X20SM1436

1 Order data

Order number	Short description	Figure
	Motor controllers	
X20SM1436	X20 stepper motor module, module power supply 24 to 39 VDC ±25%, 1 motor connection, 3 A continuous current, 3.5 A peak current, 4 digital inputs 24 VDC, sink, configurable as incremental encoder, NetTime function	
	Required accessories	
	Bus modules	
X20BM31	X20 bus module for double-width modules, 24 VDC keyed, internal I/O supply continuous	
	Terminal blocks	
X20TB12	X20 terminal block, 12-pin, 24 VDC keyed	

Table 1: X20SM1436 - Order data

2 Module description

The stepper motor module is used to control stepper motors with a nominal voltage of 24 to 39 VDC (±25%) at a motor current up to 3 A (3.5 A peak).

Functions:

- Integrated motor detection
- Currents independently configurable
- 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.

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. As soon as the value is within the limit value again, the outputs are automatically started up again.

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

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.

3 Technical data

Order number	**X20SM1436**
Short description	
I/O module	1 full bridge for controlling stepper motors
General information	
B&R ID code	0x2682
Status indicators	I/O function per channel, operating state, module status
Diagnostics	
Module run/error	Yes, using LED status indicator and software
Output	Yes, using LED status indicator and software
I/O power supply	Yes, using software
Power consumption	
Bus	0.01 W
Internal I/O	-
External I/O	
24 VDC	2.45 W
48 VDC	3.15 W
Additional power dissipation caused by actuators (resistive) [W]	-

Table 2: X20SM1436 - Technical data

Order number	X20SM1436
Certifications	
CE	Yes
ATEX	Zone 2, II 3G Ex nA nC IIA T5 Gc IP20, Ta (see X20 user's manual) FTZÚ 09 ATEX 0083X
UL	cULus E225616 Power conversion equipment
HazLoc	cCSAus 244665 Process control equipment for hazardous locations Class I, Division 2, Groups ABCD, T5
EAC	Yes
KC	Yes
Motor bridge - Power unit	
Quantity	1
Type	2-phase bipolar stepper motor (full bridge)
Nominal voltage	24 to 39 VDC ±25% 1)
Nominal current	3 A
Maximum current	3.5 A for 2 s (after a recovery time of at least 10 s at maximum 3 A)
Controller frequency	38.4 kHz
DC bus capacitance	100 µF
Step resolution	Max. 256 microsteps per step
Module power supply	
Supply	External
Fuse	Required line fuse: Max. 10 A, slow-blow
Output protection	No reverse polarity protection of the supply voltage
Digital inputs	
Quantity	4
Nominal voltage	24 VDC
Input circuit	Sink
Input filter	
Hardware	<5 µs
Software	-
Connection type	1-wire connections
Input resistance	Typ. 18.2 kΩ
Additional functions	1x ABR incremental encoder
Switching threshold	
Low	<5 VDC
High	>15 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 Channel not isolated from I/O power supply
Operating conditions	
Mounting orientation	
Horizontal	Yes
Installation elevation above sea level	
0 to 2000 m	No limitation
>2000 m	Reduction of ambient temperature by 0.5°C per 100 m
Degree of protection per EN 60529	IP20
Ambient conditions	
Temperature	
Operation	
Horizontal mounting orientation	0 to 50°C
Vertical mounting orientation	Not permitted
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. Order 1x bus module X20BM31 separately.
Pitch	$25^{+0.2}$ mm

Table 2: X20SM1436 - 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.

4 LED status indicators

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

Figure	LED	Color	Status	Description
	r	Green	Off	No power to module
			Single flash	RESET mode
			Double flash	BOOT mode (during firmware update)[1]
			Blinking	PREOPERATIONAL mode
			On	RUN mode
	e	Red	Off	No power to module or everything OK
			On	Error or reset state
	e + r	Red on / Green single flash		Invalid firmware
	1 - 4	Green		Input state of the corresponding digital input
	M	Orange	On	Motor is active

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

5 Pinout

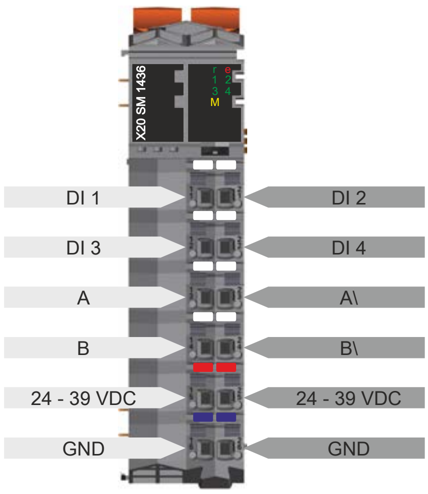
In accordance with the EN 60204-1 standard, a cable cross section of 0.75 mm² or larger must be used for the motor outputs in order to handle the maximum motor current of 3.5 A. To ensure full motor power, voltage drops that could result from the cable length and the electrical connections must also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

Warning!

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

Information:

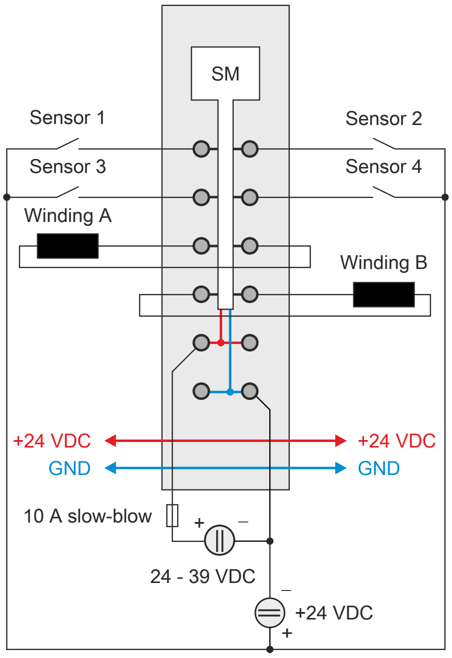
Shielded motor cables must be used in order to meet the limit values per standard EN 55011 (emissions).



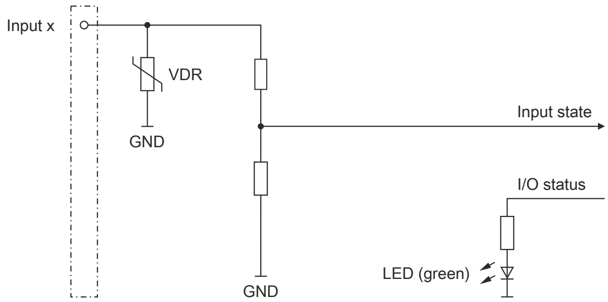
6 Connection example

Information:

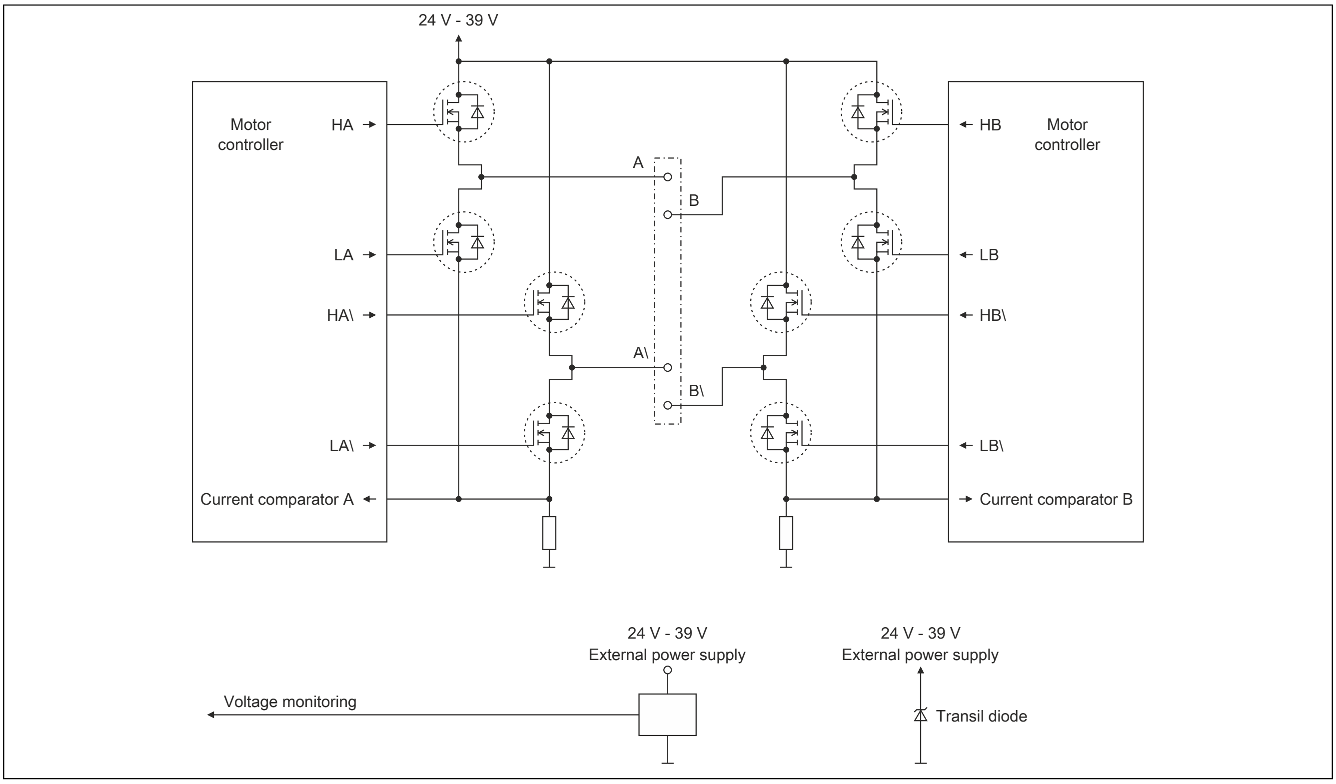
This module can only be operated if supplied with power via the terminal block.



