes. Position overflow is not possible when this function is enabled. Movement is always contained within the two limits.

If a position is specified that overshoots/undershoots the software limits or in the event of an invalid configuration (minimum > maximum), bit "Internal limit active" is set in the status word. The motor movement will be stopped until a position is specified within the limits.



#### Information:

**Monitoring software limits works only when in connection with the following CANopen bus controllers:**

- X20BC0043-10
- X20BC0143-10
- X67BC4321-10
- X67BC4321.L08-10
- X67BC4321.L12-10



#### Information:

**The registers are described in ["Limitations"](#) on page 52.**

## 3.7 Motion generator

### Mode

The module can independently generate a number of different movements based on specified parameters:

- [Position mode](#)
- [Velocity setpoint](#)
- [Homing](#)

| Information                         |                                                                                                                                                                                                                                                                                                                                                                                                         |
|-------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|                                     | No mode selected                                                                                                                                                                                                                                                                                                                                                                                        |
| <b>Positioning</b>                  |                                                                                                                                                                                                                                                                                                                                                                                                         |
|                                     | <a href="#">Velocity setpoint</a>                                                                                                                                                                                                                                                                                                                                                                       |
|                                     | <a href="#">Position mode</a><br>Depending on bit 0 in the general configuration, the position mode behaves as follows: <ul style="list-style-type: none"> <li>• Without extended control word: Move to target position as soon as the target position is changed.</li> <li>• Position mode with extended control word: Move to the target position as described in "Extended control word".</li> </ul> |
| <b>Moving to absolute positions</b> |                                                                                                                                                                                                                                                                                                                                                                                                         |
|                                     | <a href="#">Home position with residual distance</a>                                                                                                                                                                                                                                                                                                                                                    |
|                                     | <a href="#">Moving to the target position</a> if digital input is set                                                                                                                                                                                                                                                                                                                                   |
|                                     | <a href="#">Moving to a fixed position</a> depending on digital input                                                                                                                                                                                                                                                                                                                                   |
|                                     | <a href="#">Moving to a fixed position</a> (first or second position)                                                                                                                                                                                                                                                                                                                                   |
| <b>Homing</b>                       |                                                                                                                                                                                                                                                                                                                                                                                                         |
|                                     | <a href="#">Homing in the forward direction</a>                                                                                                                                                                                                                                                                                                                                                         |
|                                     | <a href="#">Homing in the reverse direction</a>                                                                                                                                                                                                                                                                                                                                                         |
| <b>Applying positions</b>           |                                                                                                                                                                                                                                                                                                                                                                                                         |
|                                     | <a href="#">Applying the actual position</a> (homing or actual position)                                                                                                                                                                                                                                                                                                                                |



### Information:

**For all modes: Bit "Target reached" is set in when the current action is ended (i.e. when the position or speed is reached, depending on the mode).**

**A new position or speed can be specified even before the current action is finished.**

### Velocity setpoint

The desired velocity setpoint is specified to the module (microsteps per cycle).

Observing the maximum permissible acceleration, the motor moves with a ramp to the desired speed setpoint and maintains this speed until a new speed setpoint is specified.

## Position mode

A position setpoint is specified. The motor is then moved to this new position. This is done with a ramp function that accounts for the defined maximum speed and acceleration values.

The position setpoint can also be changed during an active positioning procedure.

The position setpoint is specified in microsteps (1/256 of a full step).

How the position is applied can be controlled in the configuration by bit 0:

- If bit 0 equals 0 (no extended control word), the position setpoint will be applied as soon as it is not equal to the current position. The new position is then used for the movement.
- If bit 0 equals 1, the position setpoint is accepted as described in "Extended control word".

## Extended position mode

Position mode with extended control word behaves like the previously described position mode (without the extended control word), but the new position setpoint is applied according to the extended control word.

## Extended control word

Additional commands can be sent depending on the state of the module:

- (Do not) Apply the new target position.
- Process or interrupt the current positioning and start the next positioning.
- Define the target position as an absolute or relative value.
- Stopping a movement

## Relative position setting

If bit *abs / rel* in extended control word is set, then the target position is interpreted as a relative value. At each New setpoint trigger, the target position will be increased by this value (or decreased if the value is negative).

If the mode changes between the position settings, relative movement will then proceed starting at the last specified position. The position setpoint mode is initialized with 0 when the module is started.

## Specifying the target position

The target position can be defined in 2 different ways:

| Type of setpoint definition | Description                                                                                                                                                                                                                                                     |
|-----------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Single setpoint             | After the target position is reached, bit Target reached is set in the status word. A new target position (setpoint) is then defined. The drive stops at each target position before starting the movement to the next target position.                         |
| Set of setpoints            | After the target position has been reached, the movement to the next target position is started immediately without stopping the drive. It is therefore possible to initiate a new positioning by specifying another target position during active positioning. |

The two options "Single setpoint" and "Set of setpoints" are controlled by the timing of bits *New setpoint* and *Change set immediately* in the extended control word and *Setpoint acknowledge* in the extended status word register.

These bits can be used to create a Request-Response mechanism. This makes it possible to specify a target position while a previous position specification is still being processed.

## Specifying the target position

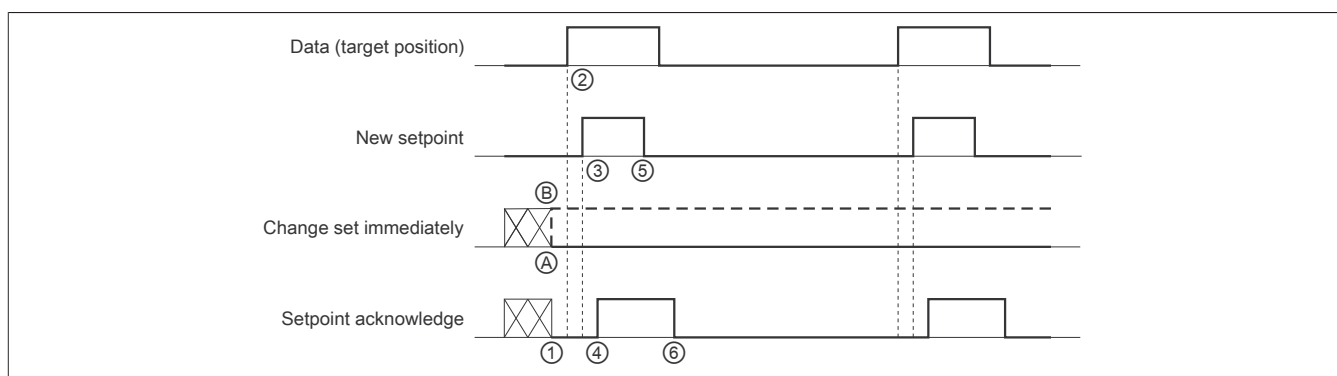


Figure 2: Principle for applying the setpoint

## Function description

### Transferring a new setpoint:

- 1) If bit Setpoint acknowledge in the extended status word is 0, the module will accept a new target position.
- 2) Specify the new target position.
- 3) A rising edge on bit New setpoint in the extended control word indicates that the new target position is valid and can be used for the next positioning movement.
- 4) After the module has received and saved the new target position, bit Setpoint acknowledge is set to 1 in register Status word.
- 5) Now the controller can reset the New setpoint bit to 0.
- 6) Then the module resets bit Setpoint acknowledge to 0 to signal when a new target position is accepted.

### Position specification "Single setpoint"

If bit Change set immediately is set to 0 (Ⓐ in figure "Principle for applying the setpoint"), then the module is operating with position specification Single setpoint. This mechanism results in a speed of 0 when the motor reaches target position  $x_1$  at time  $t_1$ . After the controller has been notified that the setpoint has been reached, the next target position  $x_2$  will be processed at time  $t_2$  and reached at  $t_3$ .

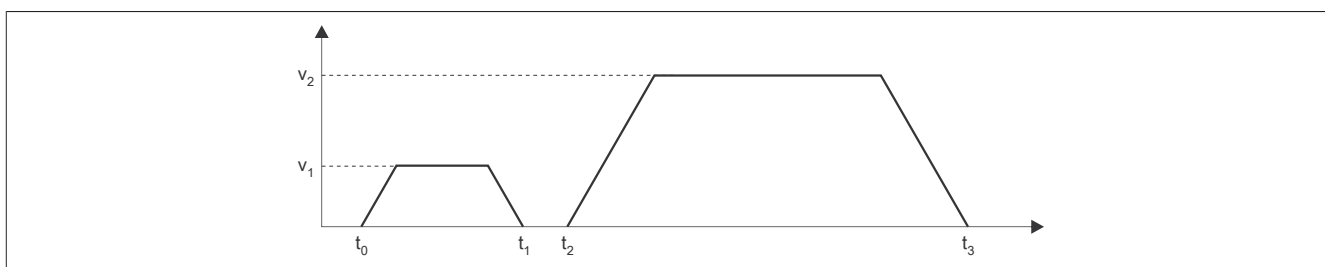


Figure 3: Ramp characteristics in mode Single setpoint

### Position specification "Set of setpoints"

If bit Change set immediately is set to 1 (Ⓑ in figure "Principle for applying the setpoint"), then the module is operating with position specification Set of setpoints. This means that the module receives the first target position at  $t_0$ . A second target position is received at time  $t_1$ . The drive immediately adapts the current movement to the new target position.

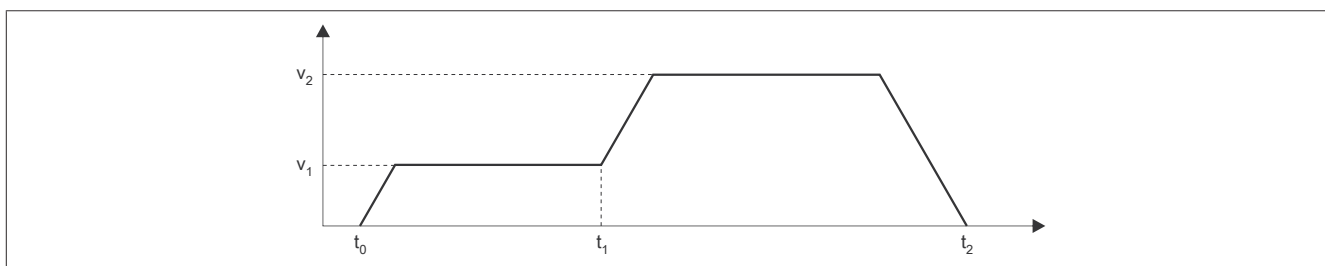


Figure 4: Ramp characteristics in mode Set of setpoints

### Home position with residual distance

In the event of a rising or falling edge on digital input 3, the current target position is discarded and only a set number of steps is moved forward or backward.

Negative values are also permitted for the set offset.

A new target position is no longer accepted after the trigger event. There must first be a switch made to mode 0 and then back to mode -121.

Bit "Target reached" in the status word is only set to 1 when the end position (after the trigger event) is reached.

The homing configuration defines whether a rising or falling edge of the digital input is used as a trigger.

The [reversing loop](#) is not active in this mode. Any configured values are ignored.

### Moving to the target position

A preset position setpoint is approached on a rising edge of digital input 3.

A changed position setpoint is only applied on a new rising edge of the associated digital input. This can also take place during the ongoing positioning process and is then immediately effective.

In addition, a [reversing loop](#) can be set.

### Moving to a fixed position

2 fixed positions can be transferred acyclically to the module that are approached differently depending on the mode.

- Mode -124:  
   "1" on digital input 3 moves to the first fixed position.  
   "0" on digital input 3 moves to the second fixed position.  
   Switching is possible during an active positioning procedure.
- Mode -125: Move to the first fixed position
- Mode -126: Move to the second fixed position

In addition, a [reversing loop](#) can be set.

### Applying the actual position

Before a position can be applied, the motor must be at a standstill and physically located at the point for which the position being set should be applied. The new position is applied when the state machine is in state "Operation enable".

Depending on the mode, the following positions can be applied:

- The set target position is applied as the current actual position in the internal position counter.
- The current actual position is modified such that the specified position exists at the reference. If moved to this position, the motor is at the home position. The home position in the referenced position register is also set to this value. Before this mode is called, the motor must be at a standstill and the home position must have been determined using the positive/negative homing mode.

### Reversing loop

This parameter is only available for absolute positioning.

A reversing loop can be used to avoid mechanical backlash and different movement tolerances.

If the value is not equal to 0, the target position is approached directly when coming from one direction; when coming from the other direction, the target position is initially overshoot by the configured number of steps before finally moving to the target position. The target position is therefore always approached from the same direction. The sign of the defined value determines the direction in which the reversing loop runs.

- Positive sign: Forward movement
- Negative sign: Backward movement

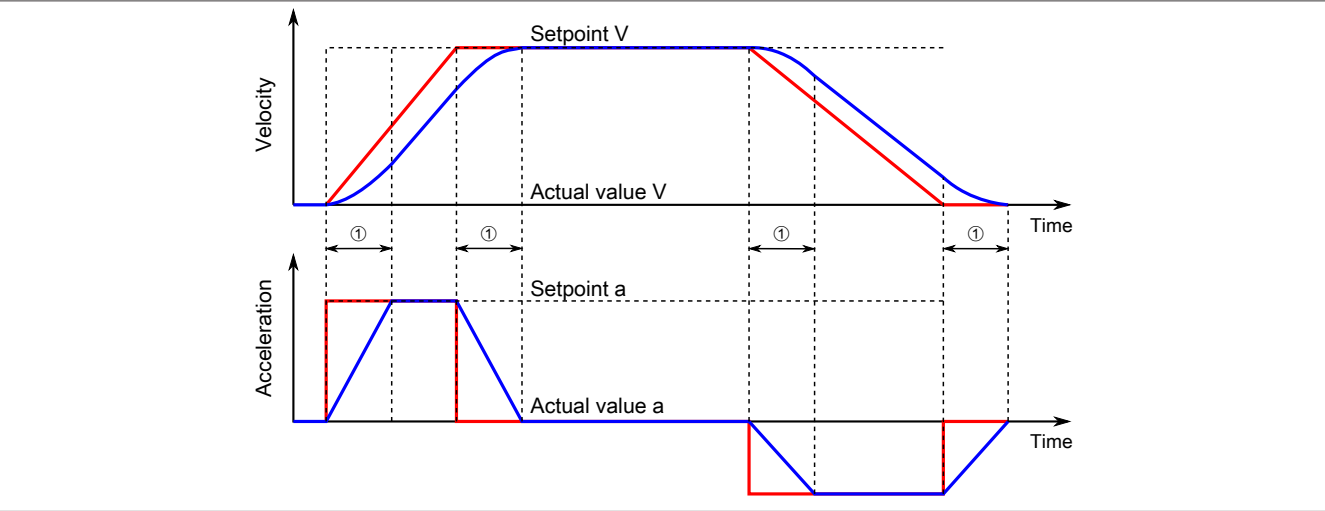
Function description

Jerk limitation

To avoid noticeable jumps when starting the motor or when the acceleration changes (e.g. from 1 m/s<sup>2</sup> to 3 m/s<sup>2</sup>), a jerk time (①) can be defined. This indicates the number of cycles during which the acceleration is adapted to the new setpoint. If more than 80 cycles are entered, they are limited to 80.

Changes made to the jerk time while the motor is running are only applied when the preset position is reached or the next motor standstill.

The following diagram shows the change of acceleration and speed with (blue line) and without (red line) jerk limitation time.



① Set jerk time in cycles

3.8 Counters

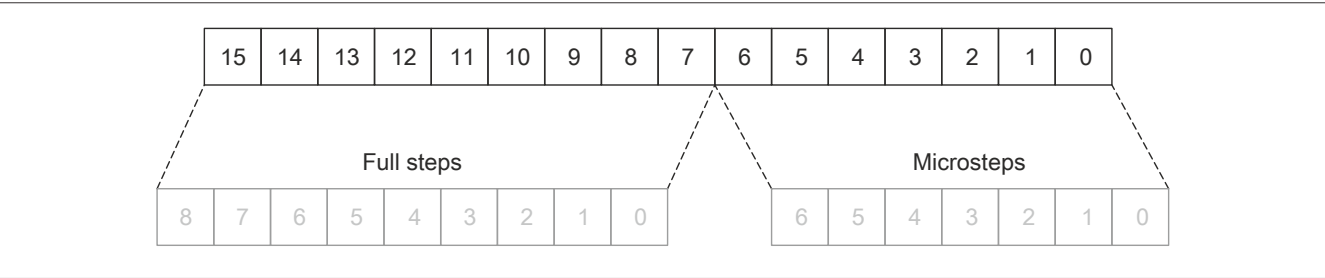
The module has 2 different modes that can be used to determine the position.

