BECKHOFF New Automation Technology

Documentation | EN

EP7041-4032

1-channel motion interface, stepper motor, 48 V DC, 5 A, with BiSS® C encoder

2026-01-22 | Version: 1.0

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1 Foreword

1.1 Notes on the documentation

This description is intended exclusively for trained specialists in control and automation technology who are familiar with the applicable national standards.
The documentation and the following notes and explanations must be complied with when installing and commissioning the components.
The trained specialists must always use the current valid documentation.

The trained specialists must ensure that the application and use of the products described is in line with all safety requirements, including all relevant laws, regulations, guidelines, and standards.

Disclaimer

The documentation has been compiled with care. The products described are, however, constantly under development.
We reserve the right to revise and change the documentation at any time and without notice.
Claims to modify products that have already been supplied may not be made on the basis of the data, diagrams, and descriptions in this documentation.

Trademarks

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1.2 For your safety

Safety regulations

Read the following explanations for your safety.
Always observe and follow product-specific safety instructions, which you may find at the appropriate places in this document.

Exclusion of liability

All the components are supplied in particular hardware and software configurations which are appropriate for the application. Modifications to hardware or software configurations other than those described in the documentation are not permitted, and nullify the liability of Beckhoff Automation GmbH & Co. KG.

Personnel qualification

This description is only intended for trained specialists in control, automation, and drive technology who are familiar with the applicable national standards.

Signal words

The signal words used in the documentation are classified below. In order to prevent injury and damage to persons and property, read and follow the safety and warning notices.

Personal injury warnings

⚠ DANGER
Hazard with high risk of death or serious injury.

⚠ WARNING
Hazard with medium risk of death or serious injury.

⚠ CAUTION
There is a low-risk hazard that could result in medium or minor injury.

Warning of damage to property or environment

NOTICE
The environment, equipment, or data may be damaged.

Information on handling the product

This information includes, for example:
recommendations for action, assistance or further information on the product.

1.3 Documentation issue status

Version	Comment
1.0	• First release

Firmware and hardware versions

This documentation refers to the firmware and hardware version that was applicable at the time the documentation was written.

The module features are continuously improved and developed further. Modules having earlier production statuses cannot have the same properties as modules with the latest status. However, existing properties are retained and are not changed, so that older modules can always be replaced with new ones.

The firmware and hardware version (delivery state) can be found in the batch number (D-number) printed on the side of the EtherCAT Box.

Syntax of the batch number (D-number)

D: WW YY FF HH	Example with D no. 29 10 02 01:
WW - week of production (calendar week) YY - year of production FF - firmware version HH - hardware version	29 - week of production 29 10 - year of production 2010 02 - firmware version 02 01 - hardware version 01

Further information on this topic: Version identification of EtherCAT devices [▶ 111].

2 EtherCAT Box - Introduction

The EtherCAT system has been extended with EtherCAT Box modules with protection class IP67. Through the integrated EtherCAT interface the modules can be connected directly to an EtherCAT network without an additional Coupler Box. The high-performance of EtherCAT is thus maintained into each module.

The extremely low dimensions of only 126 x 30 x 26.5 mm (h x w x d) are identical to those of the Fieldbus Box extension modules. They are thus particularly suitable for use where space is at a premium. The small mass of the EtherCAT modules facilitates applications with mobile I/O interface (e.g. on a robot arm). The EtherCAT connection is established via screened M8 connectors.

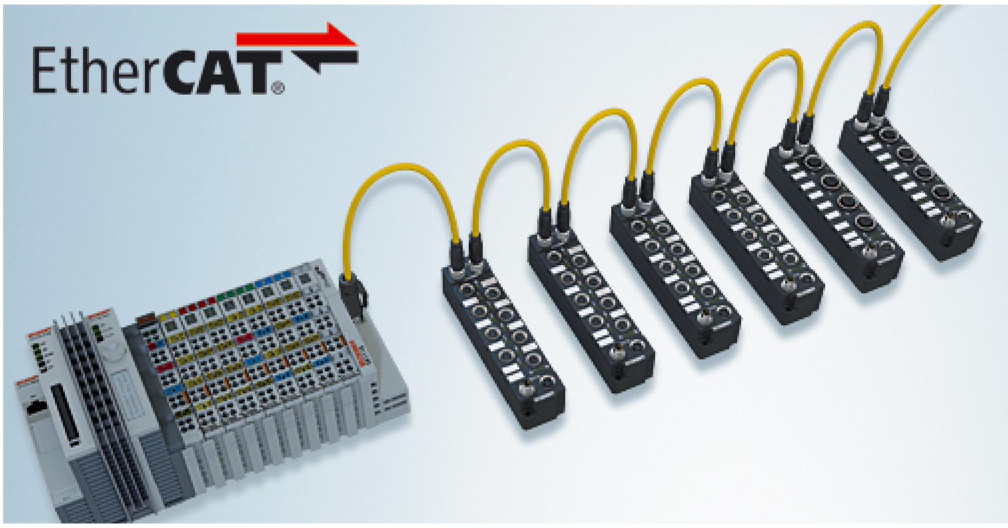


Fig. 1: EtherCAT Box Modules within an EtherCAT network

The robust design of the EtherCAT Box modules enables them to be used directly at the machine. Control cabinets and terminal boxes are now no longer required. The modules are fully sealed and therefore ideally prepared for wet, dirty or dusty conditions.

Pre-assembled cables significantly simplify EtherCAT and signal wiring. Very few wiring errors are made, so that commissioning is optimized. In addition to pre-assembled EtherCAT, power and sensor cables, field-configurable connectors and cables are available for maximum flexibility. Depending on the application, the sensors and actuators are connected through M8 or M12 connectors.

The EtherCAT modules cover the typical range of requirements for I/O signals with protection class IP67:

- digital inputs with different filters (3.0 ms or 10 µs)
- digital outputs with 0.5 or 2 A output current
- analog inputs and outputs with 16 bit resolution
- Thermocouple and RTD inputs
- Stepper motor modules

XFC (eXtreme Fast Control Technology) modules, including inputs with time stamp, are also available.

Fig. 2: EtherCAT Box with M8 connections for sensors/actuators

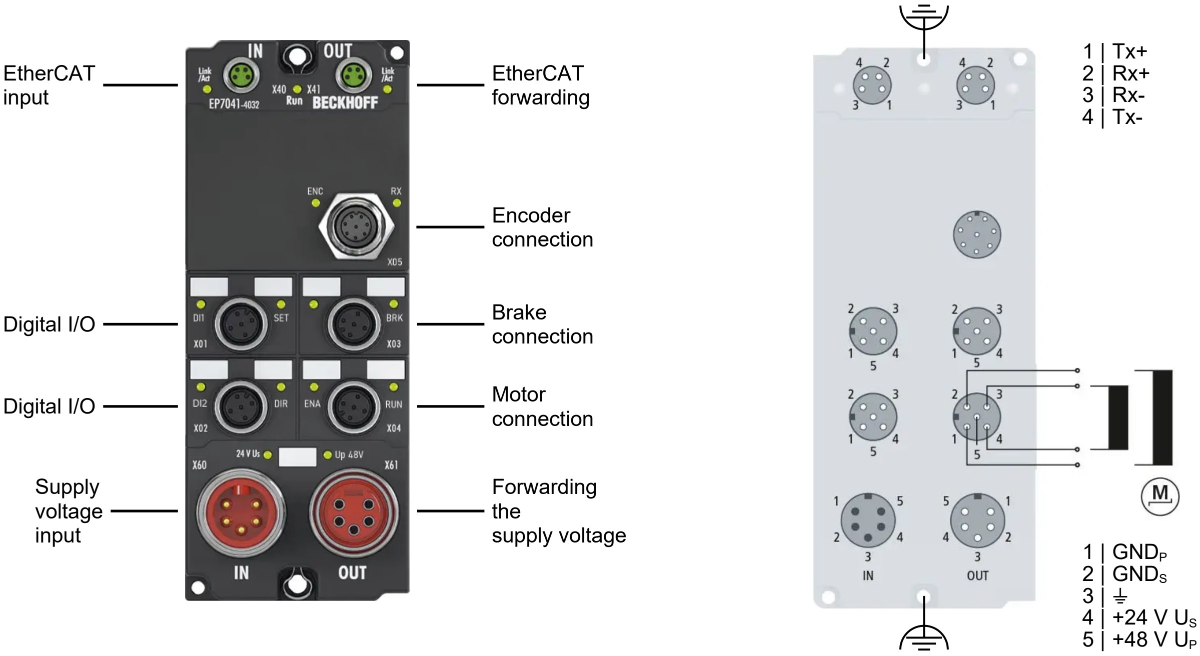
Fig. 3: EtherCAT Box with M12 connections for sensors/actuators

Basic EtherCAT documentation

You will find a detailed description of the EtherCAT system in the Basic System Documentation for EtherCAT, which is available for download from our website (www.beckhoff.com) under Downloads.

3 Product overview

3.1 Introduction



The EP7041-4032 EtherCAT Box is designed for direct connection of different stepper motors. The PWM output stages for two motor coils cover a wide range of voltages and currents. With just a few parameters the EP7041-4032 can be adapted to the motor and the application. 256-fold microstepping ensures particularly quiet and precise motor operation.

Connection of a BiSS® C encoder or an SSI encoder enables a simple servo axis to be implemented. The control loop is closed via TwinCAT. The encoder allows absolute feedback so that no homing is necessary when starting the system.

Four digital inputs/outputs allow the connection of limit switches and a motor brake.

Quick links

Technical data [▶ 11]
Process image [▶ 14]
Connections [▶ 22]
Commissioning [▶ 35]

3.2 Technical data

All values are typical values over the entire temperature range, unless stated otherwise.

EtherCAT	
Connection	2 x M8 socket, 4-pin, A-coded, shielded
Electrical isolation	500 V
Distributed Clocks	yes

Supply voltages	
Connection	Input: 7/8" plug, 5-pin, 16-UN thread Downstream connection: 7/8" socket, 5-pin, 16-UN thread
U_S nominal voltage	24 V_{DC} (-15 % / +20 %)
U_S sum current	max. 16 A at 40 °C
Current consumption from U_S	120 mA + Encoder supply + Digital output currents + Current for the holding brake
U_P rated voltage	8…48 V_{DC}
U_P sum current	max. 16 A at 40 °C
Current consumption from U_P	= Current consumption of the motor output stage

Motor	
Number of channels	1
Motor type	2-phase stepper motor, unipolar or bipolar
Connection	M12 socket, 5-pin, A-coded
Motor supply	8…48 V_{DC} from U_P
Rated current	3.5 A per phase
Peak current	5 A per phase
Overload- and short-circuit proof	Yes
Step frequency	max. 8,000 full steps/s
Current controller frequency	Dynamic
Microstepping	max. 256 intermediate steps per full step

Encoder interface	
Number of channels	1
Protocols	• BiSS® C unidirectional • SSI
Connection	1 x M12 socket, 8-pin, A-coded
Resolution	max. 64 bit position value, 2 bit status, 16 bit CRC
Encoder supply	Configurable: 5 V_{DC} (default) or 9 V_{DC} from U_S max. 0.5 A
Digital outputs for control signals	Zero, Direction See Technical data of the digital outputs [▶ 12]

Holding brake	
Number of channels	1
Connection	1 x M12 socket, 5-pin, A-coded
Rated voltage	24 V_{DC} from U_S
Output current	max 0.5 A

Digital outputs	
Number	2
Connection	Each digital output is available on two connections in parallel: • Encoder connection X05 • Digital I/O connection X01 / X02 (M12 sockets, 5-pin, A-coded)
Cable length	max. 30 m
Load type	Ohmic, inductive, lamp load
Output voltage	Corresponds to the configured encoder supply
Output current	max. 0.5 A per channel, individually short-circuit proof
Auxiliary voltage output	24 V_{DC} from U_S,max. 0.5 A in total, short-circuit proof

Digital inputs	
Number	2
Application options	• Touch probe inputs • "Plc cam": referencing cams for homing • "Hardware Enable" to enable the output stage • "Auto start" for the Positioning Interface • Digital inputs can be used as required
Connection	2 x M12 socket, 5-pin, A-coded
Cable length	max. 30 m
Sensor power supply	24 V_{DC} from U_S max. 0.5 A in total, short-circuit proof

Environmental conditions	
Ambient temperature during operation	-25 … +60 °C
Ambient temperature during storage	-40 … +85 °C
Vibration / shock resistance	conforms to EN 60068-2-6 / EN 60068-2-27
EMC immunity / emission	conforms to EN 61000-6-2 / EN 61000-6-4
Protection class	IP65, IP66, IP67 conforms to EN 60529

Approvals/markings	
Approvals/markings *)	CE, cURus [▶ 33]

*) Real applicable approvals/markings see type plate on the side (product marking).

Additional tests

The devices have undergone the following additional tests:

Test	Explanation
Vibration	10 frequency sweeps in 3 axes
	5 Hz < f < 60 Hz displacement 0.35 mm, constant amplitude
	60.1 Hz < f < 500 Hz acceleration 5 g, constant amplitude
Shocks	1000 shocks in each direction, in 3 axes
	35 g, 11 ms

3.3 Scope of supply

Make sure that the following components are included in the scope of delivery:

- 1x EP7041-4032 EtherCAT Box
- 2x protective caps for EtherCAT socket (mounted)
- 1x protective cap for 7/8" socket (mounted)
- 10 x labels, blank (1 strip of 10)

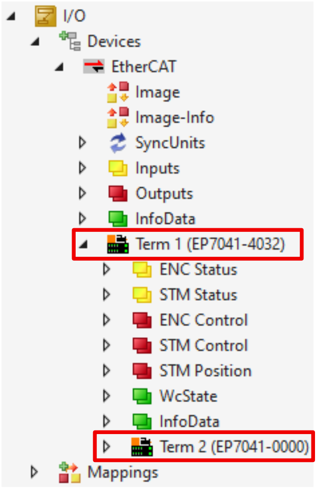
Pre-assembled protective caps do not ensure IP67 protection

Protective caps are pre-assembled at the factory to protect connectors during transport. They may not be tight enough to ensure IP67 protection.

Ensure that the protective caps are correctly seated to ensure IP67 protection.

3.4 Process image

The EP7041-4032 is represented in TwinCAT in the Solution Explorer by two devices.

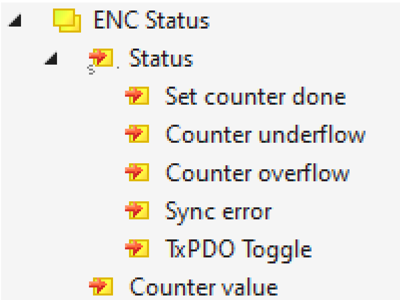


- The EP7041-4032 device contains the process data for the stepper motor.
  See chapter Process data objects EP7041-4032 [▶ 15].
- The EP7041-0000 device contains the process data for the encoder.
  See chapter Process data objects EP7041-0000 [▶ 17].

3.4.1 Process data objects EP7041-4032

The EP7041-4032 device contains the process data for the stepper motor.

ENC Status



Set counter done
Confirms the successful setting of the internal counter. (Triggered by "ENC Control > Control > Set counter").

Counter underflow
Is set to 1 if the counter falls below the value 0.

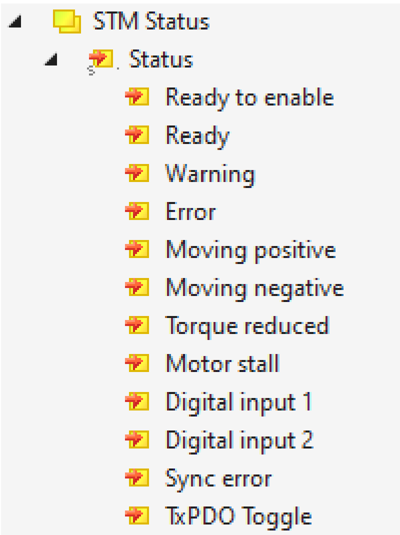
Counter overflow
Is set to 1 if the counter exceeds the maximum value.

Sync error
This bit is only relevant in operation with distributed clocks. It has the value 1 if a synchronization error occurred in the previous EtherCAT cycle.

TxPDO Toggle
This bit is inverted each time the process data object "ENC Status" is updated.

Counter value
Position according to internal step counter.

STM Status



Ready to enable
Signals that the axis can be enabled. This bit is 0 if the "Error" bit has the value 1.

Ready
The axis is enabled, the output stage is activated and the motor phases are energized.

Warning
Warning message. Possible reason e.g.: incorrectly set supply voltage 8010:03 "Nominal voltage".

Error
Error message. The output stage has been deactivated due to an error.
If the error has been rectified, you can acknowledge the error message with a positive edge on the "STM Control > Control > Reset" bit.

Moving positive
The motor is currently being driven in the positive counting direction.

Moving negative
The motor is currently being driven in the positive counting direction.

Torque reduced
Reduced torque is active. The coil current is reduced to the value of 8010:02 "Reduced current".
See also chapter Motor [▶ 36].

Motor stall
A loss of step has occurred.

Digital input 1
Logic level of the digital input at X01.

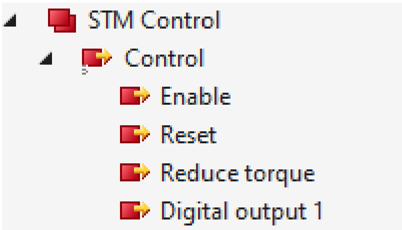
Digital input 2
Logic level of the digital input at X02.

POS Status

See chapter Commissioning with the Positioning Interface [▶ 53].

ENC Control

STM Control



Enable
Enables the axis and activates the output stage. Prerequisite: the bit "STM Status > Status > Ready to enable" is 1.
A successful enable is signaled by the bit "STM Status > Status > Ready" and green illumination of the "ENA" LED.
Notice **Configure the motor before enabling. See chapter** Motor [▶ 36].

Reset
Acknowledges all pending error messages from the box. Errors are reported via the bit "STM Status > Status > Error".

Reduce torque
Reduces the torque. The coil current is set to the value of parameter 0x8010:02 "Reduced current".

Digital output 1
Controls the motor brake (connection X03).

STM Velocity

Velocity

Target speed, related to parameter 8012:05 "Speed range".

POS Control

See chapter Commissioning with the Positioning Interface [▶ 53].

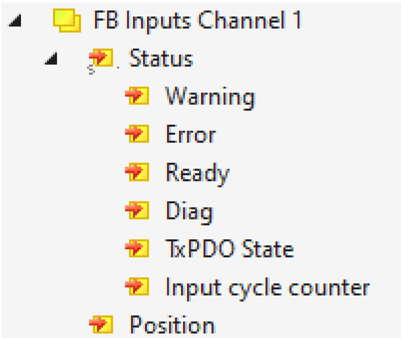
POS Control 2

See chapter Commissioning with the Positioning Interface [▶ 53].

3.4.2 Process data objects EP7041-0000

The EP7041-0000 device contains the process data for the encoder.

FB Inputs Channel 1



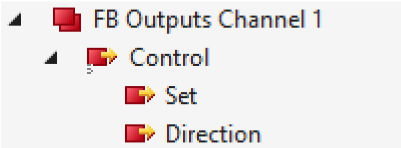
In BiSS® C mode

- **Warning**
  Forwarded warning bit from the BiSS® C encoder telegram. For interpretation, see the encoder documentation.
- **Error**
  Forwarded error bit from the BiSS® C encoder telegram. For interpretation, see the encoder documentation.
- **Ready**
  The encoder signals that it is ready by a high level on the data line.
- **Diag**
  Indicates that there are unread Diag Messages in Diag History.
- **TxPDO State**
  Validity of the process data object "FB Inputs Channel 1". If this bit has the value 1, all current values of this process data object are invalid.
- **Input cycle counter**
  A 2-bit counter that is incremented each time the process data object "FB Inputs Channel 1" is updated.
- **Position**
  The current position value of the encoder.

In SSI mode

- **Warning**
  No significance, as the parameter 8008:02 "Disable Status Bits" is automatically set to TRUE in SSI mode.
- **Error**
  No significance, as parameter 8008:02 "Disable Status Bits" is automatically set to TRUE in SSI mode.
- **Ready**
  The encoder signals that it is ready for operation with a high level on the data line.
- **Diag**
  Indicates that a new Diag Message is available in the Diag History.
- **TxPDO State**
  Validity of the process data object "FB Inputs Channel 1". If this bit has the value 1, all current values of this process data object are invalid.
- **Input cycle counter**
  A 2-bit counter that is incremented each time the process data object "FB Inputs Channel 1" is updated.
- **Position**
  The current position value of the encoder.

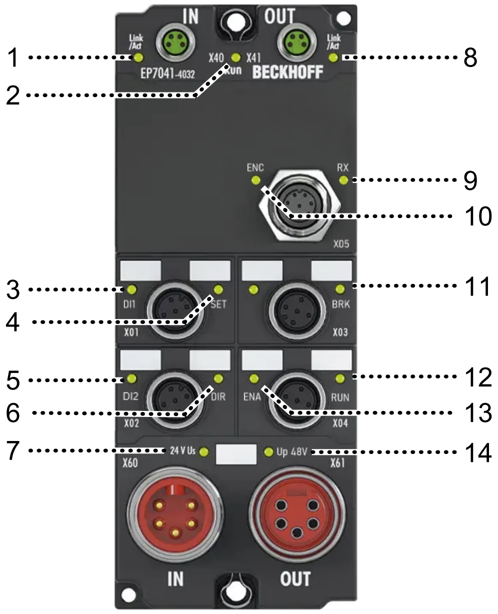
FB Outputs Channel 1



Set
Controls the "SET" digital output for zeroing the encoder position. "SET" is available at two connections:
Connection X01, pin 2
Connection X05, pin 7

Direction
Controls the digital output "DIR" to reverse the encoder counting direction. "DIR" is available at two connections:
Connection X02, pin 2
Connection X05, pin 8

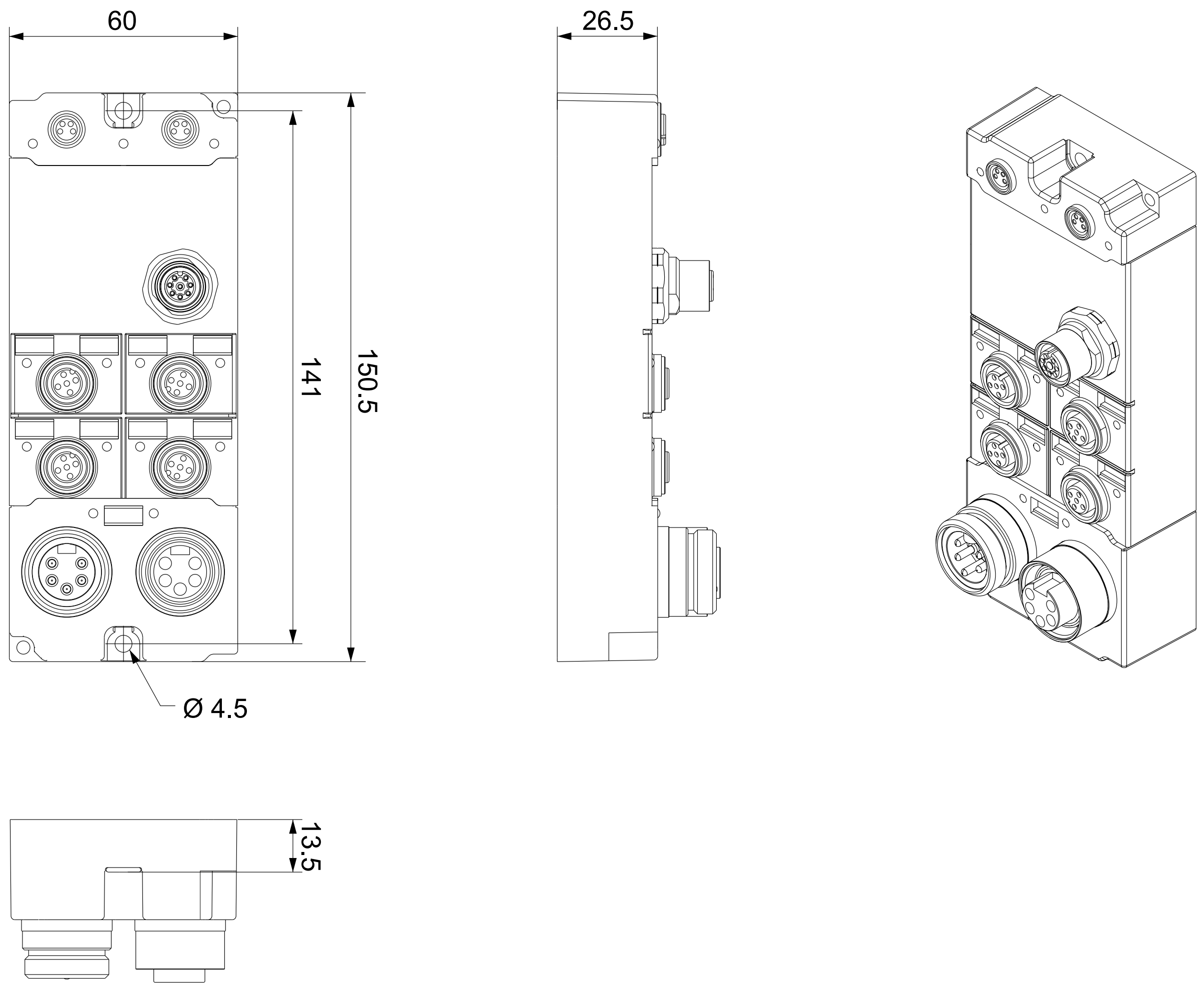
3.5 Status LEDs



Position	Name	Meaning
1	Link/Act IN	Status of the EtherCAT connection at the EtherCAT input.
2	Run	EtherCAT status
3	DI1	High level at digital input 1.
4	SET	The digital output "SET" is switched on.
5	DI2	High level at digital input 1.
6	DIR	The digital output "DIR" is switched on.
7	24V Us	The supply voltage U_S is available.
8	Link/Act OUT	Status of the EtherCAT connection at the EtherCAT output.
9	RX	Status of the encoder communication. • Lights up red: No encoder connected or position values invalid. • Lights up green: The box is receiving valid position data.
10	ENC	The connected encoder is initialized and ready for operation. (The LED visualizes the status bit "FB Inputs Channel 1 > Ready")
11	BRK	The brake output is switched on.
12	RUN	The motor shaft rotates.
13	ENA	Status of the axis: • Lights up red: Error message. The "STM Status > Status > Error" bit is set. • Lights up orange: Axis not enabled or warning message (the "STM Status > Status > Warning" bit is set). • Lights up green: Axis enabled, no warning, no error.
14	Up 48V	The supply voltage U_P is available.

4 Mounting and connection

4.1 Dimensions



All dimensions are given in millimeters.
The drawing is not true to scale.

Housing features

Housing material	PA6 (polyamide)
Sealing compound	polyurethane
Mounting	two mounting holes Ø 4.5 mm for M4
Metal parts	brass, nickel-plated
Contacts	CuZn, gold-plated
Installation position	variable
Protection class	IP65, IP66, IP67 (conforms to EN 60529) when screwed together
Dimensions (H x W x D)	approx. 150 x 60 x 26.5 mm (without connectors)

4.2 Fixing

NOTICE

Dirt during assembly

Dirty connectors can lead to malfunctions. Protection class IP67 can only be guaranteed if all cables and connectors are connected.

- Protect the plug connectors against dirt during the assembly.

Mount the module with two M4 screws in the centrally located mounting holes.

4.3 Functional earth (FE)

The mounting holes also serve as connections for the functional earth.

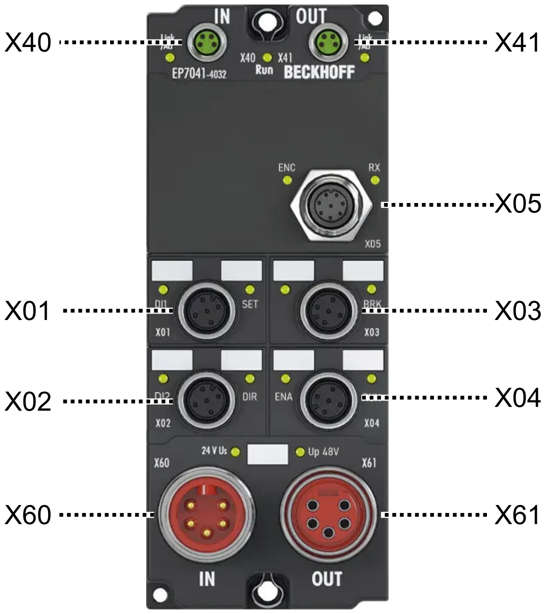
Make sure that the box is earthed with low impedance via both fastening screws. You can achieve this, for example, by mounting the box on a grounded machine bed.

4.4 Tightening torques for plug connectors

Screw connectors tight with a torque wrench. (e.g. ZB8801 from Beckhoff)

Connector diameter	Tightening torque
M8	0.4 Nm
M12	0.6 Nm
7/8”	1.5 Nm

4.5 Connections



Connection	Description	See chapter
X01	Digital I/O	Digital I/O X01, X02 [▸ 28]
X02	Digital I/O	Digital I/O X01, X02 [▸ 28]
X03	Brake connection	Motor brake X03 [▸ 29]
X04	Motor connection	Stepper motor X04 [▸ 30]
X05	Encoder connection	Encoder X05 [▸ 32]
X40	EtherCAT input	EtherCAT [▸ 23]
X41	EtherCAT forwarding	EtherCAT [▸ 23]
X60	Supply voltage input	Supply voltages [▸ 25]
X61	Forwarding the supply voltage	Supply voltages [▸ 25]

4.5.1 EtherCAT

4.5.1.1 Connectors

NOTICE

Risk of confusion: supply voltages and EtherCAT

Defect possible through incorrect insertion.

- Observe the color coding of the connectors:
  black: Supply voltages
  green: EtherCAT

EtherCAT Box Modules have two green M8 sockets for the incoming and downstream EtherCAT connections.

Fig. 4: EtherCAT connectors

Connection

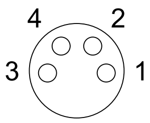


Fig. 5: M8 socket

EtherCAT	M8 socket	Core colors		
Signal	**Contact**	**ZB9010, ZB9020, ZB9030, ZB9032, ZK1090-6292, ZK1090-3xxx-xxxx**	**ZB9031 and old versions of ZB9030, ZB9032, ZK1090-3xxx-xxxx**	**TIA-568B**
Tx +	1	yellow[1)]	orange/white	white/orange
Tx -	4	orange[1)]	orange	orange
Rx +	2	white[1)]	blue/white	white/green
Rx -	3	blue[1)]	blue	green
Shield	Housing	Shield	Shield	Shield

[1)] Core colors according to EN 61918

Adaptation of core colors for cables ZB9030, ZB9032 and ZK1090-3xxxx-xxxx

For standardization, the core colors of the ZB9030, ZB9032 and ZK1090-3xxx-xxxx cables have been changed to the EN61918 core colors: yellow, orange, white, blue. So there are different color codes in circulation. The electrical properties of the cables have been retained when the core colors were changed.

