X67SM2436

1 General information

The stepper motor module is used to control up to 2 stepper motors with a nominal voltage of 24 to 38.5 VDC ±25% at a motor current up to 3 A (5 A peak).

In addition, this module has 6 digital inputs that can be used as limit switches or encoder inputs.

Due to the individual adjustment of the coil currents, the motor is only operated with the current it actually needs. 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, boost and nominal current values. The current for microsteps is automatically adjusted to the configured current values.

The automatic motor identification system is an enormous help during standstills. The stepper motor modules can identify the connected motors using their coil characteristics and generate feedback in the form of an analog value. This makes it possible to detect not only wiring errors, but also incorrect motor types being used mistakenly. A stall detection mechanism is integrated to analyze the motor load. Detection of the stall is defined via a configurable threshold. This allows an overload or motor standstill to be detected precisely in many different types of applications.

- 2 stepper motors, 24 to 38.5 VDC ±25%, 3 A (5 A peak)
- Current value resolution of 1%
- Boost, nominal and holding current separately configurable
- 38.5 kHz PWM frequency
- Integrated motor detection
- 256 microsteps
- Stall detection
- Complete integration in Automation Studio and CNC applications
- 2x 3 inputs, 24 VDC, configurable for ABR incremental encoders
- Integrated short-circuit proof encoder power supply
- Function model 3 ("Ramp") based on CANopen communication profile DS402
- NetTime timestamp: Position change, trigger time

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.

The timestamp function is based on synchronized timers. If a timestamp event occurs, the module immediately saves the current NetTime. After the respective data is transferred to the CPU, including this precise time, the CPU can then evaluate the data using its own NetTime (or system time), if necessary.

2 Order data

Model number	Short description	Figure
	Motor modules	
X67SM2436	X67 stepper motor module, I/O power supply 24-38.5 VDC ±25%, max. 8 A, 2 motor connections, 3 A continuous current, 5 A peak current, 2x 3 digital inputs 24 VDC, sink, configurable as incremental encoder, NetTime function	

Table 1: X67SM2436 - Order data

Required accessories
For a general overview, see section "Accessories - General overview" of the X67 system user's manual.

3 Technical data

Model number	X67SM2436
Short description	
I/O module	2 full bridges for controlling stepper motors
General information	
B&R ID code	0x1DCB
Status indicators	I/O function for each channel, supply voltage, bus function
Diagnostics	
I/O power supply	Yes, using status LED and software
Motor status	Yes, using status LED and software
Connection type	
X2X Link	M12, B-keyed
Inputs/Outputs	4x M12, A-keyed
I/O power supply	M8, 4-pin
Power consumption	
X2X Link power supply	0.75 W
Internal I/O	
At 24 VDC	Max. 1.7 W
At 48 VDC	Max. 2 W
Certifications	
CE	Yes
ATEX	Zone 2, II 3G Ex nA IIA T5 Gc IP67, Ta = 0 - Max. 60°C TÜV 05 ATEX 7201X
UL	cULus E115267 Industrial control 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	2
Type	2-phase bipolar stepper motor (full bridge)
Nominal voltage	24 to 38.5 VDC ±25%
Nominal current	3 A
Max. current/motor	5 A for 2 s (after a recovery time of at least 10 s at maximal 3 A)
Max. current/module	8 A
Controller frequency	38.5 kHz
DC bus capacitance	200 µF
Step resolution	256 microsteps per full step
I/O power supply	
Nominal voltage	24 to 38.5 VDC ±25%
Power consumption	
Sensor power supply	Max. 0.96 W

Table 2: X67SM2436 - Technical data

Model number	X67SM2436
Integrated protection	
Reverse polarity protection	No
Digital inputs	
Quantity	6
Nominal voltage	24 VDC
Input characteristics per EN 61131-2	Type 1
Input voltage	24 VDC -15% / +20%
Input current at 24 VDC	Approx. 4 mA
Input circuit	Sink
Input filter	
Hardware	<5 µs
Software	-
Input resistance	Typ. 5.4 kΩ
Additional functions	2x ABR incremental encoder
Switching threshold	
Low	<5 VDC
High	>15 VDC
Isolation voltage between channel and bus	500 V_{Eff}
ABR incremental encoder	
Quantity	2
Encoder inputs	24 V, asymmetrical
Counter size	16-bit
Input frequency	Max. 50 kHz
Evaluation	4x
Encoder power supply	Module-internal, max. 20 mA per encoder
Signal form	Square wave pulse
Counter 1	Inputs 1 to 3
Counter 2	Inputs 4 to 6
Counter frequency	Max. 200 kHz
Sensor power supply	
Supply voltage	24 VDC
Short-circuit proof	Yes
Supply voltage	
Min. voltage at 20 mA / group	20 VDC
Electrical properties	
Electrical isolation	Channel isolated from bus Channel not isolated from channel
Operating conditions	
Mounting orientation	
Any	Yes
Installation elevation above sea level	
0 to 2000 m	No limitations
>2000 m	Reduction of ambient temperature by 0.5°C per 100 m
Degree of protection per EN 60529	IP67
Ambient conditions	
Temperature	
Operation	0 to 50°C
Derating	-
Storage	-25 to 85°C
Transport	-25 to 85°C
Mechanical properties	
Dimensions	
Width	53 mm
Height	85 mm
Depth	42 mm
Weight	195 g
Torque for connections	
M8	Max. 0.4 Nm
M12	Max. 0.6 Nm

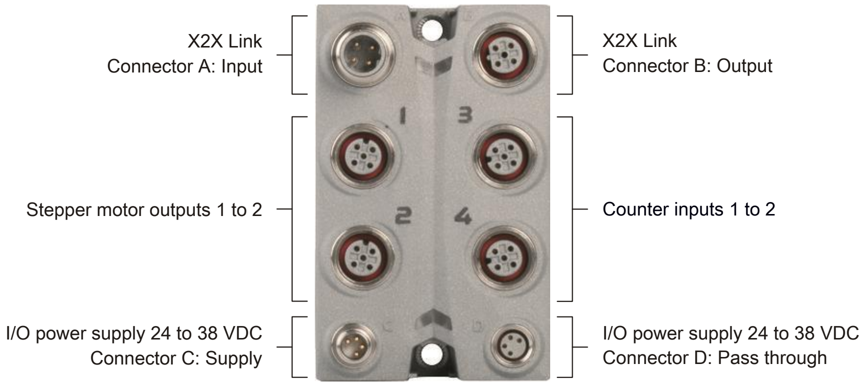
Table 2: X67SM2436 - Technical data

4 LED status indicators

Figure	LED	Color/Status		Description
Status indicator 1: Left: Green, Right: Red  Status indicator 2: Left: Green, Right: Red	**Status indicator 1**: Status indicator for X2X Link			
	Left/Right	**Green(left)**	**Red(right)**	**Description**
		Off	Off	No power supply via X2X Link
		On	Off	X2X Link supplied, communication OK
		Off	On	X2X Link supplied but X2X Link communication not functioning
		On	On	PREOPERATIONAL: X2X Link supplied, module not initialized
	I/O LEDs: Status indicator			
	1 - 2	**Color**	**Status**	**Description**
		Yellow	On	Motor 1 or 2 is active
	3	**Color**	**Status**	**Description**
		Green	On	Input 1 to 3 (in)
	4	**Color**	**Status**	**Description**
		Green	On	Input 4 to 6 (in)
	Status indicator 2: Status indicator for module function			
	Left	**Color**	**Status**	**Description**
		Green	Off	No power supplied to the module
			Single flash	RESET mode
			Blinking	PREOPERATIONAL mode
			Double flash	BOOT mode (during firmware update)[1]
			On	RUN mode
	Right	**Color**	**Status**	**Description**
		Red	Off	No power to module or everything OK
			On	Error or reset status
			Single flash	Warning/Error on an I/O channel. Overflow in analog inputs.
			Double flash	Supply voltage not in the valid range

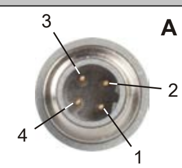
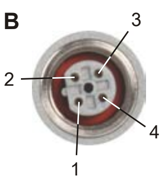
1) Depending on the configuration, a firmware update can take up to several minutes.

5 Connection elements



6 X2X Link

This module is connected to X2X Link using pre-assembled cables. The connection is made using M12 circular connectors.

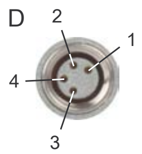
Connection	Pinout	
 	**Pin**	**Description**
	1	X2X+
	2	X2X
	3	X2X⊥
	4	X2X\
	Shield connection made via threaded insert in the module. A → B-coded (male), input B → B-coded (female), output	

7 I/O power supply 24 to 38.5 VDC

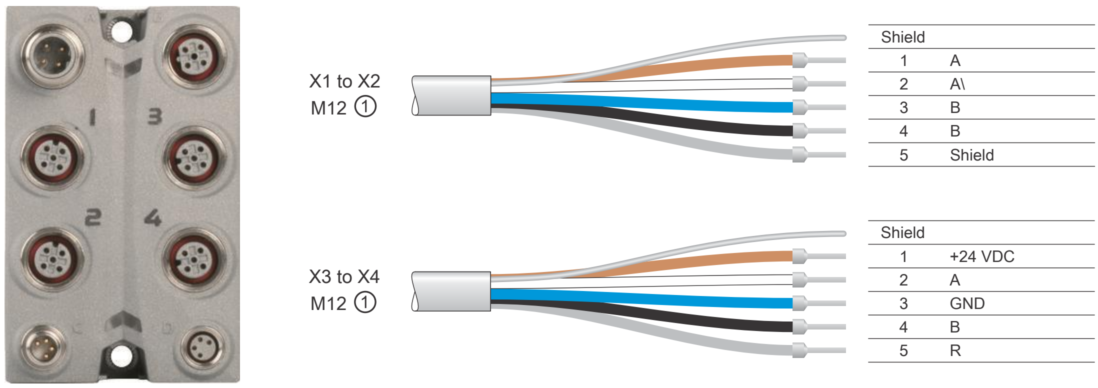
The I/O power supply is connected using circular connectors (M8, 4-pin). The supply is connected via connector C (male). Connector D (female) is used to route the power supply to other modules.

Information:

The maximum permissible current per supply is 4 A (in summation 8 A)!

Connection	Pinout	
 	**Pin**	**Name**
	1	24 to 38.5 VDC ±25%
	2	24 to 38.5 VDC ±25%
	3	GND
	4	GND
	C → Connector (male) in module, supply D → Connector (female) in module, routing	

8 Pinout



① X67CA0A41.xxxx: M12 sensor cable, straight
X67CA0A51.xxxx: M12 sensor cable, angled

8.1 Connections X1 to X2

M12, 5-pin	Pinout	
X1 / X2	**Pin**	**Description**
	1	Stepper motor A
	2	Stepper motor A\
	3	Stepper motor B
	4	Stepper motor B\
	5	Shield

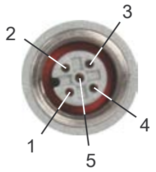
Warning!

Circular connectors are not permitted to be plugged in or unplugged during operation.