Internal position counter

The internal position counter is the position calculated by the module (position setpoint). This is a cyclic 16-bit counter.

The lowest 5 to 8 bits represent microsteps, and the higher bits represent full steps. In function model Standard with SDC, this value is defined as "8-bit microstep" and cannot be changed.

Example of the internal position counter format (7-bit microsteps, i.e. set bit 5 and 6 of the module configuration to binary 10):



ABR counter

This counter is a cyclic 16-bit counter. The relationship between this counter and the internal position counter depends on the resolution of the ABR encoder and the microsteps defined for the internal position counter.

To evaluate the counter values, latch events can be defined where the counter values are frozen and transferred to specific registers.

**Information:**

The registers are described in "Counter configuration" on page 47.

### 3.9 ABR interface and digital inputs

The module is equipped with 4 digital inputs that can perform different functions. Inputs DI1 to DI3 can also be used as an ABR interface.

#### Function model "Standard"

| Channel | Function      |  |               |
|---------|---------------|--|---------------|
| DI 1    | Digital input |  | A             |
| DI 2    | Digital input |  | B             |
| DI 3    | Digital input |  | R             |
| DI 4    | Digital input |  | Trigger input |

#### Function model "Ramp"

| Channel | Function      |               |                       |
|---------|---------------|---------------|-----------------------|
| DI 1    | Digital input | A             | A                     |
| DI 2    | Digital input | B             | B                     |
| DI 3    | Digital input | R             | Negative limit switch |
| DI 4    | Digital input | Digital input | Positive limit switch |

#### Open circuit

The module is equipped with open-circuit detection for the digital inputs. If the digital input is not connected to ground or to 24 V, an open circuit is detected.

### 3.10 Automatic shutdown

To prevent damage to the module or motor, both the voltage of the module power supply and the module temperature are monitored. In addition, the communication of the module with the controller can be monitored.

#### 3.10.1 Motor shutdown in the event of overvoltage

The module power supply voltage is monitored. Its status can be read. An error is reported in the event of a voltage greater or less than the limit values.

If the supply voltage in the module rises above the limit value, e.g. due to regenerative operation, or falls below the limit value, then the motor output is cut off.

If the supply voltage is within the permissible range again, the error must first be acknowledged. The output stage can then be switched on again.

#### Limit values for the supply voltage

|             | Drive cut off | Drive switched back on |
|-------------|---------------|------------------------|
| Lower limit | <17.4 V       | >17.8 V                |
| Upper limit | >60.3 V       | <58.6 V                |



#### Information:

The registers for the error message and acknowledgment are described in ["Input counter value" on page 56](#) and ["Error acknowledgment" on page 58](#).

#### 3.10.2 Overtemperature shutdown

If the module temperature reaches or overshoots the limit value, the module performs the following actions:

- Sets the "overtemperature" error bit
- The outputs are cut off.

As soon as the temperature is reduced below the module temperature limit value again, the error must first be acknowledged so that the channels can be switched on again.

| Module temperature limit value |
|--------------------------------|
| 116°C                          |



#### Information:

The registers for the error message and acknowledgment are described in ["Error status" on page 57](#) and ["Error acknowledgment" on page 58](#).

### 3.10.3 Monitoring the module communication

The communication between the module and controller can be monitored with SDC life sign monitoring.

After life sign monitoring is enabled, counter and timestamp information is exchanged and evaluated between the module and controller. If bit "SDC information" is additionally enabled, bit "EncOK01" is displayed in the Automation Studio I/O mapping. This bit is permanently linked to bit ModulOK and always indicates its value.

If the [NetTime timestamp](#) specified by the controller is in the past, then an error is triggered for the motor axis (only when the motor is switched on). The module performs the following steps:

- 1) The controller is informed of the error using the drive bit (DrvOK) = 0.
- 2) Braking at the configured nominal current with speed setpoint = 0
- 3) Wait for the configured switch-off delay to expire
- 4) Switch off the motor current

When the timestamp is back within the valid range, the motor can be started up again by a rising edge on bit DriveEnable.



#### Information:

The registers for the configuration are described in ["SDC configuration" on page 46](#) and ["Motor current" on page 54](#).

### 3.11 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.



#### 3.11.1 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  $\mu$ s; an overflow occurs after 71 min, 34 s, 967 ms and 296  $\mu$ s.

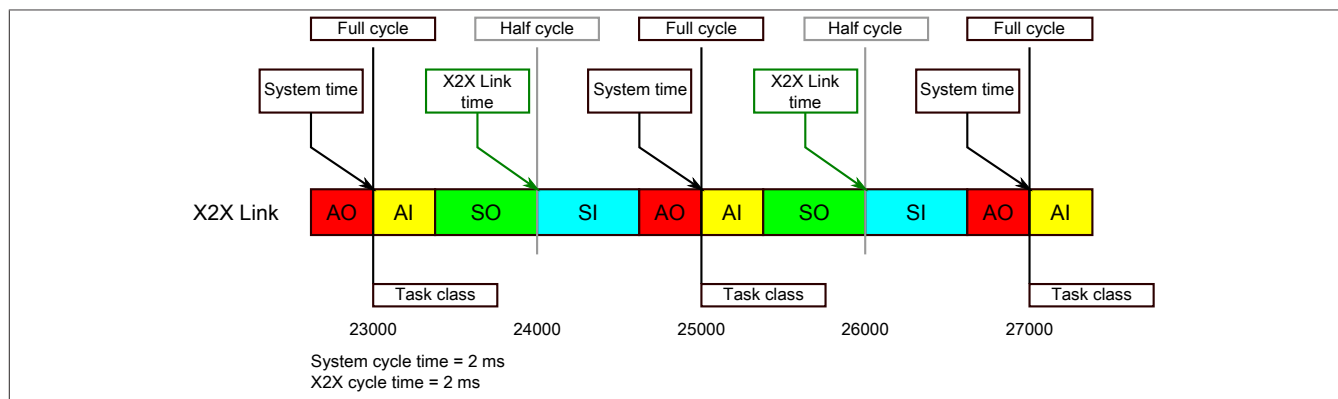
The initialization of the times is based on the system time during the startup of the X2X Link, the I/O modules or the POWERLINK interface.

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

##### 3.11.1.1 Controller data points

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

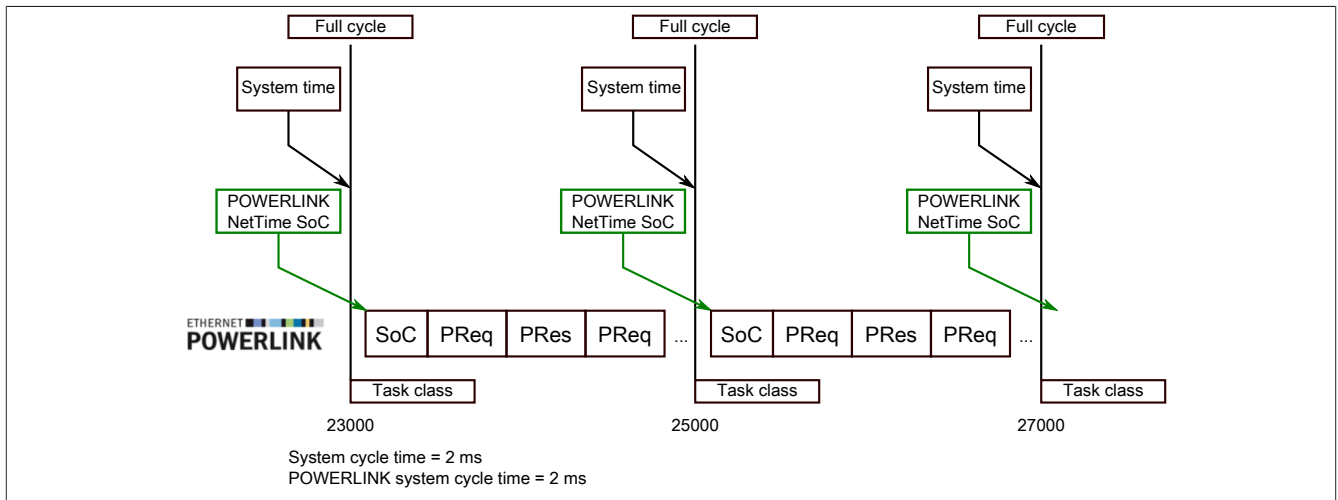
##### 3.11.1.2 X2X Link - Reference time point



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.

### 3.11.1.3 POWERLINK - Reference time point

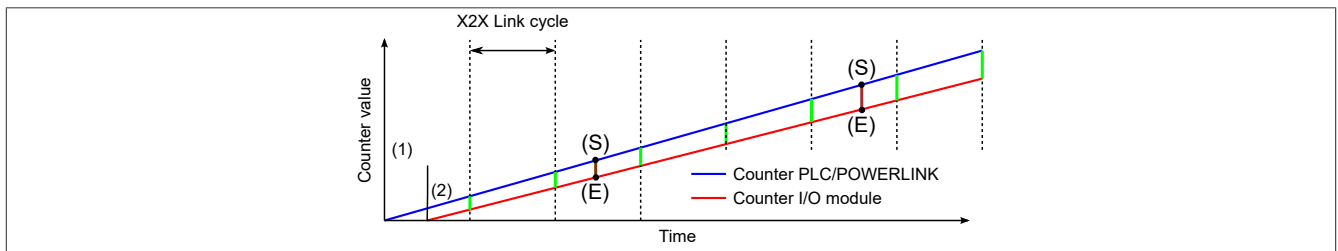


The POWERLINK reference time point is always calculated at the start of cycle (SoC) of the POWERLINK network. The SoC starts 20 μs after the system clock due to the system. This results in the following difference between the system time and the POWERLINK reference time:

POWERLINK reference time = System time - POWERLINK cycle time + 20 μs

In the example above, this means a difference of 1980 μs, i.e. if the system time and POWERLINK reference time are compared at time 25000 in the task, then the system time returns the value 25000 and the POWERLINK reference time returns the value 23020.

### 3.11.1.4 Synchronization of system time/POWERLINK time and I/O module



At startup, the internal counters for the controller/POWERLINK (1) and the I/O module (2) start at different times and increase the values with microsecond resolution.

At the beginning of each X2X Link cycle, the controller or POWERLINK network sends time information to the I/O module. The I/O module compares this time information with the module's internal time and forms a difference (green line) between the two times and stores it.

When a NetTime event (E) occurs, the internal module time is read out and corrected with the stored difference value (brown line). This means that the exact system moment (S) of an event can always be determined, even if the counters are not absolutely synchronous.

#### Note

The deviation from the clock signal is strongly exaggerated in the picture as a red line.

### 3.11.2 Timestamp functions

NetTime-capable modules provide various timestamp functions depending on the scope of functions. If a timestamp event occurs, the module immediately saves the current NetTime. After the respective data is transferred to the controller, including this precise moment, the controller can then evaluate the data using its own NetTime (or system time), if necessary.

For details, see the respective module documentation.

#### 3.11.2.1 Time-based inputs

NetTime Technology can be used to determine the exact moment of a rising edge at an input. The rising and falling edges can also be detected and the duration between 2 events can be determined.

**Information:**

**The determined moment always lies in the past.**

#### 3.11.2.2 Time-based outputs

NetTime Technology can be used to specify the exact moment of a rising edge on an output. The rising and falling edges can also be specified and a pulse pattern generated from them.

**Information:**

**The specified time must always be in the future, and the set X2X Link cycle time must be taken into account for the definition of the moment.**

#### 3.11.2.3 Time-based measurements

NetTime Technology can be used to determine the exact moment of a measurement that has taken place. Both the starting and end moment of the measurement can be transmitted.

# 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 2 analog logical slots on CAN I/O.

## 4.2 Setting full step limit values

A rotational speed is configured with the [Full step limit value](#). When the defined speed has been reached, the drive will automatically change from microstep to full step mode. This makes it possible to optimize the torque at higher speeds, while microstep mode ensures optimal radial runout at lower speeds.

It does not make sense to switch to full step mode at a standstill since fine positioning would then no longer be possible. For this reason, the value 0 is interpreted as deactivating full step mode, i.e. the motor is always operated in microstep mode.

### Example

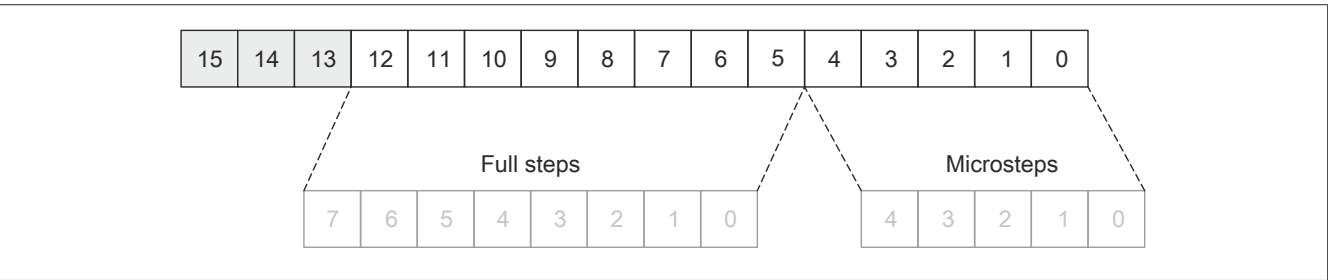
Microstep mode should change to full step mode at 500 steps/second. A [Full step limit value](#) of 500 for a motor with 200 steps/revolution corresponds to a speed of:

$$T^{-1} = \frac{500 \text{ steps/second}}{200 \text{ steps/rotation}} = 2.5 \frac{\text{rotations}}{\text{second}} = 150 \text{ min}^{-1}$$

### Setting the microsteps

Depending on the required resolution and maximum configurable speed, bits 5 and 6 of the [module configuration](#) can be used to set the bit position at which the 1s position of the full steps starts.

Example for 5-bit microsteps, i.e. bits 5 and 6 of the module configuration are set to binary 00:



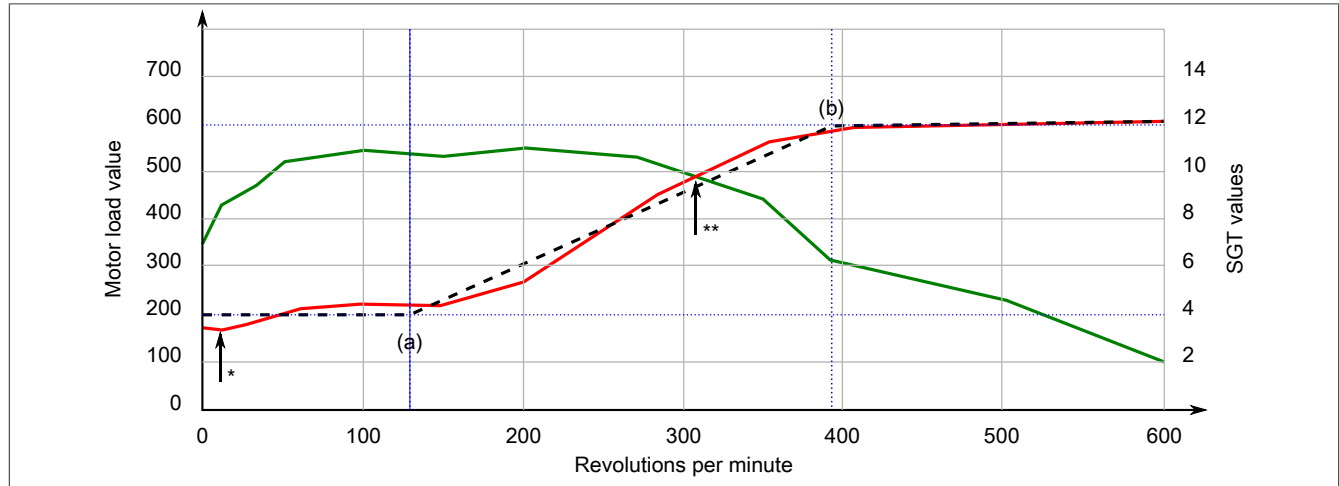
(For the meaning of bits 13 to 15, see ["Motor settings" on page 54.](#))

### 4.3 Configuring the motor load curve

Creating a motor load characteristic curve is helpful to set the points (SGT\_Value01a and SGT\_Value01b) for the offset of the motor load value.