4.5.1.2 Status LEDs

Fig. 6: EtherCAT Status LEDs

L/A (Link/Act)

A green LED labelled "L/A" is located next to each EtherCAT socket. The LED indicates the communication state of the respective socket:

LED	Meaning
off	no connection to the connected EtherCAT device
lit	LINK: connection to the connected EtherCAT device
flashes	ACT: communication with the connected EtherCAT device

Run

Each EtherCAT slave has a green LED labelled "Run". The LED signals the status of the slave in the EtherCAT network:

LED	Meaning
off	Slave is in "Init" state
flashes uniformly	Slave is in "Pre-Operational“ state
flashes sporadically	Slave is in "Safe-Operational" state
lit	Slave is in "Operational" state

Description of the EtherCAT slave states

4.5.1.3 Cables

For connecting EtherCAT devices only shielded Ethernet cables that meet the requirements of at least category 5 (CAT5) according to EN 50173 or ISO/IEC 11801 should be used.

EtherCAT uses four wires for signal transmission.
Thanks to automatic line detection ("Auto MDI-X"), both symmetrical (1:1) or cross-over cables can be used between Beckhoff EtherCAT.

Detailed recommendations for the cabling of EtherCAT devices

4.5.2 Supply voltages

⚠ WARNING

Power supply from SELV / PELV power supply unit!

SELV / PELV circuits (safety extra-low voltage / protective extra-low voltage) according to IEC 61010-2-201 must be used to supply this device.

Notes:

- SELV / PELV circuits may give rise to further requirements from standards such as IEC 60204-1 et al, for example with regard to cable spacing and insulation.
- A SELV supply provides safe electrical isolation and limitation of the voltage without a connection to the protective conductor, a PELV supply also requires a safe connection to the protective conductor.

⚠ CAUTION

Observe the UL requirements

- When operating under UL conditions, observe the warnings in the chapter UL Requirements [▶ 33].

The EtherCAT Box has one input for two supply voltages:

- **Control voltage U_S**
  The following sub-functions are supplied from the control voltage U_S:
  - the fieldbus
  - the processor logic
  - typically the inputs and the sensors if the EtherCAT Box has inputs.
- **Peripheral voltage U_P**
  For EtherCAT Box modules with digital outputs the digital outputs are typically supplied from the peripheral voltage U_P. U_P can be supplied separately. If U_P is switched off, the fieldbus function, the function of the inputs and the supply of the sensors are maintained.

The exact assignment of U_S and U_P can be found in the pin assignment of the I/O connections.

Redirection of the supply voltages

The power IN and OUT connections are bridged in the module. Hence, the supply voltages U_s and U_p can be passed from EtherCAT Box to EtherCAT Box in a simple manner.

NOTICE

Note the maximum current!

Ensure that the permitted current for the connectors is not exceeded when routing the supply voltages U_S and U_P:

M8 connector: max. 4 A
7/8" connector: max 16 A

NOTICE

Unintentional cancellation of the electrical isolation possible

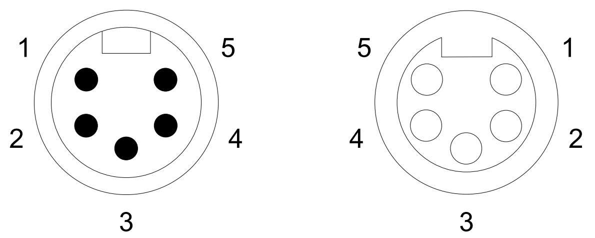
In some types of EtherCAT Box modules the ground potentials GND_S and GND_P are connected.

- If several EtherCAT Box modules are supplied with the same electrically isolated voltages, check whether there is an EtherCAT Box among them in which the ground potentials are connected.

4.5.2.1 Connectors

Two 7/8 " connectors at the low-end of the modules are used for feeding and routing the supply voltages:

- "IN" (male): left connector for feeding the supply voltages
- "OUT" (female): right connector for downstream connection of supply voltages



Plug　　　　　Socket

Feed-in　　　　Forwarding

NOTICE

Defect possible through polarity reversal

The input for the DC link voltage U_P is not protected against polarity reversal.

- Ensure that the polarity is correct.

NOTICE

Fuse protection of the DC link voltage

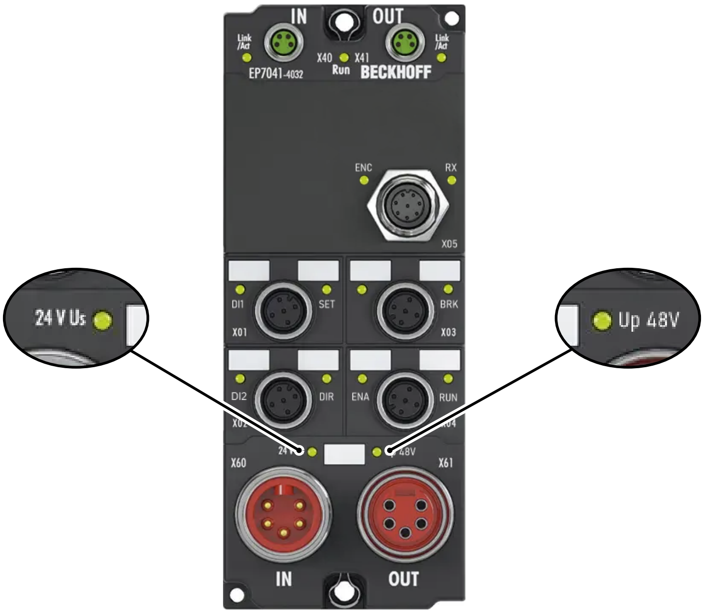
The electrical fuse protection of the DC link voltage must be selected in such a way that the maximum current is limited to 16 A (max. 1 second)!

Pin	Name	Comment	Core colors [1)]
1	GND_P	GND to U_P	Black
2	GND_S	GND to U_S	Blue
3	⏚	Functional earthing	Gray
4	+24 V_{DC} U_S	Control voltage U_S	Brown
5	+48 V_{DC} U_P	DC link voltage U_P	White

[1)] The core colors apply to cables of type: Beckhoff ZK203x-xxxx.

4.5.2.2 Status LEDs

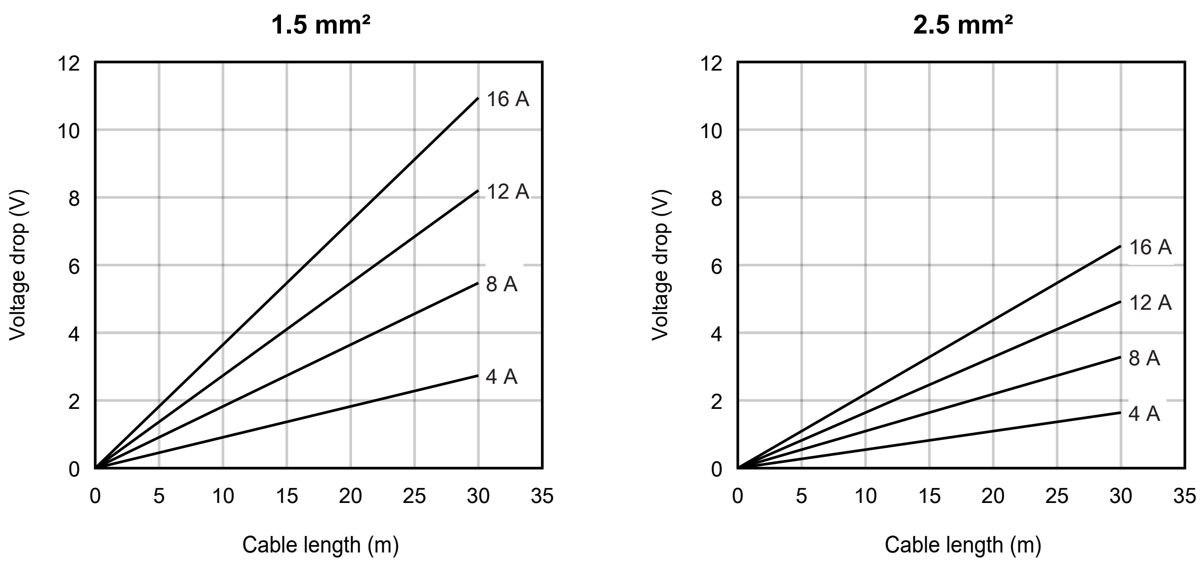
The status of the supply voltages is signaled by two LEDs. A Status LED lights up green when the respective supply voltage is present on the supply voltage input.



4.5.2.3 Conductor losses

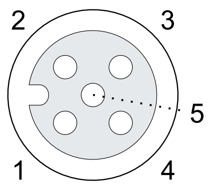
Take into account the voltage drop on the supply line when planning a system. Avoid the voltage drop being so high that the supply voltage at the box lies below the minimum nominal voltage.
Variations in the voltage of the power supply unit must also be taken into account.

Voltage drop on the supply line



4.5.3 Digital I/O X01, X02

The connections for the digital I/O are two 5-pin M12 sockets, A-coded.



X01

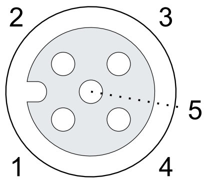
Pin	Function	Description
1	24 V U_S	Supply voltage output U_S = 24 V_{DC}
2	SET	Digital output, intended for zeroing the encoder counter reading. This pin is directly connected to X05, pin 7 "SET". The high level of this digital output corresponds to the configured encoder supply voltage, 5 V or 9 V. See chapter Setting the encoder supply voltage [▶ 37].
3	GND	Ground
4	DI1	Digital input 1
5	⏚	Functional earth

X02

Pin	Function	Description
1	24 V U_S	Supply voltage output U_S = 24 V_{DC}
2	DIR	Digital output, intended for changing the counting direction of the encoder. This pin is directly connected to X05, pin 8 "DIR". The high level of this digital output corresponds to the configured encoder supply voltage, 5 V or 9 V. See chapter Setting the encoder supply voltage [▶ 37].
3	GND	Ground
4	DI2	Digital input 2
5	⏚	Functional earth

4.5.4 Motor brake X03

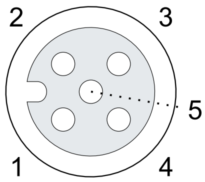
The connection for the motor brake is a 4-pin M12 socket, A-coded.



Pin	Function	Description
1	n.c.	--
2	n.c.	--
3	GND	Ground
4	BRK	Brake output
5	⏚	Functional earth

4.5.5 Stepper motor X04

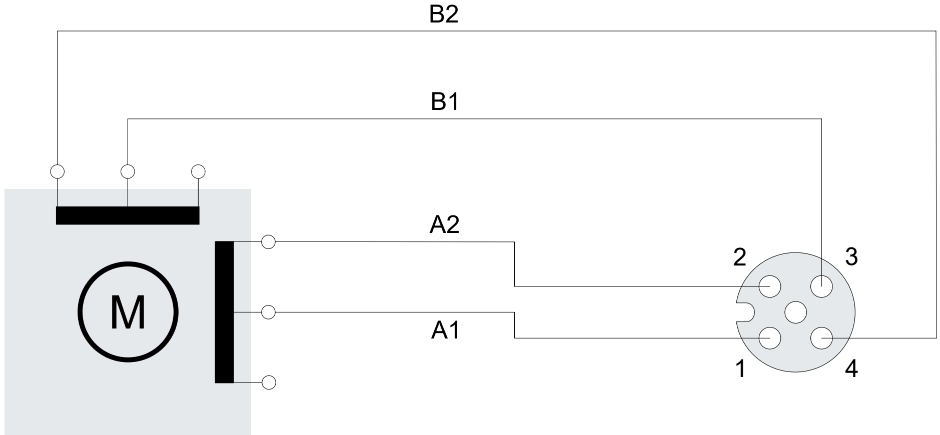
The motor connection is a 4-pin M12 socket, A-coded.



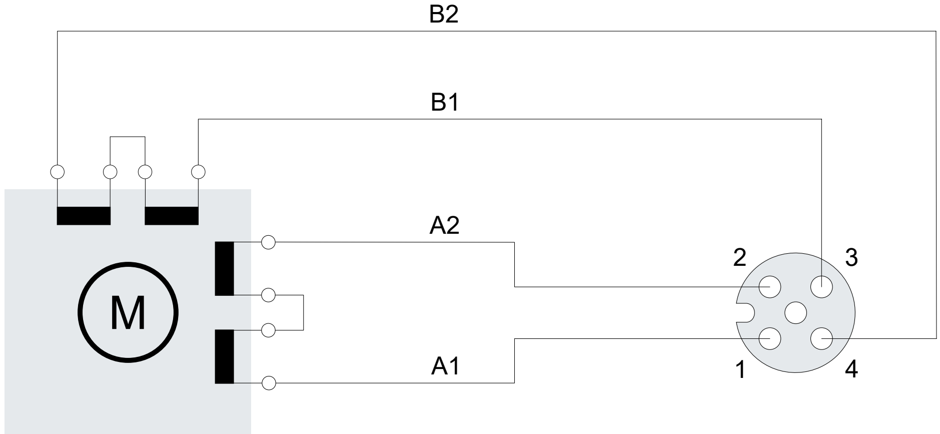
Pin	Function	Description
1	A1	Motor phase 1
2	A2	Motor phase 1
3	B1	Motor phase 2
4	B2	Motor phase 2
5	⏚	Functional earth

Connection diagrams

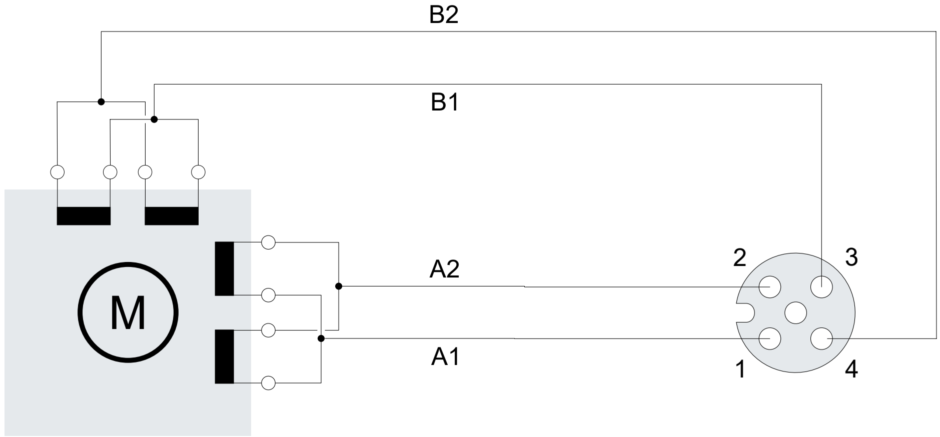
- Unipolar stepper motor



- Bipolar stepper motor, serial connection

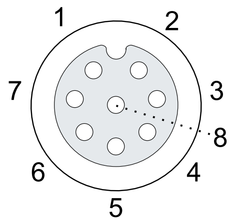


- Bipolar stepper motor, parallel connection



4.5.6 Encoder X05

The encoder interface is an 8-pin M12 socket. A BiSS® C encoder or an SSI encoder can be connected.



Pin	Function	Description
1	ENC-	GND
2	ENC+	Supply voltage output, configurable for 5 V_{DC} or 9 V_{DC}. See chapter Setting the encoder supply voltage [▸ 37].
3	Clock+	Clock output
4	Clock-	Clock output
5	Data+	Data input
6	Data-	Data input
7	SET	Digital output. This pin is directly connected to X01, pin 2 "SET".
8	DIR	Digital output. This pin is directly connected to X02, pin 2 "DIR".

4.6 UL Requirements

The installation of the EtherCAT Box Modules certified by UL has to meet the following requirements.

Supply voltage

⚠ CAUTION

CAUTION!

This UL requirements are valid for all supply voltages of all marked EtherCAT Box Modules!
For the compliance of the UL requirements the EtherCAT Box Modules should only be supplied

- by a 24 V_{DC} supply voltage, supplied by an isolating source and protected by means of a fuse (in accordance with UL248), rated maximum 4 Amp, or
- by a 24 V_{DC} power source, that has to satisfy *NEC class 2*.
  A *NEC class 2* power supply shall not be connected in series or parallel with another (class 2) power source!

⚠ CAUTION

CAUTION!

To meet the UL requirements, the EtherCAT Box Modules must not be connected to unlimited power sources!

Networks

⚠ CAUTION

CAUTION!

To meet the UL requirements, EtherCAT Box Modules must not be connected to telecommunication networks!

Ambient temperature range

⚠ CAUTION

CAUTION!

To meet the UL requirements, EtherCAT Box Modules has to be operated only at an ambient temperature range of -25 °C to +55 °C!

Marking for UL

All EtherCAT Box Modules certified by UL (Underwriters Laboratories) are marked with the following label.

Fig. 7: UL label

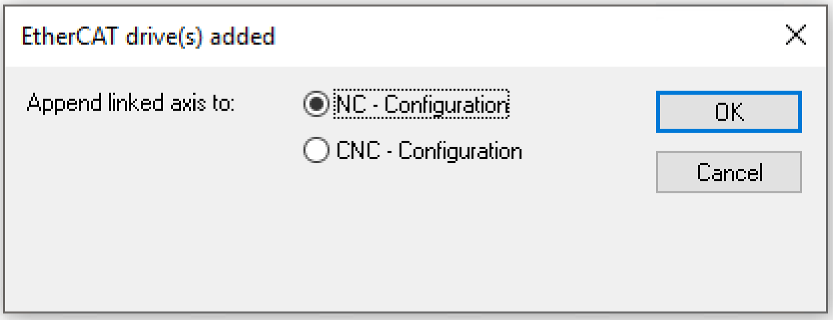
4.7 Disposal

Products marked with a crossed-out wheeled bin shall not be discarded with the normal waste stream. The device is considered as waste electrical and electronic equipment. The national regulations for the disposal of waste electrical and electronic equipment must be observed.

5 Commissioning

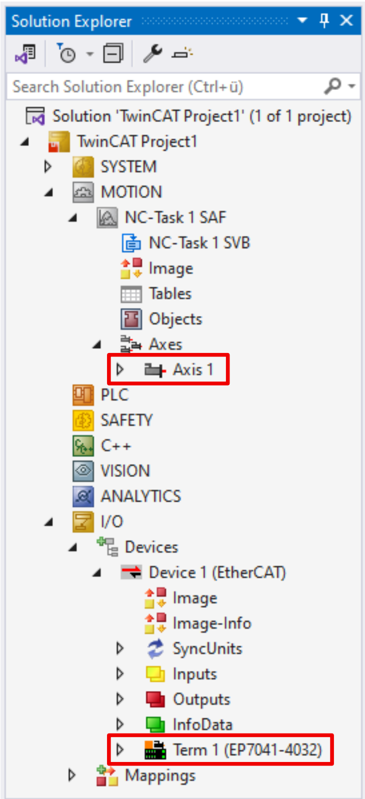
5.1 Integrating into a TwinCAT project

1. Integrate the EP7041-4032 in the Solution Explorer under "I/O". Either by scanning or manually.
   ⇨ A dialog box appears:



2. If you want to use the TwinCAT NC, select "NC - Configuration" and click on "OK".
   Otherwise, click on "Cancel".

⇨ The EP7041-4032 is integrated into the I/O configuration and, if necessary, into the NC configuration of your TwinCAT project.



5.2 Configuration of the hardware

Recommendation: reset to the delivery state before configuration: Restore the delivery state [▶ 69].

Most of the parameters are preconfigured on delivery for smooth commissioning.

5.2.1 Motor

NOTICE

Some motor parameters are not fault-tolerant

Defect possible if the motor is operated with incorrect motor parameters.

- Take care when setting the motor parameters below.

To ensure safe commissioning, it is sufficient to set the parameters listed in this chapter correctly.
Further motor parameters can be found in the CoE objects:

- 0x8010 "STM Motor Settings Ch.1", see chapter .
- 0x8012 "STM Features Ch.1", see chapter .

8010:01 "Maximal current"

The maximum current that the current controller outputs per motor winding.

Unit: mA
Factory setting: 5000_{dec}

Enter the rated current of the motor here. The rated current can usually be found in the data sheet of the motor.

8010:02 "Reduced current"

Reduced winding current. You can activate the reduced current by setting the "Reduce torque" bit. If you are using TwinCAT NC, the current is automatically set to "Reduced Current" when the motor is at a standstill.

Unit: mA
Factory setting: 2500_{dec}

This value must not exceed the rated current of the motor or the "Maximal current".

8010:03 "Nominal voltage"

The DC link voltage U_P, which you connect to X60.

Risk of confusion: DC link voltage and rated voltage of the motor

- *Do not* enter the rated voltage of the motor here, but the actual supply voltage U_P.

Unit: [mV]
Factory setting: 50000_{dec}

8010:06 "Motor Fullsteps"

Number of full step motor steps per revolution.

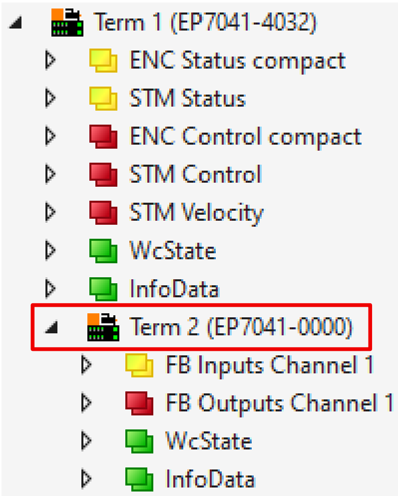
5.2.2 Encoder

5.2.2.1 Setting the encoder supply voltage

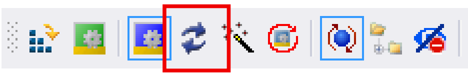
The EP7041-4032 can supply the connected encoder with either 5 V_{DC} or 9 V_{DC}. The factory setting is 5 V_{DC}. This setting also applies to the high level of the "DIR" and "SET" signals.

Procedure for changing the encoder operating voltage:

1. Select the subordinate device "EP7041-0000" in the Solution Explorer.



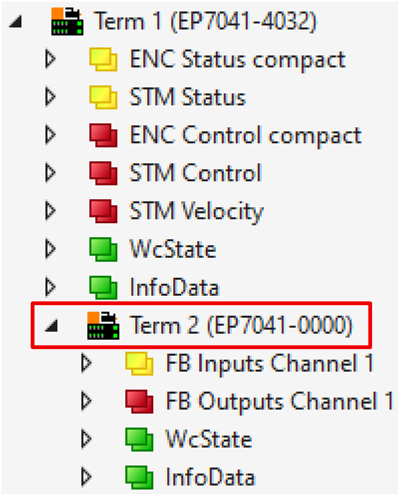
2. Write the value 0x72657375 (ASCII: "user") to the CoE parameter 0xF008 "Code word".
   ⇨ The supply voltage setting is enabled.
3. Select the desired supply voltage in CoE parameter 0x8008:12 "Supply Voltage".
4. Click on "Reload Devices".



⇨ The selected supply voltage is output.

5.2.2.2 Parameterization for a BiSS® C encoder

1. Select the subordinate device "EP7041-0000" in the Solution Explorer.



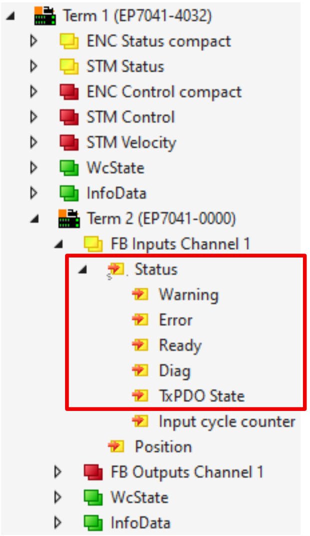
2. Select the value 0 "BiSS-C" in CoE parameter 8008:18 "Mode".
   ⇨ The parameter 0x8008:02 "Disable Status Bits" is automatically set to FALSE.
3. Configure the encoder with the following CoE parameters:
   - **0x8008:11 "CRC polynomial"**
     Enter the CRC polynomial used by the encoder to calculate the checksum here.
     Common values are the default value 0x43 ($67_{dec.}$) or 0x97 ($151_{dec.}$).
     Not recommended: You can deactivate the CRC check by setting "CRC polynomial" to 0.
     As a rule, the CRC checksum is transmitted inverted. If not, set the CoE parameter 0x8008:03 "CRC invert" to FALSE.
   - **0x8008:13 "Clock Frequency"**
     Set the clock frequency at which the EP7041-4032 should read the values from the encoder here.
     Value range: max. 10 MHz.
     Select a clock frequency that does not exceed the maximum clock frequency of the encoder.
     Also take into account possible restrictions due to long cable lengths.
   - **0x8008:15 "Multiturn [Bit]"**
     The multi-turn resolution of the encoder. It corresponds to the number of multi-turn bits transmitted by the encoder.
     If the encoder only provides single-turn bits (e.g. linear encoder), set "Multiturn [Bit]" to "0".
   - **0x8008:16 "Singleturn [Bit]"**
     The single-turn resolution of the encoder. It corresponds to the number of single-turn bits transmitted by the encoder.
   - **0x8008:17 "Offset LSB Bits [Bit]"**
     You can use the "Offset LSB Bits" to hide additional bits that some encoders transmit after the position data in the BiSS® C frame, e.g. a parity bit or a power good bit.

Structure of a BiSS® C frame

Offset MSB Bit (optional)	Position [max. 64 bits]		Offset LSB Bit (optional)	Error [1 bit]	Warning [1 bit]	CRC [8 bit]
Not relevant	Multi-turn data	Single-turn data	Optional	Status bits		CRC polynomial
	0x80p8:15 Multi-turn	0x80p8:16 Single-turn	0x80p8:17 Offset LSB Bit (right aligned)	0x80p8:02 Disable Status Bits = TRUE; Bits are not evaluated separately		0x80p8:11 CRC polynomial

Error handling

The following status bits are available in the process data for error handling of the BiSS® C interface:



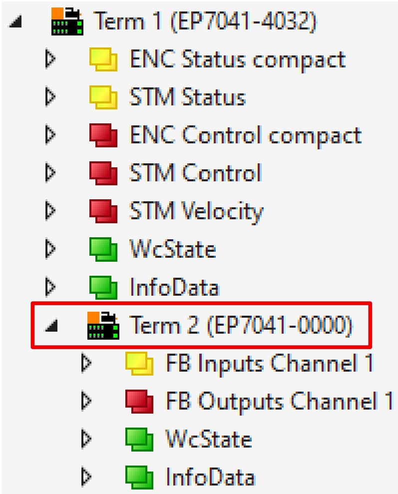
Warning	Error	Ready	TxPDO	Error description	Possible causes
0	0	1	0	No error, encoder is ready for communication, position value is valid	Encoder is connected correctly, communication is established
0	0	0	1	Encoder is not ready for communication, or position value is invalid	**Wiring error:** • Encoder is not supplied with power • Up not connected • Data lines (D + / D-) reversed **Incorrect parameterization:** • Invalid CRC • Incorrect 0x80n0 settings **Communication error:** • Watchdog error
0	0	1	1	Encoder is ready for communication, but position value is invalid	**Incorrect parameterization:** • Invalid CRC • Incorrect 0x80n0 settings **Communication error:** • Watchdog error
1	0	X	0	BiSS® C warning bit set	Encoder-specific warning, check manufacturer's data sheet
0	1	X	1	BiSS® C error bit set	Encoder-specific error, check manufacturer data sheet
X	X	X	X	Position value is invalid	**Incorrect parameterization:** • Incorrect 0x80n0 settings, check coding 0x80n0:14
1	1	X	1	BiSS® C warning and error bit set	Encoder-specific error and warning, check manufacturer's data sheet

Legend

Status	Description
1	Permanent bit status TRUE
X	Bit Change of state, depending on the encoder position

5.2.2.3 Parameterization for an SSI encoder

1. Select the subordinate device "EP7041-0000" in the Solution Explorer.



2. Select the value 1 "SSI" in CoE parameter 8008:18 "Mode".
   ⇨ The parameter 0x8008:18 "CRC Polynomial" is automatically set to 0. This disables the CRC check because the SSI protocol does not support a checksum.
   ⇨ The parameter 0x8008:02 "Disable Status Bits" is automatically set to TRUE.
   The status bits in "FB Inputs Channel 1 > Status" are not functional.
3. Configure the encoder with the following CoE parameters:
   - **0x8008:13 "Clock Frequency"**
     Set the clock frequency at which the EP7041-4032 should read the values from the encoder here.
     Value range: max. 2 MHz.
     Select a clock frequency that does not exceed the maximum clock frequency of the encoder.
     Also take into account possible restrictions due to long cable lengths.
   - **0x8008:15 "Multiturn [Bit]"**
     The multi-turn resolution of the encoder. It corresponds to the number of multi-turn bits transmitted by the encoder.
     If the encoder only provides single-turn bits (e.g. linear encoder), set "Multiturn [Bit]" to "0".
   - **0x8008:16 "Singleturn [Bit]"**
     The single-turn resolution of the encoder. It corresponds to the number of single-turn bits transmitted by the encoder.
   - **0x8008:17 „Offset LSB Bits [Bit]“**
     You can use the "Offset LSB Bits" to hide additional bits that some encoders transmit after the position data in the SSI frame, e.g. a parity bit or a power good bit.