Information:

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

8.2 Connections X3 to X4

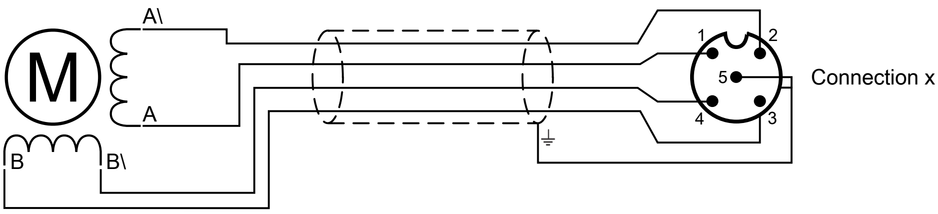
M12, 5-pin	Pinout		
X3 / X4	Pin	Connection 3[1)]	Connection 4[1)]
	1	Power supply for digital inputs (24 V summation current 0.02 A)	
	2	Digital input 1, ABR1 - A	Digital input 4, ABR2 - A
	3	GND	GND
	4	Digital input 2, ABR1 - B	Digital input 5, ABR2 - B, Trigger input
	5	Digital input 3, ABR1 - R	Digital input 6, ABR2 - R
	Shield connection made via threaded insert in the module		

1) All digital inputs: 24 V / <4 µs

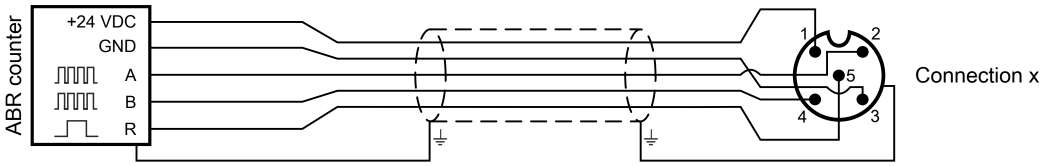
> **Warning!**
>
> **Circular connectors are not permitted to be plugged in or unplugged during operation.**

9 Connection example

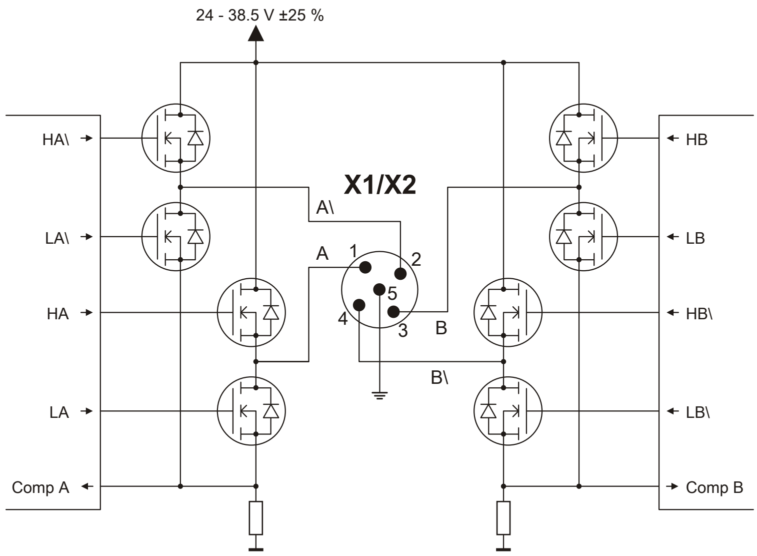
Connection 1 to 2: Stepper motor



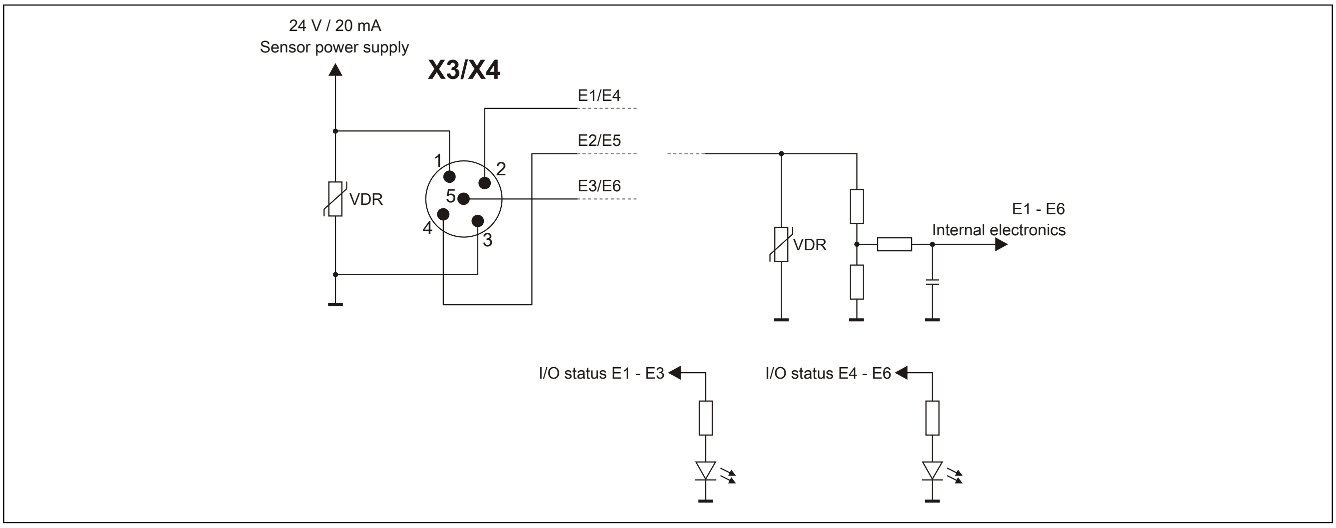
Connection 3 to 4: Digital inputs



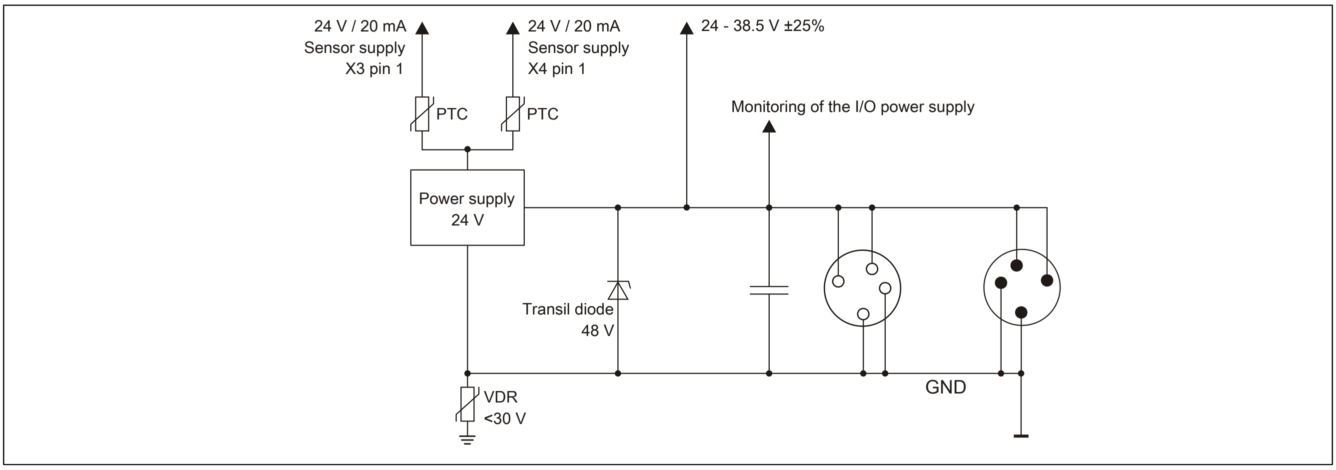
10 Output circuit diagram



11 Input circuit diagram



12 I/O power supply circuit diagram



13 Installation

Top-hat rail installation can only be recommended if the module is used for low power ratings.

In order to improve heat dissipation, it is recommended to install the module on a cooler machine part or on a base plate of at least 1 dm². A minimum distance of 1 cm must be maintained between X67 modules.

14 Monitoring of the I/O power supply

The I/O power supply voltage is monitored. Its status can be read. The error "Module power supply error" occurs when the voltage falls below 18 V or rises above 50 V.

Overvoltage cutoff

This function is supported starting with the following hardware revision or runtime version:

- From hardware revision: B0
- From firmware version: I2.88

If the supply voltage on the module exceeds 50 V (e.g. due to feedback during generator operation), then the motor output is switched off. The motor output is reactivated as soon as the supply voltage is back within the valid range.

14.1 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

Important!

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

15 Overtemperature cutoff (at 85°C)

If the module temperature reaches or exceeds 85°C...

- ... the application receives notification via the "Overtemperature" error bit
- ... The PWM outputs are disabled.

Once the module temperature sinks to 83°C, the error bit is automatically cleared by the module and the outputs become operational again.

16 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

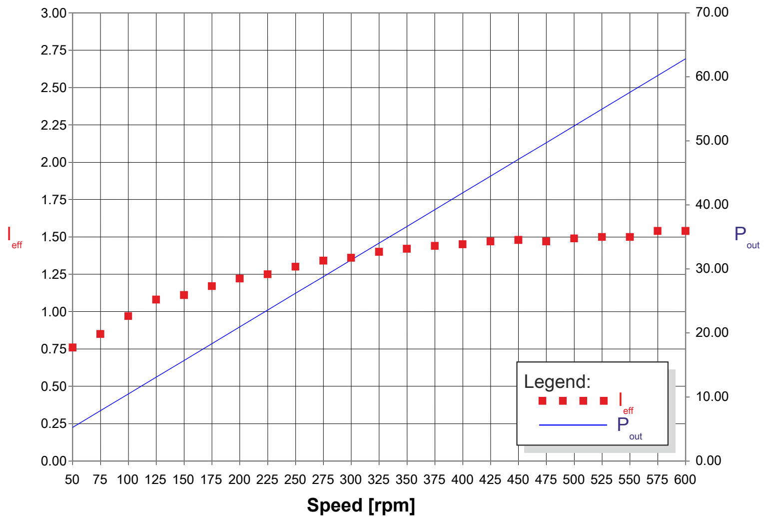


Figure 1: Power supply dimensioning example - Power/Speed relationship

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.

17 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

18 Register description

18.1 General data points

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

General data points are described in section "Additional information - General data points" of the X67 system user's manual.

18.2 Function model 0 - Standard

Register	Name	Data type	Read		Write	
			Cyclic	Acyclic	Cyclic	Acyclic
Configuration						
44	ConfigOutput01 (stall threshold)	UINT				•
46	ConfigOutput02 (module configuration)	UINT				•
33	ConfigOutput03 (holding current 1)	USINT				•
34	ConfigOutput04 (nominal current 1)	USINT				•
35	ConfigOutput05 (maximum current 1)	USINT				•
36	ConfigOutput06 (holding current 2)	USINT				•
37	ConfigOutput07 (nominal current 2)	USINT				•
38	ConfigOutput08 (maximum current 2)	USINT				•
32	ConfigOutput09 (counter configuration)	USINT				•
52	ConfigOutput16 (mixed decay threshold)	UINT				•
40	SetCounter01	UINT				•
42	SetCounter02	UINT				•
92	StallDetectMinSpeed01	UINT				•
94	StallDetectMinSpeed02	UINT				•
Reading back the configuration						
33	ConfigOutput03Read (holding current 1)	USINT		•		
34	ConfigOutput04Read (nominal current 1)	USINT		•		
35	ConfigOutput05Read (maximum current 1)	USINT		•		
36	ConfigOutput06Read (holding current 2)	USINT		•		
37	ConfigOutput07Read (nominal current 2)	USINT		•		
38	ConfigOutput08Read (maximum current 2)	USINT		•		
Communication						
16	Motor1Step0	UINT			•	
18	Motor1Step1	UINT			•	
20	Motor1Step2	UINT			•	
22	Motor1Step3	UINT			•	
24	Motor2Step0	UINT			•	
26	Motor2Step1	UINT			•	
28	Motor2Step2	UINT			•	
30	Motor2Step3	UINT			•	
54	Error acknowledgment	USINT			•	
	ClearError01	Bit 0				
	ClearError02	Bit 1				
0	Position1Sync	UINT	•			
2	Position2Sync	UINT	•			
4	StatusInput	USINT	•			
6	Position1async	UINT		•		
8	Position2async	UINT		•		
10	Error status	UINT		•		
	StallError01	Bit 0				
	OvertemperatureError01	Bit 1				
	OpenLoadError01	Bit 2				
	OvercurrentError01	Bit 3				
	StallError02	Bit 4				
	OvertemperatureError02	Bit 5				
	OpenLoadError02	Bit 6				
	OvercurrentError02	Bit 7				
80	Temperature	SINT		•		
74	MotorLoad	USINT	•			
81	MotorIdentTrigger	USINT				•
12	Motoridentification01	UINT		•		
14	Motoridentification02	UINT		•		