In the following example, assuming 200 steps per revolution results in the following values:

|           | SGT_Value | SGT_Speed                                  |
|-----------|-----------|--------------------------------------------|
| Value (a) | 4         | 129 revolutions/minute = 430 steps/second  |
| Value (b) | 12        | 392 revolutions/minute = 1307 steps/second |



#### Legend

- Green line Motor load characteristic curve without load
- Red line Offset-corrected motor load characteristic curve
- Black line Interpolated motor load characteristic curve
- \* Minimum speed for stall detection (>10 rpm)
- \*\* Back EMF reaches supply voltage

Since the back EMF increases with increasing speed (motor load value decreases to 0) and counteracts, there is a maximum speed for stall detection.



#### Information:

The registers are described in "[Motor identification](#)" on page 53 .

## 4.4 Configuring the SCT values / stall detection

### 4.4.1 Stall detection for variable speeds

If stall detection is needed for a range of speeds ([SGT\\_Speed01a](#) and [SGT\\_Speed01b](#)), the module can be configured as follows:

- 1) Set the initial values.
  - Disable current control. ([CurrentControlEnabel01](#) = 0)
  - Disable stall detection. ([StallDetectMinSpeed01](#) = 65535)
  - Set register [SGT\\_Speed01x](#) to 0.
  - Set register [SGT\\_Value01x](#) to 0.
- 2) Operate the motor at the start of the speed range ([SGT\\_Speed01a](#)) without load and observe the [motor load value](#).
- 3) Adjust the value.
  - a) Slowly increase the load on the motor. If the motor stops before the [motor load value](#) indicates 0, reduce [SGT\\_Value01x](#) by 1.
  - b) If the motor load value is 0 before the motor stops, increase [SGT\\_Value01x](#) by 1.  
The optimal setting is achieved when the motor load value remains above 0 at the maximum load necessary. If the value becomes 0, the maximum load on the motor is exceeded. In this case, bit 0 "StallError" is set in register [Error status](#).
- 4) Operate the motor at the end of the speed range ([SGT\\_Speed01b](#)) without load and observe the [motor load value](#).
- 5) Adjust the values, see item 3).
- 6) Set the determined range values.  
The [SGT\\_Value0x](#) values between the range start and range end are interpolated linearly.
  - Set [SGT\\_Value01a](#) and [SGT\\_Speed01a](#) for the range start with the determined values.
  - Set [SGT\\_Value01b](#) and [SGT\\_Speed01b](#) for the range end with the determined values.
- 7) In register [StallDetectMinSpeed01](#), set the speed value from which stall detection is enabled.

### 4.4.2 Stall detection for constant speed

If stall detection is only needed for a constant speed, the module can be configured as follows:

- 1) Set the initial values.
  - Disable current control. ([CurrentControlEnabel01](#) = 0)
  - Disable stall detection. ([StallDetectMinSpeed01](#) = 65535)
  - Set register [SGT\\_Speed01x](#) to 0.
  - Set register [SGT\\_Value01x](#) to 0.
- 2) Operate the motor at the speed needed for the application without load and observe the [motor load value](#).
- 3) Adjust the value.
  - a) Slowly increase the load on the motor. If the motor stops before the [motor load value](#) indicates 0, reduce [SGT\\_Value01x](#) by 1.



#### Information:

**Registers [SGT\\_Value01a](#) and [SGT\\_Value01b](#) must always be set to the same value!**

- b) If the motor load value is 0 before the motor stops, increase [SGT\\_Value01x](#) by 1.  
The optimal setting is achieved when the motor load value remains above 0 at the maximum load necessary. If the value becomes 0, the maximum load on the motor is exceeded. In this case, bit 0 "StallError" is set in register [Error status](#).
- 4) In register [StallDetectMinSpeed01](#), set the speed value from which stall detection is enabled.

## 4.5 Operating function model "Ramp"

Commands for controlling the module are written to the ["Control word" on page 66](#). In register ["Status word" on page 67](#), the current state of the module is reported. The function mode (absolute position, constant speed, homing, etc.) is set in the ["mode register" on page 63](#).

### 4.5.1 Structure of the control word

Control word bits and their state for the commands of the state machine:

| Command           | Stall detection | Encoder position sync/async | Current error detection | Warning reset | Motor ID trigger | Reserved | CurrentControlEnable | Stop | Fault reset | Mode-specific | Mode-specific | Mode-specific | Enable operation | Quick stop | Enable voltage | Switch on |
|-------------------|-----------------|-----------------------------|-------------------------|---------------|------------------|----------|----------------------|------|-------------|---------------|---------------|---------------|------------------|------------|----------------|-----------|
| Bit <sup>1)</sup> | 15              | 14                          | 13                      | 12            | 11               | 10       | 9                    | 8    | 7           | 6             | 5             | 4             | 3                | 2          | 1              | 0         |
| Shutdown          | x               | x                           | x                       | x             | x                | 0        | 0                    | x    | 0           | x             | x             | x             | x                | 1          | 1              | 0         |
| Switch on         | x               | x                           | x                       | x             | x                | 0        | 0                    | x    | 0           | x             | x             | x             | 0                | 1          | 1              | 1         |
| Disable voltage   | x               | x                           | x                       | x             | x                | 0        | 0                    | x    | 0           | x             | x             | x             | x                | x          | 0              | x         |
| Quick stop        | x               | x                           | x                       | x             | x                | 0        | 0                    | x    | 0           | x             | x             | x             | x                | 0          | 1              | x         |
| Disable operation | x               | x                           | x                       | x             | x                | 0        | 0                    | x    | 0           | x             | x             | x             | 0                | 1          | 1              | 1         |
| Enable operation  | x               | x                           | x                       | x             | x                | 0        | 0                    | x    | 0           | x             | x             | x             | 1                | 1          | 1              | 1         |
| Fault reset       | x               | x                           | x                       | x             | x                | 0        | 0                    | x    | ↑           | x             | x             | x             | x                | x          | x              | x         |

1) x ... Any, ↑ ... Rising edge

|                                                             |                                                                                                                                                                                                                                                                                                                                                                                                      |
|-------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Bits 0, 1, 2, 3 and 7<br>(light gray in the previous table) | These bits control the state of the <a href="#">State machine</a> according to the commands in the table above.                                                                                                                                                                                                                                                                                      |
| Fault reset                                                 | A rising edge resets errors and warnings (see <a href="#">"State machine" on page 37</a> )                                                                                                                                                                                                                                                                                                           |
| Stop                                                        | 0 ... Perform motor movement<br>1 ... Stop axis with deceleration<br><br>This bit is only evaluated when the extended control word is enabled in register <a href="#">"General configuration" on page 49</a> .                                                                                                                                                                                       |
| CurrentControlEnable                                        | 0 ... Load-dependent current control disabled<br>1 ... Load-dependent current control enabled                                                                                                                                                                                                                                                                                                        |
| Motor ID trigger                                            | A rising edge enables the motor ID measurement.                                                                                                                                                                                                                                                                                                                                                      |
| Warning reset                                               | A rising edge resets warnings (no effect on errors, which are reset using "Fault reset"; the state machine is not affected by this bit).                                                                                                                                                                                                                                                             |
| Current error detection                                     | 0 ... Current error detection disabled<br>1 ... Current error detection enabled                                                                                                                                                                                                                                                                                                                      |
| Encoder position sync/async                                 | 0 ... Value of the ABR counter on register <a href="#">"Current position (acyclic)" on page 69</a> .<br>Internal position counter of the ramp generator on register "Current position (cyclic)".<br>1 ... Value of the ABR counter on register <a href="#">"Current position (cyclic)" on page 69</a> .<br>Internal position counter of the ramp generator on register "Current position (acyclic)". |
| Stall detection                                             | 0 ... Stall detection disabled<br>1 ... Stall detection enabled                                                                                                                                                                                                                                                                                                                                      |

## 4.5.2 Structure of the status word

The individual bits of this register and its states depend on the current state of the state machine:

| Status                 | Reserved | Reserved | Reserved | Reserved | Int. limit active | Target reached | Remote | Reserved | Warning | Switch on disabled | Quick stop | Voltage enabled | Fault | Operation enabled | Switched on | Ready to switch on |
|------------------------|----------|----------|----------|----------|-------------------|----------------|--------|----------|---------|--------------------|------------|-----------------|-------|-------------------|-------------|--------------------|
| Bit                    | 15       | 14       | 13       | 12       | 11                | 10             | 9      | 8        | 7       | 6                  | 5          | 4               | 3     | 2                 | 1           | 0                  |
| Not ready to switch on | x        | x        | x        | x        | x                 | x              | 1      | 0        | x       | 0                  | x          | 0               | 0     | 0                 | 0           | 0                  |
| Switch-on disabled     | x        | x        | x        | x        | x                 | x              | 1      | 0        | x       | 1                  | x          | 0               | 0     | 0                 | 0           | 0                  |
| Ready to switch on     | x        | x        | x        | x        | x                 | x              | 1      | 0        | x       | 0                  | 1          | 0               | 0     | 0                 | 0           | 1                  |
| Switched on            | x        | x        | x        | x        | x                 | x              | 1      | 0        | x       | 0                  | 1          | 1               | 0     | 0                 | 1           | 1                  |
| Operation enable       | x        | x        | x        | x        | x                 | x              | 1      | 0        | x       | 0                  | 1          | 1               | 0     | 1                 | 1           | 1                  |
| Quick stop active      | x        | x        | x        | x        | x                 | x              | 1      | 0        | x       | 0                  | 0          | 1               | 0     | 1                 | 1           | 1                  |
| Fault reaction active  | x        | x        | x        | x        | x                 | x              | 1      | 0        | x       | 0                  | x          | 0               | 1     | 1                 | 1           | 1                  |
| Fault                  | x        | x        | x        | x        | x                 | x              | 1      | 0        | x       | 0                  | x          | 0               | 1     | 0                 | 0           | 0                  |

Information about the status word:

|                                                                                                         |                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |                                                                     |
|---------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------|
| Bits 0, 1, 2, 3, 5 and 6<br>(light gray in the previous table)                                          | These bits are set according to the current state of the <a href="#">State machine</a> .                                                                                                                                                                                                                                                                                                                                                                                      |                                                                     |
| Voltage enabled                                                                                         | Becomes 1 as soon as the motor is powered                                                                                                                                                                                                                                                                                                                                                                                                                                     |                                                                     |
| Warning                                                                                                 | Becomes 1 if a warning is detected ("Overcurrent", "Undercurrent"). The type of warning is indicated in register " <a href="#">Error code</a> " on <a href="#">page 68</a> . The highest priority error / warning is shown in each case, with the priority corresponding to the order in the respective table. Warnings can be reset with a rising edge on the "Warning reset" bit in the control word.                                                                       |                                                                     |
| Remote                                                                                                  | Always 1                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |                                                                     |
| Target reached <sup>1)</sup> , depends on bit 8 (Stop) in <a href="#">Structure of the control word</a> | <b>If stop = 0</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                            | <b>If stop = 1</b>                                                  |
|                                                                                                         | <b>In modes 1, -123, -124, -125 and -126 (absolute positioning):</b><br>0...Positioning begins<br>1...Target has been reached<br><br><b>In mode 2 (constant speed):</b><br>0...Motor accelerates/brakes<br>1...Speed setpoint reached<br><br><b>In modes -127 and -128 (homing):</b><br>0...Homing started<br>1...Homing ended<br><br><b>In mode -122 (set actual position):</b><br>The bit briefly becomes 0 and immediately becomes 1 again as soon as the position is set. | <b>In all modes:</b><br>0...Axis decelerating<br>1...Axis speed = 0 |
| Internal limit active                                                                                   | 0 ... No limit violation<br>1 ... Internal limit is active (upper/lower software limit violated)                                                                                                                                                                                                                                                                                                                                                                              |                                                                     |

1) If the extended control word in register ["General configuration" on page 49](#) was not enabled, "Target reached" behaves the same as if "Stop = 0".

### 4.5.3 State machine

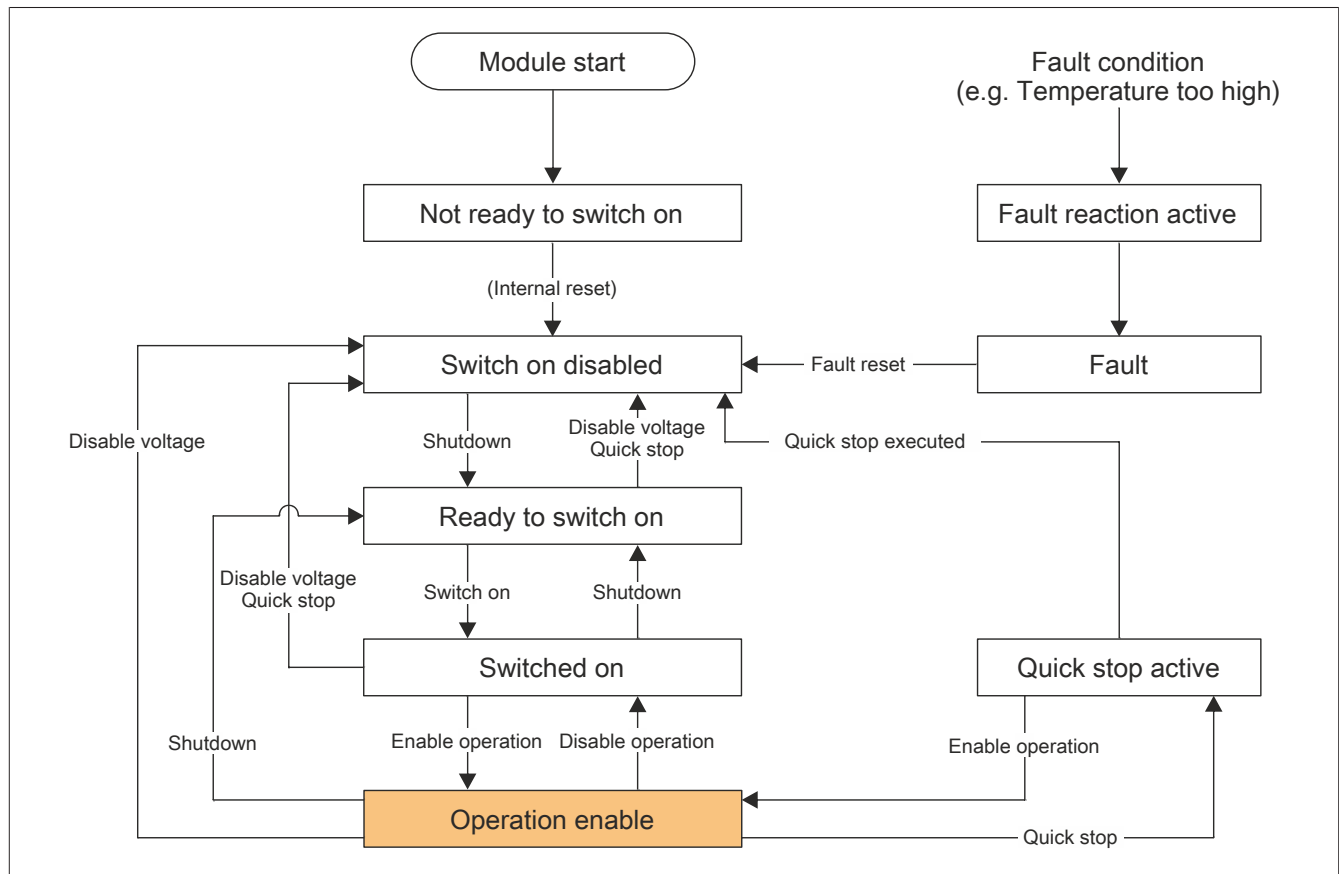
Control of the motor takes place according to the state machine illustrated below. After the module is started, the state machine automatically changes to state "Not ready to switch on". The application then operates the state machine by writing commands to the ["Control word" on page 66](#).

The state machine successively reaches states "Ready to switch on", "Switched on" and "Operation enable" by writing the consecutive commands "Shutdown", "Switch on" and "Enable operation".