Structure of an SSI frame

Position [max. 64 bits]		**Offset LSB Bit (optional)**	**Error [1 bit] (optional)**	**Warning [1 bit] (optional)**
Multi-turn data	Single-turn data	Optional	Status bits, disabled (default)	
0x80p8:15 Multi-turn	0x80p8:16 Single-turn	0x80p8:17 Offset LSB Bit (right aligned)	0x80p8:02 Disable Status Bits = TRUE (default in SSI mode); bits are not evaluated separately	

5.3 Commissioning with the TwinCAT NC

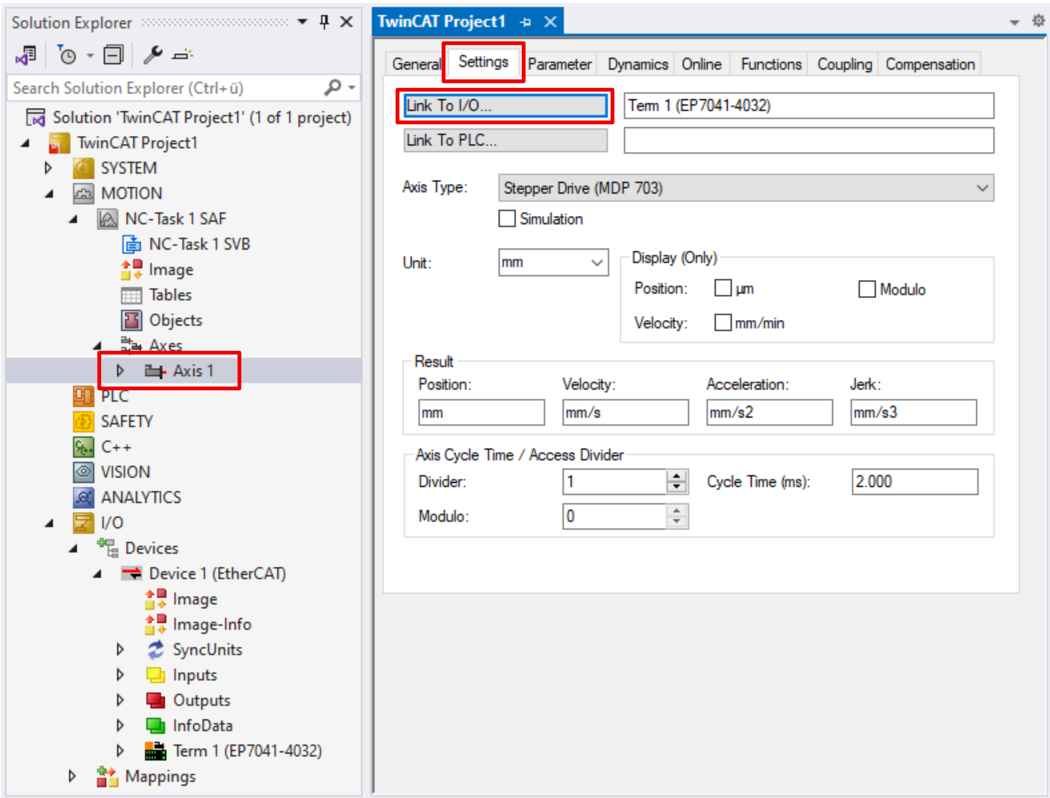
This chapter assumes that you have carried out the hardware configuration completely and conscientiously. See chapter Configuration of the hardware [▸ 36].

This chapter describes the commissioning of the EP7041-4032 with the TwinCAT NC. A general and complete documentation of TwinCAT NC: TF50x0 | TwinCAT 3 NC PTP.

5.3.1 Linking with an NC axis

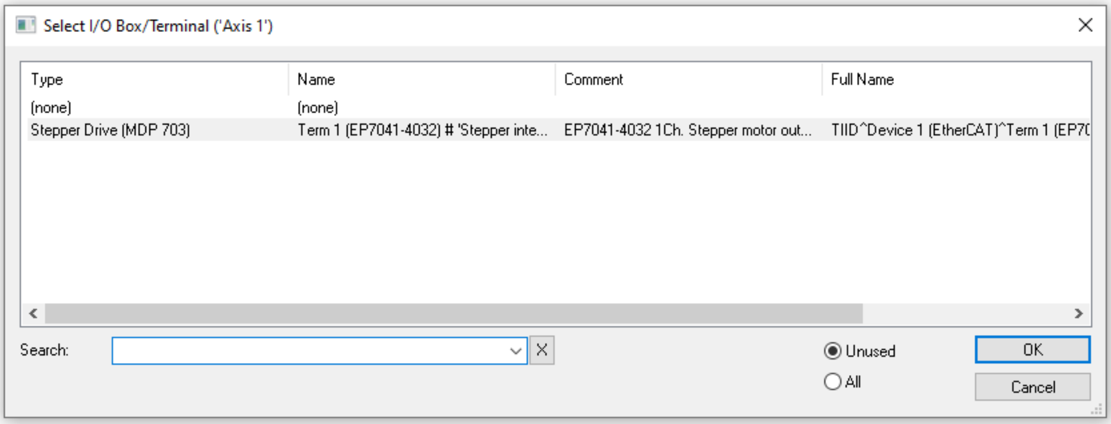
This step can usually be skipped

If you have carried out the commissioning in accordance with this documentation, an NC axis has already been linked to EP7041-4032. See chapter Integrating into a TwinCAT project [▸ 35].



1. Create an axis in the Solution Explorer under "MOTION" if the axis to be linked does not yet exist there.
2. Click on the "Axis *n*" axis and select the "Settings" tab.
3. Click the "Link to I/O" button.

⇨ A dialog box opens.



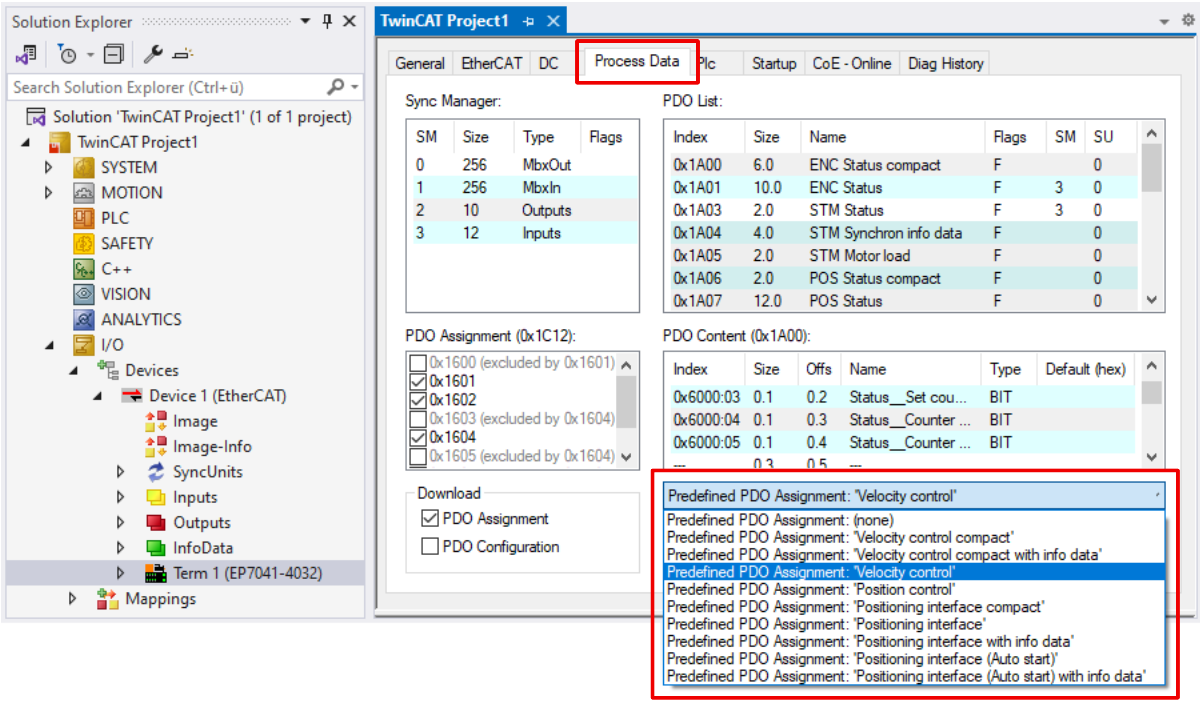
4. Select the EP7041-4032 and click on "OK".
   If the EP7041-4032 is not available for choice here, check whether the EP7041-4032 is available as an EtherCAT device in the "I/O" section.

⇨ The process data of EP7041-4032 are linked to the axis.

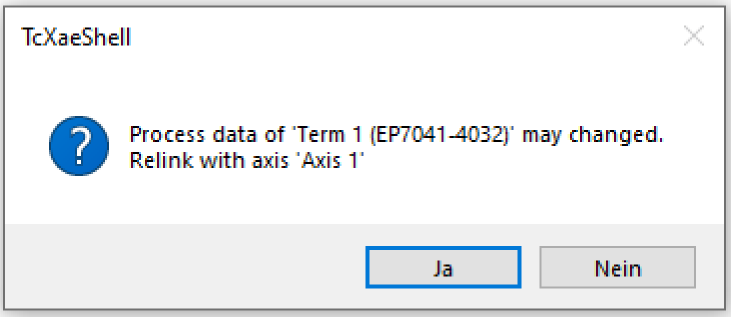
5.3.2 Selecting the controlled variable

You can choose between velocity control and position control.

1. Ensure that the value 0 "Automatic" is set in parameter 8012:01 "Operation Mode" (factory setting).
2. Open the tab "Process Data".



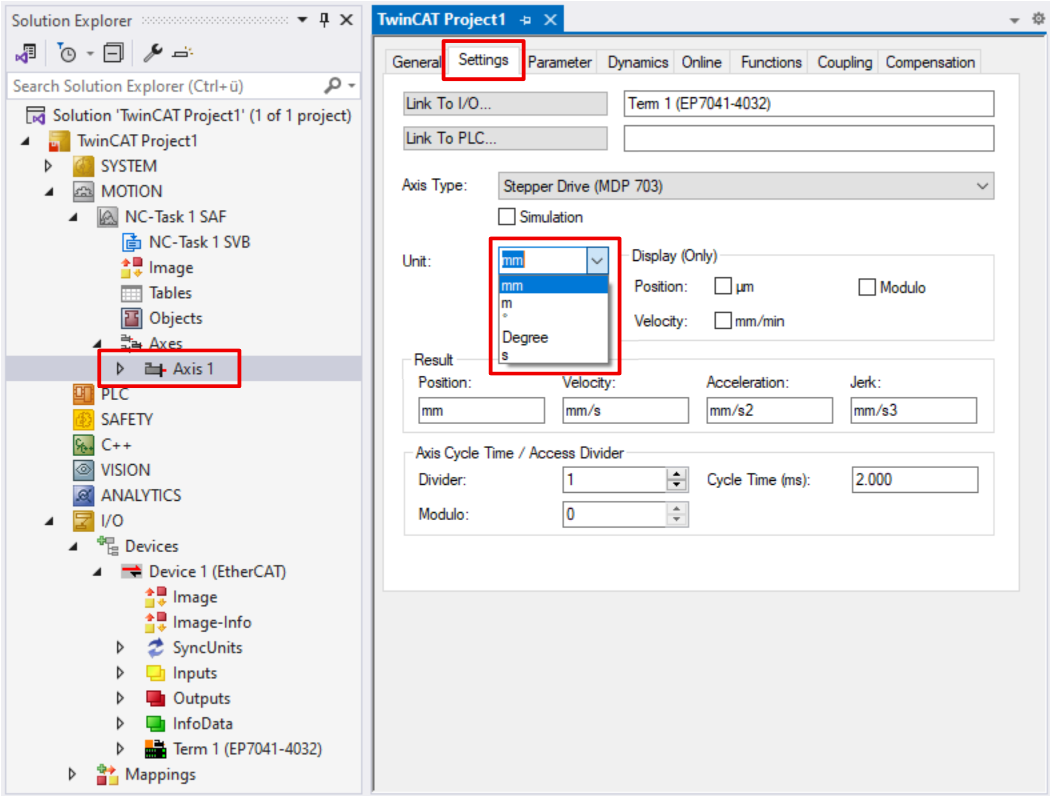
3. For velocity control: select the Predefined PDO Assignment "Velocity control".
   For position control: select the Predefined PDO Assignment "Position control".
   ⇨ The process data for the selected controlled variable is activated.
   ⇨ A dialog box appears:



4. Confirm with "Yes".

5.3.3 Selecting the unit

Choose the physical unit for the axis position:

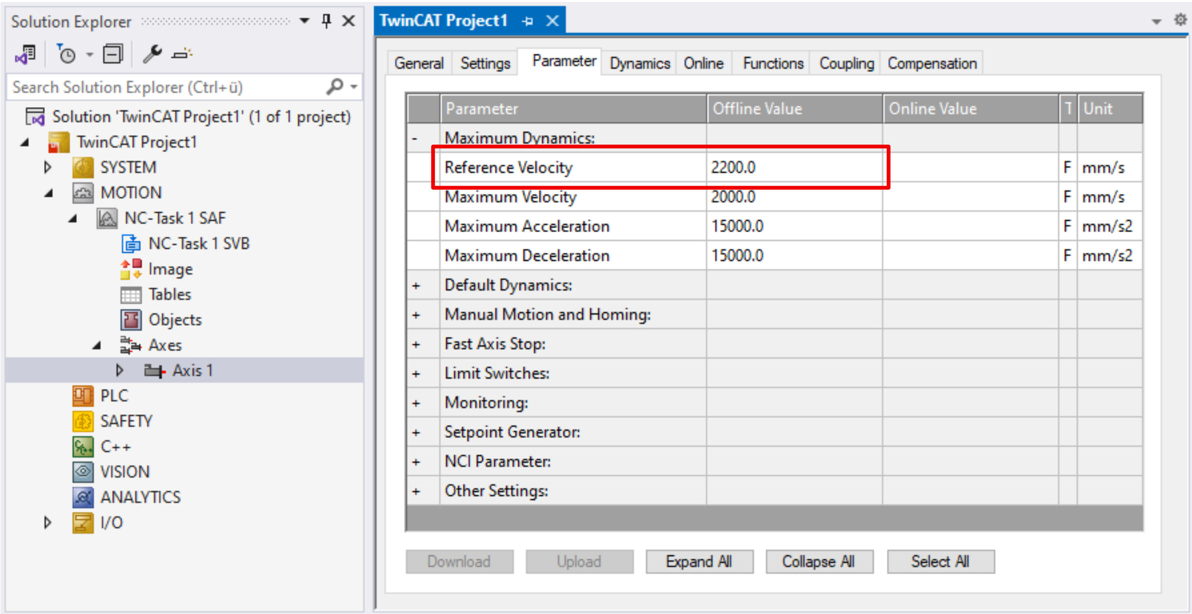


The physical units of the axis parameters are automatically adapted to this unit. For example, velocity parameters are displayed in °/s or mm/s depending on the selected unit of the axis position.

5.3.4 Parameterization

5.3.4.1 Axis

Parameter "Reference Velocity"



Factory setting: 2200

Calculate the "Reference Velocity" according to this formula:

$$v_{ref} = f_{max} \times \frac{x}{SPR}$$

v_{ref}: "Reference Velocity“ [°/s or mm/s]
(unit depends on the selected unit, see chapter Selecting the unit [▶ 44])

f_{max}: "Speed range" [full steps/s]
(CoE parameter 8012:05)

x: Distance traveled or angle per revolution

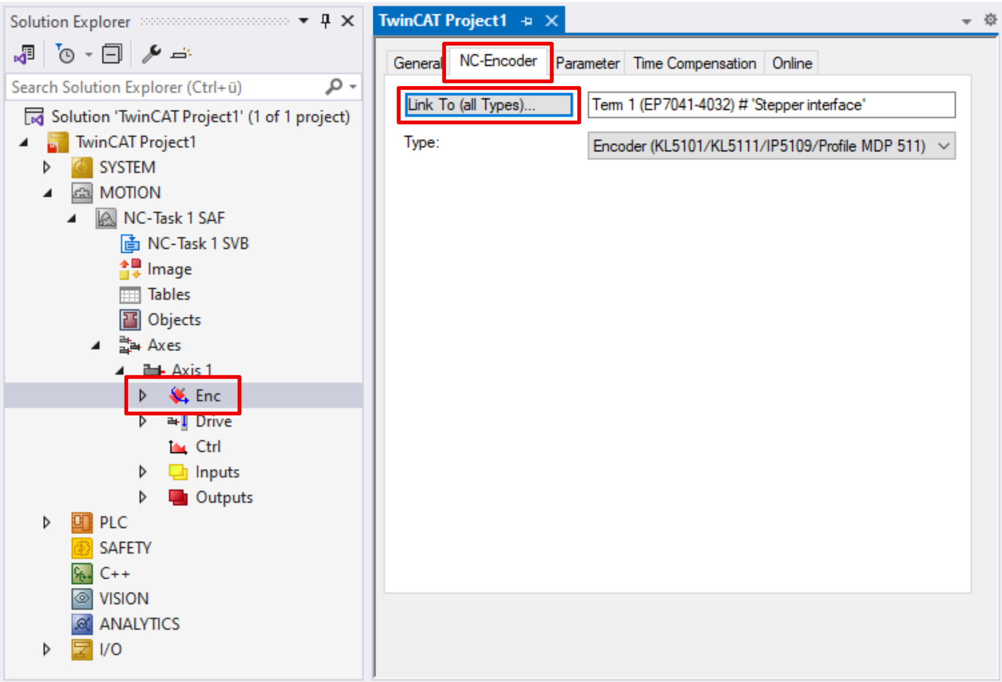
SPR: Steps per revolution

Example of a rotary axis without gearbox, e.g. a Beckhoff AS1xxx stepper motor with 200 steps per revolution:

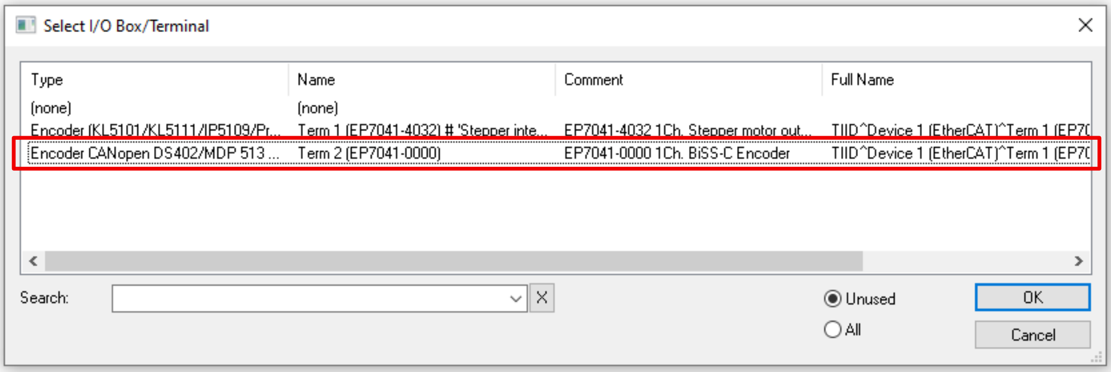
$$v_{ref} = 2000\frac{1}{s} \times \frac{360°}{200} = 3600\frac{°}{s}$$

5.3.4.2 Encoder

1. Select the "EP7041-0000" device under "I/O" in the Solution Explorer and open the "Process Data" tab.
2. Select the Predefined PDO Assignment "1 Ch. Compact" if the encoder used has a maximum resolution of 32 bit single-turn+multi-turn.
   ⇨ The calculation in TwinCAT NC is performed internally with 32-bit position values.
3. Select MOTION > NC-Task 1 SAF > Axis n > Enc in the Solution Explorer
4. Open the tab "NC-Encoder" and click on "Link To (all Types)"



5. Select the device EP7041-0000.
   (If you want to operate the box without an encoder, select the entry "(None)")



6. Open the "Parameter" tab and set the following parameters:

Invert Encoder Counting Direction

If the positive direction of rotation of the motor is opposite to the positive counting direction of the encoder, set this parameter to "TRUE".

"Scaling Factor Numerator" and "Scaling Factor Denominator"

The "Scaling Factor" is a measure of the distance or angle corresponding to a certain number of encoder steps. It is specified in the TwinCAT NC as a fraction with numerator (Numerator) and denominator (Denominator).

For rotary axes with absolute encoders (BiSS®, SSI):

- Scaling Factor Numerator = 360°
- Scaling Factor Denominator = 2^N, with N = single-turn resolution [bit]
  Example with 13 bit single-turn resolution: 2^{13} = 8192_{dec}.

Encoder Mask (maximum encoder value)

Calculate the Encoder Mask using the following formula and enter the result as a hexadecimal number:

$$2^{(\text{singleturn resolution} + \text{multiturn resolution})} - 1$$

Example for 13 bit single-turn resolution and 12 bit multi-turn resolution:

$$2^{(13+12)} - 1 = 2^{25} - 1 = \text{0x1FFFFFF}$$

Encoder Sub Mask (absolute range maximum value)

Calculate the Encoder Sub Mask using the following formula and enter the result as a hexadecimal number:

Enter the value (hexadecimal):

$$2^{(\text{singleturn resolution})} - 1$$

Example for 13 bit single-turn:

$$2^{13} - 1 = \text{0x1FFF}$$

Dead time compensation

The dead time compensation can be adjusted on the *Time Compensation* tab of *Axis1_ENC*.
It should theoretically be 3 cycles of the NC cycle time, although in practice 4 cycles are preferable.
Therefore, the settings of the parameters *Time Compensation Mode Encoder* should be ‚ON (with velocity)‘ and *Encoder Delay in Cycles* ‘4’.

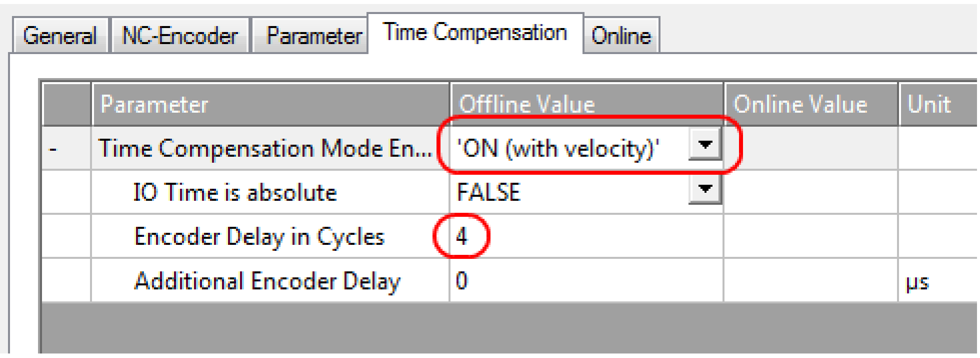
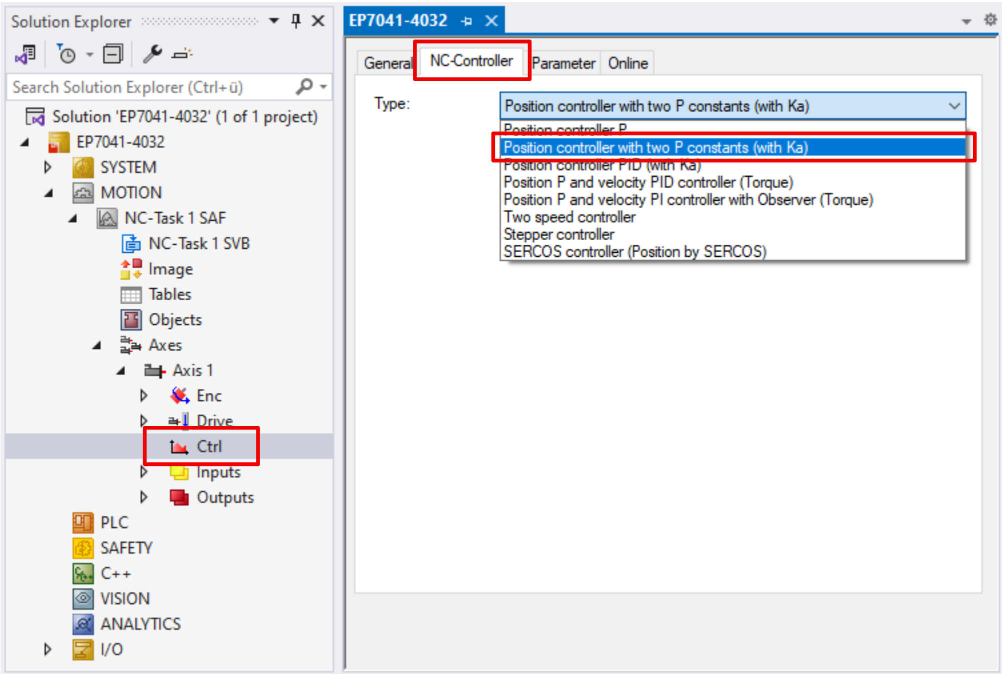


Fig. 8: Dead time compensation parameter

5.3.4.3 Position controller

Configure the position controller as follows:

1. In the Solution Explorer, select the entry "Motion > NC-Task 1 SAF > Axes > Axis 1 > Ctrl".
2. Open the tab "NC-Controller".
3. Select "Position controller with two P constants (with Ka)"



4. Open the tab "Parameter".
5. Set the following parameters:

"Position Lag Monitoring"

NOTICE

Risk of material damage due to incorrect configuration

If you set limit values that are too high, devices, machines and peripheral parts may be damaged.

Position lag monitoring is activated ex factory. You can configure it with two parameters:

- "Maximum Position Lag Value" is the amount of the maximum permissible following error in [Inc] (encoder increments).
  To convert this value into an angle or a distance, you must multiply it by the "Scaling factor", see chapter Encoder [▶ 46].
- "Maximum Position Lag Filter Time" is the maximum permissible time span for which the following error may be outside the "Maximum Position Lag Value".
  If this time span is exceeded, the motor is stopped and an error message is issued.

"Position Control: Dead Band Position Deviation"

If a target position lies between two scanning points of the encoder during position control, the position error (control deviation) is always greater than zero. In this case, the controller continues to control endlessly; the axis constantly moves in small movements around the target position.

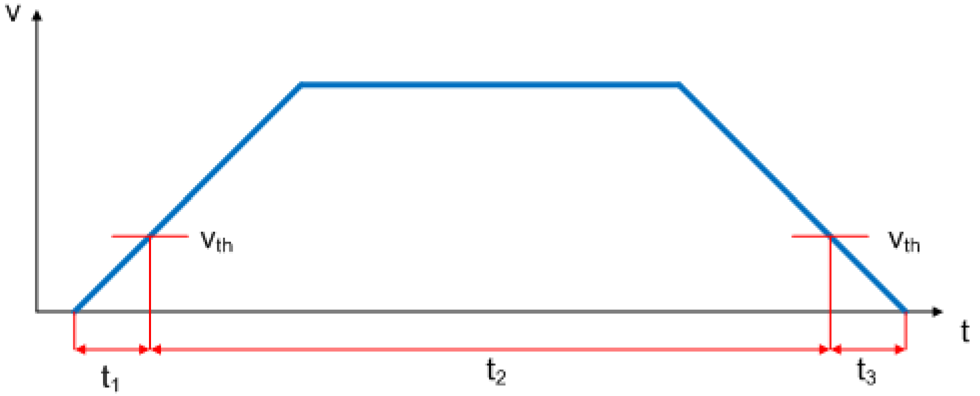
You can solve this problem by specifying a tolerance in the parameter "Position Control: Dead Band Position Deviation" within which the position error is interpreted as zero.

Controller parameters

The P controller "Position controller with two P constants (with Ka)" used in these instructions has two parameters for the P component. Depending on the operating state, only one of these parameters is used:

- During standstill, starting and stopping: "Position Control: Proportional Factor Kv (standstill)"
- In motion: "Position Control: Proportional Factor Kv (moving)"

For stepper motors, you can usually enter the same factor in both parameters.
If you enter different values, you can use the parameter "Position control: Velocity threshold V dyn [0.0 … 1.0]" to specify the threshold value in % at which the switchover between the P components takes place. Example:

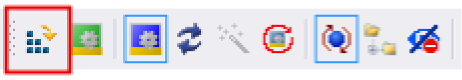


During times t_1 and t_3, the Kv factor "standstill" is active; at t_2, the Kv factor "moving" is active.

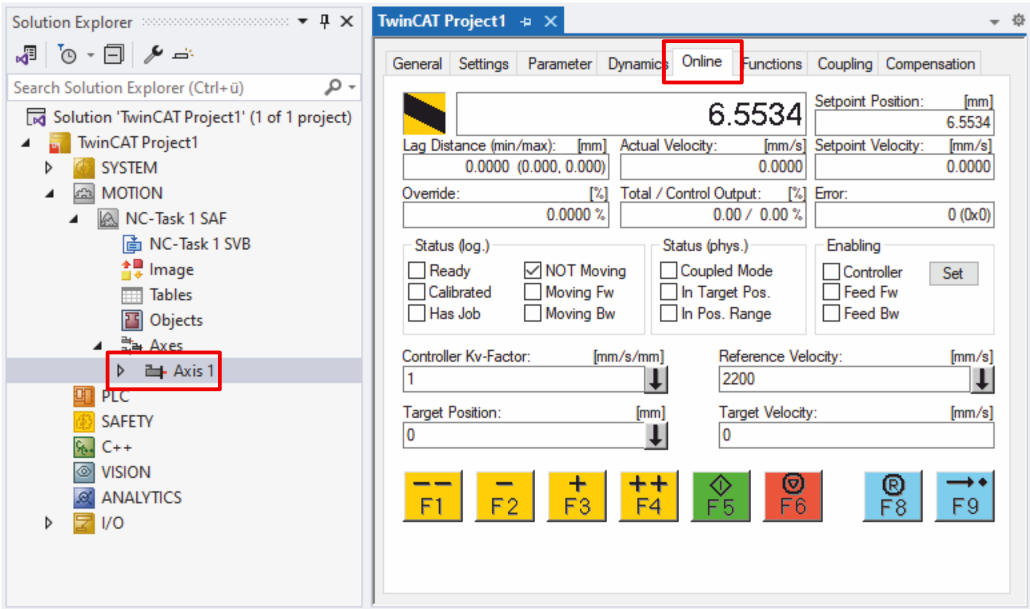
5.3.5 Execution of a test run

Step 1: Preparation

1. Activate the configuration.



2. Click on the axis and select the "Online" tab.



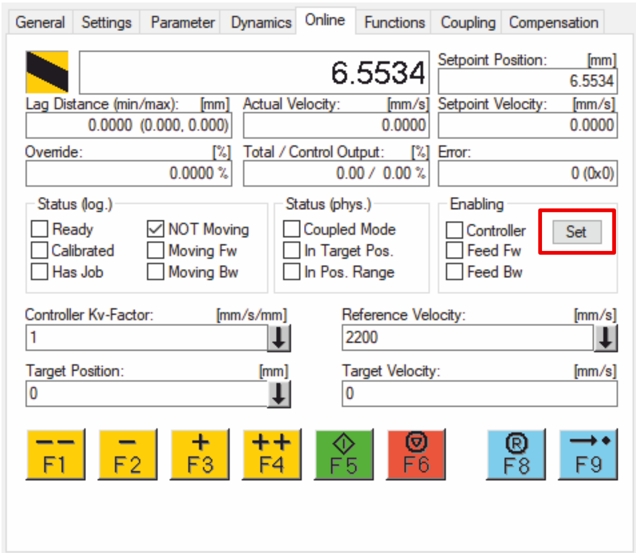
3. Move the motor shaft by hand to check the configuration of the encoder.
   Does a relative movement of 360° actually correspond to a full rotation of the motor shaft?

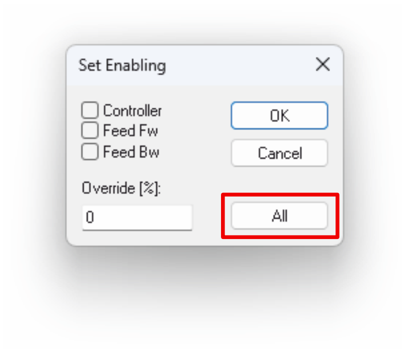
   ⇨ If not: check the scaling factor. See chapter Encoder [▶ 46].