7 Input circuit diagram



8 Output circuit diagram



9 Power supply dimensioning

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

Example	
Motor model number	80MPD5.300S000-01
Defined current in the motor module	3 A
Motor module supply voltage	48 VDC
Motor load	1 Nm

Table 3: Power supply dimensioning example - Basic data

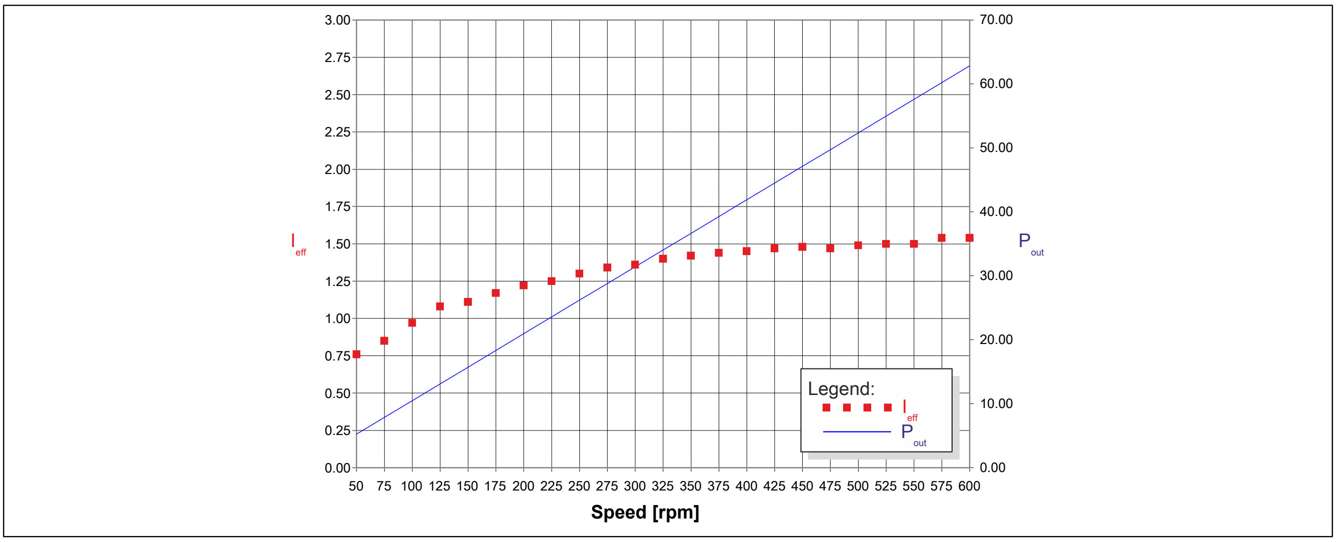


Figure 1: Power supply dimensioning example - Power/Speed relationship

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.

10 Fuse protection

The power supply line should be protected by a circuit breaker or a fuse. 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):

$I_{Power\ system}$	≤	I_b	≤	I_Z
Power system	≤	Fuse	≤	Line/cable

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

Table 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 wires on walls
E	Cables or wires on open-ended cable tray

Table 5: Type of wiring used for the mains power input

11 Energy regeneration of the voltage

If voltage is regenerated during generator operation of the motor, the built-in Transil diode may be overloaded and the module could be irreparably damaged as a result. The following recovery values are therefore not permitted to be exceeded:

- 6 W at more than 53 V

Notice!

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

12 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

Modules directly next to the SM module can have a power loss of 1 W. If the SM module is operated at the rated load over the entire temperature range (3 A rated current), the power loss of neighboring modules must be derated starting at 45°C.

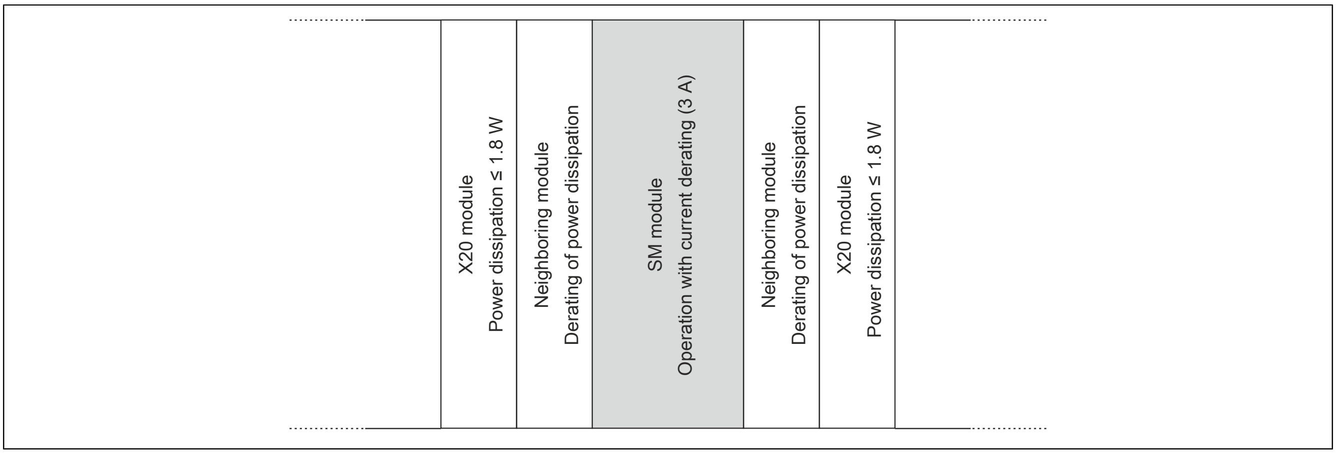
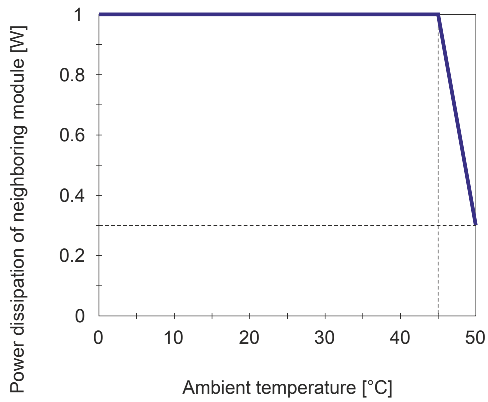
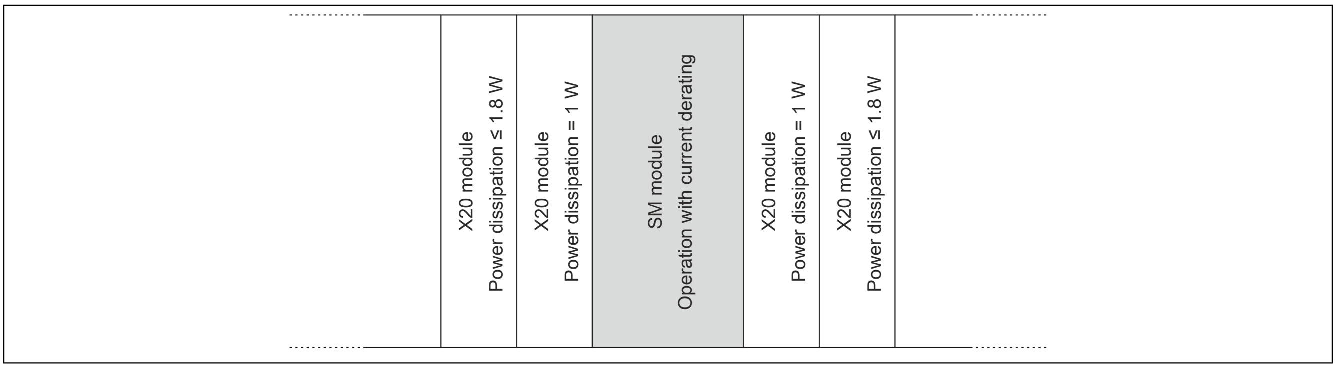


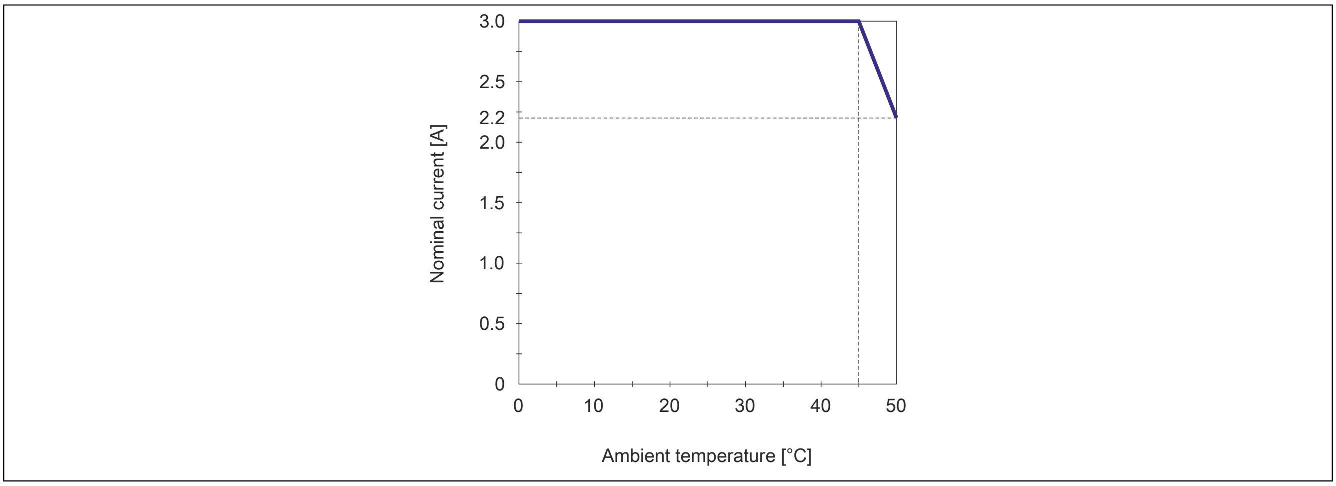
Figure 2: Operating the SM module over the entire temperature range at 3.0 A rated current



Current derating of the SM module

If the power loss 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.





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.

