BECKHOFF New Automation Technology

Documentation | EN

# EL7201-000x, EL7211-000x

Servo Motor Terminals, 48 V DC

2024-10-01 | Version: 3.8.0

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# 1 Foreword

## 1.1 Product overview Servo Motor Terminals

| | |
|---|---|
| EL7201 [▶ 17] | Servo Motor Terminal (MDP742 profile), 48 $V_{DC}$, 2,8 $A_{rms}$ |
| EL7201-0001 [▶ 17] | Servo Motor Terminal (DS402 profile), 48 $V_{DC}$, 2,8 $A_{rms}$ |
| EL7211 [▶ 17] | Servo Motor Terminal (MDP742 profile), 48 $V_{DC}$, 4,5 $A_{rms}$ |
| EL7211-0001 [▶ 17] | Servo Motor Terminal (DS402 profile), 48 $V_{DC}$, 4,5 $A_{rms}$ |

## 1.2 Notes on the documentation

### Intended audience

This description is only intended for the use of trained specialists in control and automation engineering who are familiar with the applicable national standards.
It is essential that the documentation and the following notes and explanations are followed when installing and commissioning these components.
The qualified personnel is obliged to always use the currently valid documentation.

The responsible staff must ensure that the application or use of the products described satisfy all the requirements for safety, including all the relevant laws, regulations, guidelines and standards.

### Disclaimer

The documentation has been prepared 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 prior announcement.

No claims for the modification of products that have already been supplied may be made on the basis of the data, diagrams and descriptions in this documentation.

### Trademarks

Beckhoff®, TwinCAT®, TwinCAT/BSD®, TC/BSD®, EtherCAT®, EtherCAT G®, EtherCAT G10®, EtherCAT P®, Safety over EtherCAT®, TwinSAFE®, XFC®, XTS® and XPlanar® are registered trademarks of and licensed by Beckhoff Automation GmbH. Other designations used in this publication may be trademarks whose use by third parties for their own purposes could violate the rights of the owners.

### Patent Pending

The EtherCAT Technology is covered, including but not limited to the following patent applications and patents: EP1590927, EP1789857, EP1456722, EP2137893, DE102015105702 with corresponding applications or registrations in various other countries.

EtherCAT® is registered trademark and patented technology, licensed by Beckhoff Automation GmbH, Germany.

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## 1.3 Guide through documentation

*NOTICE*

**Further components of documentation**

This documentation describes device-specific content. It is part of the modular documentation concept for Beckhoff I/O components. For the use and safe operation of the device / devices described in this documentation, additional cross-product descriptions are required, which can be found in the following table.

| Title | Description |
|---|---|
| **EtherCAT System Documentation** (PDF) | • System overview<br>• EtherCAT basics<br>• Cable redundancy<br>• Hot Connect<br>• EtherCAT devices configuration |
| **I/O Analog Manual** (PDF) | Notes on I/O components with analog in and outputs |
| **Infrastructure for EtherCAT/Ethernet** (PDF) | Technical recommendations and notes for design, implementation and testing |
| **Software Declarations I/O** (PDF) | Open source software declarations for Beckhoff I/O components |

The documentations can be viewed at and downloaded from the Beckhoff website (www.beckhoff.com) via:

- the “Documentation and Download” area of the respective product page,
- the Download finder,
- the Beckhoff Information System.

If you have any suggestions or proposals for our documentation, please send us an e-mail stating the documentation title and version number to: documentation@beckhoff.com

## 1.4 Safety instructions

### Safety regulations

Please note the following safety instructions and explanations!
Product-specific safety instructions can be found on following pages or in the areas mounting, wiring, commissioning etc.

### Exclusion of liability

All the components are supplied in particular hardware and software configurations 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 engineering 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

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

## 1.5 Documentation issue status

| Version | Comment |
|---|---|
| 3.8.0 | • Update chapter “LEDs and connection”<br>• Update revision status<br>• Update structure |
| 3.7 | • Update chapter “Commissioning”<br>• Update structure |
| 3.5 | • Update chapter “Introduction EL72x1”<br>• Update chapter “Technical data”<br>• Update revision status<br>• Update chapter “LEDs and connection”<br>• Update structure |
| 3.4 | • Note for fuse protection of the supply voltage added<br>• Update revision status<br>• Update structure |
| 3.3 | • Update chapter “Technical data”<br>• Chapter “UL notices” added<br>• Chapter “Installation instructions for enhanced mechanical load capacity” added<br>• Update structure |
| 3.2 | • Update chapter “Object description” |
| 3.1 | • Update chapter “Technical data”<br>• Update chapter “Shielding concept”<br>• Update chapter “Operating mode CSP”<br>• Update chapter “Object description”<br>• Addenda note “Diag messages”<br>• Update structure<br>• Update revision status |
| 3.0 | • Migration<br>• Update structure<br>• Update revision status |
| 0.1 – 2.9 | *archived* |

# 1.6 Version identification of EtherCAT devices

## 1.6.1 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<br>12 mm, non-pluggable connection level | 3314<br>4-channel thermocouple terminal | 0000<br>basic type | 0016 |
| ES3602-0010-0017 | ES terminal<br>12 mm, pluggable connection level | 3602<br>2-channel voltage measurement | 0010<br>high-precision version | 0017 |
| CU2008-0000-0000 | CU device | 2008<br>8-port fast ethernet switch | 0000<br>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.

## 1.6.2 Version identification of EL terminals

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) | 12 - production week 12 |
| YY - year of production | 06 - production year 2006 |
| FF - firmware version | 3A - firmware version 3A |
| HH - hardware version | 02 - hardware version 02 |

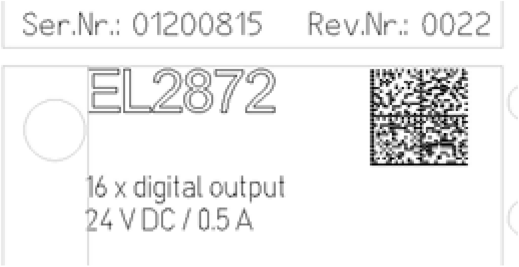


Fig. 1: EL2872 with revision 0022 and serial number 01200815

## 1.6.3 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.

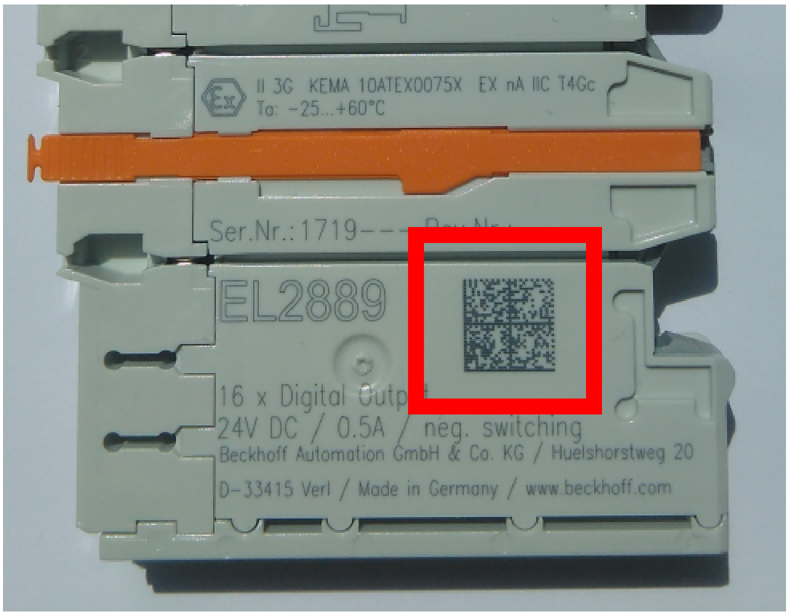

II 3G KEMA 10ATEX0075X EX nA IIC T4Gc
Ta: -25...+60°C
Ser.Nr.: 1719---
EL2889
16 x Digital Outp
24V DC / 0.5A / neg. switching
Beckhoff Automation GmbH & Co. KG / Huelshorstweg 20
D-33415 Verl / Made in Germany / www.beckhoff.com

Fig. 2: 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 | 1P072222 |
| 2 | Beckhoff Traceability Number (BTN) | **Unique serial number, see note below** | SBTN | 12 | SBTNk4p562d7 |
| 3 | Article description | **Beckhoff article description, e.g. EL1008** | 1K | 32 | 1KEL1809 |
| 4 | Quantity | **Quantity in packaging unit, e.g. 1, 10, etc.** | Q | 6 | Q1 |
| 5 | Batch number | Optional: Year and week of production | 2P | 14 | 2P401503180016 |
| 6 | ID/serial number | Optional: Present-day serial number system, e.g. with safety products | 51S | 12 | 51S678294 |
| 7 | Variant number | Optional: Product variant number on the basis of standard products | 30P | 32 | 30PF971, 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:

**1P**072222**S**BTNk4p562d7**1K**EL1809 **Q**1 **51S**678294

Accordingly as DMC:

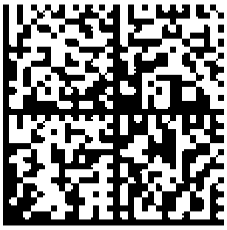


Fig. 3: Example DMC **1P**072222**S**BTNk4p562d7**1K**EL1809 **Q**1 **51S**678294

### 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.

## 1.6.4 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.

### K-bus devices (IP20, IP67)

Currently, no electronic storage or readout is planned for these devices.

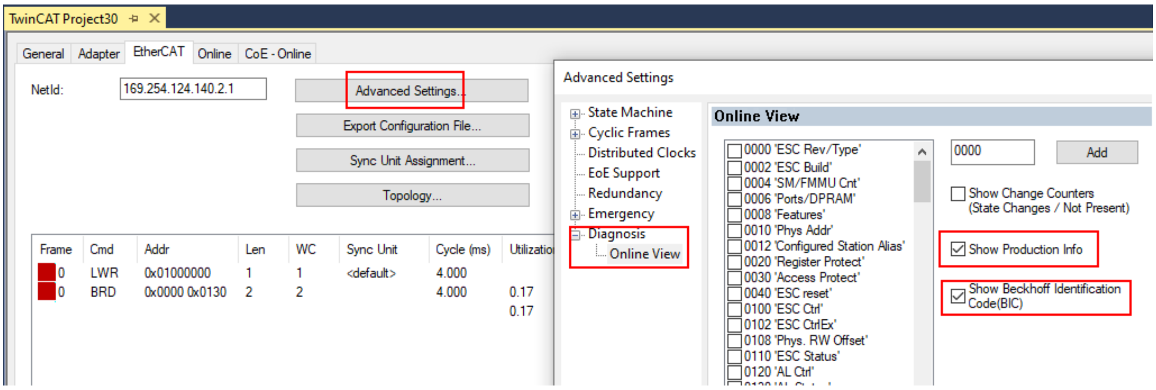
### EtherCAT devices (IP20, IP67)

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:



NetId: 169.254.124.140.2.1

| Frame | Cmd | Addr | Len | WC | Sync Unit | Cycle (ms) | Utilizatio |
|---|---|---|---|---|---|---|---|
| 0 | LWR | 0x01000000 | 1 | 1 | <default> | 4.000 | |
| 0 | BRD | 0x0000 0x0130 | 2 | 2 | | 4.000 | 0.17 |
| | | | | | | | 0.17 |

Online View

☐ 0000 'ESC Rev/Type'
☐ 0002 'ESC Build'
☐ 0004 'SM/FMMU Cnt'
☐ 0006 'Ports/DPRAM'
☐ 0008 'Features'
☐ 0010 'Phys Addr'
☐ 0012 'Configured Station Alias'
☐ 0020 'Register Protect'
☐ 0030 'Access Protect'
☐ 0040 'ESC reset'
☐ 0100 'ESC Ctrl'
☐ 0102 'ESC CtrlEx'
☐ 0108 'Phys. RW Offset'
☐ 0110 'ESC Status'
☐ 0120 'AL Ctrl'

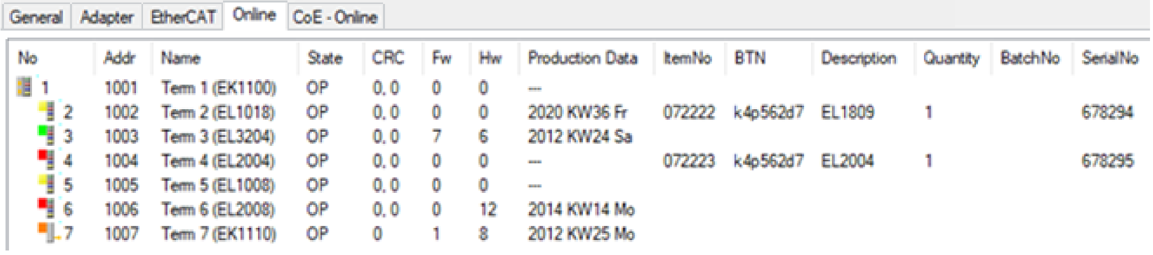
0000

☐ Show Change Counters (State Changes / Not Present)

☑ Show Production Info

☑ Show Beckhoff Identification Code(BIC)

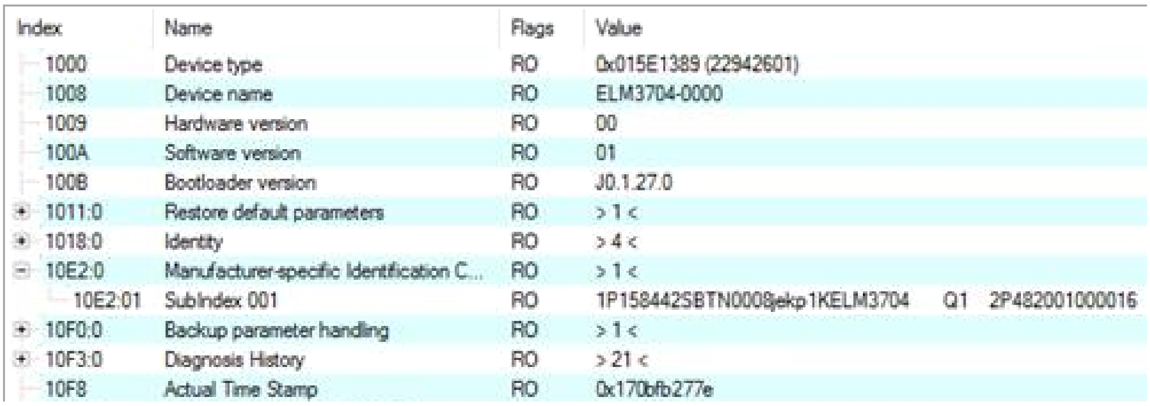
  - The BTN and its contents are then displayed:



| No | Addr | Name | State | CRC | Fw | Hw | Production Data | ItemNo | BTN | Description | Quantity | BatchNo | SerialNo |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 1001 | Term 1 (EK1100) | OP | 0, 0 | 0 | 0 | --- | | | | | | |
| 2 | 1002 | Term 2 (EL1018) | OP | 0, 0 | 0 | 0 | 2020 KW36 Fr | 072222 | k4p562d7 | EL1809 | 1 | | 678294 |
| 3 | 1003 | Term 3 (EL3204) | OP | 0, 0 | 7 | 6 | 2012 KW24 Sa | | | | | | |
| 4 | 1004 | Term 4 (EL2004) | OP | 0, 0 | 0 | 0 | --- | 072223 | k4p562d7 | EL2004 | 1 | | 678295 |
| 5 | 1005 | Term 5 (EL1008) | OP | 0, 0 | 0 | 0 | --- | | | | | | |
| 6 | 1006 | Term 6 (EL2008) | OP | 0, 0 | 0 | 12 | 2014 KW14 Mo | | | | | | |
| 7 | 1007 | Term 7 (EK1110) | OP | 0 | 1 | 8 | 2012 KW25 Mo | | | | | | |

  - 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.

### PROFIBUS; PROFINET, and DeviceNet devices

Currently, no electronic storage or readout is planned for these devices.

# 2 Product overview

## 2.1 Introduction EL72x1

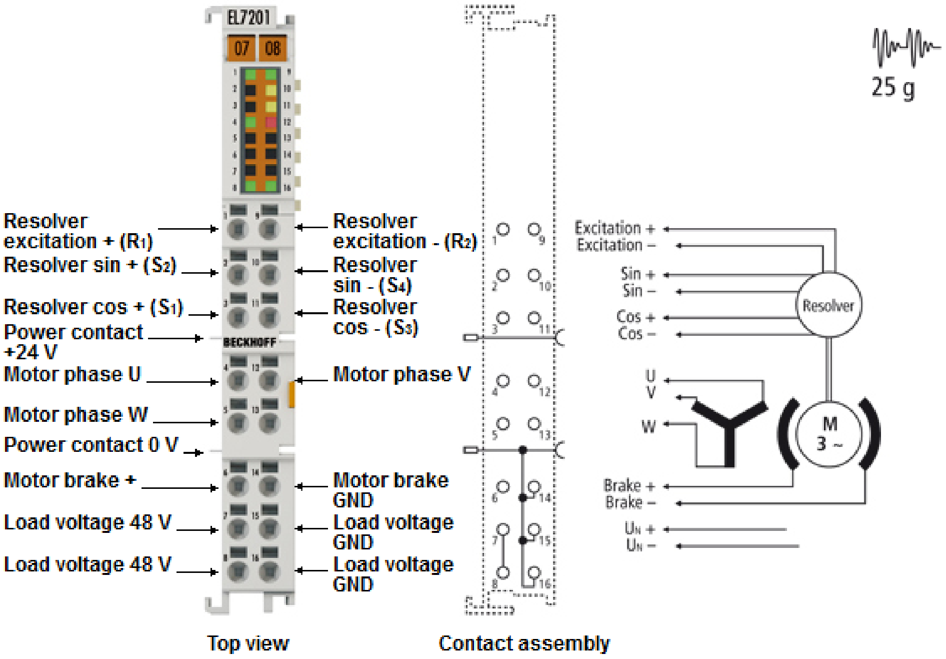


Fig. 4: EL7201

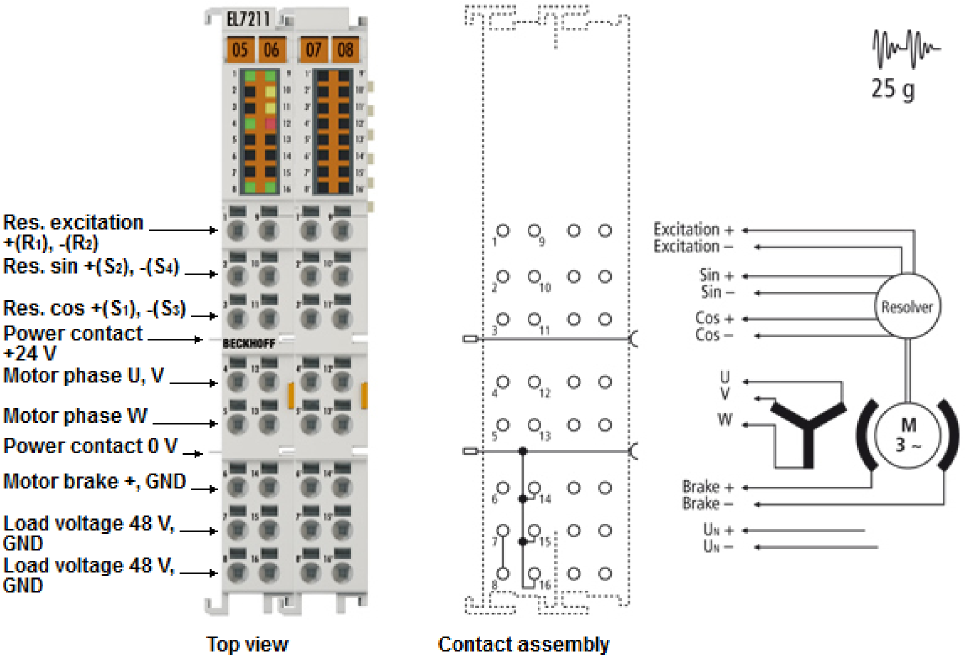


Fig. 5: EL7211

### Servomotor terminals, 48 $V_{DC}$

The servomotor EtherCAT Terminals EL7201 (MDP742 profile, 48 $V_{DC}$, 2.8 $A_{rms}$) / EL7201-0001 (DS402 profile, 48 $V_{DC}$, 2.8 $A_{rms}$) and EL7211 (MDP742 profile, 48 $V_{DC}$, 4.5 $A_{rms}$) / EL7211-0001 (DS402 profile, 48 $V_{DC}$, 4.5 $A_{rms}$) with integrated resolver interface offer high servo performance with a very compact design. The EL72x1 was designed for the motor types of the AM31xx and AM81xx series from Beckhoff Automation.

The fast control technology, based on field-orientated current and PI speed control, supports fast and highly dynamic positioning tasks. The monitoring of numerous parameters, such as overvoltage and undervoltage, overcurrent, terminal temperature or motor load via the calculation of an $I^2T$ model, offers maximum operational reliability.

EtherCAT, as a high-performance system communication, and CAN-over-EtherCAT (CoE), as the application layer, enable ideal interfacing with PC-based control technology.
The latest power semiconductors guarantee minimum power loss and enable feedback into the DC link when braking.

The LEDs indicate status, warning and error messages as well as possibly active limitations.

**Recommended TwinCAT version**

In order to be able to utilize the full power of the EL72x1, we recommend using the EL72x1 with TwinCAT 2.11 R3 or higher!

**Mandatory hardware**

The EL72x1 must be operated with a real-time capable computer and distributed clocks.

**Approved motors**

Trouble-free operation can only be guaranteed with motors approved by Beckhoff.

#### Quick links

#### Connection instructions

- Chapter "Mounting and wiring",
  - LEDs and connection [▶ 53]
  - Shielding concept [▶ 49]
  - Notes on current measurement via Hall sensor [▶ 52]

#### Configuration instructions

- Chapter "Commissioning",
  - Configuration of the main parameters [▶ 94]
- Chapter "Configuration with the TwinCAT System Manager",
  - Object description and parameterization [▶ 145]

#### Application example

- Chapter "Commissioning",
  - Application example [▶ 106]

## 2.2 Technical data

| Technical data | EL7201, EL7201-0001 | EL7211, EL7211-0001 |
|---|---|---|
| Number of outputs | 3 motor phases, 2 resolver excitations, 2 motor holding brakes | |
| Number of inputs | 2 (4) DC link voltages, 4 resolvers | |
| DC link supply voltage | 8 ... 48 $V_{DC}$ | |
| Supply voltage | 24 $V_{DC}$ via the power contacts, via the E-bus | |
| Output current | 2.8 $A_{rms}$ (without fan cartridge ZB8610)<br>4.5 $A_{rms}$ (with fan cartridge ZB8610) | 4.5 $A_{rms}$ |
| Peak current | 5.7 $A_{rms}$ for 1 second 2.8 $A_{rms}$ (without fan cartridge ZB8610)<br>9 $A_{rms}$ for 1 second 2.8 $A_{rms}$ (with fan cartridge ZB8610) | 9 $A_{rms}$ for 1 second |
| Rated power | 170 W (without fan cartridge ZB8610)<br>276 W (with fan cartridge ZB8610) | 276 W |
| Motor holding brake output voltage | 24 V (+ 6 %, - 10 %) | |
| Max. motor holding brake output current | max. 0.5 A | |
| Load type | Permanent magnet synchronous motors, inductive (series AM31xx) | |
| PWM switching frequency | 16 kHz | |
| Current controller frequency | double PWM switching frequency | |
| Velocity controller frequency | 16 kHz | |
| Diagnostics LED | Status, warning, errors and limits | |
| Power loss | typ. 1.6 W | |
| Current consumption via E-bus | typ. 120 mA | |
| Current consumption from the 24 V | typ. 50 mA + holding brake | |
| Supports NoCoeStorage [▸ 28] function | Yes | |
| Reverse polarity protection | 24 V power supply yes, with leakage capacitor<br>50 V power supply yes, with leakage capacitor | |
| Fuse protection | 24 V power supply 10 A<br>50 V power supply 10 A | |
| Electrical isolation | 500 V (E-bus/signal voltage) | |
| Possible EtherCAT cycle times | Multiple of 125 µs | |
| Configuration | no address setting required<br>configuration via TwinCAT System Manager | |
| Weight | approx. 60 g | approx. 95 g |
| Permissible ambient temperature range during operation | 0°C ... + 55°C | |
| Permissible ambient temperature range during storage | -25°C ... + 85°C | |
| Permissible relative humidity | 95 %, no condensation | |
| Dimensions (W x H x D) | approx. 15 mm x 100 mm x 70 mm (width aligned: 12 mm) | approx. 27 mm x 100 mm x 70 mm (width aligned: 24 mm) |
| Mounting [▸ 35] | on 35 mm mounting rail conforms to EN 60715 | |
| Vibration/shock resistance | conforms to EN 60068-2-6 / EN 60068-2-27,<br>see also installation instructions [▸ 38] for enhanced mechanical load capacity | |
| EMC immunity/emission | conforms to EN 61000-6-2 / EN 61000-6-4<br>according to IEC/EN 61800-3 | |
| EMC category | Category C3 - standard<br>Category C2, C1 - auxiliary filter required | |
| Protection class | IP20 | |
| Installation position | without fan cartridge ZB8610: standard installing position<br>with fan cartridge ZB8610: standard installing position, other installing positions (example 1 and 2)<br>see notice [▸ 45] | |
| Approvals / markings* | CE, EAC, UKCA,<br>cULus [▸ 58] | |

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

## 2.3 Technology

The very compact EL72x1 servomotor terminal integrates a complete servo drive for servomotors up to 276 W.

**Servomotor**

The servomotor is an electrical motor. Together with a servo amplifier the servomotor forms a servo drive.
The servomotor is operated in a closed control loop with position, torque or speed control.
The servo terminal EL72x1 supports control of permanent magnet synchronous motors. These consist of 3 coils which are offset by 120° and a permanent magnet rotor.

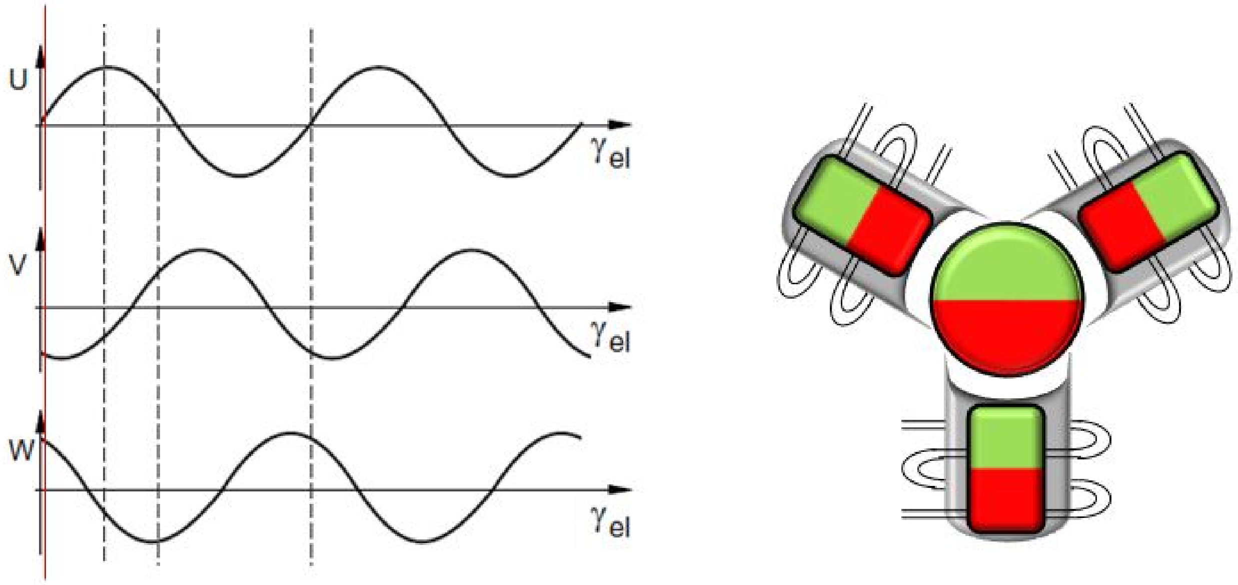


Fig. 6: Three synchronous motor coils, each offset by 120°

Servomotors particularly demonstrate their advantages in highly dynamic and precise positioning applications:

- very high positioning accuracy in applications where maximum precision is required through integrated position feedback
- high efficiency and high acceleration capacity
- servomotors are overload-proof and therefore have far greater dynamics than stepper motors, for example.
- load-independent high torque right up to the higher speed ranges
- maintenance requirements reduced to a minimum

The EtherCAT servomotor terminal offers users the option to configure compact and cost-effective systems without having to give up the benefits of a servomotor.

**The Beckhoff servo terminal**

The EL72x1 is a fully capable servo drive for direct connection to servomotors in the lower performance range. There is no need for further modules or cabling to make a connection to the control system. This results in a very compact control system solution. The E-Bus connection of the EL72x1 makes the full functionality of EtherCAT available to the user. This includes in particular the short cycle time, low jitter, simultaneity and easy diagnostics provided by EtherCAT. With this performance from EtherCAT the dynamics that a servomotor can achieve can be used optimally.

A rated voltage of max. 48 $V_{DC}$ and a rated current of max. 4.5 A enable the user to drive a servomotor with a rating of up to 276 W using the EL7211. Permanent magnet synchronous motors with a rated current of up to 4.5 A can be connected as loads. The monitoring of numerous parameters, such as overvoltage and undervoltage, overcurrent, terminal temperature or motor load, offers maximum operational reliability. Modern power semiconductors guarantee minimum power loss and enable feedback into the DC link when braking.

Beckhoff sets new benchmarks with regard to size with the integration of a fully-featured servo drive in a standard EtherCAT terminal – the EL7201 – with a width of just 12 mm. This small manufactured size is possible thanks to the latest semiconductor technology and the resulting very high power factor. And yet, despite the small dimensions, nothing has to be sacrificed.

The integrated fast control technology, with a field-orientated current and PI speed control, supports highly dynamic positioning tasks. Apart from the direct connection of motor and resolver, the connection of a motor holding brake is also possible.

### Connection to the control system

A further big advantage of the EL72x1 is the easy incorporation into the control solution. The complete integration into the control system simplifies commissioning and parameterization. As with all the other Beckhoff terminals, the EL72x1 is simply inserted into the terminal network. Then the full terminal network can be scanned by the TwinCAT System Manager or manually added by the application engineer. In the System Manager the EL72x1 can be linked with the TwinCAT NC and parameterized.

### Scalable motion solution

The servo terminal complements the product range of compact drive technology for Beckhoff I/O systems that are available for stepper motors, AC and DC motors. With the EL72x1, the range of servo drives becomes even more finely scalable: from the miniature servo drive up to 200 W in the EtherCAT Terminal through to the AX5000 servo drive with 118 KW, Beckhoff offers a wide range including the servomotors. The AM31xx series was specially developed for the servomotor terminal EL72x1.

### Thermal I²T motor model

The thermal I²T motor model represents the thermal behavior of the motor winding taking into account the absolute thermal resistance $R_{th}$ and the thermal capacity $C_{th}$ of motor and the stator winding.

The model assumes that the motor reaches its maximum continuous operating temperature $T_{nom}$ during continuous operation with rated current $I_{nom}$. This temperature corresponds to 100% motor load. During operation at rated current the motor model reaches a load of 63% after a time of $\tau_{th}=R_{th}\cdot C_{th}$ and slowly reaches its continuous operating temperature.

If the motor is operated with a current that is greater than the rated current, the model reaches 100% load more quickly.

If the load of the I²T model exceeds 100%, the requested set current is limited to the rated current, in order to protect the motor winding thermally. The load reduces to a maximum of 100%. If the current falls below the rated current, the load falls below 100% and the set current limitation is cancelled.

For a motor that has been cooled to ambient temperature, the time for reaching 100% load with a set current that exceeds the rated current can be estimated with $\tau_{th}\cdot I_{nom}{}^2/I_{actual}{}^2$.

The actual load must be known for exact calculation of the time when the 100% load threshold is exceeded.

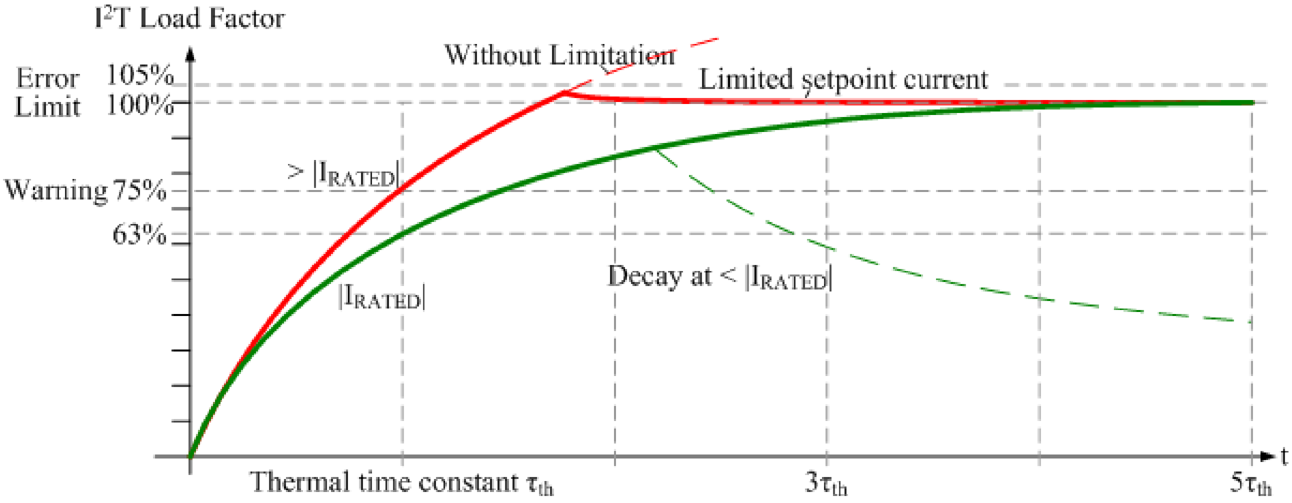


Fig. 7: Limitation to the rated motor current

## 2.4 Start-up

For commissioning:

- mount the EL72x1-000x as described in the chapter Mounting and wiring [▸ 35]
- configure the EL72x1-000x in TwinCAT as described in the chapter Commissioning [▸ 60].

# 3 Basics communication

## 3.1 EtherCAT basics

Please refer to the EtherCAT System Documentation for the EtherCAT fieldbus basics.

## 3.2 EtherCAT cabling – wire-bound

The cable length between two EtherCAT devices must not exceed 100 m. This results from the FastEthernet technology, which, above all for reasons of signal attenuation over the length of the cable, allows a maximum link length of 5 + 90 + 5 m if cables with appropriate properties are used. See also the Design recommendations for the infrastructure for EtherCAT/Ethernet.

### Cables and connectors

For connecting EtherCAT devices only Ethernet connections (cables + plugs) that meet the requirements of at least category 5 (CAt5) according to EN 50173 or ISO/IEC 11801 should be used. EtherCAT uses 4 wires for signal transfer.

EtherCAT uses RJ45 plug connectors, for example. The pin assignment is compatible with the Ethernet standard (ISO/IEC 8802-3).

| Pin | Color of conductor | Signal | Description |
|---|---|---|---|
| 1 | yellow | TD + | Transmission Data + |
| 2 | orange | TD - | Transmission Data - |
| 3 | white | RD + | Receiver Data + |
| 6 | blue | RD - | Receiver Data - |

Due to automatic cable detection (auto-crossing) symmetric (1:1) or cross-over cables can be used between EtherCAT devices from Beckhoff.

**Recommended cables**

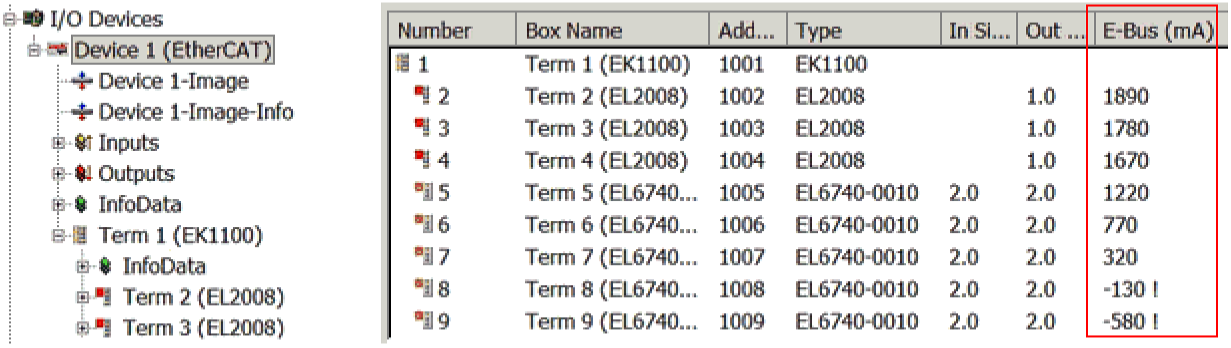
It is recommended to use the appropriate Beckhoff components e.g.
- cable sets ZK1090-9191-xxxx respectively
- RJ45 connector, field assembly ZS1090-0005
- EtherCAT cable, field assembly ZB9010, ZB9020

Suitable cables for the connection of EtherCAT devices can be found on the Beckhoff website!

### E-Bus supply

A bus coupler can supply the EL terminals added to it with the E-bus system voltage of 5 V; a coupler is thereby loadable up to 2 A as a rule (see details in respective device documentation).
Information on how much current each EL terminal requires from the E-bus supply is available online and in the catalogue. If the added terminals require more current than the coupler can supply, then power feed terminals (e.g. EL9410) must be inserted at appropriate places in the terminal strand.

The pre-calculated theoretical maximum E-Bus current is displayed in the TwinCAT System Manager. A shortfall is marked by a negative total amount and an exclamation mark; a power feed terminal is to be placed before such a position.