Step 2: Performing a test run

> **⚠ CAUTION**
>
> **The motor may behave differently than expected**
>
> Injuries and damage to property are possible.
>
> • Before the test run, ensure that nobody is injured and no damage is caused by any movements of the motor shaft.

1. Enable the axis: click on "Set" and click on "All" in the window that appears.





⇨ If the enable fails: check whether one of the digital inputs is configured as "Hardware enable" (8012:32, 8012:36) and whether this input is set accordingly.

2. Try out different movement commands.
3. Check that the motor is stable and reliably follows the specifications.

5.3.6 Optimization

Setting the acceleration time

In order to pass through any resonances that may occur as quickly as possible, the ramps for the acceleration time and the deceleration time should be as steep as possible.

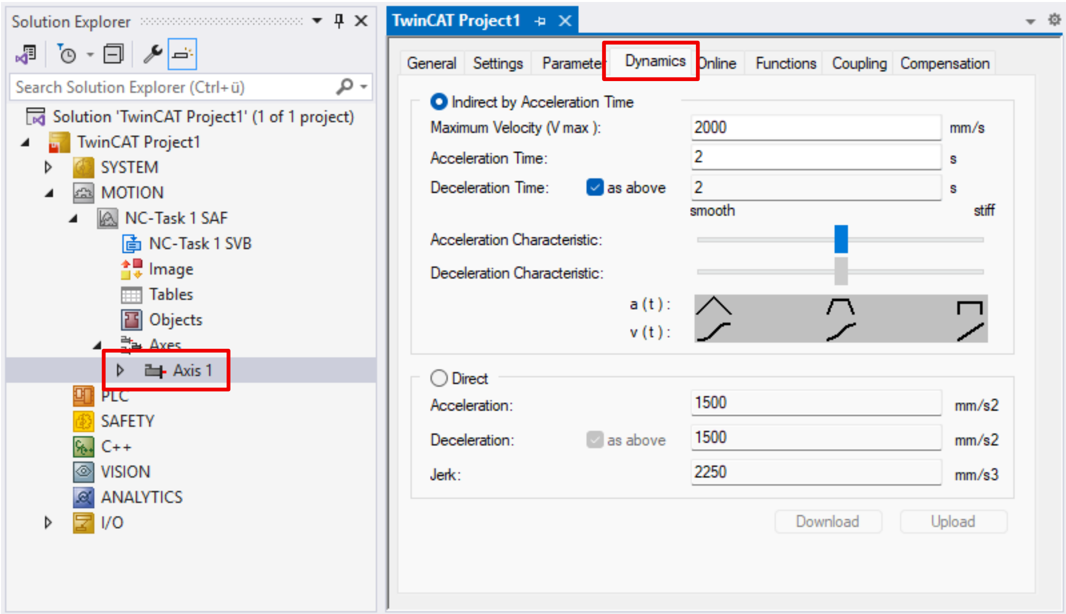


Fig. 9: Setting the acceleration time on the "Dynamics" tab

NOTICE

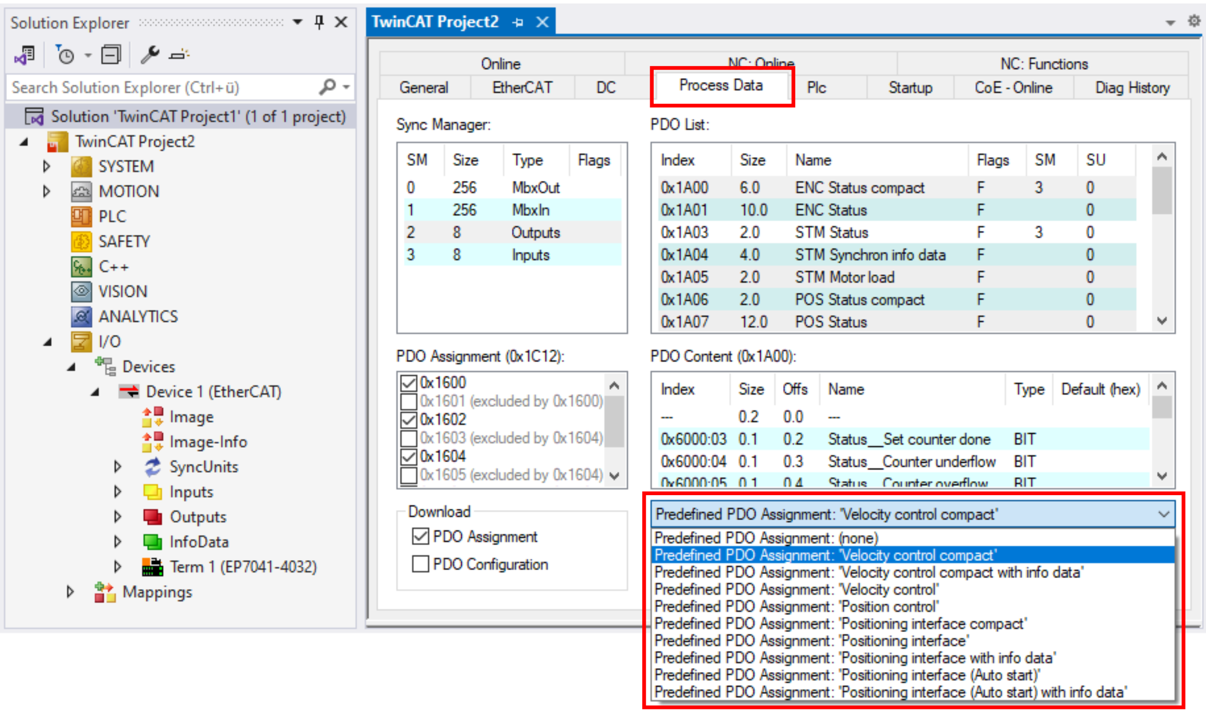
Use a buffer capacitor terminal (EL9570) for short deceleration ramps

Very short deceleration ramps may lead to temporarily increased feedback. In this case the terminal would report an error. To prevent this, one should connect a buffer capacitor terminal (EL9570) with a suitable braking resistor (e.g. 10 ohms) in parallel with the power supply of the motor (50 V) in order to absorb energy being fed back.

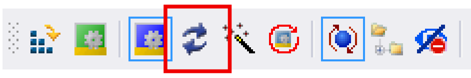
5.4 Commissioning with the Positioning Interface

5.4.1 Activating the Positioning Interface

1. Ensure that the CoE parameter 8012:01 "Operation mode" is set to 0 "Automatic".
2. Select the Predefined PDO Assignment "Positioning Interface".



3. Click on "Reload Devices".



5.4.2 Basic principles for the Positioning Interface

The *Positioning interface* offers the user a possibility to implement travel commands directly on the terminal.

5.4.2.1 Predefined PDO Assignment

The "Predefined PDO Assignment" enables a simplified selection of the process data. Select the function "Positioning interface" or "Positioning interface compact" in the lower part of the Process data tab. As a result, all necessary PDOs are automatically activated and the unnecessary PDOs are deactivated.

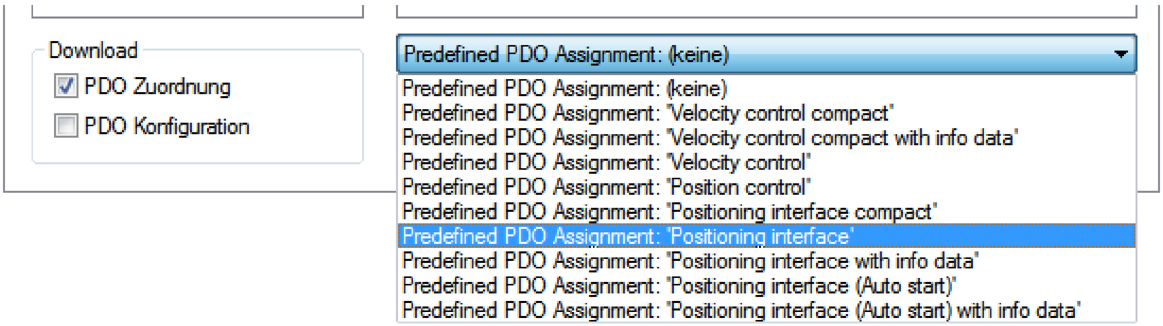


Fig. 10: Predefined PDO Assignment

5.4.2.2 Parameter set

Two objects are at the user's disposal in the CoE for the configuration – the "POS Settings" (Index 0x8020) and the "POS Features" (Index 0x8021).

Index	Name	Flags	Wert
8020:0	POS Settings Ch.1	RW	> 16 <
8020:01	Velocity min.	RW	100
8020:02	Velocity max.	RW	10000
8020:03	Acceleration pos.	RW	0x03E8 (1000)
8020:04	Acceleration neg.	RW	0x03E8 (1000)
8020:05	Deceleration pos.	RW	0x03E8 (1000)
8020:06	Deceleration neg.	RW	0x03E8 (1000)
8020:07	Emergency deceleration	RW	0x0064 (100)
8020:08	Calibration position	RW	0x00000000 (0)
8020:09	Calibration velocity (towards plc cam)	RW	200
8020:0A	Calibration Velocity (off plc cam)	RW	50
8020:0B	Target window	RW	0x000A (10)
8020:0C	In-Target timeout	RW	0x03E8 (1000)
8020:0D	Dead time compensation	RW	50
8020:0E	Modulo factor	RW	0x00000000 (0)
8020:0F	Modulo tolerance window	RW	0x00000000 (0)
8020:10	Position lag max.	RW	0x0000 (0)
8021:0	POS Features Ch.1	RW	> 22 <
8021:01	Start type	RW	Absolute (1)
8021:11	Time information	RW	Elapsed time (0)
8021:13	Invert calibration cam search direction	RW	TRUE
8021:14	Invert sync impulse search direction	RW	FALSE
8021:15	Emergency stop on position lag error	RW	FALSE
8021:16	Enhanced diag history	RW	FALSE

Fig. 11: Settings objects in the CoE

POS Settings: Velocity min.:

For reasons of performance when ramping down to the target position, the terminal needs a safety margin of 0.5 %. That means that, depending on the maximum velocity reached and the configured deceleration, the time is calculated at which the deceleration ramp begins. In order to always reach the destination reliably, 0.5 % is subtracted from the position determined. If the deceleration ramp has ended and the destination has not yet been reached, the terminal drives at the velocity "*Velocity min.*" to the destination. It must be configured in such a way that the motor is able to stop abruptly and without a step loss at this velocity.

Velocity max.:
The maximum velocity with which the motor drives during a travel command

> **"Speed range" (index 0x8012:05) [applies to EL70x1]**
>
> Velocity min./max. are standardized to the configured "Speed range" (Index 0x8012:05). This means that for a "Speed range" of 4000 full steps/second, for example, for a speed output of 100 % (i.e. 4000 full steps/second) 10,000 should be entered under "Velocity max.", and 5,000 for 50 % (i.e. 2000 full steps/second).

Acceleration pos.:
Acceleration time in the positive direction of rotation.
The five parameters for acceleration also refer to the set "*Speed range*" and are given in ms. With a setting of 1000, the terminal accelerates the motor from 0 to 100 % in 1000 ms. At a speed of 50 % the acceleration time is linearly reduced to half accordingly.

Acceleration neg.:
Acceleration time in the negative direction of rotation.

Deceleration pos.:
Deceleration time in the positive direction of rotation.

Deceleration neg.:
Deceleration time in the negative direction of rotation.

Emergency deceleration:
Emergency deceleration time (both directions of rotation). If "*Emergency stop*" is set in the appropriate PDO, the motor is stopped within this time.

Calibration position:
The current counter value is loaded with this value after calibration.

Calibration velocity (towards plc cam):
Velocity with which the motor travels towards the cam during calibration.

Calibration velocity (off plc cam):
Velocity with which the motor travels away from the cam during calibration.

Target window:
Target window of the travel distance control. "*In-Target*" is set if the motor comes to a stop within this target window.

In-Target timeout:
"In-Target" is not set if the motor is not within the target window after the expiry of the travel distance control after this set time. This condition can be recognized only by checking the falling edge of "*Busy*".

Dead time compensation:
Compensation of the internal propagation delays. This parameter does not have to be changed with standard applications.

Modulo factor:
The "*Modulo factor*" is referred to for the calculation of the target position and the direction of rotation in the modulo operating modes. It refers to the controlled system.

Modulo tolerance window:
Tolerance window for the determination of the start condition of the modulo operating modes.

POS Features:

Start type:
The "*Start type*" specifies the type of calculation used to determine the target position (see below).

Time information:
The meaning of the "*Actual drive time*" displayed is configured by this parameter. At present this value cannot be changed, since there are no further selection options. The elapsed time of the travel command is displayed.

Invert calibration cam search direction:
In relation to a positive direction of rotation, the direction of the search for the calibration cam is configured here (travel towards the cam).

Invert sync impulse search direction:
In relation to a positive direction of rotation, the direction of the search is configured here in accordance with the HW sync pulse (travel away from the cam).

5.4.2.3 Information and diagnostic data

Via the information and diagnostic data, the user can obtain a more exact statement about which error occurred during a travel command.

Index	Name	Flags	Wert
9020:0	POS Info data Ch.1	RO	> 4 <
9020:01	Status word	RO	0x0000 (0)
9020:03	State (drive controller)	RO	Init (0)
9020:04	Actual position lag	RO	0
A010:0	STM Diag data Ch.1	RO	> 17 <
A020:0	POS Diag data Ch.1	RO	> 6 <
A020:01	Command rejected	RO	FALSE
A020:02	Command aborted	RO	FALSE
A020:03	Target overrun	RO	FALSE
A020:04	Target timeout	RO	FALSE
A020:05	Position lag	RO	FALSE
A020:06	Emergency stop	RO	FALSE

Fig. 12: Diagnostic objects in the CoE

POS Info data:

Status word:
The "*Status word*" reflects the status bits used in *Index 0xA020* in a data word, in order to be able to process them more simply in the PLC. The positions of the bits correspond to the number of the subindex-1.

Bit 0: Command rejected
Bit 1: Command aborded
Bit 2: Target overrun

State (drive controller):
The current status of the internal state machine is displayed here (see below).

POS Diag data:

Command rejected:
A dynamic change of the target position is not accepted each time by the terminal, since this is then not possible. The new command is rejected in this case and indicated by the setting of this bit.
These 3 diagnostic bits are transmitted synchronously to the controller by setting "*Warning*" in the PDO.

Command aborted:
The current travel command was prematurely aborted due to an internal error or by an "Emergency stop".

Target overrun:
In the case of a dynamic change of the target position, the change may take place at a relatively late point in time. The consequence of this may be that a change in the direction of rotation is necessary and that the new target position may be overrun. "*Target overrun*" is set if this occurs.

5.4.2.4 States of the internal state machine

The state (drive controller) (*Index* 0x9020:03) provides information about the current state of the internal state machine. For diagnostic purposes this can be read out by the PLC for the propagation delay. The internal cycle works constantly with 250 µs. A connected PLC cycle is very probably slower (e.g. 1 ms). For this reason it may be the case that some states are not visible at all in the PLC, since these will sometimes run through only one internal cycle.

Name	ID	Description
INIT	0x0000	Initialization/preparation for the next travel command.
IDLE	0x0001	Wait for the next travel command.
START	0x0010	The new command is evaluated and the corresponding calculations are performed.
ACCEL	0x0011	Acceleration phase.
CONST	0x0012	Constant phase
DECEL	0x0013	Deceleration phase
EMCY	0x0020	An "*Emergency stop"* has been triggered.
STOP	0x0021	The motor has stopped.
CALI_START	0x0100	Start of a calibration command.
CALI_GO_CAM	0x0110	The motor is being driven towards the cam.
CALI_ON_CAM	0x0111	The cam has been reached.
CALI_GO_SYNC	0x0120	The motor is being driven in the direction of the HW sync pulse.
CALI_LEAVE_CAM	0x0121	The motor is being driven away from the cam.
CALI_STOP	0x0130	End of the calibration phase.
CALIBRATED	0x0140	The motor is calibrated.
NOT_CALIBRATED	0x0141	The motor is not calibrated.
PRE_TARGET	0x1000	The set position has been reached; the position controller "pulls" the motor further into the target; "*In-Target timeout*" is started here.
TARGET	0x1001	The motor has reached the target window within the timeout.
TARGET_RESTART	0x1002	A dynamic change of the target position is processed here.
END	0x2000	End of the positioning phase.
WARNING	0x4000	A warning state occurred during the travel command; this is processed here.
ERROR	0x8000	An error state occurred during the travel command; this is processed here.
UNDEFINED	0xFFFF	Undefined state (can occur, for example, if the driver stage has no control voltage).

5.4.2.5 Standard sequence of a travel command

The “normally” sequence of a travel command is shown in the following flow diagram.
Coarse distinction is made between these four stages:

Startup

Test the system and the ready status of the motor.

Start positioning

Write all variables and calculate the desired target position with the appropriate “*Start type*”. Subsequently, start the travel command.

Evaluate status

Monitor the terminal state and, if necessary, dynamically change the target position.

Error handling

In case of error, procure the necessary information from the CoE and evaluate it.

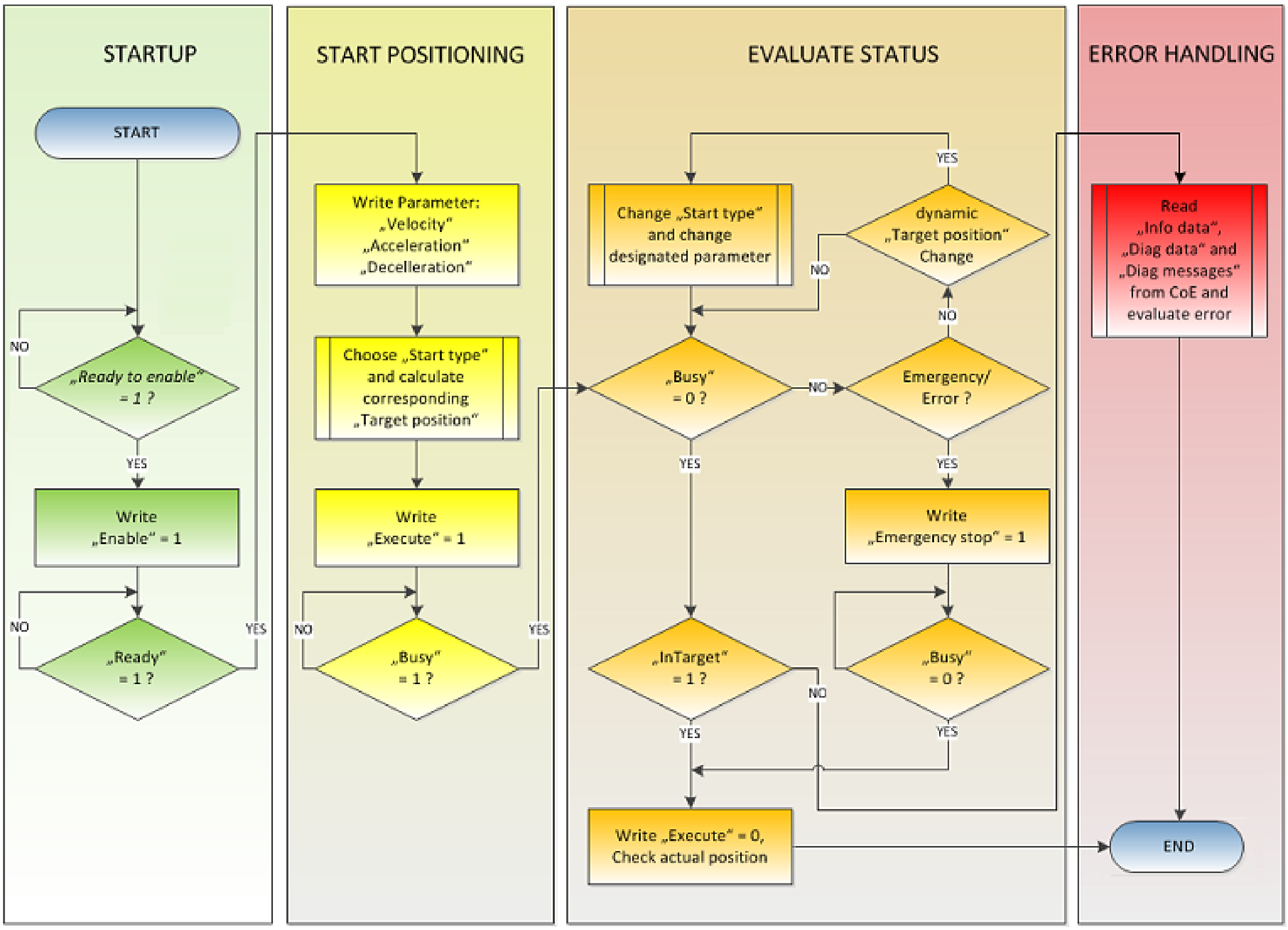


Fig. 13: Flow diagram for a travel command

5.4.2.6 Start types

The *Positioning interface* offers different types of positioning. The following table contains all commands supported; these are divided into four groups.

Supported "Start types" of the "Positioning interface"

Name	Command	Group	Description
ABSOLUTE	0x0001	Standard [▶ 60]	Absolute positioning to a specified target position
RELATIVE	0x0002		Relative positioning to a calculated target position; a specified position difference is added to the current position
ENDLESS_PLUS	0x0003		Endless travel in the positive direction of rotation (direct specification of a speed)
ENDLESS_MINUS	0x0004		Endless travel in the negative direction of rotation (direct specification of a speed)
ADDITIVE	0x0006		Additive positioning to a calculated target position; a specified position difference is added to the last target position
ABSOLUTE_CHANGE	0x1001	Standard Ext. [▶ 61]	Dynamic change of the target position during a travel command to a new absolute position
RELATIVE_CHANGE	0x1002		Dynamic change of the target position during a travel command to a new relative position (the current changing position value is used here also)
ADDITIVE_CHANGE	0x1006		Dynamic change of the target position during a travel command to a new additive position (the last target position is used here)
MODULO_SHORT	0x0105	Modulo [▶ 63]	Modulo positioning along the shortest path to the modulo position (positive or negative), calculated by the "*Modulo factor*" (Index 0x8020:0E)
MODULO_SHORT_EXT	0x0115		Modulo positioning along the shortest path to the modulo position; the "*Modulo tolerance window*" (Index 0x8020:0F) is ignored
MODULO_PLUS	0x0205		Modulo positioning in the positive direction of rotation to the calculated modulo position
MODULO_PLUS_EXT	0x0215		Modulo positioning in the positive direction of rotation to the calculated modulo position; the "*Modulo tolerance window*" is ignored
MODULO_MINUS	0x0305		Modulo positioning in the negative direction of rotation to the calculated modulo position
MODULO_MINUS_EXT	0x0315		Modulo positioning in the negative direction of rotation to the calculated modulo position; the "*Modulo tolerance window*" is ignored
MODULO_CURRENT	0x0405		Modulo positioning in the last direction of rotation to the calculated modulo position
MODULO_CURRENT_EXT	0x0415		Modulo positioning in the last direction of rotation to the calculated modulo position; the "*Modulo tolerance window*" is ignored
CALI_PLC_CAM	0x6000	Calibration [▶ 62]	Start a calibration with cam (digital inputs)
CALI_HW_SYNC	0x6100		Start a calibration with cam and HW sync pulse (C-track)
SET_CALIBRATION	0x6E00		Manually set the terminal to "*Calibrated*"
SET_CALIBRATION_AUTO	0x6E01		Automatically set the terminal to "*Calibrated"* on the first rising edge on "*Enable*"
CLEAR_CALIBRATION	0x6F00		Manually delete the calibration

ABSOLUTE

The absolute positioning represents the simplest positioning case. A position B is specified and travelled to from the start point A.

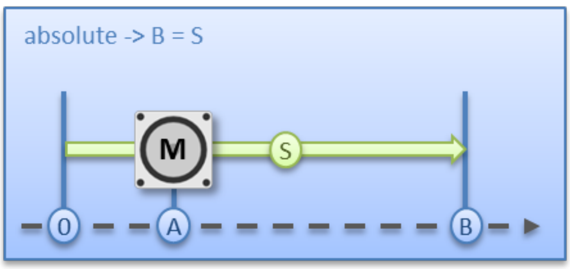


Fig. 14: Absolute positioning

RELATIVE

In relative positioning, the user specifies a position delta S, which is added to the current position A, producing the target position B.

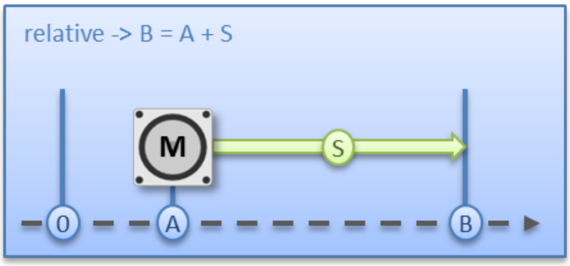


Fig. 15: Relative positioning

ENDLESS_PLUS / ENDLESS_MINUS

The two start types ENDLESS_PLUS and ENDLESS_MINUS offer the possibility in the *Positioning Interface* to specify a direct motor velocity in order to travel endlessly in the positive or negative direction with the specified accelerations.

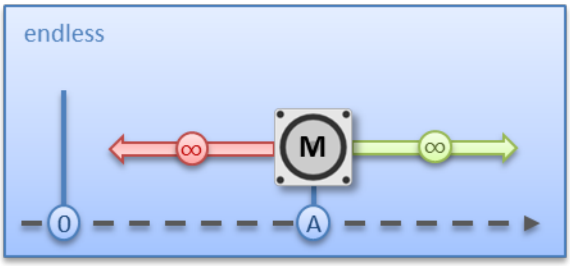


Fig. 16: Endless travel

ADDITIVE

For additive positioning, the position delta S specified by the user is added to the target position E used for the last travel command in order to calculate the target position B.

This kind of positioning resembles the relative positioning, but there is a difference. If the last travel command was completed successfully, the new target position is the same. If there was an error, however, be it that the motor entered a stall state or an *Emergency stop* was triggered, the current position is arbitrary and not foreseeable. The user now has the advantage that he can use the last target position for the calculation of the following target position.

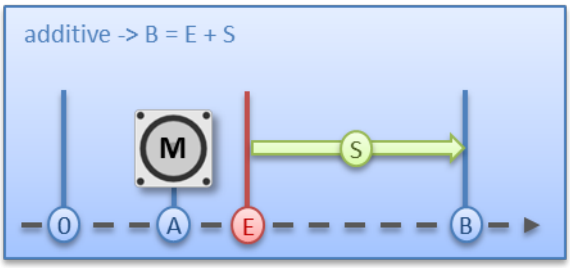


Fig. 17: Additive positioning

ABSOLUTE_CHANGE / RELATIVE_CHANGE / ADDITIVE_CHANGE

These three kinds of positioning are completely identical to those described above. The important difference thereby is that the user uses these commands during an active travel command in order to dynamically specify a new target position.

The same rules and conditions apply as to the “normal” start types. ABSOLUTE_CHANGE and ADDITIVE_CHANGE are unique in the calculation of the target position i.e. in absolute positioning an absolute position is specified and in additive positioning a position delta is added to the momentarily active target position.

NOTICE

Caution when using the RELATIVE_CHANGE positioning

The change by means of RELATIVE_CHANGE must be used with caution, since the current position of the motor is also used here as the start position. Due to propagation delays in the system, the position indicated in the PDO never corresponds to the actual position of the motor! Therefore a difference to the desired target position always results in the calculation of the transferred position delta.

Time of the change of the target position

A change of the target position cannot take place at an arbitrary point in time. If the calculation of the output parameters shows that the new target position cannot be readily reached, the command is rejected by the terminal and the Command rejected [▶ 57] bit is set. This is the case, for example, at standstill (since the terminal expects a standard positioning here) and in the acceleration phase (since at this point the braking time cannot be calculated yet).

CALI_PLC_CAM / CALI_HW_SYNC / SET_CALIBRATION / SET_CALIBRATION_AUTO / CLEAR_CALIBRATION:

The simplest calibration case is calibration by cam only (connected to one digital input).

Here, the motor travels in the 1st step with velocity 1 (Index 0x8020:09) in direction 1 (Index 0x8021:13) towards the cam. Subsequently, in the 2nd step, it travels with velocity 2 (Index 0x8020:0A) in direction 2 (Index 0x8021:14) away from the cam. After the *In-Target timeout"*(Index 0x8020:0C) has elapsed, the calibration position (Index 0x8020:08) is taken on by the terminal as the current position.

NOTICE

Observe the switching hysteresis of the cam switch

With this simple calibration it must be noted that the position detection of the cam is only exact to a certain degree. The digital inputs are not interrupt-controlled and are "only" polled. The internal propagation delays may therefore result in a system-related position difference.

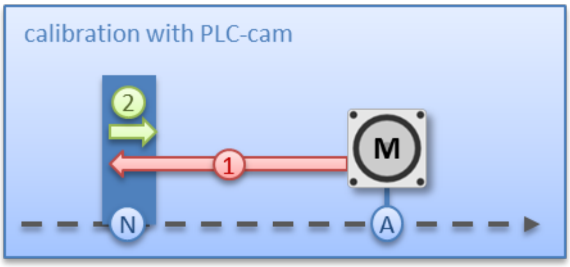


Fig. 18: Calibration with cam

For a more precise calibration, an HW sync pulse (C-track) is used in addition to the cam. This calibration proceeds in exactly the same way as described above, up to the point at which the motor travels away from the cam. The travel is not stopped immediately; instead, the sync pulse is awaited. Subsequently, the *In-Target timeout* runs down again and the calibration position is taken on by the terminal as the current position.

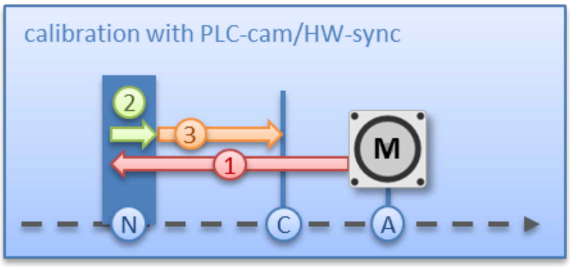


Fig. 19: Calibration with cam and C-track

If calibration by hardware is not possible due to the circumstances of the application, the user can also set the *Calibrated* bit manually or automatically. The manual setting or deletion takes place with the commands SET_CALIBRATION and CLEAR_CALIBRATION.

It is simpler, however, if the standard start types (Index 0x8021:01) are set to SET_CALIBRATION_AUTO. The *Calibrated* bit will now be set automatically by the first rising edge on *Enable*. The command is conceived only for this purpose; therefore, it does not make sense to use it via the synchronous data exchange.

5.4.2.7 Modulo - general description

MODULO

The modulo position of the axis is a piece of additional information about the absolute axis position. Modulo positioning represents the required target position in a different way. Contrary to the standard types of positioning, the modulo positioning has several pitfalls, since the desired target position can be interpreted differently.