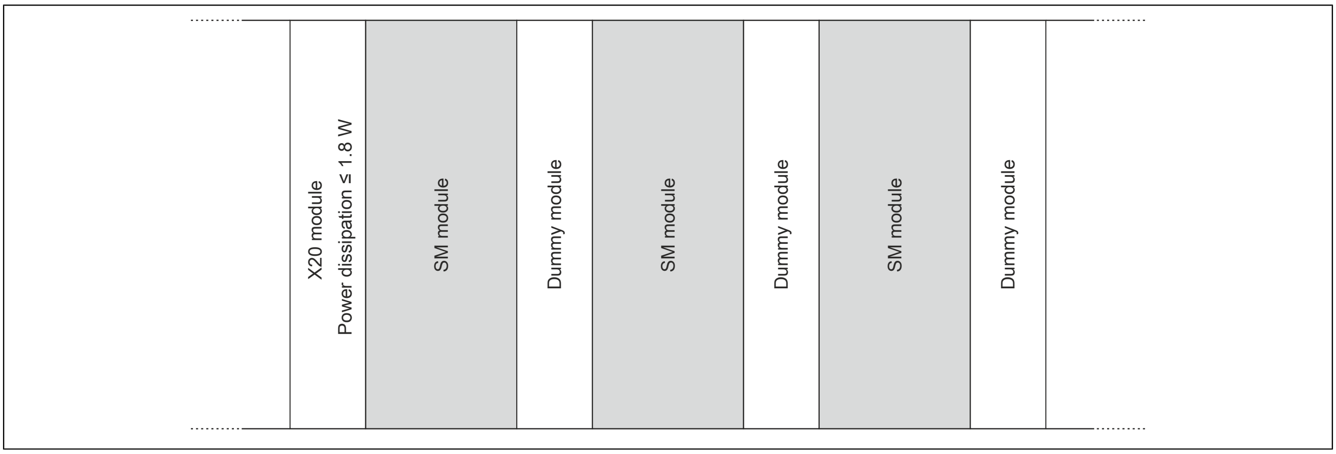


Figure 3: Operating three or more SM modules in a cluster

13 Function description

13.1 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.

When the motor is powered on, a ground fault check is performed before motor identification.

After successful measurement, the time required to apply a current increase of $\Delta I = 1$ 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: • Full steps are divisible by 4. • Microsteps = 0
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:

Registers are described in "Motor identification" on page 42.

13.2 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 motor's nominal current is entered in the nominal current register according to the motor's data sheet.

Reasonable values are:

- Holding current < Nominal current < Maximum current

Information:

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

Register	Description
Nominal current	Current during operation at constant speed
Maximum current	Current during short acceleration phases when a higher motor torque is required. In mode "Homing", the nominal current is always used instead of the maximum current, even in acceleration phases.
Holding current	Power 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:

For a description of the registers, see "Configure currents (function model 0)" on page 35 and "Configure currents (function model 3 and 254)" on page 35.

13.3 Stall detection

The SM module is equipped with integrated sensorless load measurement for the motor axis. This functionality is particularly useful for detecting a "stall condition" (e.g. if the motor moves against the endpoint during a homing procedure). It is not suitable for torque monitoring during dynamic movements.

The threshold value valid for the motor must be determined individually since the result of the load measurement depends on various influences.

- Motor speed: A higher speed results in higher measured values.
- Speeds at which motor resonances occur that falsify the load measurement must be avoided.
- Motor accelerations that generate a dynamic load and thus also falsify the measurement must be avoided.
- In particular, it is important to note that mixed decay mode must be optimized for reliable stall detection (see "Mixed decay threshold" on page 36).

The higher the load measured value, the lower the load. This means that a stall condition is detected if the load measured value falls below the trigger threshold for stall detection.

Mixed decay threshold

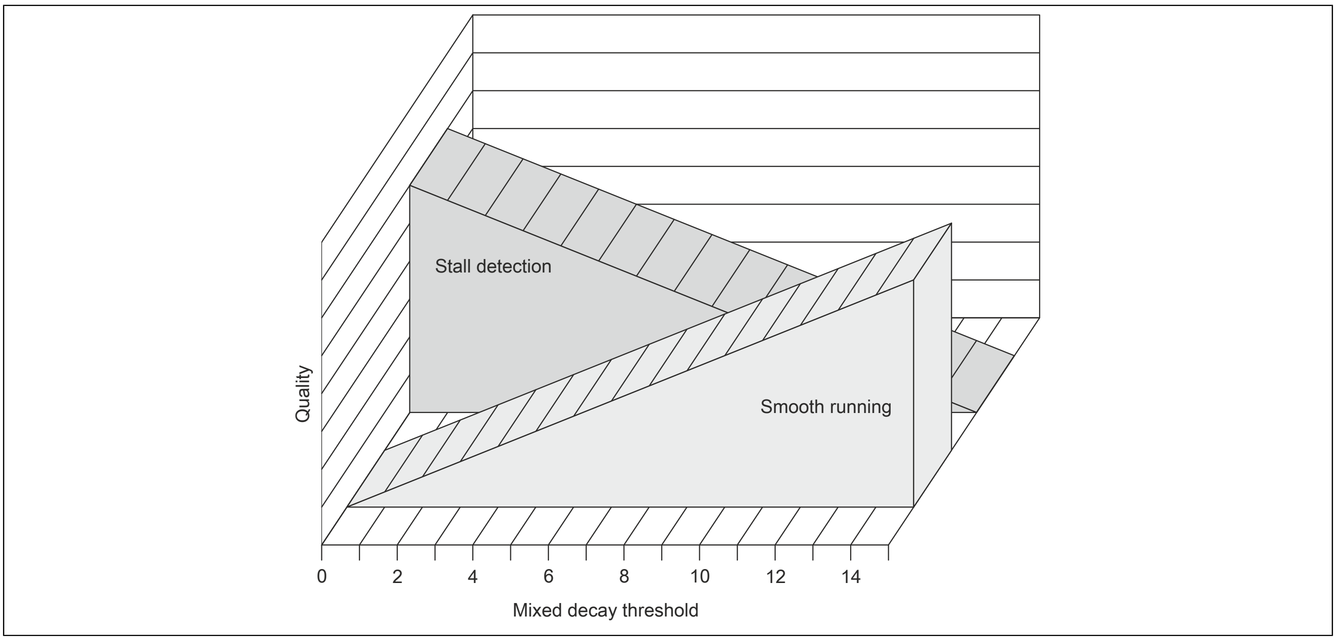
Mixed decay modules provide a greatly optimized sinusoidal current profile in the individual phases of the stepper motor, especially for fast current changes and low current values.

Mixed decay interferes with reliable stall detection, however. For this reason, mixed decay mode can be disabled during stall detection (motor load measurement) using the mixed decay threshold. The smaller the configured mixed decay threshold, the larger the range in which mixed decay is disabled while motor load measurement takes place.

Mixed decay mode is always enabled if the mixed decay threshold is set to 15.

Relationship between stall detection and mixed decay

Depending on the application and the motor used, satisfactorily smooth operation can be achieved while using stall detection by setting the mixed decay threshold to a value between 1 and 14. This is a compromise between smooth operation and stall detection quality and must be fine tuned during commissioning.



Information:

Registers are described in "Stall detection" on page 36.

13.4 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 referencing 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 at the digital input. Movement continues at homing speed in the homing direction until the active level for "homing-stop" 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 40.

13.5 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 exceeded, 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.

These limit monitors are 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:

The software limits will only be monitored when using the following CANopen bus controllers:

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

Information:

Registers are described in "Limitations" on page 41.

13.6 Motion generator

Mode

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

- Position mode
- Speed setpoint
- Homing

	Information
	No mode selected
Positioning	
	Speed setpoint
	Position mode Depending on bit 0 in the general configuration, the position mode behaves as follows: • Without extended control word: Move to target position as soon as the target position is changed. • Position mode with extended control word: Move to the target position as described in "Extended control word".
Moving to absolute positions	
	Reference position with residual distance
	Moving to the target position if digital input is set
	Moving to a fixed position depending on digital input
	Moving to a fixed position (first or second position)
Homing	
	Homing in the forward direction
	Homing in the reverse direction
Applying positions	
	Applying the actual position (reference 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.

Speed setpoint

The module is given the desired speed setpoint (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 modus (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.
- Stop the 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

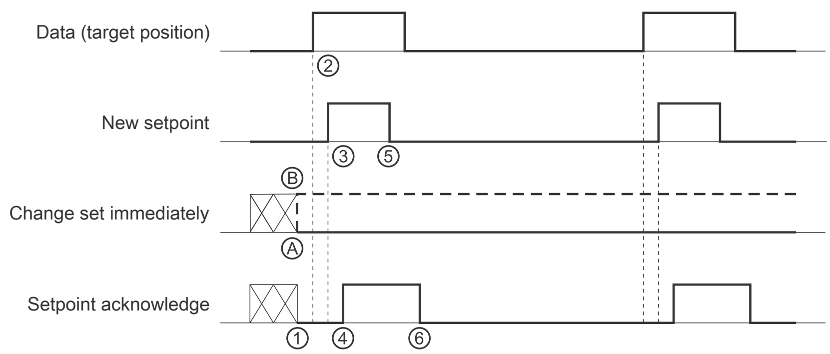


Figure 4: Principle for applying the setpoint

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.

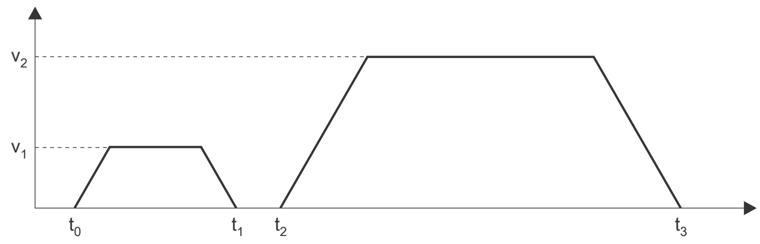


Figure 5: Ramp in *Single setpoint*

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.