#### Information:

**Motor movements are performed according to the setting in register ["Mode" on page 63](#) only in state "Operation enable".**



## Commissioning

| State change                                   | Description                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |
|------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Not ready to switch on<br>→ Switch on disabled | This state change occurs automatically after starting the module and internal initialization has taken place.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |
| Switch on disabled<br>→ Ready to switch on     | This state change is initiated by command <code>Shutdown</code> .<br>No others actions are performed.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |
| Ready to switch on<br>→ Switch on disabled     | This state change is initiated by command <code>Disable voltage</code> or <code>Quick stop</code> .<br>No others actions are performed.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |
| Switched on<br>→ Switch on disabled            | This state change is initiated by command <code>Disable voltage</code> or <code>Quick stop</code> .<br>The motor voltage is switched off immediately.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |
| Ready to switch on<br>→ Switched on            | This state change is initiated by command <code>Switch on</code> .<br>The motor voltage is switched on.<br>When this state change occurs for the first time since the module is started, the motor ID measurement is performed before state <code>Switched on</code> is achieved. This can take approximately 1 second.                                                                                                                                                                                                                                                                                                                                                   |
| Switched on<br>→ Ready to switch on            | This state change is initiated by command <code>Shutdown</code> .<br>The motor voltage is switched off immediately.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |
| Switched on<br>→ Operation enable              | This state change is initiated by command <code>Enable operation</code> .<br>Motor movements are now performed depending on the defined mode.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |
| Operation enable<br>→ Switched on              | This state change is initiated by command <code>Disable operation</code> .<br>If in motion, the motor is decelerated with the configured deceleration.<br>Motor voltage remains on in state <code>Switched on</code> .                                                                                                                                                                                                                                                                                                                                                                                                                                                    |
| Operation enable<br>→ Ready to switch on       | This state change is initiated by command <code>Shutdown</code> .<br>The motor voltage is switched off immediately.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |
| Operation enable<br>→ Switch on disabled       | This state change is initiated by command <code>Disable voltage</code> .<br>Motor voltage switched off.<br>It is strongly recommended to only make this state change on a stopped motor since regeneration on a motor running at no load can cause an overvoltage error on the DC bus (0x3210).                                                                                                                                                                                                                                                                                                                                                                           |
| Operation enable<br>→ Quick stop active        | This state change is initiated by command <code>Quick stop</code> .<br>If in motion, the motor is decelerated with the configured deceleration. During the deceleration, the state machine remains in state <code>Quick stop active</code> . If the motor comes to standstill, the switch to state <code>Switch on disabled</code> takes place automatically.<br>While the state machine is in state <code>Quick stop active</code> , command <code>Enable operation</code> can be used to switch back to state <code>Operation enable</code> .                                                                                                                           |
| → Fault reaction active                        | This state change is brought on when an error occurs and cannot be triggered by a command from the user. It can be triggered by an error type classified as "Error" (see "Error code" on page 68). (Other error types listed as a "warning" only cause bit "Warning" to be set in the status word and do not cause a state change in the state machine.)<br>The motor voltage is cut off, and the state machine then changes immediately to state <code>Fault</code> .<br>The error type is listed in the error code register (see table in "Error code" on page 68). The highest priority error is shown. The priority corresponds to the order in the error code table. |
| Fault<br>→ Switch on disabled                  | This state change is initiated by command <code>Fault reset</code> . However, the state only changes if no more errors are present when the command is written. All errors and warnings are reset. The error code register contains 0 or the warning code if a warning is still present.                                                                                                                                                                                                                                                                                                                                                                                  |

## 5 Register description

### 5.1 mapp Motion system requirements

This module can be operated with mapp Motion function blocks. The following minimum versions are required for this:

- Automation Studio: 4.7.2
- Automation Runtime: 4.72
- mapp Technology Package: mapp Motion 5.9
- Hardware module upgrade: 2.2.0.0

### 5.2 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.

### 5.3 Function model 0 - Standard

| Register                       | Name                                    | Data type | Read   |         | Write  |         |
|--------------------------------|-----------------------------------------|-----------|--------|---------|--------|---------|
|                                |                                         |           | Cyclic | Acyclic | Cyclic | Acyclic |
| Configuration                  |                                         |           |        |         |        |         |
| Module / Motor configuration   |                                         |           |        |         |        |         |
| 46                             | ConfigOutput02 (module configuration 1) | UINT      |        |         |        | •       |
| Configure currents             |                                         |           |        |         |        |         |
| 33                             | ConfigOutput03 (holding current)        | USINT     |        |         |        | •       |
| 34                             | ConfigOutput04 (nominal current)        | USINT     |        |         |        | •       |
| 35                             | ConfigOutput05 (maximum current)        | USINT     |        |         |        | •       |
| Counter configuration          |                                         |           |        |         |        |         |
| 32                             | ConfigOutput09 (counter configuration)  | USINT     |        |         |        | •       |
| Stall detection                |                                         |           |        |         |        |         |
| 84                             | FullStepThreshold01                     | UINT      |        |         |        | •       |
| 92                             | StallDetectMinSpeed01                   | UINT      |        |         |        | •       |
| Load-dependent current control |                                         |           |        |         |        |         |
| 130                            | CfO_SmartEnable01                       | UINT      |        |         |        | •       |
| SGT configuration              |                                         |           |        |         |        |         |
| 120                            | SGT_Speed01a                            | UINT      |        |         |        | •       |
| 122                            | SGT_Speed01b                            | UINT      |        |         |        | •       |
| 124                            | SGT_Value01a                            | INT       |        |         |        | •       |
| 126                            | SGT_Value01b                            | INT       |        |         |        | •       |
| Reading back the configuration |                                         |           |        |         |        |         |
| 33                             | ConfigOutput03Read (holding current)    | USINT     |        | •       |        |         |
| 34                             | ConfigOutput04Read (nominal current)    | USINT     |        | •       |        |         |
| 35                             | ConfigOutput05Read (maximum current)    | USINT     |        | •       |        |         |
| Communication                  |                                         |           |        |         |        |         |
| Motor detection                |                                         |           |        |         |        |         |
| 81                             | MotorIdentTrigger                       | USINT     |        |         |        | •       |
| 12                             | Motoridentification01                   | UINT      |        | •       |        |         |
| 74                             | MotorLoad                               | UINT      | •      |         |        |         |
| Motor control                  |                                         |           |        |         |        |         |
| 54                             | Load-dependent current control          | USINT     |        |         | •      |         |
|                                | CurrentControlEnable                    | Bit 7     |        |         |        |         |
| Index* 2 + 16                  | MotorStepN (index N = 0 to 3)           | UINT      |        |         | •      |         |
| Input state                    |                                         |           |        |         |        |         |
| 4                              | Input counter value                     | USINT     | •      |         |        |         |
|                                | StatusInput01                           | Bit 2     |        |         |        |         |
|                                | ...                                     | ...       |        |         |        |         |
|                                | StatusInput04                           | Bit 5     |        |         |        |         |
| Error handling                 |                                         |           |        |         |        |         |
| 4                              | Module power supply error               | USINT     | •      |         |        |         |
|                                | ModulePowerSupplyError                  | Bit 0     |        |         |        |         |

## Register description

| Register          | Name                 | Data type | Read   |         | Write  |         |
|-------------------|----------------------|-----------|--------|---------|--------|---------|
|                   |                      |           | Cyclic | Acyclic | Cyclic | Acyclic |
| 10                | Error status         | USINT     | ●      |         |        |         |
|                   | StallError           | Bit 0     |        |         |        |         |
|                   | OvertemperatureError | Bit 1     |        |         |        |         |
|                   | CurrentError         | Bit 2     |        |         |        |         |
|                   | OvercurrentError     | Bit 3     |        |         |        |         |
|                   | OpenCircuit01        | Bit 12    |        |         |        |         |
|                   | ...                  | ...       |        |         |        |         |
|                   | OpenCircuit04        | Bit 15    |        |         |        |         |
| 54                | Error acknowledgment | USINT     |        |         | ●      |         |
|                   | ClearError           | Bit 5     |        |         |        |         |
| Positioning       |                      |           |        |         |        |         |
| 0                 | PositionSync         | INT       | ●      |         |        |         |
| 6                 | Positionasync        | UINT      |        | ●       |        |         |
| 86                | PositionSync02       | INT       | ●      |         |        |         |
| 60                | PositionLatchedSync  | INT       | ●      |         |        |         |
| 64                | PositionLatchedASync | INT       |        | ●       |        |         |
| Latch and trigger |                      |           |        |         |        |         |
| 54                | Latch configuration  | USINT     |        |         | ●      |         |
|                   | StartLatch           | Bit 0     |        |         |        |         |
|                   | TriggerEdgePos       | Bit 1     |        |         |        |         |
|                   | TriggerEdgeNeg       | Bit 2     |        |         |        |         |
|                   | TriggerEdge          | Bit 3     |        |         |        |         |
|                   | StartTrigger         | Bit 4     |        |         |        |         |
| 72                | Latch trigger status | USINT     | ●      |         |        |         |
|                   | LatchInput           | Bit 0     |        |         |        |         |
|                   | LatchDone            | Bit 1     |        |         |        |         |
|                   | TriggerInput         | Bit 4     |        |         |        |         |
| 68                | usSinceTrigger       | UINT      | ●      |         |        |         |

## 5.4 Function model 0 - Standard with SDC and function model MotionConfiguration

| Register                       | Name                                    | Data type | Read   |         | Write  |         |
|--------------------------------|-----------------------------------------|-----------|--------|---------|--------|---------|
|                                |                                         |           | Cyclic | Acyclic | Cyclic | Acyclic |
| Configuration                  |                                         |           |        |         |        |         |
| Module / Motor configuration   |                                         |           |        |         |        |         |
| 46                             | ConfigOutput02 (module configuration 1) | UINT      |        |         |        | •       |
| 102                            | SDCConfig01                             | USINT     |        |         |        | •       |
| 103                            | MotorSettlingTime01                     | USINT     |        |         |        | •       |
| 107                            | DelayedCurrentSwitchOff01               | USINT     |        |         |        | •       |
| Configure currents             |                                         |           |        |         |        |         |
| 33                             | ConfigOutput03 (holding current)        | USINT     |        |         |        | •       |
| 34                             | ConfigOutput04 (nominal current)        | USINT     |        |         |        | •       |
| 35                             | ConfigOutput05 (maximum current)        | USINT     |        |         |        | •       |
| Counter configuration          |                                         |           |        |         |        |         |
| 32                             | ConfigOutput09 (counter configuration)  | USINT     |        |         |        | •       |
| Stall detection                |                                         |           |        |         |        |         |
| 84                             | FullStepThreshold01                     | UINT      |        |         |        | •       |
| 92                             | StallDetectMinSpeed01                   | UINT      |        |         |        | •       |
| Load-dependent current control |                                         |           |        |         |        |         |
| 130                            | CfO_SmartEnable01                       | UINT      |        |         |        | •       |
| SGT configuration              |                                         |           |        |         |        |         |
| 120                            | SGT_Speed01a                            | UINT      |        |         |        | •       |
| 122                            | SGT_Speed01b                            | UINT      |        |         |        | •       |
| 124                            | SGT_Value01a                            | INT       |        |         |        | •       |
| 126                            | SGT_Value01b                            | INT       |        |         |        | •       |
| Reading back the configuration |                                         |           |        |         |        |         |
| 33                             | ConfigOutput03Read (holding current)    | USINT     |        | •       |        |         |
| 34                             | ConfigOutput04Read (nominal current)    | USINT     |        | •       |        |         |
| 35                             | ConfigOutput05Read (maximum current)    | USINT     |        | •       |        |         |
| Communication                  |                                         |           |        |         |        |         |
| Motor detection                |                                         |           |        |         |        |         |
| 81                             | MotorIdentTrigger                       | USINT     |        |         |        | •       |
| 12                             | Motoridentification01                   | UINT      |        | •       |        |         |
| 74                             | MotorLoad                               | UINT      | •      |         |        |         |
| Motor control                  |                                         |           |        |         |        |         |
| 100                            | Motor current                           | USINT     |        |         | •      |         |
|                                | DriveEnable01                           | Bit 0     |        |         |        |         |
|                                | BoostCurrent01                          | Bit 1     |        |         |        |         |
|                                | StandstillCurrent01                     | Bit 2     |        |         |        |         |
|                                | CurrentControlEnable01                  | Bit 7     |        |         |        |         |
| 16                             | Motor1Step0                             | INT       |        |         | •      |         |

| Register                 | Name                      | Data type | Read   |         | Write  |         |
|--------------------------|---------------------------|-----------|--------|---------|--------|---------|
|                          |                           |           | Cyclic | Acyclic | Cyclic | Acyclic |
| SDC life sign monitoring |                           |           |        |         |        |         |
| 112                      | SetTime01                 | INT       |        |         | •      |         |
| 73                       | LifeCnt                   | SINT      | •      |         |        |         |
| Input state              |                           |           |        |         |        |         |
| 4                        | Input counter value       | USINT     | •      |         |        |         |
|                          | StatusInput01             | Bit 2     |        |         |        |         |
|                          | ...                       | ...       |        |         |        |         |
|                          | StatusInput04             | Bit 5     |        |         |        |         |
| Error handling           |                           |           |        |         |        |         |
| 4                        | Module power supply error | USINT     | •      |         |        |         |
|                          | ModulePowerSupplyError    | Bit 0     |        |         |        |         |
| 10                       | Error status              | USINT     | •      |         |        |         |
|                          | StallError01              | Bit 0     |        |         |        |         |
|                          | OvertemperatureError01    | Bit 1     |        |         |        |         |
|                          | CurrentError01            | Bit 2     |        |         |        |         |
|                          | OvercurrentError01        | Bit 3     |        |         |        |         |
|                          | DrvOk01                   | Bit 4     |        |         |        |         |
|                          | OpenCircuit01             | Bit 12    |        |         |        |         |
|                          | ...                       | ...       |        |         |        |         |
|                          | OpenCircuit04             | Bit 15    |        |         |        |         |
| 54                       | Error acknowledgment      | USINT     |        |         | •      |         |
|                          | ClearError01              | Bit 5     |        |         |        |         |
| Homing                   |                           |           |        |         |        |         |
| 200                      | RefPulsePos01             | INT       | •      |         |        |         |
| 204                      | RefPulsePos01             |           |        |         |        |         |
| 212                      | RefPulseCnt01             | SINT      | •      |         |        |         |
| 214                      | RefPulseCnt01             |           |        |         |        |         |
| Positioning              |                           |           |        |         |        |         |
| 0                        | ActPos01                  | INT       | •      |         |        |         |
| 6                        | Positionasync             | UINT      |        | •       |        |         |
| 64                       | PositionLatchedAsync      | INT       |        | •       |        |         |
| 220                      | ActTime01                 | INT       | •      |         |        |         |
| Trigger                  |                           |           |        |         |        |         |
| 216                      | TriggerCnt01              | SINT      | •      |         |        |         |
| 208                      | TriggerTime01             | INT       | •      |         |        |         |