The modulo positioning refers in principle to the *Modulo factor* (Index 0x8020:0E), which can be set in the CoE. In the following examples, a rotary axis with a "*Modulo factor*" equivalent to 360 degrees is assumed.

The *Modulo tolerance window* (Index 0x8020:0F) defines a position window around the current modulo target position of the axis. The window width is twice the specified value (set position ± tolerance value). A detailed description of the tolerance window is provided below.

The positioning of an axis is always referenced to its current actual position. The actual position of an axis is normally the position moved to with the last travel command. Under certain circumstances (incorrect positioning due to the axis stalling, or a very coarse resolution of the connected encoder), however, a position not expected by the user may arise. If this possibility is not considered, subsequent positioning may lead to unexpected behavior.

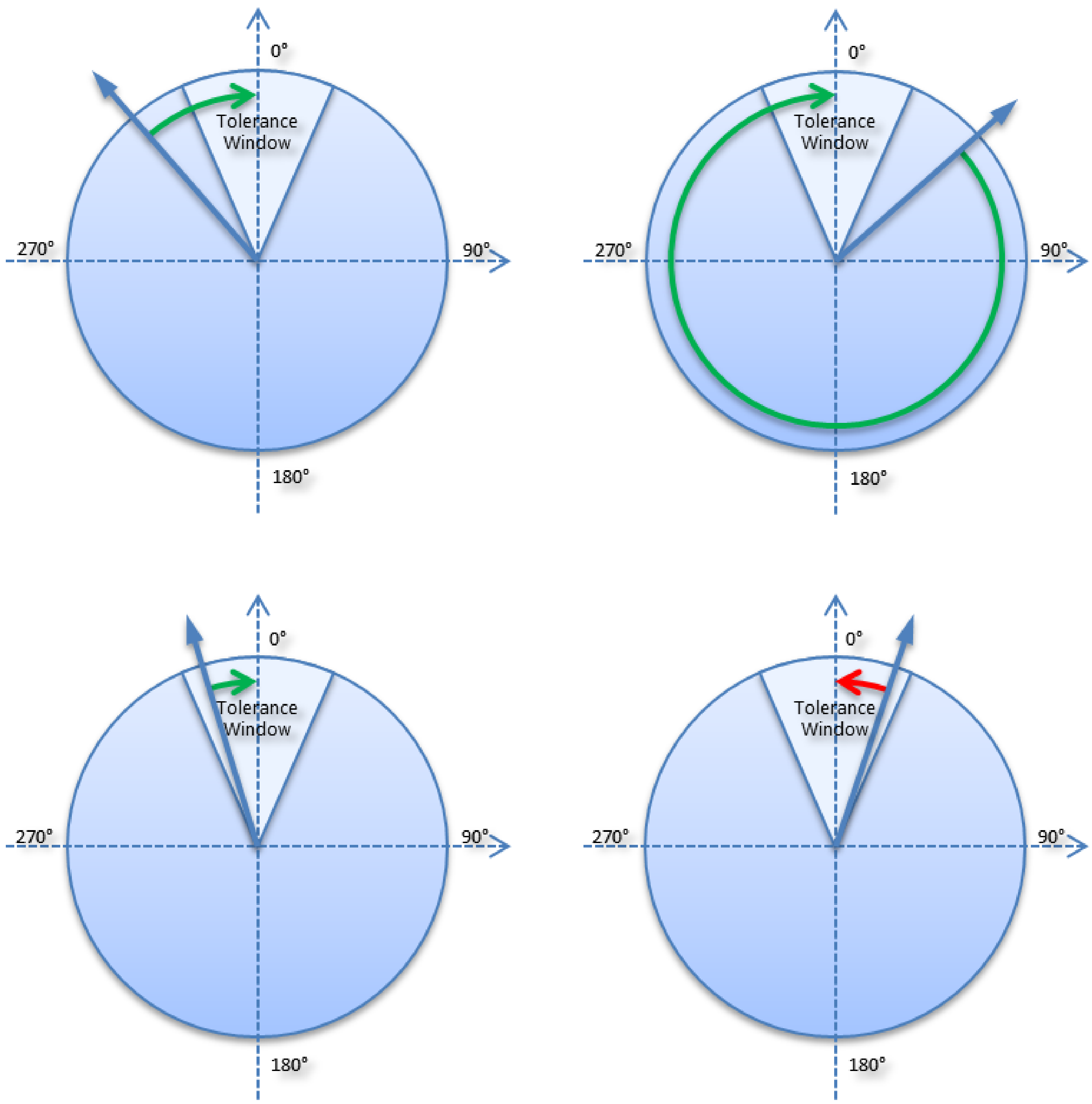


Fig. 20: Effect of the modulo tolerance window - modulo target position 0° in positive direction

Example

An axis is positioned to 0°, with the result that subsequently the actual position of the axis is exactly 0°. A further modulo travel command to 360° in *positive direction* results in a full turn, with the subsequent modulo position of the axis of once again being exactly 0°. If the axis comes to a stop somewhat in front of or behind the target position for mechanical reasons, the next travel command does not behave as one would expect. If the actual position lies slightly below 0° (see fig. *Calibration with cam*, below left), a new travel command to 0° in the *positive direction* leads only to a minimal movement. The deviation that arose beforehand is compensated and the position is subsequently exactly 0° once more. If the position lies slightly above 0°, however, the same travel command leads to a full revolution in order to reach the exact position of 0° again. This problem occurs if complete turns by 360° or multiples of 360° were initiated. For positioning to an angle that is significantly different from the current modulo position, the travel command is unambiguous.

In order to solve the problem, a "*Modulo tolerance window*" (Index 0x8020:0F) can be parameterized. This ensures that small deviations from the position that are within the window do not lead to different axis behavior. If, for example, a window of 1° is parameterized, in the case described above the axis will behave identically, as long the actual position is between 359° and 1°. If the position exceeds 0° by less than 1°, the axis is re-positioned in *positive direction* at a modulo start. In both cases, a target position of 0° therefore leads to minimum movement to exactly 0°. A target position of 360° leads to a full turn in both cases.

For values that are within the window range, the modulo tolerance window can therefore lead to movements against the specified direction. For small windows this is usually not a problem, because system deviations between set and actual position are compensated in both directions. This means that the tolerance window may also be used for axes that may only be moved in one direction due to their construction.

Modulo positioning by less than one turn

Modulo positioning from a starting position to a non-identical target position is unambiguous and requires no special consideration. A modulo target position in the range [0 ≤; position < 360] reaches the required target in less than one whole turn. No motion occurs if target position and starting position are identical. Target positions of more than 360° lead to one or more full turns before the axis travels to the required target position.

For a movement from 270° to 0°, a modulo target position of 0° (not 360°) should therefore be specified, because 360° is outside the basic range and would lead to an additional turn.

The modulo positioning distinguishes between three direction specifications: *positive direction*, *negative direction* and *along the shortest path* (*MODULO_PLUS, MODULO_MINUS, MODULO_SHORT*). For positioning along the shortest path, target positions of more than 360° are not sensible, because the movement towards the target is always direct. In contrast to positive or negative direction, it is therefore not possible to carry out several turns before the axis moves to the target.

NOTICE

Only basic periods of less than 360° are permitted

For modulo positioning with start type "MODULO_SHORT", only modulo target positions within the basic period (e.g. less than 360°) are permitted, otherwise an error is returned.

Positioning without the modulo tolerance window

The "Modulo tolerance window" (Index 0x8020:0F) is always taken into account in the "normal" types of modulo positioning. However, this is less desirable in some situations. In order to eliminate this "disadvantage", the comparable start types "MODULO_SHORT_EXT", "MODULO_PLUS_EXT", "MODULO_MINUS_EXT" and "MODULO_CURRENT_EXT" can be used, which ignore the modulo tolerance window.

The following table shows examples of modulo positioning with less than one revolution.

Modulo start type	Absolute start position	Modulo target position	Relative travel path	Absolute end position	Modulo end position
MODULO_PLUS	90°	0°	270°	360°	0°
MODULO_PLUS	90°	360°	630°	720°	0°
MODULO_PLUS	90°	720°	990°	1080°	0°
MODULO_MINUS	90°	0°	-90°	0°	0°
MODULO_MINUS	90°	360°	-450°	-360°	0°
MODULO_MINUS	90°	720°	-810°	-720°	0°
MODULO_SHORT	90°	0°	-90°	0°	0°

Modulo positioning with full turns

In principle, modulo positioning by one or full turns are no different than positioning to an angle that differs from the starting position. No motion occurs if target position and starting position are identical. For a full turn, 360° has to be added to the starting position. The behavior described in the example shows that special attention must be paid to positionings with whole revolutions. The following table shows positioning examples for a starting position of approximately 90°. The modulo tolerance window (TF) is set to 1° here. Special cases for which the starting position is outside this window are identified.

The following table shows examples of modulo positioning with whole revolutions

Modulo start type	Absolute start position	Modulo target position	Relative travel path	Absolute end position	Modulo end position	Note
MODULO_PLUS	90.00°	90.00°	0.00°	90.00°	90.00°	
MODULO_PLUS	90.90°	90.00°	-0.90°	90.00°	90.00°	
MODULO_PLUS	91.10°	90.00°	358.90°	450.00°	90.00°	outside TF
MODULO_PLUS	89.10°	90.00°	0.90°	90.00°	90.00°	
MODULO_PLUS	88.90°	90.00°	1.10°	90.00°	90.00°	outside TF
MODULO_PLUS	90.00°	450.00	360.00°	450.00°	90.00°	
MODULO_PLUS	90.90°	450.00°	359.10°	450.00°	90.00°	
MODULO_PLUS	91.10°	450.00°	718.90°	810.00°	90.00°	outside TF
MODULO_PLUS	89.10°	450.00°	360.90°	450.00°	90.00°	
MODULO_PLUS	88.90°	450.00°	361.10°	450.00°	90.00°	outside TF
MODULO_PLUS	90.00°	810.00	720.00°	810.00°	90.00°	
MODULO_PLUS	90.90°	810.00	719.10°	810.00°	90.00°	
MODULO_PLUS	91.10°	810.00	1078.90°	1170.00°	90.00°	outside TF
MODULO_PLUS	89.10°	810.00	720.90°	810.00°	90.00°	
MODULO_PLUS	88.90°	810.00	721.10°	810.00°	90.00°	outside TF
MODULO_MINUS	90.00°	90.00°	0.00°	90.00°	90.00°	
MODULO_MINUS	90.90°	90.00°	-0.90°	90.00°	90.00°	
MODULO_MINUS	91.10°	90.00°	-1.10°	90.00°	90.00°	outside TF
MODULO_MINUS	89.10°	90.00°	0.90°	90.00°	90.00°	
MODULO_MINUS	88.90°	90.00°	-358.90°	-270.00°	90.00°	outside TF
MODULO_MINUS	90.00°	450.00°	-360.00°	-270.00°	90.00°	
MODULO_MINUS	90.90°	450.00°	-360.90°	-270.00°	90.00°	
MODULO_MINUS	91.10°	450.00°	-361.10°	-270.00°	90.00°	outside TF
MODULO_MINUS	89.10°	450.00°	-359.10°	-270.00°	90.00°	
MODULO_MINUS	88.90°	450.00°	-718.90°	-630.00°	90.00°	outside TF
MODULO_MINUS	90.00°	810.00°	-720.00°	-630.00°	90.00°	
MODULO_MINUS	90.90°	810.00°	-720.90°	-630.00°	90.00°	
MODULO_MINUS	91.10°	810.00°	-721.10°	-630.00°	90.00°	outside TF
MODULO_MINUS	89.10°	810.00°	-719.10°	-630.00°	90.00°	
MODULO_MINUS	88.90°	810.00°	-1078.90°	-990.00°	90.00°	outside TF

5.4.2.8 Examples of two travel commands with a dynamic change of the target position

Without overrun of the target position

Time	POS Outputs	POS Inputs	Description
t1:	Execute = 1 Target position = 200000 Velocity = 2000 Start type = 0x0001 Acceleration = 1000 Deceleration = 1000	Busy = 1 Accelerate = 1	• Specification of the first parameter • Start of the acceleration phase
t2:		Accelerate = 0	• End of the acceleration phase
t3:	Target position = 100000 Velocity = 1500 Start type = 0x1001 Acceleration = 2000 Deceleration = 2000		• Change of the parameters • Activation by new start types
t4:		Decelerate = 1	• Start of the deceleration phase
t5:	Execute = 0	Busy = 0 In-Target = 1 Decelerate = 0	• End of the deceleration phase • Motor is at the new target position
t6 - t9:			• Absolute travel back to the start position 0

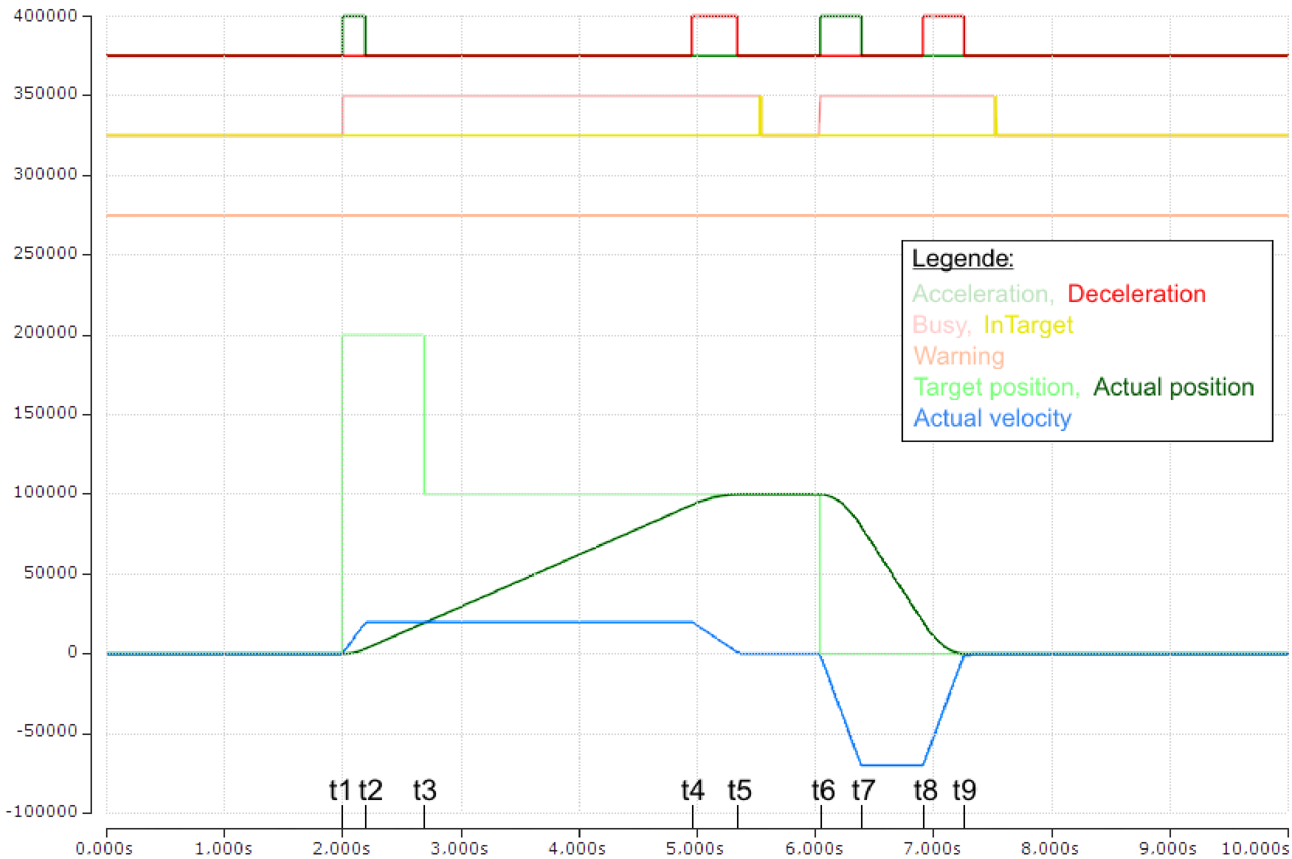


Fig. 21: Scope recording without overrunning the target position

The axis scaling refers only to the positions, not to the speed or the status bits.

With overrun of the target position

Time	POS Outputs	POS Inputs	Description
t1:	Execute = 1 Target position = 200000 Velocity = 5000 Start type = 0x0001 Acceleration = 3000 Deceleration = 5000	Busy = 1 Accelerate = 1	• Specification of the 1st parameter • Start of the 1st acceleration phase
t2:		Accelerate = 0	• End of the 1st acceleration phase
t3:	Target position = 100000 Velocity = 1500 Start type = 0x1001 Acceleration = 1000 Deceleration = 2000	Warning = 1 Decelerate = 1	• Change of the parameters • Activation by new start types • Warning of overrunning the target position • Start of the 1st deceleration phase
t4:		Accelerate = 1 Decelerate = 0	• End of the 1st deceleration phase • Start of the 2nd acceleration phase in the opposite direction
t5:		Accelerate = 0 Decelerate = 1	• End of the 2nd acceleration phase • Start of the 2nd deceleration phase
t6:	Execute = 0	Busy = 0 In-Target = 1 Decelerate = 0	• End of the 2nd deceleration phase • Motor is at the new target position
t7 - t10:			• Absolute travel back to the start position 0

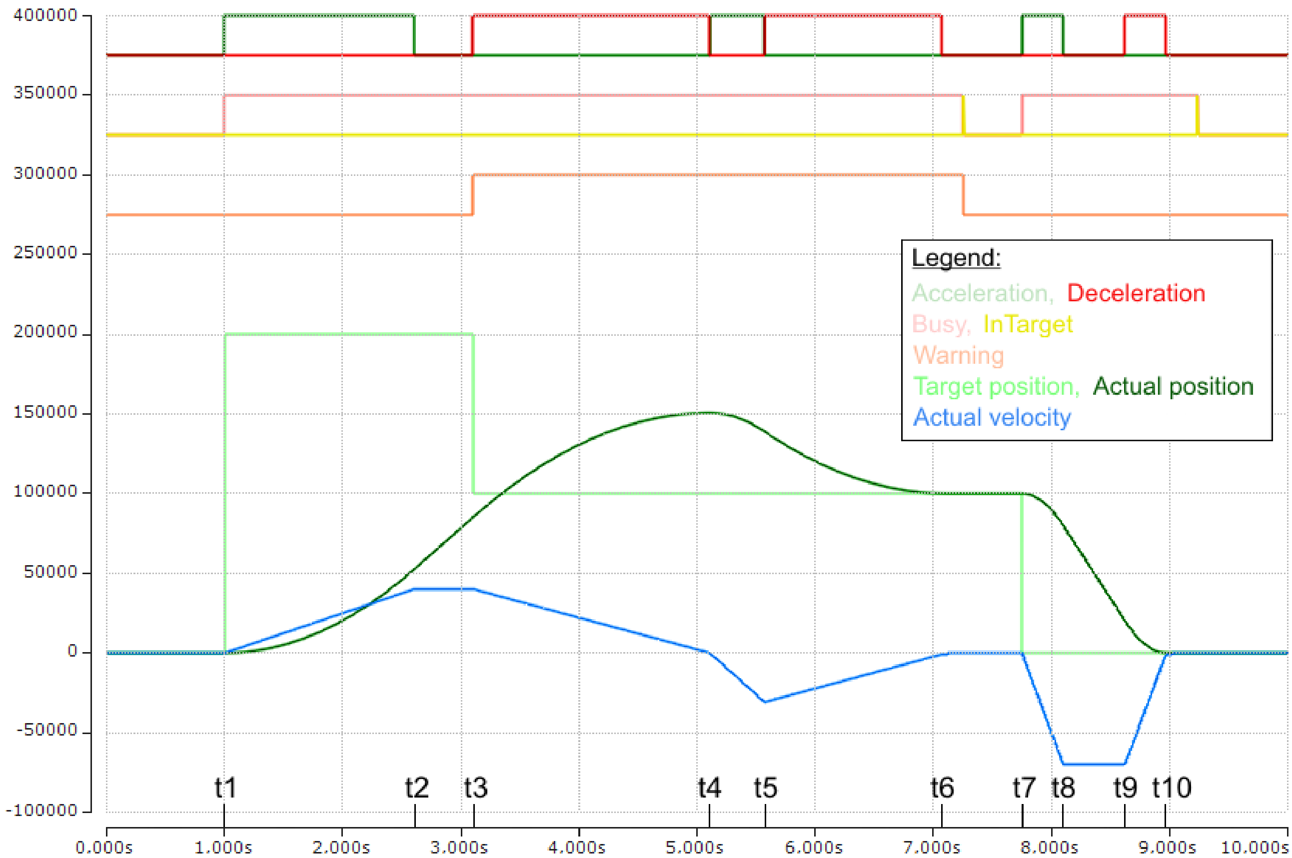


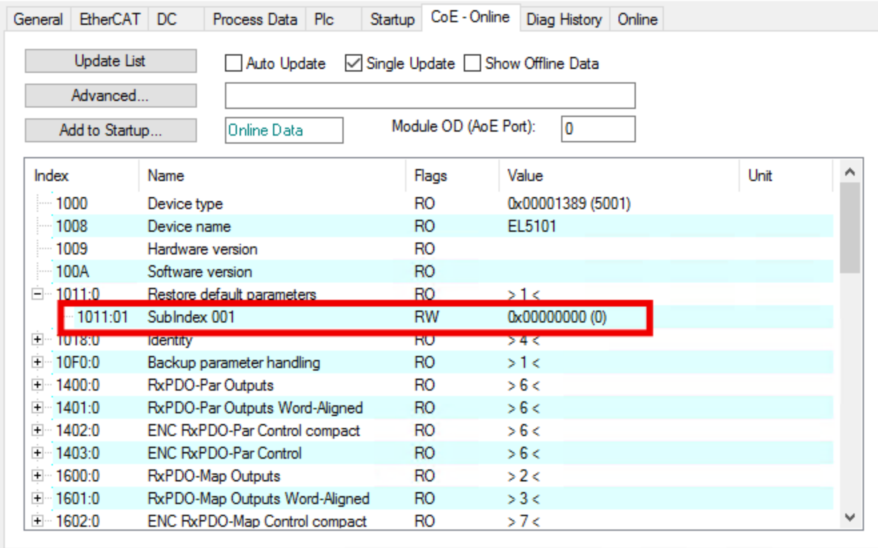
Fig. 22: Scope recording with overrunning of the final target position

The axis scaling refers only to the positions, not to the speed or the status bits.

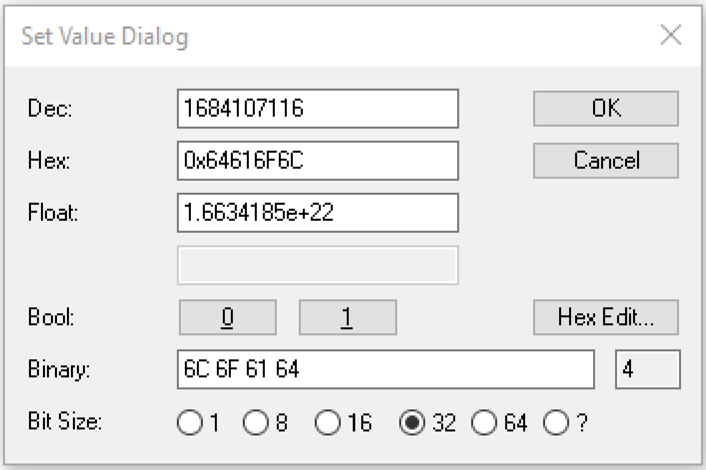
5.5 Restore the delivery state

You can restore the delivery state of the backup objects as follows:

1. Ensure that TwinCAT is running in Config mode.
2. In CoE object 1011:0 "Restore default parameters" select parameter 1011:01 "Subindex 001".



3. Double-click on "Subindex 001".
   ⇨ The "Set Value Dialog" dialog box opens.
4. Enter the value 1684107116 in the "Dec" field.
   Alternatively: enter the value 0x64616F6C in the "Hex" field.



5. Confirm with "OK".

⇨ All backup objects are reset to the delivery state.

Alternative restore value

With some older modules the backup objects can be changed with an alternative restore value:
Decimal value: 1819238756
Hexadecimal value: 0x6C6F6164

An incorrect entry for the restore value has no effect.

6 CoE parameters

The EP7041-4032 is represented in TwinCAT by two EtherCAT devices. Each EtherCAT device has its own CoE directory:

- Device EP7041-4032 [▶ 71]
- Device EP7041-0000 [▶ 95]

6.1 Device EP7041-4032

Index (hex)	Name
1000	Device type [▸ 83]
1008	Device name [▸ 83]
1009	Hardware version [▸ 83]
100A	Software version [▸ 83]
1011	Restore default parameters [▸ 83]
1018	Identity [▸ 83]
10E2	Manufacturer-specific Identification Code [▸ 83]
10F0	Backup parameter handling [▸ 84]
10F3	Diagnosis History [▸ 84]
10F8	Timestamp Object [▸ 84]
1400	ENC RxPDO-Par Control compact [▸ 84]
1401	ENC RxPDO-Par Control [▸ 84]
1403	STM RxPDO-Par Position [▸ 85]
1404	STM RxPDO-Par Velocity [▸ 85]
1405	POS RxPDO-Par Control compact [▸ 85]
1406	POS RxPDO-Par Control [▸ 85]
1407	POS RxPDO-Par Control 2 [▸ 85]
1600	ENC RxPDO-Map Control compact [▸ 85]
1601	ENC RxPDO-Map Control [▸ 86]
1602	STM RxPDO-Map Control [▸ 86]
1603	STM RxPDO-Map Position [▸ 86]
1604	STM RxPDO-Map Velocity [▸ 86]
1605	POS RxPDO-Map Control compact [▸ 86]
1606	POS RxPDO-Map Control [▸ 87]
1607	POS RxPDO-Map Control 2 [▸ 87]
1800	ENC TxPDO-Par Status compact [▸ 87]
1801	ENC TxPDO-Par Status [▸ 87]
1806	POS TxPDO-Par Status compact [▸ 87]
1807	POS TxPDO-Par Status [▸ 88]
1A00	ENC TxPDO-Map Status compact [▸ 88]
1A01	ENC TxPDO-Map Status [▸ 88]
1A03	STM TxPDO-Map Status [▸ 88]
1A04	STM TxPDO-Map Synchron info data [▸ 89]
1A05	STM TxPDO-Map Motor load [▸ 89]
1A06	POS TxPDO-Map Status compact [▸ 89]
1A07	POS TxPDO-Map Status [▸ 89]
1A08	STM TxPDO-Map Internal position [▸ 89]
1A09	STM TxPDO-Map External position [▸ 90]
1A0A	POS TxPDO-Map Actual position lag [▸ 90]
1C00	Sync manager type [▸ 90]
1C12	RxPDO assign [▸ 90]
1C13	TxPDO assign [▸ 90]
1C32	SM output parameter [▸ 91]
1C33	SM input parameter [▸ 91]
6000	ENC Inputs Ch.1 [▸ 93]
6010	STM Inputs Ch.1 [▸ 93]
6020	POS Inputs Ch.1 [▸ 93]

Index (hex)	Name
7000	ENC Outputs Ch.1 [▸ 94]
7010	STM Outputs Ch.1 [▸ 94]
7020	POS Outputs Ch.1 [▸ 94]
7021	POS Outputs 2 Ch.1 [▸ 94]
8000	ENC Settings Ch.1 [▸ 73]
8010	STM Motor Settings Ch.1 [▸ 73]
8012	STM Features Ch.1 [▸ 73]
8013	STM Controller Settings 2 Ch.1 [▸ 75]
8014	STM Motor Features Ch.1 [▸ 76]
8020	POS Settings Ch.1 [▸ 79]
8021	POS Features Ch.1 [▸ 79]
9010	STM Info data Ch.1 [▸ 81]
9020	POS Info data Ch.1 [▸ 81]
A010	STM Diag data Ch.1 [▸ 81]
A020	POS Diag data Ch.1 [▸ 81]
F000	Modular Device Profile [▸ 91]
F008	Code word [▸ 91]
F010	Module Profile List [▸ 92]
F081	Download revision [▸ 92]
F80F	STM Vendor data [▸ 79]
F81F	STM Vendor data 2 [▸ 80]
F900	STM Info data [▸ 82]
FB00	STM Command [▸ 92]

6.1.1 Configuration objects

8000 ENC Settings Ch.1

Index (hex)	Name	Meaning	Data type	Flags	Default
8000:0	ENC Settings Ch.1		USINT	RO	0xE (14_{dec})
8000:0E	Reversion of rotation	Inverts the counting direction of the encoder.	BOOL	RW	00

8010 STM Motor Settings Ch.1

Index (hex)	Name	Meaning	Data type	Flags	Default
8010:0	STM Motor Settings Ch.1		USINT	RO	0x11 (17_{dec})
8010:01	Maximal current	The maximum current in [mA] that the current controller outputs per motor winding.	UINT	RW	0x1388 (5000_{dec})
8010:02	Reduced current	Coil current at reduced torque in [mA]. The reduced torque is activated by the "STM Control > Control > Reduce torque" bit.	UINT	RW	0x9C4 (2500_{dec})
8010:03	Nominal voltage	Rated value of the applied supply voltage U_P (8...48 V).	UINT	RW	0xC350 (50000_{dec})
8010:06	Motor fullsteps	Number of full steps per motor revolution.	UINT	RW	0xC8 (200_{dec})
8010:09	Start velocity	This value is a threshold value. The box keeps the motor at standstill, as long as the speed setting is smaller than this value. It is specified in 0.01 % of the parameter 8012:05 "Speed Range".	UINT	RW	0x0 (0_{dec})
8010:10	Drive on delay time	The delay in [ms] between enabling the output stage (bit "Enable") and setting the bit "Ready". (deactivation of the brake if necessary)	UINT	RW	0x64 (100_{dec})
8010:11	Drive off delay time	The delay in [ms] between setting the "Ready" bit to 0 and deactivating the output stage. (activation of the brake if necessary)	UINT	RW	0x96 (150_{dec})

8012 STM Features Ch.1

Index (hex)	Name	Meaning	Data type	Flags	Default
8012:0	STM Features Ch.1		USINT	RO	0x45 (69_{dec})
8012:01	Operation mode	Controller operation mode Possible values: • 0_{dec}: Automatic • 1_{dec}: Velocity direct • 2_{dec}: Velocity controller • 3_{dec}: Position controller If the value 0 "Automatic" is set, the controller operation mode is set automatically based on the activated process data objects. You can find the automatically set operation mode in parameter A010:11 "Actual operation mode".	USINT	RW	0x0 (0_{dec})