18.3 Function model 1 - ARNC0

Register	Name	Data type	Read		Write	
			Cyclic	Acyclic	Cyclic	Acyclic
Configuration						
44	ConfigOutput01 (stall threshold)	UINT				•
46	ConfigOutput02 (module configuration)	UINT				•
33	ConfigOutput03 (holding current 1)	USINT				•
34	ConfigOutput04 (nominal current 1)	USINT				•
35	ConfigOutput05 (maximum current 1)	USINT				•
36	ConfigOutput06 (holding current 2)	USINT				•
37	ConfigOutput07 (nominal current 2)	USINT				•
38	ConfigOutput08 (maximum current 2)	USINT				•
32	ConfigOutput09 (counter configuration)	USINT				•
52	ConfigOutput16 (mixed decay threshold)	UINT				•
84	FullStepThreshold01	UINT				•
86	FullStepThreshold02	UINT				•
92	StallDetectMinSpeed01	UINT				•
94	StallDetectMinSpeed02	UINT				•
Reading back the configuration						
33	ConfigOutput03Read (holding current 1)	USINT		•		
34	ConfigOutput04Read (nominal current 1)	USINT		•		
35	ConfigOutput05Read (maximum current 1)	USINT		•		
36	ConfigOutput06Read (holding current 2)	USINT		•		
37	ConfigOutput07Read (nominal current 2)	USINT		•		
38	ConfigOutput08Read (maximum current 2)	USINT		•		
Communication						
10	Error status	UINT	•			
	StallError01	Bit 0				
	OvertemperatureError01	Bit 1				
	OpenLoadError01	Bit 2				
	OvercurrentError01	Bit 3				
	StallError02	Bit 4				
	OvertemperatureError02	Bit 5				
	OpenLoadError02	Bit 6				
	OvercurrentError02	Bit 7				
	InputPowerSupplyError01	Bit 8				
	DrvOk01	Bit 9				
	InputPowerSupplyError02	Bit 12				
	DrvOk02	Bit 13				
16	Motor1Step0	UINT			•	
18	Motor1Step1	UINT			•	
20	Motor1Step2	UINT			•	
22	Motor1Step3	UINT			•	
24	Motor2Step0	UINT			•	
26	Motor2Step1	UINT			•	
28	Motor2Step2	UINT			•	
30	Motor2Step3	USINT			•	
74	MotorLoad	USINT	•			
76	Stepper latch configuration	USINT			•	
	StartLatch01	Bit 0				
	StartLatch02	Bit 4				
	TriggerEdgePos01	Bit 1				
	TriggerEdgeNeg01	Bit 2				
	TriggerEdgePos02	Bit 5				
	TriggerEdgeNeg02	Bit 6				
78	Trigger configuration	USINT			•	
	StartTrigger	Bit 1				
	TriggerEdge	Bit 0				
54	Error acknowledgment	USINT			•	
	ClearError01	Bit 0				
	ClearError02	Bit 1				
0	Position1Sync	UINT		•		
2	Position2Sync	UINT		•		
4	Input counter value	USINT	•			
	ModulePowerSupplyError	Bit 0				
	StatusInput01	Bit 2				
	StatusInput03	Bit 3				
	StatusInput05	Bit 4				
	StatusInput02	Bit 5				
	StatusInput04	Bit 6				
	StatusInput06	Bit 7				
60	Position1LatchedSync	SINT		•		
62	Position2LatchedSync	USINT				•
68	usSinceTrigger	UINT		•		

Register	Name	Data type	Read		Write	
			Cyclic	Acyclic	Cyclic	Acyclic
72	Stepper latch trigger status	USINT	•			
	LatchInput01	Bit 0				
	LatchDone01	Bit 1				
	LatchInput02	Bit 2				
	LatchDone02	Bit 3				
	TriggerInput	Bit 4				
6	Position1async	INT		•		
8	Position2async	INT		•		
64	Position1LatchedAsync	UINT		•		
66	Position2LatchedAsync	UINT		•		
12	Motoridentification01	UINT		•		
14	Motoridentification02	UINT		•		
80	Temperature	SINT		•		
81	MotorIdentTrigger	USINT				•

18.4 Function model 1 - ARNC0 with SDC

Register	Name	Data type	Read		Write	
			Cyclic	Acyclic	Cyclic	Acyclic
Configuration						
44	ConfigOutput01 (stall threshold)	UINT				•
33	ConfigOutput03 (holding current 1)	USINT				•
34	ConfigOutput04 (nominal current 1)	USINT				•
35	ConfigOutput05 (maximum current 1)	USINT				•
36	ConfigOutput06 (holding current 2)	USINT				•
37	ConfigOutput07 (nominal current 2)	USINT				•
38	ConfigOutput08 (maximum current 2)	USINT				•
32	ConfigOutput09 (counter configuration)	USINT				•
52	ConfigOutput16 (mixed decay threshold)	UINT				•
84	FullStepThreshold01	UINT				•
86	FullStepThreshold02	UINT				•
92	StallDetectMinSpeed01	UINT				•
94	StallDetectMinSpeed02	UINT				•
103	MotorSettlingTime01	USINT				•
104	MotorSettlingTime02	USINT				•
102	SDCConfig01	USINT				•
107	DelayedCurrentSwitchOff01	USINT				•
108	DelayedCurrentSwitchOff02	USINT				•
Reading back the configuration						
33	ConfigOutput03Read (holding current 1)	USINT		•		
34	ConfigOutput04Read (nominal current 1)	USINT		•		
35	ConfigOutput05Read (maximum current 1)	USINT		•		
36	ConfigOutput06Read (holding current 2)	USINT		•		
37	ConfigOutput07Read (nominal current 2)	USINT		•		
38	ConfigOutput08Read (maximum current 2)	USINT		•		
Communication						
10	Error status	UINT	•			
	StallError01	Bit 0				
	OvertemperatureError01	Bit 1				
	OpenLoadError01	Bit 2				
	OvercurrentError01	Bit 3				
	StallError02	Bit 4				
	OvertemperatureError02	Bit 5				
	OpenLoadError02	Bit 6				
	OvercurrentError02	Bit 7				
	InputPowerSupplyError01	Bit 8				
	DrvOk01	Bit 9				
	InputPowerSupplyError02	Bit 12				
	DrvOk02	Bit 13				
54	Error acknowledgment	USINT			•	
	ClearError01	Bit 0				
	ClearError02	Bit 1				
0	Position1Sync	UINT		•		
2	Position2Sync	UINT		•		
4	Input counter value	USINT	•			
	ModulePowerSupplyError	Bit 0				
	StatusInput01	Bit 2				
	StatusInput03	Bit 3				
	StatusInput05	Bit 4				
	StatusInput02	Bit 5				
	StatusInput04	Bit 6				
	StatusInput06	Bit 7				
73	LifeCnt	SINT	•			

Register	Name	Data type	Read		Write	
			Cyclic	Acyclic	Cyclic	Acyclic
16	Motor1Step0	INT			•	
200 204	RefPulsePos01 (internal) RefPulsePos01 (ABR)	INT	•			
212 214	RefPulseCnt01 (internal) RefPulseCnt01 (ABR)	SINT	•			
220	ActTime01	INT	•			
24	Motor2Step0	INT			•	
74	MotorLoad	USINT	•			
100	Motor current	USINT			•	
	DriveEnable01	Bit 0				
	BoostCurrent01	Bit 1				
	StandstillCurrent01	Bit 2				
	DriveEnable02	Bit 4				
	BoostCurrent02	Bit 5				
	StandstillCurrent02	Bit 6				
202 206	RefPulsePos02 (internal) RefPulsePos02 (ABR)	INT	•			
213 215	RefPulseCnt02 (internal) RefPulseCnt02 (ABR)	SINT	•			
220	ActTime02	INT	•			
208	TriggerTime01	INT	•			
216	TriggerCnt01	SINT	•			
6	Position1async	INT		•		
8	Position2async	INT		•		
12	Motoridentification01	UINT		•		
14	Motoridentification02	UINT		•		
112	SetTime01	INT			•	
114	SetTime02	INT			•	
80	Temperature	SINT		•		
81	MotorIdentTrigger	USINT				•

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

Register	Offset[1]	Name	Data type	Read		Write	
				Cyclic	Acyclic	Cyclic	Acyclic
Configuration							
48	-	ConfigOutput03a (holding current 1)	USINT				•
49	-	ConfigOutput04a (nominal current 1)	USINT				•
50	-	ConfigOutput05a (maximum current 1)	USINT				•
112	-	ConfigOutput06a (holding current 2)	USINT				•
113	-	ConfigOutput07a (nominal current 2)	USINT				•
114	-	ConfigOutput08a (maximum current 2)	USINT				•
72	-	FullStepThreshold01	UINT				•
136	-	FullStepThreshold02	UINT				•
52	-	MaxSpeed01pos	UINT				•
116	-	MaxSpeed02pos	UINT				•
54	-	MaxAcc01	UINT				•
56	-	MaxDec01	UINT				•
118	-	MaxAcc02	UINT				•
120	-	MaxDec02	UINT				•
58	-	RevLoop01	INT				•
122	-	RevLoop02	INT				•
60	-	FixedPos01a	DINT				•
64	-	FixedPos01b	DINT				•
124	-	FixedPos02a	DINT				•
128	-	FixedPos02b	DINT				•
68	-	RefSpeed01	UINT				•
132	-	RefSpeed02	UINT				•
70	-	RefConfig01	SINT				•
134	-	RefConfig02	SINT				•
51	-	StallDetectConfig01	USINT				•
115	-	StallDetectConfig02	USINT				•
74	-	StallRecognitionDelay01	USINT				•
138	-	StallRecognitionDelay02	USINT				•
75	-	JoltTime01	USINT				•
139	-	JoltTime02	USINT				•
78	-	StallDetectMinSpeed01	UINT				•
142	-	StallDetectMinSpeed02	UINT				•
304	-	GeneralConfig01	USINT				•
306	-	LimitSwitchConfig01	USINT				•
308	-	LimitSwitchConfig02	USINT				•
380	-	PositionLimitMin01	DINT				•
388	-	PositionLimitMin02	DINT				•
384	-	PositionLimitMax01	DINT				•

Register	Offset[1]	Name	Data type	Read		Write	
				Cyclic	Acyclic	Cyclic	Acyclic
392	-	PositionLimitMax02	DINT				●
Reading back the configuration							
48	-	ConfigOutput03aRead (holding current 1)	USINT		●		
49	-	ConfigOutput04aRead (nominal current 1)	USINT		●		
50	-	ConfigOutput05aRead (maximum current 1)	USINT		●		
112	-	ConfigOutput06aRead (holding current 2)	USINT		●		
113	-	ConfigOutput07aRead (nominal current 2)	USINT		●		
114	-	ConfigOutput08aRead (maximum current 2)	USINT		●		
Communication							
0	0	AbsPos01	DINT			●	
4	4	MpGenControl01	UINT			●	
6	6	MpGenMode01	SINT			●	
0	0	AbsPos01ActVal	DINT	●			
4	4	MpGenStatus01	UINT	●			
8	8	AbsPos02	DINT			●	
12	12	MpGenControl02	UINT			●	
14	14	MpGenMode02	SINT			●	
8	8	AbsPos02ActVal	DINT	●			
12	12	MpGenStatus02	UINT	●			
6	6	InputStatus	USINT	●			
84	-	Motoridentification01	UINT		●		
148	-	Motoridentification02	UINT		●		
46	-	Temperature	SINT		●		
86	-	RefPos01CyclicCounter	DINT		●		
150	-	RefPos02CyclicCounter	DINT		●		
94	-	RefPos01AcyclicCounter	DINT		●		
158	-	RefPos02AcyclicCounter	DINT		●		
90	-	AbsPos01ActValAcyclic	DINT		●		
154	-	AbsPos02ActValAcyclic	DINT		●		
80	-	ControlReadback01	UINT		●		
144	-	ControlReadback02	UINT		●		
82	-	ModeReadback01	SINT		●		
146	-	ModeReadback02	SINT		●		
98	-	ErrorCode01	UINT		●		
162	-	ErrorCode02	UINT		●		

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

18.5.1 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 additional registers and functions depending on the fieldbus used.

For detailed information, see section "Additional information - Using I/O modules on the bus controller" of the X67 user's manual (version 3.30 or later).

18.5.2 CAN I/O bus controller

The module occupies 2 analog logical slots on CAN I/O.

18.6 Register description: General registers

18.6.1 Configuration registers

18.6.1.1 Stall threshold

Name:
ConfigOutput01

The SM module features integrated sensorless load measurement for the motor axis. This is especially useful for detecting a "stall condition" (e.g. if the motor moves to the end point during a homing procedure). It cannot be used for torque monitoring during dynamic movements.

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 status" on page 19).

This threshold value must be determined on a case-by-case basis, since the results of load measurement are influenced by a variety of factors.

- Motor speed: A higher speed results in higher measurement values
- Speeds that cause motor resonances (which interfere with load measurement) are to be avoided
- Motor accelerations that create a dynamic load (and also affect the measurement) should also be avoided
- It is especially important to be aware that mixed decay mode must be disabled or optimized for reliable stall detection (see "Mixed decay threshold" on page 16)

The higher the load measurement value, the lower the load. That means: A stall condition is detected if the load measurement value drops below the trigger threshold for stall detection.

Data type	Values
UINT	See the bit structure.