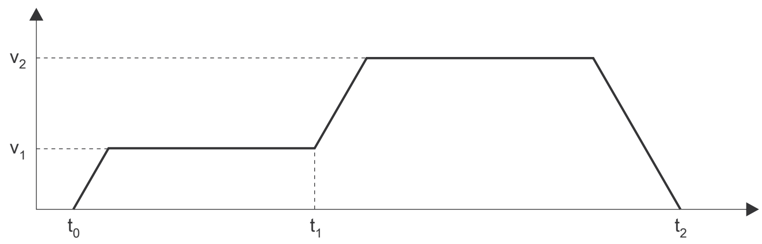


Figure 6: Ramp in *Set of setpoints*

Reference 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 overshot 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.

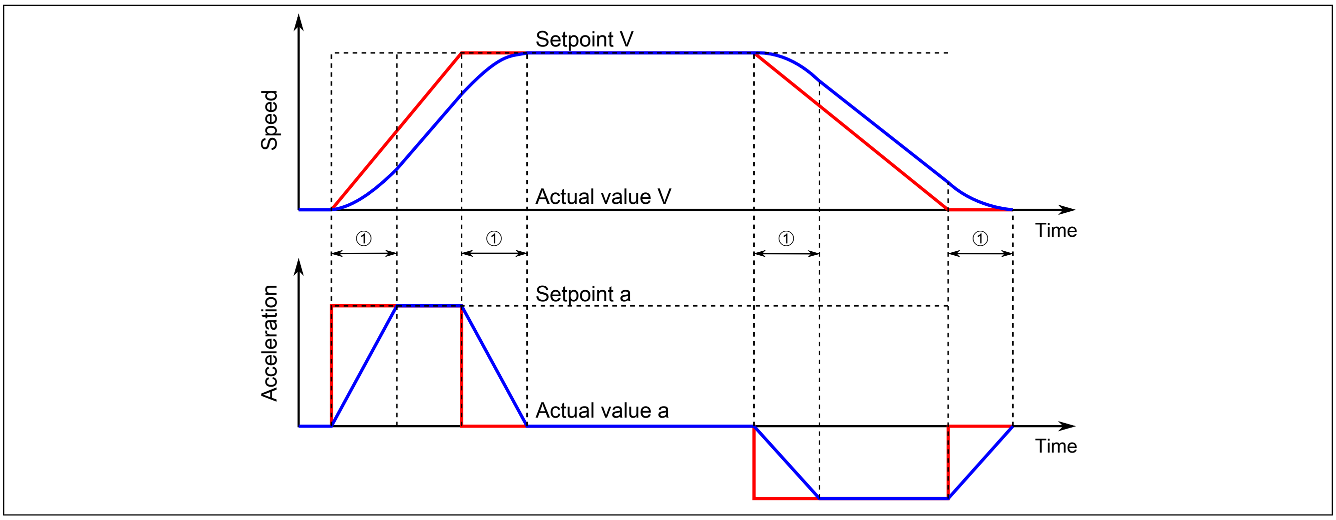
- Positive sign: Forward movement
- Negative sign: Backward movement

Jerk limitation

To avoid noticeable jumps when starting the motor or when the acceleration changes (e.g. from 1 m/s^2 to 3 m/s^2), 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

13.7 Counters

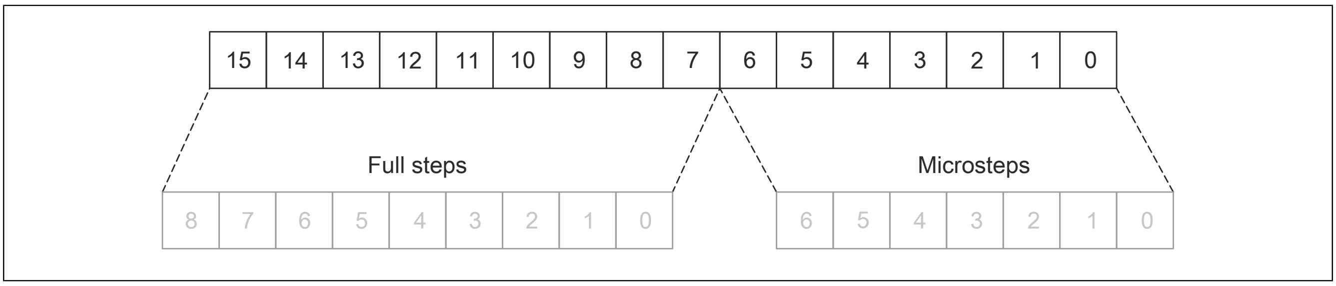
The module has 2 different modes that can be used to determine the position.

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, while the highest 8 to 11 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:

Registers are described in "Counter configuration" on page 35.

13.8 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

13.9 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 PLC can be monitored.

13.9.1 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.

As soon as the supply voltage is again within the permissible range, the outputs are put back into operation and the error bit is reset.

Limit values for the supply voltage

	Drive cut off	Drive switched back on
Lower limit	<18 V	19.5 V
Upper limit	>50 V	<49 V

Information:

For the error message and acknowledgment, see register "Input counter state" on page 44.

13.9.2 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:
85°C

Information:

For the error message and acknowledgment, see register "Error state" on page 45 and register "Error acknowledgment" on page 46.

13.9.3 Monitoring the module communication

The communication between the module and PLC 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 PLC. 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 PLC 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 CPU 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:

For the configuration, see "SDC configuration" on page 34 and "Motor current" on page 42.

13.10 NetTime Technology

NetTime refers to the ability to precisely synchronize and transfer system times between individual components of the controller or network (CPU, 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.

NetTime TECHNOLOGY

13.10.1 Time information

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

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

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

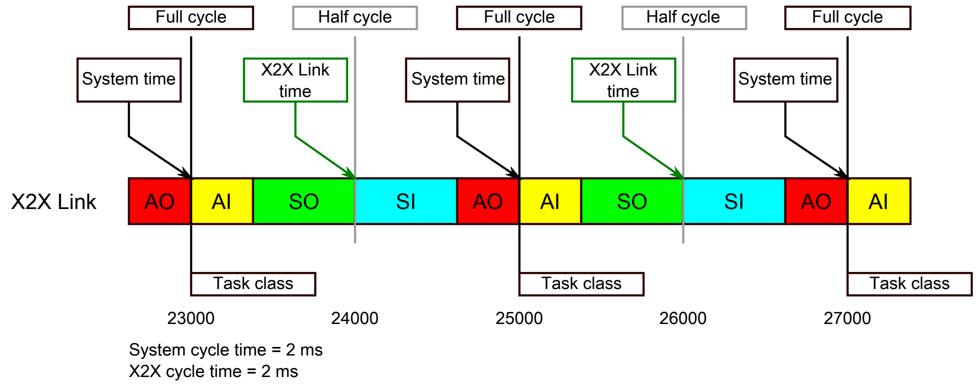
The initialization of the times is based on the system time during the startup of the X2X Link, the I/O modules or the POWERLINK interface.

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

13.10.1.1 PLC/Controller data points

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

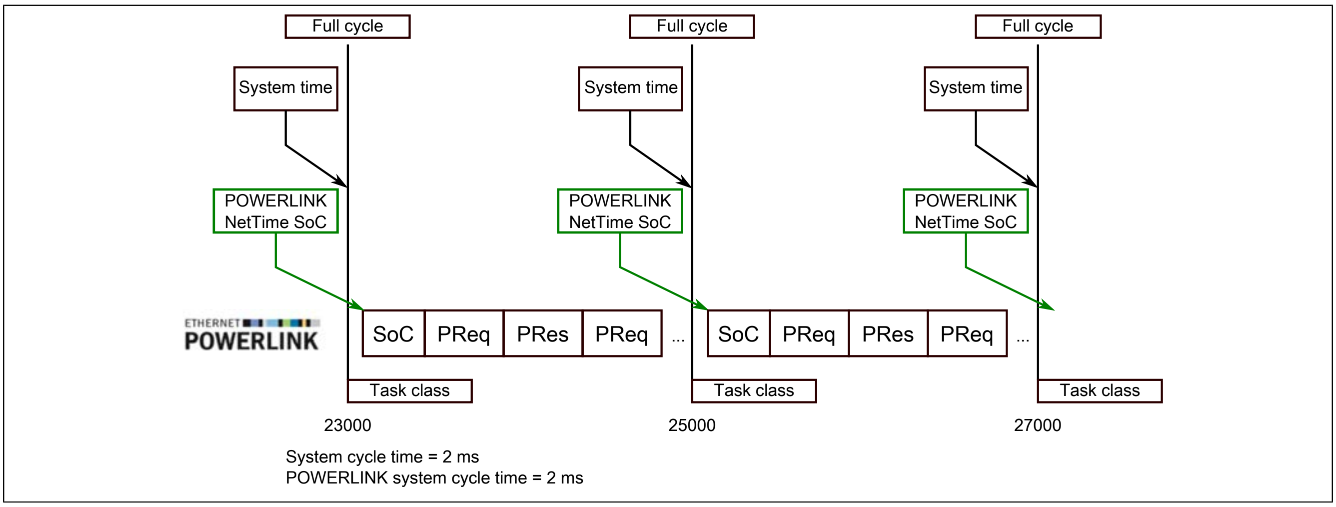
13.10.1.2 X2X Link reference moment



The reference moment 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 moment 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 moment are compared at time 25000 in the task, then the system time returns the value 25000 and the X2X Link reference moment returns the value 24000.

13.10.1.3 POWERLINK reference moment

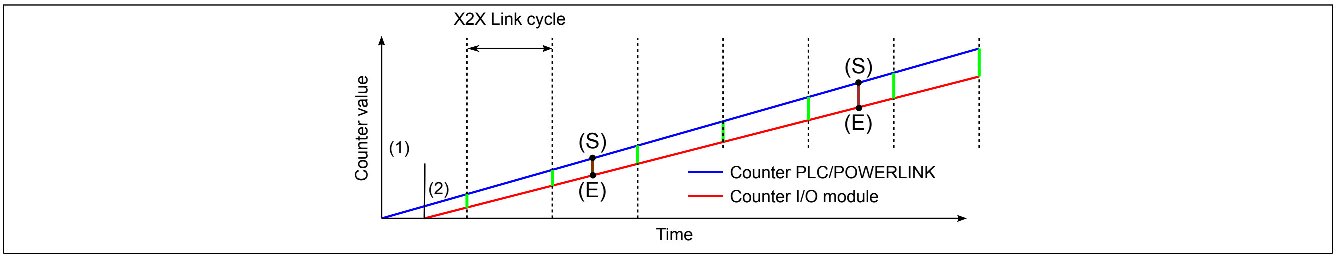


The reference moment on the POWERLINK network is always calculated at the start of cycle (SoC) of the POWERLINK network. The SoC starts 20 µs after the system tick. This results in the following difference between the system time and the POWERLINK reference time:

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 moment are compared at time 25000 in the task, then the system time returns the value 25000 and the POWERLINK reference moment returns the value 23020.