- I/O Devices
  - Device 1 (EtherCAT)
    - Device 1-Image
    - Device 1-Image-Info
    - Inputs
    - Outputs
    - InfoData
    - Term 1 (EK1100)
      - InfoData
      - Term 2 (EL2008)
      - Term 3 (EL2008)

| Number | Box Name | Add... | Type | In Si... | Out ... | E-Bus (mA) |
|---|---|---|---|---|---|---|
| 1 | Term 1 (EK1100) | 1001 | EK1100 | | | |
| 2 | Term 2 (EL2008) | 1002 | EL2008 | | 1.0 | 1890 |
| 3 | Term 3 (EL2008) | 1003 | EL2008 | | 1.0 | 1780 |
| 4 | Term 4 (EL2008) | 1004 | EL2008 | | 1.0 | 1670 |
| 5 | Term 5 (EL6740... | 1005 | EL6740-0010 | 2.0 | 2.0 | 1220 |
| 6 | Term 6 (EL6740... | 1006 | EL6740-0010 | 2.0 | 2.0 | 770 |
| 7 | Term 7 (EL6740... | 1007 | EL6740-0010 | 2.0 | 2.0 | 320 |
| 8 | Term 8 (EL6740... | 1008 | EL6740-0010 | 2.0 | 2.0 | -130 ! |
| 9 | Term 9 (EL6740... | 1009 | EL6740-0010 | 2.0 | 2.0 | -580 ! |

Fig. 8: System manager current calculation

**NOTICE**

**Malfunction possible!**

The same ground potential must be used for the E-Bus supply of all EtherCAT terminals in a terminal block!

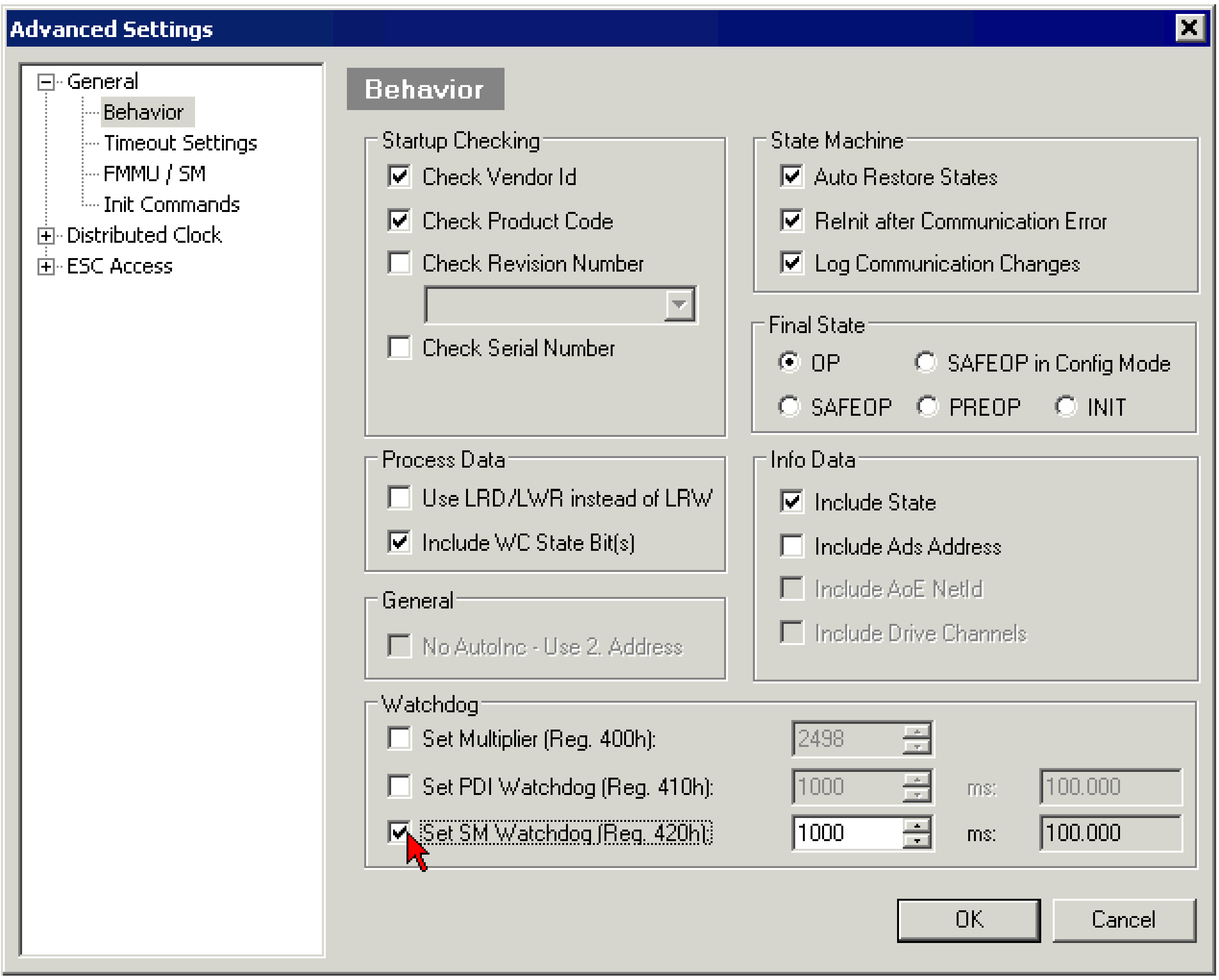
## 3.3 General notes for setting the watchdog

The EtherCAT terminals are equipped with a safety device (watchdog) which, e. g. in the event of interrupted process data traffic, switches the outputs (if present) to a presettable state after a presettable time, depending on the device and setting, e. g. to FALSE (off) or an output value.

The EtherCAT slave controller features two watchdogs:

- Sync Manager (SM) watchdog (default: 100 ms)
- Process Data (PDI) watchdog (default: 100 ms)

Their times are individually parameterized in TwinCAT as follows:



Advanced Settings

- General
  - Behavior
  - Timeout Settings
  - FMMU / SM
  - Init Commands
- Distributed Clock
- ESC Access

Behavior

Startup Checking
☑ Check Vendor Id
☑ Check Product Code
☐ Check Revision Number
☐ Check Serial Number

State Machine
☑ Auto Restore States
☑ ReInit after Communication Error
☑ Log Communication Changes

Final State
● OP ○ SAFEOP in Config Mode
○ SAFEOP ○ PREOP ○ INIT

Process Data
☐ Use LRD/LWR instead of LRW
☑ Include WC State Bit(s)

Info Data
☑ Include State
☐ Include Ads Address
☐ Include AoE NetId
☐ Include Drive Channels

General
☐ No AutoInc - Use 2. Address

Watchdog
☐ Set Multiplier (Reg. 400h): 2498
☐ Set PDI Watchdog (Reg. 410h): 1000 ms: 100.000
☑ Set SM Watchdog (Reg. 420h): 1000 ms: 100.000

Fig. 9: eEtherCAT tab -> Advanced Settings -> Behavior -> Watchdog

Notes:

- the Multiplier Register 400h (hexadecimal, i. e. 0x0400) is valid for both watchdogs.
- each watchdog has its own timer setting 410h or 420h, which together with the Multiplier results in a resulting time.
- important: the Multiplier/Timer setting is only loaded into the slave at EtherCAT startup if the checkbox in front of it is activated.
- if it is not checked, nothing is downloaded and the setting located in the ESC remains unchanged.
- the downloaded values can be seen in the ESC registers 400h, 410h and 420h: ESC Access -> Memory

### SM watchdog (SyncManager Watchdog)

The SyncManager watchdog is reset with each successful EtherCAT process data communication with the terminal. If, for example, no EtherCAT process data communication with the terminal takes place for longer than the set and activated SM watchdog time due to a line interruption, the watchdog is triggered. The status of the terminal (usually OP) remains unaffected. The watchdog is only reset again by a successful EtherCAT process data access.

The SyncManager watchdog is therefore a monitoring for correct and timely process data communication with the ESC from the EtherCAT side.

The maximum possible watchdog time depends on the device. For example, for "simple" EtherCAT slaves (without firmware) with watchdog execution in the ESC it is usually up to 170 seconds. For complex EtherCAT slaves (with firmware) the SM watchdog function is usually parameterized via register 400h/420h but executed by the microcontroller (µC) and can be significantly lower. In addition, the execution may then be subject to a certain time uncertainty. Since the TwinCAT dialog may allow inputs up to 65535, a test of the desired watchdog time is recommended.

### PDI watchdog (Process Data Watchdog)

If there is no PDI communication with the ESC for longer than the set and activated Process Data Interface (PDI) watchdog time, this watchdog is triggered.

The PDI is the internal interface of the ESC, e.g. to local processors in the EtherCAT slave. With the PDI watchdog this communication can be monitored for failure.

The PDI watchdog is therefore a monitoring for correct and timely process data communication with the ESC, but viewed from the application side.

### Calculation

Watchdog time = [1/25 MHz * (Watchdog multiplier + 2)] * SM/PDI watchdog

Example: default setting Multiplier = 2498, SM watchdog = 1000 => 100 ms

The value in “Watchdog multiplier + 2” in the formula above corresponds to the number of 40ns base ticks representing one watchdog tick.

**⚠ CAUTION**

**Undefined state possible!**

The function for switching off the SM watchdog via SM watchdog = 0 is only implemented in terminals from revision -0016. In previous versions this operating mode should not be used.

**⚠ CAUTION**

**Damage of devices and undefined state possible!**

If the SM watchdog is activated and a value of 0 is entered the watchdog switches off completely. This is the deactivation of the watchdog! Set outputs are NOT set in a safe state if the communication is interrupted.

## 3.4 EtherCAT State Machine

The state of the EtherCAT slave is controlled via the EtherCAT State Machine (ESM). Depending upon the state, different functions are accessible or executable in the EtherCAT slave. Specific commands must be sent by the EtherCAT master to the device in each state, particularly during the bootup of the slave.

A distinction is made between the following states:

- Init
- Pre-Operational
- Safe-Operational
- Operational

- Bootstrap

The regular state of each EtherCAT slave after bootup is the OP state.

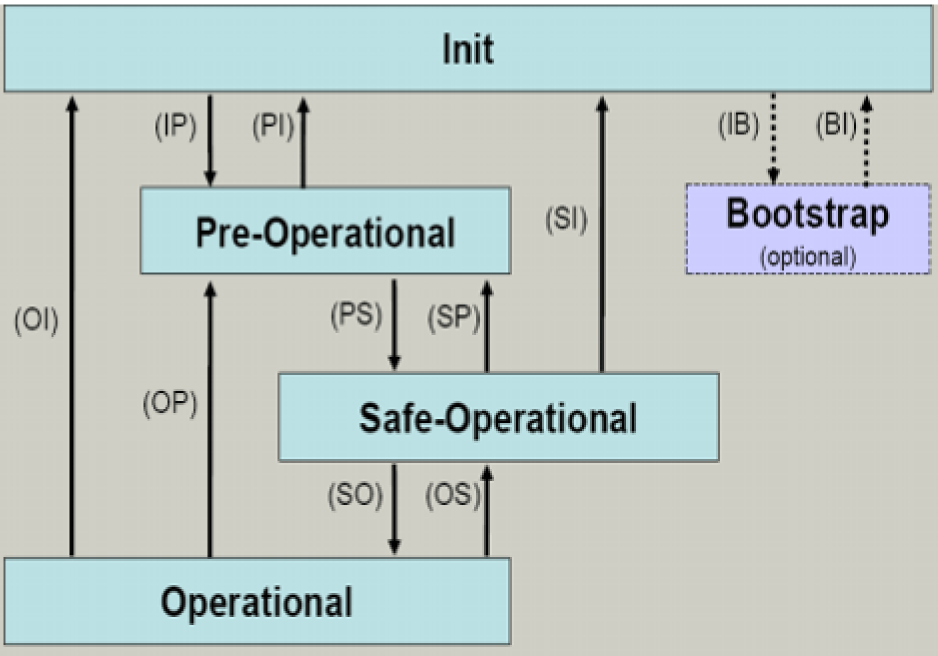


Fig. 10: States of the EtherCAT State Machine

### Init

After switch-on the EtherCAT slave in the *Init* state. No mailbox or process data communication is possible. The EtherCAT master initializes sync manager channels 0 and 1 for mailbox communication.

### Pre-Operational (Pre-Op)

During the transition between *Init* and *Pre-Op* the EtherCAT slave checks whether the mailbox was initialized correctly.

In *Pre-Op* state mailbox communication is possible, but not process data communication. The EtherCAT master initializes the sync manager channels for process data (from sync manager channel 2), the Fieldbus Memory Management Unit (FMMU) channels and, if the slave supports configurable mapping, PDO mapping or the sync manager PDO assignment. In this state the settings for the process data transfer and perhaps terminal-specific parameters that may differ from the default settings are also transferred.

### Safe-Operational (Safe-Op)

During transition between *Pre-Op* and *Safe-Op* the EtherCAT slave checks whether the sync manager channels for process data communication and, if required, the Distributed Clocks settings are correct. Before it acknowledges the change of state, the EtherCAT slave copies current input data into the associated Dual Port (DP)-RAM areas of the ESC.

In *Safe-Op* state mailbox and process data communication is possible, although the slave keeps its outputs in a safe state, while the input data are updated cyclically.

**Outputs in SAFEOP state**

The default set watchdog monitoring sets the outputs of the ESC module in a safe state - depending on the settings in SAFEOP and OP - e.g. in OFF state. If this is prevented by deactivation of the monitoring in the module, the outputs can be switched or set also in the SAFEOP state.

### Operational (Op)

Before the EtherCAT master switches the EtherCAT slave from *Safe-Op* to *Op* it must transfer valid output data.

In the *Op* state the slave copies the output data of the masters to its outputs. Process data and mailbox communication is possible.

**Boot**

In the *Boot* state the slave firmware can be updated. The *Boot* state can only be reached via the *Init* state.

In the *Boot* state mailbox communication via the file access over EtherCAT (FoE) protocol is possible, but no other mailbox communication and no process data communication.

## 3.5 CoE Interface

**General description**

The CoE interface (CAN application protocol over EtherCAT interface) is used for parameter management of EtherCAT devices. EtherCAT slaves or the EtherCAT master manage fixed (read only) or variable parameters which they require for operation, diagnostics or commissioning.

CoE parameters are arranged in a table hierarchy. In principle, the user has access via the fieldbus. The EtherCAT master (TwinCAT System Manager) can access the local CoE lists of the slaves via EtherCAT in read or write mode, depending on the attributes.

Different CoE data types are possible, including string (text), integer numbers, Boolean values or larger byte fields. They can be used to describe a wide range of features. Examples of such parameters include manufacturer ID, serial number, process data settings, device name, calibration values for analog measurement or passwords.

The order is specified in two levels via hexadecimal numbering: (main)index, followed by subindex.

The value ranges are

- Index: 0x0000 …0xFFFF (0...65535$_{\text{dec}}$)
- Subindex: 0x00…0xFF (0...255$_{\text{dec}}$)

A parameter localized in this way is normally written as 0x8010:07, with preceding “0x” to identify the hexadecimal numerical range and a colon between index and subindex.

The relevant ranges for EtherCAT fieldbus users are:

- 0x1000: This is where fixed identity information for the device is stored, including name, manufacturer, serial number etc., plus information about the current and available process data configurations.
- 0x8000: This is where the operational and functional parameters for all channels are stored, such as filter settings or output frequency.

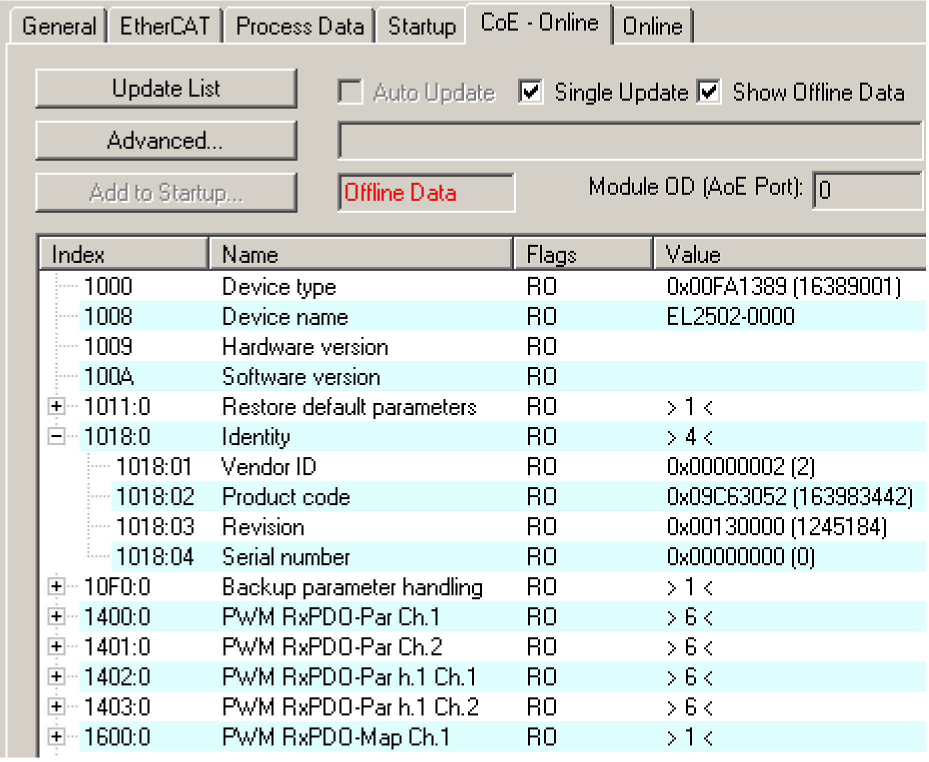
Other important ranges are:

- 0x4000: here are the channel parameters for some EtherCAT devices. Historically, this was the first parameter area before the 0x8000 area was introduced. EtherCAT devices that were previously equipped with parameters in 0x4000 and changed to 0x8000 support both ranges for compatibility reasons and mirror internally.
- 0x6000: Input PDOs (“inputs” from the perspective of the EtherCAT master)
- 0x7000: Output PDOs (“outputs” from the perspective of the EtherCAT master)

**Availability**

Not every EtherCAT device must have a CoE list. Simple I/O modules without dedicated processor usually have no variable parameters and therefore no CoE list.

If a device has a CoE list, it is shown in the TwinCAT System Manager as a separate tab with a listing of the elements:



□ Auto Update ☑ Single Update ☑ Show Offline Data

Module OD (AoE Port): 0

| Index | Name | Flags | Value |
|---|---|---|---|
| 1000 | Device type | RO | 0x00FA1389 (16389001) |
| 1008 | Device name | RO | EL2502-0000 |
| 1009 | Hardware version | RO | |
| 100A | Software version | RO | |
| + 1011:0 | Restore default parameters | RO | > 1 < |
| − 1018:0 | Identity | RO | > 4 < |
| 1018:01 | Vendor ID | RO | 0x00000002 (2) |
| 1018:02 | Product code | RO | 0x09C63052 (163983442) |
| 1018:03 | Revision | RO | 0x00130000 (1245184) |
| 1018:04 | Serial number | RO | 0x00000000 (0) |
| + 10F0:0 | Backup parameter handling | RO | > 1 < |
| + 1400:0 | PWM RxPDO-Par Ch.1 | RO | > 6 < |
| + 1401:0 | PWM RxPDO-Par Ch.2 | RO | > 6 < |
| + 1402:0 | PWM RxPDO-Par h.1 Ch.1 | RO | > 6 < |
| + 1403:0 | PWM RxPDO-Par h.1 Ch.2 | RO | > 6 < |
| + 1600:0 | PWM RxPDO-Map Ch.1 | RO | > 1 < |

Fig. 11: “CoE Online” tab

The figure “’CoE Online’ tab” shows the CoE objects available in device “EL2502”, ranging from 0x1000 to 0x1600. The subindices for 0x1018 are expanded.

**NOTICE**

**Changes in the CoE directory (CAN over EtherCAT directory), program access**

When using/manipulating the CoE parameters observe the general CoE notes in chapter "CoE interface" of the EtherCAT system documentation:

- Keep a startup list if components have to be replaced,
- Distinction between online/offline dictionary,
- Existence of current XML description (download from the Beckhoff website),
- "CoE-Reload" for resetting the changes
- Program access during operation via PLC (see TwinCAT3 | PLC Library: Tc2_EtherCAT and Example program R/W CoE)

### Data management and function “NoCoeStorage”

Some parameters, particularly the setting parameters of the slave, are configurable and writeable,

- via the System Manager (Fig. “CoE Online” tab) by clicking.
  This is useful for commissioning of the system or slaves. Click on the row of the index to be parameterized and enter a value in the “SetValue” dialog.
- from the control system or PLC via ADS, e.g. through blocks from the TcEtherCAT.lib library.
  This is recommended for modifications while the system is running or if no System Manager or operating staff are available.

### Data management

If slave CoE parameters are modified online, Beckhoff devices store any changes in a fail-safe manner in the EEPROM, i.e. the modified CoE parameters are still available after a restart.
The situation may be different with other manufacturers.

An EEPROM is subject to a limited lifetime with respect to write operations. From typically 100,000 write operations onwards it can no longer be guaranteed that new (changed) data are reliably saved or are still readable. This is irrelevant for normal commissioning. However, if CoE parameters are continuously changed via ADS at machine runtime, it is quite possible for the lifetime limit to be reached. Support for the NoCoeStorage function, which suppresses the saving of changed CoE values, depends on the firmware version.
Please refer to the technical data in this documentation as to whether this applies to the respective device.

- If the function is supported: the function is activated by entering the code word 0x12345678 once in CoE index 0xF008 and remains active as long as the code word is not changed. After switching the device on it is then inactive. Changed CoE values are not saved in the EEPROM and can thus be changed any number of times.
- If the function is not supported: continuous changing of CoE values is not permissible in view of the lifetime limit.

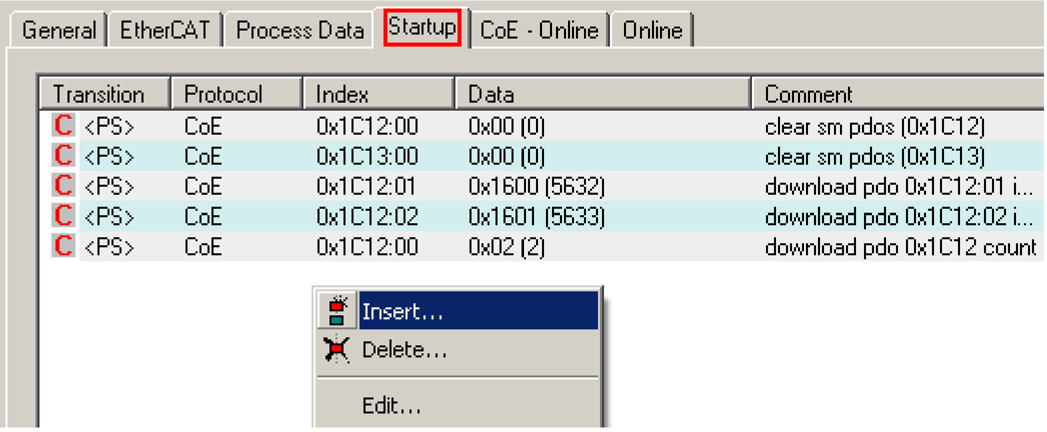
### Startup list

Changes in the local CoE list of the terminal are lost if the terminal is replaced. If a terminal is replaced with a new Beckhoff terminal, it will have the default settings. It is therefore advisable to link all changes in the CoE list of an EtherCAT slave with the Startup list of the slave, which is processed whenever the EtherCAT fieldbus is started. In this way a replacement EtherCAT slave can automatically be parameterized with the specifications of the user.

If EtherCAT slaves are used which are unable to store local CoE values permanently, the Startup list must be used.

### Recommended approach for manual modification of CoE parameters

- Make the required change in the System Manager
  (the values are stored locally in the EtherCAT slave).
- If the value is to be stored permanently, enter it in the Startup list.
  The order of the Startup entries is usually irrelevant.



| Transition | Protocol | Index | Data | Comment |
|---|---|---|---|---|
| C <PS> | CoE | 0x1C12:00 | 0x00 (0) | clear sm pdos (0x1C12) |
| C <PS> | CoE | 0x1C13:00 | 0x00 (0) | clear sm pdos (0x1C13) |
| C <PS> | CoE | 0x1C12:01 | 0x1600 (5632) | download pdo 0x1C12:01 i... |
| C <PS> | CoE | 0x1C12:02 | 0x1601 (5633) | download pdo 0x1C12:02 i... |
| C <PS> | CoE | 0x1C12:00 | 0x02 (2) | download pdo 0x1C12 count |

Fig. 12: Startup list in the TwinCAT System Manager

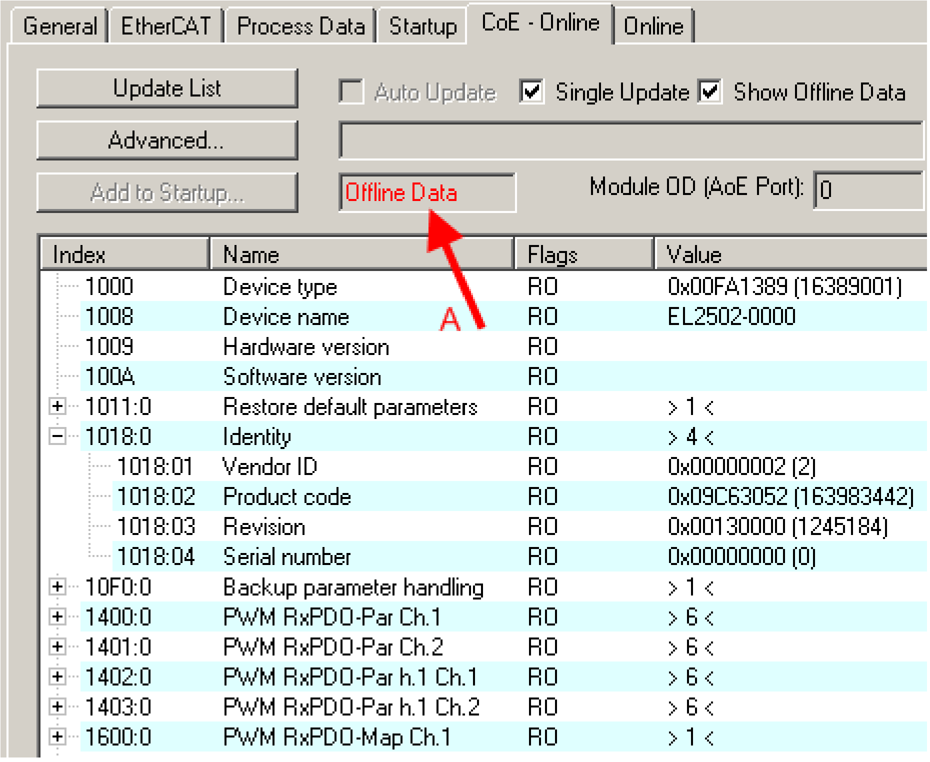
The Startup list may already contain values that were configured by the System Manager based on the ESI specifications. Additional application-specific entries can also be created.

### Online / offline list

When working with the TwinCAT System Manager, a distinction must be made as to whether the EtherCAT device is currently "available", i.e. switched on and connected via EtherCAT - i.e. **online** - or whether a configuration is created **offline** without slaves being connected.

In both cases a CoE list as shown in Fig. “CoE online tab” is displayed. The connectivity is shown as offline/ online.

- If the slave is offline:
    - The offline list from the ESI file is displayed. In this case modifications are not meaningful or possible.
    - The configured status is shown under Identity.
    - No firmware or hardware version is displayed since these are features of the physical device.
    - **Offline Data** is shown in red.



□ Auto Update ☑ Single Update ☑ Show Offline Data

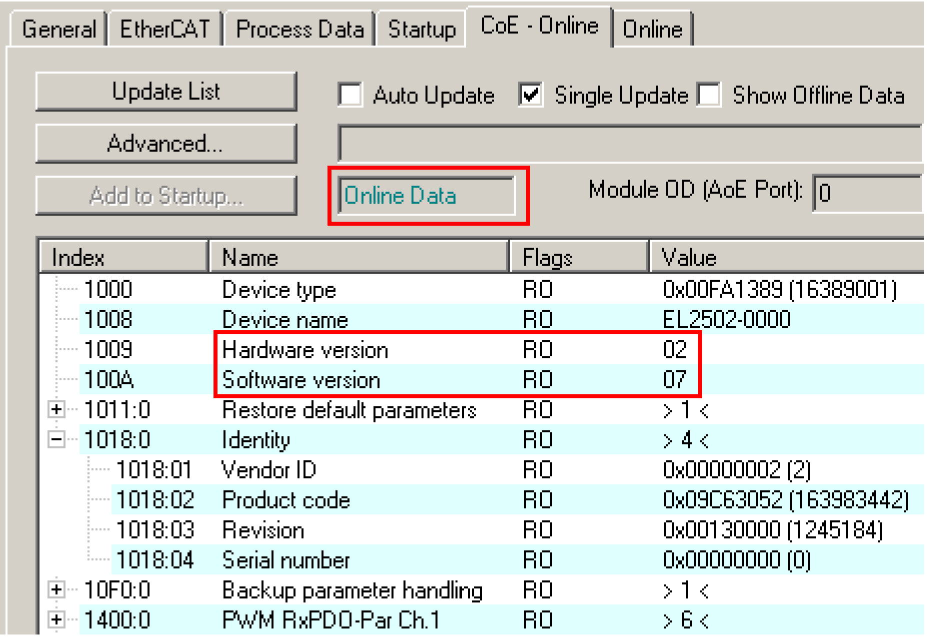
Offline Data

Module OD (AoE Port): 0

| Index | Name | Flags | Value |
|---|---|---|---|
| 1000 | Device type | RO | 0x00FA1389 (16389001) |
| 1008 | Device name | RO | EL2502-0000 |
| 1009 | Hardware version | RO | |
| 100A | Software version | RO | |
| + 1011:0 | Restore default parameters | RO | > 1 < |
| − 1018:0 | Identity | RO | > 4 < |
| 1018:01 | Vendor ID | RO | 0x00000002 (2) |
| 1018:02 | Product code | RO | 0x09C63052 (163983442) |
| 1018:03 | Revision | RO | 0x00130000 (1245184) |
| 1018:04 | Serial number | RO | 0x00000000 (0) |
| + 10F0:0 | Backup parameter handling | RO | > 1 < |
| + 1400:0 | PWM RxPDO-Par Ch.1 | RO | > 6 < |
| + 1401:0 | PWM RxPDO-Par Ch.2 | RO | > 6 < |
| + 1402:0 | PWM RxPDO-Par h.1 Ch.1 | RO | > 6 < |
| + 1403:0 | PWM RxPDO-Par h.1 Ch.2 | RO | > 6 < |
| + 1600:0 | PWM RxPDO-Map Ch.1 | RO | > 1 < |

Fig. 13: Offline list

- If the slave is online:
    - The actual current slave list is read. This may take several seconds, depending on the size and cycle time.
    - The actual identity is displayed.
    - The firmware and hardware status of the device is displayed in the CoE.
    - **Online Data** is shown in green.



☐ Auto Update ☑ Single Update ☐ Show Offline Data

Module OD (AoE Port): 0

| Index | Name | Flags | Value |
|---|---|---|---|
| 1000 | Device type | RO | 0x00FA1389 (16389001) |
| 1008 | Device name | RO | EL2502-0000 |
| 1009 | Hardware version | RO | 02 |
| 100A | Software version | RO | 07 |
| + 1011:0 | Restore default parameters | RO | > 1 < |
| − 1018:0 | Identity | RO | > 4 < |
| 1018:01 | Vendor ID | RO | 0x00000002 (2) |
| 1018:02 | Product code | RO | 0x09C63052 (163983442) |
| 1018:03 | Revision | RO | 0x00130000 (1245184) |
| 1018:04 | Serial number | RO | 0x00000000 (0) |
| + 10F0:0 | Backup parameter handling | RO | > 1 < |
| + 1400:0 | PWM RxPDO-Par Ch.1 | RO | > 6 < |

Fig. 14: Online list

### Channel-based order

The CoE list is available in EtherCAT devices that usually feature several functionally equivalent channels, for example, a 4-channel analog input terminal also has four logical channels and therefore four identical sets of parameter data for the channels. In order to avoid having to list each channel in the documentation, the placeholder “n” tends to be used for the individual channel numbers.

In the CoE system 16 indices, each with 255 subindices, are generally sufficient for representing all channel parameters. The channel-based order is therefore arranged in $16_{dec}$ or $10_{hex}$ steps. The parameter range 0x8000 exemplifies this:

- Channel 0: parameter range 0x8000:00 ... 0x800F:255
- Channel 1: parameter range 0x8010:00 ... 0x801F:255
- Channel 2: parameter range 0x8020:00 ... 0x802F:255
- ...

This is generally written as 0x80n0.

Detailed information on the CoE interface can be found in the EtherCAT system documentation on the Beckhoff website.

## 3.6 Distributed Clock

The distributed clock represents a local clock in the EtherCAT slave controller (ESC) with the following characteristics:

- Unit *1 ns*
- Zero point *1.1.2000 00:00*
- Size *64 bit* (sufficient for the next 584 years; however, some EtherCAT slaves only offer 32-bit support, i.e. the variable overflows after approx. 4.2 seconds)
- The EtherCAT master automatically synchronizes the local clock with the master clock in the EtherCAT bus with a precision of < 100 ns.

For detailed information please refer to the EtherCAT system description.

# 4 Installation

## 4.1 Instructions for ESD protection

*NOTICE*

**Destruction of the devices by electrostatic discharge possible!**

The devices contain components at risk from electrostatic discharge caused by improper handling.

- When handling the components, ensure that there is no electrostatic discharge; also avoid touching the spring contacts directly (see illustration).
- Contact with highly insulating materials (synthetic fibers, plastic films, etc.) should be avoided when handling components at the same time.
- When handling the components, ensure that the environment (workplace, packaging and persons) is properly earthed.
- Each bus station must be terminated on the right-hand side with the EL9011 or EL9012 end cap to ensure the degree of protection and ESD protection.

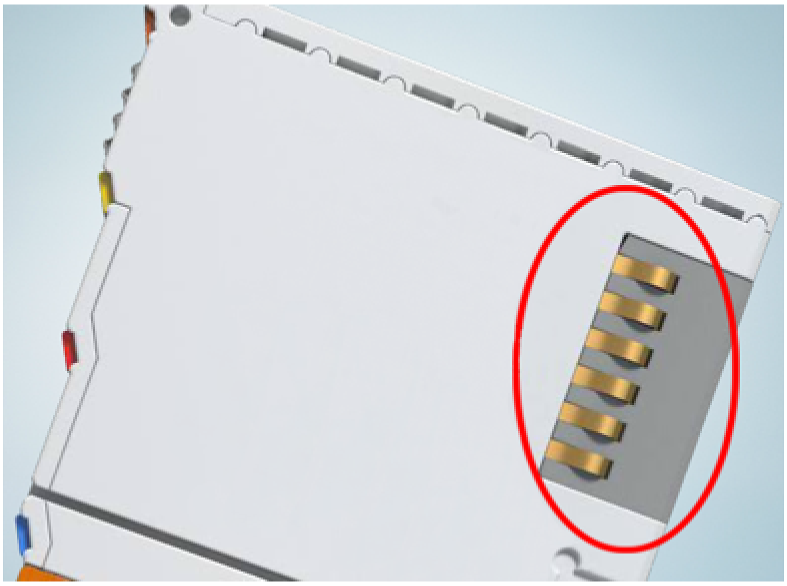


Fig. 15: Spring contacts of the Beckhoff I/O components

## 4.2 Installation on mounting rails

**⚠ WARNING**

**Risk of electric shock and damage of device!**

Bring the bus terminal system into a safe, powered down state before starting installation, disassembly or wiring of the bus terminals!

The Bus Terminal system and is designed for mounting in a control cabinet or terminal box.

**Assembly**

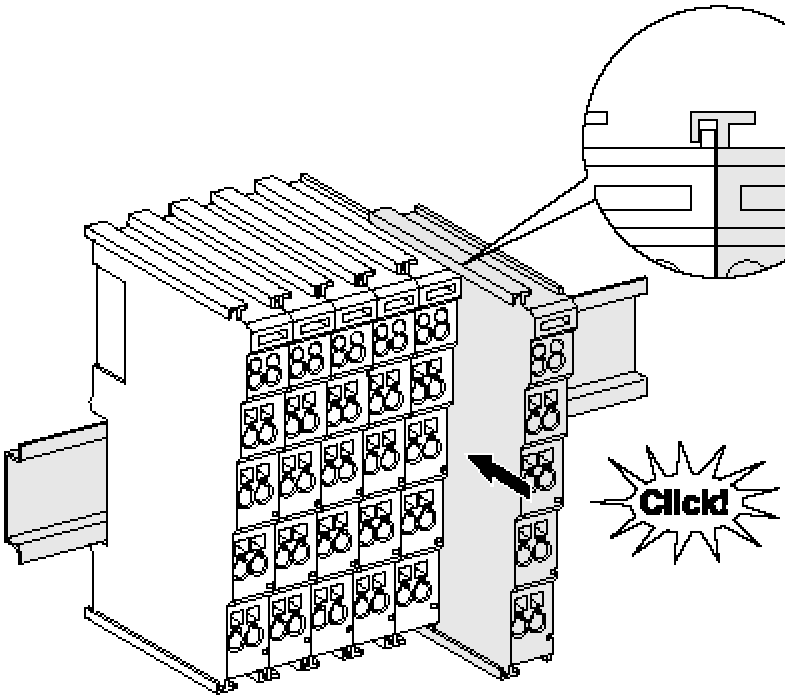


Fig. 16: Attaching on mounting rail

The bus coupler and bus terminals are attached to commercially available 35 mm mounting rails (DIN rails according to EN 60715) by applying slight pressure:

1. First attach the fieldbus coupler to the mounting rail.
2. The bus terminals are now attached on the right-hand side of the fieldbus coupler. Join the components with tongue and groove and push the terminals against the mounting rail, until the lock clicks onto the mounting rail.
   If the terminals are clipped onto the mounting rail first and then pushed together without tongue and groove, the connection will not be operational! When correctly assembled, no significant gap should be visible between the housings.

**Fixing of mounting rails**

The locking mechanism of the terminals and couplers extends to the profile of the mounting rail. At the installation, the locking mechanism of the components must not come into conflict with the fixing bolts of the mounting rail. To mount the mounting rails with a height of 7.5 mm under the terminals and couplers, you should use flat mounting connections (e.g. countersunk screws or blind rivets).