Bit structure:

Bit	Description	Value	Information
0 - 2	Trigger threshold stall detection for Motor 1	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	Reserved	0	
4 - 6	Trigger threshold stall detection for Motor 2	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
7 - 15	Reserved	0	

18.6.1.2 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" on page 15. 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 Motor 1	0	Mixed decay disabled
		1 to 14	Setting for mixed decay threshold
		15	Mixed decay always enabled
4 - 7	Mixed Decay Threshold Motor 2	0 to 15	See motor 1
8 - 15	Reserved	-	

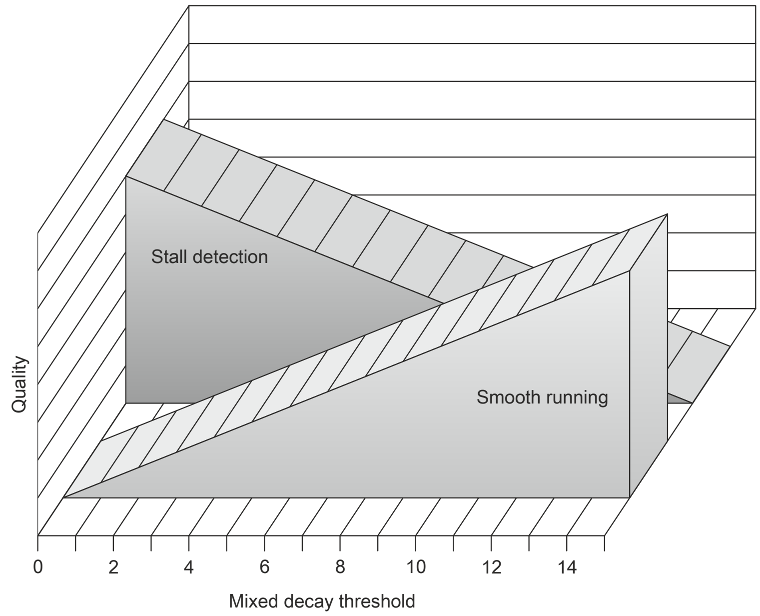
Mixed decay modules provide a greatly optimized sinusoidal current profile in the individual phases of the stepper motor, especially for fast current changes and low current values.

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.



18.6.1.3 Minimum speed for stall detection

Name:
StallDetectMinSpeed01 to StallDetectMinSpeed02

If the motor speed exceeds the value set in this register, then stall detection is enabled and the configured "mixed decay threshold" on page 16 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	Values	Information
UINT	0 to 65,535	Minimum speed in steps per second.

18.6.1.4 Holding current, nominal current and maximum current

Name:
ConfigOutput03 (holding current 1)
ConfigOutput04 (nominal current 1)
ConfigOutput05 (maximum current 1)
ConfigOutput06 (holding current 2)
ConfigOutput07 (nominal current 2)
ConfigOutput08 (maximum current 2)

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

Reasonable values are:

- Holding current < Nominal current < Maximum current

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

Register	Description
Nominal current	Current during normal operation
Maximum current	Should be selected if a higher motor torque is required briefly during acceleration phases.
Holding current	The holding current should be used in situations when less torque is required (e.g. at a standstill). This reduces the amount of heat generated by the motor.

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

Function model	Switching between preset current values at runtime
Standard and ARNC0	Using bits 14 and 15 in registers "Motor setting - MotorXStepX" on page 26
ARNC0 with enabled SDC information	Using register "Motor current" on page 32

Data type	Values	Unit
USINT	0 to 167	Percent of the module's nominal current • 100% corresponds to the nominal current of the motor bridge power unit listed in the technical data • 167% corresponds to the maximum current of the motor bridge power unit listed in the technical data

18.6.1.5 Counter configuration

Name:
ConfigOutput09

Data type	Values
USINT	See the bit structure.

Bit structure:

<table>
<tr><th colspan="2">Bit</th><th rowspan="2">Value</th><th colspan="2">Description</th></tr>
<tr><th>Motor 1</th><th>Motor 2</th><th>Function model "Standard"</th><th>Function model ARNC0/ARNC0 with SDC</th></tr>
<tr><td rowspan="2">0</td><td rowspan="2">4</td><td>0</td><td>Counter value ABRx unaffected</td><td>Negative edge: Disables latch function ABRx</td></tr>
<tr><td>1</td><td>Positive edge: Enables homing counter value ABRx with default value (register Set counter)</td><td>Positive edge: Enables latch function ABRx</td></tr>
<tr><td rowspan="4">1 - 2</td><td rowspan="4">5 - 6</td><td>00</td><td>Homing counter value ABRx unconditionally</td><td>Latch counter value ABRx unconditionally</td></tr>
<tr><td>01</td><td>Homing counter value ABRx on positive edge of the R input of ABRx</td><td>Latch counter value ABRx on positive edge of the R input of ABRx</td></tr>
<tr><td>10</td><td>Homing counter value ABRx on negative edge of the R input of ABRx</td><td>Latch counter value ABRx on negative edge of the R input of ABRx</td></tr>
<tr><td>11</td><td>Reserved</td><td>Reserved</td></tr>
<tr><td rowspan="2">3</td><td rowspan="2">7</td><td>0</td><td>• Position sync: Internal position counter
• Position async: ABRx counter value</td><td>• Position sync: Internal position counter
• Position async: ABRx counter value
• Position latched sync: Internal position counter
• Position latched async: ABRx counter value</td></tr>
<tr><td>1</td><td>• Position sync: ABRx counter value
• Position async: Internal position counter</td><td>• Position sync: ABRx counter value
• Position async: Internal position counter
• Position latched sync: ABRx counter value
• Position latched async: Internal position counter</td></tr>
</table>

18.6.2 Registers for reading back the configuration

18.6.2.1 Reading back the holding current, nominal current and maximum current

Name:
ConfigOutput03Read (holding current 1)
ConfigOutput04Read (nominal current 1)
ConfigOutput05Read (maximum current 1)
ConfigOutput06Read (holding current 2)
ConfigOutput07Read (nominal current 2)
ConfigOutput08Read (maximum current 2)

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

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

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)

18.6.3 Communication registers

18.6.3.1 Error status

Name: The bits in this register are distributed between Motor 1 and Motor 2 as follows.

Motor 1	**Motor 2**
StallError01	StallError02
OvertemperatureError01	OvertemperatureError02
OpenLoadError01	OpenLoadError02
OvercurrentError01	OvercurrentError02
InputPowerSupplyError01	InputPowerSupplyError02
DrvOk01	DrvOk02

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 7, then the corresponding bit remains set until the error has been acknowledged (see "Error acknowledgment" on page 20).

Data type	Values
UINT	See the bit structure.

Bit structure:

Bit		Description		Value	Information
Motor 1	Motor 2	Motor 1	Motor 2		
0	4	StallError01	StallError02	0	No stall
				1	Stall
1	5	Overtemperature error for motor 1 OvertemperatureError01	Overtemperature error for motor 2 OvertemperatureError02	0	No overtemperature
				1	Overtemperature
2	6	Current error for motor 1 OpenLoadError01	Current error for motor 2 OpenLoadError02	0	No current error
				1	Current error
3	7	Overcurrent error for motor 1 OvercurrentError01	Overcurrent error for motor 2 OvercurrentError02	0	No overcurrent
				1	Overcurrent
8	12	Power supply error digital inputs 1 to 3 (female connector 3) InputPowerSupplyError01 1)	Power supply error digital inputs 4 to 6 (female connector 4) InputPowerSupplyError02 1)	0	Power supply of the digital inputs OK
				1	Error in the power supply of the digital inputs:
9	13	Status of the drive motor 1 DrvOk01 2)	Status of the drive motor 2 DrvOk02 2)	0	An error was triggered for the motor axis
				1	The drive is running error-free
10 - 11	14 - 15	Reserved		0	

1) Only with function model ARNC0 and ARNC0 with SDC
2) Only with function model ARNC0 with SDC

Overtemperature error

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

- The temperature of the output stage of a motor output exceeds a certain temperature.
- The module temperature exceeds .

Current error

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

Overcurrent error

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

Error in the power supply of the digital inputs

This error occurs in the event of undervoltage or overvoltage on the module power supply.

In function model "Standard", bits 8 and 12 do not exist in this form. If the module detects undervoltage or overvoltage of the module power supply, all bits of the error state register are set to 1.

Status of the drive

The status of the drive is only shown in function model ARNC0 when SDC information is enabled. The drive bit is 1 when the following conditions are met:

- The motor is switched on (see "Motor current" on page 32).
- 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 33).

18.6.3.2 Error acknowledgment

Name:
ClearError01 to ClearError02

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

For more info, see register "Error status" on page 19.

Data type	Values
USINT	See the bit structure.

Bit structure:

Bit	Description	Value	Information
0	ClearError01	0	No effect
		1	Error acknowledgment for motor 1
1	ClearError02	0	No effect
		1	Error acknowledgment for Motor 2
2 - 7	Reserved	0	

18.6.3.3 Position sync/async

Name:
Position1Sync to Position2Sync
Position1async to Position2async
ActPos01 to ActPos02

Depending on the "Counter configuration" on page 18, these registers can be used to read either the internal position counter or the counter value on the ABR input.

Data type	Values
INT	-32768 to 32767

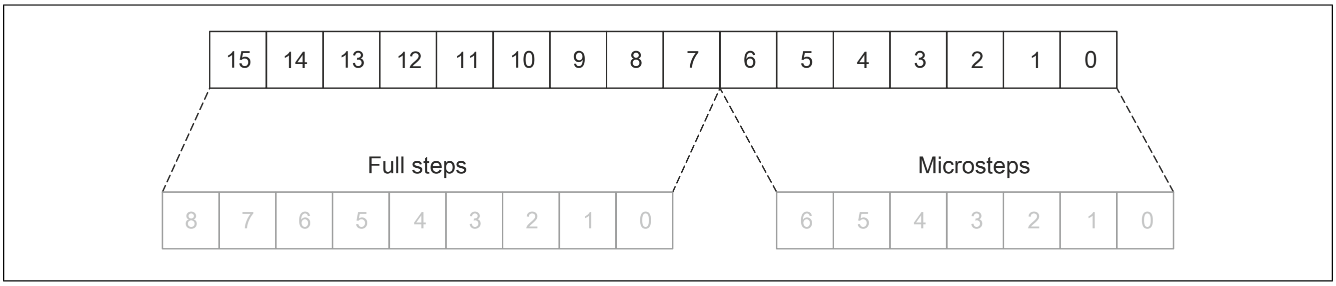
Register	Counter configuration	
	Bit 3 (channel 1) / Bit 7 (channel 2) = 0	Bit 3 (channel 1) / Bit 7 (channel 2) = 1
Position sync	Internal position counter	ABR counter
Position async	ABR counter	Internal position counter

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 (depending on bits 5 and 6 of the "Module configuration" on page 25).

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



Information:

In operating mode, the following limitation only applies to "Normal mode".

The smallest physical step division that is possible is 1/64 of a full-step. Therefore, bits with a rating of 1/128 or 1/256 of a full-step remain 0. This must be taken into account if this position register is used for controller feedback.

ABR counter

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

18.6.3.4 Temperature

Name:
Temperature

The internal module temperature is displayed in °C with this register.

Data type	Values
SINT	-128 to 127

18.6.3.5 Measuring motor load

Name:
MotorLoad

This register contains the current measured load value for stall detection. This can be used to tune stall detection.

Data type	Values
USINT	See the bit structure.

Bit structure:

Bit	Description	Value	Information
0 - 2	Motor 1	0 to 7	Motor load value
3	Reserved	-	
4 - 6	Motor 2	0 to 7	Motor load value
7	Reserved	-	

18.6.3.6 Motor ID trigger

Name:
MotorIdentTrigger

With this register, a measurement of the motor ID can be initiated acyclically (see "Module configuration" on page 25). The application must ensure that the conditions for measurement are fulfilled.

Data type	Values
USINT	See the bit structure.

Bit structure:

Bit	Description	Value	Information
0		0	No effect
		1	Positive edge triggers motor ID measurements for motor 1
1		0	No effect
		1	Positive edge triggers motor ID measurements for motor 2
2 - 7	Reserved	0	

18.6.3.7 Motor identification

Name:
Motoridentification01 to Motoridentification02

This register is used to identify the connected motor type for service purposes and to differentiate between motors in the application. The function of this register depends on the set operating mode (see bit 11 in register "Module configuration" on page 25).

Normal operating mode (module configuration: Bit 11 = 0)

The value of this register is an indicator of how long the current has been applied in the motor windings.

This depends on:

- Level of current being applied
- Amplitude of operating voltage
- The inductance and resistance of the motor winding
  These two influences characterize a motor type.

Notes		
1)	To achieve reproducible results, the measurement must be made under the following defined conditions:	
	a)	Operation with holding current (see "Holding current, nominal current and maximum current" on page 17)
	b)	At standstill
	c)	Motors must be in a half-step position (phase A with full current, phase B with no current).
2)	Conditions 1b and 1c are present after a reset/power-up of the SM module. Immediately afterwards, when the holding current is applied to the motors for the first time (at a 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 optimal operating point for motor identification (depending on the current used) must be determined by users based on experience.	

Enhanced operating mode (module configuration: Bit 11 = 1)

After successful measurement, this register contains the time [µs] required to apply a current increase of ΔI = 1 A to a motor winding.

This depends on:

- Operating voltage
- Inductance and resistance of the motor winding

Notes		
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.	

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)
	65534	Invalid value: Overflow

18.7 Register description: Function model 0 - Standard

18.7.1 Configuration registers

18.7.1.1 Set counter

Name:
SetCounter01 to SetCounter02

This register can be used to define the value to which the position counter is set during homing.