13.10.1.4 Synchronization of system time/POWERLINK time and I/O module



At startup, the internal counters for the PLC/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 PLC or the 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.

13.10.2 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 CPU, including this precise moment, the CPU can then evaluate the data using its own NetTime (or system time), if necessary.

13.10.2.1 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.**

13.10.2.2 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.**

13.10.2.3 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.

14 Commissioning

14.1 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 microsteps 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

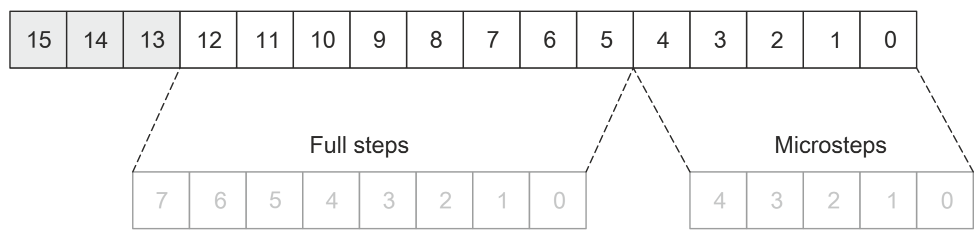
Microstep mode should change to full step mode at 500 steps/second. A Full step limit value of 500 for a motor with 200 steps/revolution corresponds to a speed of:

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

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 step starts.

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



14.2 Operating function model "Ramp"

Commands for controlling the modules are written to the "Control word" on page 53. The current module state is returned in register "Status word" on page 54. The function mode (absolute position, constant speed, homing, etc.) is set in the "mode register" on page 50.

14.2.1 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	Reserved	Stop	Fault reset	Mode-specific	Mode-specific	Mode-specific	Enable operation	Quick stop	Enable voltage	Switch on
Bit[1]	**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 (light gray in the previous table)	These bits control the state of the State machine according to the commands in the table above.
Fault reset	A rising edge resets errors and warnings (see State machine).
Stop	0 ... Perform motor movement 1 ... Stop axis with deceleration This bit is only evaluated when the extended control word is activated in the "General configuration" on page 37 register.
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 1 ... Current error detection enabled
Encoder position sync/async.	0 ... Value of the ABR counter on the "Current position (acyclic)" on page 56 register. Internal position counter of the ramp generator on the "Current position (cyclic)" register. 1 ... Value of the ABR counter on the "Current position (cyclic)" on page 56 register. Internal position counter of the ramp generator on the "Current position (acyclic)" register.
Stall detection	0 ... Stall detection disabled 1 ... Stall detection enabled

14.2.2 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 / MotorLoadBit 2 [1)]	Reserved / MotorLoadBit 1 [1)]	Reserved / MotorLoadBit 0 [1)]	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

1) If bit 7 is set to 1 in the "Mixed Decay / Stall Detection" on page 40 register, then the motor load value is returned in bits 13-15 of the status word. Otherwise these bits are always 0.

Information about the status word:

<table>
<tr><td>Bits 0,1,2,3,5 and 6
(light gray in the previous table)</td><td colspan="2">These bits are set according to the currently active state of the State machine.</td></tr>
<tr><td>Voltage enabled</td><td colspan="2">Becomes 1 as soon as the motor is powered</td></tr>
<tr><td>Warning</td><td colspan="2">Becomes 1 if a warning is detected ("Overcurrent", "Undercurrent"). The type of warning is indicated in the "Error code" on page 55 register. 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.</td></tr>
<tr><td>Remote</td><td colspan="2">Always 1</td></tr>
<tr><td rowspan="2">Target reached[1)], depends on bit 8 (Stop) in "Structure of the control word" on page 25</td><td>If stop = 0</td><td>If stop = 1</td></tr>
<tr><td>In modes 1, -123, -124, -125 and -126 (absolute positioning):
0...Positioning begins
1...Target has been reached

In mode 2 (constant speed):
0...Motor accelerates/brakes
1...Speed setpoint reached

In modes -127 and -128 (homing):
0...Homing started
1...Homing ended

In mode -122 (set actual position):
The bit briefly becomes 0 and immediately becomes 1 again as soon as the position is set.</td><td>In all modes:
0...Axis decelerating
1...Axis speed = 0</td></tr>
<tr><td>Internal limit active</td><td colspan="2">0 ... No limit violation
1 ... Internal limit is active (upper/lower software limit violated)</td></tr>
</table>

1) If the extended control word in register "General configuration" on page 37 was not enabled, "Target reached" behaves the same as if "Stop = 0".

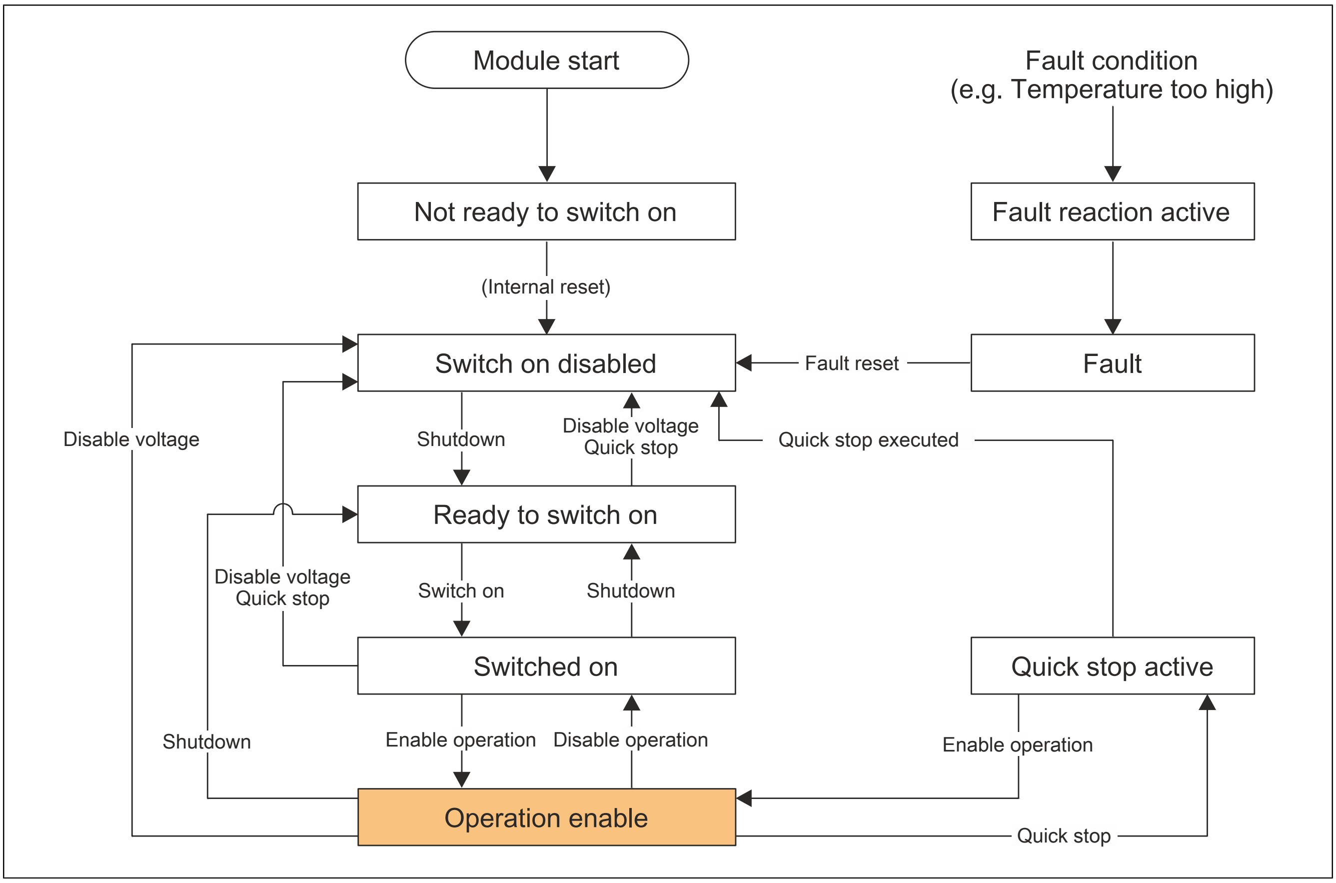
14.2.3 State machine

The motor is controlled 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 53.

The state machine successively reaches the 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 50 only in state *"Operation enable"*.