## 5.5 Function model 254 - "Bus controller" and function model 3 - "Ramp"

| Register                       | Offset <sup>1)</sup> | Name                                  | Data type | Read   |         | Write  |         |
|--------------------------------|----------------------|---------------------------------------|-----------|--------|---------|--------|---------|
|                                |                      |                                       |           | Cyclic | Acyclic | Cyclic | Acyclic |
| Configuration                  |                      |                                       |           |        |         |        |         |
| Configure currents             |                      |                                       |           |        |         |        |         |
| 48                             | -                    | ConfigOutput03a (holding current)     | USINT     |        |         |        | •       |
| 49                             | -                    | ConfigOutput04a (nominal current)     | USINT     |        |         |        | •       |
| 50                             | -                    | ConfigOutput05a (maximum current)     | USINT     |        |         |        | •       |
| Motion generator               |                      |                                       |           |        |         |        |         |
| 306                            | -                    | GeneralConfig01                       | USINT     |        |         |        | •       |
| 52                             | -                    | MaxSpeed01pos                         | UINT      |        |         |        | •       |
| 54                             | -                    | MaxAcc01                              | UINT      |        |         |        | •       |
| 56                             | -                    | MaxDec01                              | UINT      |        |         |        | •       |
| 58                             | -                    | RevLoop01                             | INT       |        |         |        | •       |
| 75                             | -                    | JoltTime01                            | USINT     |        |         |        | •       |
| 60                             | -                    | FixedPos01a                           | DINT      |        |         |        | •       |
| 64                             | -                    | FixedPos01b                           | DINT      |        |         |        | •       |
| Stall detection                |                      |                                       |           |        |         |        |         |
| 72                             | -                    | FullStepThreshold01                   | UINT      |        |         |        | •       |
| 74                             | -                    | StallRecognitionDelay01               | USINT     |        |         |        | •       |
| 78                             | -                    | StallDetectMinSpeed01                 | UINT      |        |         |        | •       |
| Homing                         |                      |                                       |           |        |         |        |         |
| 68                             | -                    | RefSpeed01                            | UINT      |        |         |        | •       |
| 70                             | -                    | RefConfig01                           | SINT      |        |         |        | •       |
| Limitations                    |                      |                                       |           |        |         |        |         |
| 308                            | -                    | LimitSwitchConfig01                   | USINT     |        |         |        | •       |
| 344                            | -                    | PositionLimitMin01                    | DINT      |        |         |        | •       |
| 348                            | -                    | PositionLimitMax01                    | DINT      |        |         |        | •       |
| Load-dependent current control |                      |                                       |           |        |         |        |         |
| 130                            | -                    | CfO_SmartEnable01                     | UINT      |        |         |        | •       |
| SGT configuration              |                      |                                       |           |        |         |        |         |
| 120                            | -                    | SGT_Speed01a                          | UINT      |        |         |        | •       |
| 122                            | -                    | SGT_Speed01b                          | UINT      |        |         |        | •       |
| 124                            | -                    | SGT_Value01a                          | INT       |        |         |        | •       |
| 126                            | -                    | SGT_Value01b                          | INT       |        |         |        | •       |
| Reading back the configuration |                      |                                       |           |        |         |        |         |
| 48                             | -                    | ConfigOutput03aRead (holding current) | USINT     |        | •       |        |         |
| 49                             | -                    | ConfigOutput04aRead (nominal current) | USINT     |        | •       |        |         |
| 50                             | -                    | ConfigOutput05aRead (maximum current) | USINT     |        | •       |        |         |
| Communication                  |                      |                                       |           |        |         |        |         |
| Motor detection                |                      |                                       |           |        |         |        |         |
| 84                             | -                    | Motoridentification01                 | UINT      |        | •       |        |         |
| 8                              | 8                    | MotorLoad                             | UINT      | •      |         |        |         |
| Motor control                  |                      |                                       |           |        |         |        |         |
| 6                              | 6                    | MpGenMode01                           | SINT      |        |         | •      |         |
| 82                             | -                    | ModeReadback01                        | SINT      |        | •       |        |         |
| 4                              | 4                    | MpGenControl01                        | UINT      |        |         | •      |         |
| 80                             | -                    | ControlReadback01                     | UINT      |        | •       |        |         |
| 4                              | 4                    | MpGenStatus01                         | UINT      | •      |         |        |         |
| Input state                    |                      |                                       |           |        |         |        |         |
| 6                              | 6                    | InputStatus                           | USINT     | •      |         |        |         |
| Error handling                 |                      |                                       |           |        |         |        |         |
| 98                             | -                    | ErrorCode01                           | UINT      |        | •       |        |         |
| Homing                         |                      |                                       |           |        |         |        |         |
| 86                             | -                    | RefPos01CyclicCounter                 | DINT      |        | •       |        |         |
| 94                             | -                    | RefPos01AcyclicCounter                | DINT      |        | •       |        |         |
| Positioning and speed          |                      |                                       |           |        |         |        |         |
| 0                              | 0                    | AbsPos01                              | DINT      |        |         | •      |         |
| 0                              | 0                    | AbsPos01ActVal                        | INT       | •      |         |        |         |
| 90                             | -                    | AbsPos1ActValAcyclic                  | DINT      |        | •       |        |         |

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

## 5.6 All function models - Configuration registers

### 5.6.1 Load-dependent current control

#### 5.6.1.1 Configuring current control

Name:

CfO\_SmartEnable01

The values for load-dependent current control can be set in this register. In order to save energy, the power supply can thus be reduced to a minimum of 25% of the nominal current when the motor load is low.

For increased motor loads, the module automatically adjusts the power supply according to the set values.

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

Bit structure:

| Bit     | Name                           | Value   | Information                                                              |
|---------|--------------------------------|---------|--------------------------------------------------------------------------|
| 0 - 3   | MotorLoad_LowerLimit           | 0       | Current control disabled (bus controller default setting)                |
|         |                                | 1 to 15 |                                                                          |
| 4       | Reserved                       | 0       |                                                                          |
| 5 - 6   | Current increase <sup>1)</sup> | 0       | 1 measured values (bus controller default setting)                       |
|         |                                | 1       | 2 measured values                                                        |
|         |                                | 2       | 4 measured values                                                        |
|         |                                | 3       | 8 measured values                                                        |
| 7       | Reserved                       | 0       |                                                                          |
| 8 - 11  | MotorLoad_UpperLimit           | 0 to 15 |                                                                          |
| 12      | Reserved                       | 0       |                                                                          |
| 13 - 14 | Current decrease <sup>1)</sup> | 0       | 32 measured values (bus controller default setting)                      |
|         |                                | 1       | 8 measured values                                                        |
|         |                                | 2       | 2 measured values                                                        |
|         |                                | 3       | 1 measured value                                                         |
| 15      | Current reduction              | 0       | Reduction to 50% of the nominal current (bus controller default setting) |
|         |                                | 1       | Reduction to 25% of the nominal current                                  |

1) The measured values are recorded with each full step of the motor.

#### MotorLoad\_LowerLimit

Increase of the current up to a maximum of 100% of the nominal current set in register "ConfigOutput04" on page 47 if the motor load is less than (MotorLoad\_LowerLimit \* 32). If MotorLoad\_LowerLimit = 0, load-dependent current control is disabled.

#### Current increase

Specifies the number of motor load measured values that are less than or equal to the limit value (MotorLoad\_LowerLimit \* 32) in order to increase current.

#### MotorLoad\_UpperLimit

Reduces the current if the motor load is greater than (MotorLoad\_LowerLimit + MotorLoad\_UpperLimit + 1) \* 32.

#### Current decrease

Number of motor load measured values that are greater than or equal to the limit value (MotorLoad\_LowerLimit + MotorLoad\_UpperLimit + 1) \* 32 in order to decrease the current.

#### Current reduction

Maximum reduction of the current to 25% or 50% of the nominal current.

## 5.6.2 SGT configuration

### 5.6.2.1 SGT speed

Name:

SGT\_Speed01a to SGT\_Speed01b

The associated speed value for the respective [SGT\\_Value](#) can be set in these registers.

| Data type | Values     | Information                                                                                                                             |
|-----------|------------|-----------------------------------------------------------------------------------------------------------------------------------------|
| UINT      | 0 to 65535 | In steps/second (function models Standard and MotionConfiguration)<br>In microsteps/cycle (function models "Bus controller" and "Ramp") |

### 5.6.2.2 SGT correction values

Name:

SGT\_Value01a to SGT\_Value01b

These registers optimize the motor load measurement.

The SGT value (stall guard threshold) optimizes the motor load measurement. A negative value increases the sensitivity of the measurement; a positive value decreases it.

The correction value used depends on the value of [SGT\\_Speed](#). The following applies:

- SGT\_Value0xa is used if the motor speed  $\leq$  SGTSpeed0xa.
- SGT\_Value0xb is used if the motor speed  $\geq$  SGTSpeed0xb.
- If the motor speed lies between the values, the SGT\_Value is interpolated linearly.

The initial value for the optimization is 0. Values below -10 or over +10 should not be used.

| Data type | Values    |
|-----------|-----------|
| INT       | -64 to 63 |

## 5.7 Configuration registers - Function model 0 and function model MotionConfiguration

### 5.7.1 Module configuration

#### 5.7.1.1 Module configuration 1

Name:  
ConfigOutput02

The number of transfer values and the resolution of microsteps for the drive can be configured in this register.

| Data type | Values                 |
|-----------|------------------------|
| UINT      | See the bit structure. |

Bit structure:

| Bit    | Description                                                                                                                                                                      | Value | Information                                                                   |
|--------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------|-------------------------------------------------------------------------------|
| 0      | The setting for these two bits determines the meaning of bits 2 and 3 in register "Input counter value" on page 56.                                                              | x     |                                                                               |
| 1 - 2  | Reserved                                                                                                                                                                         | 0     |                                                                               |
| 3 - 4  | Number of transfer values per X2X Link cycle (see "Motor settings" on page 54)                                                                                                   | 00    | 1 x $\Delta s / \Delta t$ (transfer values: MotorStep0)                       |
|        |                                                                                                                                                                                  | 01    | 2 x $\Delta s / \Delta t$ (transfer values: MotorStep0 - MotorStep1)          |
|        |                                                                                                                                                                                  | 10    | 4 x $\Delta s / \Delta t$ (transfer values: MotorStep0 - MotorStep3)          |
|        |                                                                                                                                                                                  | 11    | Reserved                                                                      |
| 5 - 6  | Resolution of microsteps for the following registers:<br><ul style="list-style-type: none"> <li>"Motor settings" on page 54</li> <li>"Position sync/async" on page 59</li> </ul> | 00    | Resolution: 5 bits (bits 0 to 4) microsteps, 8 bits (bits 5 to 12) full steps |
|        |                                                                                                                                                                                  | 01    | Resolution: 6 bits (bits 0 to 5) microsteps, 7 bits (bits 6 to 12) full steps |
|        |                                                                                                                                                                                  | 10    | Resolution: 7 bits (bits 0 to 6) microsteps, 6 bits (bits 7 to 12) full steps |
|        |                                                                                                                                                                                  | 11    | Resolution: 8 bits (bits 0 to 7) microsteps, 5 bits (bits 8 to 12) full steps |
| 7 - 15 | Reserved                                                                                                                                                                         | 0     |                                                                               |

#### 5.7.1.2 Module configuration 1 with SDC

Register "Module configuration 1" on page 45 is ignored in function model "Standard" with SDC information enabled. The module behaves as follows, i.e. whether the module configuration was written in this way:

| Data type | Values                 |
|-----------|------------------------|
| UINT      | See the bit structure. |

Bit structure:

| Bit    | Description                                                          | Value | Information                                                      |
|--------|----------------------------------------------------------------------|-------|------------------------------------------------------------------|
| 0      | Meaning of bits 2 and 3 in register "Input counter value" on page 56 | x     |                                                                  |
| 1 - 2  | Reserved                                                             | 0     |                                                                  |
| 3 - 4  | Number of transfer values per X2X cycle                              | 00    | 1x $\Delta s / \Delta t$ (see register "Motor1Step0" on page 55) |
| 5 - 6  | Resolution of microsteps                                             | 11    | 8-bit microsteps                                                 |
| 7 - 15 | Reserved                                                             | 0     |                                                                  |

## Register description

### 5.7.1.3 SDC configuration

Name:  
SDCConfig01

This register can be used to enable or disable additional SDC information.

The additional cyclic registers are hidden or shown depending on whether SDC information is disabled or enabled. It is comparable to the two variants of function model "Standard" [with](#) and [without SDC information](#).

| Data type | Values                 |
|-----------|------------------------|
| USINT     | See the bit structure. |

Bit structure:

| Bit   | Description                              | Value | Information          |
|-------|------------------------------------------|-------|----------------------|
| 0     | Trigger edge                             | 0     | Rising trigger edge  |
|       |                                          | 1     | Falling trigger edge |
| 1 - 5 | Reserved                                 | 0     |                      |
| 6     | <a href="#">SDC life sign monitoring</a> | 0     | Disabled             |
|       |                                          | 1     | Enabled              |
| 7     | SDC information <sup>1)</sup>            | 0     | Disabled             |
|       |                                          | 1     | Enabled              |

- 1) If bit "SDC information" is enabled, bit "EncOK01" is displayed in the Automation Studio I/O mapping. This bit is permanently linked to bit ModulOK and always indicates its value.



#### Information:

**Neither SDC information nor SDC life sign monitoring is permitted to be changed at run-time.**

### 5.7.1.4 Motor settling time

Name:  
MotorSettlingTime01

This register determines the motor settling time. The motor settling time determines the minimum time between when the motor is powered on to when the DrvOk bit is set (see ["Error status" on page 57](#)). The setting is made in steps of 10 ms.

| Data type | Values   | Information                     |
|-----------|----------|---------------------------------|
| USINT     | 1 to 255 | 10 ms to 2.55 s, default: 10 ms |

### 5.7.1.5 Switch-off delay

Name:  
DelayedCurrentSwitchOff01

If the [SDC life sign monitoring](#) is triggered (i.e. the [NetTime timestamp](#) is in the past), the motor is decelerated at nominal current with speed setpoint = 0.

Then the motor is switched off after the delay configured with this register.

| Data type | Values   | Information                                      |
|-----------|----------|--------------------------------------------------|
| USINT     | 0 to 255 | 0 to 25.5 s in steps of 100 ms (default: 100 ms) |

## 5.7.2 Configuring currents

### 5.7.2.1 Holding current, nominal current and maximum current

Name:

ConfigOutput03 (holding current)

ConfigOutput04 (nominal current)

ConfigOutput05 (maximum current)

The holding current, nominal current and maximum current registers are used to configure the desired motor current.

| Register        | Description                                |
|-----------------|--------------------------------------------|
| Nominal current | Current during operation at constant speed |
| Maximum current | Current during acceleration phases         |
| Holding current | Current when motor at standstill           |

Switching between preset current values (holding current, rated current, maximum current):

| Function model                        | Switching between preset current values at runtime            |
|---------------------------------------|---------------------------------------------------------------|
| Standard                              | Using bits 14 and 15 in registers "Motor settings" on page 54 |
| Standard with enabled SDC information | Using register "Motor current" on page 54                     |

| Data type | Values   | Unit                                                                                                                                                                                                                                                                                                        |
|-----------|----------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| USINT     | 0 to 200 | Percentage of the nominal motor current <ul style="list-style-type: none"> <li>100% corresponds to the nominal current of the motor bridge power unit listed in the technical data</li> <li>200% corresponds to the maximum current of the motor bridge power unit listed in the technical data.</li> </ul> |

### 5.7.2.2 Reading back the holding current, nominal current and maximum current

ConfigOutput03Read (holding current)

ConfigOutput04Read (nominal current)

ConfigOutput05Read (maximum current)

These registers are used to read the respective current values in percent.

| Data type | Values   | Unit                                                                                                                                  |
|-----------|----------|---------------------------------------------------------------------------------------------------------------------------------------|
| USINT     | 0 to 255 | Percentage of module's nominal current (100% corresponds to the nominal current of the motor bridge power unit in the technical data) |

## 5.7.3 Counter configuration

### 5.7.3.1 Counter configuration

Name:

ConfigOutput09

| Data type | Values                 |
|-----------|------------------------|
| USINT     | See the bit structure. |

Bit structure:

| Bit   | Description                  | Value | Information                                                                                                                                                                                                                                                                  |
|-------|------------------------------|-------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 0     | ABR latch function           | 0     | Negative edge: Disable ABR latch function                                                                                                                                                                                                                                    |
|       |                              | 1     | Positive edge: Enables latch function ABR. After a latch event has occurred, the latch function can be started again on a new rising edge.                                                                                                                                   |
| 1 - 2 | Definition of the latch mode | 00    | Latch counter value: ABR unconditional                                                                                                                                                                                                                                       |
|       |                              | 01    | Latch counter value: ABR on a positive edge of input R                                                                                                                                                                                                                       |
|       |                              | 10    | Latch counter value: ABR on a negative edge of input R                                                                                                                                                                                                                       |
|       |                              | 11    | Reserved                                                                                                                                                                                                                                                                     |
| 3     |                              | 0     | <ul style="list-style-type: none"> <li>Position sync: Internal position counter</li> <li>Position async: ABR counter state</li> <li>Position latched sync: Internal position counter<sup>1)</sup></li> <li>Position latched async: ABR counter value<sup>1)</sup></li> </ul> |
|       |                              | 1     | <ul style="list-style-type: none"> <li>Position sync: ABR counter state</li> <li>Position async: Internal position counter</li> <li>Position latched sync: ABR counter value<sup>1)</sup></li> <li>Position latched async: Internal position counter<sup>1)</sup></li> </ul> |
| 4 - 7 | Reserved                     |       |                                                                                                                                                                                                                                                                              |

1) These registers are not available in function model "Standard" with SDC information enabled.