Data type	Values
UINT	0 to 65,535

18.7.2 Communication registers

18.7.2.1 Input counter value

Name:
StatusInput

This register contains the state of the digital inputs and counters.

Data type	Values
USINT	See the bit structure.

Bit structure:

Bit	Description	Value	Information
0		0	OK
		1	Module power supply error
1		0	Reserved
2		**If bit 0 in module configuration = 0**	
		0 or 1	Input state - Digital input 1
		If bit 0 in module configuration = 1	
		x	Homing toggle bit for ABR counter 1: After homing is completed, the state of this bit is changed.
3		**If bit 0 in module configuration = 0**	
		0 or 1	Input state - Digital input 2
		If bit 0 in module configuration = 1	
		0	The homing procedure for the ABR counter 1 is active.
		1	The homing procedure of the ABR counter 1 is completed.
4		0 or 1	Input state - Digital input 3
5		**If bit 1 in module configuration = 0**	
		0 or 1	Input state - Digital input 4
		If bit 1 in module configuration = 1	
		0 or 1	Homing toggle bit for ABR counter 2: After homing is completed, the state of this bit is changed.
6		**If bit 1 in module configuration = 0**	
		0 or 1	Input state - Digital input 5
		If bit 1 in module configuration = 1	
		0	The homing procedure for the ABR counter 2 is active.
		1	The homing procedure of the ABR counter 2 is completed.
7		0 or 1	Input state - Digital input 6

18.8 Register description: Function model 0 - Standard and function model 1 - ARNC0 without SDC

18.8.1 Configuration registers

18.8.1.1 Module configuration

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 - 1	The setting for these two bits determines the meaning of bits 2 and 3 in register "Input counter value" on page 28.	x	
2	Reserved	0	
3 - 4	Number of transfer values per X2X Link cycle (see "Motor setting - MotorXStepX" on page 26)	00	1 x Δs / Δt (transfer values: MotorXStep0)
		01	2 x Δs / Δt (transfer values: MotorXStep0 - MotorXStep1)
		10	4 x Δs / Δt (transfer values: MotorXStep0 - MotorXStep3)
		11	Reserved
5 - 6	Resolution of microsteps for the following registers: • "Motor setting - MotorXStepX" on page 26 • "Position sync/async" on page 21	00	Resolution: 5 bits (bits 0 - 4) microsteps; 8 bits (bits 5 - 13) full steps
		01	Resolution: 6 bits (bits 0 - 5) microsteps; 7 bits (bits 6 - 13) full steps
		10	Resolution: 7 bits (bits 0 - 6) microsteps; 6 bits (bits 7 - 13) full steps
		11	Resolution: 8 bits (bits 0 - 7) microsteps; 5 bits (bits 8 - 13) full steps
7 - 10	Reserved	0	
11	Operating mode	0	Normal mode (standard setting)
		1	Enhanced mode
12 - 15	Reserved		

18.8.2 Communication registers

18.8.2.1 Motor setting - MotorXStepX

Name:
Motor1Step0 to Motor1Step3 and
Motor2Step0 to Motor2Step3

These registers are used to specify the number and direction of steps that must be carried out by the module during the next X2X Link cycle, and to select the motor current (see also "Holding current, nominal current and maximum current" on page 17).

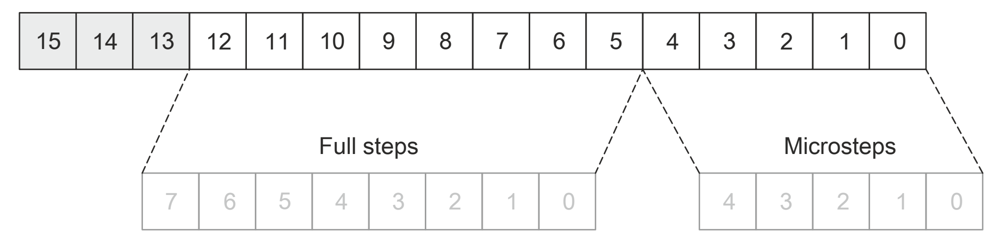
Data type	Values
UINT	See the bit structure.

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

Depending on the required resolution and maximum configurable speed, the module configuration can be used to set which bit position is used as the 1s position for full steps (see bits 5 and 6 of the "Module configuration" on page 25).

Example for 5-bit microsteps (set bits 5 and 6 of the module configuration to binary 00):



The number of transfer values per X2X Link cycle is specified by bits 3 and 4 in the module configuration (see "Module configuration" on page 25). If only one transfer value (bits 3 and 4 = 00) is specified, then the motor is advanced by MotorXStep0 until the next X2X Link cycle. If 2 or 4 transfer values are specified, then the X2X Link cycle is divided accordingly.

Example: X2X link cycle = 1 ms (1000 µs)

Time	Number of transfer values (see "Module configuration" on page 25)		
	1 (bits 3 - 4 = 00)	2 (bits 3 - 4 = 01)	4 (bits 3 - 4 = 10)
0 - 250 µs	MotorXStep0	MotorXStep0	MotorXStep0
250 - 500 µs			MotorXStep1
500 - 750 µs		MotorXStep1	MotorXStep2
750 - 1000 µs			MotorXStep3

18.9 Register description: Function model 1 - ARNC0 without SDC

18.9.1 Configuration registers

18.9.1.1 Full step threshold

Name:
FullStepThreshold01 to FullStepThreshold02

This register configures angular velocity. When this 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 change to full step mode at a standstill because fine positioning would then no longer be possible. This is why value "0" does not make sense in the full step threshold register and is interpreted as disabling full step mode (i.e. the motor will always be operated in microstep mode).

Data type	Values	Information
UINT	0	Full step mode disabled
	1 to 65,535	Steps/second

Example

Microstep mode should change to full step mode at 500 steps/second. On a motor with 200 steps per revolution, this would be equal to a speed of:

$$T^{-1} = \frac{500\ steps/second}{200\ steps/revolution} = 2.5\ \frac{revolutions}{second} = 150\ \mathrm{min}^{-1}$$

18.9.2 Communication registers

18.9.2.1 Stepper latch configuration

Name: The bits in this register are distributed between Motor 1 and Motor 2 as follows.

Motor 1	**Motor 2**
StartLatch01	StartLatch02
TriggerEdgePos01	TriggerEdgePos02
TriggerEdgeNeg01	TriggerEdgeNeg02

This register is used to configure the latch mode and latch function for the position of the stepper motor.

Data type	Values
USINT	See the bit structure.

Bit structure:

Bit		Description		Value	Information
Motor 1	Motor 2	Motor 1	Motor 2		
0	4	**Latch function for stepper motor position:**			
		StartLatch01	StartLatch02	0	The latch function for the current motor position is disabled on the negative edge of this bit.
				1	The latch function for the current motor position is disabled on the positive edge of this bit. After a latch event has occurred, the latch function can be started again on a new rising edge.
1 - 2	5 - 6	**Latch mode for stepper motor position:**			
		Bit 1: TriggerEdgePos01 Bit 2: TriggerEdgeNeg01	Bit 5: TriggerEdgePos02 Bit 6: TriggerEdgeNeg02	00	Latch position of stepper motor unconditional
				01	Latch position of stepper motor on positive edge of associated digital input[1]
				10	Latch position of stepper motor on negative edge of associated digital input
				11	Reserved
3	7	Reserved		0	

1) For motor 1: Digital input DI3 (female connector 3, pin 5)
For motor 2: Digital input DI6 (female connector 4, pin 5)

18.9.2.2 Trigger configuration

Name:
StartTrigger
TriggerEdge

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	TriggerEdge	0	Trigger edge (input DI 5) = Positive
		1	Trigger edge (input DI 5) = Negative
1	Enable trigger (when a change occurs) StartTrigger	x	
2 - 7	Reserved	0	

Trigger function procedure:

- Selection of the desired trigger edge using bit 0
- Enabling of the trigger function by changing the state of bit 1. When this bit changes, usSinceTrigger (µs counter) is cleared.
- When the trigger event occurs, µs counter usSinceTrigger is started
- Counter usSinceTrigger cannot overflow, i.e. the counter is stopped at 2^{16} - 1 and retains this value until the next time the trigger function is enabled.

The trigger function can be re-enabled at any time by changing the state of bit 1, regardless of whether a trigger event has occurred or if usSinceTrigger has reached the maximum value.

18.9.2.3 Input counter value

Name:
ModulePowerSupplyError
StatusInput01 to StatusInput06

This register contains the state of the digital inputs and counters.

Data type	Values
USINT	See the bit structure.

Bit structure:

Bit	Description	Value	Information
0	ModulePowerSupplyError	0	OK
		1	Module power supply error
1	Reserved	0	
2	StatusInput01	**If bit 0 in module configuration = 0**	
		0 or 1	Input state - Digital input 1
		If bit 0 in module configuration = 1	
		x	Homing toggle bit for ABR counter 1: After homing is completed, the state of this bit is changed.
3	StatusInput03	**If bit 0 in module configuration = 0**	
		0 or 1	Input state - Digital input 2
		If bit 0 in module configuration = 1	
		0	The homing procedure for the ABR counter 1 is active.
		1	The homing procedure of the ABR counter 1 is completed.
4	StatusInput05	0 or 1	Input state - Digital input 3
5	StatusInput02	**If bit 1 in module configuration = 0**	
		0 or 1	Input state - Digital input 4
		If bit 1 in module configuration = 1	
		0 or 1	Homing toggle bit for ABR counter 2: After homing is completed, the state of this bit is changed.
6	StatusInput04	**If bit 1 in module configuration = 0**	
		0 or 1	Input state - Digital input 5
		If bit 1 in module configuration = 1	
		0	The homing procedure for the ABR counter 2 is active.
		1	The homing procedure of the ABR counter 2 is completed.
7	StatusInput06	0 or 1	Input state - Digital input 6

18.9.2.4 Position latched sync-async

Name:
Position1LatchedSync to Position2LatchedSync
Position1LatchedAsync to Position2LatchedAsync

The position counter (internal position counter or ABR counter) is applied at the latch event (see "Stepper latch configuration" on page 27). Bits 3 and 7 of the counter configuration register are used to determine which counter value (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 (channel 1) / Bit 7 (channel 2) = 0	Bit 3 (channel 1) / Bit 7 (channel 2) = 1
Position latched sync	Internal position counter	ABR counter
Position latched async	ABR counter	Internal position counter

Description of the two counters (internal position counter and ABR counter), see "Position sync/async" on page 21.

18.9.2.5 usSinceTrigger

Name:
usSinceTrigger

This register indicates the time (in µs) that has passed since the trigger event occurred (see "Trigger configuration" on page 28).

Data type	Values
UINT	0 to 65,535

18.9.2.6 Stepper latch trigger status

Name: The bits in this register are distributed between Motor 1 and Motor 2 as follows.

Motor 1	**Motor 2**
LatchInput01	LatchInput02
LatchDone01	LatchDone02
Motor 1 and 2	
TriggerInput	

Data type	Values
USINT	See the bit structure.

Bit structure:

Bit		Description		Value	Information
Motor 1	Motor 2	Motor 1	Motor 2		
0	2	LatchInput01	LatchInput02	x	Digital input for the latch event (level)
1	3	LatchDone01	LatchDone02	x	Changes its state each time the counter state is successfully latched (reset value = 0)
4		TriggerInput		x	Trigger input (level)
5 - 7		Reserved		0	

1) For motor 1: Digital input DI3 (female connector 3, pin 5)
For motor 2: Digital input DI6 (female connector 4, pin 5)

18.10 Register description: Function model 1 - ARNC0 with SDC

18.10.1 Configuration registers

18.10.1.1 Motor settling time

Name:
MotorSettlingTime01 to MotorSettlingTime02

The motor settling time determines the minimum time from the time the motor is energized until the drive bit (DrvOk) is set (see "Error status" on page 19). 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

18.10.1.2 SDC configuration

Name:
SDCConfig01

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

The additional cyclic registers are hidden or shown depending on whether SDC information is disabled or enabled. Compare the two variants of the ARNC0 function model ARNC0 with and without SDC information enabled.

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 shown 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.**

18.10.1.3 Switch-off delay

Name:
DelayedCurrentSwitchOff01 to DelayedCurrentSwitchOff02

If the "SDC life sign monitoring" on page 33 is triggered (i.e. the NetTime timestamp is in the past) the motor is decelerated at nominal current with speed setpoint = 0.

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

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

18.10.2 Communication registers

18.10.2.1 Input counter value

Name:
ModulePowerSupplyError
StatusInput01 to StatusInput06

This register contains the state of the digital inputs and counter.

Data type	Values
USINT	See the bit structure.