### Disassembly

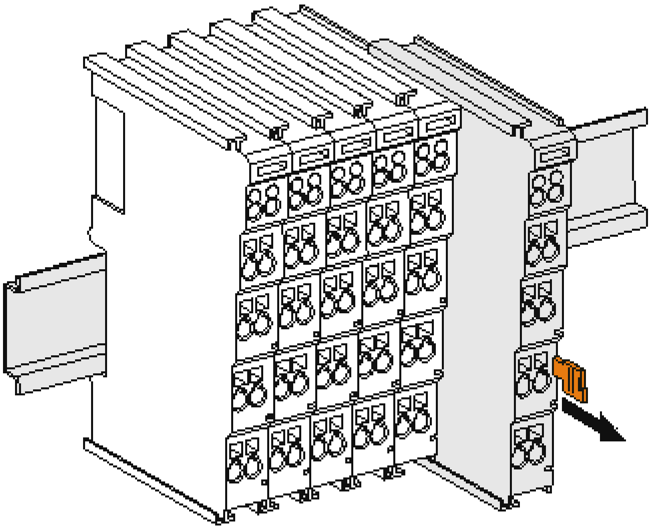


Fig. 17: Disassembling of terminal

Each terminal is secured by a lock on the mounting rail, which must be released for disassembly:

1. Pull the terminal by its orange-colored lugs approximately 1 cm away from the mounting rail. In doing so for this terminal the mounting rail lock is released automatically and you can pull the terminal out of the bus terminal block easily without excessive force.
2. Grasp the released terminal with thumb and index finger simultaneous at the upper and lower grooved housing surfaces and pull the terminal out of the bus terminal block.

### Connections within a bus terminal block

The electric connections between the Bus Coupler and the Bus Terminals are automatically realized by joining the components:

- The six spring contacts of the K-Bus/E-Bus deal with the transfer of the data and the supply of the Bus Terminal electronics.
- The power contacts deal with the supply for the field electronics and thus represent a supply rail within the bus terminal block. The power contacts are supplied via terminals points on the Bus Coupler (up to 24 V) or for higher voltages via power feed terminals.

**Power Contacts**

During the design of a bus terminal block, the pin assignment of the individual Bus Terminals must be taken account of, since some types (e.g. analog Bus Terminals or digital 4-channel Bus Terminals) do not or not fully loop through the power contacts. Power Feed Terminals (KL91xx, KL92xx or EL91xx, EL92xx) interrupt the power contacts and thus represent the start of a new supply rail.

### PE power contact

The power contact labeled PE can be used as a protective earth. For safety reasons this contact mates first when plugging together, and can ground short-circuit currents of up to 125 A.

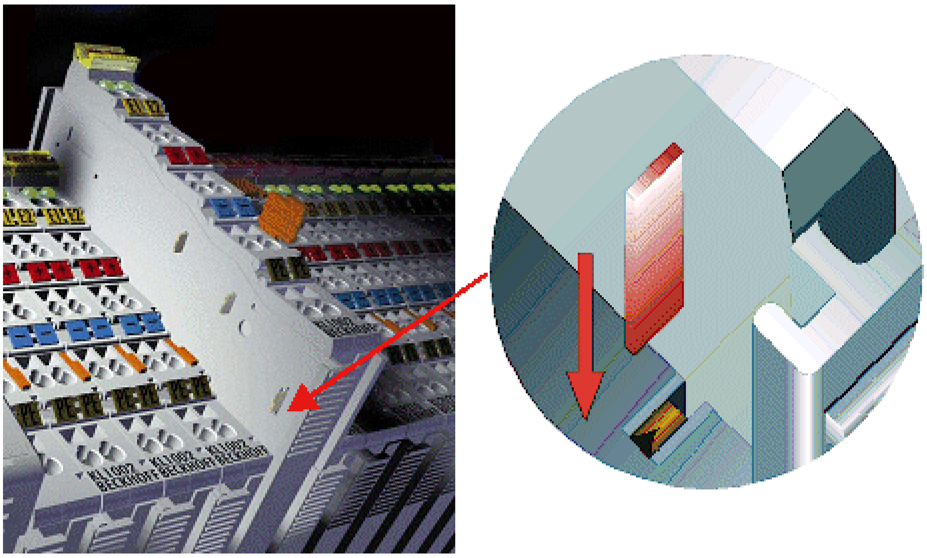


Fig. 18: Power contact on left side

**NOTICE**

**Possible damage of the device**

Note that, for reasons of electromagnetic compatibility, the PE contacts are capacitatively coupled to the mounting rail. This may lead to incorrect results during insulation testing or to damage on the terminal (e.g. disruptive discharge to the PE line during insulation testing of a consumer with a nominal voltage of 230 V). For insulation testing, disconnect the PE supply line at the Bus Coupler or the Power Feed Terminal! In order to decouple further feed points for testing, these Power Feed Terminals can be released and pulled at least 10 mm from the group of terminals.

**⚠ WARNING**

**Risk of electric shock!**

The PE power contact must not be used for other potentials!

## 4.3 Installation instructions for enhanced mechanical load capacity

⚠ **WARNING**

**Risk of injury through electric shock and damage to the device!**

Bring the Bus Terminal system into a safe, de-energized state before starting mounting, disassembly or wiring of the Bus Terminals!

### Additional checks

The terminals have undergone the following additional tests:

| Verification | Explanation |
|---|---|
| Vibration | 10 frequency runs in 3 axes |
| | 6 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 |
| | 25 *g*, 6 ms |

### Additional installation instructions and notes

For terminals with enhanced mechanical load capacity, the following additional installation instructions and notes apply:

- The enhanced mechanical load capacity is valid for all permissible installation positions.
- Use a mounting rail according to EN 60715 TH35-15.
- Fix the terminal segment on both sides of the mounting rail with a mechanical fixture, e.g. an earth terminal or reinforced end clamp.
- The maximum total extension of the terminal segment (without coupler) is:
  64 terminals (12 mm mounting width) or 32 terminals (24 mm mounting width)
- Avoid deformation, twisting, crushing and bending of the mounting rail during edging and installation of the rail.
- The mounting points of the mounting rail must be set at 5 cm intervals.
- Use countersunk head screws to fasten the mounting rail.
- The free length between the strain relief and the wire connection should be kept as short as possible. A distance of approx. 10 cm should be maintained to the cable duct.

# 4.4 Connection

## 4.4.1 Connection system

⚠ WARNING

**Risk of electric shock and damage of device!**

Bring the bus terminal system into a safe, powered down state before starting installation, disassembly or wiring of the bus terminals!

### Overview

The bus terminal system offers different connection options for optimum adaptation to the respective application:

- The terminals of ELxxxx and KLxxxx series with standard wiring include electronics and connection level in a single enclosure.
- The terminals of ESxxxx and KSxxxx series feature a pluggable connection level and enable steady wiring while replacing.
- The High Density Terminals (HD Terminals) include electronics and connection level in a single enclosure and have advanced packaging density.

### Standard wiring (ELxxxx / KLxxxx)

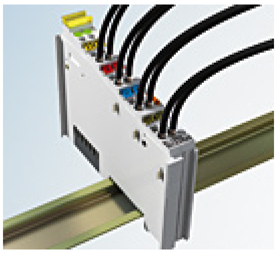


Fig. 19: Standard wiring

The terminals of the ELxxxx and KLxxxx series integrate screwless spring-cage technology for quick and easy wiring.

### Pluggable wiring (ESxxxx / KSxxxx)

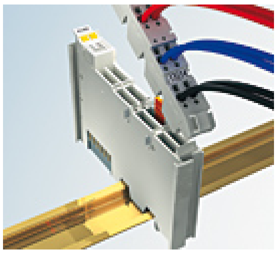


Fig. 20: Pluggable wiring

The terminals of ESxxxx and KSxxxx series feature a pluggable connection level.
The assembly and wiring procedure is the same as for the ELxxxx and KLxxxx series.
The pluggable connection level enables the complete wiring to be removed as a plug connector from the top of the housing for servicing.
The lower section can be removed from the terminal block by pulling the unlocking tab.
Insert the new component and plug in the connector with the wiring. This reduces the installation time and eliminates the risk of wires being mixed up.

The familiar dimensions of the terminal only had to be changed slightly. The new connector adds about 3 mm. The maximum height of the terminal remains unchanged.

A tab for strain relief of the cable simplifies assembly in many applications and prevents tangling of individual connection wires when the connector is removed.

Conductor cross sections between 0.08 mm$^2$ and 2.5 mm$^2$ can continue to be used with the proven spring force technology.

The overview and nomenclature of the product names for ESxxxx and KSxxxx series has been retained as known from ELxxxx and KLxxxx series.

### High Density Terminals (HD Terminals)

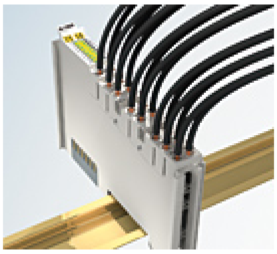


Fig. 21: High Density Terminals

The terminals from these series with 16 terminal points are distinguished by a particularly compact design, as the packaging density is twice as large as that of the standard 12 mm bus terminals. Massive conductors and conductors with a wire end sleeve can be inserted directly into the spring loaded terminal point without tools.

**Wiring HD Terminals**

The High Density Terminals of the ELx8xx and KLx8xx series doesn't support pluggable wiring.

### Ultrasonically compacted (ultrasonically welded) strands

**Ultrasonically compacted (ultrasonically welded) strands**

Ultrasonically compacted (ultrasonically welded) strands can also be connected to the standard and high-density terminals. In this case, please note the tables concerning the wire-size width [▶ 42]!

## 4.4.2 Wiring

**⚠ WARNING**

**Risk of electric shock and damage of device!**

Bring the bus terminal system into a safe, powered down state before starting installation, disassembly or wiring of the bus terminals!

**Terminals for standard wiring ELxxxx/KLxxxx and for pluggable wiring ESxxxx/KSxxxx**

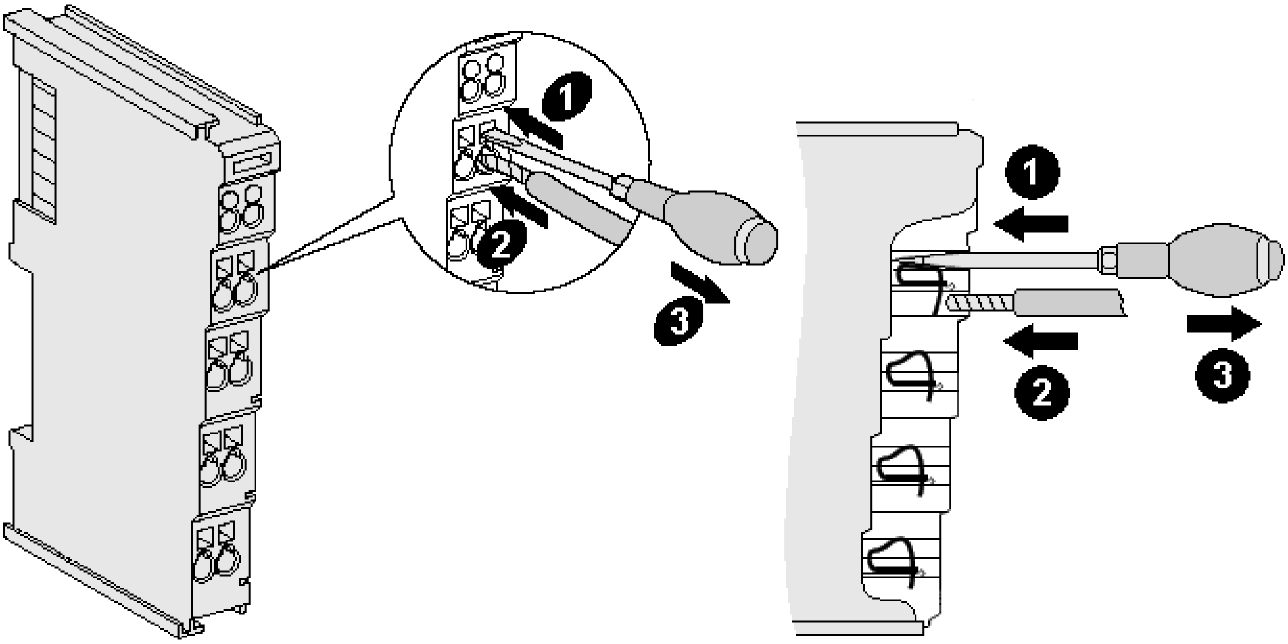


Fig. 22: Connecting a cable on a terminal point

Up to eight terminal points enable the connection of solid or finely stranded cables to the bus terminal. The terminal points are implemented in spring force technology. Connect the cables as follows (see fig. “Connecting a cable on a terminal point”:

1. Open a terminal point by pushing a screwdriver straight against the stop into the square opening above the terminal point. Do not turn the screwdriver or move it alternately (don't toggle).
2. The wire can now be inserted into the round terminal opening without any force.
3. When the screwdriver is removed, the terminal point closes automatically and holds the wire securely and permanently in place

See the following table for the suitable wire size width:

| Terminal housing | ELxxxx, KLxxxx | ESxxxx, KSxxxx |
|---|---|---|
| Wire size width (single core wires) | 0.08 ... 2.5 mm$^2$ | 0.08 ... 2.5 mm$^2$ |
| Wire size width (fine-wire conductors) | 0.08 ... 2.5 mm$^2$ | 0.08 ... 2.5 mm$^2$ |
| Wire size width (conductors with a wire end sleeve) | 0.14 ... 1.5 mm$^2$ | 0.14 ... 1.5 mm$^2$ |
| Wire stripping length | 8 ... 9 mm | 9 ... 10 mm |

### High Density Terminals (HD Terminals [▶ 40]) with 16 terminal points

The conductors of the HD Terminals are connected without tools for single-wire conductors using the direct plug-in technique, i.e. after stripping the wire is simply plugged into the terminal point. The cables are released, as usual, using the contact release with the aid of a screwdriver. See the following table for the suitable wire size width.

| Terminal housing | High Density Housing |
|---|---|
| Wire size width (single core wires) | 0.08 ... 1.5 mm$^2$ |
| Wire size width (fine-wire conductors) | 0.25 ... 1.5 mm$^2$ |
| Wire size width (conductors with a wire end sleeve) | 0.14 ... 0.75 mm$^2$ |
| Wire size width (ultrasonically compacted [ultrasonically welded] strands) | only 1.5 mm$^2$ (see notice [▶ 40]) |
| Wire stripping length | 8 ... 9 mm |

## 4.4.3 Shielding

**Shielding**

Feedback signal, sensors and actuators should always be connected with shielded, twisted paired wires.

## 4.5 Note - power supply

⚠ 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.

## 4.6 Note on load voltage supply

⚠ WARNING

**Load voltage supply**

Some devices permit an additional load voltage, e.g. 48 V DC, to be connected for the operation of a motor. In order to avoid stray currents on the protective conductor during operation, EN 60204-1:2018 provides for the possibility that the negative pole of the load voltage does not necessarily have to be connected to the protective conductor system (SELV).
Therefore, the load voltage supply should be designed as an SELV supply.

## 4.7 Positioning of passive Terminals

**Hint for positioning of passive terminals in the bus terminal block**

EtherCAT Terminals (ELxxxx / ESxxxx), which do not take an active part in data transfer within the bus terminal block are so called passive terminals. The passive terminals have no current consumption out of the E-Bus.

To ensure an optimal data transfer, you must not directly string together more than two passive terminals!

**Examples for positioning of passive terminals (highlighted)**

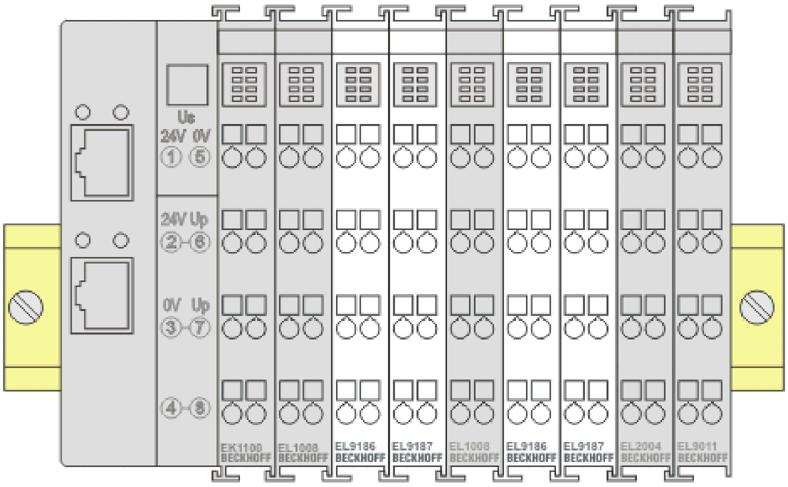


Fig. 23: Correct positioning

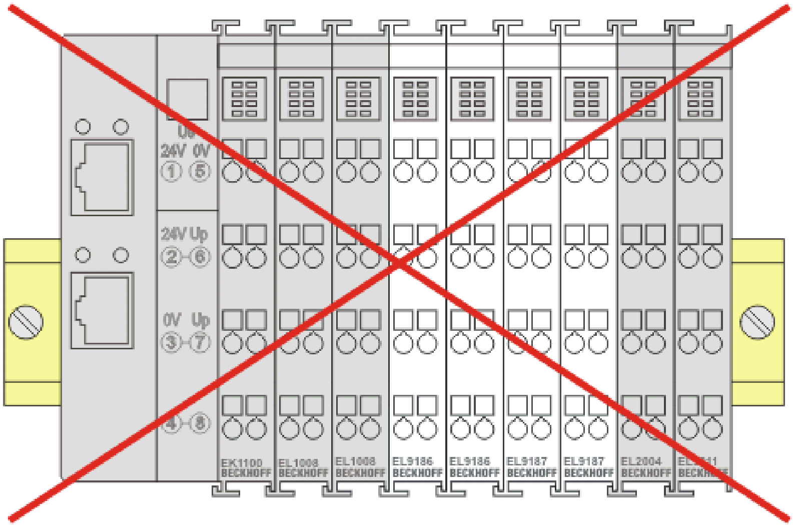


Fig. 24: Incorrect positioning

## 4.8 Installation position for operation with or without fan

**NOTICE**

**Constraints regarding installation position and operating temperature range**

When installing the terminals ensure that an adequate spacing is maintained between other components above and below the terminal in order to guarantee adequate ventilation!

### Prescribed installation position for operation without fan

The prescribed installation position requires the mounting rail to be installed horizontally and the connection surfaces of the EL/KL terminals to face forward (see Fig. "*Recommended distances of installation position for operating without fan*").

The terminals are ventilated from below, which enables optimum cooling of the electronics through convection.

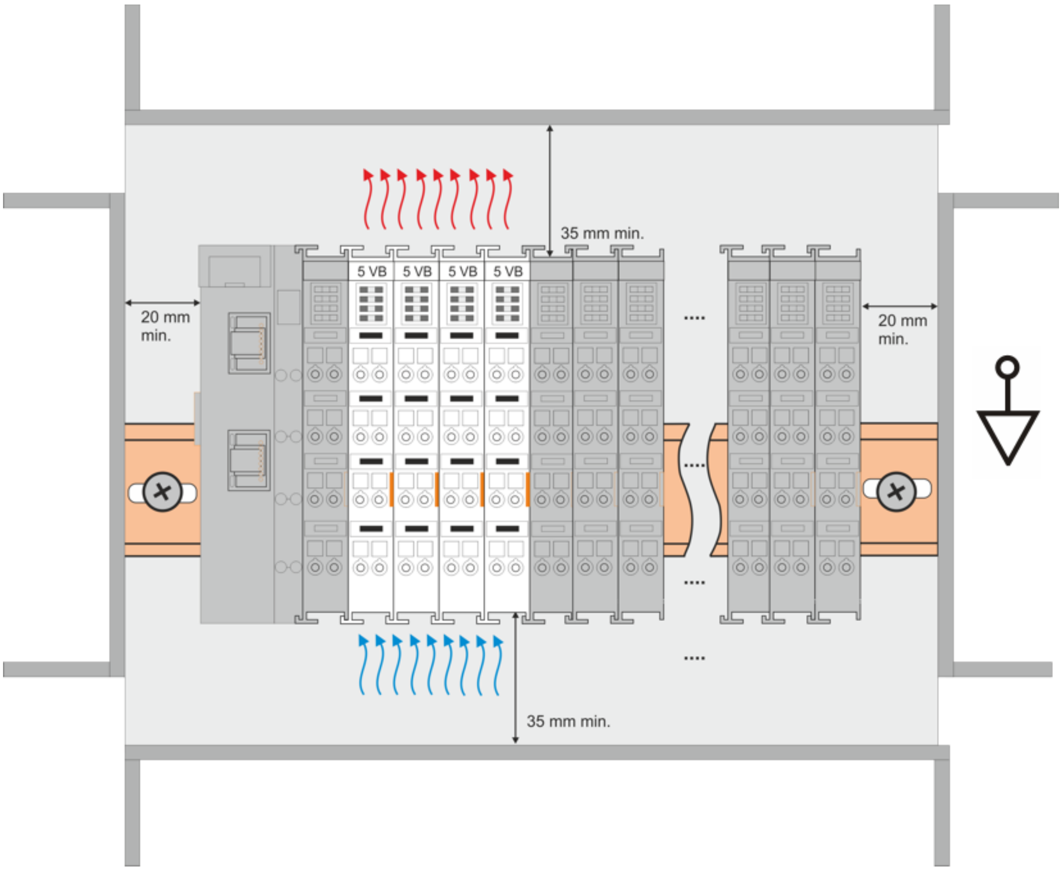


Fig. 25: Recommended distances of installation position for operating without fan

Compliance with the distances shown in Fig. "*Recommended distances of installation position for operating without fan*" is recommended.

For further information regarding the operation without fan refer to the Technical Data of the terminal.

### Standard installation position for operation with fan

The standard installation position for operation with fan requires the mounting rail to be installed horizontally and the connection surfaces of the EL/KL terminals to face forward (see Fig. *Recommended distances for installation position for operation with fan*).
The terminals are ventilated fan supported (e.g. with ZB8610 fan cartridge) from below.

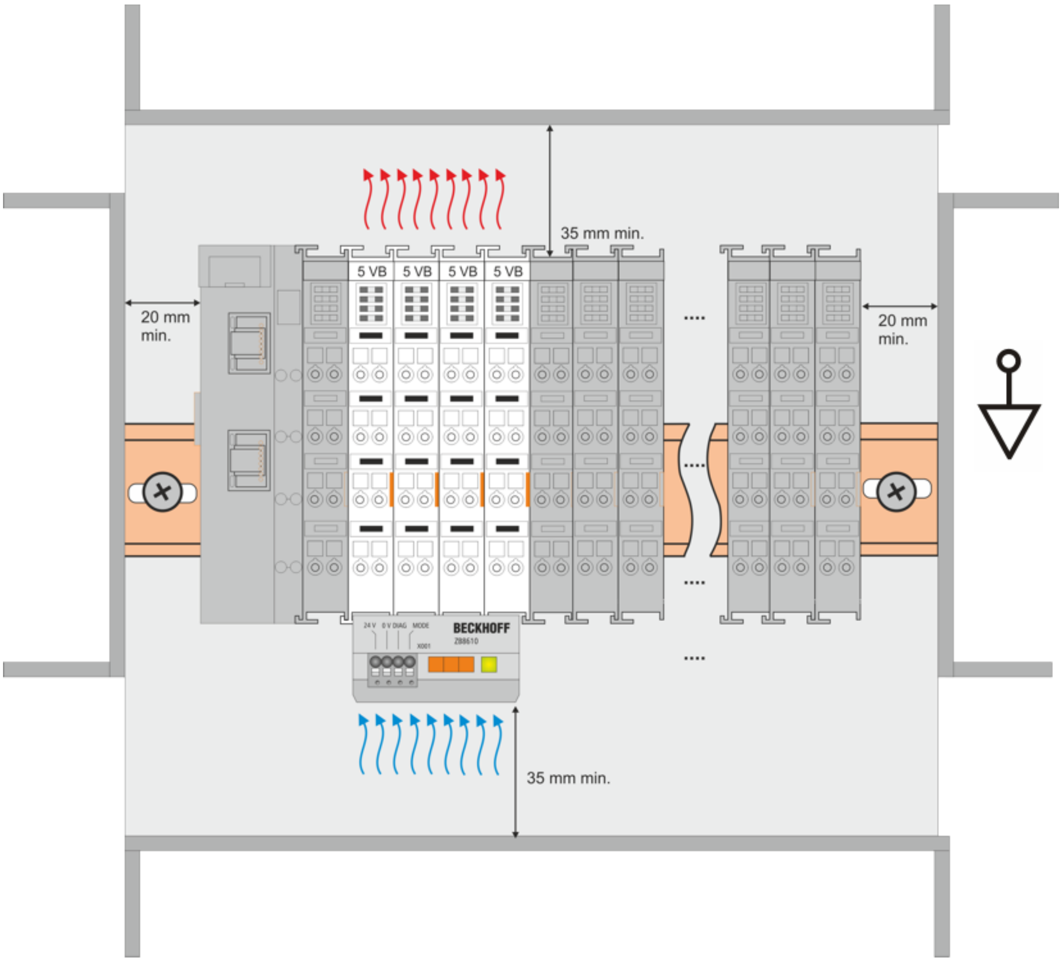


Fig. 26: Recommended distances for installation position for operation with fan

**Other installation positions**

Due to the enforced effect of the fan on the ventilation of the terminals, other installation positions (see Fig. “*Other installation positions, example 1 + 2*“) may be permitted where appropriate.

See corresponding notes in the Technical Data of the terminal.

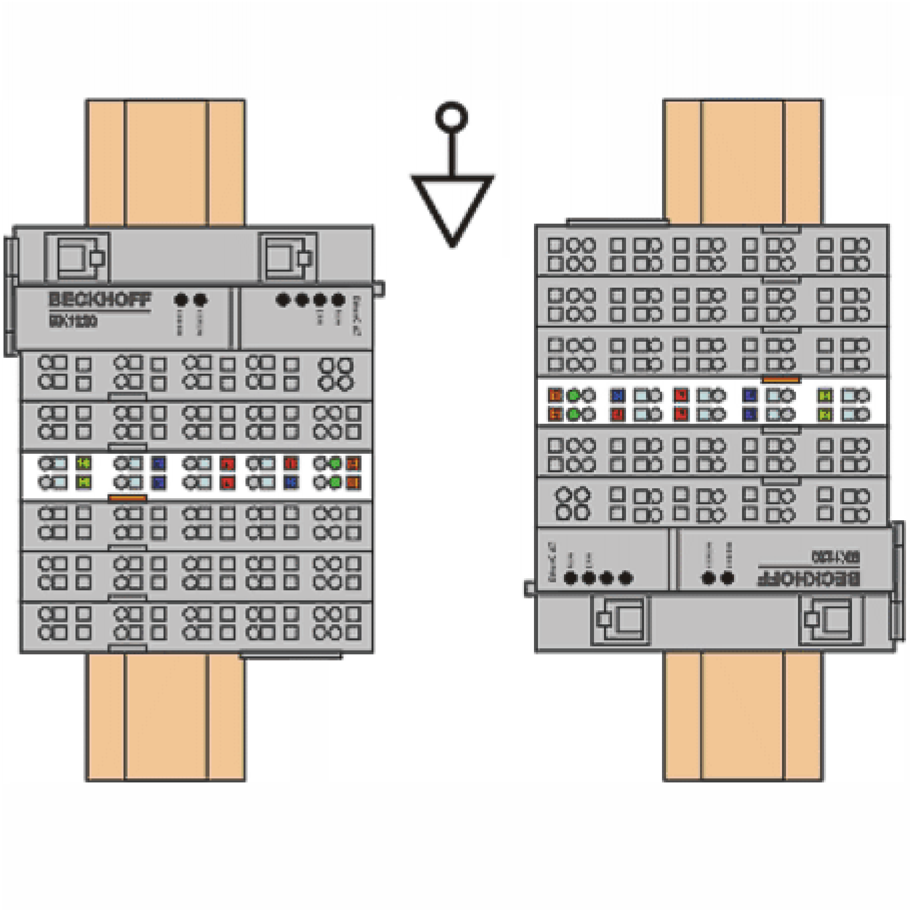


Fig. 27: Other installation positions, example 1

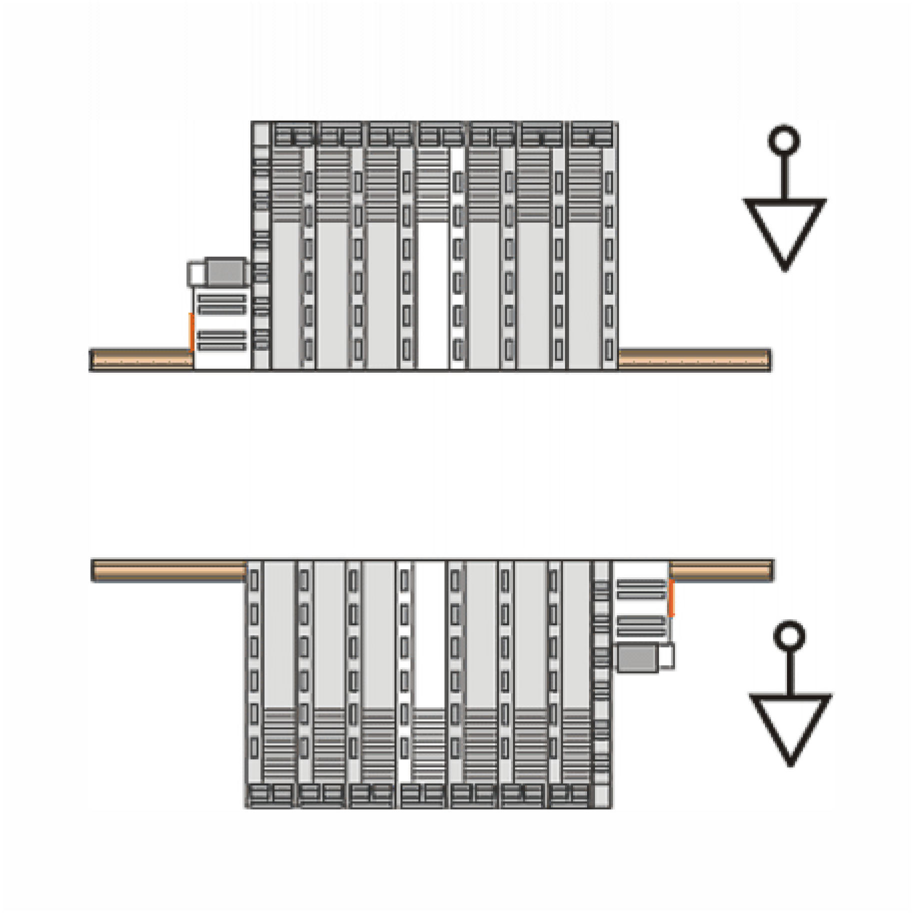


Fig. 28: Other installation positions, example 2

## 4.9 Shielding concept

Together with the shield busbar, the prefabricated cables from Beckhoff Automation offer optimum protection against electromagnetic interference.
It is highly recommended to apply the shield as close as possible to the terminal, in order to minimize operational disturbances.

### Connection of the motor cable to the shield busbar

Fasten the shield busbar supports 1 to the DIN rail 2. The mounting rail 2 must be in contact with the metallic rear wall of the control cabinet over a wide area. Install the shield busbar 3 as shown below.
As an alternative, a shield busbar clamp 3a can be screwed directly to the metallic rear wall of the control cabinet (fig. “shield busbar clamp”)

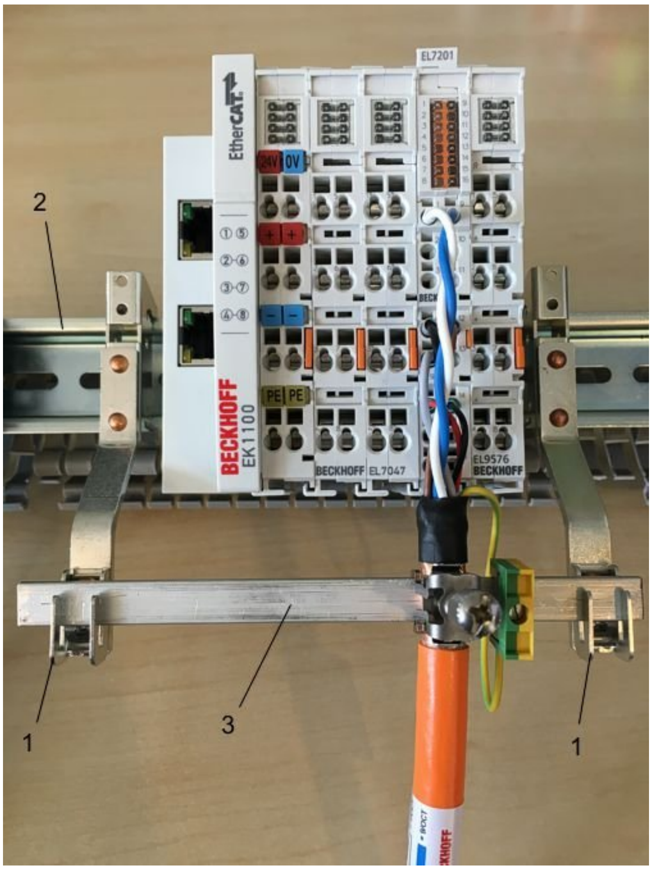


Fig. 29: Shield busbar

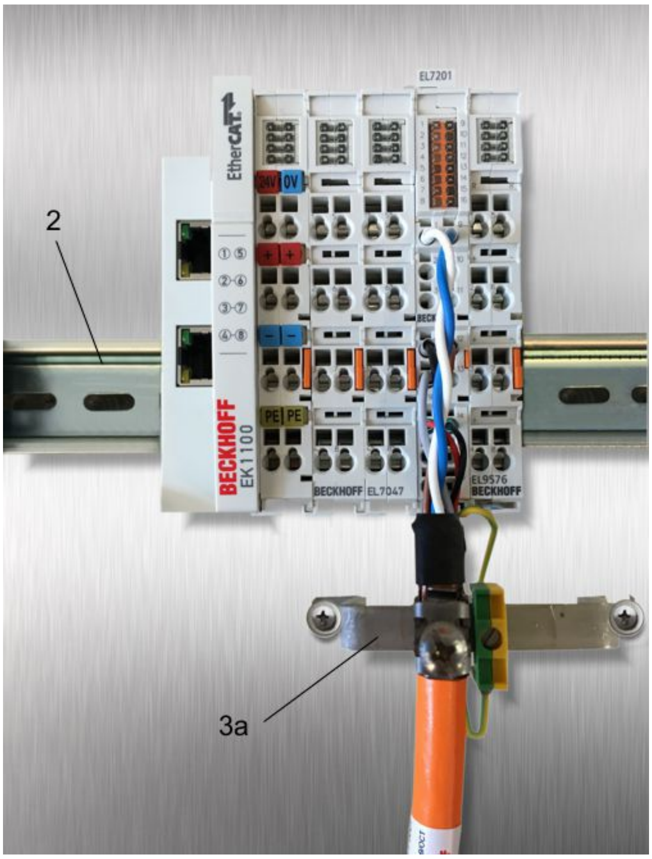


Fig. 30: Shield busbar clamp

Connect the cores 4 of the motor cable 5, then attach the copper-sheathed end 6 of the motor cable 5 with the shield clamp 7 to the shield busbar 3 or shield busbar clamp 3a. Tighten the screw 8 to the stop. Fasten the PE clamp 9 to the shield busbar 3 or shield busbar clamp 3a. Clamp the PE core 10 of the motor cable 5 under the PE clamp 9.

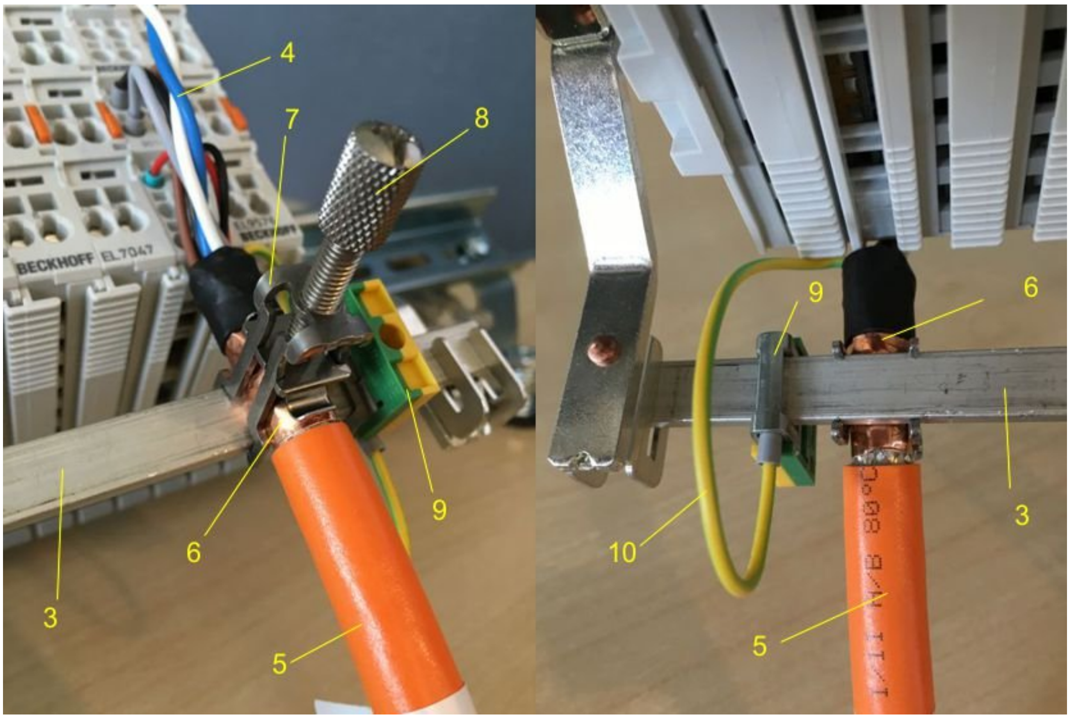


Fig. 31: Shield connection

### Connection of the feedback cable to the motor

**Twisting of the feedback cable cores**

The feedback cable cores should be twisted, in order to avoid operational disturbances.

When screwing the feedback plug to the motor, the shield of the feedback cable is connected via the metallic plug fastener.
On the terminal side the shield can also be connected. Connect the cores of the feedback cable and attach the copper-sheathed end of the feedback cable to the shield busbar 3 or shield busbar clamp 3a with the shield clamp 7. The motor cable and the feedback cable can be connected to the shield clamp 7 with the screw 8.

## 4.10 Notes on current measurements using Hall sensors

The device described in this documentation features one or several integrated Hall sensor for the purpose of current measurements.

During this process, the Hall sensor monitors the magnetic field generated by a current flowing through a conductor.

In order to prevent compromising the measurement we recommend screening exterior magnetic fields from the device, or to keep such fields at an adequate distance.