Index (hex)	Name	Meaning	Data type	Flags	Default
8012:05	Speed range	Preselection of the speed range. Possible values: • 0_{dec}: 1000 Fullsteps/sec • 1_{dec}: 2000 Fullsteps/sec • 2_{dec}: 4000 Fullsteps/sec • 3_{dec}: 8000 Fullsteps/sec • 4_{dec}: 16000 Fullsteps/sec • 5_{dec}: 32000 Fullsteps/sec Important: If you are using TwinCAT NC, you must recalculate the "Reference Velocity" each time you change the "Speed range", see chapter Axis [▶ 45].	USINT	RW	0x1 (1_{dec})
8012:09	Invert motor polarity	Reverses the direction of rotation of the motor.	BOOL	RW	00
8012:11	Select info data 1	Choice of operating data to be transmitted in the process value "STM Synchron info data > Info data 1". Possible values: • 0_{dec}: Status word • 7_{dec}: Motor velocity • 9_{dec}: Status word 2 • 10_{dec}: Motor load • 11_{dec}: Motor smart current • 101_{dec}: Internal temperature • 103_{dec}: Control voltage • 104_{dec}: Motor supply voltage • 106_{dec}: Motor supply current • 150_{dec}: Drive - Status word • 151_{dec}: Drive - State • 152_{dec}: Drive - Position lag (low word) • 153_{dec}: Drive - Position lag (high word)	USINT	RW	0x0 (0_{dec})
8012:19	Select info data 2	Choice of operating data to be transmitted in the process value "STM Synchron info data > Info data 2". Possible values: • 0_{dec}: Status word • 7_{dec}: Motor velocity • 9_{dec}: Status word 2 • 10_{dec}: Motor load • 11_{dec}: Motor smart current • 101_{dec}: Internal temperature • 103_{dec}: Control voltage • 104_{dec}: Motor supply voltage • 106_{dec}: Motor supply current • 150_{dec}: Drive - Status word • 151_{dec}: Drive - State • 152_{dec}: Drive - Position lag (low word) • 153_{dec}: Drive - Position lag (high word)	USINT	RW	0x9 (9_{dec})
8012:30	Invert digital input 1	Inverts the input level of input DI1 (X01, pin 4).	BOOL	RW	00
8012:31	Invert digital input 2	Inverts the input level of input DI2 (X02, pin 4).	BOOL	RW	00
8012:32	Function for input 1	Function of input DI1 (X01, pin 4) Possible values: • 0_{dec}: Normal input • 1_{dec}: Hardware enable A logical 1 is also required at DI1 for axis enable. • 2_{dec}: Plc cam	USINT	RW	0x0 (0_{dec})

Index (hex)	Name	Meaning	Data type	Flags	Default
		• 3_{dec}: Auto start			
8012:36	Function for input 2	Function of input DI2 (X02, pin 4) Possible values: • 0_{dec}: Normal input • 1_{dec}: Hardware enable A logical 1 is also required at DI2 for axis enable. • 2_{dec}: Plc cam • 3_{dec}: Auto start	USINT	RW	0x0 (0_{dec})
8012:3A	Function for output 1	Function of the brake output on X03 Possible values: • 0_{dec}: Normal output • 1_{dec}: Break (linked with driver enable) Links the brake output with the axis enable: The brake output is switched on when the axis is enabled.	USINT	RW	0x0 (0_{dec})
8012:45	Microstepping	Microstep resolution Possible values: • 0_{dec}: Fullstep • 1_{dec}: Halfstep • 2_{dec}: 1/4 Microstepping • 3_{dec}: 1/8 Microstepping • 4_{dec}: 1/16 Microstepping • 5_{dec}: 1/32 Microstepping • 6_{dec}: 1/64 Microstepping • 7_{dec}: 1/128 Microstepping • 8_{dec}: 1/256 Microstepping	USINT	RW	0x8 (8_{dec})

8013 STM Controller Settings 2 Ch.1

Index (hex)	Name	Meaning	Data type	Flags	Default
8013:0	STM Controller Settings 2 Ch.1		USINT	RO	0x8 (8_{dec})
8013:01	Kp factor (velo./pos.)	Proportional component of the controller	UINT	RW	0x3E8 (1000_{dec})
8013:02	Ki factor (velo./pos.)	Integral component of the controller	UINT	RW	0x0 (0_{dec})
8013:03	Inner window (velo./pos.)	Inner window of the integral component in [%]	USINT	RW	0x0 (0_{dec})
8013:05	Outer window (velo./pos.)	Outer window of the integral component in [%]	USINT	RW	0x0 (0_{dec})
8013:06	Filter cut off frequency (velo./pos.)	Low-pass filter cut-off frequency Unit: Hz	UINT	RW	0x0 (0_{dec})
8013:07	Ka factor (velo./pos.)	Factor for adjusting the output current in acceleration phases	UINT	RW	0x0 (0_{dec})
8013:08	Kd factor (velo./pos.)	Factor for adjusting the output current in braking phases	UINT	RW	0x0 (0_{dec})

8014 STM Motor Features Ch.1

Index (hex)	Name	Meaning	Data type	Flags	Default
8014:0	STM Motor Features Ch.1		USINT	RO	0x31 (49$_{dec}$)
8014:01	Chopper: Mode	Possible values: • 0$_{dec}$: Intelligent off time • 1$_{dec}$: Constant off time • 2$_{dec}$: Random off time	USINT	RW	0x0 (0$_{dec}$)
8014:03	Chopper: Off time	Possible values: • 2$_{dec}$: 4 µs • 3$_{dec}$: 6 µs • 4$_{dec}$: 8 µs • 5$_{dec}$: 10 µs • 6$_{dec}$: 12 µs • 7$_{dec}$: 14 µs • 8$_{dec}$: 16 µs • 9$_{dec}$: 18 µs • 10$_{dec}$: 20 µs • 11$_{dec}$: 22 µs • 12$_{dec}$: 24 µs • 13$_{dec}$: 26 µs • 14$_{dec}$: 28 µs • 15$_{dec}$: 30 µs	USINT	RW	0x5 (5$_{dec}$)
8014:07	Chopper: Comparator disabled		BOOL	RW	00
8014:08	Chopper: Fast decay time	Possible values: • 0$_{dec}$: Slow decay only • 1$_{dec}$: 2 µs • 2$_{dec}$: 4 µs • 3$_{dec}$: 6 µs • 4$_{dec}$: 8 µs • 5$_{dec}$: 10 µs • 6$_{dec}$: 12 µs • 7$_{dec}$: 14 µs • 8$_{dec}$: 16 µs • 9$_{dec}$: 18 µs • 10$_{dec}$: 20 µs • 11$_{dec}$: 22 µs • 12$_{dec}$: 24 µs • 13$_{dec}$: 26 µs • 14$_{dec}$: 28 µs • 15$_{dec}$: 30 µs	USINT	RW	0x3 (3$_{dec}$)

Index (hex)	Name	Meaning	Data type	Flags	Default
8014:0C	Chopper: Sine wave offset	Possible values: • 0_{dec}: -3 • 1_{dec}: -2 • 2_{dec}: -1 • 3_{dec}: 0 • 4_{dec}: 1 • 5_{dec}: 2 • 6_{dec}: 3 • 7_{dec}: 4 • 8_{dec}: 5 • 9_{dec}: 6 • 10_{dec}: 7 • 11_{dec}: 8 • 12_{dec}: 9 • 13_{dec}: 10 • 14_{dec}: 11 • 15_{dec}: 12	USINT	RW	0x3 (3_{dec})
8014:11	Chopper: Hysteresis start value	Possible values: • 0_{dec}: 1 • 1_{dec}: 2 • 2_{dec}: 3 • 3_{dec}: 4 • 4_{dec}: 5 • 5_{dec}: 6 • 6_{dec}: 7 • 7_{dec}: 8	USINT	RW	0x2 (2_{dec})
8014:14	Chopper: Hysteresis end value	Possible values: • 0_{dec}: -3 • 1_{dec}: -2 • 2_{dec}: -1 • 3_{dec}: 0 • 4_{dec}: 1 • 5_{dec}: 2 • 6_{dec}: 3 • 7_{dec}: 4 • 8_{dec}: 5 • 9_{dec}: 6 • 10_{dec}: 7 • 11_{dec}: 8 • 12_{dec}: 9 • 13_{dec}: 10 • 14_{dec}: 11 • 15_{dec}: 12	USINT	RW	0x6 (6_{dec})
8014:18	Chopper: Hysteresis decrement time	Possible values: • 0_{dec}: 1 µs • 1_{dec}: 2 µs • 2_{dec}: 3 µs • 3_{dec}: 4 µs	USINT	RW	0x0 (0_{dec})
8014:1A	Stall guard: Filter enable		BOOL	RW	01
8014:1B	Stall guard: Current up step width	Possible values: • 0_{dec}: 1 • 1_{dec}: 2 • 2_{dec}: 4	USINT	RW	0x0 (0_{dec})

Index (hex)	Name	Meaning	Data type	Flags	Default
		• 3_{dec}: 8			
8014:1D	Stall guard: Current down step speed	Possible values: • 0_{dec}: 1/32 • 1_{dec}: 1/8 • 2_{dec}: 1/2 • 3_{dec}: 1	USINT	RW	0x0 (0_{dec})
8014:1F	Stall guard: Minimum current	Possible values: • 0_{dec}: 1/2 max. current • 1_{dec}: 1/4 max. current	BOOL	RW	00
8014:21	Stall guard: Minimum value	Possible values: • 0_{dec}: Stall guard off • 1_{dec}: 1 • 2_{dec}: 2 • 3_{dec}: 3 • 4_{dec}: 4 • 5_{dec}: 5 • 6_{dec}: 6 • 7_{dec}: 7 • 8_{dec}: 8 • 9_{dec}: 9 • 10_{dec}: 10 • 11_{dec}: 11 • 12_{dec}: 12 • 13_{dec}: 13 • 14_{dec}: 14 • 15_{dec}: 15	USINT	RW	0x0 (0_{dec})
8014:25	Stall guard: Hysteresis value	Possible values: • 0_{dec}: 0 • 1_{dec}: 1 • 2_{dec}: 2 • 3_{dec}: 3 • 4_{dec}: 4 • 5_{dec}: 5 • 6_{dec}: 6 • 7_{dec}: 7 • 8_{dec}: 8 • 9_{dec}: 9 • 10_{dec}: 10 • 11_{dec}: 11 • 12_{dec}: 12 • 13_{dec}: 13 • 14_{dec}: 14 • 15_{dec}: 15	USINT	RW	0x0 (0_{dec})
8014:31	Stall guard: Threshold value		SINT	RW	0x1 (1_{dec})

8020 POS Settings Ch.1

Index (hex)	Name	Meaning	Data type	Flags	Default
8020:0	POS Settings Ch.1		USINT	RO	0x11 (17_{dec})
8020:01	Velocity min.	Settings for the Positioning Interface; see chapter Parameter set [▶ 54]	INT	RW	0x64 (100_{dec})
8020:02	Velocity max.		INT	RW	0x2710 (10000_{dec})
8020:03	Acceleration pos.		UINT	RW	0x3E8 (1000_{dec})
8020:04	Acceleration neg.		UINT	RW	0x3E8 (1000_{dec})
8020:05	Deceleration pos.		UINT	RW	0x3E8 (1000_{dec})
8020:06	Deceleration neg.		UINT	RW	0x3E8 (1000_{dec})
8020:07	Emergency deceleration		UINT	RW	0x64 (100_{dec})
8020:08	Calibration position		UDINT	RW	0x0 (0_{dec})
8020:09	Calibration velocity (towards plc cam)		INT	RW	0x64 (100_{dec})
8020:0A	Calibration Velocity (off plc cam)		INT	RW	0xA (10_{dec})
8020:0B	Target window		UINT	RW	0xA (10_{dec})
8020:0C	In-Target timeout		UINT	RW	0x3E8 (1000_{dec})
8020:0D	Dead time compensation		INT	RW	0x32 (50_{dec})
8020:0E	Modulo factor		UDINT	RW	0x0 (0_{dec})
8020:0F	Modulo tolerance window		UDINT	RW	0x0 (0_{dec})
8020:10	Position lag max.		UINT	RW	0x0 (0_{dec})
8020:11	Calibration acceleration (around plc cam)		UINT	RW	0x0 (0_{dec})

8021 POS Features Ch.1

Index (hex)	Name	Meaning	Data type	Flags	Default
8021:0	POS Features Ch.1		USINT	RO	0x16 (22_{dec})
8021:01	Start type	Settings for the Positioning Interface; see chapter Parameter set [▶ 54]	UINT	RW	0x1 (1_{dec})
8021:11	Time information		USINT	RW	0x0 (0_{dec})
8021:13	Invert calibration cam search direction		BOOL	RW	01
8021:14	Invert sync impulse search direction		BOOL	RW	00
8021:15	Emergency stop on position lag error		BOOL	RW	00
8021:16	Enhanced diag history		BOOL	RW	00

F80F STM Vendor data

Index (hex)	Name	Meaning	Data type	Flags	Default
F80F:0	STM Vendor data		USINT	RO	0x9 (9_{dec})
F80F:04	Warning temperature	Temperature threshold value in [°C] for reporting an overtemperature warning.	SINT	RW	0x50 (80_{dec})
F80F:05	Switch off temperature	Temperature threshold value in [°C] for shutdown of the output stage.	SINT	RW	0x64 (100_{dec})
F80F:09	Maximum current		UINT	RW	0x1DC9 (7625_{dec})

F81F STM Vendor data 2

Index (hex)	Name	Meaning	Data type	Flags	Default
F81F:0	STM Vendor data 2		USINT	RO	0x8 (8_{dec})
F81F:01	Slope control low side	Possible values: • 0_{dec}: min. • 2_{dec}: med. • 3_{dec}: max.	USINT	RW	0x3 (3_{dec})
F81F:03	Slope control high side	Possible values: • 0_{dec}: min. • 1_{dec}: min. + tc • 2_{dec}: med. + tc • 3_{dec}: max.	USINT	RW	0x3 (3_{dec})
F81F:05	Sense voltage	Possible values: • 0_{dec}: 305 mV • 1_{dec}: 165 mV	BOOL	RW	00
F81F:08	Blank time	Possible values: • 0_{dec}: 1,0 µs • 1_{dec}: 1,5 µs • 2_{dec}: 2,3 µs • 3_{dec}: 3,4 µs	USINT	RW	0x2 (2_{dec})

6.1.2 Information objects

9010 STM Info data Ch.1

Index (hex)	Name	Meaning	Data type	Flags	Default
9010:0	STM Info data Ch.1		USINT	RO	0x13 (19_{dec})
9010:01	Status word		UINT	RO	-
9010:08	Motor velocity	Present motor velocity	INT	RO	-
9010:09	Internal position	Internal position (microincrements)	UDINT	RO	-
9010:0A	Status word 2		UINT	RO	-
9010:0B	Motor load	Current motor load Unit: 0.01°	UINT	RO	-
9010:0C	Motor smart current		USINT	RO	-
9010:13	External position	Position value of the connected encoder	UDINT	RO	-

9020 POS Info data Ch.1

Index (hex)	Name	Meaning	Data type	Flags	Default
9020:0	POS Info data Ch.1		USINT	RO	0x4 (4_{dec})
9020:01	Status word	-	UINT	RO	-
9020:03	State (drive controller)	-	UINT	RO	-
9020:04	Actual position lag	-	DINT	RO	-

A010 STM Diag data Ch.1

Index (hex)	Name	Meaning	Data type	Flags	Default
A010:0	STM Diag data Ch.1		USINT	RO	0x11 (17_{dec})
A010:01	Saturated	The output stage operates at maximum duty cycle	BOOL	RO	-
A010:02	Over temperature	The internal temperature of the box is higher than F80F:04 = 80 °C.	BOOL	RO	-
A010:03	Torque overload	The current motor current is higher than the rated current	BOOL	RO	-
A010:04	Under voltage	The supply voltage of the motor (U_P) is at least 20 % lower than the configured rated voltage 8010:03 "Nomimal voltage".	BOOL	RO	-
A010:05	Over voltage	The supply voltage of the motor (U_P) is at least 10 % higher than the configured rated voltage 8010:03 "Nomimal voltage".	BOOL	RO	-
A010:06	Short circuit	Short circuit	BOOL	RO	-
A010:08	No control power	The supply voltage U_S is too low.	BOOL	RO	-
A010:09	Misc error	Initialization has failed or the internal temperature of the box is higher than 0xF80F:05 = 100 °C	BOOL	RO	-
A010:0A	Configuration	A CoE change has not yet been adopted into the current configuration	BOOL	RO	-
A010:0B	Motor stall	A loss of step has occurred	BOOL	RO	-
A010:11	Actual operation mode	Shows the currently set controller operation mode. The controller operation mode is set automatically if the value 0 "Automatic" is selected in parameter 8012:01 (default).	USINT	RO	-

A020 POS Diag data Ch.1

Index (hex)	Name	Meaning	Data type	Flags	Default
A020:0	POS Diag data Ch.1		USINT	RO	0x6 (6_{dec})
A020:01	Command rejected	-	BOOL	RO	-
A020:02	Command aborted	-	BOOL	RO	-
A020:03	Target overrun	-	BOOL	RO	-
A020:04	Target timeout	-	BOOL	RO	-
A020:05	Position lag	-	BOOL	RO	-
A020:06	Emergency stop	-	BOOL	RO	-

F900 STM Info data

Index (hex)	Name	Meaning	Data type	Flags	Default
F900:0	STM Info data		USINT	RO	0x7 (7_{dec})
F900:01	Software version (driver)		STRING(2)	RO	-
F900:02	Internal temperature		SINT	RO	-
F900:04	Control voltage		UINT	RO	-
F900:05	Motor supply voltage	Measured value of the supply voltage U_P in [mV].	UINT	RO	-
F900:06	Cycle time		UINT	RO	-
F900:07	Motor supply current		UINT	RO	-

6.1.3 Standard objects

1000 Device type

Index (hex)	Name	Meaning	Data type	Flags	Default
1000:0	Device type	Device type of the EtherCAT device: the low word contains the used CoE profile (5001). The high word contains the module profile according to the modular device profile.	UDINT	RO	0x89130000 (2299723776_{dec})

1008 Device name

Index (hex)	Name	Meaning	Data type	Flags	Default
1008:0	Device name	Device name of the EtherCAT device	STRING(11)	RO	EP7041-4032

1009 Hardware version

Index (hex)	Name	Meaning	Data type	Flags	Default
1009:0	Hardware version	Hardware version of the EtherCAT device	STRING(2)	RO	-

100A Software version

Index (hex)	Name	Meaning	Data type	Flags	Default
100A:0	Software version	Firmware version of the EtherCAT slave	STRING(2)	RO	-

1011 Restore default parameters

Index (hex)	Name	Meaning	Data type	Flags	Default
1011:0	Restore default parameters	Restoring the delivery state, see chapter Restore the delivery state [▸ 69]	USINT	RO	0x1 (1_{dec})

1018 Identity

Index (hex)	Name	Meaning	Data type	Flags	Default
1018:0	Identity	Information for identifying the device	USINT	RO	0x4 (4_{dec})
1018:01	Vendor ID	Vendor ID of the EtherCAT device	UDINT	RO	0x2 (2_{dec})
1018:02	Product code	Product code of the EtherCAT device	UDINT	RO	0x1B814052 (461455442_{dec})
1018:03	Revision	Revision number of the EtherCAT devices. The low word (bit 0-15) indicates the special terminal number, the high word (bit 16-31) refers to the device description	UDINT	RO	-
1018:04	Serial number	Serial number of the EtherCAT slave; the low byte (bit 0-7) of the low word contains the year of production, the high byte (bit 8-15) of the low word contains the week of production, the high word (bit 16-31) is 0	UDINT	RO	-

10E2 Manufacturer-specific Identification Code

Index (hex)	Name	Meaning	Data type	Flags	Default
10E2:0	Manufacturer-specific Identification Code		USINT	RO	0x1 (1_{dec})

10F0 Backup parameter handling

Index (hex)	Name	Meaning	Data type	Flags	Default
10F0:0	Backup parameter handling		USINT	RO	0x1 (1_{dec})
10F0:01	Checksum	Checksum across all backup entries of the EtherCAT slave	UDINT	RO	-

10F3 Diagnosis History

Index (hex)	Name	Meaning	Data type	Flags	Default
10F3:0	Diagnosis History		USINT	RO	0x37 (55_{dec})
10F3:01	Maximum Messages	Maximum number of stored messages	USINT	RO	-
10F3:02	Newest Message	Subindex of the newest message	USINT	RO	-
10F3:03	Newest Acknowledged Message	Subindex of the last acknowledged message	USINT	RW	-
10F3:04	New Messages Available	Indicates that a new message is available	BOOL	RO	-
10F3:05	Flags		UINT	RW	-
10F3:06	Diagnosis Message 001		ARRAY [0..19] OF BYTE	RO	-
10F3:07	Diagnosis Message 002		ARRAY [0..19] OF BYTE	RO	-
10F3:08	Diagnosis Message 003		ARRAY [0..19] OF BYTE	RO	-
…	…	…	…	…	…
10F3:35	Diagnosis Message 048		ARRAY [0..19] OF BYTE	RO	-
10F3:36	Diagnosis Message 049		ARRAY [0..19] OF BYTE	RO	-
10F3:37	Diagnosis Message 050		ARRAY [0..19] OF BYTE	RO	-

10F8 Timestamp Object

Index (hex)	Name	Meaning	Data type	Flags	Default
10F8:0	Timestamp Object	-	ULINT	RO	-

1400 ENC RxPDO-Par Control compact

Index (hex)	Name	Meaning	Data type	Flags	Default
1400:0	ENC RxPDO-Par Control compact		USINT	RO	0x6 (6_{dec})
1400:06	Exclude RxPDOs		ARRAY [0..7] OF BYTE	RO	[0116000000000000]

1401 ENC RxPDO-Par Control

Index (hex)	Name	Meaning	Data type	Flags	Default
1401:0	ENC RxPDO-Par Control		USINT	RO	0x6 (6_{dec})
1401:06	Exclude RxPDOs		ARRAY [0..7] OF BYTE	RO	[0016000000000000]

1403 STM RxPDO-Par Position

Index (hex)	Name	Meaning	Data type	Flags	Default
1403:0	STM RxPDO-Par Position		USINT	RO	0x6 (6_{dec})
1403:06	Exclude RxPDOs		ARRAY [0..7] OF BYTE	RO	[04160516061 60716]

1404 STM RxPDO-Par Velocity

Index (hex)	Name	Meaning	Data type	Flags	Default
1404:0	STM RxPDO-Par Velocity		USINT	RO	0x6 (6_{dec})
1404:06	Exclude RxPDOs		ARRAY [0..7] OF BYTE	RO	[03160516061 60000]

1405 POS RxPDO-Par Control compact

Index (hex)	Name	Meaning	Data type	Flags	Default
1405:0	POS RxPDO-Par Control compact		USINT	RO	0x6 (6_{dec})
1405:06	Exclude RxPDOs		ARRAY [0..7] OF BYTE	RO	[03160416061 60000]

1406 POS RxPDO-Par Control

Index (hex)	Name	Meaning	Data type	Flags	Default
1406:0	POS RxPDO-Par Control		USINT	RO	0x6 (6_{dec})
1406:06	Exclude RxPDOs		ARRAY [0..7] OF BYTE	RO	[03160416051 60000]

1407 POS RxPDO-Par Control 2

Index (hex)	Name	Meaning	Data type	Flags	Default
1407:0	POS RxPDO-Par Control 2		USINT	RO	0x6 (6_{dec})
1407:06	Exclude RxPDOs		ARRAY [0..7] OF BYTE	RO	[03160416051 60000]

1600 ENC RxPDO-Map Control compact

Index (hex)	Name	Meaning	Data type	Flags	Default
1600:0	ENC RxPDO-Map Control compact		USINT	RO	0x5 (5_{dec})
1600:01	SubIndex 001		UDINT	RO	0x0000:00, 2
1600:02	SubIndex 002	PDO Mapping Entry for "Set counter".	UDINT	RO	0x7000:03, 1
1600:03	SubIndex 003		UDINT	RO	0x0000:00, 5
1600:04	SubIndex 004		UDINT	RO	0x0000:00, 8
1600:05	SubIndex 005	PDO Mapping Entry for "Set counter value".	UDINT	RO	0x7000:11, 16

1601 ENC RxPDO-Map Control

Index (hex)	Name	Meaning	Data type	Flags	Default
1601:0	ENC RxPDO-Map Control		USINT	RO	0x5 (5_{dec})
1601:01	SubIndex 001		UDINT	RO	0x0000:00, 2
1601:02	SubIndex 002	PDO Mapping Entry for "Set counter".	UDINT	RO	0x7000:03, 1
1601:03	SubIndex 003		UDINT	RO	0x0000:00, 5
1601:04	SubIndex 004		UDINT	RO	0x0000:00, 8
1601:05	SubIndex 005	PDO Mapping Entry for "Set counter value".	UDINT	RO	0x7000:11, 32

1602 STM RxPDO-Map Control

Index (hex)	Name	Meaning	Data type	Flags	Default
1602:0	STM RxPDO-Map Control		USINT	RO	0x7 (7_{dec})
1602:01	SubIndex 001	PDO Mapping Entry for "Enable".	UDINT	RO	0x7010:01, 1
1602:02	SubIndex 002	PDO Mapping Entry for "Reset".	UDINT	RO	0x7010:02, 1
1602:03	SubIndex 003	PDO Mapping Entry for "Reduce torque".	UDINT	RO	0x7010:03, 1
1602:04	SubIndex 004		UDINT	RO	0x0000:00, 5
1602:05	SubIndex 005		UDINT	RO	0x0000:00, 3
1602:06	SubIndex 006	PDO Mapping Entry for "Digital output 1".	UDINT	RO	0x7010:0c, 1
1602:07	SubIndex 007		UDINT	RO	0x0000:00, 4

1603 STM RxPDO-Map Position

Index (hex)	Name	Meaning	Data type	Flags	Default
1603:0	STM RxPDO-Map Position		USINT	RO	0x1 (1_{dec})
1603:01	SubIndex 001	PDO Mapping Entry for "Position".	UDINT	RO	0x7010:11, 32

1604 STM RxPDO-Map Velocity

Index (hex)	Name	Meaning	Data type	Flags	Default
1604:0	STM RxPDO-Map Velocity		USINT	RO	0x1 (1_{dec})
1604:01	SubIndex 001	PDO Mapping Entry for "Velocity".	UDINT	RO	0x7010:21, 16

1605 POS RxPDO-Map Control compact

Index (hex)	Name	Meaning	Data type	Flags	Default
1605:0	POS RxPDO-Map Control compact		USINT	RO	0x5 (5_{dec})
1605:01	SubIndex 001	PDO Mapping Entry for "Execute".	UDINT	RO	0x7020:01, 1
1605:02	SubIndex 002	PDO Mapping Entry for "Emergency stop".	UDINT	RO	0x7020:02, 1
1605:03	SubIndex 003		UDINT	RO	0x0000:00, 6
1605:04	SubIndex 004		UDINT	RO	0x0000:00, 8
1605:05	SubIndex 005	PDO Mapping Entry for "Target position".	UDINT	RO	0x7020:11, 32

1606 POS RxPDO-Map Control

Index (hex)	Name	Meaning	Data type	Flags	Default
1606:0	POS RxPDO-Map Control		USINT	RO	0x9 (9_{dec})
1606:01	SubIndex 001	PDO Mapping Entry for "Execute".	UDINT	RO	0x7020:01, 1
1606:02	SubIndex 002	PDO Mapping Entry for "Emergency stop".	UDINT	RO	0x7020:02, 1
1606:03	SubIndex 003		UDINT	RO	0x0000:00, 6
1606:04	SubIndex 004		UDINT	RO	0x0000:00, 8
1606:05	SubIndex 005	PDO Mapping Entry for "Target position".	UDINT	RO	0x7020:11, 32
1606:06	SubIndex 006	PDO Mapping Entry for "Velocity".	UDINT	RO	0x7020:21, 16
1606:07	SubIndex 007	PDO Mapping Entry for "Start type".	UDINT	RO	0x7020:22, 16
1606:08	SubIndex 008	PDO Mapping Entry for "Acceleration".	UDINT	RO	0x7020:23, 16
1606:09	SubIndex 009	PDO Mapping Entry for "Deceleration".	UDINT	RO	0x7020:24, 16

1607 POS RxPDO-Map Control 2

Index (hex)	Name	Meaning	Data type	Flags	Default
1607:0	POS RxPDO-Map Control 2		USINT	RO	0x9 (9_{dec})
1607:01	SubIndex 001		UDINT	RO	0x0000:00, 2
1607:02	SubIndex 002	PDO Mapping Entry for "Enable auto start".	UDINT	RO	0x7021:03, 1
1607:03	SubIndex 003		UDINT	RO	0x0000:00, 5
1607:04	SubIndex 004		UDINT	RO	0x0000:00, 8
1607:05	SubIndex 005	PDO Mapping Entry for "Target position".	UDINT	RO	0x7021:11, 32
1607:06	SubIndex 006	PDO Mapping Entry for "Velocity".	UDINT	RO	0x7021:21, 16
1607:07	SubIndex 007	PDO Mapping Entry for "Start type".	UDINT	RO	0x7021:22, 16
1607:08	SubIndex 008	PDO Mapping Entry for "Acceleration".	UDINT	RO	0x7021:23, 16
1607:09	SubIndex 009	PDO Mapping Entry for "Deceleration".	UDINT	RO	0x7021:24, 16

1800 ENC TxPDO-Par Status compact

Index (hex)	Name	Meaning	Data type	Flags	Default
1800:0	ENC TxPDO-Par Status compact		USINT	RO	0x6 (6_{dec})
1800:06	Exclude TxPDOs		ARRAY [0..1] OF BYTE	RO	[011a]

1801 ENC TxPDO-Par Status

Index (hex)	Name	Meaning	Data type	Flags	Default
1801:0	ENC TxPDO-Par Status		USINT	RO	0x6 (6_{dec})
1801:06	Exclude TxPDOs		ARRAY [0..1] OF BYTE	RO	[001a]

1806 POS TxPDO-Par Status compact

Index (hex)	Name	Meaning	Data type	Flags	Default
1806:0	POS TxPDO-Par Status compact		USINT	RO	0x6 (6_{dec})
1806:06	Exclude TxPDOs		ARRAY [0..1] OF BYTE	RO	[071a]

1807 POS TxPDO-Par Status

Index (hex)	Name	Meaning	Data type	Flags	Default
1807:0	POS TxPDO-Par Status		USINT	RO	0x6 (6_{dec})
1807:06	Exclude TxPDOs		ARRAY [0..1] OF BYTE	RO	[061a]