State change	Description
Not ready to switch on → Switch on disabled	This state change occurs automatically after starting the module and internal initialization has taken place.
Switch on disabled → Ready to switch on	This state change is initiated by command *Shutdown*. No others actions are performed.
Ready to switch on → Switch-on disabled	This state change is brought on by the command *Disable voltage* or *Quick stop*. No others actions are performed.
Switched on → Switch-on disabled	This state change is brought on by the command *Disable voltage* or *Quick stop*. The motor voltage is cut off immediately.
Ready to switch on → Switched on	This state change is brought on by the *Switch on* command. The motor voltage is switched on. When this state change occurs for the first time since the module is started, the motor ID measurement is performed before state *Switched on* is achieved. This can take approximately 1 second.
Switched on → Ready to switch on	This state change is initiated by command *Shutdown*. The motor voltage is cut off immediately.
Switched on → Operation enable	This state change is brought on by the *Enable operation* command. Motor movements are now performed depending on the set mode.
Operation enable → Switched on	This state change is brought on by the *Disable operation* command. If in motion, the motor is decelerated with the configured braking deceleration. The motor voltage remains switched on in state *Switched on*.
Operation enable → Ready to switch on	This state change is initiated by command *Shutdown*. The motor voltage is cut off immediately.
Operation enable → Switch on disabled	This state change is brought on by the *Disable voltage* command. Motor voltage switched off. 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 → Quick stop active	This state change is brought on by the *Quick stop* command. If in motion, the motor is decelerated with the configured braking deceleration. During the deceleration, the state machine remains in state *Quick stop active*. If the motor comes to standstill, the switch to state *Switch on disabled* takes place automatically. While the state machine is in state *Quick stop active*, command *Enable operation* can be used to switch it back to state *Operation enable*.
→ 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 error types classified as "Error" (see "Error code" on page 55). (Other error types listed as "Warning" only cause the "Warning" bit to be set in the status word and do not cause a state change in the state machine.) The motor voltage is cut off and the state machine then changes immediately to state *Fault*. The type of error is listed in the error code register (see table in "Error code" on page 55). The highest priority error is shown. The priority corresponds to the order in the error code table.
Fault → Switch-on disabled	This state change is brought on by the *Fault reset* command. 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.

15 Register description

15.1 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

15.2 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.

15.3 Function model 0 - Standard

Register	Name	Data type	Read		Write	
			Cyclic	Non-cyclic	Cyclic	Non-cyclic
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						
44	ConfigOutput01 (Stall threshold)	UINT				•
52	ConfigOutput16 (Mixed decay threshold)	UINT				•
84	FullStepThreshold01	UINT				•
92	StallDetectMinSpeed01	UINT				•
Reads 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	USINT	•			
Motor control						
Index* 2 + 16	MotorStepN (Index N = 0 to 3)	UINT			•	
Input state						
4	Input counter state	USINT	•			
	StatusInput01	Bit 2				
	...	...				
	StatusInput04	Bit 5				
Error handling						
4	Module power supply error	USINT	•			
	ModulePowerSupplyError	Bit 0				
10	Error state	USINT	•			
	StallError	Bit 0				
	OvertemperatureError	Bit 1				
	CurrentError	Bit 2				
	OvercurrentError	Bit 3				
54	Error acknowledgment	USINT			•	
	ClearError	Bit 5				
Positioning						
6	PositionSync	UINT		•		
0	Positionasync	INT	•			
86	PositionSync02	INT	•			
60	PositionLatchedSync	INT	•			
64	PositionLatchedASync	INT		•		
Latch and trigger						
54	Stepper latch configuration	USINT			•	
	StartLatch	Bit 0				
	TriggerEdgePos	Bit 1				
	TriggerEdgeNeg	Bit 2				
	TriggerEdge	Bit 3				
	StartTrigger	Bit 4				
72	Stepper latch trigger status	USINT	•			
	LatchInput	Bit 0				
	LatchDone	Bit 1				
	TriggerInput	Bit 4				
68	usSinceTrigger	UINT	•			

15.4 Function model 0 - Standard with SDC and function model MotionConfiguration

Register	Name	Data type	Read		Write	
			Cyclic	Non-cyclic	Cyclic	Non-cyclic
Configuration						
Module / Motor configuration						
-	ConfigOutput02 (Module configuration 1)	UINT				•
103	MotorSettlingTime01	USINT				•
102	SDCConfig01	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						
44	ConfigOutput01 (Stall threshold)	UINT				•
52	ConfigOutput16 (Mixed decay threshold)	UINT				•
84	FullStepThreshold01	UINT				•
92	StallDetectMinSpeed01	UINT				•
Reads 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	USINT	•			
Motor control						
100	Motor current	USINT			•	
	DriveEnable01	Bit 0				
	BoostCurrent01	Bit 1				
	StandstillCurrent01	Bit 2				
16	Motor1Step0	INT			•	
SDC life sign monitoring						
112	SetTime01	INT			•	
73	LifeCnt	SINT	•			
Input state						
4	Input counter state	USINT	•			
	StatusInput01	Bit 2				
	...	...				
	StatusInput04	Bit 5				
Error handling						
4	Module power supply error	USINT	•			
	ModulePowerSupplyError	Bit 0				
10	Error state	USINT	•			
	StallError01	Bit 0				
	OvertemperatureError01	Bit 1				
	CurrentError01	Bit 2				
	OvercurrentError01	Bit 3				
	DrvOk01	Bit 4				
54	Error acknowledgment	USINT		•		
	ClearError01	Bit 5				
Homing						
200 204	RefPulsePos01 RefPulsePos01	INT	•			
212 214	RefPulseCnt01 RefPulseCnt01	SNT	•			
Positioning						
0	ActPos01	INT	•			
6	Positionasync	UINT		•		
220	ActTime01	INT	•			
Trigger						
216	TriggerCnt01	SINT	•			
208	TriggerTime01	INT	•			

15.5 Function model 254 - Bus controller and function model 3 - Ramp

Register	Offset[1]	Name	Data type	Read		Write	
				Cyclic	Non-cyclic	Cyclic	Non-cyclic
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				•
60	-	FixedPos01a	DINT				•
64	-	FixedPos01b	DINT				•
75	-	JoltTime01	USINT				•
Stall detection							
72	-	FullStepThreshold01	UINT				•
74	-	StallRecognitionDelay01	USINT				•
78	-	StallDetectMinSpeed01	UINT				•
51	-	StallDetectConfig01	USINT				•
Homing							
68	-	RefSpeed01	UINT				•
70	-	RefConfig01	SINT				•
Limitations							
308	-	LimitSwitchConfig01	USINT				•
344	-	PositionLimitMin01	DINT				•
348	-	PositionLimitMax01	DINT				•
Reads the configuration							
48	-	ConfigOutput03aRead (Holding current)	USINT		•		
49	-	ConfigOutput04aRead (Nominal current)	USINT		•		
50	-	ConfigOutput05aRead (Maximum current)	USINT		•		
Communication							
Motor detection							
84	-	MotorIdentification01	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	DINT	•			
90	-	AbsPos1ActValAcyclic	DINT		•		

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

15.5.1 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).

15.5.2 CAN I/O bus controller

The module occupies 1 analog logical slot on CAN I/O.

15.6 Configuration registers - Function model 0 and function model MotionConfiguration

15.6.1 Module configuration

15.6.1.1 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 the "Input counter state" on page 44 register.	x	
1 - 2	Reserved	0	
3 - 4	Number of transfer values per X2X cycle (See "Motor setting" on page 43.)	00	1 x Δs / Δt (transfer values: MotorStep0)
		01	2 x Δs / Δt (transfer values: MotorStep0 - MotorStep1
		10	4 x Δs / Δt (transfer values: MotorStep0 - MotorStep3
		11	Reserved
5 - 6	Resolution of microsteps for the following registers: • "Motor setting" on page 43 • "Position sync/async" on page 47	00	Resolution: 5 bits (bit 0 - 4) microsteps; 8 bits (bit 5 - 13) full steps
		01	Resolution: 6 bits (bit 0 - 5) microsteps; 7 bits (bit 6 - 13) full steps
		10	Resolution: 7 bits (bit 0 - 6) microsteps; 6 bits (bit 7 - 13) full steps
		11	Resolution: 8 bits (bit 0 - 7) microsteps; 5 bits (bit 8 - 13) full steps
7 - 15	Reserved	0	

15.6.1.2 Module configuration 1 with SDC

The "Module configuration 1" on page 33 register is ignored in the standard function model with SDC information enabled. The module behaves as if the module configuration were described as follows:

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 state" on page 44		
1 - 2	Reserved	0	
3 - 4	Number of transfer values per X2X cycle	00	1x Δs / Δt (transfer values: Motor settings Step specification)
5 - 6	Resolution of microsteps	11	8-bit microsteps
7 - 15	Reserved	0	

15.6.1.3 SDC configuration

Name:
SDCConfig01

This register can be used to enable/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 the standard function model 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	SDC life sign monitoring	0	Disabled
		1	Enabled
7	SDC information[1]	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.

Note:

Neither SDC information nor SDC life sign monitoring is permitted to be changed at runtime.

15.6.1.4 Motor settling time

Name:
MotorSettlingTime01

This register determines the motor setting time. This is the minimum time from the time the motor is energized until the drive bit (DrvOk) is set (see "Error state" on page 45). 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

15.6.1.5 Turn-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	Value	Information
USINT	0 to 255	0 to 25.5 ms in steps of 100 ms (default: 100 ms)

15.6.2 Configure currents

15.6.2.1 Holding current, rated current and maximum current

Name:
ConfigOutput03 (holding current)
ConfigOutput04 (rated 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
Default	Using bits 14 and 15 in the registers "Motor setting" on page 43
Standard with enabled SDC information	Using the register "Motor current" on page 42

Data type	Value	Unit
USINT	0 to 120	Percent of the module's rated current • 100% corresponds to the rated current of the motor bridge power unit listed in the technical data • 120% corresponds to the maximum current of the motor bridge power unit listed in the technical data.

15.6.2.2 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)

15.6.3 Counter configuration

15.6.3.1 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: Enable latch ABR latch function. After a latch event has occurred, the latch function can be started again with a new rising edge.
1 - 2	Definition of the latch mode	00	Latch ABR counter state unconditionally
		01	Latch ABR counter state at a positive edge on the R input
		10	Latch ABR counter state at a negative edge on the R input
		11	Reserved
3		0	• Position sync: Internal position counter • Position async: ABR counter state • Position latched sync: Internal position counter[1)] • Position latched async: ABR counter value[1)]
		1	• Position sync: ABR counter state • Position async: Internal position counter • Position latched sync: ABR counter value[1)] • Position latched async: Internal position counter[1)]
4 - 7	Reserved		

1) These registers are not available in the standard function model with SDC information enabled.

15.6.4 Stall detection

15.6.4.1 Stall threshold

Name:
ConfigOutput01

With the "stall threshold" register, a threshold can be defined according to the motor load, and the module detects a stall condition started at this threshold (see "Error state" on page 45).

Data type	Values
UINT	See the bit structure.