Fig. 32: Note

**Background**

A current-carrying conductor generates a magnetic field around it according to

$B = \mu_0 * I / (2\pi * d)$

with

B [Tesla] magnetic field

$\mu0 = 4*\pi*10^{-7}$ [H/m] (assumption: no magnetic shielding)

I [A] current

d [m] distance to conductor

**Interference from external magnetic fields**

The magnetic field strength should not exceed a permitted level all around the device.
In practice this equates to a recommended minimum distance between a conductor and the device surface as follows:

- Current 10 A: 12 mm
- Current 20 A: 25 mm
- Current 40 A: 50 mm

Unless specified otherwise in the device documentation, stringing together modules (e.g. terminal blocks based on a 12 mm grid) of same type (e.g. EL2212-0000) is permitted.

## 4.11 LEDs and connection

### 4.11.1 EL7201, EL7201-0001

**LEDs**

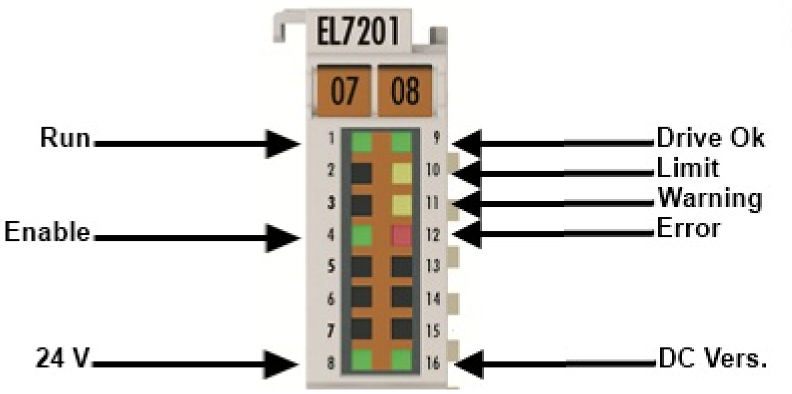


Fig. 33: EL7201, EL7201-0001 - LEDs

| LED | Color | Meaning | |
|---|---|---|---|
| RUN | green | This LED indicates the terminal's operating state: | |
| | | off | State of the EtherCAT State Machine [▸ 84]: **INIT** = initialization of the terminal |
| | | flashing rapidly | State of the EtherCAT State Machine: **BOOTSTRAP** = function for firmware updates [▸ 188] of the terminal |
| | | flashing | State of the EtherCAT State Machine: **PREOP** = function for mailbox communication and different standard-settings set |
| | | single flash | State of the EtherCAT State Machine: **SAFEOP** = verification of the Sync Manager [▸ 84] channels and the distributed clocks.<br>Outputs remain in safe state |
| | | on | State of the EtherCAT State Machine: **OP** = normal operating state; mailbox and process data communication is possible |
| Driver | green | on | Driver stage ready for operation |
| Limit | orange | on | The LED is linked with bit 11 of the status word (MDP742 [▸ 151] / DS402 [▸ 167]) (internal limit active)<br>Limit reached (e.g. torque or speed limit) |
| Warning | orange | on | The LED is linked with bit 7 of the status word (MDP742 [▸ 151] / DS402 [▸ 167]) (warning)<br>The “Warning” threshold value is exceeded.<br>I²T model<br>Temperature (90 °C) exceeded<br>Voltage |
| Enabled | green | on | The LED is linked with the bits 1 and 2 of status word (MDP742 [▸ 151] / DS402 [▸ 167]) (if "Switched on" or "Operation enabled")<br>Driver stage enabled |
| Error | red | on | The LED is linked with bit 3 of the status word (MDP742 [▸ 151] / DS402 [▸ 167]) (fault)<br>The “Error” threshold value is exceeded.<br>Overcurrent<br>Voltage not available<br>Resolver not connected<br>Max. temperature (105 °C) exceeded |
| +24 V via power contacts | green | on | 24 V voltage supply for the terminal is present. |
| DC link supply | green | on | Voltage for the DC link supply is present. |

### Connection

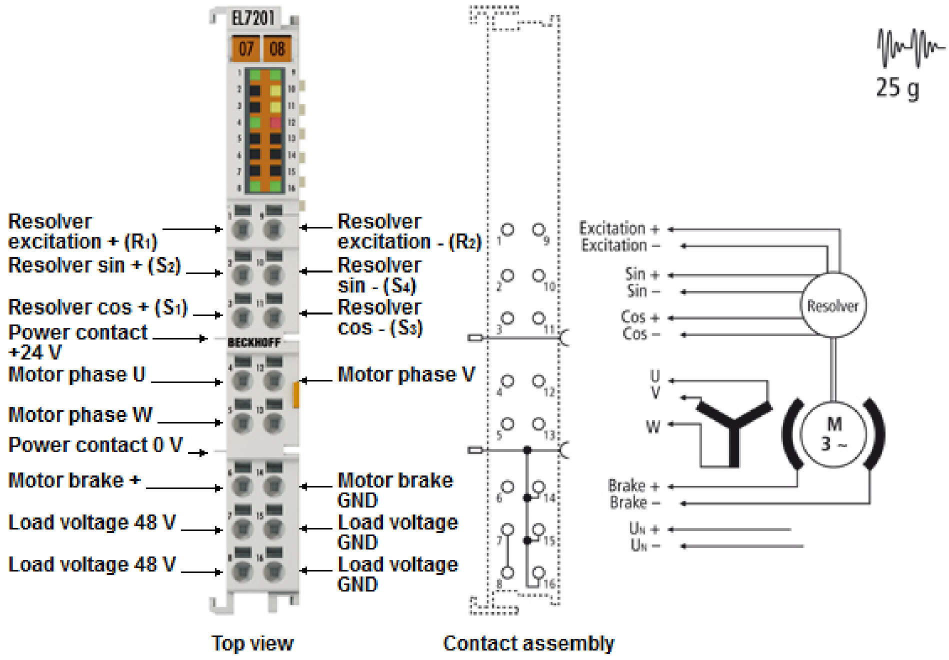


Fig. 34: EL7201, EL7201-0001 connection

## NOTICE

**Fuse protection of the supply voltage**

The electrical protection of the load voltage must be selected in such a way that the maximum flowing current is limited to 3 times the rated current (max. 1 second)!

| Terminal point | Name | Comment |
|---|---|---|
| 1 | Ref + | Resolver excitation + |
| 2 | Sin + | Resolver sine + |
| 3 | Cos + | Resolver cosine + |
| 4 | U | Motor phase U |
| 5 | W | Motor phase W |
| 6 | Brake + | Motor brake + |
| 7 | 48 V | DC link supply + (8 ... 48 V) |
| 8 | 48 V | DC link supply + (8 ... 48 V |
| 9 | Ref - | Resolver excitation - |
| 10 | Sin - | Resolver sine - |
| 11 | Cos - | Resolver cosine - |
| 12 | V | Motor phase V |
| 13 | n.c. | not connected |
| 14 | GND | Motor brake GND |
| 15 | 0 V | DC link 0 V supply |
| 16 | 0 V | DC link 0 V supply |

## 4.11.2 EL7211, EL7211-0001

### LEDs

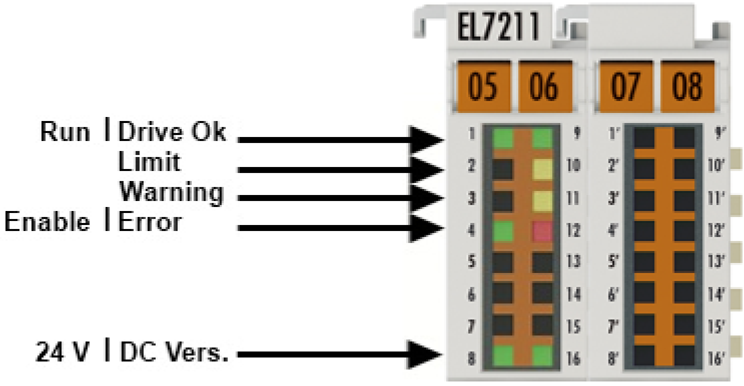


Fig. 35: EL7211, EL7211-0001 - LEDs

| LED | Color | Meaning | |
|---|---|---|---|
| RUN | green | This LED indicates the terminal's operating state: | |
| | | off | State of the EtherCAT State Machine [▶ 84]: **INIT** = initialization of the terminal |
| | | flashing rapidly | State of the EtherCAT State Machine: **BOOTSTRAP** = function for firmware updates [▶ 188] of the terminal |
| | | flashing | State of the EtherCAT State Machine: **PREOP** = function for mailbox communication and different standard-settings set |
| | | single flash | State of the EtherCAT State Machine: **SAFEOP** = verification of the Sync Manager [▶ 84] channels and the distributed clocks.<br>Outputs remain in safe state |
| | | on | State of the EtherCAT State Machine: **OP** = normal operating state; mailbox and process data communication is possible |
| Driver | green | on | Driver stage ready for operation |
| Limit | orange | on | The LED is linked with bit 11 of the status word (MDP742 [▶ 151] / DS402 [▶ 167]) (internal limit active)<br>Limit reached (e.g. torque or speed limit) |
| Warning | orange | on | The LED is linked with bit 7 of the status word (MDP742 [▶ 151] / DS402 [▶ 167]) (warning)<br>The “Warning” threshold value is exceeded.<br>I²T model<br>Temperature (90 °C) exceeded<br>Voltage |
| Enabled | green | on | The LED is linked with the bits 1 and 2 of status word (MDP742 [▶ 151] / DS402 [▶ 167]) (if "Switched on" or "Operation enabled")<br>Driver stage enabled |
| Error | red | on | The LED is linked with bit 3 of the status word (MDP742 [▶ 151] / DS402 [▶ 167]) (fault)<br>The “Error” threshold value is exceeded.<br>Overcurrent<br>Voltage not available<br>Resolver not connected<br>Max. temperature (105 °C) exceeded |
| +24 V via power contacts | green | on | 24 V voltage supply for the terminal is present. |
| DC link supply | green | on | Voltage for the DC link supply is present. |

### Connection

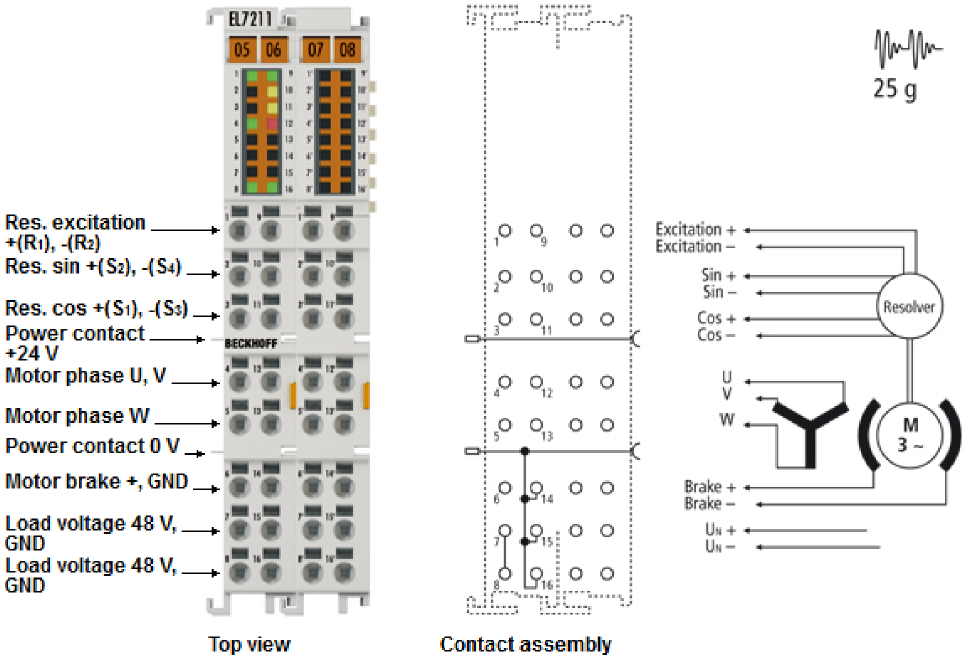


Fig. 36: EL7211, EL7211-0001 connection

**NOTICE**

**Fuse protection of the supply voltage**

The electrical protection of the load voltage must be selected in such a way that the maximum flowing current is limited to 3 times the rated current (max. 1 second)!

| Terminal point | Name | Comment |
|---|---|---|
| 1 | Ref + | Resolver excitation + (R1) |
| 2 | Sin + | Resolver sine + (S2) |
| 3 | Cos + | Resolver cosine + (S1) |
| 4 | U | Motor phase U |
| 5 | W | Motor phase W |
| 6 | Brake + | Motor brake + |
| 7 | 48 V | DC link supply + (8 ... 48 V) |
| 8 | 48 V | DC link supply + (8 ... 48 V) |
| 9 | Ref - | Resolver excitation - (R2) |
| 10 | Sin - | Resolver sine - (S4) |
| 11 | Cos - | Resolver cosine - (S3) |
| 12 | V | Motor phase V |
| 13 | n.c. | not connected |
| 14 | GND | Motor brake GND |
| 15 | 0 V | DC link 0 V supply |
| 16 | 0 V | DC link 0 V supply |
| 1 ' - 16' |  | not connected |

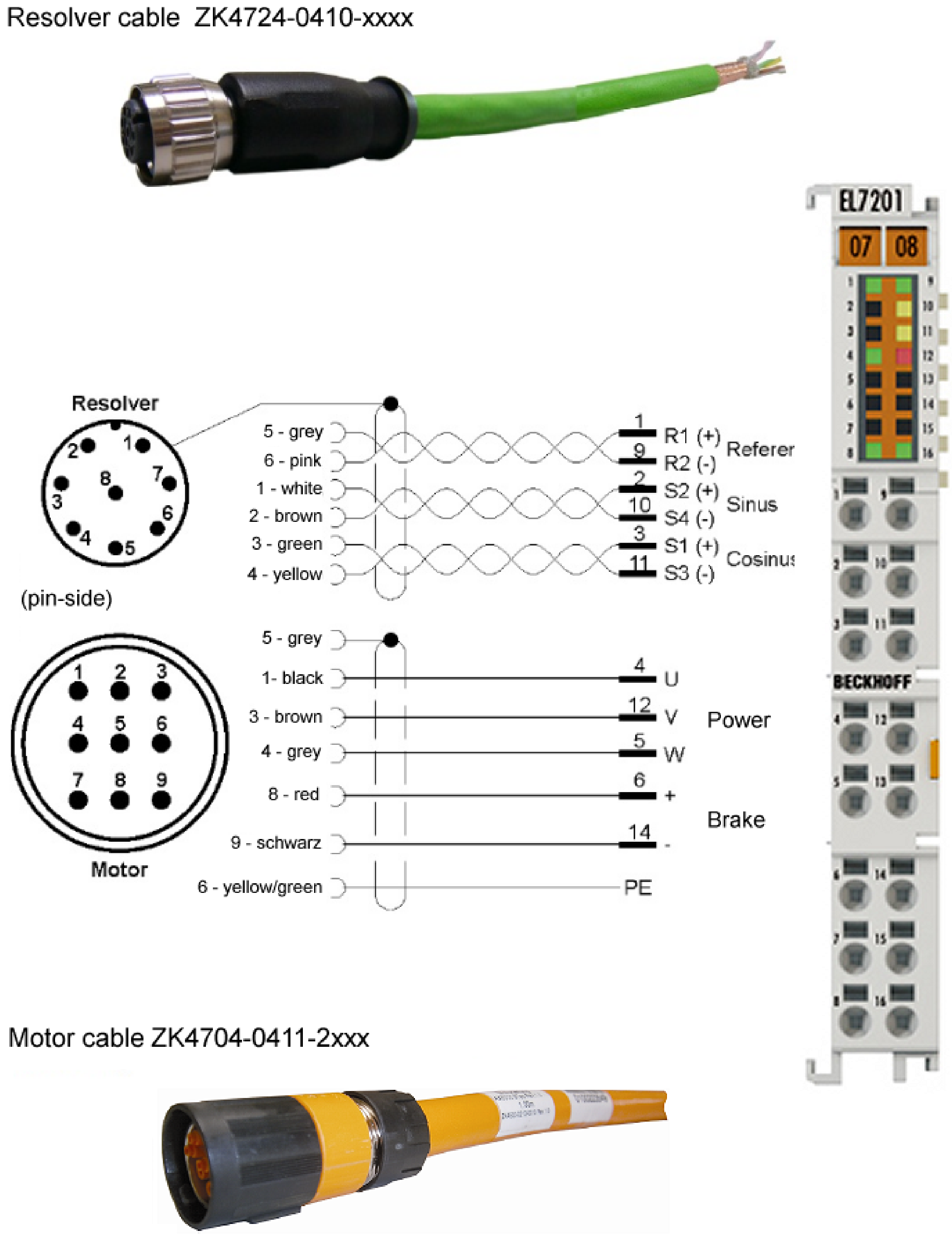


Fig. 37: Connection resolver and motor cable

## 4.12 UL notice - Compact Motion

**⚠ CAUTION**

**Application**

Beckhoff EtherCAT modules are intended for use with Beckhoff’s UL Listed EtherCAT System only.

**⚠ CAUTION**

**Examination**

For cULus examination, the Beckhoff I/O System has only been investigated for risk of fire and electrical shock (in accordance with UL508 and CSA C22.2 No. 142).

**⚠ CAUTION**

**For devices with Ethernet connectors**

Not for connection to telecommunication circuits.

**⚠ CAUTION**

**Notes on motion devices**

- *Motor overtemperature*
  Motor overtemperature sensing is not provided by the drive.
- *Application for compact motion devices*
  The modules are intended for use only within Beckhoff’s Programmable Controller system Listed in File E172151.
- *Galvanic isolation from the supply*
  The modules are intended for operation within circuits not connected directly to the supply mains (galvanically isolated from the supply, i.e. on transformer secondary).
- *Requirement for environmental conditions*
  For use in Pollution Degree 2 Environment only.

### Basic principles

UL certification according to UL508. Devices with this kind of certification are marked by this sign:

## 4.13 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 TwinCAT Development Environment

The Software for automation TwinCAT (The Windows Control and Automation Technology) will be distinguished into:

- TwinCAT 2: System Manager (Configuration) & PLC Control (Programming)
- TwinCAT 3: Enhancement of TwinCAT 2 (Programming and Configuration takes place via a common Development Environment)

**Details:**

- **TwinCAT 2:**
    - Connects I/O devices to tasks in a variable-oriented manner
    - Connects tasks to tasks in a variable-oriented manner
    - Supports units at the bit level
    - Supports synchronous or asynchronous relationships
    - Exchange of consistent data areas and process images
    - Datalink on NT - Programs by open Microsoft Standards (OLE, OCX, ActiveX, DCOM+, etc.)
    - Integration of IEC 61131-3-Software-SPS, Software- NC and Software-CNC within Windows NT/2000/XP/Vista, Windows 7, NT/XP Embedded, CE
    - Interconnection to all common fieldbusses
    - More...

**Additional features:**

- **TwinCAT 3** (eXtended Automation)**:**
    - Visual Studio® integration
    - Choice of the programming language
    - Supports object orientated extension of IEC 61131-3
    - Usage of C/C++ as programming language for real time applications
    - Connection to MATLAB®/Simulink®
    - Open interface for expandability
    - Flexible run-time environment
    - Active support of multi-core- and 64 bit operating system
    - Automatic code generation and project creation with the TwinCAT Automation Interface
    - More...

Within the following sections commissioning of the TwinCAT Development Environment on a PC System for the control and also the basically functions of unique control elements will be explained.

Please see further information to TwinCAT 2 and TwinCAT 3 at http://infosys.beckhoff.com.

### 5.1.1 Installation of the TwinCAT real-time driver

In order to assign real-time capability to a standard Ethernet port of an IPC controller, the Beckhoff real-time driver has to be installed on this port under Windows.

This can be done in several ways.

**A: Via the TwinCAT Adapter dialog**

In the System Manager call up the TwinCAT overview of the local network interfaces via Options → Show Real Time Ethernet Compatible Devices.

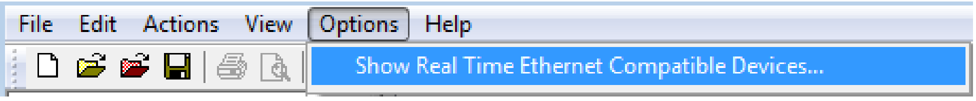


Fig. 38: System Manager “Options” (TwinCAT 2)

This have to be called up by the menu “TwinCAT” within the TwinCAT 3 environment:

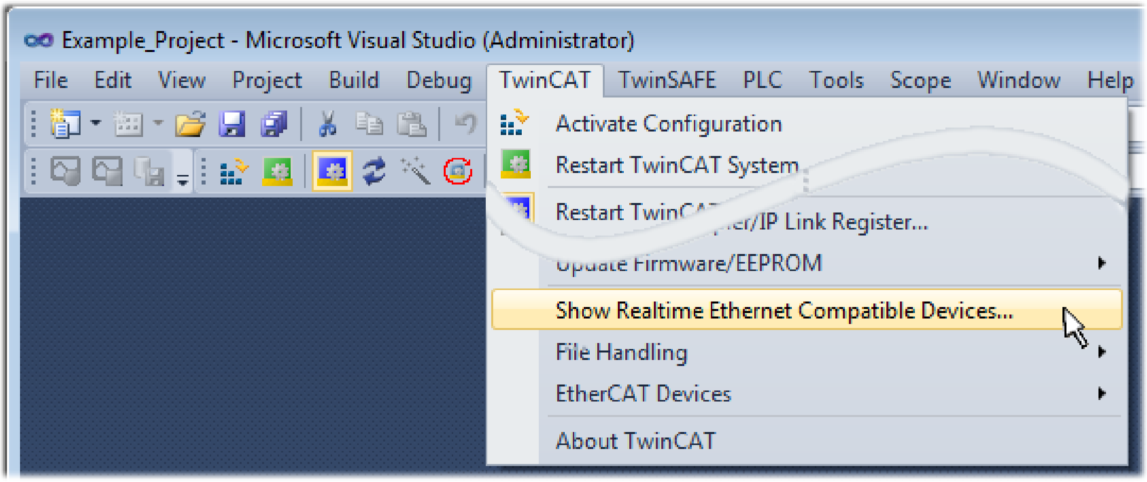
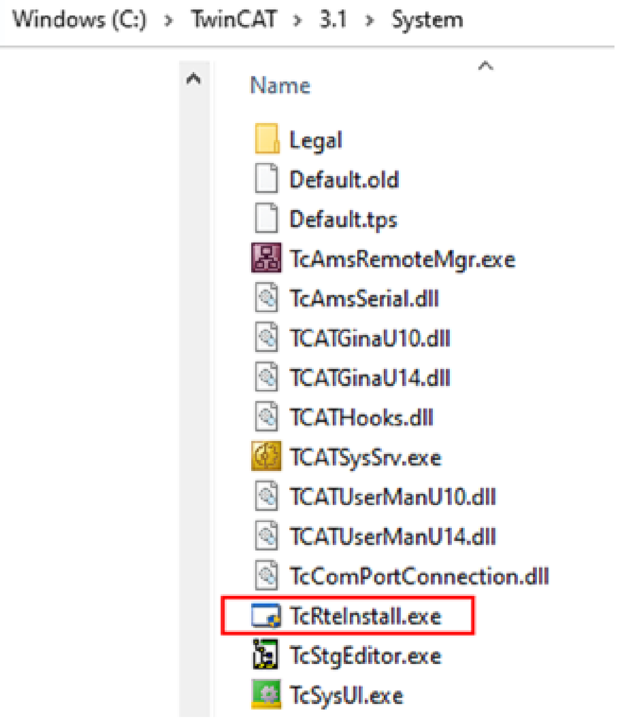


Fig. 39: Call up under VS Shell (TwinCAT 3)

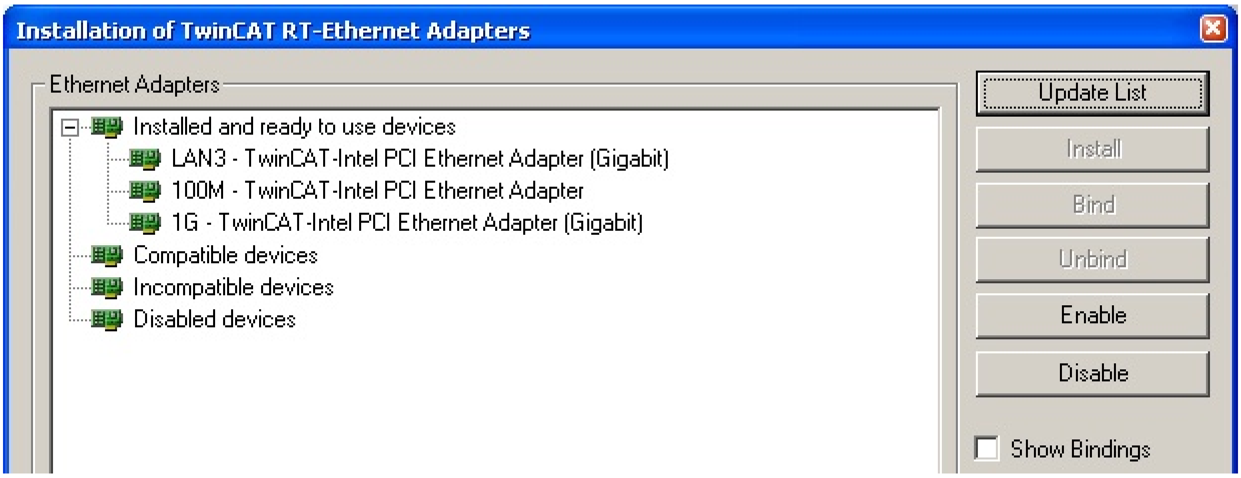
**B: Via TcRteInstall.exe in the TwinCAT directory**



Legal
Default.old
Default.tps
TcAmsRemoteMgr.exe
TcAmsSerial.dll
TCATGinaU10.dll
TCATGinaU14.dll
TCATHooks.dll
TCATSysSrv.exe
TCATUserManU10.dll
TCATUserManU14.dll
TcComPortConnection.dll
TcRteInstall.exe
TcStgEditor.exe
TcSysUI.exe

Fig. 40: TcRteInstall in the TwinCAT directory

In both cases, the following dialog appears:


Installation of TwinCAT RT-Ethernet Adapters

Ethernet Adapters

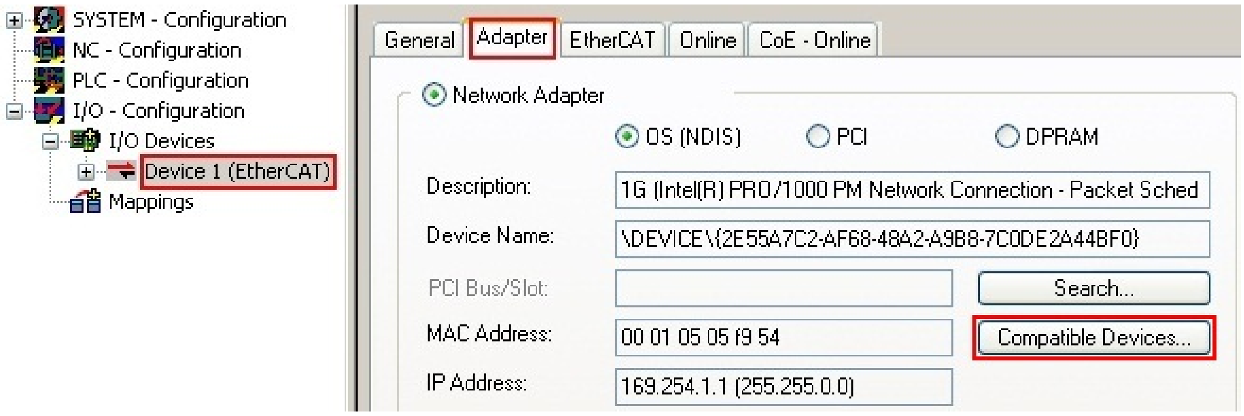
- Installed and ready to use devices
  - LAN3 - TwinCAT-Intel PCI Ethernet Adapter (Gigabit)
  - 100M - TwinCAT-Intel PCI Ethernet Adapter
  - 1G - TwinCAT-Intel PCI Ethernet Adapter (Gigabit)
- Compatible devices
- Incompatible devices
- Disabled devices

Fig. 41: Overview of network interfaces

Interfaces listed under “Compatible devices” can be assigned a driver via the “Install” button. A driver should only be installed on compatible devices.

A Windows warning regarding the unsigned driver can be ignored.

**Alternatively** an EtherCAT-device can be inserted first of all as described in chapter Offline configuration creation, section “Creating the EtherCAT device” [▶ 71] in order to view the compatible ethernet ports via its EtherCAT properties (tab “Adapter”, button “Compatible Devices…”):


- SYSTEM - Configuration
- NC - Configuration
- PLC - Configuration
- I/O - Configuration
  - I/O Devices
    - Device 1 (EtherCAT)
  - Mappings

● Network Adapter

● OS (NDIS) ○ PCI ○ DPRAM

Description: 1G (Intel(R) PRO/1000 PM Network Connection - Packet Sched

Device Name: \DEVICE\{2E55A7C2-AF68-48A2-A9B8-7C0DE2A44BF0}

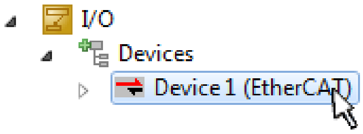
PCI Bus/Slot:

MAC Address: 00 01 05 05 f9 54

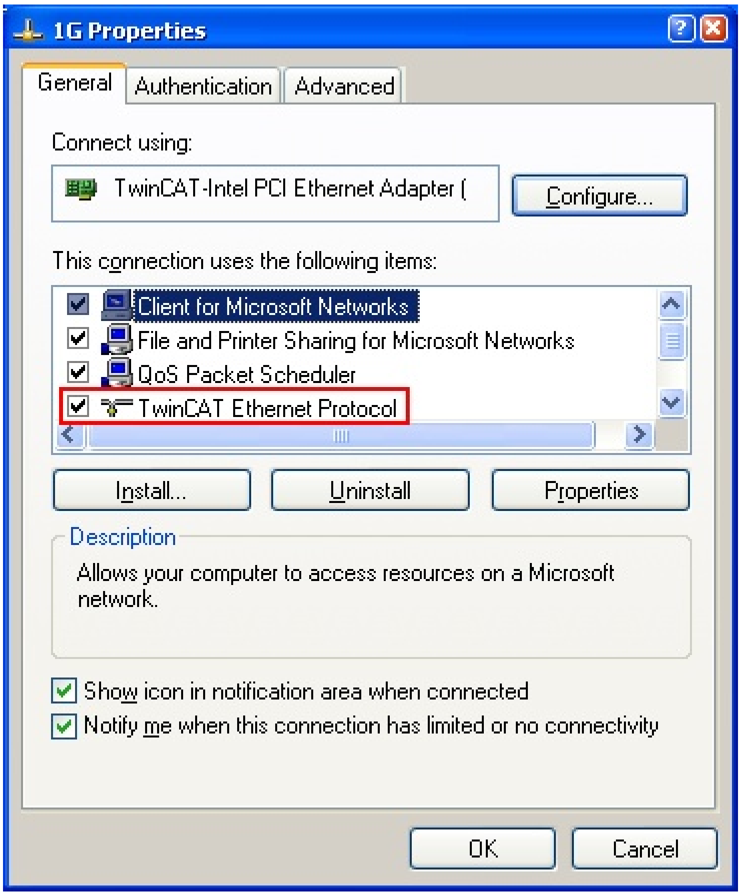
IP Address: 169.254.1.1 (255.255.0.0)

Fig. 42: EtherCAT device properties (TwinCAT 2): click on “Compatible Devices…” of tab “Adapter”

TwinCAT 3: the properties of the EtherCAT device can be opened by double click on “Device .. (EtherCAT)” within the Solution Explorer under “I/O”:


- I/O
  - Devices
    - Device 1 (EtherCAT)

After the installation the driver appears activated in the Windows overview for the network interface (Windows Start → System Properties → Network)


1G Properties

Connect using:

TwinCAT-Intel PCI Ethernet Adapter (

This connection uses the following items:

☑ Client for Microsoft Networks
☑ File and Printer Sharing for Microsoft Networks
☑ QoS Packet Scheduler
☑ TwinCAT Ethernet Protocol

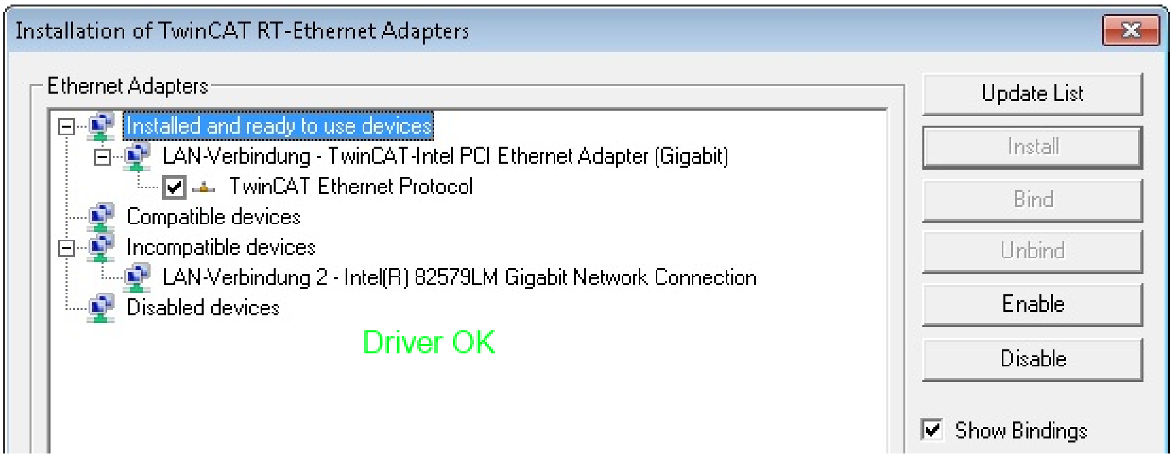
Description

Allows your computer to access resources on a Microsoft network.