## Register description

### 5.7.4 Stall detection

#### 5.7.4.1 Full step limit value

Name:

FullStepThreshold01

Starting with the speed specified in this register, the motor is operated in full step mode; below it, it is operated in steps per second.

| Data type | Values     | Information             |
|-----------|------------|-------------------------|
| UINT      | 0          | Full step mode disabled |
|           | 1 to 65535 | Steps/second            |

#### 5.7.4.2 Minimum speed for stall detection

Name:

StallDetectMinSpeed01

If the motor speed exceeds the value set in this register, then stall detection is enabled. No stall error is reported below this threshold value.

| Data type | Values     | Information                    |
|-----------|------------|--------------------------------|
| UINT      | 0 to 65535 | Minimum speed in steps/second. |

## 5.8 Function models 3 and 254 - Configuration registers

### 5.8.1 Configuring currents

#### 5.8.1.1 Holding current, nominal current and maximum current

Name:

ConfigOutput03a (holding current)

ConfigOutput04a (nominal current)

ConfigOutput05a (maximum current)

The holding current, nominal current and maximum current registers are used to configure the desired motor current.

| Register        | Description                                |
|-----------------|--------------------------------------------|
| Nominal current | Current during operation at constant speed |
| Maximum current | Current during acceleration phases         |
| Holding current | Current when motor at standstill           |

| Data type | Values   | Unit                                                                                                                                                                                                                                                                                                                                       |
|-----------|----------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| USINT     | 0 to 200 | Percentage of the nominal motor current <ul style="list-style-type: none"> <li>100% corresponds to the rated current of the motor bridge power unit listed in the technical data</li> <li>200% corresponds to the maximum current of the motor bridge power unit listed in the technical data</li> </ul> Bus controller default setting: 0 |

#### 5.8.1.2 Reading back the holding current, nominal current and maximum current

ConfigOutput03aRead (holding current)

ConfigOutput04aRead (nominal current)

ConfigOutput05aRead (maximum current)

These registers are used to read the respective current values in percent.

| Data type | Values   | Unit                                                                                                                                            |
|-----------|----------|-------------------------------------------------------------------------------------------------------------------------------------------------|
| USINT     | 0 to 255 | Percentage of the nominal motor current<br>100% corresponds to the nominal current of the motor bridge power unit listed in the technical data. |

## 5.8.2 Motion generator

### 5.8.2.1 General configuration

Name:

GeneralConfig01

This register can be used to switch the positioning mode with bit 0 and to configure the cycle time of the movement profile generator.

- 0: "Mode 1: Position mode" without extended control word
- 1: "Mode 1: Position mode with extended control word"

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

Bit structure:

| Bit   | Description                                              | Value | Information                                                    |
|-------|----------------------------------------------------------|-------|----------------------------------------------------------------|
| 0     | Position mode                                            | 0     | Without extended control word (bus controller default setting) |
|       |                                                          | 1     | With extended control word                                     |
| 1 - 2 | Cycle time of the motion profile generator <sup>1)</sup> | 00    | 25 ms (bus controller default setting)                         |
|       |                                                          | 01    | 10 ms                                                          |
|       |                                                          | 10    | 5 ms                                                           |
|       |                                                          | 11    | Reserved                                                       |
| 3 - 7 | Reserved                                                 | 0     |                                                                |

1) The cycle time for the motion profile generator is configured with this cycle. This cycle time affects the unit for specifying the speed and acceleration:

- Unit for speed: Microsteps/Cycle
- Unit for acceleration: Microsteps/Cycle<sup>2</sup>

## Register description

### 5.8.2.2 Reversing loop

Name:

RevLoop01

This register defines the steps for the reverse loop.

This parameter is only used in modes [1](#), [-123](#), [-124](#), [-125](#), [-126](#) (absolute positioning modes).

| Data type | Values          | Information                       |
|-----------|-----------------|-----------------------------------|
| INT       | -32768 to 32767 | Bus controller default setting: 0 |

### 5.8.2.3 Jerk time

Name:

JoltTime01

This register is used to specify the number of cycles for the jerk limitation time. If more than 80 cycles are entered, they are limited to 80.

| Data type | Values  | Information                                                   |
|-----------|---------|---------------------------------------------------------------|
| USINT     | 0       | No jerk limitation time.<br>Bus controller default setting: 0 |
|           | 1 to 80 | Number of cycles                                              |

### 5.8.2.4 Fixed position A

Name:

FixedPos01a

Depending on the mode, this register can be used to define a number of steps or a target position:

- [-121](#): Number of steps to be moved
- [-124](#) (with 1 on the digital input) and [-125](#): Value of target position to be approached

| Data type | Values                             | Information                       |
|-----------|------------------------------------|-----------------------------------|
| DINT      | -2,147,483,648<br>to 2,147,483,647 | Bus controller default setting: 0 |

### 5.8.2.5 Fixed position B

Name:

FixedPos01b

This register defines the position to move to in modes [-124](#) (if the digital input is set to 0) and [-126](#).

| Data type | Values                             | Information                       |
|-----------|------------------------------------|-----------------------------------|
| DINT      | -2,147,483,648<br>to 2,147,483,647 | Bus controller default setting: 0 |

### 5.8.2.6 Maximum speed

Name:

MaxSpeed01pos

This register defines the maximum speed for the absolute positioning modes ([1](#), [-123](#), [-124](#), [-125](#), [-126](#)).



#### Information:

The setting does not apply to the speed and homing modes ([2](#), [-127](#), [-128](#)).

| Data type | Values     | Information                                                                       |
|-----------|------------|-----------------------------------------------------------------------------------|
| UNIT      | 0 to 65535 | Speed in microsteps/ <a href="#">cycle</a> .<br>Bus controller default setting: 0 |

### 5.8.2.7 Maximum acceleration

Name:  
MaxAcc01

This register defines the maximum acceleration. (also applies for homing modes).

| Data type | Values     | Information                                                                                           |
|-----------|------------|-------------------------------------------------------------------------------------------------------|
| UINT      | 0 to 65535 | Acceleration in microsteps/ <a href="#">cycle</a> <sup>2</sup> .<br>Bus controller default setting: 0 |

### 5.8.2.8 Maximum deceleration

Name:  
MaxDec01

This register defines the maximum deceleration. (also applies for homing modes).

| Data type | Values     | Information                                                                                                 |
|-----------|------------|-------------------------------------------------------------------------------------------------------------|
| UINT      | 0 to 65535 | Brake deceleration in microsteps/ <a href="#">cycle</a> <sup>2</sup> .<br>Bus controller default setting: 0 |

## 5.8.3 Stall detection

### 5.8.3.1 Full step limit value

Name:  
FullStepThreshold01

Starting with the speed specified in this register, the motor is operated in full step mode; it is operated in microstep mode below it.

| Data type | Values     | Information                                                                       |
|-----------|------------|-----------------------------------------------------------------------------------|
| UINT      | 1 to 65534 | Speed in microsteps/ <a href="#">cycle</a> .<br>Bus controller default setting: 0 |
|           | 65535      | Motor is always operated in microstep mode                                        |

### 5.8.3.2 Stall recognition delay

Name:  
StallRecognitionDelay01

The value in this register is only relevant for mode [Home during stall](#).

A stall is only detected after the time specified here has expired and after the homing procedure has started.

The delay time must be set in cycles.

Delay time = Value \* [Cycle time of the movement profile generator](#)

For example, a setting of 4 (and a cycle time of 25 ms) means that a stall will not be detected until 100 ms after the motor starts moving (start of the homing procedure).

| Data type | Values   | Information                                                                    |
|-----------|----------|--------------------------------------------------------------------------------|
| USINT     | 0        | No delay (bus controller default setting)                                      |
|           | 1 to 255 | Delay time in cycles, see <a href="#">"General configuration" on page 49</a> . |

### 5.8.3.3 Minimum speed for stall detection

Name:  
StallDetectMinSpeed01

If the motor speed exceeds the value set in this register, then stall detection is enabled. No stall error is reported below this threshold value.

| Data type | Values     | Information                                                             |
|-----------|------------|-------------------------------------------------------------------------|
| UINT      | 0 to 65535 | Minimum speed in microsteps/cycle.<br>Bus controller default setting: 0 |

## Register description

### 5.8.4 Homing

#### 5.8.4.1 Homing speed

Name:

RefSpeed01

This register sets the speed for homing modes -127 and -128.

| Data type | Values     | Information                                                     |
|-----------|------------|-----------------------------------------------------------------|
| UINT      | 0 to 65535 | Speed in microsteps/cycle.<br>Bus controller default setting: 0 |

#### 5.8.4.2 Homing configuration

Name:

RefConfig01

The homing mode can be set with this register.

| Data type | Values     | Information                                                                          |
|-----------|------------|--------------------------------------------------------------------------------------|
| SINT      | -120       | Set home position                                                                    |
|           | -121       | Homing on positive edge of input DI 4                                                |
|           | -122       | Homing on negative edge of input DI 4                                                |
|           | -125       | Homing on positive edge of input DI 3 (R pulse).<br>(Bus controller default setting) |
|           | -126       | Homing on negative edge of input DI 3 (R pulse)                                      |
|           | -127       | Homing during stall detection                                                        |
|           | -128       | Immediate homing                                                                     |
|           | All others | No effect                                                                            |

### 5.8.5 Limitations

#### 5.8.5.1 Limit switch configuration

Name:

LimitSwitchConfig01

The behavior of limit switches for limit monitoring can be configured with this register.

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

Bit structure:

| Bit   | Description           | Value | Information                                   |
|-------|-----------------------|-------|-----------------------------------------------|
| 0 - 1 | Negative limit switch | 00    | Switched off (bus controller default setting) |
|       |                       | 01    | Active if low                                 |
|       |                       | 10    | Reserved                                      |
|       |                       | 11    | Active if high                                |
| 2 - 3 | Positive limit switch | 00    | Switched off (bus controller default setting) |
|       |                       | 01    | Active if low                                 |
|       |                       | 10    | Reserved                                      |
|       |                       | 11    | Active if high                                |
| 4 - 6 | Reserved              | 0     |                                               |
| 7     | Direction monitoring  | 0     | Off (bus controller default setting)          |
|       |                       | 1     | On                                            |

#### 5.8.5.2 Software limit

Name:

PositionLimitMin01

PositionLimitMax01

This register configures software limits. The function is enabled if at least one of the two registers is not equal to zero.

| Data type | Values                             | Information                       |
|-----------|------------------------------------|-----------------------------------|
| DINT      | -2,147,483,648<br>to 2,147,483,647 | Bus controller default setting: 0 |

## 5.9 Communication registers - Function model 0 and function model Motion-Configuration

### 5.9.1 Motor detection

#### 5.9.1.1 Motor ID trigger

Name:

MotorIdentTrigger

With this register, a measurement of the motor ID can be initiated acyclically (see ["Motor identification" on page 53](#)). The application must ensure that the conditions for measurement are met (see section ["Integrated motor detection" on page 17](#)).

| Data type | Values                 |
|-----------|------------------------|
| USINT     | See the bit structure. |

Bit structure:

| Bit   | Description              | Value | Information                                         |
|-------|--------------------------|-------|-----------------------------------------------------|
| 0     | Starting motor detection | 0     | No effect                                           |
|       |                          | 1     | Positive edge triggers motor identifier measurement |
| 1 - 7 | Reserved                 | 0     |                                                     |

#### 5.9.1.2 Measuring the motor load

Name:

MotorLoad

This register contains the current load measurement value of stall detection and can be used to tune stall detection.

A high value indicates a small load on the motor; the lower the value, the higher the motor load. The SGT values (see ["SGT speed" on page 44](#) and ["SGT correction values" on page 44](#)) should be set so that the motor load returns value 0 at maximum load (shortly before stall).

This register can be shown and hidden via the module configuration.

| Data type | Values    |
|-----------|-----------|
| UINT      | 0 to 1023 |

#### 5.9.1.3 Motor identification

Name:

Motoridentification01

This register is used for differentiation in the application and to identify the connected motor type (for service purposes). After successful measurement, this register contains the time [ $\mu$ s] required to apply a current increase of  $\Delta I = 1$  A to a motor winding.

| Data type | Motor ID values | Explanation                                                                                              |
|-----------|-----------------|----------------------------------------------------------------------------------------------------------|
| UINT      | 0               | No motor identifier available (after switching on for as long as the measurement conditions are not met) |
|           | 1 to 32767      | Valid range of values for the motor ID register (unit: $\mu$ s)                                          |
|           | 65534           | Invalid value: Overflow                                                                                  |

## Register description

### 5.9.2 Motor control

#### 5.9.2.1 Motor current

Name:

DriveEnable01

BoostCurrent01

StandstillCurrent01

CurrentControlEnable01

Bits 0 to 2 of this register control the motor's current feed.

| Data type | Values                 |
|-----------|------------------------|
| USINT     | See the bit structure. |

Bit structure:

| Bit   | Description            | Value | Information                             |
|-------|------------------------|-------|-----------------------------------------|
| 0     | DriveEnable01          | x     | Motor powered                           |
| 1     | BoostCurrent01         | x     | Maximum current                         |
| 2     | StandstillCurrent01    | x     | Holding current                         |
| 3 - 6 | Reserved               | 0     |                                         |
| 7     | CurrentControlEnable01 | 0     | Disables load-dependent current control |
|       |                        | 1     | Enables load-dependent current control  |

#### The possible status of bits 0 to 2

| StandstillCurrent01 | BoostCurrent01 | DriveEnable01 | Description                       |
|---------------------|----------------|---------------|-----------------------------------|
| x                   | x              | 0             | Motor not supplied with current   |
| 0                   | 0              | 1             | Nominal current supplied to motor |
| 0                   | 1              | 1             | Maximum current supplied to motor |
| 1                   | 0              | 1             | Holding current supplied to motor |
| 1                   | 1              | 1             | Holding current supplied to motor |

#### 5.9.2.2 Motor settings

Name:

MotorStep0 to MotorStep3

These registers specify the number and direction of steps that must be moved by the module during the next X2X cycle and also select the motor current (see also "[Holding current, nominal current and maximum current](#)" on page 47).

| Data type | Values                 |
|-----------|------------------------|
| UINT      | See the bit structure. |

Bit structure:

| Bit     | Description                                                      | Value | Information       |
|---------|------------------------------------------------------------------|-------|-------------------|
| 0 - 12  | Number of steps for the module to move during the next X2X cycle | x     |                   |
| 13      | Direction of movement                                            | 0     | Positive          |
|         |                                                                  | 1     | Negative          |
| 14 - 15 | Selection of motor current                                       | 00    | Motor not powered |
|         |                                                                  | 01    | Holding current   |
|         |                                                                  | 10    | Nominal current   |
|         |                                                                  | 11    | Maximum current   |

The number of transfer values per X2X cycle is specified by bits 3 and 4 in the module configuration 1 (see "[Module configuration 1](#)" on page 45). If only one transfer value (bits 3 and 4 = 00) is specified, then the motor is advanced by MotorStep0 until the next X2X cycle. If 2 or 4 transfer values are specified, they are added and executed in the next X2X cycle.

Example: X2X cycle = 1 ms (1000 µs)

| Time           | Number of transfer values (see " <a href="#">Module configuration 1</a> " on page 45) |                     |                     |
|----------------|---------------------------------------------------------------------------------------|---------------------|---------------------|
|                | 1 (bits 3 - 4 = 00)                                                                   | 2 (bits 3 - 4 = 01) | 4 (bits 3 - 4 = 10) |
| 0 - 250 µs)    | MotorStep0                                                                            | MotorStep0          | MotorStep0          |
| 250 - 500 µs)  |                                                                                       |                     | MotorStep1          |
| 500 - 750 µs)  |                                                                                       | MotorStep1          | MotorStep2          |
| 750 - 1000 µs) |                                                                                       |                     | MotorStep3          |

### 5.9.2.3 Step specification

Name:  
Motor1Step0

This registers is used to specify the number and direction of steps that should be carried out by the module during the next X2X cycle.

The value is specified with a resolution of 1/256 of a full step (corresponds to 8-bit microsteps).

The direction of movement is derived from the value's sign:

| Data type | Values | Information                                            |
|-----------|--------|--------------------------------------------------------|
| INT       | >0     | Movement in the positive direction in 1/256 full steps |
|           | <0     | Movement in the negative direction in 1/256 full steps |

## 5.9.3 Life sign monitoring

### 5.9.3.1 SDC life sign monitoring

Name:  
SetTime01

The module uses SDC life sign monitoring to check whether valid values have been received for the speed setpoint.