1A00 ENC TxPDO-Map Status compact

Index (hex)	Name	Meaning	Data type	Flags	Default
1A00:0	ENC TxPDO-Map Status compact		USINT	RO	0xB (11_{dec})
1A00:01	SubIndex 001		UDINT	RO	0x0000:00, 2
1A00:02	SubIndex 002	PDO Mapping Entry for "Set counter done".	UDINT	RO	0x6000:03, 1
1A00:03	SubIndex 003	PDO Mapping Entry for "Counter underflow".	UDINT	RO	0x6000:04, 1
1A00:04	SubIndex 004	PDO Mapping Entry for "Counter overflow".	UDINT	RO	0x6000:05, 1
1A00:05	SubIndex 005		UDINT	RO	0x0000:00, 3
1A00:06	SubIndex 006		UDINT	RO	0x0000:00, 5
1A00:07	SubIndex 007	PDO Mapping Entry for "Sync error".	UDINT	RO	0x6000:0e, 1
1A00:08	SubIndex 008		UDINT	RO	0x0000:00, 1
1A00:09	SubIndex 009	PDO Mapping Entry for "TxPDO Toggle".	UDINT	RO	0x6000:10, 1
1A00:0A	SubIndex 010	PDO Mapping Entry for "Counter value".	UDINT	RO	0x6000:11, 16
1A00:0B	SubIndex 011		UDINT	RO	0x0000:00, 16

1A01 ENC TxPDO-Map Status

Index (hex)	Name	Meaning	Data type	Flags	Default
1A01:0	ENC TxPDO-Map Status		USINT	RO	0xB (11_{dec})
1A01:01	SubIndex 001		UDINT	RO	0x0000:00, 2
1A01:02	SubIndex 002	PDO Mapping Entry for "Set counter done".	UDINT	RO	0x6000:03, 1
1A01:03	SubIndex 003	PDO Mapping Entry for "Counter underflow".	UDINT	RO	0x6000:04, 1
1A01:04	SubIndex 004	PDO Mapping Entry for "Counter overflow".	UDINT	RO	0x6000:05, 1
1A01:05	SubIndex 005		UDINT	RO	0x0000:00, 3
1A01:06	SubIndex 006		UDINT	RO	0x0000:00, 5
1A01:07	SubIndex 007	PDO Mapping Entry for "Sync error".	UDINT	RO	0x6000:0e, 1
1A01:08	SubIndex 008		UDINT	RO	0x0000:00, 1
1A01:09	SubIndex 009	PDO Mapping Entry for "TxPDO Toggle".	UDINT	RO	0x6000:10, 1
1A01:0A	SubIndex 010	PDO Mapping Entry for "Counter value".	UDINT	RO	0x6000:11, 32
1A01:0B	SubIndex 011		UDINT	RO	0x0000:00, 32

1A03 STM TxPDO-Map Status

Index (hex)	Name	Meaning	Data type	Flags	Default
1A03:0	STM TxPDO-Map Status		USINT	RO	0xE (14_{dec})
1A03:01	SubIndex 001	PDO Mapping Entry for "Ready to enable".	UDINT	RO	0x6010:01, 1
1A03:02	SubIndex 002	PDO Mapping Entry for "Ready".	UDINT	RO	0x6010:02, 1
1A03:03	SubIndex 003	PDO Mapping Entry for "Warning".	UDINT	RO	0x6010:03, 1
1A03:04	SubIndex 004	PDO Mapping Entry for "Error".	UDINT	RO	0x6010:04, 1
1A03:05	SubIndex 005	PDO Mapping Entry for "Moving positive".	UDINT	RO	0x6010:05, 1
1A03:06	SubIndex 006	PDO Mapping Entry for "Moving negative".	UDINT	RO	0x6010:06, 1
1A03:07	SubIndex 007	PDO Mapping Entry for "Torque reduced".	UDINT	RO	0x6010:07, 1
1A03:08	SubIndex 008	PDO Mapping Entry for "Motor stall".	UDINT	RO	0x6010:08, 1
1A03:09	SubIndex 009		UDINT	RO	0x0000:00, 3
1A03:0A	SubIndex 010	PDO Mapping Entry for "Digital input 1".	UDINT	RO	0x6010:0c, 1
1A03:0B	SubIndex 011	PDO Mapping Entry for "Digital input 2".	UDINT	RO	0x6010:0d, 1
1A03:0C	SubIndex 012	PDO Mapping Entry for "Sync error".	UDINT	RO	0x6010:0e, 1
1A03:0D	SubIndex 013		UDINT	RO	0x0000:00, 1
1A03:0E	SubIndex 014	PDO Mapping Entry for "TxPDO Toggle".	UDINT	RO	0x6010:10, 1

1A04 STM TxPDO-Map Synchron info data

Index (hex)	Name	Meaning	Data type	Flags	Default
1A04:0	STM TxPDO-Map Synchron info data		USINT	RO	0x2 (2_{dec})
1A04:01	SubIndex 001	PDO Mapping Entry for "Info data 1".	UDINT	RO	0x6010:11, 16
1A04:02	SubIndex 002	PDO Mapping Entry for "Info data 2".	UDINT	RO	0x6010:12, 16

1A05 STM TxPDO-Map Motor load

Index (hex)	Name	Meaning	Data type	Flags	Default
1A05:0	STM TxPDO-Map Motor load		USINT	RO	0x1 (1_{dec})
1A05:01	SubIndex 001	PDO Mapping Entry for "Motor load".	UDINT	RO	0x6010:13, 16

1A06 POS TxPDO-Map Status compact

Index (hex)	Name	Meaning	Data type	Flags	Default
1A06:0	POS TxPDO-Map Status compact		USINT	RO	0x9 (9_{dec})
1A06:01	SubIndex 001	PDO Mapping Entry for "Busy".	UDINT	RO	0x6020:01, 1
1A06:02	SubIndex 002	PDO Mapping Entry for "In-Target".	UDINT	RO	0x6020:02, 1
1A06:03	SubIndex 003	PDO Mapping Entry for "Warning".	UDINT	RO	0x6020:03, 1
1A06:04	SubIndex 004	PDO Mapping Entry for "Error".	UDINT	RO	0x6020:04, 1
1A06:05	SubIndex 005	PDO Mapping Entry for "Calibrated".	UDINT	RO	0x6020:05, 1
1A06:06	SubIndex 006	PDO Mapping Entry for "Accelerate".	UDINT	RO	0x6020:06, 1
1A06:07	SubIndex 007	PDO Mapping Entry for "Decelerate".	UDINT	RO	0x6020:07, 1
1A06:08	SubIndex 008	PDO Mapping Entry for "Ready to execute".	UDINT	RO	0x6020:08, 1
1A06:09	SubIndex 009		UDINT	RO	0x0000:00, 8

1A07 POS TxPDO-Map Status

Index (hex)	Name	Meaning	Data type	Flags	Default
1A07:0	POS TxPDO-Map Status		USINT	RO	0xC (12_{dec})
1A07:01	SubIndex 001	PDO Mapping Entry for "Busy".	UDINT	RO	0x6020:01, 1
1A07:02	SubIndex 002	PDO Mapping Entry for "In-Target".	UDINT	RO	0x6020:02, 1
1A07:03	SubIndex 003	PDO Mapping Entry for "Warning".	UDINT	RO	0x6020:03, 1
1A07:04	SubIndex 004	PDO Mapping Entry for "Error".	UDINT	RO	0x6020:04, 1
1A07:05	SubIndex 005	PDO Mapping Entry for "Calibrated".	UDINT	RO	0x6020:05, 1
1A07:06	SubIndex 006	PDO Mapping Entry for "Accelerate".	UDINT	RO	0x6020:06, 1
1A07:07	SubIndex 007	PDO Mapping Entry for "Decelerate".	UDINT	RO	0x6020:07, 1
1A07:08	SubIndex 008	PDO Mapping Entry for "Ready to execute".	UDINT	RO	0x6020:08, 1
1A07:09	SubIndex 009		UDINT	RO	0x0000:00, 8
1A07:0A	SubIndex 010	PDO Mapping Entry for "Actual position".	UDINT	RO	0x6020:11, 32
1A07:0B	SubIndex 011	PDO Mapping Entry for "Actual velocity".	UDINT	RO	0x6020:21, 16
1A07:0C	SubIndex 012	PDO Mapping Entry for "Actual drive time".	UDINT	RO	0x6020:22, 32

1A08 STM TxPDO-Map Internal position

Index (hex)	Name	Meaning	Data type	Flags	Default
1A08:0	STM TxPDO-Map Internal position		USINT	RO	0x1 (1_{dec})
1A08:01	SubIndex 001	PDO Mapping Entry for "Internal position".	UDINT	RO	0x6010:14, 32

1A09 STM TxPDO-Map External position

Index (hex)	Name	Meaning	Data type	Flags	Default
1A09:0	STM TxPDO-Map External position		USINT	RO	0x1 (1_{dec})
1A09:01	SubIndex 001	PDO Mapping Entry for "External position".	UDINT	RO	0x6010:15, 32

1A0A POS TxPDO-Map Actual position lag

Index (hex)	Name	Meaning	Data type	Flags	Default
1A0A:0	POS TxPDO-Map Actual position lag		USINT	RO	0x1 (1_{dec})
1A0A:01	SubIndex 001	PDO Mapping Entry for "Actual position lag".	UDINT	RO	0x6020:23, 32

1C00 Sync manager type

Index (hex)	Name	Meaning	Data type	Flags	Default
1C00:0	Sync manager type		USINT	RO	0x4 (4_{dec})
1C00:01	SubIndex 001		USINT	RO	0x1 (1_{dec})
1C00:02	SubIndex 002		USINT	RO	0x2 (2_{dec})
1C00:03	SubIndex 003		USINT	RO	0x3 (3_{dec})
1C00:04	SubIndex 004		USINT	RO	0x4 (4_{dec})

1C12 RxPDO assign

Index (hex)	Name	Meaning	Data type	Flags	Default
1C12:0	RxPDO assign		USINT	RO	0x3 (3_{dec})
1C12:01	SubIndex 001		UINT	RW	0x16 (22_{dec})
1C12:02	SubIndex 002		UINT	RW	0x216 (534_{dec})
1C12:03	SubIndex 003		UINT	RW	0x416 (1046_{dec})
1C12:04	SubIndex 004		UINT	RW	0x0 (0_{dec})

1C13 TxPDO assign

Index (hex)	Name	Meaning	Data type	Flags	Default
1C13:0	TxPDO assign		USINT	RO	0x2 (2_{dec})
1C13:01	SubIndex 001		UINT	RW	0x1A (26_{dec})
1C13:02	SubIndex 002		UINT	RW	0x31A (794_{dec})
1C13:03	SubIndex 003		UINT	RW	0x0 (0_{dec})
1C13:04	SubIndex 004		UINT	RW	0x0 (0_{dec})
1C13:05	SubIndex 005		UINT	RW	0x0 (0_{dec})
1C13:06	SubIndex 006		UINT	RW	0x0 (0_{dec})
1C13:07	SubIndex 007		UINT	RW	0x0 (0_{dec})
1C13:08	SubIndex 008		UINT	RW	0x0 (0_{dec})

1C32 SM output parameter

Index (hex)	Name	Meaning	Data type	Flags	Default
1C32:0	SM output parameter		USINT	RO	0x20 (32_{dec})
1C32:01	Sync mode	-	UINT	RW	-
1C32:02	Cycle time	-	UDINT	RW	-
1C32:03	Shift time	-	UDINT	RO	-
1C32:04	Sync modes supported	-	UINT	RO	-
1C32:05	Minimum cycle time	-	UDINT	RO	-
1C32:06	Calc and copy time	-	UDINT	RO	-
1C32:07	Minimum delay time	-	UDINT	RO	-
1C32:08	Get Cycle Time	-	UINT	RW	-
1C32:09	Maximum delay time	-	UDINT	RO	-
1C32:0B	SM event missed counter	-	UINT	RO	-
1C32:0C	Cycle exceeded counter	-	UINT	RO	-
1C32:0D	Shift too short counter	-	UINT	RO	-
1C32:20	Sync error	-	BOOL	RO	-

1C33 SM input parameter

Index (hex)	Name	Meaning	Data type	Flags	Default
1C33:0	SM input parameter		USINT	RO	0x20 (32_{dec})
1C33:01	Sync mode	-	UINT	RW	-
1C33:02	Cycle time	-	UDINT	RW	-
1C33:03	Shift time	-	UDINT	RO	-
1C33:04	Sync modes supported	-	UINT	RO	-
1C33:05	Minimum cycle time	-	UDINT	RO	-
1C33:06	Calc and copy time	-	UDINT	RO	-
1C33:07	Minimum delay time	-	UDINT	RO	-
1C33:08	Get Cycle Time	-	UINT	RW	-
1C33:09	Maximum delay time	-	UDINT	RO	-
1C33:0B	SM event missed counter	-	UINT	RO	-
1C33:0C	Cycle exceeded counter	-	UINT	RO	-
1C33:0D	Shift too short counter	-	UINT	RO	-
1C33:20	Sync error	-	BOOL	RO	-

F000 Modular Device Profile

Index (hex)	Name	Meaning	Data type	Flags	Default
F000:0	Modular Device Profile		USINT	RO	0x2 (2_{dec})
F000:01	Index distance		UINT	RO	0x10 (16_{dec})
F000:02	Maximum number of modules		UINT	RO	0x3 (3_{dec})

F008 Code word

Index (hex)	Name	Meaning	Data type	Flags	Default
F008:0	Code word	-	UDINT	RO	-

F010 Module Profile List

Index (hex)	Name	Meaning	Data type	Flags	Default
F010:0	Module Profile List		USINT	RO	0x3 (3_{dec})
F010:01	SubIndex 001		UDINT	RO	0xFF010000 (4278255616_{dec})
F010:02	SubIndex 002		UDINT	RO	0xBF020000 (3204579328_{dec})
F010:03	SubIndex 003		UDINT	RO	0xC0020000 (3221356544_{dec})

F081 Download revision

Index (hex)	Name	Meaning	Data type	Flags	Default
F081:0	Download revision		USINT	RO	0x1 (1_{dec})
F081:01	Revision number	-	UDINT	RW	-

FB00 STM Command

Index (hex)	Name	Meaning	Data type	Flags	Default
FB00:0	STM Command		USINT	RO	0x3 (3_{dec})
FB00:01	Request	-	ARRAY [0..1] OF BYTE	RW	-
FB00:02	Status	-	USINT	RO	-
FB00:03	Response	-	ARRAY [0..3] OF BYTE	RO	-

6.1.4 Profile-specific objects

6000 ENC Inputs Ch.1

Index (hex)	Name	Meaning	Data type	Flags	Default
6000:0	ENC Inputs Ch.1		USINT	RO	0x11 (17_{dec})
6000:03	Set counter done	-	BOOL	RO	-
6000:04	Counter underflow	-	BOOL	RO	-
6000:05	Counter overflow	-	BOOL	RO	-
6000:0E	Sync error	-	BOOL	RO	-
6000:10	TxPDO Toggle	-	BOOL	RO	-
6000:11	Counter value	-	UDINT	RO	-

6010 STM Inputs Ch.1

Index (hex)	Name	Meaning	Data type	Flags	Default
6010:0	STM Inputs Ch.1		USINT	RO	0x15 (21_{dec})
6010:01	Ready to enable	-	BOOL	RO	-
6010:02	Ready	-	BOOL	RO	-
6010:03	Warning	-	BOOL	RO	-
6010:04	Error	-	BOOL	RO	-
6010:05	Moving positive	-	BOOL	RO	-
6010:06	Moving negative	-	BOOL	RO	-
6010:07	Torque reduced	-	BOOL	RO	-
6010:08	Motor stall	-	BOOL	RO	-
6010:0C	Digital input 1	-	BOOL	RO	-
6010:0D	Digital input 2	-	BOOL	RO	-
6010:0E	Sync error	-	BOOL	RO	-
6010:10	TxPDO Toggle	-	BOOL	RO	-
6010:11	Info data 1	-	UINT	RO	-
6010:12	Info data 2	-	UINT	RO	-
6010:13	Motor load	-	UINT	RO	-
6010:14	Internal position	-	UDINT	RO	-
6010:15	External position	-	UDINT	RO	-

6020 POS Inputs Ch.1

Index (hex)	Name	Meaning	Data type	Flags	Default
6020:0	POS Inputs Ch.1		USINT	RO	0x23 (35_{dec})
6020:01	Busy	-	BOOL	RO	-
6020:02	In-Target	-	BOOL	RO	-
6020:03	Warning	-	BOOL	RO	-
6020:04	Error	-	BOOL	RO	-
6020:05	Calibrated	-	BOOL	RO	-
6020:06	Accelerate	-	BOOL	RO	-
6020:07	Decelerate	-	BOOL	RO	-
6020:08	Ready to execute	-	BOOL	RO	-
6020:11	Actual position	-	UDINT	RO	-
6020:21	Actual velocity	-	INT	RO	-
6020:22	Actual drive time	-	UDINT	RO	-
6020:23	Actual position lag	-	DINT	RO	-

7000 ENC Outputs Ch.1

Index (hex)	Name	Meaning	Data type	Flags	Default
7000:0	ENC Outputs Ch.1		USINT	RO	0x11 (17_{dec})
7000:03	Set counter	-	BOOL	RO	-
7000:11	Set counter value	-	UDINT	RO	-

7010 STM Outputs Ch.1

Index (hex)	Name	Meaning	Data type	Flags	Default
7010:0	STM Outputs Ch.1		USINT	RO	0x21 (33_{dec})
7010:01	Enable	-	BOOL	RO	-
7010:02	Reset	-	BOOL	RO	-
7010:03	Reduce torque	-	BOOL	RO	-
7010:0C	Digital output 1	-	BOOL	RO	-
7010:11	Position	-	UDINT	RO	-
7010:21	Velocity	-	INT	RO	-

7020 POS Outputs Ch.1

Index (hex)	Name	Meaning	Data type	Flags	Default
7020:0	POS Outputs Ch.1		USINT	RO	0x24 (36_{dec})
7020:01	Execute	-	BOOL	RO	-
7020:02	Emergency stop	-	BOOL	RO	-
7020:11	Target position	-	UDINT	RO	-
7020:21	Velocity	-	INT	RO	-
7020:22	Start type	-	UINT	RO	-
7020:23	Acceleration	-	UINT	RO	-
7020:24	Deceleration	-	UINT	RO	-

7021 POS Outputs 2 Ch.1

Index (hex)	Name	Meaning	Data type	Flags	Default
7021:0	POS Outputs 2 Ch.1		USINT	RO	0x24 (36_{dec})
7021:03	Enable auto start	-	BOOL	RO	-
7021:11	Target position	-	UDINT	RO	-
7021:21	Velocity	-	INT	RO	-
7021:22	Start type	-	UINT	RO	-
7021:23	Acceleration	-	UINT	RO	-
7021:24	Deceleration	-	UINT	RO	-

6.2 Device EP7041-0000

Index (hex)	Name
1000	Device type [▸ 99]
1008	Device name [▸ 99]
1009	Hardware version [▸ 99]
100A	Software version [▸ 99]
1011	Restore default parameters [▸ 99]
1018	Identity [▸ 99]
10F0	Backup parameter handling [▸ 99]
10F3	Diagnosis History [▸ 100]
10F8	Actual Time Stamp [▸ 100]
1600	FB RxPDO-Map Outputs Ch.1 [▸ 100]
1800	FB TxPDO-Par Inputs Ch.1 [▸ 100]
1802	FB TxPDO-Par Inputs Ch.1 compact [▸ 100]
1A00	FB TxPDO-Map Inputs Ch.1 [▸ 101]
1A02	FB TxPDO-Map Inputs Ch.1 compact [▸ 101]
1C00	Sync manager type [▸ 101]
1C12	RxPDO assign [▸ 101]
1C13	TxPDO assign [▸ 101]
1C32	SM output parameter [▸ 102]
1C33	SM input parameter [▸ 102]
6000	FB Inputs Ch.1 [▸ 104]
7000	FB Outputs Ch.1 [▸ 104]
8000	FB Settings Ch.1 [▸ 96]
8008	FB BiSS Settings Ch.1 [▸ 96]
A008	FB BiSS Diag data Ch.1 [▸ 98]
B008	FB BiSS Command Ch.1 [▸ 97]
F000	Modular device profile [▸ 102]
F008	Code word [▸ 102]
F010	Module list [▸ 103]

6.2.1 Configuration objects

8000 FB Settings Ch.1

Index (hex)	Name	Meaning	Data type	Flags	Default
8000:0	FB Settings Ch.1		USINT	RO	0x11 (17_{dec})
8000:01	Invert Feedback Direction	Inverts the encoder counting direction by reversing the sign of the position value Note: Parameter 8008:01 also inverts the counting direction. If both are TRUE at the same time, the counting direction is *not* inverted.	BOOL	RW	00
8000:11	Device Type		UDINT	RW	0x7 (7_{dec})

8008 FB BiSS Settings Ch.1

This object contains the configuration parameters for the encoder. For parameterization, see also chapter Encoder [▸ 37].

Index (hex)	Name	Meaning	Data type	Flags	Default
8008:0	FB BiSS Settings Ch.1		USINT	RO	0x18 (24_{dec})
8008:01	Invert Feedback Direction	Inverts the encoder counting direction. Note: Parameter 8000:01 also inverts the counting direction. If both are TRUE at the same time, the counting direction is *not* inverted.	BOOL	RW	00
8008:02	Disable Status Bits	Deactivates the evaluation of the status bits "Warning" and "Error" sent by the BiSS® C encoder.	BOOL	RW	00
8008:03	CRC Invert	Determines whether the CRC is transmitted inverted	BOOL	RW	01
8008:11	CRC Polynomial	The CRC polynomial used by the BiSS® C encoder to calculate the checksum	UDINT	RW	0x43 (67_{dec})
8008:12	Supply Voltage	Encoder supply voltage in [0.1 V] This parameter can only be changed after activation, see chapter Setting the encoder supply voltage [▸ 37]. Possible values: • 50: 5 V_{DC} • 90: 9 V_{DC}	USINT	RW	0x32 (50_{dec})
8008:13	Clock Frequency	Possible values: • 0_{dec}: 10 MHz • 1_{dec}: 5 MHz • 2_{dec}: 3,33 MHz • 3_{dec}: 2,5 MHz • 4_{dec}: 2 MHz • 9_{dec}: 1 MHz • 17_{dec}: 500 kHz • 19_{dec}: 250 kHz	USINT	RW	0x0 (0_{dec})
8008:14	Coding	Possible values: • 0_{dec}: Dual Code • 1_{dec}: Gray Code	USINT	RW	0x0 (0_{dec})
8008:15	Multiturn [Bit]	Multi-turn encoder resolution	USINT	RW	0xC (12_{dec})
8008:16	Singleturn [Bit]	Single-turn encoder resolution	USINT	RW	0xD (13_{dec})
8008:17	Offset LSB Bits [Bit]	Number of bits that the encoder transmits following the position data, if applicable	USINT	RW	0x0 (0_{dec})
8008:18	Mode	Possible values: • 0_{dec}: BiSS-C • 1_{dec}: SSI	USINT	RW	0x0 (0_{dec})

B008 FB BiSS Command Ch.1

Index (hex)	Name	Meaning	Data type	Flags	Default
B008:0	FB BiSS Command Ch.1		USINT	RO	0x3 (3_{dec})
B008:01	Request	Command	ARRAY [0..68] OF BYTE	RW	-
B008:02	Status	Status of the command currently being executed	USINT	RO	-
B008:03	Response	Return value	ARRAY [0..68] OF BYTE	RO	-

6.2.2 Information objects

A008 FB BiSS Diag data Ch.1

Index (hex)	Name	Meaning	Data type	Flags	Default
A008:0	FB BiSS Diag data Ch.1		USINT	RO	0x11 (17_{dec})
A008:01	Power Supply Present	Supply voltage present	BOOL	RO	-
A008:02	Error	Error	BOOL	RO	-
A008:03	SCD Error	Sync Cycle Data error	BOOL	RO	-
A008:04	WD Error	Watchdog error	BOOL	RO	-
A008:05	Data Valid	Valid data available	BOOL	RO	-
A008:11	Data Raw Value	Position raw value without inversion and offset	ULINT	RO	-

6.2.3 Standard objects

1000 Device type

Index (hex)	Name	Meaning	Data type	Flags	Default
1000:0	Device type	Device type of the EtherCAT device: the low word contains the used CoE profile (5001). The high word contains the module profile according to the modular device profile.	UDINT	RO	0x89130102 (2299724034_{dec})

1008 Device name

Index (hex)	Name	Meaning	Data type	Flags	Default
1008:0	Device name	Device name of the EtherCAT device	STRING(11)	RO	EP7041-0000

1009 Hardware version

Index (hex)	Name	Meaning	Data type	Flags	Default
1009:0	Hardware version	Hardware version of the EtherCAT device	STRING(2)	RO	-

100A Software version

Index (hex)	Name	Meaning	Data type	Flags	Default
100A:0	Software version	Firmware version of the EtherCAT slave	STRING(2)	RO	-

1011 Restore default parameters

Index (hex)	Name	Meaning	Data type	Flags	Default
1011:0	Restore default parameters	Restoring the delivery state, see chapter Restore the delivery state [▸ 69]	USINT	RO	0x1 (1_{dec})

1018 Identity

Index (hex)	Name	Meaning	Data type	Flags	Default
1018:0	Identity	Information for identifying the device	USINT	RO	0x4 (4_{dec})
1018:01	Vendor ID	Vendor ID of the EtherCAT device	UDINT	RO	0x2 (2_{dec})
1018:02	Product code	Product code of the EtherCAT device	UDINT	RO	0x1B814052 (461455442_{dec})
1018:03	Revision	Revision number of the EtherCAT devices. The low word (bit 0-15) indicates the special terminal number, the high word (bit 16-31) refers to the device description	UDINT	RO	-
1018:04	Serial number	Serial number of the EtherCAT slave; the low byte (bit 0-7) of the low word contains the year of production, the high byte (bit 8-15) of the low word contains the week of production, the high word (bit 16-31) is 0	UDINT	RO	-

10F0 Backup parameter handling

Index (hex)	Name	Meaning	Data type	Flags	Default
10F0:0	Backup parameter handling		USINT	RO	0x1 (1_{dec})
10F0:01	Checksum	Checksum across all backup entries of the EtherCAT slave	UDINT	RO	-

10F3 Diagnosis History

Index (hex)	Name	Meaning	Data type	Flags	Default
10F3:0	Diagnosis History		USINT	RO	0x37 (55$_{dec}$)
10F3:01	Maximum Messages	Maximum number of stored messages	USINT	RO	-
10F3:02	Newest Message	Subindex of the newest message	USINT	RO	-
10F3:03	Newest Acknowledged Message	Subindex of the last acknowledged message	USINT	RW	-
10F3:04	New Messages Available	Indicates that a new message is available	BOOL	RO	-
10F3:05	Flags	-	UINT	RW	-
10F3:06	Diagnosis Message 001	-	ARRAY [0..27] OF BYTE	RO	-
10F3:07	Diagnosis Message 002	-	ARRAY [0..27] OF BYTE	RO	-
10F3:08	Diagnosis Message 003	-	ARRAY [0..27] OF BYTE	RO	-
…	…	…	…	…	…
10F3:35	Diagnosis Message 048	-	ARRAY [0..27] OF BYTE	RO	-
10F3:36	Diagnosis Message 049	-	ARRAY [0..27] OF BYTE	RO	-
10F3:37	Diagnosis Message 050	-	ARRAY [0..27] OF BYTE	RO	-

10F8 Actual Time Stamp

Index (hex)	Name	Meaning	Data type	Flags	Default
10F8:0	Actual Time Stamp	-	ULINT	RO	-

1600 FB RxPDO-Map Outputs Ch.1

Index (hex)	Name	Meaning	Data type	Flags	Default
1600:0	FB RxPDO-Map Outputs Ch.1		USINT	RO	0x3 (3$_{dec}$)
1600:01	SubIndex 001	PDO Mapping Entry for "Set".	UDINT	RO	0x7000:01, 1
1600:02	SubIndex 002	PDO Mapping Entry for "Direction".	UDINT	RO	0x7000:02, 1
1600:03	SubIndex 003		UDINT	RO	0x0000:00, 14

1800 FB TxPDO-Par Inputs Ch.1

Index (hex)	Name	Meaning	Data type	Flags	Default
1800:0	FB TxPDO-Par Inputs Ch.1		USINT	RO	0x6 (6$_{dec}$)
1800:06	Exclude TxPDOs		ARRAY [0..1] OF BYTE	RO	[021a]

1802 FB TxPDO-Par Inputs Ch.1 compact

Index (hex)	Name	Meaning	Data type	Flags	Default
1802:0	FB TxPDO-Par Inputs Ch.1 compact		USINT	RO	0x6 (6$_{dec}$)
1802:06	Exclude TxPDOs		ARRAY [0..1] OF BYTE	RO	[001a]

1A00 FB TxPDO-Map Inputs Ch.1

Index (hex)	Name	Meaning	Data type	Flags	Default
1A00:0	FB TxPDO-Map Inputs Ch.1		USINT	RO	0x9 (9_{dec})
1A00:01	SubIndex 001	PDO Mapping Entry for "Warning".	UDINT	RO	0x6000:01, 1
1A00:02	SubIndex 002	PDO Mapping Entry for "Error".	UDINT	RO	0x6000:02, 1
1A00:03	SubIndex 003	PDO Mapping Entry for "Ready".	UDINT	RO	0x6000:03, 1
1A00:04	SubIndex 004		UDINT	RO	0x0000:00, 5
1A00:05	SubIndex 005		UDINT	RO	0x0000:00, 4
1A00:06	SubIndex 006	PDO Mapping Entry for "Diag".	UDINT	RO	0x6000:0d, 1
1A00:07	SubIndex 007	PDO Mapping Entry for "TxPDO State".	UDINT	RO	0x6000:0e, 1
1A00:08	SubIndex 008	PDO Mapping Entry for "Input Cycle Counter".	UDINT	RO	0x6000:0f, 2
1A00:09	SubIndex 009	PDO Mapping Entry for "Position".	UDINT	RO	0x6000:11, 64

1A02 FB TxPDO-Map Inputs Ch.1 compact

Index (hex)	Name	Meaning	Data type	Flags	Default
1A02:0	FB TxPDO-Map Inputs Ch.1 compact		USINT	RO	0x9 (9_{dec})
1A02:01	SubIndex 001	PDO Mapping Entry for "Warning".	UDINT	RO	0x6000:01, 1
1A02:02	SubIndex 002	PDO Mapping Entry for "Error".	UDINT	RO	0x6000:02, 1
1A02:03	SubIndex 003	PDO Mapping Entry for "Ready".	UDINT	RO	0x6000:03, 1
1A02:04	SubIndex 004		UDINT	RO	0x0000:00, 5
1A02:05	SubIndex 005		UDINT	RO	0x0000:00, 4
1A02:06	SubIndex 006	PDO Mapping Entry for "Diag".	UDINT	RO	0x6000:0d, 1
1A02:07	SubIndex 007	PDO Mapping Entry for "TxPDO State".	UDINT	RO	0x6000:0e, 1
1A02:08	SubIndex 008	PDO Mapping Entry for "Input Cycle Counter".	UDINT	RO	0x6000:0f, 2
1A02:09	SubIndex 009	PDO Mapping Entry for "Position".	UDINT	RO	0x6000:11, 32