☑ Show icon in notification area when connected
☑ Notify me when this connection has limited or no connectivity

Fig. 43: Windows properties of the network interface

A correct setting of the driver could be:


Installation of TwinCAT RT-Ethernet Adapters

Ethernet Adapters

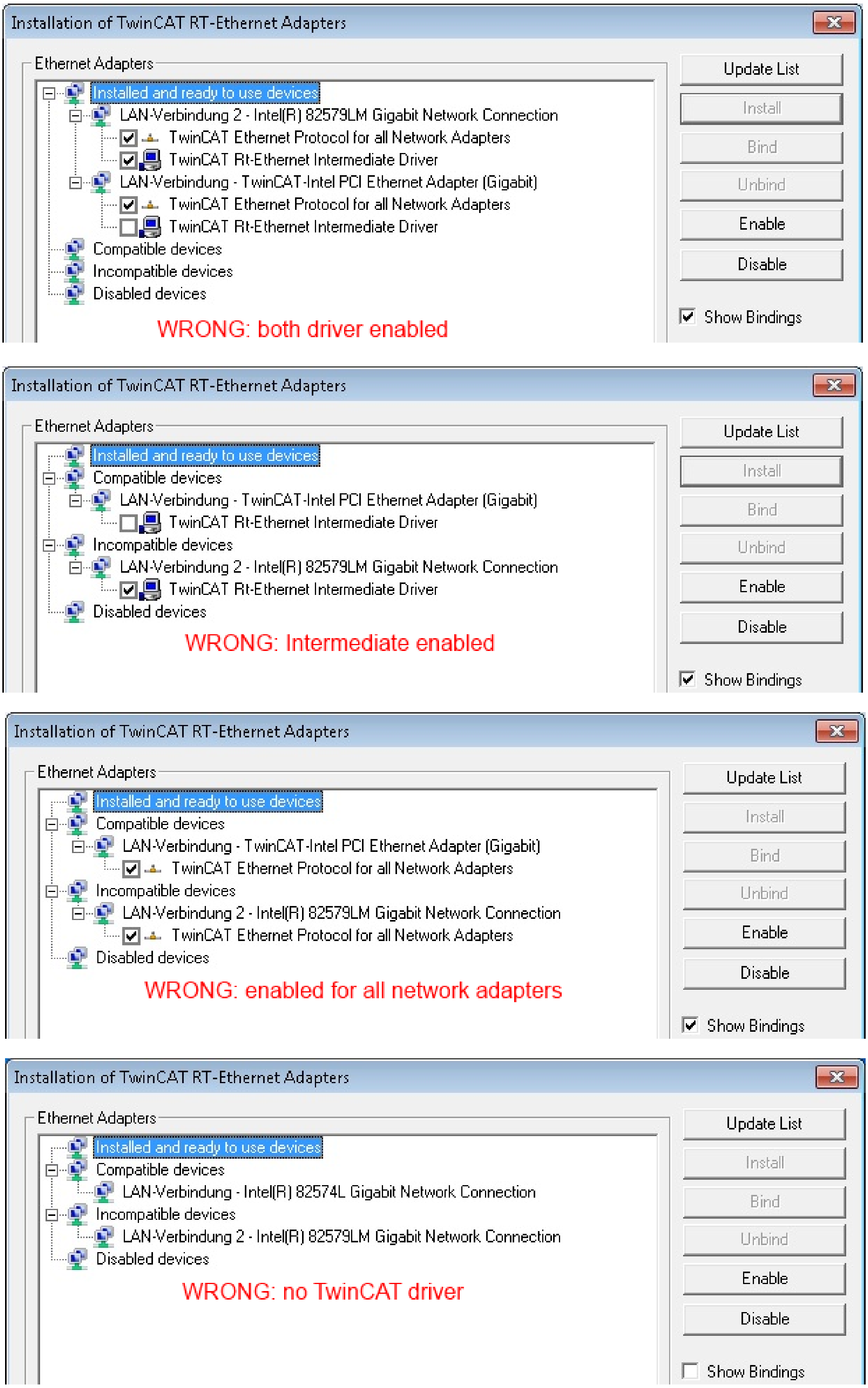
- Installed and ready to use devices
  - LAN-Verbindung - TwinCAT-Intel PCI Ethernet Adapter (Gigabit)
    - ☑ TwinCAT Ethernet Protocol
- Compatible devices
- Incompatible devices
  - LAN-Verbindung 2 - Intel(R) 82579LM Gigabit Network Connection
- Disabled devices

Driver OK

☑ Show Bindings

Fig. 44: Exemplary correct driver setting for the Ethernet port

Other possible settings have to be avoided:



Installation of TwinCAT RT-Ethernet Adapters

Ethernet Adapters
- Installed and ready to use devices
  - LAN-Verbindung 2 - Intel(R) 82579LM Gigabit Network Connection
    - ☑ TwinCAT Ethernet Protocol for all Network Adapters
    - ☑ TwinCAT Rt-Ethernet Intermediate Driver
  - LAN-Verbindung - TwinCAT-Intel PCI Ethernet Adapter (Gigabit)
    - ☑ TwinCAT Ethernet Protocol for all Network Adapters
    - □ TwinCAT Rt-Ethernet Intermediate Driver
- Compatible devices
- Incompatible devices
- Disabled devices

WRONG: both driver enabled

☑ Show Bindings

Installation of TwinCAT RT-Ethernet Adapters

Ethernet Adapters
- Installed and ready to use devices
- Compatible devices
  - LAN-Verbindung - TwinCAT-Intel PCI Ethernet Adapter (Gigabit)
    - □ TwinCAT Rt-Ethernet Intermediate Driver
- Incompatible devices
  - LAN-Verbindung 2 - Intel(R) 82579LM Gigabit Network Connection
    - ☑ TwinCAT Rt-Ethernet Intermediate Driver
- Disabled devices

WRONG: Intermediate enabled

☑ Show Bindings

Installation of TwinCAT RT-Ethernet Adapters

Ethernet Adapters
- Installed and ready to use devices
- Compatible devices
  - LAN-Verbindung - TwinCAT-Intel PCI Ethernet Adapter (Gigabit)
    - ☑ TwinCAT Ethernet Protocol for all Network Adapters
- Incompatible devices
  - LAN-Verbindung 2 - Intel(R) 82579LM Gigabit Network Connection
    - ☑ TwinCAT Ethernet Protocol for all Network Adapters
- Disabled devices

WRONG: enabled for all network adapters

☑ Show Bindings

Installation of TwinCAT RT-Ethernet Adapters

Ethernet Adapters
- Installed and ready to use devices
- Compatible devices
  - LAN-Verbindung - Intel(R) 82574L Gigabit Network Connection
- Incompatible devices
  - LAN-Verbindung 2 - Intel(R) 82579LM Gigabit Network Connection
- Disabled devices

WRONG: no TwinCAT driver

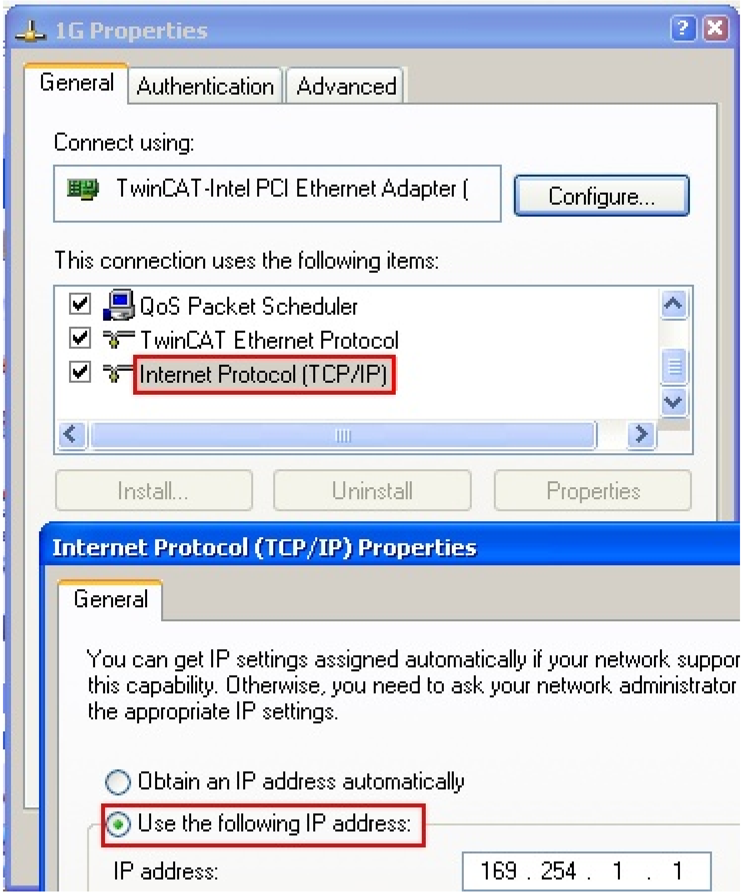
□ Show Bindings

Fig. 45: Incorrect driver settings for the Ethernet port

**IP address of the port used**

### IP address/DHCP

In most cases an Ethernet port that is configured as an EtherCAT device will not transport general IP packets. For this reason and in cases where an EL6601 or similar devices are used it is useful to specify a fixed IP address for this port via the “Internet Protocol TCP/IP” driver setting and to disable DHCP. In this way the delay associated with the DHCP client for the Ethernet port assigning itself a default IP address in the absence of a DHCP server is avoided. A suitable address space is 192.168.x.x, for example.


1G Properties
General
Authentication
Advanced
Connect using:
TwinCAT-Intel PCI Ethernet Adapter (
Configure...
This connection uses the following items:
☑ QoS Packet Scheduler
☑ TwinCAT Ethernet Protocol
☑ Internet Protocol (TCP/IP)
Install...
Uninstall
Properties
Internet Protocol (TCP/IP) Properties
General

You can get IP settings assigned automatically if your network suppor this capability. Otherwise, you need to ask your network administrator the appropriate IP settings.

○ Obtain an IP address automatically

● Use the following IP address:

IP address: 169 . 254 . 1 . 1

Fig. 46: TCP/IP setting for the Ethernet port

## 5.1.2 Notes regarding ESI device description

### Installation of the latest ESI device description

The TwinCAT EtherCAT master/System Manager needs the device description files for the devices to be used in order to generate the configuration in online or offline mode. The device descriptions are contained in the so-called ESI files (EtherCAT Slave Information) in XML format. These files can be requested from the respective manufacturer and are made available for download. An *.xml file may contain several device descriptions.

The ESI files for Beckhoff EtherCAT devices are available on the Beckhoff website.

The ESI files should be stored in the TwinCAT installation directory.

Default settings:

- **TwinCAT 2**: C:\TwinCAT\IO\EtherCAT
- **TwinCAT 3**: C:\TwinCAT\3.1\Config\Io\EtherCAT

The files are read (once) when a new System Manager window is opened, if they have changed since the last time the System Manager window was opened.

A TwinCAT installation includes the set of Beckhoff ESI files that was current at the time when the TwinCAT build was created.

For TwinCAT 2.11/TwinCAT 3 and higher, the ESI directory can be updated from the System Manager, if the programming PC is connected to the Internet; by

- **TwinCAT 2**: Option → “Update EtherCAT Device Descriptions”
- **TwinCAT 3**: TwinCAT → EtherCAT Devices → “Update Device Descriptions (via ETG Website)…”

The TwinCAT ESI Updater [▶ 70] is available for this purpose.

**ESI**

The *.xml files are associated with *.xsd files, which describe the structure of the ESI XML files. To update the ESI device descriptions, both file types should therefore be updated.

### Device differentiation

EtherCAT devices/slaves are distinguished by four properties, which determine the full device identifier. For example, the device identifier EL2521-0025-1018 consists of:

- family key “EL”
- name “2521”
- type “0025”
- and revision “1018”

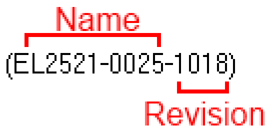
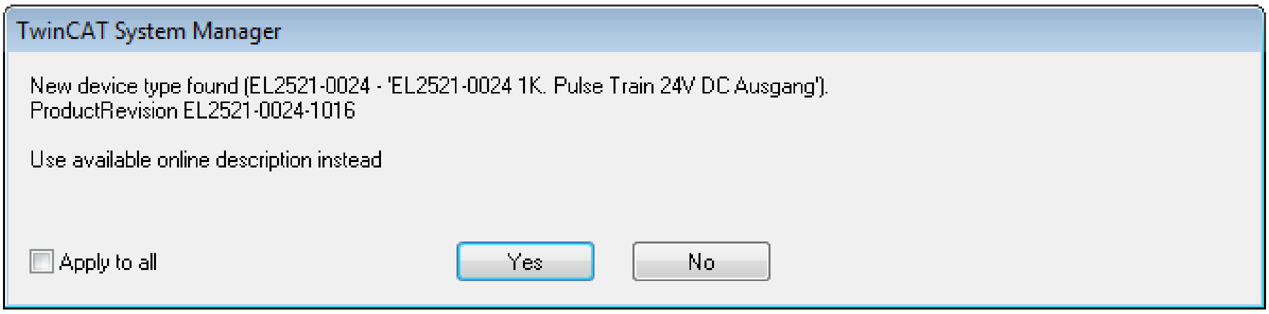


Fig. 47: Identifier structure

The order identifier consisting of name + type (here: EL2521-0025) describes the device function. The revision indicates the technical progress 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. Each revision has its own ESI description. See further notes [▶ 12].

### Online description

If the EtherCAT configuration is created online through scanning of real devices (see section Online setup) and no ESI descriptions are available for a slave (specified by name and revision) that was found, the System Manager asks whether the description stored in the device should be used. In any case, the System Manager needs this information for setting up the cyclic and acyclic communication with the slave correctly.

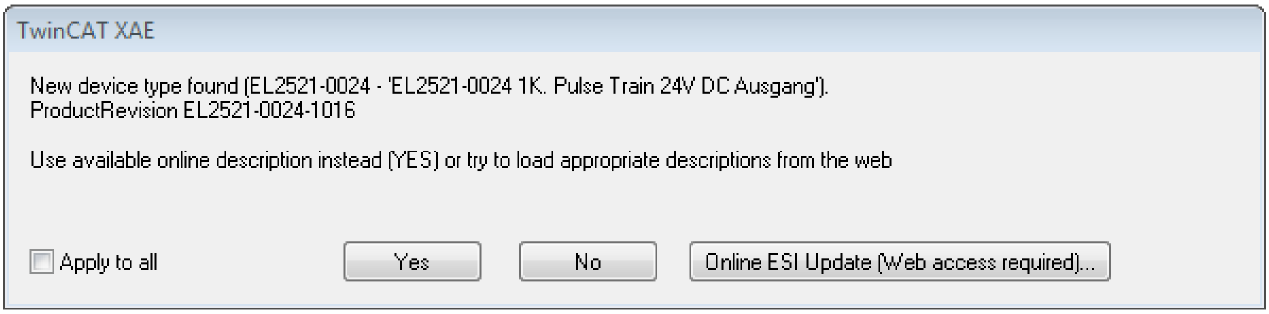

TwinCAT System Manager

New device type found [EL2521-0024 - 'EL2521-0024 1K. Pulse Train 24V DC Ausgang'].
ProductRevision EL2521-0024-1016

Use available online description instead

Fig. 48: OnlineDescription information window (TwinCAT 2)

In TwinCAT 3 a similar window appears, which also offers the Web update:


TwinCAT XAE

New device type found [EL2521-0024 - 'EL2521-0024 1K. Pulse Train 24V DC Ausgang'].
ProductRevision EL2521-0024-1016

Use available online description instead (YES) or try to load appropriate descriptions from the web

Fig. 49: Information window OnlineDescription (TwinCAT 3)

If possible, the *Yes* is to be rejected and the required ESI is to be requested from the device manufacturer. After installation of the XML/XSD file the configuration process should be repeated.

**NOTICE**

**Changing the “usual” configuration through a scan**

✓ If a scan discovers a device that is not yet known to TwinCAT, distinction has to be made between two cases. Taking the example here of the EL2521-0000 in the revision 1019

a) no ESI is present for the EL2521-0000 device at all, either for the revision 1019 or for an older revision. The ESI must then be requested from the manufacturer (in this case Beckhoff).

b) an ESI is present for the EL2521-0000 device, but only in an older revision, e.g. 1018 or 1017.
In this case an in-house check should first be performed to determine whether the spare parts stock allows the integration of the increased revision into the configuration at all. A new/higher revision usually also brings along new features. If these are not to be used, work can continue without reservations with the previous revision 1018 in the configuration. This is also stated by the Beckhoff compatibility rule.

Refer in particular to the chapter “General notes on the use of Beckhoff EtherCAT IO components” and for manual configuration to the chapter “Offline configuration creation [▶ 71]”.

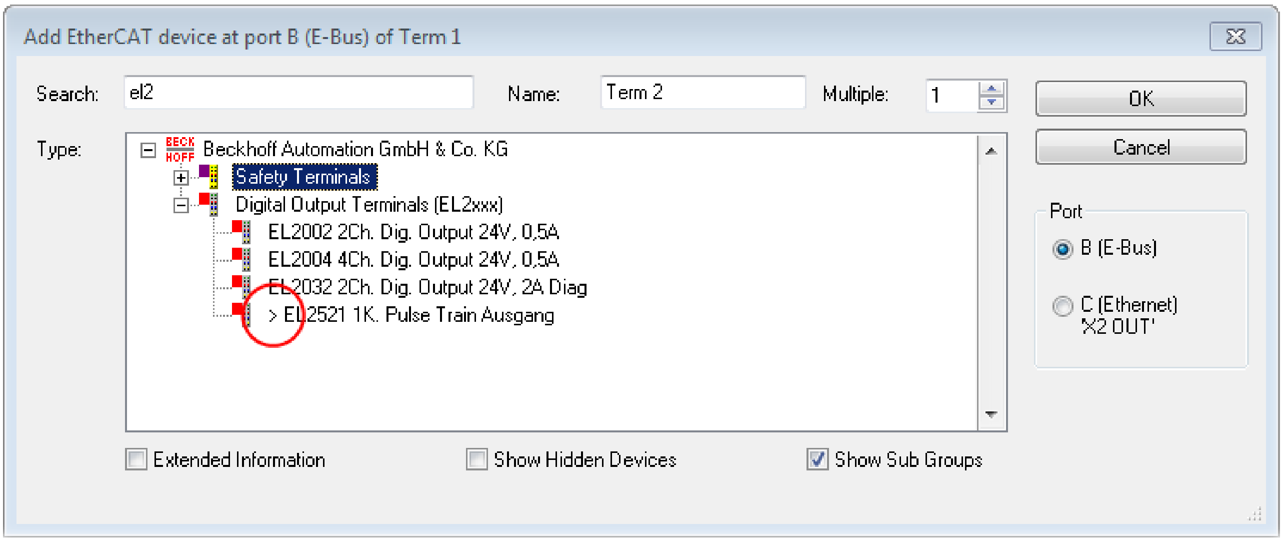
If the OnlineDescription is used regardless, the System Manager reads a copy of the device description from the EEPROM in the EtherCAT slave. In complex slaves the size of the EEPROM may not be sufficient for the complete ESI, in which case the ESI would be *incomplete* in the configurator. Therefore it’s recommended using an offline ESI file with priority in such a case.

The System Manager creates for online recorded device descriptions a new file “OnlineDescription0000...xml” in its ESI directory, which contains all ESI descriptions that were read online.

OnlineDescriptionCache00000002.xml

Fig. 50: File OnlineDescription.xml created by the System Manager

Is a slave desired to be added manually to the configuration at a later stage, online created slaves are indicated by a prepended symbol “>” in the selection list (see Figure *Indication of an online recorded ESI of EL2521 as an example)*.



Add EtherCAT device at port B (E-Bus) of Term 1

Search: el2

Name: Term 2

Multiple: 1

Type:

```
⊟ Beckhoff Automation GmbH & Co. KG
   ⊞ Safety Terminals
   ⊟ Digital Output Terminals (EL2xxx)
        EL2002 2Ch. Dig. Output 24V, 0,5A
        EL2004 4Ch. Dig. Output 24V, 0,5A
        EL2032 2Ch. Dig. Output 24V, 2A Diag
        > EL2521 1K. Pulse Train Ausgang
```

□ Extended Information □ Show Hidden Devices ☑ Show Sub Groups

Port

● B (E-Bus)

○ C (Ethernet) 'X2 OUT'

Fig. 51: Indication of an online recorded ESI of EL2521 as an example

If such ESI files are used and the manufacturer's files become available later, the file OnlineDescription.xml should be deleted as follows:

- close all System Manager windows
- restart TwinCAT in Config mode
- delete “OnlineDescription0000...xml”
- restart TwinCAT System Manager

This file should not be visible after this procedure, if necessary press <F5> to update

**OnlineDescription for TwinCAT 3.x**

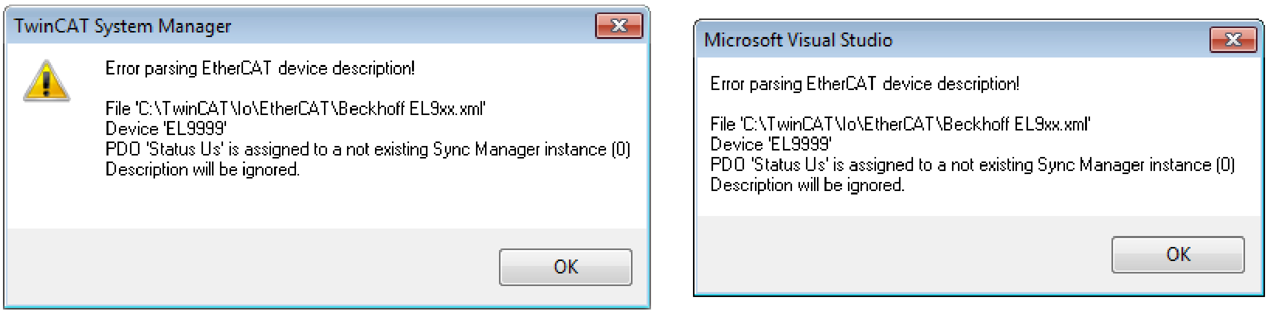
In addition to the file described above “OnlineDescription0000...xml”, a so called EtherCAT cache with new discovered devices is created by TwinCAT 3.x, e.g. under Windows 7:

*C:\User\[USERNAME]\AppData\Roaming\Beckhoff\TwinCAT3\Components\Base\EtherCATCache.xml*

(Please note the language settings of the OS!)
You have to delete this file, too.

### Faulty ESI file

If an ESI file is faulty and the System Manager is unable to read it, the System Manager brings up an information window.



TwinCAT System Manager

Error parsing EtherCAT device description!

File 'C:\TwinCAT\Io\EtherCAT\Beckhoff EL9xx.xml'
Device 'EL9999'
PDO 'Status Us' is assigned to a not existing Sync Manager instance (0)
Description will be ignored.

Microsoft Visual Studio

Error parsing EtherCAT device description!

File 'C:\TwinCAT\Io\EtherCAT\Beckhoff EL9xx.xml'
Device 'EL9999'
PDO 'Status Us' is assigned to a not existing Sync Manager instance (0)
Description will be ignored.

Fig. 52: Information window for faulty ESI file (left: TwinCAT 2; right: TwinCAT 3)

Reasons may include:

- Structure of the *.xml does not correspond to the associated *.xsd file → check your schematics
- Contents cannot be translated into a device description → contact the file manufacturer

### 5.1.3 TwinCAT ESI Updater

For TwinCAT 2.11 and higher, the System Manager can search for current Beckhoff ESI files automatically, if an online connection is available:

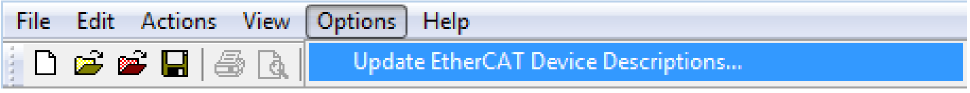
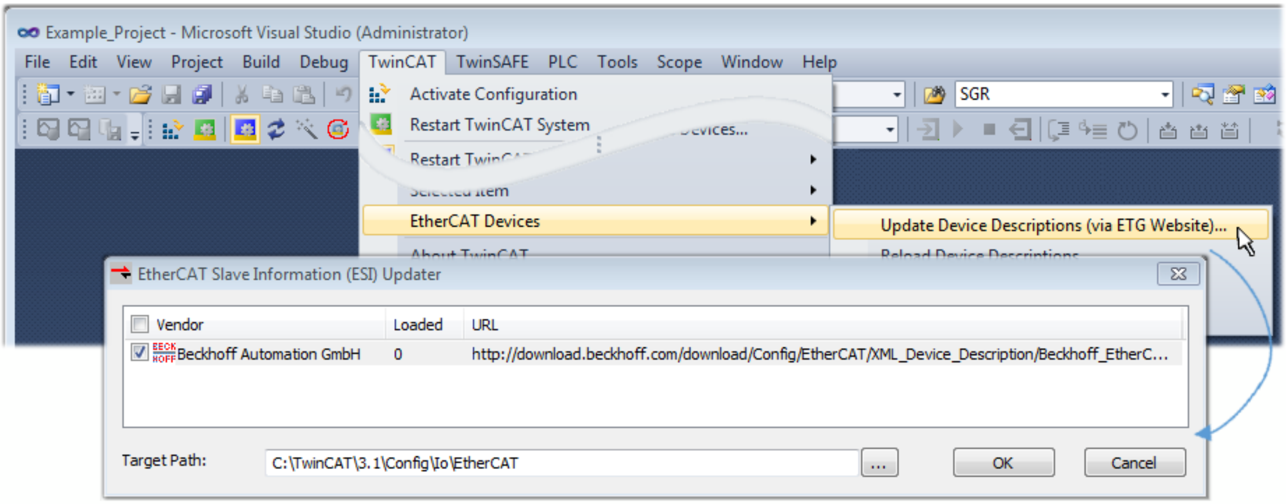


Fig. 53: Using the ESI Updater (>= TwinCAT 2.11)

The call up takes place under:
“Options” → “Update EtherCAT Device Descriptions”

Selection under TwinCAT 3:



| Vendor | Loaded | URL |
|---|---|---|
| ☑ Beckhoff Automation GmbH | 0 | http://download.beckhoff.com/download/Config/EtherCAT/XML_Device_Description/Beckhoff_EtherC... |

Target Path: C:\TwinCAT\3.1\Config\Io\EtherCAT

Fig. 54: Using the ESI Updater (TwinCAT 3)

The ESI Updater (TwinCAT 3) is a convenient option for automatic downloading of ESI data provided by EtherCAT manufacturers via the Internet into the TwinCAT directory (ESI = EtherCAT slave information). TwinCAT accesses the central ESI ULR directory list stored at ETG; the entries can then be viewed in the Updater dialog, although they cannot be changed there.

The call up takes place under:
“TwinCAT” → “EtherCAT Devices” → “Update Device Description (via ETG Website)…”.

### 5.1.4 Distinction between Online and Offline

The distinction between online and offline refers to the presence of the actual I/O environment (drives, terminals, EJ-modules). If the configuration is to be prepared in advance of the system configuration as a programming system, e.g. on a laptop, this is only possible in “Offline configuration” mode. In this case all components have to be entered manually in the configuration, e.g. based on the electrical design.

If the designed control system is already connected to the EtherCAT system and all components are energised and the infrastructure is ready for operation, the TwinCAT configuration can simply be generated through “scanning” from the runtime system. This is referred to as online configuration.

In any case, during each startup the EtherCAT master checks whether the slaves it finds match the configuration. This test can be parameterised in the extended slave settings. Refer to note “Installation of the latest ESI-XML device description” [▶ 66].

**For preparation of a configuration:**

- the real EtherCAT hardware (devices, couplers, drives) must be present and installed
- the devices/modules must be connected via EtherCAT cables or in the terminal/ module strand in the same way as they are intended to be used later
- the devices/modules be connected to the power supply and ready for communication

- TwinCAT must be in CONFIG mode on the target system.

**The online scan process consists of:**

- detecting the EtherCAT device [▶ 76] (Ethernet port at the IPC)
- detecting the connected EtherCAT devices [▶ 77]. This step can be carried out independent of the preceding step
- troubleshooting [▶ 80]

The scan with existing configuration [▶ 81] can also be carried out for comparison.

## 5.1.5 OFFLINE configuration creation

### Creating the EtherCAT device

Create an EtherCAT device in an empty System Manager window.

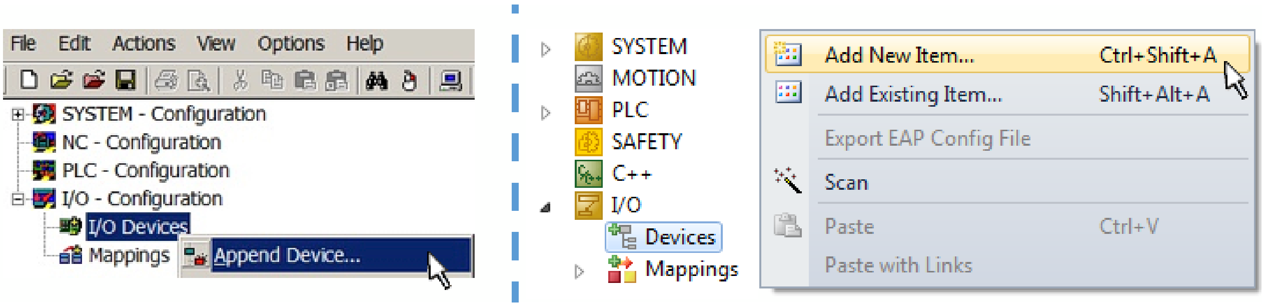


Fig. 55: Append EtherCAT device (left: TwinCAT 2; right: TwinCAT 3)

Select type “EtherCAT” for an EtherCAT I/O application with EtherCAT slaves. For the present publisher/subscriber service in combination with an EL6601/EL6614 terminal select “EtherCAT Automation Protocol via EL6601”.

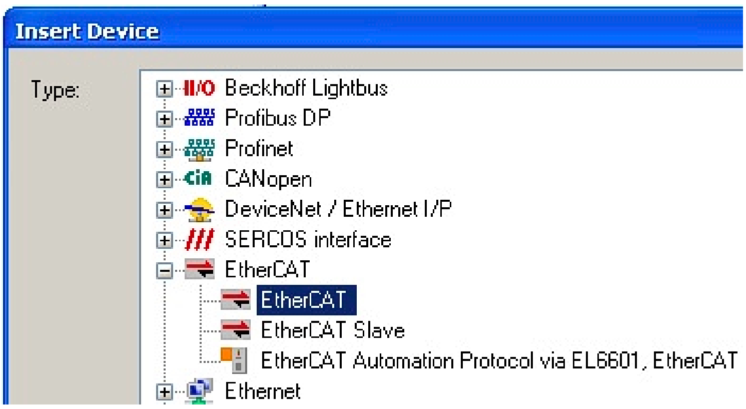


Fig. 56: Selecting the EtherCAT connection (TwinCAT 2.11, TwinCAT 3)

Then assign a real Ethernet port to this virtual device in the runtime system.

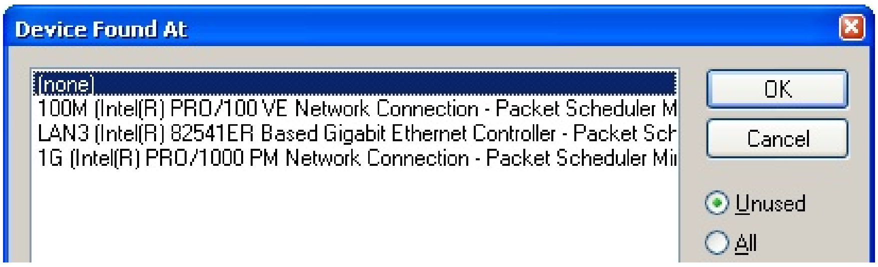
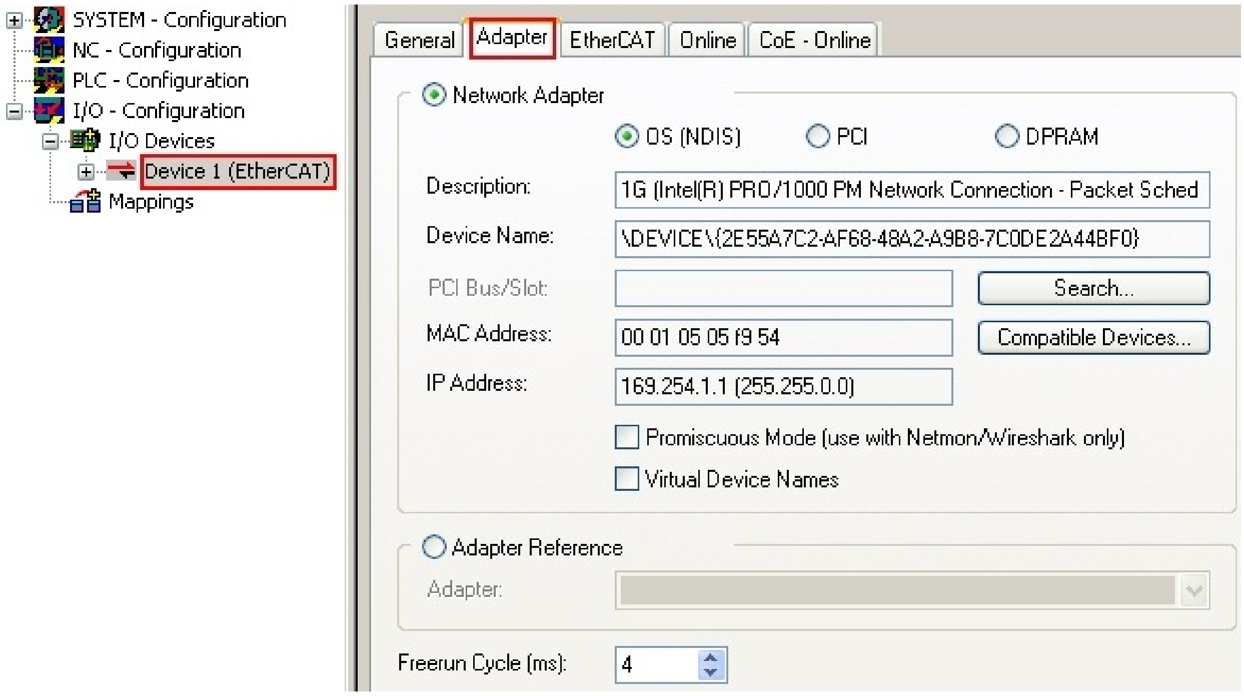

Device Found At
(none)
100M (Intel(R) PRO/100 VE Network Connection - Packet Scheduler M
LAN3 (Intel(R) 82541ER Based Gigabit Ethernet Controller - Packet Sch
1G (Intel(R) PRO/1000 PM Network Connection - Packet Scheduler Mi
OK
Cancel
● Unused
○ All

Fig. 57: Selecting the Ethernet port

This query may appear automatically when the EtherCAT device is created, or the assignment can be set/ modified later in the properties dialog; see Fig. “EtherCAT device properties (TwinCAT 2)”.



● Network Adapter

● OS (NDIS) ○ PCI ○ DPRAM

Description: 1G (Intel(R) PRO/1000 PM Network Connection - Packet Sched

Device Name: \DEVICE\{2E55A7C2-AF68-48A2-A9B8-7C0DE2A44BF0}

PCI Bus/Slot:

MAC Address: 00 01 05 05 f9 54

IP Address: 169.254.1.1 (255.255.0.0)

□ Promiscuous Mode (use with Netmon/Wireshark only)

□ Virtual Device Names

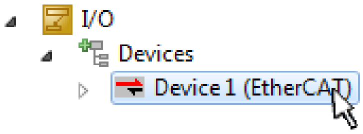
○ Adapter Reference

Adapter:

Freerun Cycle (ms): 4

Fig. 58: EtherCAT device properties (TwinCAT 2)

TwinCAT 3: the properties of the EtherCAT device can be opened by double click on “Device .. (EtherCAT)” within the Solution Explorer under “I/O”:



### Selecting the Ethernet port

Ethernet ports can only be selected for EtherCAT devices for which the TwinCAT real-time driver is installed. This has to be done separately for each port. Please refer to the respective installation page [▶ 60].

### Defining EtherCAT slaves

Further devices can be appended by right-clicking on a device in the configuration tree.

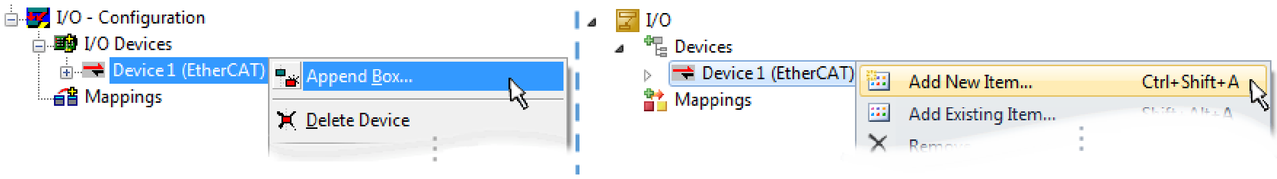


Fig. 59: Appending EtherCAT devices (left: TwinCAT 2; right: TwinCAT 3)

The dialog for selecting a new device opens. Only devices for which ESI files are available are displayed.

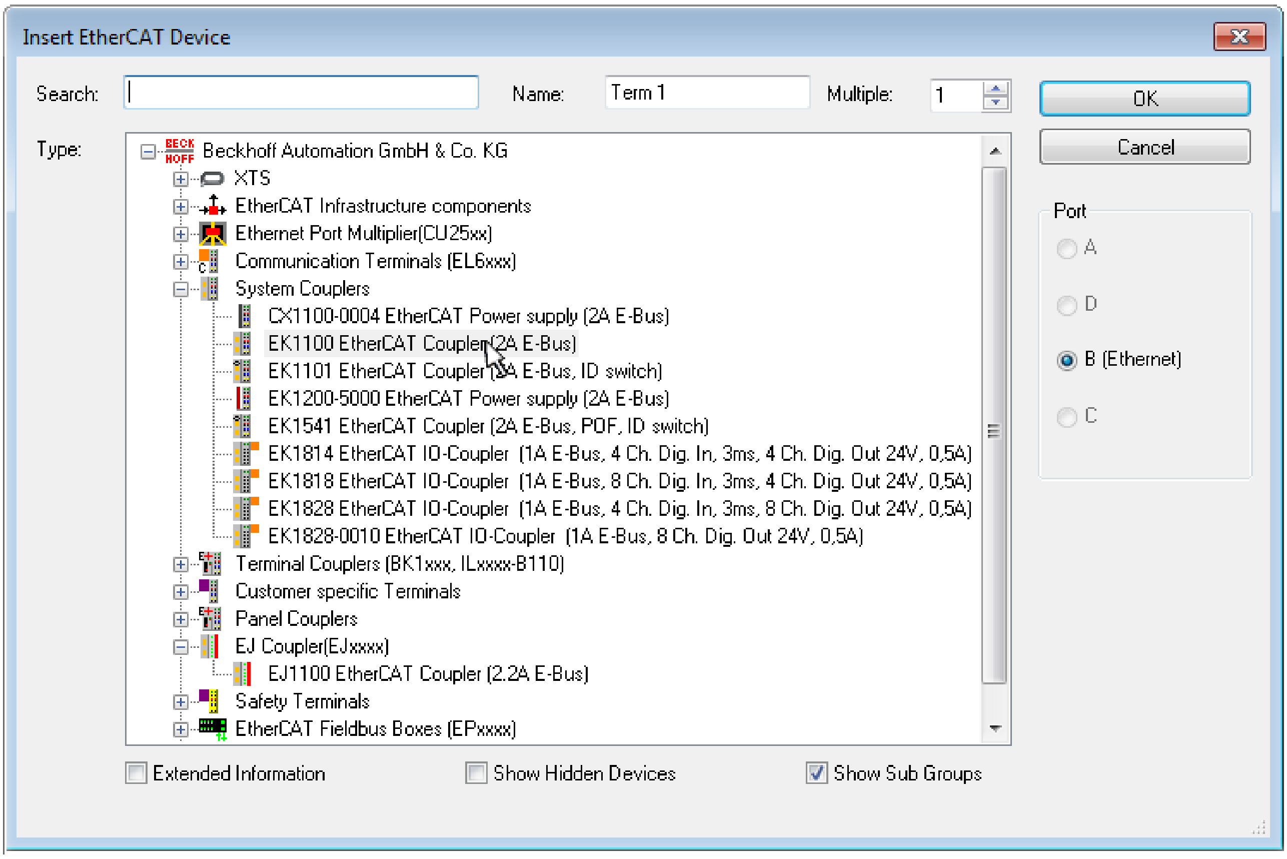
Only devices are offered for selection that can be appended to the previously selected device. Therefore, the physical layer available for this port is also displayed (Fig. “Selection dialog for new EtherCAT device”, A). In the case of cable-based Fast-Ethernet physical layer with PHY transfer, then also only cable-based devices are available, as shown in Fig. “Selection dialog for new EtherCAT device”. If the preceding device has several free ports (e.g. EK1122 or EK1100), the required port can be selected on the right-hand side (A).

Overview of physical layer

- “Ethernet”: cable-based 100BASE-TX: couplers, box modules, devices with RJ45/M8/M12 connector

- “E-Bus”: LVDS “terminal bus”, EtherCAT plug-in modules (EJ), EtherCAT terminals (EL/ES), various modular modules

The search field facilitates finding specific devices (since TwinCAT 2.11 or TwinCAT 3).