Bit structure:

Bit	Description	Value	Information
0 - 2	Trigger threshold for stall detection	0	Stall detection is disabled
		1	Minimum sensitivity for stall detection
		2 to 6	Setting the sensitivity of stall detection
		7	Maximum sensitivity for stall detection
3 - 15	Reserved	0	

15.6.4.2 Mixed decay threshold

Name:
ConfigOutput16

The mixed decay threshold is configured in this register. This value must be adjusted according to the motor being used, current and voltage when using stall detection. Otherwise, the default value 15 will be used.

Data type	Values
UINT	See the bit structure.

Bit structure:

Bit	Description	Value	Information
0 - 3	Mixed Decay Threshold	0	Mixed decay disabled
		1 to 14	Setting for mixed decay threshold
		15	Mixed decay always enabled
4 - 15	Reserved	-	

15.6.4.3 Minimum speed for stall detection

Name:
StallDetectMinSpeed01

If the motor speed exceeds the value set in this register, then stall detection is enabled and the configured mixed decay threshold is used. The value 15 is always used for the mixed decay threshold below this threshold value, and no stall error is reported. This means that mixed decay mode is always enabled at low speeds where stall detection principally does not work.

Data type	Value	Information
UINT	0 to 65535	Minimum speed in steps per second.

15.6.4.4 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 65,535	Steps/second

15.7 Function models 3 and 254 - Configuration registers

15.7.1 Configure currents

15.7.1.1 Holding current, rated current and maximum current

Name:
ConfigOutput03a (holding current)
ConfigOutput04a (rated 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	Value	Unit
USINT	0 to 120	Percent of the module's rated current • 100% corresponds to the rated current of the motor bridge power unit listed in the technical data • 120% corresponds to the maximum current of the motor bridge power unit listed in the technical data. Bus controller default setting: 0

15.7.1.2 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	Percent of the module's nominal current 100% corresponds to the nominal current of the motor bridge power unit listed in the technical data.

15.7.2 Motion generator

15.7.2.1 General configuration

Name:
GeneralConfig01

Bit 0 of this register can be used to switch the positioning mode. This register can also be used to configure the cycle time of the motion 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[1)]	00	25 ms (bus controller default setting)
		01	10 ms
		10	5 ms
		11	Reserved
3 - 7	Reserved	0	

1) This parameter is supported starting with upgrade 1.3.1.0 (firmware version 16).

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^2

15.7.2.2 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	Value	Information
UNIT	0 to 65,535	Speed in microsteps / cycle. Bus controller default setting: 0

15.7.2.3 Maximum acceleration

Name:
MaxAcc01

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

Data type	Value	Information
UINT	0 to 65,535	Acceleration in microsteps / cycle². Bus controller default setting: 0

15.7.2.4 Maximum deceleration

Name:
MaxDec01

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

Data type	Value	Information
UINT	0 to 65,535	Deceleration in microsteps / cycle². Bus controller default setting: 0

15.7.2.5 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

15.7.2.6 Jolt 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	Value	Information
USINT	0	No jolt time limitation. Bus controller default setting: 0
	1 to 80[1)]	Number of FIFO elements

1) Starting with upgrade 1.3.1.0 (firmware version 16), for older versions: 16

15.7.2.7 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 to 2,147,483,647	Bus controller default setting: 0

15.7.2.8 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 to 2,147,483,647	Bus controller default setting: 0

15.7.3 Stall detection

15.7.3.1 Full step limit value

Name:
FullStepThreshold01

This register defines the threshold speed, above which the motor is operated in full step mode, and below which it is operated in microstep mode.

Data type	Value	Information
UINT	1 to 65534	Speed in microsteps / cycle. Bus controller default setting: 0
	65535	Motor is always operated in microstep mode

15.7.3.2 Stall recognition delay

Name:
StallRecognitionDelay01

The value in this register is only relevant for mode Homing during stall.

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

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	Value	Information
USINT	0	No delay (bus controller default setting)
	1 to 255	Delay time in cycles, see "General configuration" on page 37.

15.7.3.3 Minimum speed for stall detection

Name:
StallDetectMinSpeed01

If the motor speed exceeds the value set in this register, then stall detection is enabled and the configured mixed decay threshold is used. The value 15 is always used for the mixed decay threshold below this threshold value, and no stall error is reported. This means that mixed decay mode is always enabled at low speeds where stall detection principally does not work.

Data type	Value	Information
UINT	0 to 65535	Minimum speed in microsteps per cycle. Bus controller default setting: 0

15.7.3.4 Stall detection configuration / Mixed decay

Name:
StallDetectConfig01

The mixed decay threshold and stall detection sensitivity can be configured in this register.

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

Bit structure:

Bit	Description	Value	Information
0 - 3	Mixed decay threshold	0	Mixed decay disabled (bus controller default setting)
		1 to 14	Setting for mixed decay threshold
		15	Mixed decay always enabled
4 - 6	Stall threshold	0	Stall detection is disabled (bus controller default setting)
		1 to 6	Steps involved in setting stall detection sensitivity
		7	Maximum sensitivity for stall detection
7	Motor load	0	Motor load value not shown (bus controller default setting)
		1	Show value in register "Status word" on page 54[1]

1) If this bit is 1, then the motor load value is indicated in bits 13 to 15 of the status word register (otherwise these bits are 0). This value can help when testing stall detection and Home during stall mode.

15.7.4 Homing

15.7.4.1 Homing speed

Name:
RefSpeed01

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

Data type	Value	Information
UINT	0 to 65,535	Speed in microsteps / cycle. Bus controller default setting: 0

15.7.4.2 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). (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

15.7.5 Limitations

15.7.5.1 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

15.7.5.2 Software limit

Name:
PositionLimitMin01
PositionLimitMax01

This register configures software limits. The function is active if at least one of the two registers is unequal to zero.

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

15.8 Communication registers - Function model 0 and function model MotionConfiguration

15.8.1 Motor detection

15.8.1.1 Motor ID trigger

Name:
MotorIdentTrigger

With this register, a measurement of the motor ID can be initiated acyclically (see "Motor identification" on page 42). The application must ensure that the conditions for measurement are met (see section "Integrated motor detection" on page 10).

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	

15.8.1.2 Motor identification

Name:
Motoridentification01

This register is used to identify the connected motor type for service purposes and to differentiate between motors in the application. After successful measurement, this register contains the time [µs] required to apply a current increase of ΔI = 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 (in µs)
	65504 to 65519	Ground fault: Measurement of motor identification not possible
	65528	Motor ID trigger not possible • Motor not supplied with current • Motor in movement • Nominal current set to 0 A • Ground fault present
	65529	Invalid value: Underflow
	65530	Overtemperature: Measurement not possible
	65532	Open circuit: Measurement not possible
	65533	Incorrect motor position: Measurement not possible
	65534	Invalid value: Overflow
	65535	Measurement in progress

Ground fault detection

When the motor is powered on, a ground fault check is performed before motor identification.

15.8.1.3 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.

Data type	Values
USINT	0 to 7

15.8.2 Motor control

15.8.2.1 Motor current

Name:
DriveEnable01
BoostCurrent01
StandstillCurrent01

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 - 7	Reserved	0	

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

15.8.2.2 Motor setting

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, rated current and maximum current" on page 35).

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 33). 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, then the X2X cycle is divided accordingly.

Example: X2X cycle = 1 ms (1000 µs)

Time	Number of transfer values (see "Module configuration 1" on page 33)		
	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

15.8.2.3 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

15.8.3 Life sign monitoring

15.8.3.1 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 activated in the "SDC configuration" on page 34 register by setting bit 6 (SDCSetTime = on).

Data type	Values
INT	-32768 to 32767

15.8.3.2 Lifecycle counter

Name:
LifeCnt

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

Data type	Values
SINT	-128 to 127

15.8.4 Input state

15.8.4.1 Input counter state

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

In function model 0 - "Standard with SDC", only the state of the digital inputs is available.

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: 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	-	

15.8.5 Error handling

15.8.5.1 Error state

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
CurrentError	CurrentError01
OvercurrentError	OvercurrentError01
-	DrvOK01

This register contains the error state of the drive. 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 "Stepper latch configuration" on page 48 and "Error acknowledgment" on page 46).

Data type	Values
UINT	See the bit structure.

Bit structure:

Bit	Description	Value	Information
0	StallError(01)	0	No stall
		1	Stall
1	Overtemperature error OvertemperatureError(01)	0	No overtemperature
		1	Overtemperature
2	Current error CurrentError(01)	0	No current error
		1	Current error
3	Overcurrent error OvercurrentError(01)	0	No overcurrent
		1	Overcurrent
4	Status of the drive DrvOk01 [1)]	0	An error was triggered for the motor axis
		1	The drive is running error-free.
5 - 15	Reserved	0	

1) Only if SDC information enabled

Overtemperature error

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

- The temperature of the output stage of a motor output exceeds the maximum permissible temperature.
- The module temperature exceeds 85°C.

Current error

This error bit occurs whenever the required current cannot be supplied to the motor windings. This can be triggered by an open circuit, for example. At higher speeds, this error can also occur without an open circuit depending on the motor. Due to the back EMF of the motor, this error already occurs at somewhat lower speeds if the engine is idling.

Overcurrent error

An overcurrent occurs if 2 times the motor current is measured in the motor windings (e.g. short circuit).

Status of the drive

The state of the drive is only indicated when SDC information is enabled. The drive bit is 1 when the following conditions are met:

- The motor has been switched on (see "Motor current" on page 42).
- Ground fault detection is completed and OK.
- The MotorID measurement is completed.
- The motor is energized.
- The motor settling time has expired.
- The supply voltage is within the valid range.
- No overtemperature error
- The preset position value is valid (see "SDC life sign monitoring" on page 43).

15.8.5.2 Error acknowledgment

Name:
ClearError01

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

For more info, see "Error state" on page 45.