SDC life sign monitoring is enabled in register "[SDC configuration](#)" on page 46 by setting bit 6 (SDCSetTime = On).

| Data type | Values          |
|-----------|-----------------|
| INT       | -32768 to 32767 |

### 5.9.3.2 Lifecycle counter

Name:  
LifeCnt

This register is incremented by one with each X2X Link cycle.

| Data type | Values      |
|-----------|-------------|
| SINT      | -128 to 127 |

## 5.9.4 Input state

### 5.9.4.1 Input counter value

Name:

ModulePowerSupplyError

StatusInput01 to StatusInput04

This register contains the state of the digital inputs and counters depending on the module configuration:

- **Bit 0 in module configuration = 0:** State of the digital inputs
- **Bit 0 in module configuration = 1:** State of the counter inputs

| Data type | Values                 |
|-----------|------------------------|
| USINT     | See the bit structure. |

Bit structure:

#### Status of the digital inputs

| Bit   | Description            | Value  | Information                   |
|-------|------------------------|--------|-------------------------------|
| 0     | ModulePowerSupplyError | 0      | OK                            |
|       |                        | 1      | Module power supply error     |
| 1     | Reserved               | -      |                               |
| 2     | StatusInput01          | 0 or 1 | Input state - Digital input 1 |
| ...   |                        | ...    |                               |
| 5     | StatusInput04          | 0 or 1 | Input state - Digital input 4 |
| 6 - 7 | Reserved               | -      |                               |

#### Status of the counter inputs

| Bit   | Description            | Value  | Information                                                                                        |
|-------|------------------------|--------|----------------------------------------------------------------------------------------------------|
| 0     | ModulePowerSupplyError | 0      | OK                                                                                                 |
|       |                        | 1      | Module power supply error                                                                          |
| 1     | Reserved               | -      |                                                                                                    |
| 2     | StatusInput01          | x      | Homing toggle bit for ABR counter:<br>After homing is completed, the state of this bit is changed. |
| 3     | StatusInput02          | 0      | The homing procedure for the ABR counter is active.                                                |
|       |                        | 1      | The homing procedure of the ABR counter is completed.                                              |
| 4     | StatusInput03          | 0 or 1 | Input state - Digital input 3                                                                      |
| 5     | StatusInput04          | 0 or 1 | Input state - Digital input 4                                                                      |
| 6 - 7 | Reserved               | -      |                                                                                                    |

## 5.9.5 Error handling

### 5.9.5.1 Error status

Name: The names of the bits are different depending on whether [SDC information](#) is enabled or disabled.

| Without SDC                    | With SDC            |
|--------------------------------|---------------------|
| StallError                     | StallError01        |
| Overtemperature                | Overtemperature01   |
| ErrorCurrentError              | ErrorCurrentError01 |
| OvercurrentError               | OvercurrentError01  |
| -                              | DrvOK01             |
| OpenCircuit01 to OpenCircuit04 |                     |

The current error status of the drive is indicated in this register. Each bit indicates a certain error or status. If an error is registered in bits 0 to 3, then the corresponding bit remains set until the error has been acknowledged (see ["Latch configuration" on page 60](#) and ["Error acknowledgment" on page 58](#)).

| Data type | Values                 |
|-----------|------------------------|
| UINT      | See the bit structure. |

Bit structure:

| Bit    | Description                                                       | Value | Information                               |
|--------|-------------------------------------------------------------------|-------|-------------------------------------------|
| 0      | StallError(01)                                                    | 0     | No stall                                  |
|        |                                                                   | 1     | Stall                                     |
| 1      | <a href="#">Overtemperature error</a><br>OvertemperatureError(01) | 0     | No overtemperature                        |
|        |                                                                   | 1     | Overtemperature                           |
| 2      | <a href="#">Current error</a><br>CurrentError(01)                 | 0     | No current error                          |
|        |                                                                   | 1     | Current error                             |
| 3      | <a href="#">Overcurrent error</a><br>OvercurrentError(01)         | 0     | No overcurrent                            |
|        |                                                                   | 1     | Overcurrent                               |
| 4      | <a href="#">Status of the drive</a><br>DrvOk0 <sup>1)</sup>       | 0     | An error was triggered for the motor axis |
|        |                                                                   | 1     | The drive is running error-free           |
| 5 - 11 | Reserved                                                          | 0     |                                           |
| 12     | <a href="#">Open circuit</a><br>OpenCircuit01                     | 0     | No open circuit                           |
|        |                                                                   | 1     | Open circuit detected                     |
| ...    |                                                                   | ...   |                                           |
| 15     | <a href="#">Open circuit</a><br>OpenCircuit04                     | 0     | No open circuit                           |
|        |                                                                   | 1     | Open circuit detected                     |

1) Only when SDC information is enabled

### Overtemperature error

The "Overtemperature" error bit can be set for the following reasons:

- The maximum permissible temperature is exceeded due to overload in the area of a channel.
- The module temperature exceeds the defined limit value (see ["Overtemperature shutdown" on page 27](#)).

### Current error

This error bit occurs whenever the required current cannot be supplied to the motor windings. This can be (but is not necessarily) caused by an open circuit. At higher speeds (depending on the motor), this error can also occur without an open circuit. In this case it is simply no longer possible to supply the desired current to the motor windings. Because of the Back-EMF on the motor, this bit is set at slightly lower speeds if the motor is operated with no load compared with full or partial loads.

### Overcurrent error

Overcurrent occurs if there is not enough voltage for the motor winding (e.g. short circuit).

## Register description

### Status of the drive

The status of the drive is only shown when SDC information is enabled. Bit "Drive" is 1 when the following conditions are met:

- Motor turned on (see ["Motor current" on page 54](#))
- MotorID measurement is completed
- Motor is supplied with current
- Motor settling time has passed
- Supply voltage is in the valid range
- No overtemperature fault
- Preset position value is valid (see ["SDC life sign monitoring" on page 55](#))

### Open circuit

The module is equipped with open-circuit detection for the digital inputs. If the digital input is not connected to ground or to 24 V, an open circuit is detected.

#### 5.9.5.2 Error acknowledgment

Name:

ClearError01

This register can be used to acknowledge errors that have occurred on the motor.

For more info, see ["Error status" on page 57](#).

| Data type | Values                 |
|-----------|------------------------|
| USINT     | See the bit structure. |

Bit structure:

| Bit   | Description  | Value | Information                    |
|-------|--------------|-------|--------------------------------|
| 0 - 4 | Reserved     | 0     |                                |
| 5     | ClearError01 | 0     | No effect                      |
|       |              | 1     | Error acknowledgment for motor |
| 6 - 7 | Reserved     | 0     |                                |

### 5.9.6 Homing

#### 5.9.6.1 Home position

Name:

RefPulsePos01

This register is duplicated and has the following contents:

| Register                                       | Description                                                                |
|------------------------------------------------|----------------------------------------------------------------------------|
| Home position of the internal position counter | This register contains the home position of the internal position counter. |
| Home position for the ABR counter              | This register contains the home position of the ABR counter.               |

| Data type | Values          |
|-----------|-----------------|
| INT       | -32768 to 32767 |

Setting "Position sync" in the Automation Studio I/O configuration can be used to select which of the 2 registers is addressed by variable RefPulsePos01.

| Variables in Automation Studio                                                                                        | I/O configuration, counter 01, option "Position sync"      |                                                           |
|-----------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------|-----------------------------------------------------------|
|                                                                                                                       | Step counter 01 is indicated on <a href="#">ActPos01</a> . | ABR counter 01 is indicated on <a href="#">ActPos01</a> . |
| RefPulsePos01                                                                                                         | Home position of the internal position counter             | Home position of the ABR counter                          |
| Option "Position sync" for counter 1 also sets bit 3 in register <a href="#">"Counter configuration" on page 47</a> : |                                                            |                                                           |
| Bit 3 (counter 1)                                                                                                     | 0                                                          | 1                                                         |

### 5.9.6.2 Reference pulse counter

Name:

RefPulseCnt01

This register is duplicated and has the following contents:

| Register                                                  | Description                                                                         |
|-----------------------------------------------------------|-------------------------------------------------------------------------------------|
| Reference pulse counter for the internal position counter | The reference pulses of the internal position counter are counted in this register. |
| Reference pulse counter for the ABR counter               | The reference pulses of the ABR counter are counted in this register.               |
| Data type                                                 | Values                                                                              |
| SINT                                                      | -128 to 127                                                                         |

Setting "Position sync" in the Automation Studio I/O configuration can be used to select which of 2 registers is addressed by variable RefPulsePos01.

| Variables in Automation Studio                                                                                         | I/O configuration, counter 01, option "Position sync"      |                                                           |
|------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------|-----------------------------------------------------------|
|                                                                                                                        | Step counter 01 is indicated on <a href="#">ActPos01</a> . | ABR counter 01 is indicated on <a href="#">ActPos01</a> . |
| RefPulseCnt01                                                                                                          | Reference pulse counter<br>Internal position counter       | Reference pulse counter<br>ABR counter                    |
| Option "Position sync" for counter 1 also sets bit 3 in register " <a href="#">Counter configuration</a> " on page 47: |                                                            |                                                           |
| Bit 3 (counter 1)                                                                                                      | 0                                                          | 1                                                         |

### 5.9.7 Positioning and speed

#### 5.9.7.1 Position sync/async

Name:

PositionSync (Function model 0 - Standard)

ActPos01 (function model 0 - Standard with SDC)

Positionasync

Depending on the [Counter configuration](#), these registers can be used to read either the internal position counter or the counter value on the ABR input.

| Data type | Values          |
|-----------|-----------------|
| INT       | -32768 to 32767 |

| Register                | Counter configuration     |                           |
|-------------------------|---------------------------|---------------------------|
|                         | Bit 3 = 0                 | Bit 3 = 1                 |
| PositionSync (ActPos01) | Internal position counter | ABR counter               |
| Positionasync           | ABR counter               | Internal position counter |

#### 5.9.7.2 Position sync 2

Name:

PositionSync02

This register contains the state of either the position counter or the ABR counter depending on [Counter configuration](#) (bit 3). It behaves exactly complementary to register "[PositionSync](#)" on page 59.

If "PositionSync" contains the position counter, then register "PositionSync02" contains the ABR counter state, and vice versa.

By default, the register is not visible in the I/O mapping; it must first be enabled in the I/O configuration.

| Data type | Values          |
|-----------|-----------------|
| INT       | -32768 to 32767 |

## Register description

### 5.9.7.3 Position latched sync-async

Name:

PositionLatchedSync

PositionLatchedAsync

The position counter (internal position counter or ABR counter) is applied at the latch event (see "[Latch configuration](#)" on page 60). Bits 3 and 7 of register "[Counter configuration](#)" on page 47 are used to determine which counter value (internal position counter or ABR encoder) is saved in registers PositionLatchedSync and PositionLatchedAsync.

| Data type | Values          |
|-----------|-----------------|
| INT       | -32768 to 32767 |

| Register             | Counter configuration     |                           |
|----------------------|---------------------------|---------------------------|
|                      | Bit 3 = 0                 | Bit 3 = 1                 |
| PositionLatchedSync  | Internal position counter | ABR counter               |
| PositionLatchedAsync | ABR counter               | Internal position counter |

### 5.9.7.4 NetTime of the position value

Name:

ActTime01

This register contains the NetTime of the most recent valid position value.

For additional information about NetTime and timestamps, see "[NetTime Technology](#)" on page 29.

| Data type | Values          |
|-----------|-----------------|
| INT       | -32768 to 32767 |

## 5.9.8 Latch and trigger

### 5.9.8.1 Latch configuration

Name:

StartLatch

TriggerEdgePos

TriggerEdgeNeg

StartTrigger

TriggerEdge

ClearError

CurrentControlEnable

The trigger functions for the stepper motor can be configured with this register.

| Data type | Values                 |
|-----------|------------------------|
| USINT     | See the bit structure. |

Bit structure:

| Bit   | Description                                                                      | Value | Information                                                                                            |
|-------|----------------------------------------------------------------------------------|-------|--------------------------------------------------------------------------------------------------------|
| 0     | Latch function for stepper motor 2<br>Latch byte                                 | 0     | The latch function for stepper motor position is disabled on the negative edge of this bit.            |
|       |                                                                                  | 1     | The latch function for stepper motor position is disabled on the positive edge of this bit.            |
| 1 - 2 | Latch mode for stepper motor<br>TriggerEdgePos (bit 1)<br>TriggerEdgeNeg (bit 2) | 00    | Latch position of stepper motor unconditional                                                          |
|       |                                                                                  | 01    | Latch position of stepper motor on positive edge of input DI 3                                         |
|       |                                                                                  | 10    | Latch position of stepper motor on negative edge of input DI 3                                         |
|       |                                                                                  | 11    | Reserved                                                                                               |
| 3     | TriggerEdge                                                                      | 0     | Trigger edge (input DI 4) = Positive                                                                   |
|       |                                                                                  | 1     | Trigger edge (input DI 4) = Negative                                                                   |
| 4     | Enable trigger (on change)<br>StartTrigger                                       | x     |                                                                                                        |
| 5     | ClearError                                                                       | 0     | No effect                                                                                              |
|       |                                                                                  | 1     | Error acknowledgment for motor (for more information, see " <a href="#">Error status</a> " on page 57) |
| 6     | Reserved                                                                         | -     |                                                                                                        |
| 7     | CurrentControlEnable                                                             | 0     | Disables load-dependent current control                                                                |
|       |                                                                                  | 1     | Enables load-dependent current control                                                                 |

### Trigger function procedure

- Selection of the desired trigger edge using bit 3
- Enabling of the trigger function by changing the state of bit 4. Changing this bit deletes [Time since trigger event](#) ( $\mu\text{s}$  counter).
- When the trigger event occurs,  $\mu\text{s}$  counter [Time since trigger event](#) is started.
- Counter [Time since trigger event](#) cannot overflow, i.e. the counter is stopped at  $2^{16} - 1$  and retains this value until the next time the trigger function is enabled.

The trigger function can be re-enabled at any time by changing the state of bit 4, regardless of whether a trigger event has occurred or if [Time since trigger event](#) has reached the maximum value.

#### 5.9.8.2 Latch trigger status

Name:  
LatchInput  
LatchDone  
TriggerInput

| Data type | Values                 |
|-----------|------------------------|
| USINT     | See the bit structure. |

Bit structure:

| Bit   | Description  | Value | Information                                                                             |
|-------|--------------|-------|-----------------------------------------------------------------------------------------|
| 0     | LatchInput   | x     | Digital input for the latch event (level)                                               |
| 1     | LatchDone    | x     | Changes its state each time the counter state is successfully latched (reset value = 0) |
| 2 - 3 | Reserved     | -     |                                                                                         |
| 4     | TriggerInput | x     | Trigger input (level)                                                                   |
| 5 - 7 | Reserved     | 0     |                                                                                         |

#### 5.9.8.3 Trigger timestamp

Name:  
TriggerTime01

This register contains the NetTime instant of the most recent trigger event. The trigger edge must be configured in register ["SDC configuration"](#) on page 46.

For additional information about NetTime and timestamps, see ["NetTime Technology"](#) on page 29.



#### Information:

**The absolute accuracy of the trigger can be delayed up to 5  $\mu\text{s}$  due to the input filter of the digital inputs.**

| Data type | Values          |
|-----------|-----------------|
| INT       | -32768 to 32767 |

#### 5.9.8.4 Trigger counter

Name:  
TriggerCnt01

This register contains a cyclic counter that is incremented with each trigger event.

| Data type | Values      |
|-----------|-------------|
| SINT      | -128 to 127 |

## Register description

### 5.9.8.5 Time since trigger event

Name:

usSinceTrigger

This register indicates the time in microseconds that has passed since the trigger event occurred (see ["Latch configuration" on page 60](#)).



#### Information:

The absolute accuracy of the trigger can be delayed up to 5  $\mu$ s due to the input filter of the digital inputs.

| Data type | Values     |
|-----------|------------|
| UINT      | 0 to 65535 |

## 5.10 Function models 3 and 254 - Communication registers

### 5.10.1 Motor detection

#### 5.10.1.1 Motor identification

Name:

Motoridentification01

This register is used for differentiation in the application and to identify the connected motor type (for service purposes). After successful measurement, this register contains the time [ $\mu$ s] required to apply a current increase of  $\Delta I = 1$  A to a motor winding.

| Data type | Motor ID values | Explanation                                                                                              |
|-----------|-----------------|----------------------------------------------------------------------------------------------------------|
| UINT      | 0               | No motor identifier available (after switching on for as long as the measurement conditions are not met) |
|           | 1 to 32767      | Valid range of values for the motor ID register (unit: $\mu$ s)                                          |
|           | 65534           | Invalid value: Overflow                                                                                  |

#### 5.10.1.2 Measuring the motor load

Name:

MotorLoad

This register contains the current load measurement value of stall detection and can be used to tune stall detection.

A high value indicates a small load on the motor; the lower the value, the higher the motor load. The SGT values (see ["SGT speed" on page 44](#) and ["SGT correction values" on page 44](#)) should be set so that the motor load returns value 0 at maximum load (shortly before stall).