Insert EtherCAT Device

Search: 
Name: Term 1
Multiple: 1

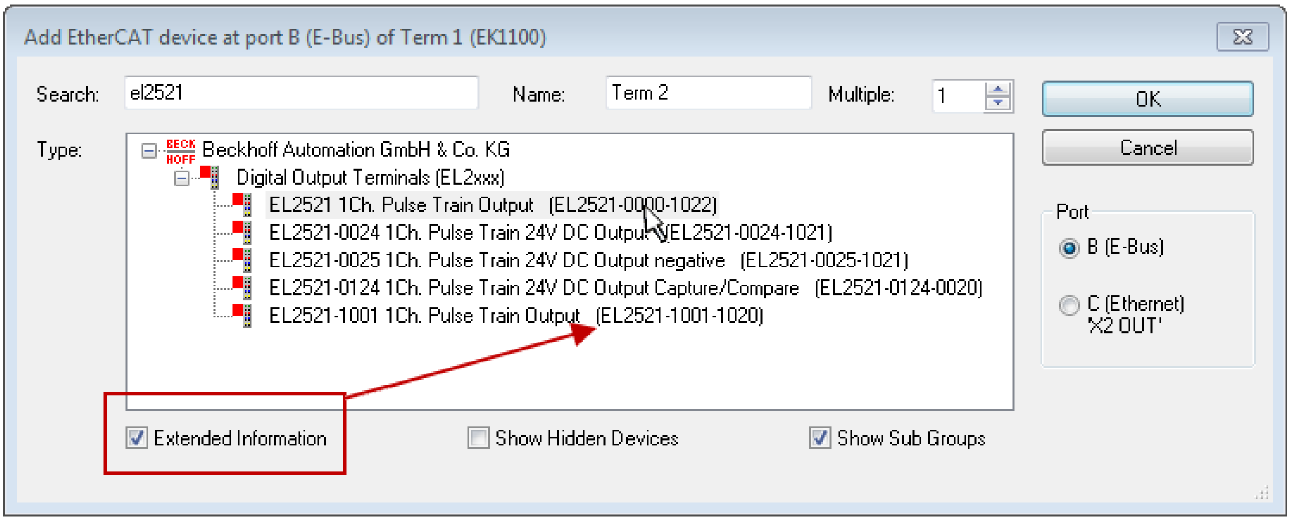
Type:
- Beckhoff Automation GmbH & Co. KG
  - XTS
  - EtherCAT Infrastructure components
  - Ethernet Port Multiplier(CU25xx)
  - Communication Terminals (EL6xxx)
  - System Couplers
    - CX1100-0004 EtherCAT Power supply (2A E-Bus)
    - EK1100 EtherCAT Coupler (2A E-Bus)
    - EK1101 EtherCAT Coupler (2A E-Bus, ID switch)
    - EK1200-5000 EtherCAT Power supply (2A E-Bus)
    - EK1541 EtherCAT Coupler (2A E-Bus, POF, ID switch)
    - EK1814 EtherCAT IO-Coupler (1A E-Bus, 4 Ch. Dig. In, 3ms, 4 Ch. Dig. Out 24V, 0,5A)
    - EK1818 EtherCAT IO-Coupler (1A E-Bus, 8 Ch. Dig. In, 3ms, 4 Ch. Dig. Out 24V, 0,5A)
    - EK1828 EtherCAT IO-Coupler (1A E-Bus, 4 Ch. Dig. In, 3ms, 8 Ch. Dig. Out 24V, 0,5A)
    - EK1828-0010 EtherCAT IO-Coupler (1A E-Bus, 8 Ch. Dig. Out 24V, 0,5A)
  - Terminal Couplers (BK1xxx, ILxxxx-B110)
  - Customer specific Terminals
  - Panel Couplers
  - EJ Coupler(EJxxxx)
    - EJ1100 EtherCAT Coupler (2.2A E-Bus)
  - Safety Terminals
  - EtherCAT Fieldbus Boxes (EPxxxx)

□ Extended Information  □ Show Hidden Devices  ☑ Show Sub Groups

Port: ○ A  ○ D  ● B (Ethernet)  ○ C

Fig. 60: Selection dialog for new EtherCAT device

By default, only the name/device type is used as selection criterion. For selecting a specific revision of the device, the revision can be displayed as “Extended Information”.



Add EtherCAT device at port B (E-Bus) of Term 1 (EK1100)

Search: el2521
Name: Term 2
Multiple: 1

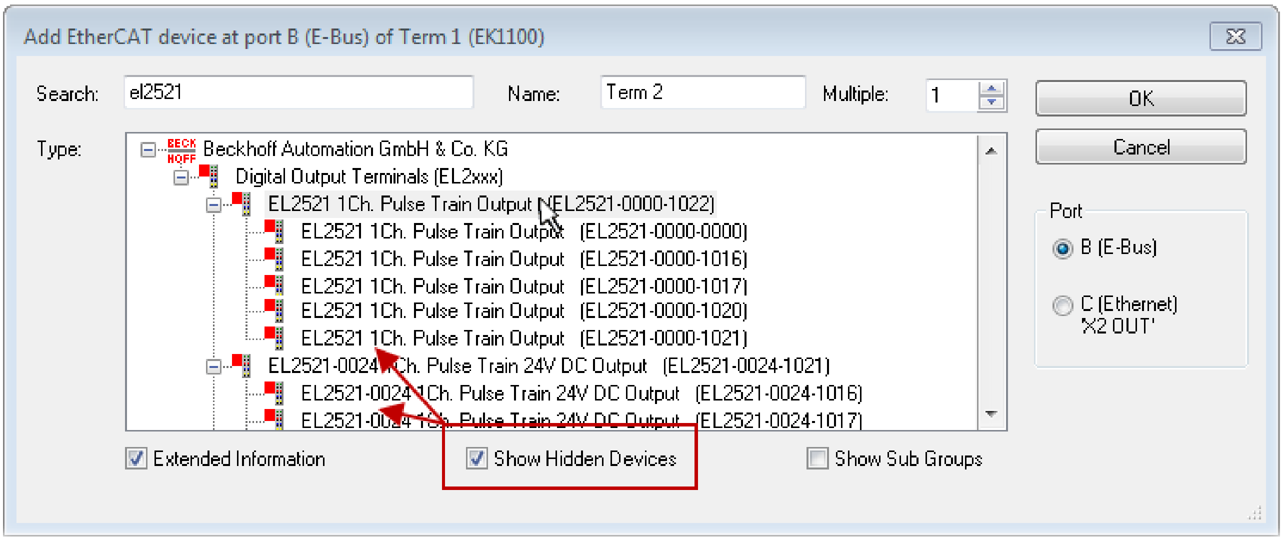
Type:
- Beckhoff Automation GmbH & Co. KG
  - Digital Output Terminals (EL2xxx)
    - EL2521 1Ch. Pulse Train Output (EL2521-0000-1022)
    - EL2521-0024 1Ch. Pulse Train 24V DC Output (EL2521-0024-1021)
    - EL2521-0025 1Ch. Pulse Train 24V DC Output negative (EL2521-0025-1021)
    - EL2521-0124 1Ch. Pulse Train 24V DC Output Capture/Compare (EL2521-0124-0020)
    - EL2521-1001 1Ch. Pulse Train Output (EL2521-1001-1020)

☑ Extended Information  □ Show Hidden Devices  ☑ Show Sub Groups

Port: ● B (E-Bus)  ○ C (Ethernet) 'X2 OUT'

Fig. 61: Display of device revision

In many cases several device revisions were created for historic or functional reasons, e.g. through technological advancement. For simplification purposes (see Fig. “Selection dialog for new EtherCAT device”) only the last (i.e. highest) revision and therefore the latest state of production is displayed in the selection dialog for Beckhoff devices. To show all device revisions available in the system as ESI descriptions tick the “Show Hidden Devices” check box, see Fig. “Display of previous revisions”.



Add EtherCAT device at port B (E-Bus) of Term 1 (EK1100)

Search: el2521

Name: Term 2

Multiple: 1

Type:

- Beckhoff Automation GmbH & Co. KG
  - Digital Output Terminals (EL2xxx)
    - EL2521 1Ch. Pulse Train Output (EL2521-0000-1022)
      - EL2521 1Ch. Pulse Train Output (EL2521-0000-0000)
      - EL2521 1Ch. Pulse Train Output (EL2521-0000-1016)
      - EL2521 1Ch. Pulse Train Output (EL2521-0000-1017)
      - EL2521 1Ch. Pulse Train Output (EL2521-0000-1020)
      - EL2521 1Ch. Pulse Train Output (EL2521-0000-1021)
    - EL2521-0024 1Ch. Pulse Train 24V DC Output (EL2521-0024-1021)
      - EL2521-0024 1Ch. Pulse Train 24V DC Output (EL2521-0024-1016)
      - EL2521-0024 1Ch. Pulse Train 24V DC Output (EL2521-0024-1017)

☑ Extended Information ☑ Show Hidden Devices □ Show Sub Groups

Port

● B (E-Bus)

○ C (Ethernet) 'X2 OUT'

Fig. 62: Display of previous revisions

### Device selection based on revision, compatibility

The ESI description also defines the process image, the communication type between master and slave/device and the device functions, if applicable. The physical device (firmware, if available) has to support the communication queries/settings of the master. This is backward compatible, i.e. newer devices (higher revision) should be supported if the EtherCAT master addresses them as an older revision. The following compatibility rule of thumb is to be assumed for Beckhoff EtherCAT Terminals/ Boxes/ EJ-modules:

**device revision in the system >= device revision in the configuration**

This also enables subsequent replacement of devices without changing the configuration (different specifications are possible for drives).

### Example

If an EL2521-0025-**1018** is specified in the configuration, an EL2521-0025-**1018** or higher (-**1019**, -**1020**) can be used in practice.

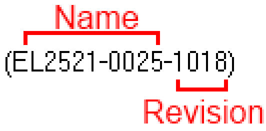
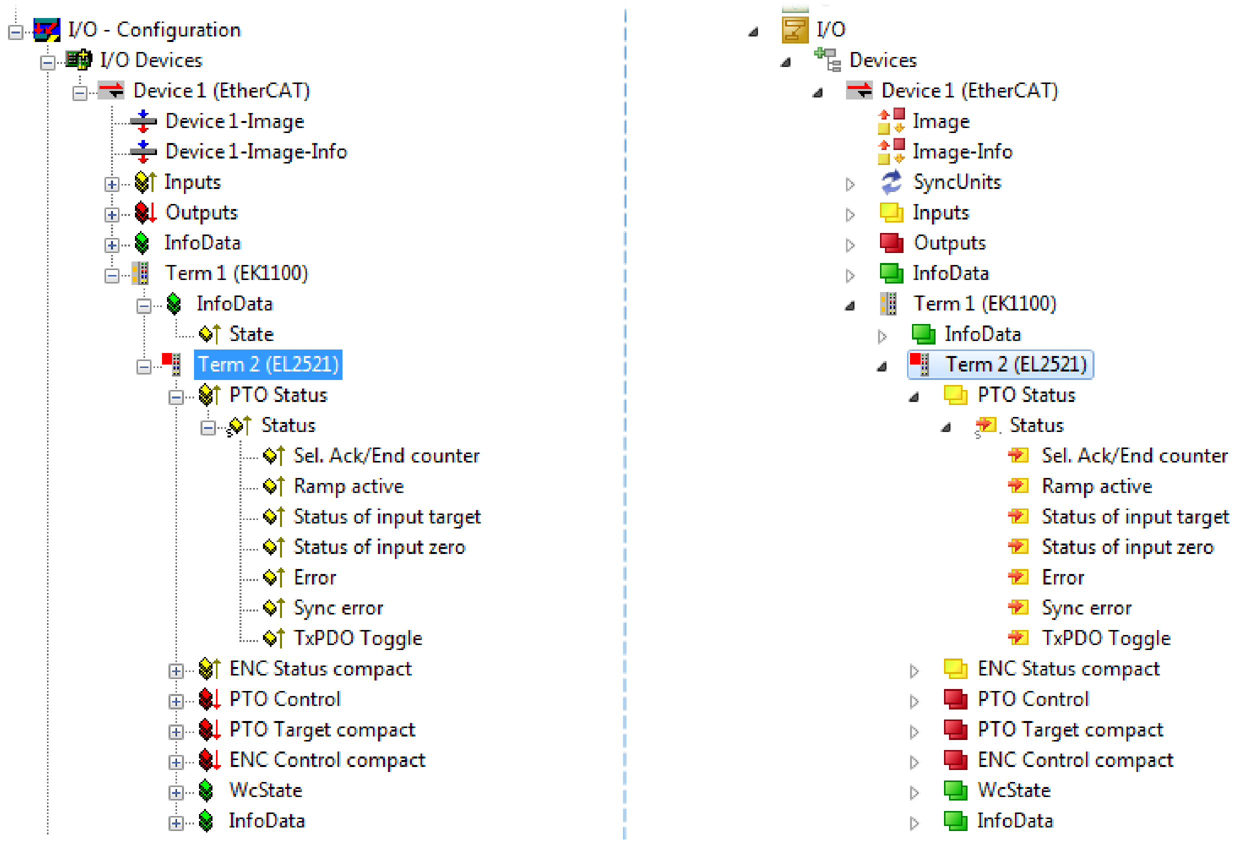


Fig. 63: Name/revision of the terminal

If current ESI descriptions are available in the TwinCAT system, the last revision offered in the selection dialog matches the Beckhoff state of production. It is recommended to use the last device revision when creating a new configuration, if current Beckhoff devices are used in the real application. Older revisions should only be used if older devices from stock are to be used in the application.

In this case the process image of the device is shown in the configuration tree and can be parameterized as follows: linking with the task, CoE/DC settings, plug-in definition, startup settings, ...



```
I/O - Configuration
  I/O Devices
    Device 1 (EtherCAT)
      Device 1-Image
      Device 1-Image-Info
      Inputs
      Outputs
      InfoData
      Term 1 (EK1100)
        InfoData
          State
        Term 2 (EL2521)
          PTO Status
            Status
              Sel. Ack/End counter
              Ramp active
              Status of input target
              Status of input zero
              Error
              Sync error
              TxPDO Toggle
          ENC Status compact
          PTO Control
          PTO Target compact
          ENC Control compact
          WcState
          InfoData
```

```
I/O
  Devices
    Device 1 (EtherCAT)
      Image
      Image-Info
      SyncUnits
      Inputs
      Outputs
      InfoData
      Term 1 (EK1100)
        InfoData
        Term 2 (EL2521)
          PTO Status
            Status
              Sel. Ack/End counter
              Ramp active
              Status of input target
              Status of input zero
              Error
              Sync error
              TxPDO Toggle
          ENC Status compact
          PTO Control
          PTO Target compact
          ENC Control compact
          WcState
          InfoData
```

Fig. 64: EtherCAT terminal in the TwinCAT tree (left: TwinCAT 2; right: TwinCAT 3)

## 5.1.6 ONLINE configuration creation

### Detecting/scanning of the EtherCAT device

The online device search can be used if the TwinCAT system is in CONFIG mode. This can be indicated by a symbol right below in the information bar:

- on TwinCAT 2 by a blue display “Config Mode” within the System Manager window: Config Mode .
- on TwinCAT 3 within the user interface of the development environment by a symbol .

TwinCAT can be set into this mode:

- TwinCAT 2: by selection of in the Menubar or by “Actions” → “Set/Reset TwinCAT to Config Mode…”
- TwinCAT 3: by selection of in the Menubar or by “TwinCAT” → “Restart TwinCAT (Config Mode)”

**Online scanning in Config mode**

The online search is not available in RUN mode (production operation). Note the differentiation between TwinCAT programming system and TwinCAT target system.

The TwinCAT 2 icon ( ) or TwinCAT 3 icon ( ) within the Windows-Taskbar always shows the TwinCAT mode of the local IPC. Compared to that, the System Manager window of TwinCAT 2 or the user interface of TwinCAT 3 indicates the state of the target system.

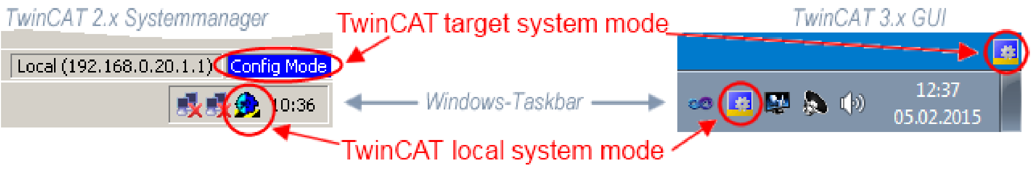


Fig. 65: Differentiation local/target system (left: TwinCAT 2; right: TwinCAT 3)

Right-clicking on “I/O Devices” in the configuration tree opens the search dialog.

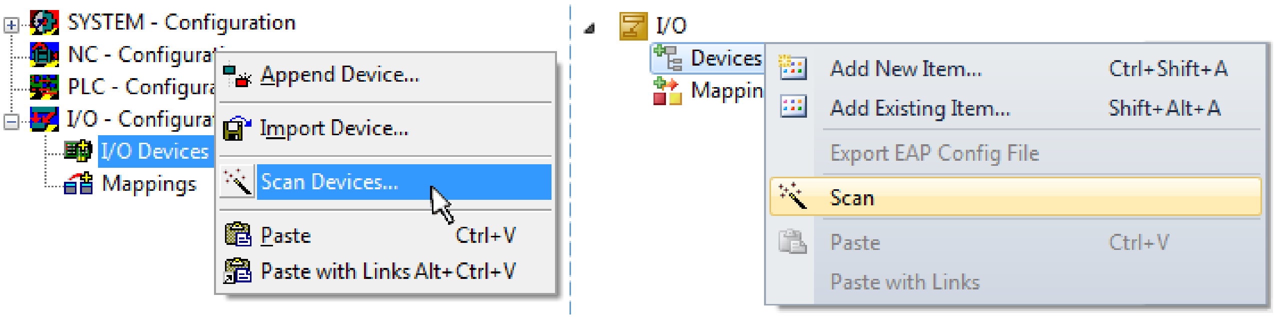
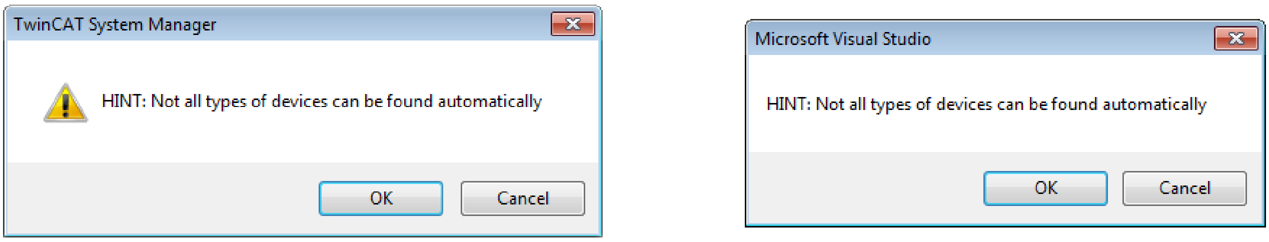


Fig. 66: Scan Devices (left: TwinCAT 2; right: TwinCAT 3)

This scan mode attempts to find not only EtherCAT devices (or Ethernet ports that are usable as such), but also NOVRAM, fieldbus cards, SMB etc. However, not all devices can be found automatically.


TwinCAT System Manager

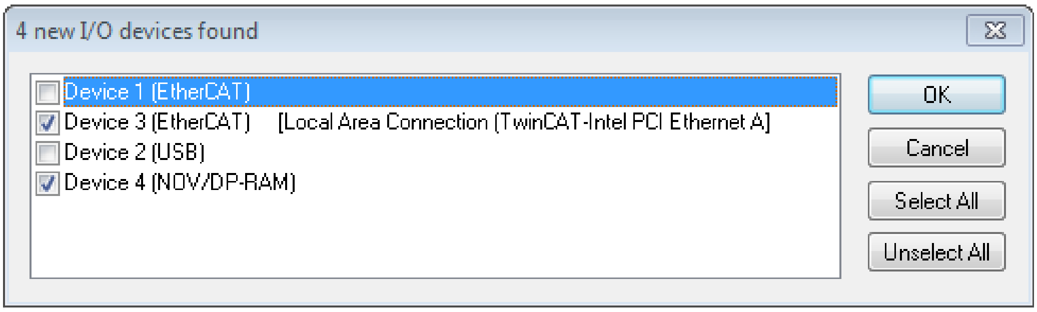
HINT: Not all types of devices can be found automatically

Microsoft Visual Studio

HINT: Not all types of devices can be found automatically

Fig. 67: Note for automatic device scan (left: TwinCAT 2; right: TwinCAT 3)

Ethernet ports with installed TwinCAT real-time driver are shown as “RT Ethernet” devices. An EtherCAT frame is sent to these ports for testing purposes. If the scan agent detects from the response that an EtherCAT slave is connected, the port is immediately shown as an “EtherCAT Device” .



4 new I/O devices found

- □ Device 1 (EtherCAT)
- ☑ Device 3 (EtherCAT) [Local Area Connection (TwinCAT-Intel PCI Ethernet A)]
- □ Device 2 (USB)
- ☑ Device 4 (NOV/DP-RAM)

Fig. 68: Detected Ethernet devices

Via respective checkboxes devices can be selected (as illustrated in Fig. “Detected Ethernet devices” e.g. Device 3 and Device 4 were chosen). After confirmation with “OK” a device scan is suggested for all selected devices, see Fig.: “Scan query after automatic creation of an EtherCAT device”.

**Selecting the Ethernet port**

Ethernet ports can only be selected for EtherCAT devices for which the TwinCAT real-time driver is installed. This has to be done separately for each port. Please refer to the respective installation page [▸ 60].

### Detecting/Scanning the EtherCAT devices

**Online scan functionality**

During a scan the master queries the identity information of the EtherCAT slaves from the slave EEPROM. The name and revision are used for determining the type. The respective devices are located in the stored ESI data and integrated in the configuration tree in the default state defined there.

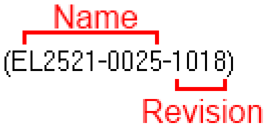


Fig. 69: Example default state

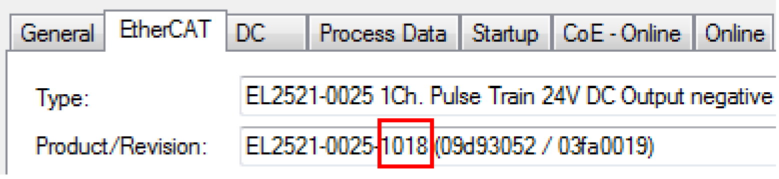
**NOTICE**

**Slave scanning in practice in series machine production**

The scanning function should be used with care. It is a practical and fast tool for creating an initial configuration as a basis for commissioning. In series machine production or reproduction of the plant, however, the function should no longer be used for the creation of the configuration, but if necessary for comparison [▸ 81] with the defined initial configuration.Background: since Beckhoff occasionally increases the revision version of the delivered products for product maintenance reasons, a configuration can be created by such a scan which (with an identical machine construction) is identical according to the device list; however, the respective device revision may differ from the initial configuration.

**Example:**

Company A builds the prototype of a machine B, which is to be produced in series later on. To do this the prototype is built, a scan of the IO devices is performed in TwinCAT and the initial configuration “B.tsm” is created. The EL2521-0025 EtherCAT terminal with the revision 1018 is located somewhere. It is thus built into the TwinCAT configuration in this way:



Type: EL2521-0025 1Ch. Pulse Train 24V DC Output negative

Product/Revision: EL2521-0025-1018 (09d93052 / 03fa0019)

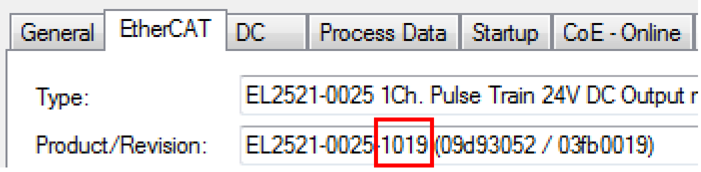
Fig. 70: Installing EthetCAT terminal with revision -1018

Likewise, during the prototype test phase, the functions and properties of this terminal are tested by the programmers/commissioning engineers and used if necessary, i.e. addressed from the PLC “B.pro” or the NC. (the same applies correspondingly to the TwinCAT 3 solution files).

The prototype development is now completed and series production of machine B starts, for which Beckhoff continues to supply the EL2521-0025-0018. If the commissioning engineers of the series machine production department always carry out a scan, a B configuration with the identical contents results again for each machine. Likewise, A might create spare parts stores worldwide for the coming series-produced machines with EL2521-0025-1018 terminals.

After some time Beckhoff extends the EL2521-0025 by a new feature C. Therefore the FW is changed, outwardly recognizable by a higher FW version and **a new revision -1019**. Nevertheless the new device naturally supports functions and interfaces of the predecessor version(s); an adaptation of “B.tsm” or even “B.pro” is therefore unnecessary. The series-produced machines can continue to be built with “B.tsm” and “B.pro”; it makes sense to perform a comparative scan [▶ 81] against the initial configuration “B.tsm” in order to check the built machine.

However, if the series machine production department now doesn’t use “B.tsm”, but instead carries out a scan to create the productive configuration, the revision **-1019** is automatically detected and built into the configuration:



Type: EL2521-0025 1Ch. Pulse Train 24V DC Output r

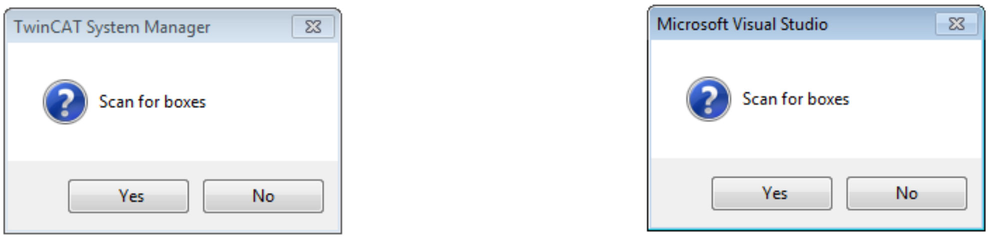
Product/Revision: EL2521-0025-1019 (09d93052 / 03fb0019)

Fig. 71: Detection of EtherCAT terminal with revision -1019

This is usually not noticed by the commissioning engineers. TwinCAT cannot signal anything either, since a new configuration is essentially created. According to the compatibility rule, however, this means that no EL2521-0025-**1018** should be built into this machine as a spare part (even if this nevertheless works in the vast majority of cases).

In addition, it could be the case that, due to the development accompanying production in company A, the new feature C of the EL2521-0025-1019 (for example, an improved analog filter or an additional process data for the diagnosis) is discovered and used without in-house consultation. The previous stock of spare part devices are then no longer to be used for the new configuration “B2.tsm” created in this way. Þ if series machine production is established, the scan should only be performed for informative purposes for comparison with a defined initial configuration. Changes are to be made with care!

If an EtherCAT device was created in the configuration (manually or through a scan), the I/O field can be scanned for devices/slaves.



Scan for boxes

Scan for boxes

Fig. 72: Scan query after automatic creation of an EtherCAT device (left: TwinCAT 2; right: TwinCAT 3)

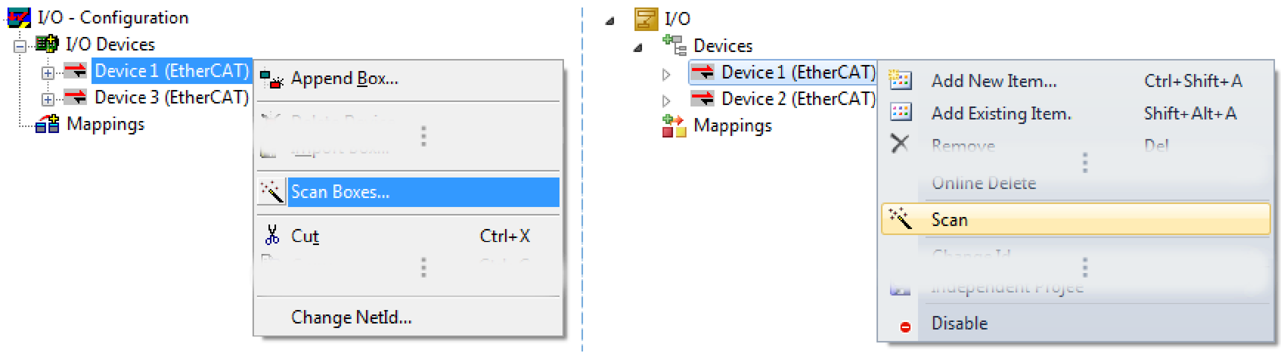


Fig. 73: Manual scanning for devices on a specified EtherCAT device (left: TwinCAT 2; right: TwinCAT 3)

In the System Manager (TwinCAT 2) or the User Interface (TwinCAT 3) the scan process can be monitored via the progress bar at the bottom in the status bar.

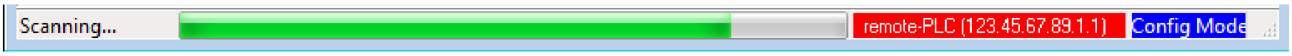
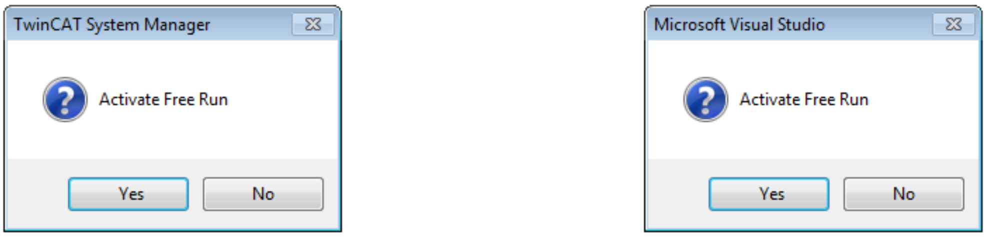


Fig. 74: *Scan progressexemplary by TwinCAT 2*

The configuration is established and can then be switched to online state (OPERATIONAL).



Activate Free Run

Activate Free Run

Fig. 75: Config/FreeRun query (left: TwinCAT 2; right: TwinCAT 3)

In Config/FreeRun mode the System Manager display alternates between blue and red, and the EtherCAT device continues to operate with the idling cycle time of 4 ms (default setting), even without active task (NC, PLC).

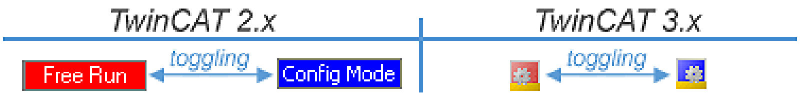


Fig. 76: Displaying of “Free Run” and “Config Mode” toggling right below in the status bar

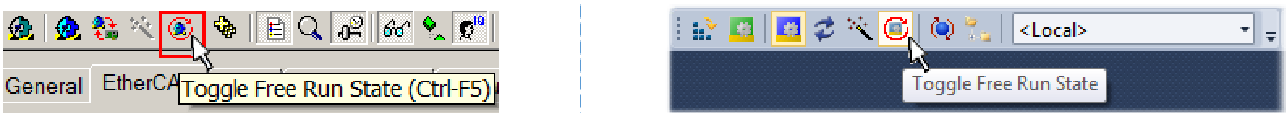
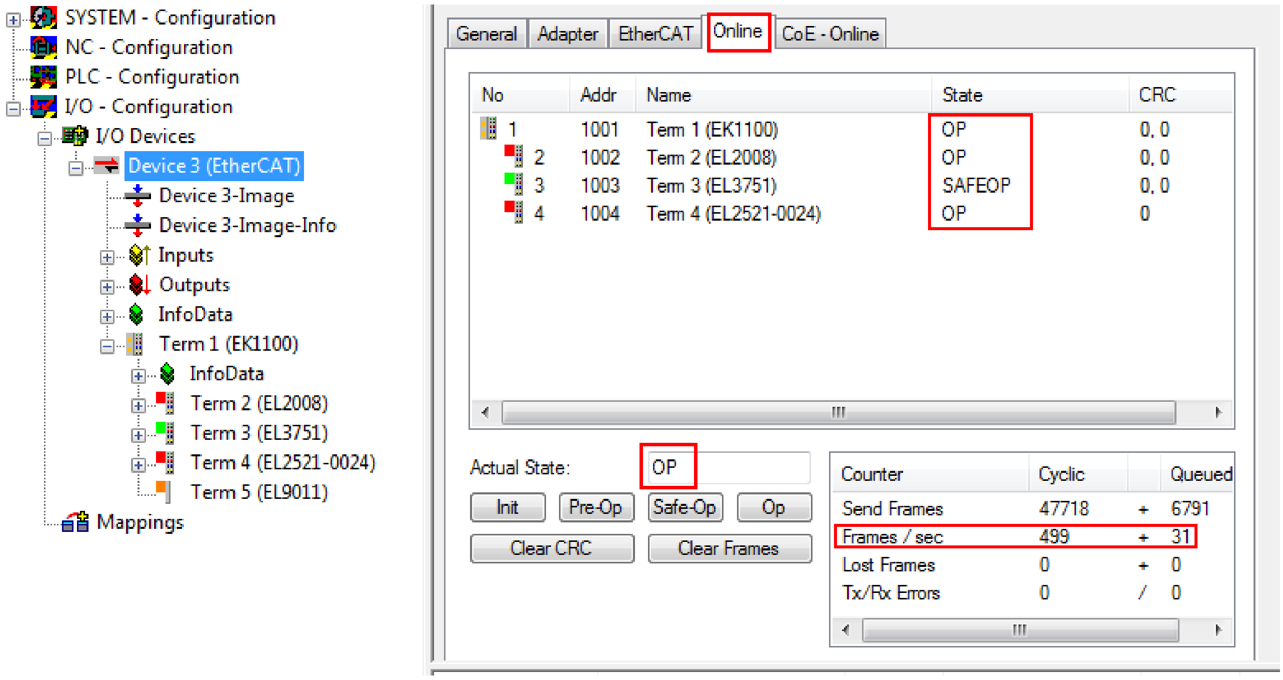


Fig. 77: TwinCAT can also be switched to this state by using a button (left: TwinCAT 2; right: TwinCAT 3)

The EtherCAT system should then be in a functional cyclic state, as shown in Fig. *Online display example*.



| No | Addr | Name | State | CRC |
|---|---|---|---|---|
| 1 | 1001 | Term 1 (EK1100) | OP | 0, 0 |
| 2 | 1002 | Term 2 (EL2008) | OP | 0, 0 |
| 3 | 1003 | Term 3 (EL3751) | SAFEOP | 0, 0 |
| 4 | 1004 | Term 4 (EL2521-0024) | OP | 0 |

Actual State: OP

| Counter | Cyclic | | Queued |
|---|---|---|---|
| Send Frames | 47718 | + | 6791 |
| Frames / sec | 499 | + | 31 |
| Lost Frames | 0 | + | 0 |
| Tx/Rx Errors | 0 | / | 0 |

Fig. 78: Online display example

Please note:

- all slaves should be in OP state
- the EtherCAT master should be in “Actual State” OP
- “frames/sec” should match the cycle time taking into account the sent number of frames
- no excessive “LostFrames” or CRC errors should occur

The configuration is now complete. It can be modified as described under manual procedure [▶ 71].

### Troubleshooting

Various effects may occur during scanning.

- An **unknown device** is detected, i.e. an EtherCAT slave for which no ESI XML description is available. In this case the System Manager offers to read any ESI that may be stored in the device. This case is described in the chapter “Notes regarding ESI device description”.
- **Device are not detected properly**
  Possible reasons include:
  - faulty data links, resulting in data loss during the scan
  - slave has invalid device description

  The connections and devices should be checked in a targeted manner, e.g. via the emergency scan. Then re-run the scan.

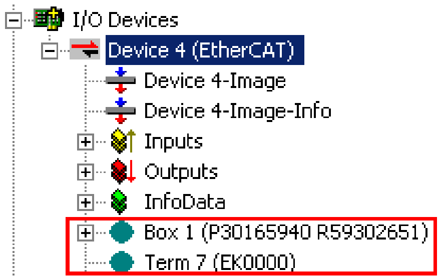


Fig. 79: Faulty identification

In the System Manager such devices may be set up as EK0000 or unknown devices. Operation is not possible or meaningful.

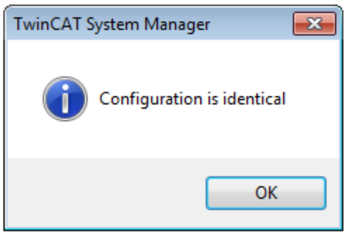
### Scan over existing Configuration

**NOTICE**

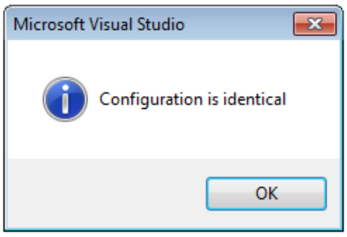
**Change of the configuration after comparison**

With this scan (TwinCAT 2.11 or 3.1) only the device properties vendor (manufacturer), device name and revision are compared at present! A “ChangeTo” or “Copy” should only be carried out with care, taking into consideration the Beckhoff IO compatibility rule (see above). The device configuration is then replaced by the revision found; this can affect the supported process data and functions.

If a scan is initiated for an existing configuration, the actual I/O environment may match the configuration exactly or it may differ. This enables the configuration to be compared.


TwinCAT System Manager

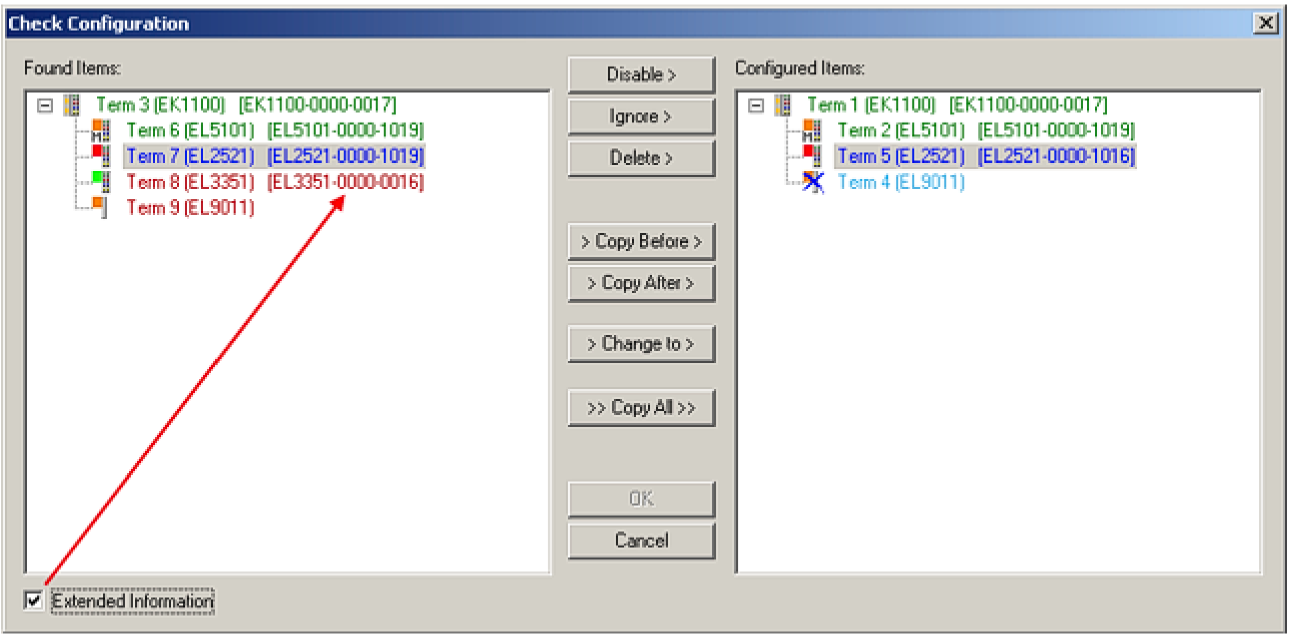
Configuration is identical


Microsoft Visual Studio

Configuration is identical

Fig. 80: Identical configuration (left: TwinCAT 2; right: TwinCAT 3)

If differences are detected, they are shown in the correction dialog, so that the user can modify the configuration as required.