Bit structure:

Bit	Description	Value	Information
0	ModulePowerSupplyError	0	OK
		1	I/O power supply error
1	Reserved	0	
2	StatusInput01	x	Input status of digital input 1
3	StatusInput03	x	Input status of digital input 2
4	StatusInput05	x	Input status of digital input 3
5	StatusInput02	x	Input status of digital input 4
6	StatusInput04	x	Input status of digital input 5
7	StatusInput06	x	Input status of digital input 6

18.10.2.2 Lifecycle counter

Name:
LifeCnt

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

Data type	Values
SINT	-128 to 127

18.10.2.3 Motor setting - MotorXStep0

Name:
Motor1Step0 to Motor2Step0

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 positive direction in 1/256 full steps
	<0	Movement in negative direction in 1/256 full steps

Unlike the ARNC0 function model without enabled SDC information, the motor current is selected using a separate register (see "Motor current" on page 32).

18.10.2.4 Home position

Name:
RefPulsePos01 to RefPulsePos02

These 4 registers have 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 "Latch sync" in the Automation Studio I/O configuration can be used to select which of the 4 registers is addressed by the RefPulsePos0x variables.

Variables in Automation Studio	I/O configuration, counter 0x, option "Latch sync"	
	Stepper counter 0x shown at ActPos0x	ABR counter 0x shown at ActPos0x
RefPulsePos0x	Home position of the internal position counter	Home position of the ABR counter
The bits 3/7 in register "Counter configuration" on page 18 are also set for counter 1/2 with option "Latch sync":		
Bit 3 (counter 1)	0	1
Bit 7 (counter 2)	0	1

18.10.2.5 Reference pulse counter

Name:
RefPulseCnt01 to RefPulseCnt02

These 4 registers have 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 "Latch sync" in the Automation Studio I/O configuration can be used to select which of 4 registers is addressed by variable RefPulsePos01.

Variables in Automation Studio	I/O configuration, counter 0x, option "Latch sync"	
	Stepper counter 0x shown at ActPos0x	ABR counter 0x shown at ActPos0x
RefPulseCnt0x	Reference pulse counter for the internal position counter	Reference pulse counter of the ABR counter
The bits 3/7 in the "Counter configuration" on page 18 register are also set for counter 1/2 with option "Latch sync":		
Bit 3 (counter 1)	0	1
Bit 7 (counter 2)	0	1

18.10.2.6 NetTime of the position value

Name:
ActTime01 to ActTime02

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

For more information about NetTime and timestamps, see "NetTime technology" on page 55.

Data type	Values
INT	-32768 to 32767

18.10.2.7 Motor current

Name: The bits in this register are distributed between Motor 1 and Motor 2 as follows.

Motor 1	**Motor 2**
DriveEnable01	DriveEnable02
BoostCurrent01	BoostCurrent02
StandstillCurrent01	StandstillCurrent02

Bits 0 to 6 of this register control the current feed of the motors.

Data type	Values
USINT	See the bit structure.

Bit structure:

Bit		Description		Value	Information
Motor 1	Motor 2	Motor 1	Motor 2		
0	4	DriveEnable01	DriveEnable02	x	Motor powered
1	5	BoostCurrent01	BoostCurrent02	x	Maximum current
2	6	StandstillCurrent01	StandstillCurrent02	x	Holding current
3	7	Reserved		0	

The possible status of bits 0 to 6

StandstillCurrent0x	BoostCurrent0x	DriveEnable0x	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

18.10.2.8 SDC life sign monitoring

Name:
SetTime01 to SetTime02

The module uses SDC life sign monitoring to check whether valid values have been received for the speed setpoint. SDC life sign monitoring is enabled in register "SDC configuration" on page 30 by setting bit 6 (SDCSetTime = On).

If the specified NetTime timestamp 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 operated again by a rising edge on the DriveEnable bit (see section "Motor current" on page 32).

Data type	Values
INT	-32768 to 32767

18.10.2.9 Trigger timestamp

Name:
TriggerTime01

This register contains the point in time (NetTime) of the most recent trigger event. The trigger edge must be configured in register "SDC configuration" on page 30.

For more information about NetTime and timestamps, see "NetTime technology" on page 55.

Data type	Values
INT	-32768 to 32767

18.10.2.10 Trigger counter

Name:
TriggerCnt01

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

Data type	Values
SINT	-128 to 127

18.11 Register description: Function model 254 - "Bus controller" and function model 3 - "Ramp"

18.11.1 Configuration registers

18.11.1.1 Holding current, nominal current and maximum current

Name:
ConfigOutput03a (holding current 1)
ConfigOutput04a (nominal current 1)
ConfigOutput05a (maximum current 1)
ConfigOutput06a (holding current 2)
ConfigOutput07a (nominal current 2)
ConfigOutput08a (maximum current 2)

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

Reasonable values are:

- Holding current < Nominal current < Maximum current

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

Register	Description
Nominal current	Current during operation at constant speed
Maximum current	Current during acceleration phases. In the mode "Referencing during stall" on page 47, the nominal current is always used instead of the maximum current, even in acceleration phases.
Holding current	Current when motor is at standstill

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.

Data type	Values	Unit
USINT	0 to 167	Percent of the module's nominal current • 100% corresponds to the nominal current of the motor bridge power unit listed in the technical data • 167% corresponds to the maximum current of the motor bridge power unit listed in the technical data Bus controller default setting: 0

18.11.1.2 Full step threshold

Name:
FullStepThreshold01 to FullStepThreshold02

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

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

18.11.1.3 Maximum speed

Name:
MaxSpeed01pos to MaxSpeed02pos

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

Information:

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

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

18.11.1.4 Maximum acceleration

Name:
MaxAcc01 to MaxAcc02

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

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

18.11.1.5 Maximum deceleration

Name:
MaxDec01 to MaxDec02

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

Data type	Values	Information
UINT	0 to 65,535	Brake deceleration in microsteps/cycle². Bus controller default setting: 0

18.11.1.6 Reversing loop

Name:
RevLoop01 to RevLoop02

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

If the value for the reversing loop 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. This ensures that the target position is always approached from the same direction (to avoid mechanical backlash).

The sign of the defined value determines the direction in which the reversing loop runs.

Sign	Effective direction
Positive	Reversing loop in positive direction of movement
Negative	Reversing loop in negative direction of movement

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

18.11.1.7 Fixed position A

Name:
FixedPos01a to FixedPos02a

This register defines the position to move to in modes -124 (if the digital input is set to 1) and -125.

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

18.11.1.8 Fixed position B

Name:
FixedPos01b to FixedPos02b

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

18.11.1.9 Homing speed

Name:
RefSpeed01 to RefSpeed02

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

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

18.11.1.10 Stall detection configuration / Mixed decay

Name:
StallDetectConfig01 to StallDetectConfig02

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	The motor load value is not shown (bus controller default setting).
		1	Show value in register "Status word" on page 48[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" on page 47 mode.

Stall threshold

The SM module features integrated sensorless load measurement for the motor axis. This is especially useful for detecting a "stall condition" (e.g. if the motor moves to the end point during a homing procedure). It cannot be used for torque monitoring during dynamic movements.

The "stall threshold" (bits 4 to 6 of this register) can be used to define a threshold value for each axis individually according to the motor load, beyond which the motor will detect a stall condition.

This threshold value must be determined on a case-by-case basis, since the results of load measurement are influenced by a variety of factors.

- Motor speed: A higher speed results in higher measurement values
- Speeds that cause motor resonances (which interfere with load measurement) are to be avoided
- Motor accelerations that create a dynamic load (and also affect the measurement) should also be avoided
- It is especially important to be aware that mixed decay mode must be optimized for reliable stall detection.

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

Mixed decay threshold

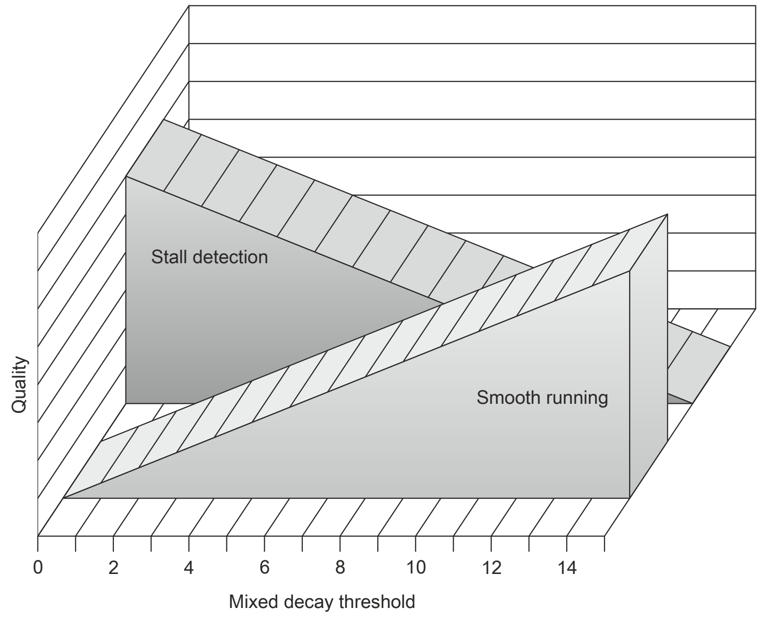
Mixed decay modules provide a greatly optimized sinusoidal current profile in the individual phases of the stepper motor, especially for fast current changes and low current values.

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.



18.11.1.11 Homing configuration

Name:
RefConfig01 to RefConfig02

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 falling edge of input DI 4
	-125	Homing on positive edge of input DI 3/6 (R pulse). Bus controller default setting
	-126	Homing on negative edge of input DI 3/6 (R pulse)
	-127	Homing during stall detection
	-128	Immediate homing
	All others	No effect

18.11.1.12 Stall recognition delay

Name:
StallRecognitionDelay01 to StallRecognitionDelay02

The value in this register is only relevant for "Referencing during stall" on page 47.

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).

Set to 0 to eliminate delay.

Data type	Values	Information
USINT	0 to 255	In cycles, see "General configuration" on page 38. Bus controller default setting: 0

18.11.1.13 Minimum speed for stall detection

Name:
StallDetectMinSpeed01 to StallDetectMinSpeed02

If the motor speed exceeds the value set in this register, then stall detection is enabled and the configured "mixed decay threshold" on page 36 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	Values	Information
UINT	0 to 65,535	Minimum speed in microsteps per cycle. Bus controller default setting: 0

18.11.1.14 Jerk time

Name:
JoltTime01 to JoltTime02

Name:
JoltTime01
JoltTime02 (X90SM546.02-00 only)

If a value other than 0 is assigned to this register, then jerk limitation is performed. This is done by averaging the values for the steps to be carried out (speed setpoint) in each cycle using a FIFO buffer. The jerk time corresponds to the number of FIFO elements (0 to 80). If a value greater than 80 is entered, then it will be limited internally to 80.

Changes made while a motor is running will be applied as soon as ...

- The motor has reached the set position (positioning mode only).
- The motor has stopped (all modes).

Data type	Values	Information
USINT	0	No jerk limitation time. Bus controller default setting
	1 to 80[1)]	Number of FIFO elements

1) Starting with upgrade 1.3.1.1 (firmware version 100), for older versions: 16

18.11.1.15 General configuration

Name:
GeneralConfig01

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

- 0: "Mode 1: Position mode without extended control word" on page 42
- 1: "Mode 1: Position mode with extended control word" on page 42

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 1.3.1.1 (firmware version 100).

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

18.11.1.16 Limit switch configuration

Name:
LimitSwitchConfig01 to LimitSwitchConfig02

This register configures the behavior of the limit switches.

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

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 by acknowledging 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 wrong direction when direction monitoring is enabled and limit switches are active.

Warning!

If the motor is wired incorrectly with this configuration (wrong 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.

18.11.1.17 Software limit

Name:
PositionLimitMin01 to PositionLimitMin02
PositionLimitMax01 to PositionLimitMax02

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

These limits 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 violates the minimum/maximum software limit, the "Internal limit active" bit will be set in the "Status word" on page 48 register. The motor movement will be stopped until a position is specified within the limits.

Bit "Internal limit active" will also be set in register "Status word" if incorrectly configured (minimum > maximum).

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

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**

18.11.2 Reading back the configuration

18.11.2.1 Reading back the holding current, nominal current and maximum current

Name:
ConfigOutput03aRead (holding current 1)
ConfigOutput04aRead (nominal current 1)
ConfigOutput05aRead (maximum current 1)
ConfigOutput06aRead (holding current 2)
ConfigOutput07aRead (nominal current 2)
ConfigOutput08aRead (maximum current 2)

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

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

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)

18.11.3 Communication registers

18.11.3.1 Set position/speed

Name:
AbsPos01 to AbsPos02

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

- Position mode (see "Mode" on page 42): 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 42): In this mode, this register is considered a signed speed setpoint.

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

18.11.3.2 Control word

Name:
MpGenControl01 to MpGenControl02

Using this register, commands can be sent depending on the state of the module.