1C00 Sync manager type

Index (hex)	Name	Meaning	Data type	Flags	Default
1C00:0	Sync manager type		USINT	RO	0x4 (4_{dec})
1C00:01	SubIndex 001		USINT	RO	0x1 (1_{dec})
1C00:02	SubIndex 002		USINT	RO	0x2 (2_{dec})
1C00:03	SubIndex 003		USINT	RO	0x3 (3_{dec})
1C00:04	SubIndex 004		USINT	RO	0x4 (4_{dec})

1C12 RxPDO assign

Index (hex)	Name	Meaning	Data type	Flags	Default
1C12:0	RxPDO assign		USINT	RO	0x1 (1_{dec})
1C12:01	SubIndex 001		UINT	RW	0x16 (22_{dec})

1C13 TxPDO assign

Index (hex)	Name	Meaning	Data type	Flags	Default
1C13:0	TxPDO assign		USINT	RO	0x1 (1_{dec})
1C13:01	SubIndex 001		UINT	RW	0x1A (26_{dec})

1C32 SM output parameter

Index (hex)	Name	Meaning	Data type	Flags	Default
1C32:0	SM output parameter		USINT	RO	0x20 (32_{dec})
1C32:01	Sync mode		UINT	RW	0x1 (1_{dec})
1C32:02	Cycle time		UDINT	RW	0xF4240 (1000000_{dec})
1C32:03	Shift time		UDINT	RO	0x0 (0_{dec})
1C32:04	Sync modes supported		UINT	RO	0x807 (2055_{dec})
1C32:05	Minimum cycle time		UDINT	RO	0x186A0 (100000_{dec})
1C32:06	Calc and copy time		UDINT	RO	0x0 (0_{dec})
1C32:07	Minimum delay time		UDINT	RO	0x0 (0_{dec})
1C32:08	Command		UINT	RW	0x0 (0_{dec})
1C32:09	Maximum delay time		UDINT	RO	0x0 (0_{dec})
1C32:0B	SM event missed counter	-	UINT	RO	-
1C32:0C	Cycle exceeded counter	-	UINT	RO	-
1C32:0D	Shift too short counter	-	UINT	RO	-
1C32:20	Sync error	-	BOOL	RO	-

1C33 SM input parameter

Index (hex)	Name	Meaning	Data type	Flags	Default
1C33:0	SM input parameter		USINT	RO	0x20 (32_{dec})
1C33:01	Sync mode		UINT	RW	0x22 (34_{dec})
1C33:02	Cycle time		UDINT	RW	0xF4240 (1000000_{dec})
1C33:03	Shift time		UDINT	RO	0x0 (0_{dec})
1C33:04	Sync modes supported		UINT	RO	0x807 (2055_{dec})
1C33:05	Minimum cycle time		UDINT	RO	0x186A0 (100000_{dec})
1C33:06	Calc and copy time		UDINT	RO	0x186A0 (100000_{dec})
1C33:07	Minimum delay time		UDINT	RO	0x0 (0_{dec})
1C33:08	Command		UINT	RW	0x0 (0_{dec})
1C33:09	Maximum delay time		UDINT	RO	0x0 (0_{dec})
1C33:0B	SM event missed counter	-	UINT	RO	-
1C33:0C	Cycle exceeded counter	-	UINT	RO	-
1C33:0D	Shift too short counter	-	UINT	RO	-
1C33:20	Sync error	-	BOOL	RO	-

F000 Modular device profile

Index (hex)	Name	Meaning	Data type	Flags	Default
F000:0	Modular device profile		USINT	RO	0x2 (2_{dec})
F000:01	Module index distance		UINT	RO	0x10 (16_{dec})
F000:02	Maximum number of modules		UINT	RO	0x1 (1_{dec})

F008 Code word

Index (hex)	Name	Meaning	Data type	Flags	Default
F008:0	Code word	-	UDINT	RO	-

F010 Module list

Index (hex)	Name	Meaning	Data type	Flags	Default
F010:0	Module list		USINT	RO	0x1 (1_{dec})
F010:01	SubIndex 001		UDINT	RW	0x1020000 (16908288_{dec})

6.2.4 Profile-specific objects

6000 FB Inputs Ch.1

Index (hex)	Name	Meaning	Data type	Flags	Default
6000:0	FB Inputs Ch.1		USINT	RO	0x11 (17_{dec})
6000:01	Warning	-	BOOL	RO	-
6000:02	Error	-	BOOL	RO	-
6000:03	Ready	-	BOOL	RO	-
6000:0D	Diag	-	BOOL	RO	-
6000:0E	TxPDO State	-	BOOL	RO	-
6000:0F	Input cycle counter	-	BIT2	RO	-
6000:11	Position	-	ULINT	RO	-

7000 FB Outputs Ch.1

Index (hex)	Name	Meaning	Data type	Flags	Default
7000:0	FB Outputs Ch.1		USINT	RO	0x2 (2_{dec})
7000:01	Set	-	BOOL	RO	-
7000:02	Direction	-	BOOL	RO	-

7 Technology

7.1 Stepper motor

Stepper motors are electric motors and are comparable with synchronous motors. The rotor is designed as a permanent magnet, while the stator consists of a coil package. In contrast to synchronous motors, stepper motors have a large number of pole pairs. In a minimum control configuration, the stepper motor is moved from pole to pole, or from step to step.

Stepper motors have been around for many years. They are robust, easy to control, and provide high torque. In many applications, the step counting facility saves expensive feedback systems. Even with the increasingly widespread use of synchronous servomotors, stepper motors are by no means "getting long in the tooth". They are considered to represent mature technology and continue to be developed further in order to reduce costs and physical size, increase torque and improve reliability.

7.1.1 Stepper motor parameters

Torque

Refers to the maximum motor torque at different speeds. This parameter is usually represented by a characteristic curve. Stepper motors have comparatively high torque in the lower speed range. In many applications, this enables them to be used directly without gearing. Compared with other motors, stepper motors can quite easily provide a holding moment of the same order of magnitude as the torque.

Speed

Stepper motors have low maximum speed, which is usually specified as a maximum step frequency.

Nominal voltage, supply voltage and winding resistance

In steady state, the rated current flows at rated voltage, depending on the winding resistance. This voltage should not be confused with the supply voltage of the power output stage.
If the supply voltage falls below the nominal voltage, the power output stage can no longer apply the full current, resulting in a loss of torque. It is desirable to aim for systems with small winding resistance and high supply voltage in order to limit warming and achieve high torque at high speeds.

Number of phases

Motors with 2 to 5 phases are common. The EL7062 supports 2-phase motors.

Resonance

At certain speeds, stepper motors run less smoothly. This phenomenon is particularly pronounced if the motor runs without load. Under certain circumstances, it may even stop. This is caused by resonance. A distinction can roughly be made between

- resonances in the lower frequency range up to approx. 250 Hz and
- resonances in the medium to upper frequency range.

Resonances in the medium to upper frequency range essentially result from electrical parameters such as inductance of the motor winding and supply line capacity. They can be controlled relatively easily through high pulsing of the control system.

Resonances in the lower range essentially result from the mechanical motor parameters. Apart from their impact on smooth running, such resonances can lead to significant loss of torque, or even loss of step of the motor, and are therefore particularly undesirable.
In principle, the stepper motor represents an oscillatory system (comparable to a mass/spring system), consisting of the moving rotor with a moment of inertia and a magnetic field that creates a restoring force that acts on the rotor. Moving and releasing the rotor creates a damped oscillation. If the control frequency corresponds to the resonance frequency, the oscillation is amplified so that in the worst case the rotor no longer follows the steps and oscillates back and forth between two detents.

The EL7062 prevents this effect with a SinCos-shaped current profile for almost all standard motors. The rotor is not switched from step to step, i.e. it no longer jumps to the next position, but instead passes through intermediate steps (microsteps), i.e. the rotor is gently guided from one step to the next. The usual loss of torque at certain speeds is avoided, and operation can be optimized for the particular application. This means that the lower speed range, where particularly high torque is available, can be fully utilized.

Step angle

The step angle indicates the angle travelled during each step. Typical values are 3.6°, 1.8° and 0.9°. This corresponds to 100, 200 and 400 steps per motor revolution. Together with the downstream transmission ratio, this value is a measure for the positioning accuracy. For technical reasons, the step angle cannot be reduced below a certain value. The positioning accuracy can only be increased mechanically through the transmission ratio. Microstepping is an elegant solution for increasing positioning accuracy. The smaller, "artificial" step angle has another positive effect: The drive can be operated at a higher speed with the same accuracy. The maximum speed is unchanged, despite the fact that the drive operates at the limit of mechanical resolution.

7.1.2 Selecting a stepper motor

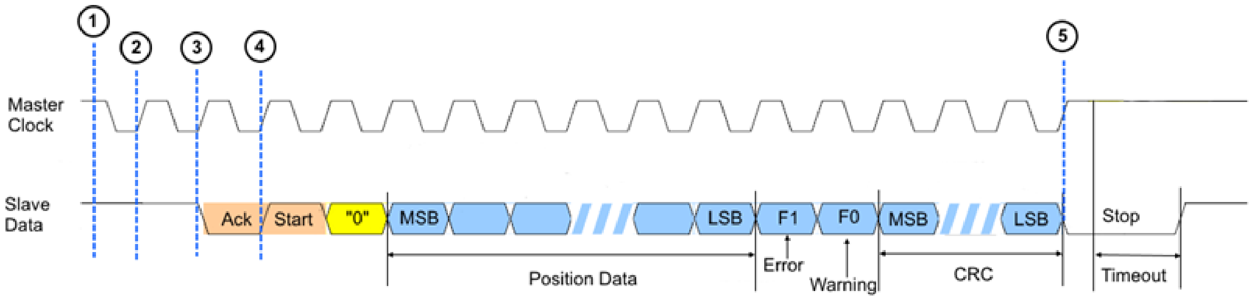
1. Determine the required positioning accuracy and hence the step resolution. The first task is to determine the maximum resolution that can be achieved. The resolution can be increased via mechanical gear reduction devices such as spindles, gears or toothed racks. Microstepping must also be taken into account.
2. Determine mass m and moments of inertia (J) of all parts to be moved.
3. Calculate the acceleration resulting from the temporal requirements of the moved mass.
4. Calculate the forces from mass, moment of inertia, and the respective accelerations.
5. Convert the forces and velocities to the motor axis, taking account of efficiencies, moments of friction and mechanical parameters such as transmission ratio. It is often best to start the calculation from the last component, usually the load. Each further element transfers a force and velocity and leads to further forces or torques due to friction. During positioning, the sum of all forces and torques acts on the motor shaft. The result is a velocity/torque curve that the motor has to provide.
6. Using the characteristic torque curve, select a motor that meets these minimum requirements. The moment of inertia of the motor has to be added to the complete drive. Verify your selection. In order to provide an adequate safety margin, the torque should be oversized by 20% to 30%. The optimization is different if the acceleration is mainly required for the rotor moment of inertia. In this case, the motor should be as small as possible.
7. Test the motor under real application conditions: The housing temperatures must be monitored during continuous operation. If the test results do not confirm the calculations, check the assumed parameters and boundary conditions. It is important to also check side effects such as resonance, mechanical play, settings for the maximum operation frequency and the ramp slope.
8. The drive can be optimized to increase performance through various measures: Selection of lighter materials, hollow bodies, instead of solid material, and reduction of mechanical masses. The controller can also have significant influence on the behavior of the drive. The terminal enables operation with different supply voltages. The characteristic torque curve can be extended by increasing the voltage. In this case, a current increase factor can supply a higher torque at the crucial moment, while a general reduction of the current can significantly reduce the motor temperature. For specific applications, it may be advisable to use a specially adapted motor winding.

7.2 BiSS® C, unidirectional

The transmission of the data is triggered by the master clock. The end of the data transmission is marked with a timeout. A typical communication telegram is shown below:

1. Idle state: the master clock displays a HIGH value and the BiSS® C slave also displays its "Ready State" with a HIGH value.
2. Synchronized position detection is started with the first rising edge of the master clock.
3. After the 2nd rising edge of the master clock, the slave responds with a LOW level ("Ack" interval).
4. After the "Ack" interval has ended, the slave generates a "Start" bit, which is always followed by a "0" bit.
   The position data is transmitted with the 2nd bit after the "Start" bit, according to the data format of the slave. Communication is synchronized with the master clock.
   The status bits "Error" and "Warning" as well as the checksum (CRC) are transmitted after the position data.
5. The telegram ends with the BiSS® timeout. No further pulses are sent to the slave, the master clock switches to the idle state (HIGH level).
   After the timeout has expired, the slave is ready to transmit new position data once it has transitioned to idle status (HIGH level). The communication telegram starts again.

Example of a BiSS® C telegram



8 Appendix

8.1 General operating conditions

Protection rating according to IP code

The degrees of protection are defined and divided into different classes in the IEC 60529 standard (EN 60529). Degrees of protection are designated by the letters "IP" and two numerals: **IPxy**

- Numeral x: Dust protection and contact protection
- Numeral y: Protection against water

x	Meaning
0	Not protected
1	Protected against access to dangerous parts with the back of the hand. Protected against solid foreign objects of 50 mm Ø
2	Protected against access to dangerous parts with a finger. Protected against solid foreign objects of 12.5 mm Ø
3	Protected against access to dangerous parts with a tool. Protected against solid foreign objects of 2.5 mm Ø
4	Protected against access to dangerous parts with a wire. Protected against solid foreign objects of 1 mm Ø
5	Protection against access to dangerous parts with a wire. Dust-protected. Ingress of dust is not prevented completely, although the quantity of dust able to penetrate is limited to such an extent that the proper function of the device and safety are not impaired
6	Protection against access to dangerous parts with a wire. Dust-tight. No ingress of dust

y	Meaning
0	Not protected
1	Protection against vertically falling water drops
2	Protection against vertically falling water drops when enclosure tilted up to 15°
3	Protection against spraying water. Water sprayed at an angle of up to 60° on either side of the vertical shall have no harmful effects
4	Protection against splashing water. Water splashed against the enclosure from any direction shall have no harmful effects
5	Protection against water jets.
6	Protection against powerful water jets.
7	Protected against the effects of temporary immersion in water. Ingress of water in quantities causing harmful effects shall not be possible when the enclosure is immersed in water at a depth of 1 m for 30 minutes

Chemical resistance

The resistance refers to the housing of the IP67 modules and the metal parts used. In the table below you will find some typical resistances.

Type	Resistance
Water vapor	unstable at temperatures > 100 °C
Sodium hydroxide solution (ph value > 12)	stable at room temperature unstable > 40 °C
Acetic acid	unstable
Argon (technically pure)	stable

Key

- resistant: Lifetime several months
- non inherently resistant: Lifetime several weeks
- not resistant: Lifetime several hours resp. early decomposition

8.2 Accessories

Mounting

Ordering information	Description	Link
ZS5300-0011	Mounting rail	Website

Cables

A complete overview of pre-assembled cables can be found on the Beckhoff website: Link.

Ordering information	Description	Link
ZK1090-3xxx-xxxx	EtherCAT cable M8, green	Website
ZK1093-3xxx-xxxx	EtherCAT cable M8, yellow	Website
ZK203x-xxxx-xxxx	Power cable 7/8", 5-pin	Website
ZK4000-6xxx-xxxx	Motor cable	Website

Labeling material, protective caps

Ordering information	Description
ZS5000-0010	Protective cap for M8 sockets, IP67 (50 pieces)
ZS5000-0020	Protective cap for M12 sockets, IP67 (50 pcs.)
ZS5100-0000	Inscription labels, unprinted, 4 strips of 10
ZS5000-xxxx	Printed inscription labels on enquiry

Tools

Ordering information	Description
ZB8801-0000	Torque wrench for plugs, 0.4…1.0 Nm
ZB8801-0001	Torque cable key for M8 / wrench size 9 for ZB8801-0000
ZB8801-0002	Torque cable key for M12 / wrench size 13 for ZB8801-0000
ZB8801-0003	Torque cable key for M12 field assembly / wrench size 18 for ZB8801-0000

Further accessories

Further accessories can be found in the price list for fieldbus components from Beckhoff and online at https://www.beckhoff.com.

8.3 Version identification of EtherCAT devices

8.3.1 General notes on marking

Designation

A Beckhoff EtherCAT device has a 14-digit designation, made up of

- family key
- type
- version
- revision

Example	Family	Type	Version	Revision
EL3314-0000-0016	EL terminal 12 mm, non-pluggable connection level	3314 4-channel thermocouple terminal	0000 basic type	0016
ES3602-0010-0017	ES terminal 12 mm, pluggable connection level	3602 2-channel voltage measurement	0010 high-precision version	0017
CU2008-0000-0000	CU device	2008 8-port fast ethernet switch	0000 basic type	0000

Notes

- The elements mentioned above result in the **technical designation**. EL3314-0000-0016 is used in the example below.
- EL3314-0000 is the order identifier, in the case of “-0000” usually abbreviated to EL3314. “-0016” is the EtherCAT revision.
- The **order identifier** is made up of
  - family key (EL, EP, CU, ES, KL, CX, etc.)
  - type (3314)
  - version (-0000)
- The **revision** -0016 shows the technical progress, such as the extension of features with regard to the EtherCAT communication, and is managed by Beckhoff.
  In principle, a device with a higher revision can replace a device with a lower revision, unless specified otherwise, e.g. in the documentation.
  Associated and synonymous with each revision there is usually a description (ESI, EtherCAT Slave Information) in the form of an XML file, which is available for download from the Beckhoff web site.
  From 2014/01 the revision is shown on the outside of the IP20 terminals, see Fig. *“EL2872 with revision 0022 and serial number 01200815”*.
- The type, version and revision are read as decimal numbers, even if they are technically saved in hexadecimal.

8.3.2 Version identification of IP67 modules

The serial number/ data code for Beckhoff IO devices is usually the 8-digit number printed on the device or on a sticker. The serial number indicates the configuration in delivery state and therefore refers to a whole production batch, without distinguishing the individual modules of a batch.

Structure of the serial number: **KK YY FF HH**	Example with serial number 12 06 3A 02:
KK - week of production (CW, calendar week) YY - year of production FF - firmware version HH - hardware version	12 - production week 12 06 - production year 2006 3A - firmware version 3A 02 - hardware version 02

Exceptions can occur in the **IP67 area**, where the following syntax can be used (see respective device documentation):

Syntax: D ww yy x y z u

D - prefix designation
ww - calendar week
yy - year
x - firmware version of the bus PCB
y - hardware version of the bus PCB
z - firmware version of the I/O PCB
u - hardware version of the I/O PCB

Example: D.22081501 calendar week 22 of the year 2008 firmware version of bus PCB: 1 hardware version of bus PCB: 5 firmware version of I/O PCB: 0 (no firmware necessary for this PCB) hardware version of I/O PCB: 1

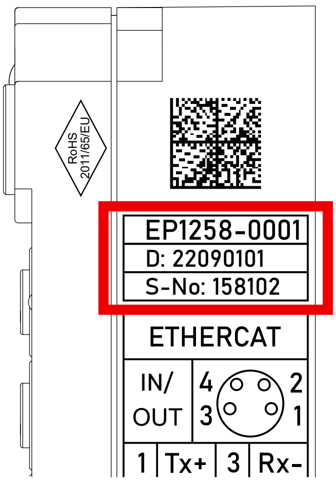


Fig. 23: EP1258-00001 IP67 EtherCAT Box with batch number/DateCode 22090101 and unique serial number 158102

8.3.3 Beckhoff Identification Code (BIC)

The Beckhoff Identification Code (BIC) is increasingly being applied to Beckhoff products to uniquely identify the product. The BIC is represented as a Data Matrix Code (DMC, code scheme ECC200), the content is based on the ANSI standard MH10.8.2-2016.

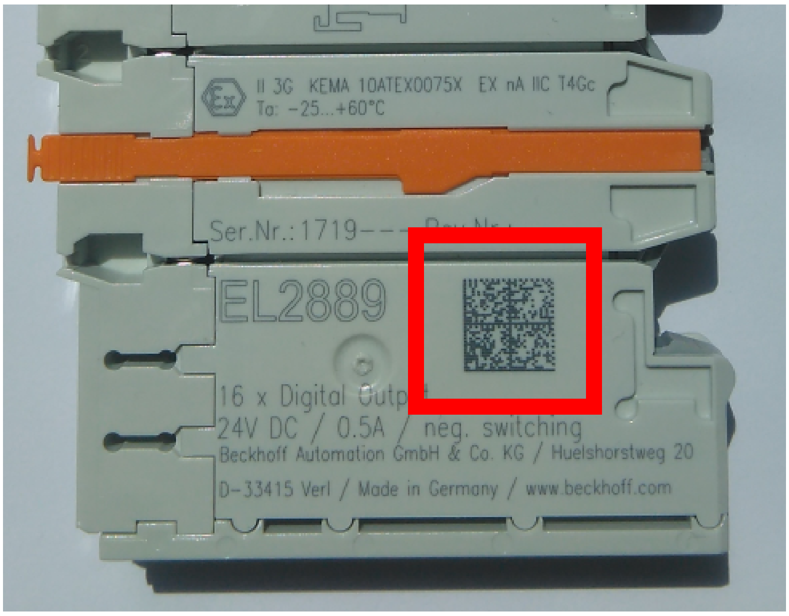


Fig. 24: BIC as data matrix code (DMC, code scheme ECC200)

The BIC will be introduced step by step across all product groups.

Depending on the product, it can be found in the following places:

- on the packaging unit
- directly on the product (if space suffices)
- on the packaging unit and the product

The BIC is machine-readable and contains information that can also be used by the customer for handling and product management.

Each piece of information can be uniquely identified using the so-called data identifier (ANSI MH10.8.2-2016). The data identifier is followed by a character string. Both together have a maximum length according to the table below. If the information is shorter, spaces are added to it.

Following information is possible, positions 1 to 4 are always present, the other according to need of production:

Posi-tion	Type of information	Explanation	Data identifier	Number of digits incl. data identifier	Example
1	Beckhoff order number	**Beckhoff order number**	1P	8	**1P**072222
2	Beckhoff Traceability Number (BTN)	**Unique serial number, see note below**	SBTN	12	**SBTN**k4p562d7
3	Article description	**Beckhoff article description, e.g. EL1008**	1K	32	**1K**EL1809
4	Quantity	**Quantity in packaging unit, e.g. 1, 10, etc.**	Q	6	**Q**1
5	Batch number	Optional: Year and week of production	2P	14	**2P**401503180016
6	ID/serial number	Optional: Present-day serial number system, e.g. with safety products	51S	12	**51S**678294
7	Variant number	Optional: Product variant number on the basis of standard products	30P	12	**30P**F971, 2*K183
...					

Further types of information and data identifiers are used by Beckhoff and serve internal processes.

Structure of the BIC

Example of composite information from positions 1 to 4 and with the above given example value on position 6. The data identifiers are highlighted in bold font:

1P072222**SBTN**k4p562d7**1K**EL1809 **Q**1 **51S**678294

Accordingly as DMC:

Fig. 25: Example DMC **1P**072222**SBTN**k4p562d7**1K**EL1809 **Q**1 **51S**678294

BTN

An important component of the BIC is the Beckhoff Traceability Number (BTN, position 2). The BTN is a unique serial number consisting of eight characters that will replace all other serial number systems at Beckhoff in the long term (e.g. batch designations on IO components, previous serial number range for safety products, etc.). The BTN will also be introduced step by step, so it may happen that the BTN is not yet coded in the BIC.

NOTICE

This information has been carefully prepared. However, the procedure described is constantly being further developed. We reserve the right to revise and change procedures and documentation at any time and without prior notice. No claims for changes can be made from the information, illustrations and descriptions in this documentation.

8.3.4 Electronic access to the BIC (eBIC)

Electronic BIC (eBIC)

The Beckhoff Identification Code (BIC) is applied to the outside of Beckhoff products in a visible place. If possible, it should also be electronically readable.

The interface that the product can be electronically addressed by is crucial for the electronic readout.

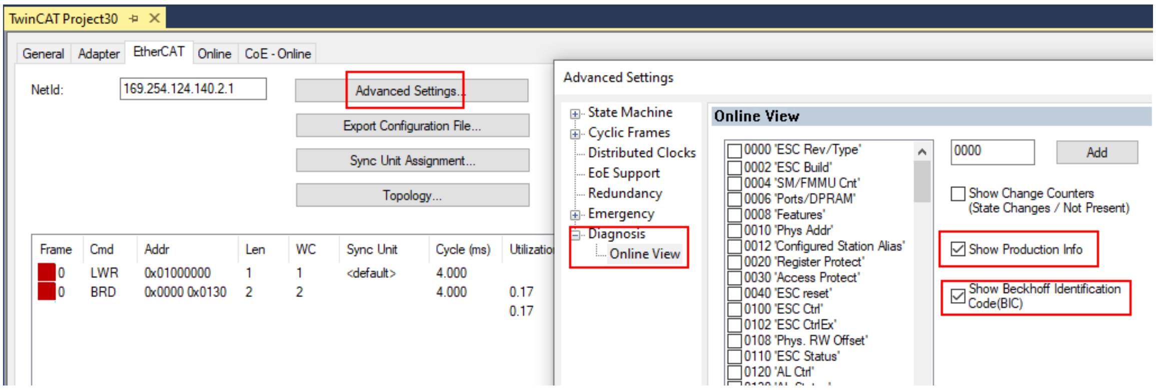
EtherCAT devices (IP20, IP67)

All Beckhoff EtherCAT devices have an ESI-EEPROM which contains the EtherCAT identity with the revision number. The EtherCAT slave information, also colloquially known as the ESI/XML configuration file for the EtherCAT master, is stored in it. See the corresponding chapter in the EtherCAT system manual (Link) for the relationships.

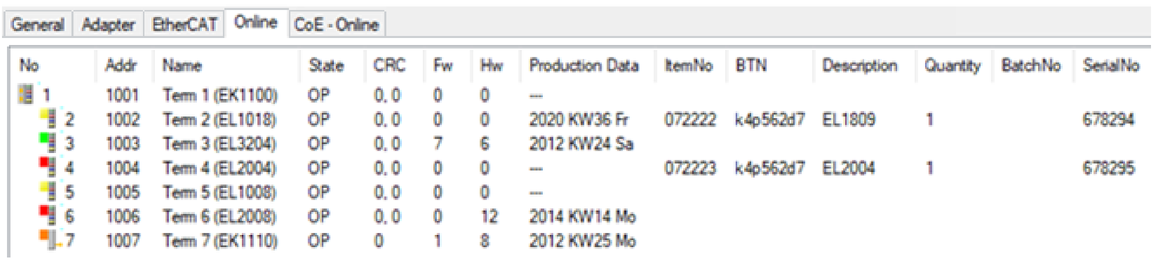
Beckhoff also stores the eBIC in the ESI-EEPROM. The eBIC was introduced into Beckhoff IO production (terminals, box modules) in 2020; as of 2023, implementation is largely complete.

The user can electronically access the eBIC (if present) as follows:

- With all EtherCAT devices, the EtherCAT master (TwinCAT) can read the eBIC from the ESI-EEPROM
  - From TwinCAT 3.1 build 4024.11, the eBIC can be displayed in the online view.
  - To do this, check the "Show Beckhoff Identification Code (BIC)" checkbox under EtherCAT → Advanced Settings → Diagnostics:



  - The BTN and its contents are then displayed:



  - Note: As shown in the figure, the production data HW version, FW version, and production date, which have been programmed since 2012, can also be displayed with "Show production info".
  - Access from the PLC: From TwinCAT 3.1. build 4024.24, the functions *FB_EcReadBIC* and *FB_EcReadBTN* for reading into the PLC are available in the Tc2_EtherCAT library from v3.3.19.0.
- EtherCAT devices with a CoE directory may also have the object 0x10E2:01 to display their own eBIC, which can also be easily accessed by the PLC:

- The device must be in PREOP/SAFEOP/OP for access:

Index	Name	Flags	Value
1000	Device type	RO	0x015E1389 (22942601)
1008	Device name	RO	ELM3704-0000
1009	Hardware version	RO	00
100A	Software version	RO	01
100B	Bootloader version	RO	J0.1.27.0
+ 1011:0	Restore default parameters	RO	> 1 <
+ 1018:0	Identity	RO	> 4 <
− 10E2:0	Manufacturer-specific Identification C...	RO	> 1 <
10E2:01	SubIndex 001	RO	1P158442SBTN0008jekp1KELM3704 Q1 2P482001000016
+ 10F0:0	Backup parameter handling	RO	> 1 <
+ 10F3:0	Diagnosis History	RO	> 21 <
10F8	Actual Time Stamp	RO	0x170bfb277e

- The object 0x10E2 will be preferentially introduced into stock products in the course of necessary firmware revision.
- From TwinCAT 3.1. build 4024.24, the functions *FB_EcCoEReadBIC* and *FB_EcCoEReadBTN* for reading into the PLC are available in the Tc2_EtherCAT library from v3.3.19.0

- The following auxiliary functions are available for processing the BIC/BTN data in the PLC in *Tc2_Utilities* as of TwinCAT 3.1 build 4024.24
  - F_SplitBIC: The function splits the Beckhoff Identification Code (BIC) sBICValue into its components using known identifiers and returns the recognized substrings in the ST_SplittedBIC structure as a return value
  - BIC_TO_BTN: The function extracts the BTN from the BIC and returns it as a return value
- Note: If there is further electronic processing, the BTN is to be handled as a string(8); the identifier "SBTN" is not part of the BTN.
- Technical background
  The new BIC information is written as an additional category in the ESI-EEPROM during device production. The structure of the ESI content is largely dictated by the ETG specifications, therefore the additional vendor-specific content is stored using a category in accordance with the ETG.2010. ID 03 tells all EtherCAT masters that they may not overwrite these data in the event of an update or restore the data after an ESI update.
  The structure follows the content of the BIC, see here. The EEPROM therefore requires approx. 50..200 bytes of memory.
- Special cases
  - If multiple hierarchically arranged ESCs are installed in a device, only the top-level ESC carries the eBIC information.
  - If multiple non-hierarchically arranged ESCs are installed in a device, all ESCs carry the eBIC information.
  - If the device consists of several sub-devices which each have their own identity, but only the top-level device is accessible via EtherCAT, the eBIC of the top-level device is located in the CoE object directory 0x10E2:01 and the eBICs of the sub-devices follow in 0x10E2:nn.

8.4 Support and Service

Beckhoff and their partners around the world offer comprehensive support and service, making available fast and competent assistance with all questions related to Beckhoff products and system solutions.

Beckhoff's branch offices and representatives

Please contact your Beckhoff branch office or representative for local support and service on Beckhoff products!

The addresses of Beckhoff's branch offices and representatives round the world can be found on her internet pages: www.beckhoff.com

You will also find further documentation for Beckhoff components there.

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The Beckhoff Support offers you comprehensive technical assistance, helping you not only with the application of individual Beckhoff products, but also with other, wide-ranging services:

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web:	www.beckhoff.com/support

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- spare parts service
- hotline service

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