Check Configuration

Found Items:
- Term 3 (EK1100) [EK1100-0000-0017]
  - Term 6 (EL5101) [EL5101-0000-1019]
  - Term 7 (EL2521) [EL2521-0000-1019]
  - Term 8 (EL3351) [EL3351-0000-0016]
  - Term 9 (EL9011)

Configured Items:
- Term 1 (EK1100) [EK1100-0000-0017]
  - Term 2 (EL5101) [EL5101-0000-1019]
  - Term 5 (EL2521) [EL2521-0000-1016]
  - Term 4 (EL9011)

☑ Extended Information

Fig. 81: Correction dialog

It is advisable to tick the “Extended Information” check box to reveal differences in the revision.

| Color | Explanation |
|---|---|
| green | This EtherCAT slave matches the entry on the other side. Both type and revision match. |
| blue | This EtherCAT slave is present on the other side, but in a different revision. This other revision can have other default values for the process data as well as other/additional functions.<br>If the found revision is higher than the configured revision, the slave may be used provided compatibility issues are taken into account.<br>If the found revision is lower than the configured revision, it is likely that the slave cannot be used. The found device may not support all functions that the master expects based on the higher revision number. |
| light blue | This EtherCAT slave is ignored (“Ignore” button) |
| red | • This EtherCAT slave is not present on the other side.<br>• It is present, but in a different revision, which also differs in its properties from the one specified. The compatibility principle then also applies here: if the found revision is higher than the configured revision, use is possible provided compatibility issues are taken into account, since the successor devices should support the functions of the predecessor devices. If the found revision is lower than the configured revision, it is likely that the slave cannot be used. The found device may not support all functions that the master expects based on the higher revision number. |

### Device selection based on revision, compatibility

The ESI description also defines the process image, the communication type between master and slave/device and the device functions, if applicable. The physical device (firmware, if available) has to support the communication queries/settings of the master. This is backward compatible, i.e. newer devices (higher revision) should be supported if the EtherCAT master addresses them as an older revision. The following compatibility rule of thumb is to be assumed for Beckhoff EtherCAT Terminals/ Boxes/ EJ-modules:

**device revision in the system >= device revision in the configuration**

This also enables subsequent replacement of devices without changing the configuration (different specifications are possible for drives).

### Example

If an EL2521-0025-**1018** is specified in the configuration, an EL2521-0025-**1018** or higher (-**1019**, -**1020**) can be used in practice.

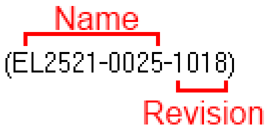
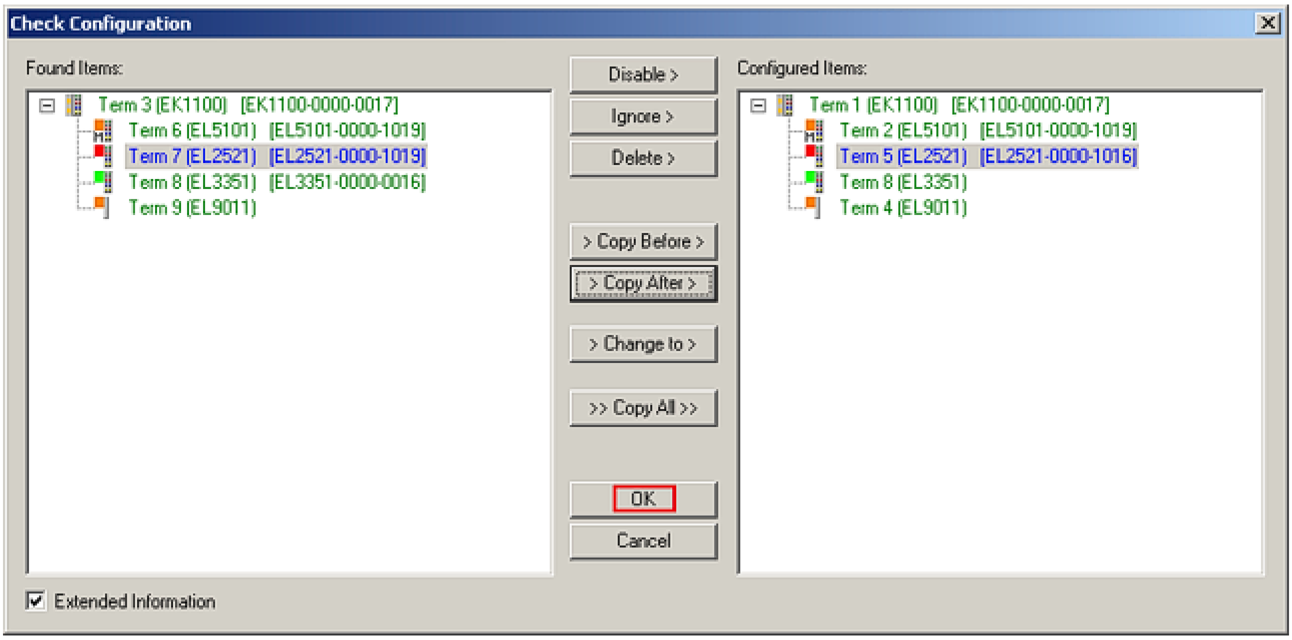


Fig. 82: Name/revision of the terminal

If current ESI descriptions are available in the TwinCAT system, the last revision offered in the selection dialog matches the Beckhoff state of production. It is recommended to use the last device revision when creating a new configuration, if current Beckhoff devices are used in the real application. Older revisions should only be used if older devices from stock are to be used in the application.

In this case the process image of the device is shown in the configuration tree and can be parameterized as follows: linking with the task, CoE/DC settings, plug-in definition, startup settings, ...



Found Items:

- Term 3 (EK1100) [EK1100-0000-0017]
  - Term 6 (EL5101) [EL5101-0000-1019]
  - Term 7 (EL2521) [EL2521-0000-1019]
  - Term 8 (EL3351) [EL3351-0000-0016]
  - Term 9 (EL9011)

Configured Items:

- Term 1 (EK1100) [EK1100-0000-0017]
  - Term 2 (EL5101) [EL5101-0000-1019]
  - Term 5 (EL2521) [EL2521-0000-1016]
  - Term 8 (EL3351)
  - Term 4 (EL9011)

Fig. 83: Correction dialog with modifications

Once all modifications have been saved or accepted, click “OK” to transfer them to the real *.tsm configuration.

### Change to Compatible Type

TwinCAT offers a function *Change to Compatible Type…* for the exchange of a device whilst retaining the links in the task.

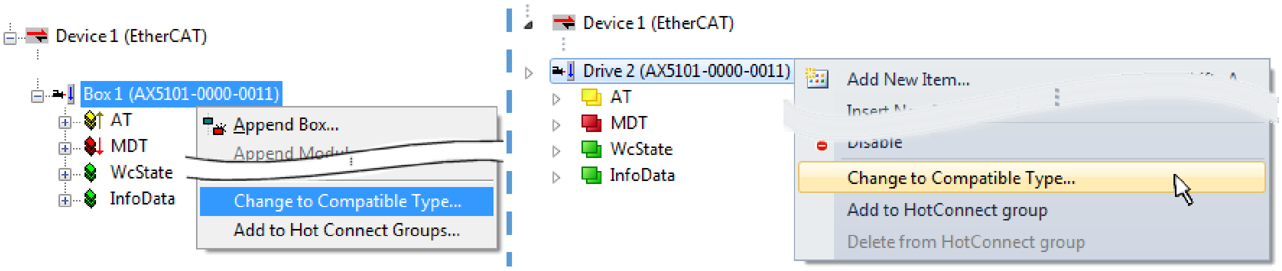


Fig. 84: Dialog “Change to Compatible Type…” (left: TwinCAT 2; right: TwinCAT 3)

The following elements in the ESI of an EtherCAT device are compared by TwinCAT and assumed to be the same in order to decide whether a device is indicated as "compatible":

- Physics (e.g. RJ45, Ebus...)

- FMMU (additional ones are allowed)

- SyncManager (SM, additional ones are allowed)

- EoE (attributes MAC, IP)

- CoE (attributes SdoInfo, PdoAssign, PdoConfig, PdoUpload, CompleteAccess)

- FoE

- PDO (process data: Sequence, SyncUnit SU, SyncManager SM, EntryCount, Ent-ry.Datatype)

This function is preferably to be used on AX5000 devices.

### Change to Alternative Type

The TwinCAT System Manager offers a function for the exchange of a device: Change to Alternative Type

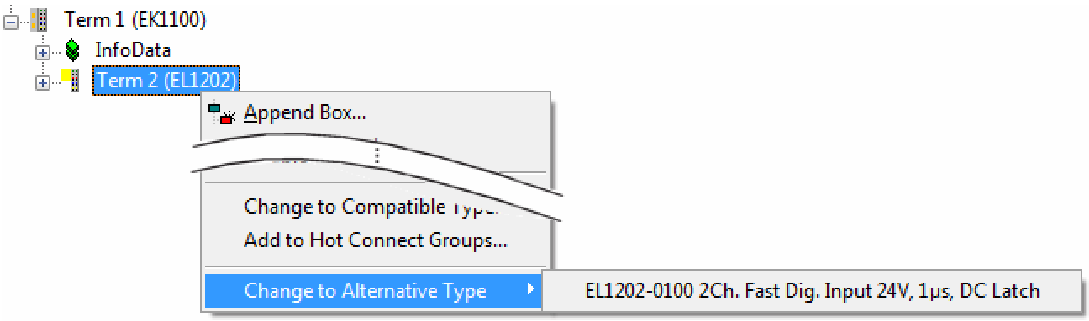

Term 1 (EK1100)
InfoData
Term 2 (EL1202)
Append Box...
Change to Compatible Type...
Add to Hot Connect Groups...
Change to Alternative Type
EL1202-0100 2Ch. Fast Dig. Input 24V, 1µs, DC Latch

Fig. 85: TwinCAT 2 Dialog Change to Alternative Type

If called, the System Manager searches in the procured device ESI (in this example: EL1202-0000) for details of compatible devices contained there. The configuration is changed and the ESI-EEPROM is overwritten at the same time – therefore this process is possible only in the online state (ConfigMode).

## 5.1.7 EtherCAT subscriber configuration

In the left-hand window of the TwinCAT 2 System Manager or the Solution Explorer of the TwinCAT 3 Development Environment respectively, click on the element of the terminal within the tree you wish to configure (in the example: EL3751 Terminal 3).

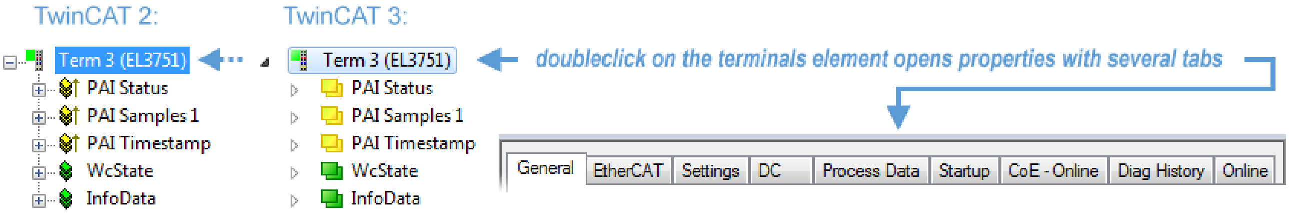
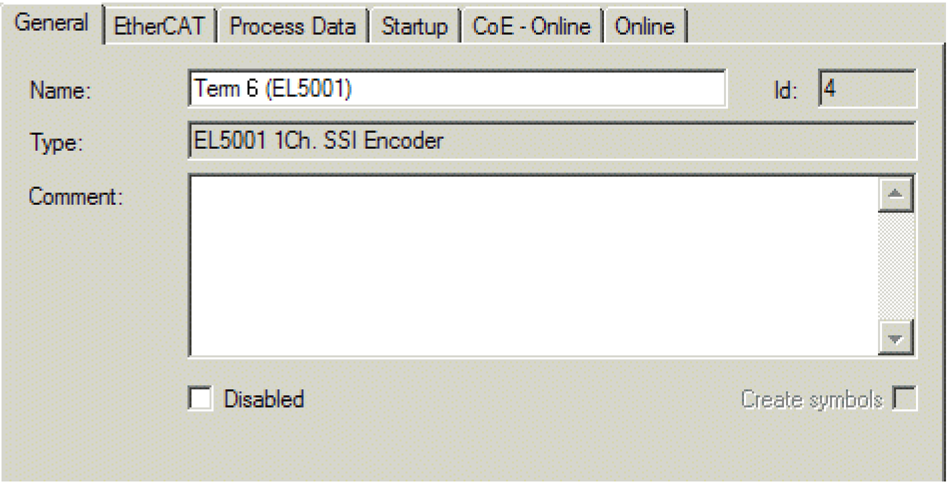


Fig. 86: Branch element as terminal EL3751

In the right-hand window of the TwinCAT System Manager (TwinCAT 2) or the Development Environment (TwinCAT 3), various tabs are now available for configuring the terminal. And yet the dimension of complexity of a subscriber determines which tabs are provided. Thus as illustrated in the example above the terminal EL3751 provides many setup options and also a respective number of tabs are available. On the contrary by the terminal EL1004 for example the tabs “General”, “EtherCAT”, “Process Data” and “Online“ are available only. Several terminals, as for instance the EL6695 provide special functions by a tab with its own terminal name, so “EL6695” in this case. A specific tab “Settings” by terminals with a wide range of setup options will be provided also (e.g. EL3751).

### “General” tab



Name: Term 6 (EL5001)

Id: 4

Type: EL5001 1Ch. SSI Encoder

Comment:

□ Disabled

Create symbols □

Fig. 87: “General” tab

**Name** Name of the EtherCAT device

**Id** Number of the EtherCAT device

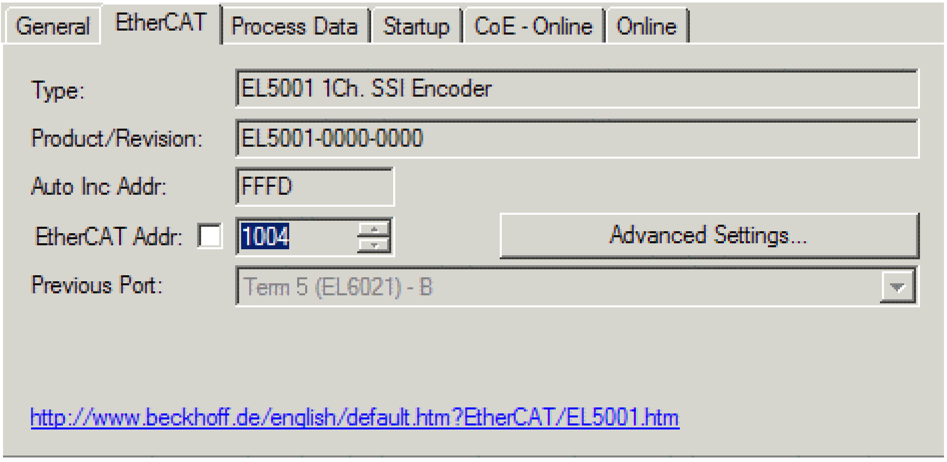
**Type** EtherCAT device type

**Comment** Here you can add a comment (e.g. regarding the system).

**Disabled** Here you can deactivate the EtherCAT device.

**Create symbols** Access to this EtherCAT slave via ADS is only available if this control box is activated.

### “EtherCAT” tab



Type: EL5001 1Ch. SSI Encoder

Product/Revision: EL5001-0000-0000

Auto Inc Addr: FFFD

EtherCAT Addr: □ 1004

Previous Port: Term 5 (EL6021) - B

http://www.beckhoff.de/english/default.htm?EtherCAT/EL5001.htm

Fig. 88: “EtherCAT” tab

**Type** EtherCAT device type

**Product/Revision** Product and revision number of the EtherCAT device

**Auto Inc Addr.** Auto increment address of the EtherCAT device. The auto increment address can be used for addressing each EtherCAT device in the communication ring through its physical position. Auto increment addressing is used during the start-up phase when the EtherCAT master allocates addresses to the EtherCAT devices. With auto increment addressing the first EtherCAT slave in the ring has the address $0000_{hex}$. For each further slave the address is decremented by 1 ($FFFF_{hex}$, $FFFE_{hex}$ etc.).

**EtherCAT Addr.** Fixed address of an EtherCAT slave. This address is allocated by the EtherCAT master during the start-up phase. Tick the control box to the left of the input field in order to modify the default value.

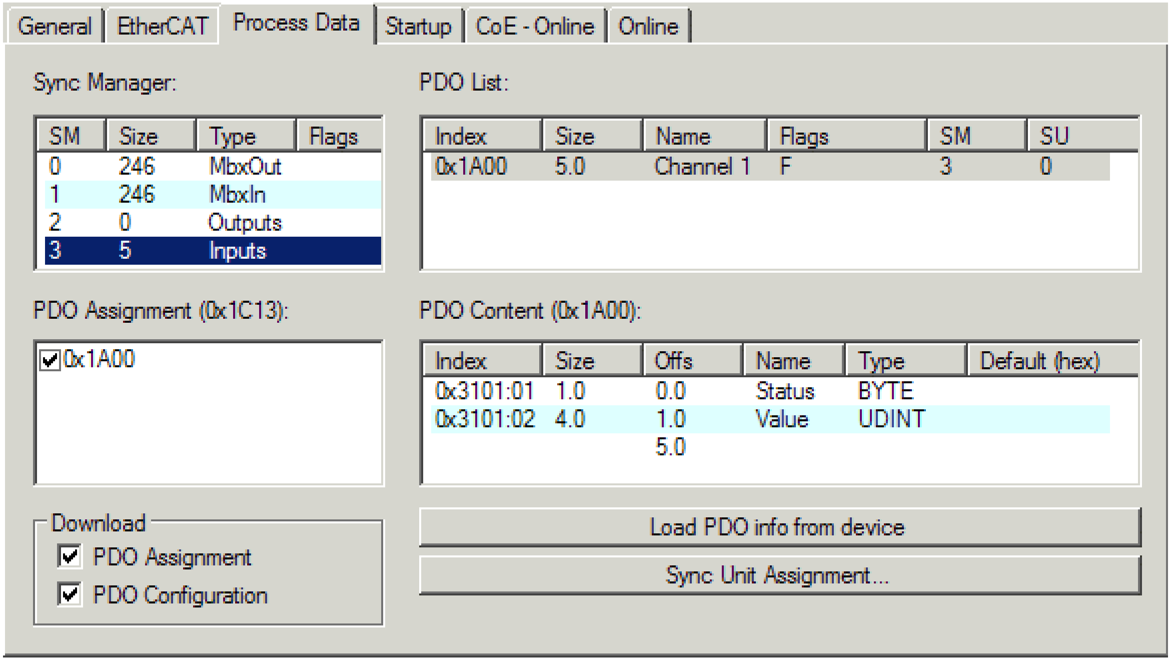
**Previous Port** Name and port of the EtherCAT device to which this device is connected. If it is possible to connect this device with another one without changing the order of the EtherCAT devices in the communication ring, then this combination field is activated and the EtherCAT device to which this device is to be connected can be selected.

**Advanced Settings** This button opens the dialogs for advanced settings.

The link at the bottom of the tab points to the product page for this EtherCAT device on the web.

### “Process Data” tab

Indicates the configuration of the process data. The input and output data of the EtherCAT slave are represented as CANopen process data objects (**P**rocess **D**ata **O**bjects, PDOs). The user can select a PDO via PDO assignment and modify the content of the individual PDO via this dialog, if the EtherCAT slave supports this function.



Sync Manager:

| SM | Size | Type | Flags |
|---|---|---|---|
| 0 | 246 | MbxOut | |
| 1 | 246 | MbxIn | |
| 2 | 0 | Outputs | |
| 3 | 5 | Inputs | |

PDO List:

| Index | Size | Name | Flags | SM | SU |
|---|---|---|---|---|---|
| 0x1A00 | 5.0 | Channel 1 | F | 3 | 0 |

PDO Assignment (0x1C13):

☑ 0x1A00

PDO Content (0x1A00):

| Index | Size | Offs | Name | Type | Default (hex) |
|---|---|---|---|---|---|
| 0x3101:01 | 1.0 | 0.0 | Status | BYTE | |
| 0x3101:02 | 4.0 | 1.0 | Value | UDINT | |
| | | 5.0 | | | |

Download
☑ PDO Assignment
☑ PDO Configuration

Fig. 89: “Process Data” tab

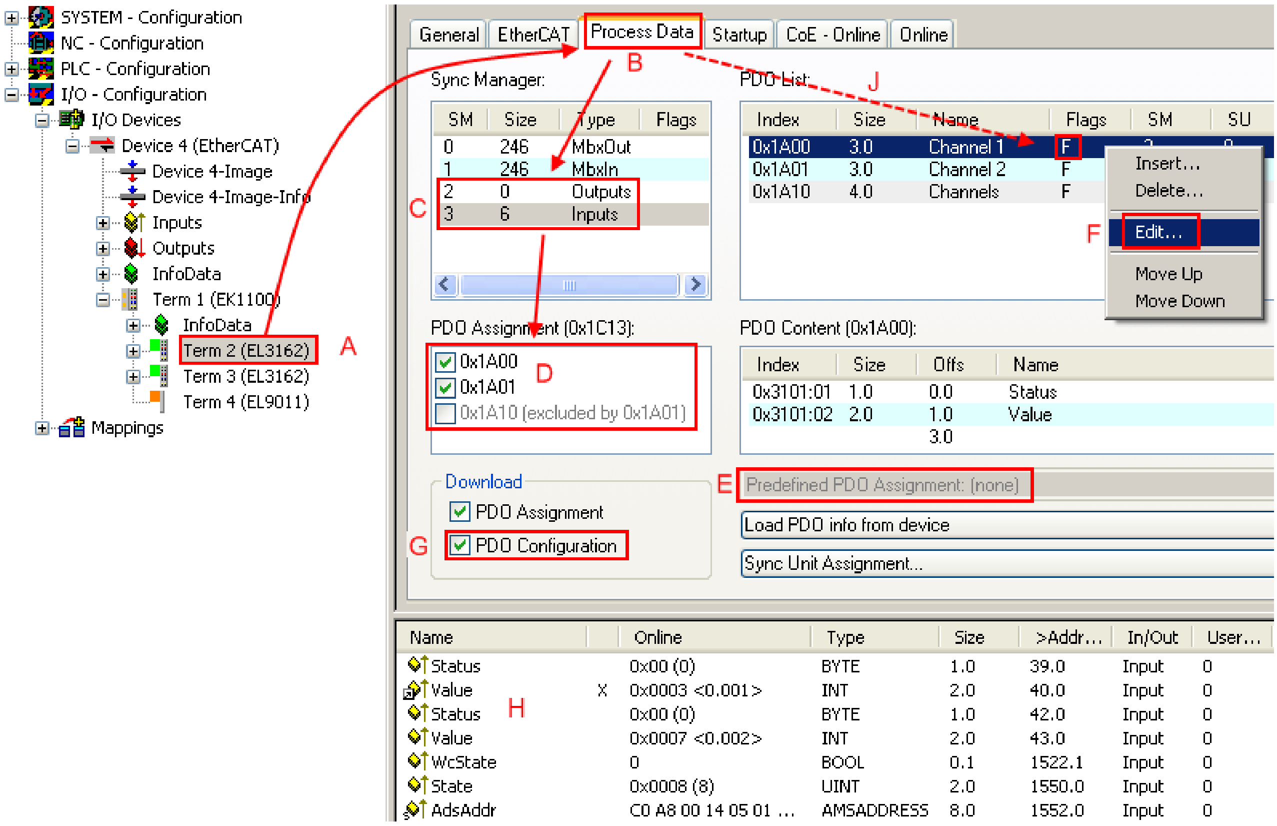
The process data (PDOs) transferred by an EtherCAT slave during each cycle are user data which the application expects to be updated cyclically or which are sent to the slave. To this end the EtherCAT master (Beckhoff TwinCAT) parameterizes each EtherCAT slave during the start-up phase to define which process data (size in bits/bytes, source location, transmission type) it wants to transfer to or from this slave. Incorrect configuration can prevent successful start-up of the slave.

For Beckhoff EtherCAT EL, ES, EM, EJ and EP slaves the following applies in general:

- The input/output process data supported by the device are defined by the manufacturer in the ESI/XML description. The TwinCAT EtherCAT Master uses the ESI description to configure the slave correctly.
- The process data can be modified in the System Manager. See the device documentation. Examples of modifications include: mask out a channel, displaying additional cyclic information, 16-bit display instead of 8-bit data size, etc.
- In so-called “intelligent” EtherCAT devices the process data information is also stored in the CoE directory. Any changes in the CoE directory that lead to different PDO settings prevent successful startup of the slave. It is not advisable to deviate from the designated process data, because the device firmware (if available) is adapted to these PDO combinations.

If the device documentation allows modification of process data, proceed as follows (see Figure *Configuring the process data*).

- A: select the device to configure
- B: in the “Process Data” tab select Input or Output under SyncManager (C)
- D: the PDOs can be selected or deselected
- H: the new process data are visible as linkable variables in the System Manager
  The new process data are active once the configuration has been activated and TwinCAT has been restarted (or the EtherCAT master has been restarted)
- E: if a slave supports this, Input and Output PDO can be modified simultaneously by selecting a so-called PDO record (“predefined PDO settings”).



- SYSTEM - Configuration
- NC - Configuration
- PLC - Configuration
- I/O - Configuration
  - I/O Devices
    - Device 4 (EtherCAT)
      - Device 4-Image
      - Device 4-Image-Info
      - Inputs
      - Outputs
      - InfoData
      - Term 1 (EK1100)
        - InfoData
        - Term 2 (EL3162)
        - Term 3 (EL3162)
        - Term 4 (EL9011)
  - Mappings

Sync Manager:

| SM | Size | Type | Flags |
|---|---|---|---|
| 0 | 246 | MbxOut | |
| 1 | 246 | MbxIn | |
| 2 | 0 | Outputs | |
| 3 | 6 | Inputs | |

PDO List:

| Index | Size | Name | Flags | SM | SU |
|---|---|---|---|---|---|
| 0x1A00 | 3.0 | Channel 1 | F | | |
| 0x1A01 | 3.0 | Channel 2 | F | | |
| 0x1A10 | 4.0 | Channels | F | | |

PDO Assignment (0x1C13):

- ☑ 0x1A00
- ☑ 0x1A01
- □ 0x1A10 (excluded by 0x1A01)

PDO Content (0x1A00):

| Index | Size | Offs | Name |
|---|---|---|---|
| 0x3101:01 | 1.0 | 0.0 | Status |
| 0x3101:02 | 2.0 | 1.0 | Value |
| | | 3.0 | |

Download
- ☑ PDO Assignment
- ☑ PDO Configuration

Predefined PDO Assignment: (none)

Load PDO info from device

Sync Unit Assignment...

| Name | | Online | Type | Size | >Addr... | In/Out | User... |
|---|---|---|---|---|---|---|---|
| Status | | 0x00 (0) | BYTE | 1.0 | 39.0 | Input | 0 |
| Value | X | 0x0003 <0.001> | INT | 2.0 | 40.0 | Input | 0 |
| Status | | 0x00 (0) | BYTE | 1.0 | 42.0 | Input | 0 |
| Value | | 0x0007 <0.002> | INT | 2.0 | 43.0 | Input | 0 |
| WcState | | 0 | BOOL | 0.1 | 1522.1 | Input | 0 |
| State | | 0x0008 (8) | UINT | 2.0 | 1550.0 | Input | 0 |
| AdsAddr | | C0 A8 00 14 05 01 ... | AMSADDRESS | 8.0 | 1552.0 | Input | 0 |

Fig. 90: Configuring the process data

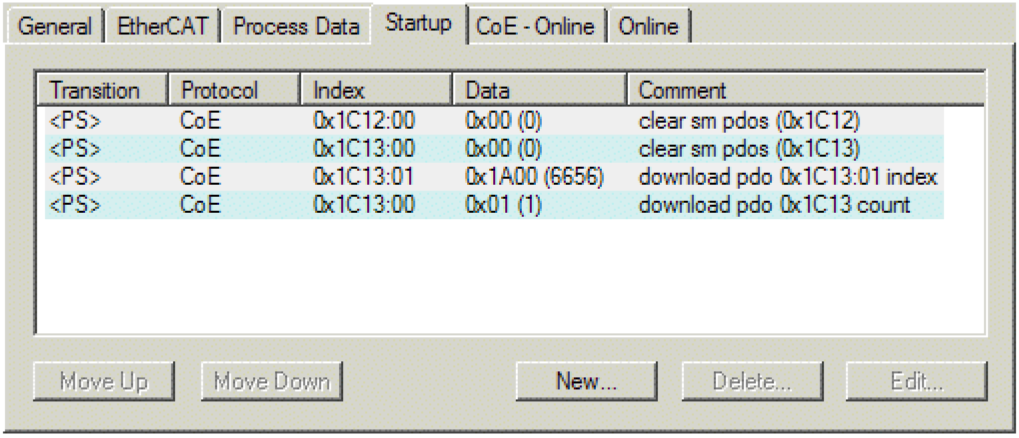
### Manual modification of the process data

According to the ESI description, a PDO can be identified as “fixed” with the flag “F” in the PDO overview (Fig. *Configuring the process data*, J). The configuration of such PDOs cannot be changed, even if TwinCAT offers the associated dialog (“Edit”). In particular, CoE content cannot be displayed as cyclic process data. This generally also applies in cases where a device supports download of the PDO configuration, “G”. In case of incorrect configuration the EtherCAT slave usually refuses to start and change to OP state. The System Manager displays an “invalid SM cfg” logger message: This error message (“invalid SM IN cfg” or “invalid SM OUT cfg”) also indicates the reason for the failed start.

A detailed description [▶ 92] can be found at the end of this section.

### “Startup” tab

The *Startup* tab is displayed if the EtherCAT slave has a mailbox and supports the *CANopen over EtherCAT* (CoE) or *Servo drive over EtherCAT* protocol. This tab indicates which download requests are sent to the mailbox during startup. It is also possible to add new mailbox requests to the list display. The download requests are sent to the slave in the same order as they are shown in the list.



| Transition | Protocol | Index | Data | Comment |
|---|---|---|---|---|
| <PS> | CoE | 0x1C12:00 | 0x00 (0) | clear sm pdos (0x1C12) |
| <PS> | CoE | 0x1C13:00 | 0x00 (0) | clear sm pdos (0x1C13) |
| <PS> | CoE | 0x1C13:01 | 0x1A00 (6656) | download pdo 0x1C13:01 index |
| <PS> | CoE | 0x1C13:00 | 0x01 (1) | download pdo 0x1C13 count |

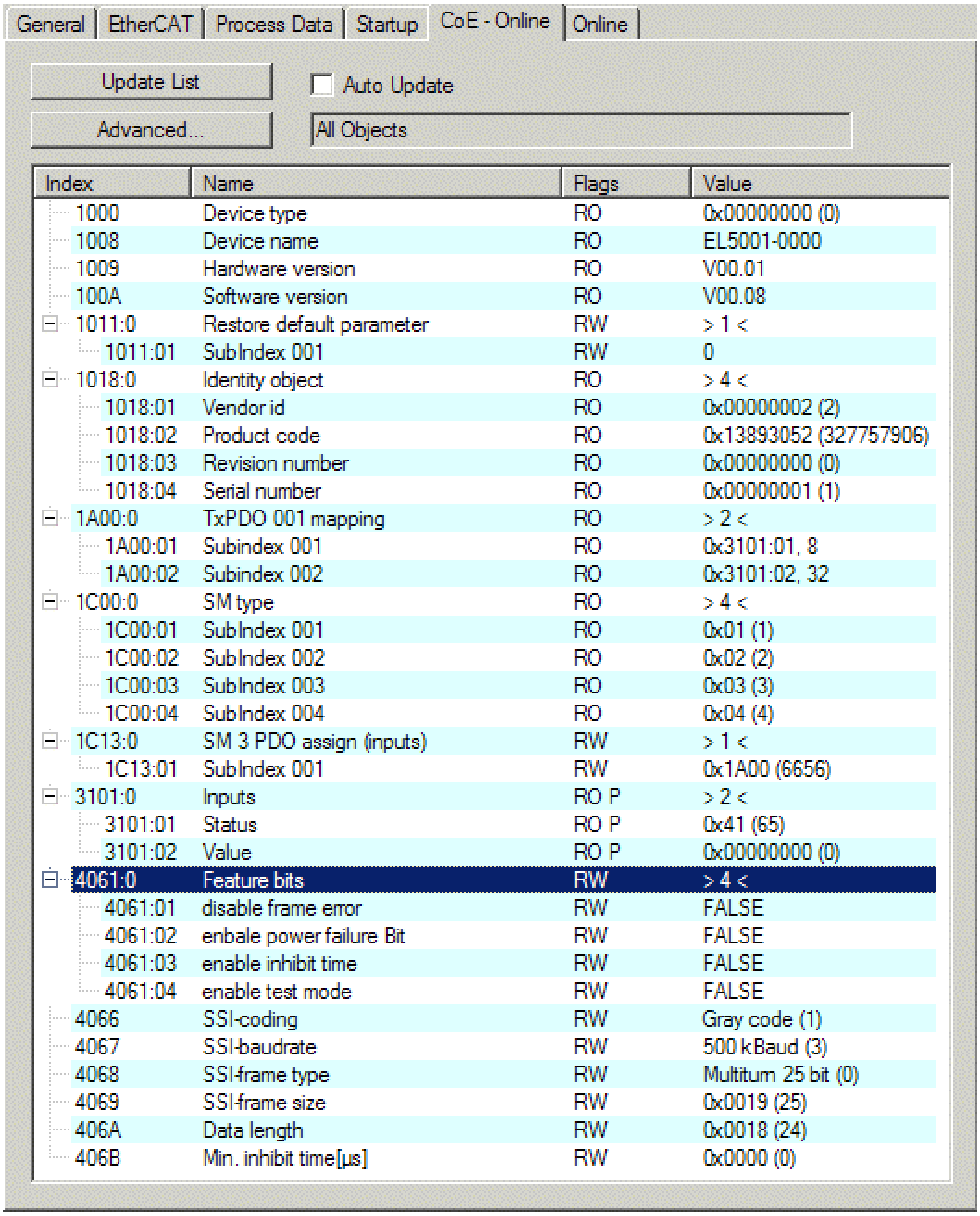
Fig. 91: “Startup” tab

| Column | Description |
|---|---|
| Transition | Transition to which the request is sent. This can either be<br>• the transition from pre-operational to safe-operational (PS), or<br>• the transition from safe-operational to operational (SO).<br>If the transition is enclosed in “<>” (e.g. <PS>), the mailbox request is fixed and cannot be modified or deleted by the user. |
| Protocol | Type of mailbox protocol |
| Index | Index of the object |
| Data | Date on which this object is to be downloaded. |
| Comment | Description of the request to be sent to the mailbox |

|  |  |
|---|---|
| **Move Up** | This button moves the selected request up by one position in the list. |
| **Move Down** | This button moves the selected request down by one position in the list. |
| **New** | This button adds a new mailbox download request to be sent during startup. |
| **Delete** | This button deletes the selected entry. |
| **Edit** | This button edits an existing request. |

### “CoE - Online” tab

The additional *CoE - Online* tab is displayed if the EtherCAT slave supports the *CANopen over EtherCAT* (CoE) protocol. This dialog lists the content of the object list of the slave (SDO upload) and enables the user to modify the content of an object from this list. Details for the objects of the individual EtherCAT devices can be found in the device-specific object descriptions.



| Index | Name | Flags | Value |
|---|---|---|---|
| 1000 | Device type | RO | 0x00000000 (0) |
| 1008 | Device name | RO | EL5001-0000 |
| 1009 | Hardware version | RO | V00.01 |
| 100A | Software version | RO | V00.08 |
| 1011:0 | Restore default parameter | RW | > 1 < |
| 1011:01 | SubIndex 001 | RW | 0 |
| 1018:0 | Identity object | RO | > 4 < |
| 1018:01 | Vendor id | RO | 0x00000002 (2) |
| 1018:02 | Product code | RO | 0x13893052 (327757906) |
| 1018:03 | Revision number | RO | 0x00000000 (0) |
| 1018:04 | Serial number | RO | 0x00000001 (1) |
| 1A00:0 | TxPDO 001 mapping | RO | > 2 < |
| 1A00:01 | Subindex 001 | RO | 0x3101:01, 8 |
| 1A00:02 | Subindex 002 | RO | 0x3101:02, 32 |
| 1C00:0 | SM type | RO | > 4 < |
| 1C00:01 | SubIndex 001 | RO | 0x01 (1) |
| 1C00:02 | SubIndex 002 | RO | 0x02 (2) |
| 1C00:03 | SubIndex 003 | RO | 0x03 (3) |
| 1C00:04 | SubIndex 004 | RO | 0x04 (4) |
| 1C13:0 | SM 3 PDO assign (inputs) | RW | > 1 < |
| 1C13:01 | SubIndex 001 | RW | 0x1A00 (6656) |
| 3101:0 | Inputs | RO P | > 2 < |
| 3101:01 | Status | RO P | 0x41 (65) |
| 3101:02 | Value | RO P | 0x00000000 (0) |
| 4061:0 | Feature bits | RW | > 4 < |
| 4061:01 | disable frame error | RW | FALSE |
| 4061:02 | enbale power failure Bit | RW | FALSE |
| 4061:03 | enable inhibit time | RW | FALSE |
| 4061:04 | enable test mode | RW | FALSE |
| 4066 | SSI-coding | RW | Gray code (1) |
| 4067 | SSI-baudrate | RW | 500 kBaud (3) |
| 4068 | SSI-frame type | RW | Multitum 25 bit (0) |
| 4069 | SSI-frame size | RW | 0x0019 (25) |
| 406A | Data length | RW | 0x0018 (24) |
| 406B | Min. inhibit time[µs] | RW | 0x0000 (0) |

Fig. 92: “CoE - Online” tab

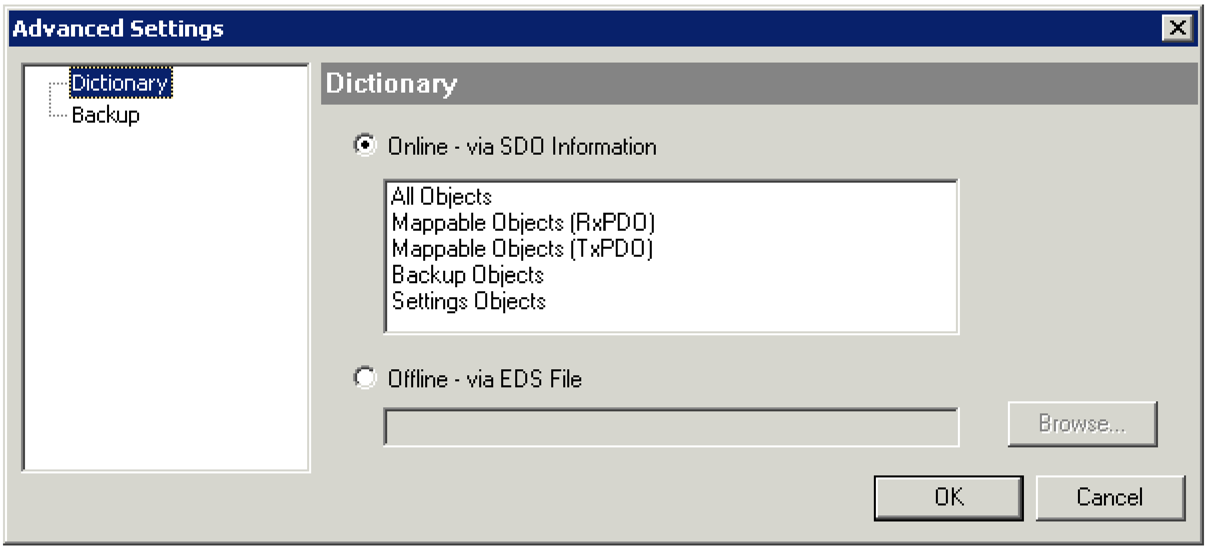
### Object list display

| Column | Description | |
|---|---|---|
| Index | Index and sub-index of the object | |
| Name | Name of the object | |
| Flags | RW | The object can be read, and data can be written to the object (read/write) |
| | RO | The object can be read, but no data can be written to the object (read only) |
| | P | An additional P identifies the object as a process data object. |
| Value | Value of the object | |

**Update List** The *Update list* button updates all objects in the displayed list

**Auto Update** If this check box is selected, the content of the objects is updated automatically.

**Advanced** The *Advanced* button opens the *Advanced Settings* dialog. Here you can specify which objects are displayed in the list.