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	CurrentControlEnable	x	
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) The "Stop" bit is only evaluated when the extended control word is enabled (see "General configuration" on page 38).
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).

18.11.3.3 Mode

Name:
MpGenMode01 to MpGenMode02

Data type	Values	Information
SINT	0	No mode selected
	1	Depending on bit 0 in the "General configuration" on page 38 register, the position mode will behave as follows: • Position mode 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 "Mode 1: Position mode with extended control word" on page 42.
	2	Speed mode: Constant speed
	-120	Set home position
	-121	Remaining distance mode
	-122	Set actual position
	-123	Move to target position when external input set
	-124	Two-position module
	-125	Move to fixed position A (position set acyclically)
	-126	Move to fixed position B (position set acyclically)
	-127	Positive homing (see also "Homing configuration" on page 37)
	-128	Negative homing (see also "Mode -127/-128: Positive/Negative homing" on page 47)

Information:

For all modes: The "Target reached" bit is set in the "Status word" on page 48 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.

18.11.3.3.1 Mode 1: Position mode

The position setpoint is specified in the "Set position/speed" on page 41 register. 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).

If bit 0 in the "General configuration" on page 38 register is 0 (no extended control word), then the position setpoint will be applied as soon as it is different from the current position. Then the new position is used for the movement.

However, if bit 0 in the "General configuration" on page 38 register is set to 1 (extended control word), then the position setpoint will be applied as described under "Mode 1: Position mode with extended control word" on page 42.

18.11.3.3.2 Mode 1: Position mode with extended control word

Position mode with extended control word behaves like "Position mode 1" on page 42 as described previously (without the extended control word), but the new position setpoint ("Position/Speed" on page 41 register) is applied according to the "extended control word" on page 43.

Extended control word

Commands can be issued using this register depending on the state of the module (see "Operating function model "Ramp"" on page 51).

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 target position.
		1	Apply target position.
5	Change set immediately	0	Complete current positioning movement and then start next positioning movement
		1	Interrupt current positioning movement and then start next positioning movement
6	abs / rel	0	Target position is an absolute value.
		1	Target position is a relative value.
7	Corresponds to the default 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 status of the state machine (for a detailed description, see "Status word" on page 52 and "State machine" on page 53).

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		**If Stop = 0**
		0	Target position not reached.
		1	Target position 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 is set. Then a new target position is defined. The drive stops at each target position before starting the movement to the next target position.
Set of setpoints	After the target position has been reached, the movement to the next target position is started immediately without stopping the drive. It is therefore possible to initiate a new positioning by specifying another target position during active positioning.

The two modes "Single setpoint" and "Set of setpoints" are controlled by the timing of bits *New setpoint* and *Change set immediately* in the "extended control word" on page 43 and *Setpoint acknowledge* in register "Extended control word" on page 43.

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

Specifying the target position

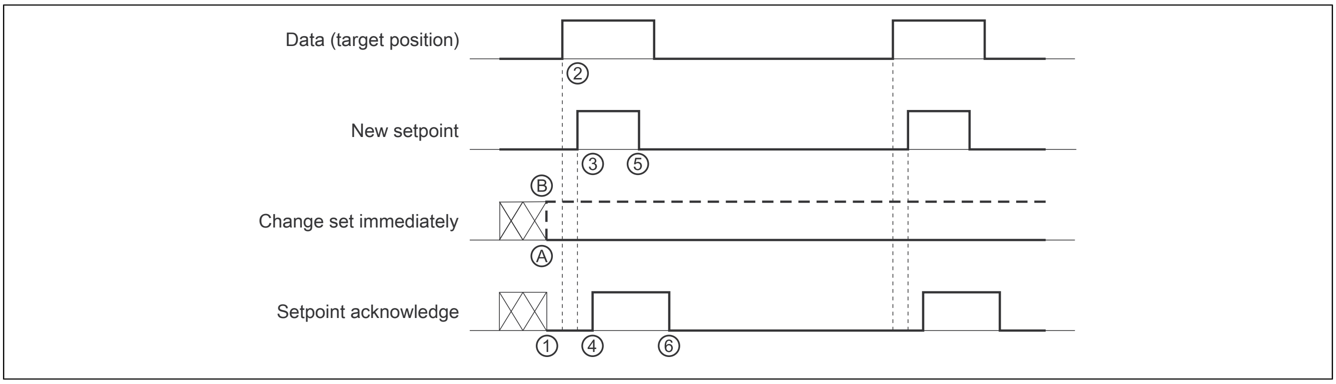


Figure 2: Principle for applying the setpoint

Transferring a new setpoint:

1) If bit *Setpoint acknowledge* in register "Extended status word" on page 43 is 0, the module will accept a new target position.
2) The new target position is specified in register "Set position/speed" on page 41.
3) A rising edge on bit *New setpoint* in the extended control word indicates that the new target position in register "Set position/speed" on page 41 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"

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

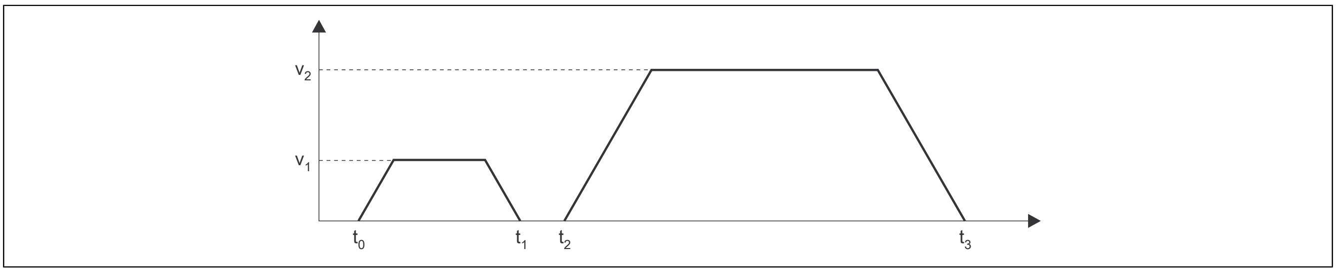


Figure 3: Ramp in *Single setpoint*

"Set of setpoints" preset position value

When the *Change set immediately* bit is set to 1 (Ⓑ in figure "Principle for applying the setpoint"), then the module is operating in *Single setpoint* mode. This means that the module receives the first target position at t_0. A second target position is received at time t_1. The drive immediately adapts the current movement to the new target position.

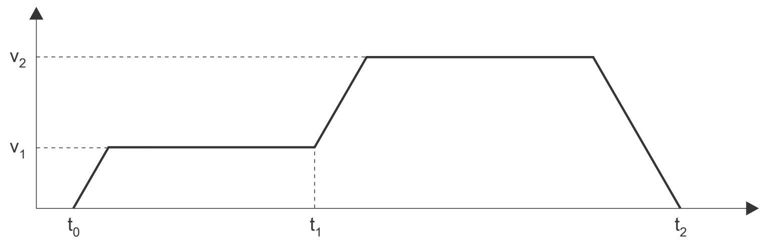


Figure 4: Ramp in *Set of setpoints*

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.

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

The value in register "Position/Speed" on page 41 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.

18.11.3.3.4 Mode -120: Set home position

This mode is supported starting with upgrade 1.3.1.1 (firmware version 100).

The current actual position is changed so that the position specified in register "Position/Speed" on page 41 is the home position. If you then move to this position, the motor is at the home position.

The home position in register "Home position" on page 49 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 "Positive / negative homing" on page 47 mode. In order to set the position, the "State machine" on page 53 must be in state "Operation enable".

18.11.3.3.5 Mode -121: Remaining distance mode (like mode 1)

The number of steps set in register "Fixed position A" on page 35 is added to the current position and the resulting position is approached on a rising/falling edge on digital input 3.

> **Note:**
>
> **Steps are not added to the target position, but rather to the actual position at the moment the trigger occurs.**

Negative values are also allowed for the offset defined in "Fixed position A" on page 35.

New target positions are no longer accepted in register "Position/Speed" on page 41 after the trigger event. There must first be a switch made to mode 0 and then back to mode -121.

Bit "Target reached" in register "Status word" on page 37 is not set to 1 until the end position (after the trigger event) has been reached.

The "homing configuration" on page 37 determines whether a rising or falling edge of the digital input is used as a trigger.

The Reversing loop is not active in this mode (i.e. any configured values not equal to 0 are ignored).

18.11.3.3.6 Mode -122: Set actual position

The target position set in register "Position/Speed" on page 41 is applied as the current actual position in the internal position counter if the state machine is in state "Operation enable".

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.

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

The position setpoint set in the "position/speed" on page 41 register is moved to when a rising edge occurs on the corresponding digital input.

A new position setpoint is not applied until another rising edge occurs on the corresponding digital input. This can also occur during the active positioning procedure and will be applied immediately.

> **Note:**
>
> **Associated digital input**
>
> - **For motor 1: DI3 (female connector 3, pin 5)**
> - **For motor 2: DI6 (female connector 4, pin 5)**

18.11.3.3.8 Mode -124: Two-position mode

Positions "Fixed position A" and "Fixed position B" are set in the acyclic registers.

Value 1 on the associated digital input moves to fixed position A. Value 0 moves to fixed position B. Toggling is also possible during an active positioning movement.

Note:

Associated digital input

- **For motor 1: DI3 (female connector 3, pin 5)**
- **For motor 2: DI6 (female connector 4, pin 5)**

18.11.3.3.9 Mode -125/-126: Move to fixed position X

The purpose of these modes is to enable a virtual switch from speed mode to position mode, which otherwise is not possible because of the shared use of the register for position and speed setpoints.

- Mode -125: "Fixed position A" on page 35
- Mode -126: "Fixed position B" on page 35

18.11.3.3.10 Mode -127/-128: Positive/Negative homing

Mode -127 and -128 are used to select which direction to move.

The motor must be at a standstill before switching from another mode to one of the homing modes.

If the referencing condition occurs, then the motor stops and the values of the position counter and ABR counter valid at the moment when the referencing condition occurs are written to the "Referenced zero position" on page 49 register.

In the "referencing configuration" on page 37 you must specify whether referencing should occur at low/high level on the digital input, during stall or unconditionally.

Homing via digital input

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

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

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

Movement continues at the referencing speed against the referencing direction until the active level for "Stop referencing" 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.

Referencing during stall

Movement continues in the referencing direction until a stall is detected. When a stall is detected, the value of the position counter is entered in the "Referenced zero position" on page 49 register 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 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 (see "Stall detection configuration / Mixed decay" on page 36).

Unconditional referencing (immediate)

Immediate referencing: The current values of the position counter and of the ABR counter are immediately entered in register "Homed zero position" on page 49 (no motor movement).

18.11.3.4 Current position (cyclic)

Name:
AbsPos01ActVal to AbsPos02ActVal

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

18.11.3.5 Status word

Name:
MpGenStatus01 to MpGenStatus02

The bits in this register reflect the state of the state machine. For a more detailed description, see "Status word" on page 52 and "State machine" on page 53.

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 since there is no local mode for the SM module
10	Target reached	x	
11	Internal limit active	0	No limit violation
		1	Internal limit is active (upper or lower software limit violated)
12	Mode-specific	x	
13 - 15	Reserved / Motor load value	0	Always 0, if bit 7 in register "Stall detection configuration / Mixed decay" on page 36 is set to 0.
		x	Returned motor load value

18.11.3.6 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
...		...	
5	Digital input 6	0 or 1	Input state - Digital input 6
6 - 7	Reserved	0	

18.11.3.7 Motor identification

Name:
Motoridentification01 to Motoridentification02

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.

This depends on:

- Operating voltage
- Inductance and resistance of the motor winding

Notes		
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.	

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)
	65534	Invalid value: Overflow

18.11.3.8 Temperature

Name:
Temperature

The internal module temperature is displayed in °C with this register.

Data type	Values
SINT	-128 to 127

18.11.3.9 Homing to the zero position

Name:
RefPos01CyclicCounter to RefPos02CyclicCounter
RefPos01AcyclicCounter to RefPos02AcyclicCounter

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 41).

The following two registers are provided for each 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

18.11.3.10 Current position (acyclic)

Name:
AbsPos01ActValAcyclic to AbsPos02ActValAcyclic

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

18.11.3.11 Read back control word

Name:
ControlReadback01 to ControlReadback02

With this register, the contents of register "Control word" on page 41 can be read back.

Data type	Values
UINT	0 to 65,535

18.11.3.12 Read back mode

Name:
ModeReadback01 to ModeReadback02

With this register, the contents of register "Mode" on page 42 can be read back.

Data type	Values
SINT	-128 to 127

18.11.3.13 Error code

Name:
ErrorCode01 to ErrorCode02

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	:	Stall 2)
	0xFF11	Warning	Low	Open circuit

1) A current error is only detected if bit 13 = 1 in the control word (current error detection enabled).
2) Stall is only detected if bit 15 = 1 in the control word (stall detection enabled).