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	

15.8.6 Homing

15.8.6.1 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"	
	Stepper counter 01 is indicated on ActPos01.	ABR counter 01 is indicated on ActPos01.
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 "Counter configuration" on page 35:		
Bit 3 (counter 1)	0	1

15.8.6.2 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"	
	Stepper counter 01 is indicated on ActPos01.	ABR counter 01 is indicated on ActPos01 .
RefPulseCnt01	Reference pulse counter for the internal position counter	Reference pulse counter of the ABR counter
Option "Position sync" for counter 1 also sets bit 3 in register "Counter configuration" on page 35:		
Bit 3 (counter 1)	0	1

15.8.7 Positioning and speed

15.8.7.1 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 state of 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

15.8.7.2 Position sync 2

Name:
PositionSync02

This register contains either the position counter or ABR counter value depending on Counter configuration (bit 3). It behaves exactly complementary to register "PositionSync" on page 47.

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

15.8.7.3 Position latched sync/async

Name:
PositionLatchedSync
PositionLatchedASync

The position counter (internal position counter or ABR counter) is applied at the latch event (see "Stepper latch configuration" on page 48). Bits 3 and 7 of the "Counter configuration" on page 35 register are used to determine which counter state (internal position counter or ABR encoder) should be saved in the registers "Position latched sync" and "Position latched async".

Data type	Values
INT	-32768 to 32767

Register	Counter configuration	
	Bit 3 ... 0	Bit 3 ... 1
Position sync	Internal position counter	ABR counter
Position async	ABR counter	Internal position counter

15.8.7.4 NetTime of the position value

Name:
ActTime01

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

For more information about NetTime and timestamps, see "NetTime Technology" on page 21.

Data type	Values
INT	-32768 to 32767

15.8.8 Latch and trigger

15.8.8.1 Stepper latch configuration

Name:
StartLatch
TriggerEdgePos
TriggerEdgeNeg
StartTrigger
TriggerEdge
ClearError

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 Latch byte	0	The latch function for stepper motor position is deactivated at the negative edge of this bit
		1	The latch function for stepper motor position is deactivated at the positive edge of this bit
1 - 2	Latch mode for stepper motor TriggerEdgePos (Bit 1) TriggerEdgeNeg (Bit 2)	00	Latch position of stepper motor, unconditional
		01	Latch position of stepper motor at positive edge on input DI 3
		10	Latch position of stepper motor at negative edge on input DI 3
		11	Reserved
3	TriggerEdge	0	Trigger edge (input DI 4) = positive
		1	Trigger edge (input DI 4) = negative
4	Enable trigger (when changes occur) StartTrigger	x	
5	ClearError	0	No effect
		1	Error acknowledgment for the motor (for more info, see "Error state" on page 45)
6 - 7	Reserved	-	

Trigger function procedure:

- Select the desired trigger edge using bit 3
- Enable the trigger function by changing the state of bit 4. When this bit changes, usSinceTrigger (µs counter) is cleared.
- When the trigger event occurs, usSinceTrigger (µs counter) is started.
- The usSinceTrigger counter cannot overrun, i.e. it is stopped at 2^{16} and retains this value until the next time the trigger function is activated.

The trigger function can be re-activated at any time by changing the state of bit 4, regardless of whether a trigger event has occurred or if usSinceTrigger has reached the maximum value.

15.8.8.2 Stepper 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	

15.8.8.3 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 34.

For more information about NetTime and timestamps, see "NetTime Technology" on page 21.

Information:

The absolute accuracy of the trigger can be delayed up to 5 µs due to the input filter of the digital inputs.

Data type	Values
INT	-32768 to 32767

15.8.8.4 Trigger counter

Name:
TriggerCnt01

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

Data type	Values
SINT	-128 to 127

15.8.8.5 usSinceTrigger

Name:
usSinceTrigger

This register indicates the time (in µs) that has passed since the trigger event occurred (see "Stepper latch configuration" on page 48).

Information:

The absolute accuracy of the trigger can be delayed up to 5 µs due to the input filter of the digital inputs.

Data type	Values
UINT	0 to 65,535

15.9 Function models 3 and 254 - Communication registers

15.9.1 Motor detection

15.9.1.1 Motor identification

Name:
Motoridentification01

This register is used to identify the connected motor type for service purposes and to differentiate between motors in the application. After successful measurement, this register contains the time [µs] required to apply a current increase of ΔI = 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 (in µs)
	65504 to 65519	Ground fault: Measurement of motor identification not possible
	65528	Motor ID trigger not possible • Motor not supplied with current • Motor in movement • Nominal current set to 0 A • Ground fault present
	65529	Invalid value: Underflow
	65530	Overtemperature: Measurement not possible
	65532	Open circuit: Measurement not possible
	65533	Incorrect motor position: Measurement not possible
	65534	Invalid value: Overflow
	65535	Measurement in progress

15.9.2 Motor control

15.9.2.1 Mode

Name:
MpGenMode01

Data type	Value	Information
SINT	0	No mode selected
	1	Depending on bit 0 in the "General configuration" on page 37 register, the position mode will behave as follows: • Position mode without extended control word: Move to target position as soon as the target position changes • Position mode with extended control word: Move to position setpoint as described in "Mode 1 - Position mode with extended control word" on page 50
	2	Speed mode: Constant speed
	-120	Set reference 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 "Homing configuration" on page 40)
	-128	Negative homing (see also "Homing configuration" on page 40)

Information:

For all modes: The "Target reached" bit is set in the "Status word" on page 54 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.

15.9.2.1.1 Mode 1 - Position mode

The position setpoint is specified in register "Set position/speed" on page 55. 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 37.

- 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 50.

15.9.2.1.2 Mode 1 - Position mode with extended control word

The position mode with extended control word behaves like previously described position mode 1 (without extended control word); the difference is that the new position setpoint ("position/speed" on page 55 register) is applied by the extended control word.

Extended control word

Commands can be issued using this register depending on the state of the module (see "Operating function model "Ramp"" on page 25).

Data type	Values
UINT	See the bit structure.

Bit structure:

Bit	Description	Value	Information
0 - 3	Corresponds to the default Control word	x	
4	New setpoint	0	Do not apply position setpoint
		1	Apply position setpoint
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	Position setpoint is an absolute value
		1	Position setpoint is a relative value
7	Corresponds to the default Control word	x	
8	Stop [1]	0	Execute positioning
		1	Stop axis with deceleration
9 - 15	Corresponds to the default Control word	x	

1) This bit applies to all modes.

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 26 and "State machine" on page 27).

Data type	Values
UINT	See the bit structure.

Bit structure:

Bit	Description	Value	Information
0 - 9	Corresponds to the default Status word	x	
10	Target reached, depends on bit 8 (Stop) in register "Control word" on page 53		**If stop = 0**
		0	Position setpoint not reached
		1	Position setpoint reached
			If stop = 1
		0	Axis decelerating
		1	Axis speed = 0
11	Corresponds to the default Status word	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 Status word	x	

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 "Status word" on page 54 is set. 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" on page 51 and *Setpoint acknowledge* in the "extended status word" on page 51 register.

Relative position setting

When the *abs / rel* bit in the "Extended control word" on page 51 register is set, then the position setpoint is interpreted as a relative value. At each *New setpoint* trigger, the position setpoint 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.

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

The value in the "Position/Speed" on page 55 register is now 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.

15.9.2.1.4 Mode -120: Set home position

This parameter is supported starting with upgrade 1.3.1.0 (firmware version 16).

The current value for the actual position is modified so that the position specified by the "Position/Speed" on page 55 register is the home position. If you subsequently move to this position, the motor is at the home position.

The home position in the "Home position" on page 55 register is also set to this value.

15.9.2.1.5 Mode -121: Remaining distance mode (like Modus 1)

With a rising or falling edge on digital input 3 or 6, the current target position is discarded and only the number of steps set in register "FixedPos01a" on page 38 will be moved forward or backward.

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

15.9.2.1.6 Mode -122: Set the actual position

The target position set in register "Position/Speed" on page 55 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.

15.9.2.1.7 Mode -123: Move to the position setpoint when the external input is set

The set position defined in the "Position/speed" on page 55 is moved to when a rising edge occurs on the corresponding digital input.

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.

15.9.2.1.8 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.

15.9.2.1.9 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 38
- Mode -126: "Fixed position B" on page 39

15.9.2.1.10 Mode -127/-128: Homing (positive/negative)

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.

If the homing condition occurs, then the motor stops and the values of the position counter and ABR counter valid at the moment when the homing condition occurs are written to the "Homed zero position" on page 55 register.

15.9.2.2 Read back mode

Name:
ModeReadback01

This register can be used to read the content of the "Mode" on page 50 register.

Data type	Values
SINT	-128 to 127

15.9.2.3 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 25).

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 [1]	x	
9 - 10	Reserved	0	
11	Motor ID trigger	0	No effect
		1	Rising edge: Motor ID trigger [2]
12	Warning reset	0	No effect
		1	Rising edge: Reset warnings
13	Undercurrent detection	0	Disable current error detection (default)
		1	Enable current error detection
14	ABR counter sync/async	0	Default: • Internal position counter, cyclic • ABR counter, acyclic
		1	• Internal position counter, acyclic • ABR counter, cyclic
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 37).
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 49 register).

15.9.2.4 Reading back the control word

Name:
ControlReadback01

With this register, the contents of register "Control word" on page 53 can be read back.

Data type	Values
UINT	0 to 65,535

15.9.2.5 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 26 and "State machine" on page 27.

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/lower software limit violated)
12	Mode-specific	x	
13 - 15	Reserved / Motor load value	0	Always 0 when bit 7 in the "Stall detection configuration / Mixed decay" on page 40 register is set to 0.
		x	Returned motor load value

15.9.3 Input state

15.9.3.1 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 - 7	Reserved	0	

15.9.4 Error handling

15.9.4.1 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[1)]
	0xFF01	Warning	Low	Stall [2)]

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 7 (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 12 (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.

15.9.5 Homing

15.9.5.1 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 53).

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

15.9.6 Positioning and speed

15.9.6.1 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 50): 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 50): In this mode, this register is considered a signed speed setpoint.

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

15.9.6.2 Current position (cyclic)

Name:
AbsPos01ActVal

This cyclic register contains the current position.

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

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

15.9.6.3 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

15.10 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	
Function model "Standard"	250 µs
Function model "Ramp"	250 µs

15.11 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	
Function model "Standard"	250 µs
Function model "Ramp" Inputs Outputs[1]	 250 µs 25 ms

1) Depends on the configuration of the "movement profile generator" on page 37.