This register can be shown and hidden via the module configuration.

| Data type | Values    |
|-----------|-----------|
| UINT      | 0 to 1023 |

## 5.10.2 Motor control

### 5.10.2.1 Mode

Name:

MpGenMode01

| Data type | Values | Information                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |
|-----------|--------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| SINT      | 0      | No mode selected                                                                                                                                                                                                                                                                                                                                                                                                                                                                |
|           | 1      | Depending on bit 0 in the <a href="#">"General configuration" on page 49</a> register, the position mode will behave as follows: <ul style="list-style-type: none"> <li>Position mode without extended control word: Move to target position as soon as the target position is changed</li> <li>Position mode with extended control word: Move to the target position as described in <a href="#">"Mode 1 - Position mode with extended control word" on page 63</a></li> </ul> |
|           | 2      | Speed mode: Constant speed                                                                                                                                                                                                                                                                                                                                                                                                                                                      |
|           | -120   | Set home position                                                                                                                                                                                                                                                                                                                                                                                                                                                               |
|           | -121   | Remaining distance mode                                                                                                                                                                                                                                                                                                                                                                                                                                                         |
|           | -122   | Set actual position                                                                                                                                                                                                                                                                                                                                                                                                                                                             |
|           | -123   | Move to target position when external input set                                                                                                                                                                                                                                                                                                                                                                                                                                 |
|           | -124   | Two position mode                                                                                                                                                                                                                                                                                                                                                                                                                                                               |
|           | -125   | Move to fixed position A                                                                                                                                                                                                                                                                                                                                                                                                                                                        |
|           | -126   | Move to fixed position B                                                                                                                                                                                                                                                                                                                                                                                                                                                        |
|           | -127   | Positive homing (see also <a href="#">"Homing configuration" on page 52</a> )                                                                                                                                                                                                                                                                                                                                                                                                   |
|           | -128   | Negative homing (see also <a href="#">"Homing configuration" on page 52</a> )                                                                                                                                                                                                                                                                                                                                                                                                   |



#### Information:

For all modes: The "Target reached" bit is set in the ["Status word" on page 67](#) register when the current action is finished (i.e. when the position or speed is reached, depending on the mode).

A new position or speed can be specified even before the current action is finished.

#### 5.10.2.1.1 Mode 1 - Position mode

The position setpoint is specified in register ["Set position/speed" on page 68](#). The motor is then moved to this new position.

How the position is applied can be controlled by bit 0 in register ["GeneralConfig01" on page 49](#).

- If bit 0 equals 0 (no extended control word), the position setpoint will be applied as soon as it is not equal to the current position. The new position is then used for the movement.
- If bit 0 equals 1, the position setpoint is applied as described in ["Mode 1 - Position mode with extended control word" on page 63](#).

#### 5.10.2.1.2 Mode 1 - Position mode with extended control word

Position mode with extended control word behaves like [Position mode 1](#) as described previously (without the extended control word), but the new position setpoint (["Position/Speed" on page 68](#) register) is applied according to the [extended control word](#).

## Register description

### 5.10.2.1.2.1 Extended control word

Commands can be issued using this register depending on the state of the module (see "Operating function model "Ramp"" on page 35).

| Data type | Values                 |
|-----------|------------------------|
| UINT      | See the bit structure. |

Bit structure:

| Bit    | Description                                             | Value | Information                                                                     |
|--------|---------------------------------------------------------|-------|---------------------------------------------------------------------------------|
| 0 - 3  | Corresponds to the default <a href="#">Control word</a> | x     |                                                                                 |
| 4      | New setpoint                                            | 0     | Do not apply target position.                                                   |
|        |                                                         | 1     | Apply target position.                                                          |
| 5      | Change set immediately                                  | 0     | Complete current positioning movement and then start next positioning movement  |
|        |                                                         | 1     | Interrupt current positioning movement and then start next positioning movement |
| 6      | abs / rel                                               | 0     | Target position is an absolute value.                                           |
|        |                                                         | 1     | Target position is a relative value.                                            |
| 7      | Corresponds to the default <a href="#">Control word</a> | x     |                                                                                 |
| 8      | Stop <sup>1)</sup>                                      | 0     | Execute positioning                                                             |
|        |                                                         | 1     | Stop axis with deceleration                                                     |
| 9 - 15 | Corresponds to the default <a href="#">Control word</a> | x     |                                                                                 |

1) This bit applies to all modes.

### 5.10.2.1.2.2 Extended status word

The bits in the status word reflect the state of the state machine (for a detailed description, see "Structure of the status word" on page 36 and "State machine" on page 37).

| Data type | Values                 |
|-----------|------------------------|
| UINT      | See the bit structure. |

Bit structure:

| Bit     | Description                                                                      | Value | Information                                     |
|---------|----------------------------------------------------------------------------------|-------|-------------------------------------------------|
| 0 - 9   | Corresponds to the default <a href="#">Status word</a>                           | x     |                                                 |
| 10      | Target reached, depends on bit 8 (Stop) in register <a href="#">Control word</a> |       | <b>If stop = 0</b>                              |
|         |                                                                                  | 0     | Target position not reached.                    |
|         |                                                                                  | 1     | Target position reached                         |
|         |                                                                                  |       | <b>If stop = 1</b>                              |
|         |                                                                                  | 0     | Axis decelerating                               |
|         |                                                                                  | 1     | Axis speed = 0                                  |
| 11      | Corresponds to the default <a href="#">Status word</a>                           | x     |                                                 |
| 12      | Setpoint acknowledge                                                             | 0     | Ramp generator did not apply the position value |
|         |                                                                                  | 1     | Ramp generator applied the position value       |
| 13 - 15 | Corresponds to the default <a href="#">Status word</a>                           | x     |                                                 |

### 5.10.2.1.2.3 Position setting

The target position can be defined in 2 different ways:

| Type of setpoint definition | Description                                                                                                                                                                                                                                                      |
|-----------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Single setpoint             | After the target position is reached, Bit Target reached in register " <a href="#">Status word</a> " on page 67 is set. Then a new target position is defined. The drive stops at each target position before starting the movement to the next target position. |
| Set of setpoints            | After the target position has been reached, the movement to the next target position is started immediately without stopping the drive. It is therefore possible to initiate a new positioning by specifying another target position during active positioning.  |

The two modes "Single setpoint" and "Set of setpoints" are controlled by the timing of bits New setpoint and Change set immediately in the "[extended control word](#)" on page 64 and Setpoint acknowledge in register "[Extended control word](#)" on page 64.

### 5.10.2.1.2.4 Relative position setting

If bit abs / rel bit in register [Extended control word](#) is set, then the target position is interpreted as a relative value. At each New setpoint trigger, the target position will be increased by this value (or decreased if the value is negative).

If the mode changes between the position settings, relative movement will then proceed starting at the last specified position. The position setpoint mode is initialized with 0 when the module is started.

#### 5.10.2.1.3 Mode 2: Speed mode - Constant speed (pos./neg.)

The value in the "position/speed" on page 68 register is interpreted as the speed setpoint (microsteps / cycle).

Observing the maximum permissible acceleration, the motor moves with a ramp to the desired speed setpoint and maintains this speed until a new speed setpoint is specified.

Values are allowed within the range -65535 to 65535. When a value is entered outside of this range, it is readjusted to these limits.

#### 5.10.2.1.4 Mode -120: Set home position

The current actual position is modified such that the position specified in the "position/speed" on page 68 register is the home position. If moved to this position, the motor is at the home position.

The home position in register "Home position" on page 68 is also set to this value.

#### 5.10.2.1.5 Mode -121: Remaining distance mode (like mode 1)

With a rising or falling edge on digital input 3, the current target position is discarded and only the number of steps set in register "Fixed position A" on page 50 will be moved forward or backward.

The "homing configuration" on page 52 defines whether a rising or falling edge of the digital input is used as a trigger.

#### 5.10.2.1.6 Mode -122: Set actual position

The target position set in register "Position/Speed" on page 68 is applied as the current actual position in the internal position counter.

Before this mode is started, the motor must be at a standstill and physically located at the point for which the position being set should be applied.

#### 5.10.2.1.7 Mode -123: Move to the target position when the external input is set

The position setpoint set in register "Position/Speed" on page 68 is approached on a rising edge on digital input 3.

A new position setpoint is only applied on a new rising edge of the associated digital input. This can also take place during the ongoing positioning process and is then immediately effective.

#### 5.10.2.1.8 Mode -124: Two-position mode

The positions to be approached are defined in registers Fixed position A and Fixed position B.

When value 1 is on digital input 3, fixed position A is approached. If value 0, fixed position B is approached. Toggling is also possible during an ongoing positioning operation.

#### 5.10.2.1.9 Mode -125/-126: Move to fixed position X

These modes can be used to move to specified fixed positions.

- Mode -125: "Fixed position A" on page 50
- Mode -126: "Fixed position B" on page 50

#### 5.10.2.1.10 Mode -127/-128: Positive/Negative homing

Mode -127 or -128 is used to select the direction used for homing. Whether referencing should occur at low/high level on the digital input, during stall or unconditionally must be set in the "referencing configuration" on page 52.

If the referencing condition occurs, then the motor stops and the values of the position counter and ABR counter valid at the moment when the referencing condition occurs are written to the "Referenced zero position" on page 68 register.

## Register description

### 5.10.2.2 Read back mode

Name:

ModeReadback01

This register can be used to read the contents of register "[Mode](#)" on page 63.

| Data type | Values      |
|-----------|-------------|
| SINT      | -128 to 127 |

### 5.10.2.3 Control word

Name:

MpGenControl01

Using this register, commands can be sent depending on the state of the module (see "[Operating function model "Ramp"](#)" on page 35).

| Data type | Values                 |
|-----------|------------------------|
| UINT      | See the bit structure. |

Bit structure:

| Bit   | Description                 | Value | Information                                                                                                             |
|-------|-----------------------------|-------|-------------------------------------------------------------------------------------------------------------------------|
| 0     | Switch on                   | x     |                                                                                                                         |
| 1     | Enable voltage              | x     |                                                                                                                         |
| 2     | Quick stop                  | x     |                                                                                                                         |
| 3     | Enable operation            | x     |                                                                                                                         |
| 4 - 6 | Mode-specific               | x     |                                                                                                                         |
| 7     | Fault reset                 | x     |                                                                                                                         |
| 8     | Stop <sup>1)</sup>          | x     |                                                                                                                         |
| 9     | CurrentControlEnable        | 0     | Disables load-dependent current control                                                                                 |
|       |                             | 1     | Enables load-dependent current control                                                                                  |
| 10    | Reserved                    | 0     |                                                                                                                         |
| 11    | Motor ID trigger            | 0     | No effect                                                                                                               |
|       |                             | 1     | Rising edge: Motor ID trigger <sup>2)</sup>                                                                             |
| 12    | Warning reset               | 0     | No effect                                                                                                               |
|       |                             | 1     | Rising edge: Reset warnings                                                                                             |
| 13    | Current error detection     | 0     | Disable current error detection (default)                                                                               |
|       |                             | 1     | Enable current error detection                                                                                          |
| 14    | Encoder position sync/async | 0     | Default: <ul style="list-style-type: none"><li>Internal position counter, cyclic</li><li>ABR counter, acyclic</li></ul> |
|       |                             | 1     | <ul style="list-style-type: none"><li>Internal position counter, acyclic</li><li>ABR counter, cyclic</li></ul>          |
| 15    | Stall detection             | 0     | Disable stall detection (default)                                                                                       |
|       |                             | 1     | Enable stall detection                                                                                                  |

1) Bit "Stop" is only evaluated if the extended control word is enabled (see "[General configuration](#)" on page 49).

2) This bit can be used to trigger a measurement of the motor ID. Keep in mind that the application must ensure that the conditions for measurement are fulfilled (see table in the "[Motor identification](#)" on page 62 register).

### 5.10.2.4 Read back control word

Name:

ControlReadback01

This register can be used to read the contents of register "[Control word](#)" on page 66.

| Data type | Values     |
|-----------|------------|
| UINT      | 0 to 65535 |

### 5.10.2.5 Status word

Name:

MpGenStatus01

The bits in this register reflect the state of the state machine. For a more detailed description, see "[Structure of the status word](#)" on page 36 and "[State machine](#)" on page 37.

| Data type | Values                 |
|-----------|------------------------|
| UINT      | See the bit structure. |

Bit structure:

| Bit     | Description           | Value | Information                                                       |
|---------|-----------------------|-------|-------------------------------------------------------------------|
| 0       | Ready to switch on    | x     |                                                                   |
| 1       | Switched on           | x     |                                                                   |
| 2       | Operation enabled     | x     |                                                                   |
| 3       | Fault (error bit)     | x     |                                                                   |
| 4       | Voltage enabled       | x     |                                                                   |
| 5       | Quick stop            | x     |                                                                   |
| 6       | Switch on disabled    | x     |                                                                   |
| 7       | Warning               | x     |                                                                   |
| 8       | Reserved              | 0     |                                                                   |
| 9       | Remote                | 1     | Always 1                                                          |
| 10      | Target reached        | x     |                                                                   |
| 11      | Internal limit active | 0     | No limit violation                                                |
|         |                       | 1     | Internal limit is active (upper or lower software limit violated) |
| 12      | Mode-specific         | x     |                                                                   |
| 13 - 15 | Reserved              | 0     | Always 0                                                          |

### 5.10.3 Input state

#### 5.10.3.1 Digital input status

Name:

InputStatus

This register indicates the logical states of digital inputs.

| Data type | Values                 |
|-----------|------------------------|
| USINT     | See the bit structure. |

Bit structure:

| Bit | Description     | Value  | Information                     |
|-----|-----------------|--------|---------------------------------|
| 0   | Digital input 1 | 0 or 1 | Input state - Digital input 1   |
| ... |                 | ...    |                                 |
| 3   | Digital input 4 | 0 or 1 | Input state - Digital input 4   |
| 4   | Open circuit 1  | 0      | No error                        |
|     |                 | 1      | Open circuit on digital input 1 |
| ... |                 | ...    |                                 |
| 7   | Open circuit 4  | 0      | No error                        |
|     |                 | 1      | Open circuit on digital input 4 |

## 5.10.4 Error handling

### 5.10.4.1 Error code

Name:  
ErrorCode01

The cause of an error or warning can be read in this register.

| Data type | Error code | Error type | Priority | Description                 |
|-----------|------------|------------|----------|-----------------------------|
| UINT      | 0x0000     | -          | -        | No error                    |
|           | 0x3000     | Error      | High     | Voltage                     |
|           | 0x4200     | Error      | ↓        | Overtemperature             |
|           | 0xFF20     | Warning    | ↓        | Negative limit switch       |
|           | 0xFF21     | Warning    | ↓        | Positive limit switch       |
|           | 0x2300     | Warning    | ↓        | Overcurrent                 |
|           | 0xFF00     | Warning    | ↓        | Current error <sup>1)</sup> |
|           | 0xFF01     | Warning    | ↓        | Stall <sup>2)</sup>         |
|           | 0xFF11     | Warning    | low      | Open circuit                |

1) A current error is only detected if bit 13 = 1 in the [control word](#) (current error detection enabled).

2) Stall is only detected if bit 15 = 1 in the [control word](#) (stall detection enabled).

Information regarding the handling of errors and warnings:

- Bit 3 (fault) and bit 8 (warning) in the [status word](#) can be used to query whether an error or a warning was reported in the error code register.
- Bit 7 (Fault Reset) and bit 8 (Warning Reset) in the [control word](#) are used to acknowledge pending errors and warnings.
- If two or more errors/warnings are pending, the one with the highest priority (the order in the table above) will be displayed in the error code register.

## 5.10.5 Homing

### 5.10.5.1 Homed zero position

Name:  
RefPos01CyclicCounter  
RefPos01AcyclicCounter

After a homing procedure, the homing point for the cyclic or acyclic position counter can be read back with these registers (either the internal position counter or ABR counter depending on bit 14 of register "[Control word](#)" on page 66).

The following two registers are provided for the motor:

- Homed zero position for cyclic counter
- Homed zero position for acyclic counter

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

## 5.10.6 Positioning and speed

### 5.10.6.1 Set position/speed

Name:  
AbsPos01

This register is used to set position or speed, depending on the operating mode.

- Position mode (see "[Mode](#)" on page 63): Cyclic setting of the position setpoint in microsteps. In this mode, one micro-step is always 1/256 full-step.
- Speed mode (see "[Mode](#)" on page 63): In this mode, this register is considered a signed speed set-point.

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

### 5.10.6.2 Current position - Cyclic

Name:

AbsPos01ActVal

This cyclic register contains the current position.

Default: Value of the internal position counter, possible to switch to ABR counter

| Data type | Values          |
|-----------|-----------------|
| INT       | -32768 to 32767 |

### 5.10.6.3 Current position - Acyclic

Name:

AbsPos1ActValAcyclic

This acyclic register contains the current position.

Default: Value of the ABR counter, can be changed to internal position counter

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

## 5.11 Minimum I/O update time

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

| Minimum I/O update time           |        |
|-----------------------------------|--------|
| All function models (except ramp) | 400 µs |
| Function model "Ramp"             |        |
| Inputs                            | 400 µs |
| Outputs <sup>1)</sup>             | 25 ms  |

1) Depends on the configuration of the ["movement profile generator" on page 49](#)

## 5.12 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  |        |
|---------------------|--------|
| All function models | 400 µs |