Information regarding the handling of errors and warnings:

- Bit 3 (Fault) and bit 7 (Warning) in the "status word" on page 48 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" on page 51 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.

18.11.4 Operating function model "Ramp"

Control for this model has been based on the CANopen communication profile DS402.

Commands for controlling the modules are written to the "Control word" on page 51. The current module state is returned in register "Status word" on page 52. The function mode (absolute position, constant speed, homing, etc.) is set in the "mode register" on page 42.

18.11.4.1 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 2)	Fault reset	Mode-specific	Mode-specific	Mode-specific	Enable operation	Quick stop	Enable voltage	Switch on
Bit1)	**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
2) Bit 8 (stop) is only evaluated if the extended control word is enabled in register "General configuration" on page 38.

Bits 0, 1, 2, 3 and 7 (light gray in the previous table)	These bits control the state of the "State machine" on page 53 according to the commands in the table above.
Stop	0 ... Perform motor movement 1 ... Stop axis with deceleration This bit is only evaluated if the extended control word is enabled in register "General configuration" on page 38.
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).
Fault reset	A rising edge resets errors and warnings (see "State machine" on page 53)
Current error detection	0 ... Current error detection disabled 1 ... Current error detection enabled
ABR counter sync/async	0 ... Value of the ABR counter on register "Current position (acyclic)" on page 49. Internal position counter of the ramp generator on the "Current position (cyclic)" register. 1 ... Value of the ABR counter on register "Current position (cyclic)" on page 48. Internal position counter of the ramp generator on the "Current position (acyclic)" register.
Stall detection	0 ... Stall detection disabled 1 ... Stall detection enabled

18.11.4.2 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)	Mode-specific	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 register "Mixed Decay / Stall Detection" on page 36, 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 current state of the "State machine" on page 53.</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 register "Error code" on page 50. 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 since there is no local mode on the SM module</td></tr>
<tr><td rowspan="2">Target reached[1), depending on bit 8 (Stop) in Control word</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 "Halt" has not been enabled in register "General configuration" on page 38, then "Target reached" behaves the same as if Stop = 0.

18.11.4.3 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 51.

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:

Only in state "*Operation enable*" are motor movements executed according to the setting in register "Mode" on page 42.

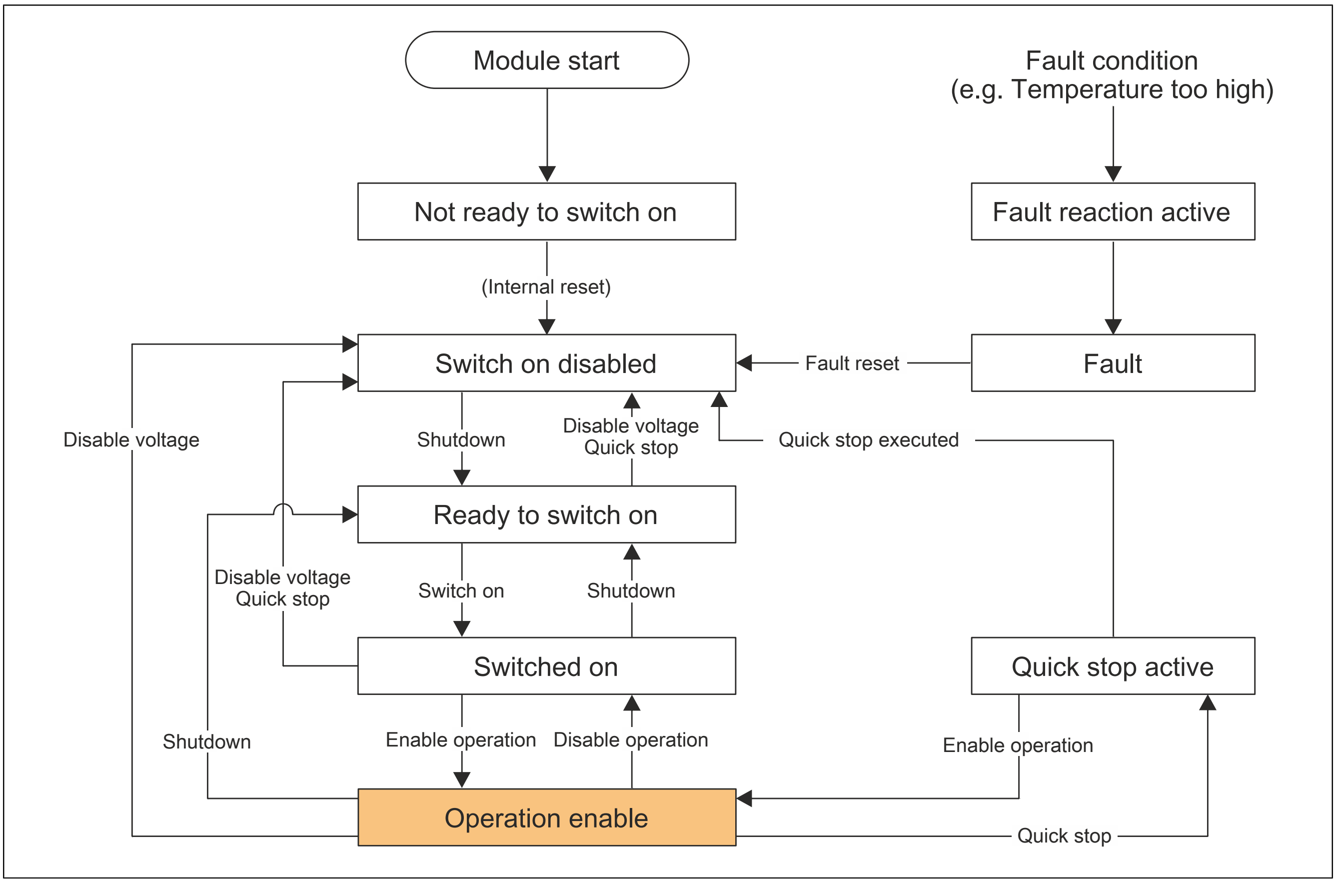


Figure 5: State machine - Flow chart

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 switched 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 the *Switched on* state 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 switched 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 defined 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 deceleration. Motor voltage remains on in the *Switched on* state.
Operation enable → Ready to switch on	This state change is initiated by command *Shutdown*. The motor voltage is switched 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 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 the *Quick stop active* state, the *Enable operation* command can be used to switch it back to the *Operation enable* state.
→ 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 an "Error" (see "Error code" on page 50). (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.) Motor voltage is switched off and the state machine then changes immediately to the *Fault* state. The type of error is listed in the Error code register (see the table under "Error code" on page 50). 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.

18.12 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 time that events occur to be determined system-wide with microsecond precision. Upcoming events can also be executed precisely at a given time.

18.12.1 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 µs timing. 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.

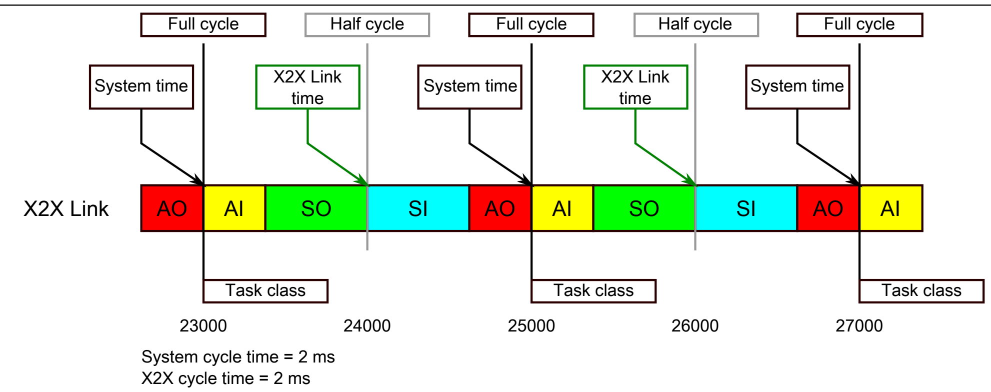
The initialization of the times is based on the system time during the startup of the X2X Link, the I/O modules or the POWERLINK interface.

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

18.12.1.1 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.

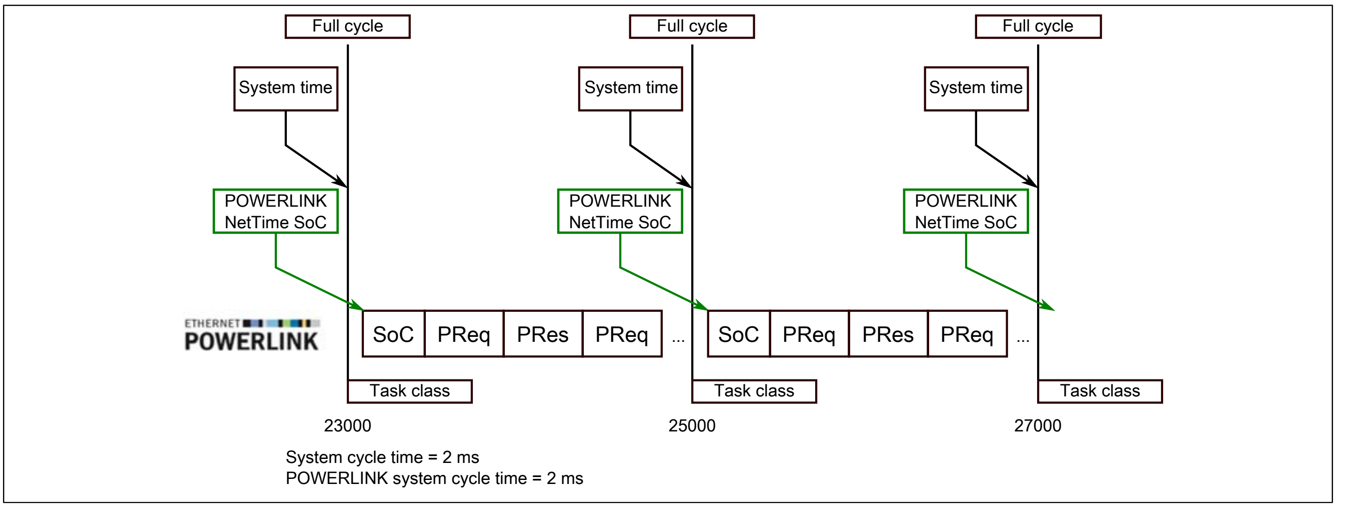
18.12.1.2 X2X Link reference time



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

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

18.12.1.3 POWERLINK reference time

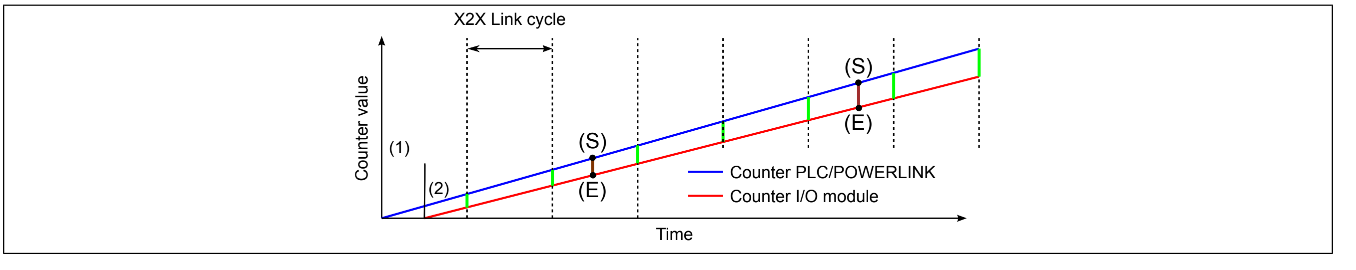


The reference time at POWERLINK is always formed at the SoC (Start of Cycle) of the POWERLINK network. The SoC starts 20 µs after the system tick. This results in the following difference between the system time and the POWERLINK reference time:

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

18.12.1.4 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 at µs intervals.

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 time (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.

18.12.2 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 time, the CPU can then evaluate the data using its own NetTime (or system time), if necessary.

18.12.2.1 Time-based inputs

NetTime Technology can be used to determine the exact time 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 time always lies in the past.

18.12.2.2 Time-based outputs

NetTime Technology can be used to specify the exact time of a rising edge at 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 time.

18.12.2.3 Time-based measurements

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

18.13 Minimum cycle time

The minimum cycle time specifies the time up to which 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 ARNC0	250 µs
Function model "Ramp"	250 µs

18.14 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 ARNC0	250 µs
Function model "Ramp" Inputs Outputs[1)]	 250 µs 25 ms

1) Depends on the configuration of the "movement profile generator" on page 38