Advanced Settings

Dictionary

● Online - via SDO Information

All Objects
Mappable Objects (RxPDO)
Mappable Objects (TxPDO)
Backup Objects
Settings Objects

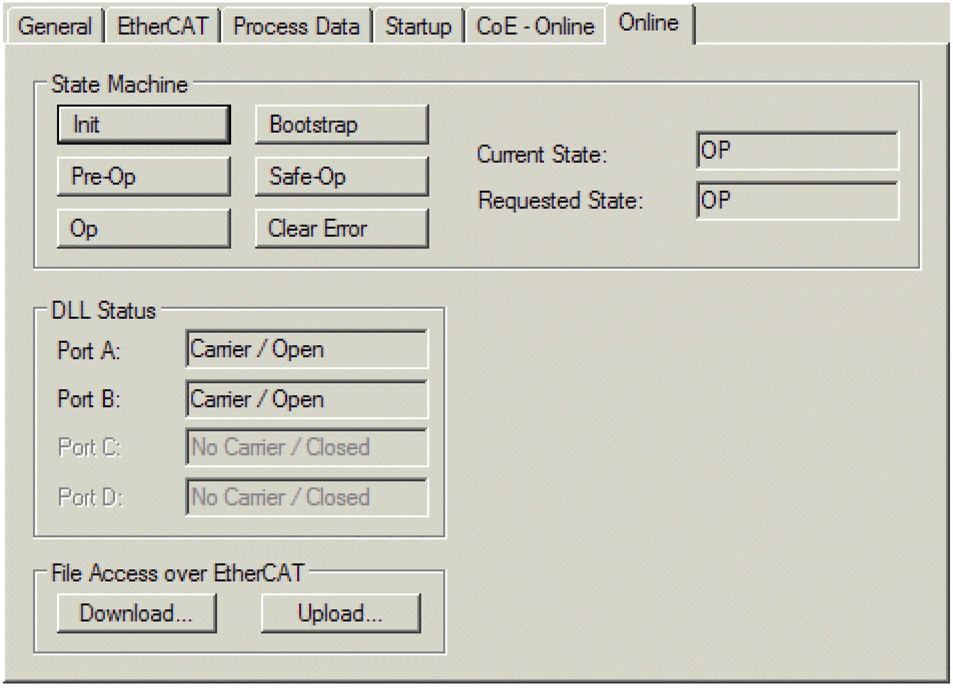
○ Offline - via EDS File

Fig. 93: Dialog “Advanced settings”

**Online - via SDO Information** If this option button is selected, the list of the objects included in the object list of the slave is uploaded from the slave via SDO information. The list below can be used to specify which object types are to be uploaded.

**Offline - via EDS File** If this option button is selected, the list of the objects included in the object list is read from an EDS file provided by the user.

**“Online” tab**


State Machine

Current State: OP

Requested State: OP

DLL Status

Port A: Carrier / Open

Port B: Carrier / Open

Port C: No Carrier / Closed

Port D: No Carrier / Closed

File Access over EtherCAT

Fig. 94: “Online” tab

### State Machine

**Init** This button attempts to set the EtherCAT device to the *Init* state.

**Pre-Op** This button attempts to set the EtherCAT device to the *pre-operational* state.

**Op** This button attempts to set the EtherCAT device to the *operational* state.

**Bootstrap** This button attempts to set the EtherCAT device to the *Bootstrap* state.

**Safe-Op** This button attempts to set the EtherCAT device to the *safe-operational* state.

**Clear Error** This button attempts to delete the fault display. If an EtherCAT slave fails during change of state it sets an error flag.

Example: An EtherCAT slave is in PREOP state (pre-operational). The master now requests the SAFEOP state (safe-operational). If the slave fails during change of state it sets the error flag. The current state is now displayed as ERR PREOP. When the *Clear Error* button is pressed the error flag is cleared, and the current state is displayed as PREOP again.

**Current State** Indicates the current state of the EtherCAT device.

**Requested State** Indicates the state requested for the EtherCAT device.

### DLL Status

Indicates the DLL status (data link layer status) of the individual ports of the EtherCAT slave. The DLL status can have four different states:

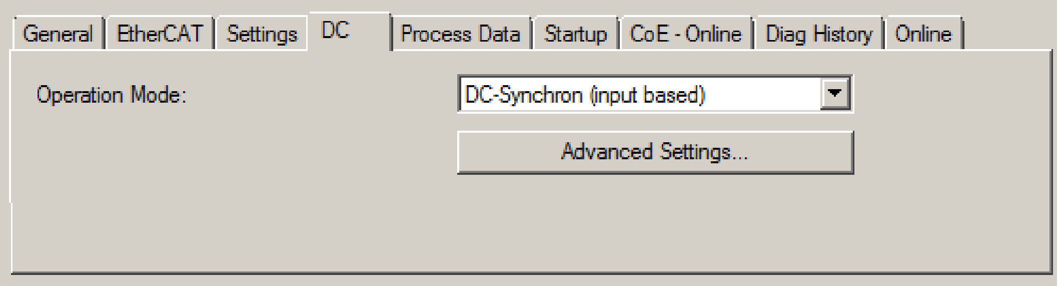
| Status | Description |
|---|---|
| No Carrier / Open | No carrier signal is available at the port, but the port is open. |
| No Carrier / Closed | No carrier signal is available at the port, and the port is closed. |
| Carrier / Open | A carrier signal is available at the port, and the port is open. |
| Carrier / Closed | A carrier signal is available at the port, but the port is closed. |

### File Access over EtherCAT

**Download** With this button a file can be written to the EtherCAT device.

**Upload** With this button a file can be read from the EtherCAT device.

### “DC” tab (Distributed Clocks)



Operation Mode: DC-Synchron (input based)

Fig. 95: “DC” tab (Distributed Clocks)

**Operation Mode** Options (optional):

- FreeRun
- SM-Synchron
- DC-Synchron (Input based)
- DC-Synchron

**Advanced Settings…** Advanced settings for readjustment of the real time determinant TwinCAT-clock

Detailed information to Distributed Clocks is specified on http://infosys.beckhoff.com:

**Fieldbus Components** → EtherCAT Terminals → EtherCAT System documentation → EtherCAT basics → Distributed Clocks

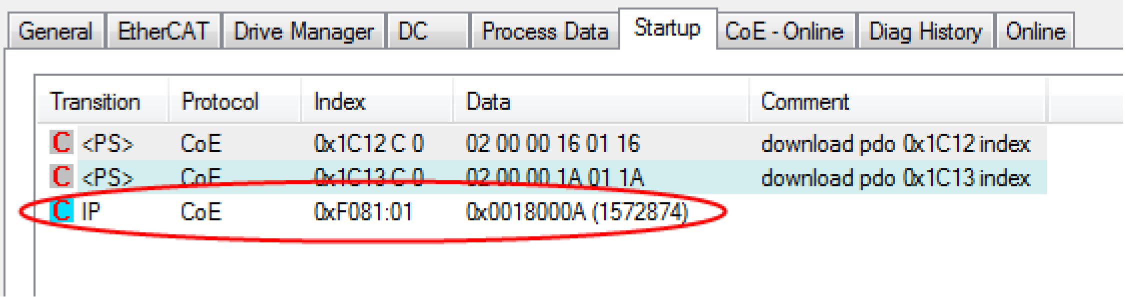
### 5.1.7.1 Download revision

**Download revision in Start-up list**

Several terminals / modules generate the entry from object 0xF081:01 in the Start-up list automatically (see fig. “Download revision in Start-up list“).

The object 0xF081:01 (Download revision) describes the revision of the terminal / module, e.g. 0x00**18**000*A* for EL7201-00*10*-00**24**, and is necessary to ensure compatibility.

Please note, that you must not delete this entry from the Start-up list!



| Transition | Protocol | Index | Data | Comment |
|---|---|---|---|---|
| C <PS> | CoE | 0x1C12 C 0 | 02 00 00 16 01 16 | download pdo 0x1C12 index |
| C <PS> | CoE | 0x1C13 C 0 | 02 00 00 1A 01 1A | download pdo 0x1C13 index |
| C IP | CoE | 0xF081:01 | 0x0018000A (1572874) | |

Fig. 96: Download revision in Start-up list

### 5.1.7.2 Detailed description of Process Data tab

**Sync Manager**

Lists the configuration of the Sync Manager (SM).
If the EtherCAT device has a mailbox, SM0 is used for the mailbox output (MbxOut) and SM1 for the mailbox input (MbxIn).
SM2 is used for the output process data (outputs) and SM3 (inputs) for the input process data.

If an input is selected, the corresponding PDO assignment is displayed in the *PDO Assignment* list below.

**PDO Assignment**

PDO assignment of the selected Sync Manager. All PDOs defined for this Sync Manager type are listed here:

- If the output Sync Manager (outputs) is selected in the Sync Manager list, all RxPDOs are displayed.
- If the input Sync Manager (inputs) is selected in the Sync Manager list, all TxPDOs are displayed.

The selected entries are the PDOs involved in the process data transfer. In the tree diagram of the System Manager these PDOs are displayed as variables of the EtherCAT device. The name of the variable is identical to the *Name* parameter of the PDO, as displayed in the PDO list. If an entry in the PDO assignment list is deactivated (not selected and greyed out), this indicates that the input is excluded from the PDO assignment. In order to be able to select a greyed out PDO, the currently selected PDO has to be deselected first.

**Activation of PDO assignment**

✓ If you have changed the PDO assignment, in order to activate the new PDO assignment,

a) the EtherCAT slave has to run through the PS status transition cycle (from pre-operational to safe-operational) once (see Online tab [▶ 90]),

b) and the System Manager has to reload the EtherCAT slaves

( button for TwinCAT 2 or button for TwinCAT 3)

**PDO list**

List of all PDOs supported by this EtherCAT device. The content of the selected PDOs is displayed in the *PDO Content* list. The PDO configuration can be modified by double-clicking on an entry.

| Column | Description | |
|---|---|---|
| Index | PDO index. | |
| Size | Size of the PDO in bytes. | |
| Name | Name of the PDO.<br>If this PDO is assigned to a Sync Manager, it appears as a variable of the slave with this parameter as the name. | |
| Flags | F | Fixed content: The content of this PDO is fixed and cannot be changed by the System Manager. |
| | M | Mandatory PDO. This PDO is mandatory and must therefore be assigned to a Sync Manager! Consequently, this PDO cannot be deleted from the *PDO Assignment* list |
| SM | Sync Manager to which this PDO is assigned. If this entry is empty, this PDO does not take part in the process data traffic. | |
| SU | Sync unit to which this PDO is assigned. | |

### PDO Content

Indicates the content of the PDO. If flag F (fixed content) of the PDO is not set the content can be modified.

### Download

If the device is intelligent and has a mailbox, the configuration of the PDO and the PDO assignments can be downloaded to the device. This is an optional feature that is not supported by all EtherCAT slaves.

### PDO Assignment

If this check box is selected, the PDO assignment that is configured in the PDO Assignment list is downloaded to the device on startup. The required commands to be sent to the device can be viewed in the Startup [▸ 87] tab.

### PDO Configuration

If this check box is selected, the configuration of the respective PDOs (as shown in the PDO list and the PDO Content display) is downloaded to the EtherCAT slave.

## 5.2 Start-up and parameter configuration

### 5.2.1 Integration into the NC configuration

(Master: TwinCAT 2.11 R3)

**Installation of the latest XML device description**

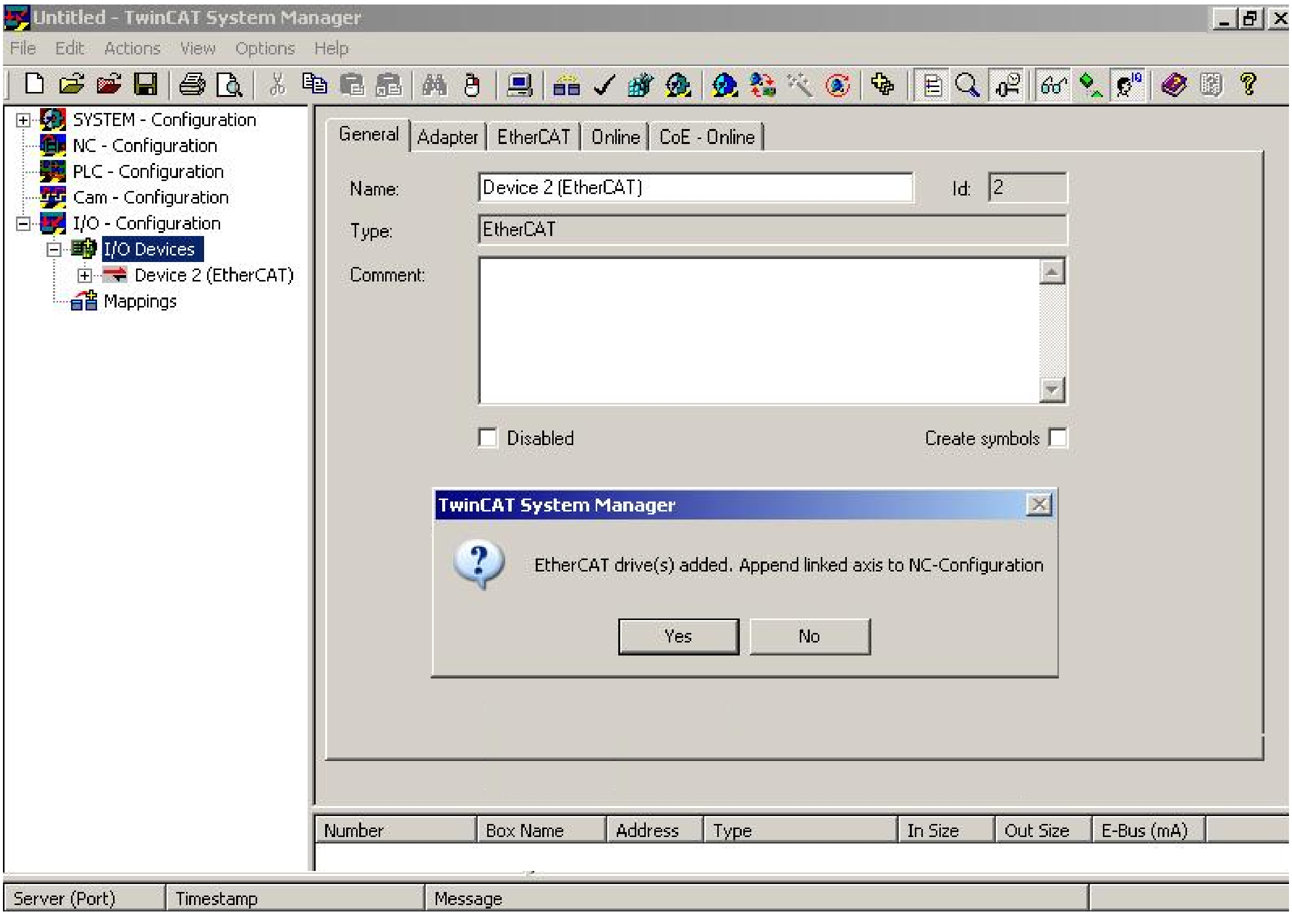
Please ensure that you have installed the corresponding latest XML device description in TwinCAT. This can be downloaded from the Beckhoff Website and installed according to the installation instructions.

Integration into the NC can be accomplished as follows:

- The terminal must already have been added manually under I/O devices or have been scanned in by the system (see section "Configuration set-up in TwinCAT [▶ 60]").

**Adding an axis automatically**

- Once the terminals have been scanned successfully, TwinCAT detects the new axes automatically. The user is asked whether the detected axes should be added automatically (see Fig. *Axis detected*). If this is confirmed, all axes are automatically liked to the NC.


Untitled - TwinCAT System Manager
File Edit Actions View Options Help
SYSTEM - Configuration
NC - Configuration
PLC - Configuration
Cam - Configuration
I/O - Configuration
I/O Devices
Device 2 (EtherCAT)
Mappings
General Adapter EtherCAT Online CoE - Online
Create symbols
Yes
No
Number Box Name Address Type In Size Out Size E-Bus (mA)
Server (Port) Timestamp Message

Name: Device 2 (EtherCAT) Id: 2

Type: EtherCAT

Comment:

□ Disabled

TwinCAT System Manager

EtherCAT drive(s) added. Append linked axis to NC-Configuration

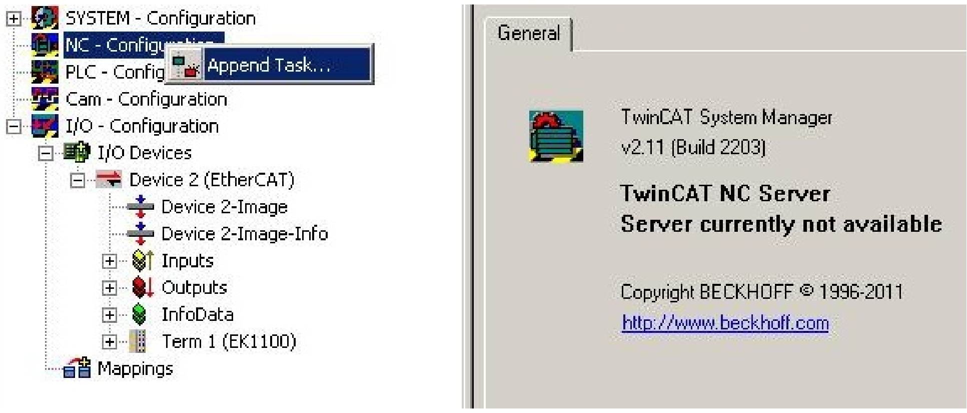
Fig. 97: Axis detected

- Several parameters have to be set before the motor can be started up. The values can be found in section "Configuration of the main parameters [▶ 102]".
Please set these parameters before continuing with the motor commissioning procedure.

**Adding an axis manually**

- First add a new task. Right-click on NC configuration and select "Append Task..." (see Fig. *Adding a new task*).

- Rename the task if required and confirm with OK.



TwinCAT System Manager
v2.11 (Build 2203)

**TwinCAT NC Server**
**Server currently not available**

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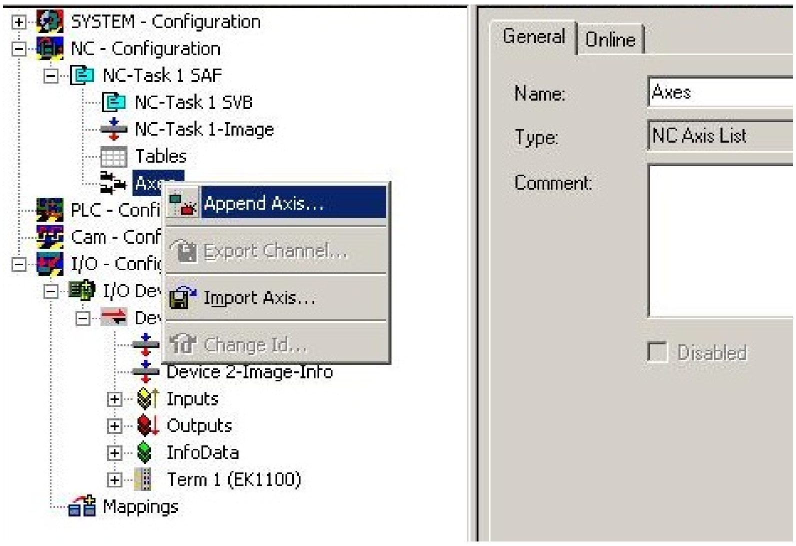
http://www.beckhoff.com

Fig. 98: Adding a new task

- Right-click on *Axes*, then add a new axis (see Fig. *Adding a new axis*).



Name: Axes

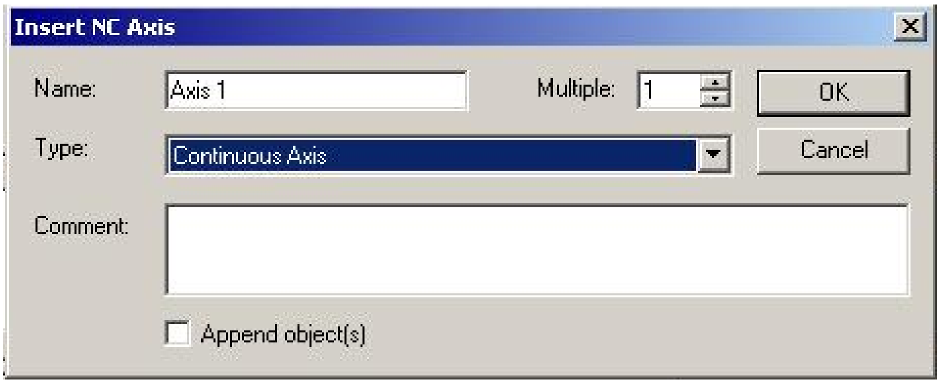
Type: NC Axis List

Comment:

□ Disabled

Fig. 99: Adding a new axis

- Select Continuous Axis type and confirm with OK (see Fig. *Selecting and confirming the axis type*).



Name: Axis 1

Multiple: 1

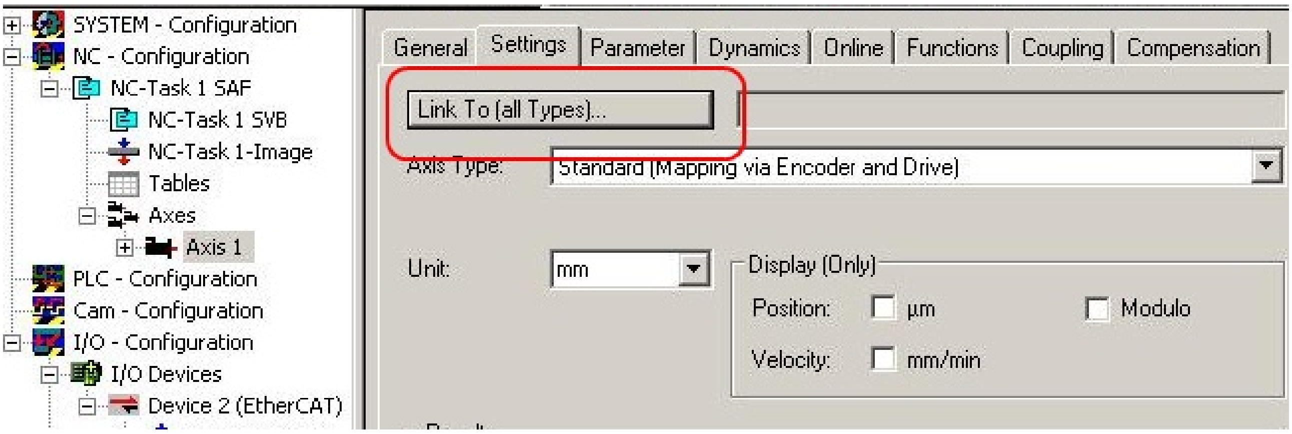
Type: Continuous Axis

Comment:

□ Append object(s)

Fig. 100: Selecting and confirming the axis type

- Left-click your axis to select it. Under the *Settings* tab select "Link To..." (see Fig. *Linking the axis with the terminal*).



Axis Type: Standard (Mapping via Encoder and Drive)

Unit: mm

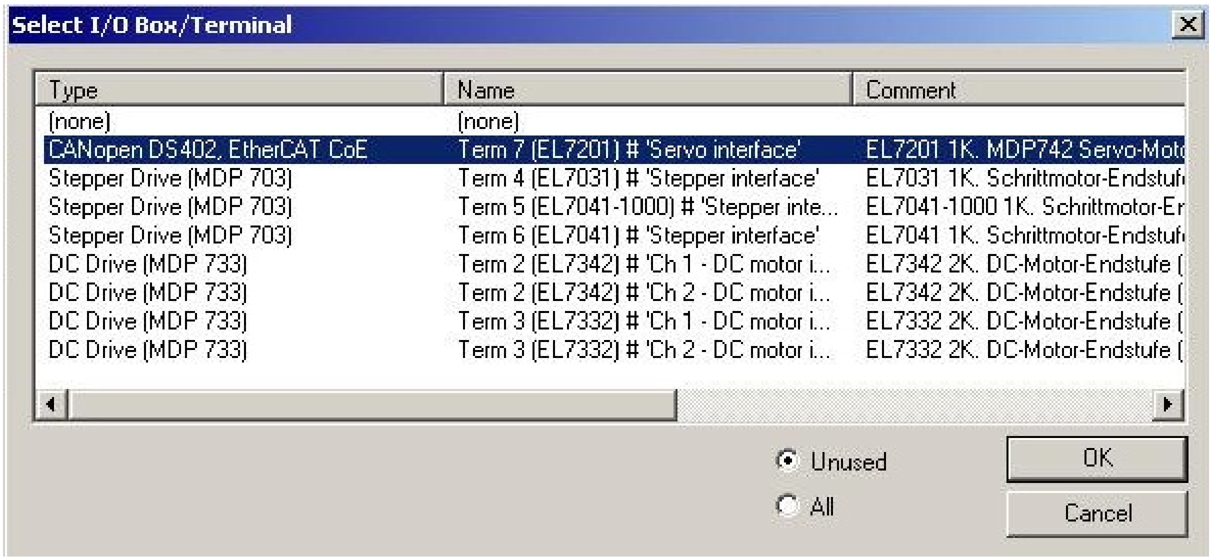
Display (Only)

Position: □ µm □ Modulo

Velocity: □ mm/min

Fig. 101: Linking the axis with the terminal

- Select the required terminal (CANopen DS402, EtherCAT CoE) and confirm with OK.



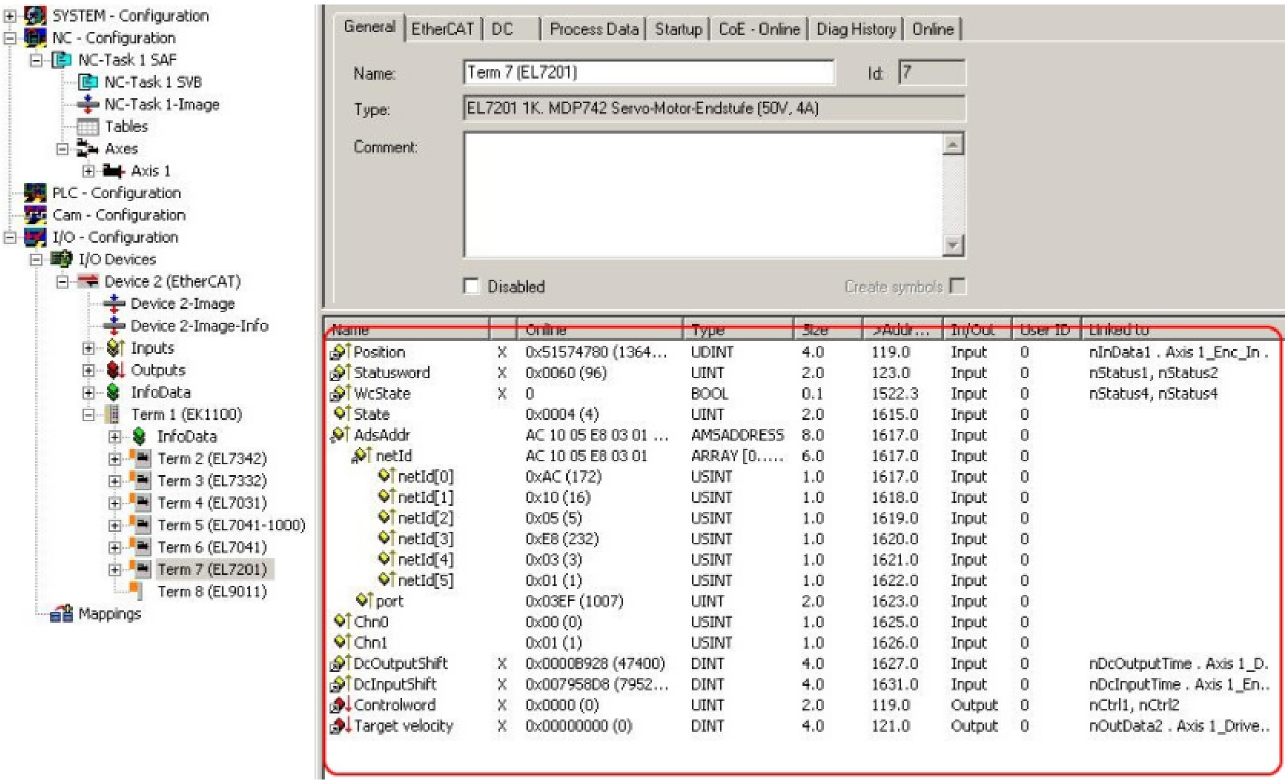
Select I/O Box/Terminal

| Type | Name | Comment |
|---|---|---|
| (none) | (none) | |
| CANopen DS402, EtherCAT CoE | Term 7 (EL7201) # 'Servo interface' | EL7201 1K. MDP742 Servo-Moto |
| Stepper Drive (MDP 703) | Term 4 (EL7031) # 'Stepper interface' | EL7031 1K. Schrittmotor-Endstufe |
| Stepper Drive (MDP 703) | Term 5 (EL7041-1000) # 'Stepper inte... | EL7041-1000 1K. Schrittmotor-Er |
| Stepper Drive (MDP 703) | Term 6 (EL7041) # 'Stepper interface' | EL7041 1K. Schrittmotor-Endstufe |
| DC Drive (MDP 733) | Term 2 (EL7342) # 'Ch 1 - DC motor i... | EL7342 2K. DC-Motor-Endstufe ( |
| DC Drive (MDP 733) | Term 2 (EL7342) # 'Ch 2 - DC motor i... | EL7342 2K. DC-Motor-Endstufe ( |
| DC Drive (MDP 733) | Term 3 (EL7332) # 'Ch 1 - DC motor i... | EL7332 2K. DC-Motor-Endstufe ( |
| DC Drive (MDP 733) | Term 3 (EL7332) # 'Ch 2 - DC motor i... | EL7332 2K. DC-Motor-Endstufe ( |

● Unused
○ All

Fig. 102: Selecting the right terminal

- All main links between the NC configuration and the terminal are set automatically (see Fig. "*Automatic linking of all main variables*")



Name: Term 7 (EL7201) Id: 7

Type: EL7201 1K. MDP742 Servo-Motor-Endstufe (50V, 4A)

Comment:

□ Disabled

| Name | | Online | Type | Size | >Addr... | In/Out | User ID | Linked to |
|---|---|---|---|---|---|---|---|---|
| Position | X | 0x51574780 (1364... | UDINT | 4.0 | 119.0 | Input | 0 | nInData1 . Axis 1_Enc_In . |
| Statusword | X | 0x0060 (96) | UINT | 2.0 | 123.0 | Input | 0 | nStatus1, nStatus2 |
| WcState | X | 0 | BOOL | 0.1 | 1522.3 | Input | 0 | nStatus4, nStatus4 |
| State | | 0x0004 (4) | UINT | 2.0 | 1615.0 | Input | 0 | |
| AdsAddr | | AC 10 05 E8 03 01 ... | AMSADDRESS | 8.0 | 1617.0 | Input | 0 | |
| netId | | AC 10 05 E8 03 01 | ARRAY [0..... | 6.0 | 1617.0 | Input | 0 | |
| netId[0] | | 0xAC (172) | USINT | 1.0 | 1617.0 | Input | 0 | |
| netId[1] | | 0x10 (16) | USINT | 1.0 | 1618.0 | Input | 0 | |
| netId[2] | | 0x05 (5) | USINT | 1.0 | 1619.0 | Input | 0 | |
| netId[3] | | 0xE8 (232) | USINT | 1.0 | 1620.0 | Input | 0 | |
| netId[4] | | 0x03 (3) | USINT | 1.0 | 1621.0 | Input | 0 | |
| netId[5] | | 0x01 (1) | USINT | 1.0 | 1622.0 | Input | 0 | |
| port | | 0x03EF (1007) | UINT | 2.0 | 1623.0 | Input | 0 | |
| Chn0 | | 0x00 (0) | USINT | 1.0 | 1625.0 | Input | 0 | |
| Chn1 | | 0x01 (1) | USINT | 1.0 | 1626.0 | Input | 0 | |
| DcOutputShift | X | 0x0000B928 (47400) | DINT | 4.0 | 1627.0 | Input | 0 | nDcOutputTime . Axis 1_D. |
| DcInputShift | X | 0x007958D8 (7952... | DINT | 4.0 | 1631.0 | Input | 0 | nDcInputTime . Axis 1_En.. |
| Controlword | X | 0x0000 (0) | UINT | 2.0 | 119.0 | Output | 0 | nCtrl1, nCtrl2 |
| Target velocity | X | 0x00000000 (0) | DINT | 4.0 | 121.0 | Output | 0 | nOutData2 . Axis 1_Drive.. |

Fig. 103: Automatic linking of all main variables

- Several parameters have to be set before the motor can be started up. The values can be found in sections "CoE settings [▶ 102]" and "NC settings [▶ 117]".
Please set these parameters before continuing with the motor commissioning procedure.

## 5.2.2 Settings with the Drive Manager

(Master TwinCAT 2.11 R3)

The data provided in this section as an example refer to an AM3121-0200-0001 servomotor from Beckhoff Automation. For other motors the values may vary, depending on the application.

**Using the Drive Manager from revision -0019**

The Drive Manager is only supported from revision -0019 [▶ 187] of the EL72x1. If you use an older version, the settings have to be made manually. See chapters "CoE settings [▶ 102]" and "NC settings [▶ 117]"

**Table of contents**

- Start-up with the Drive Manager [▶ 98]
- Setting further parameters with the Drive Manager [▶ 101]
  - Integral velocity controller component Tn [▶ 101]
  - Proportional velocity controller component Kp [▶ 101]

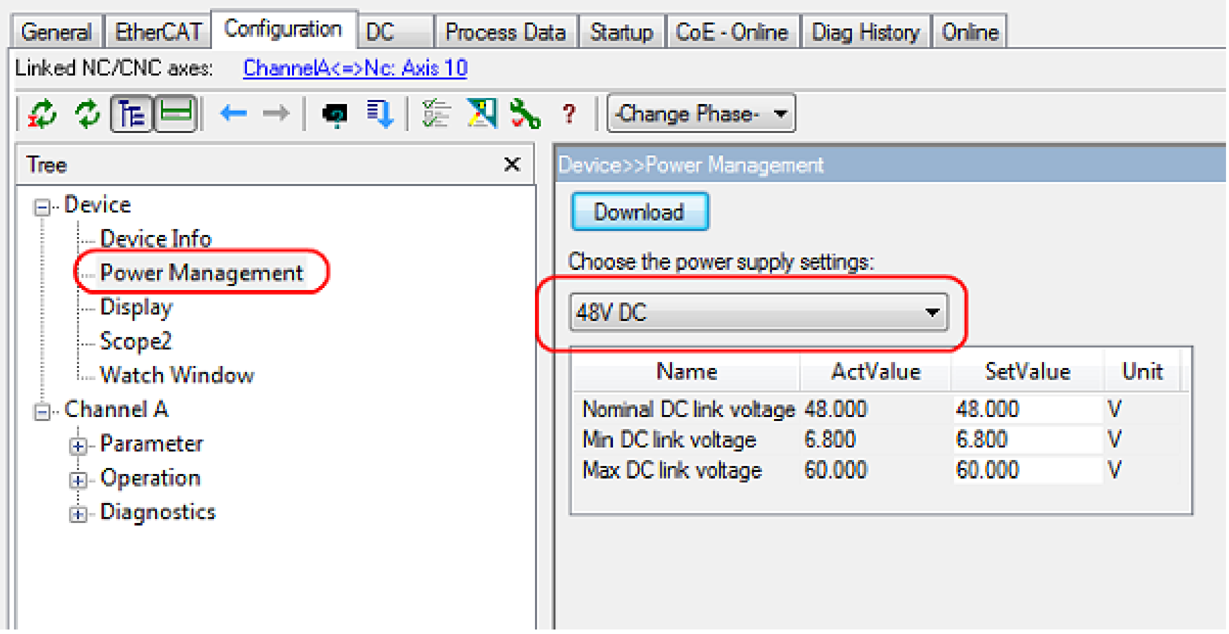
The TwinCAT Drive Manager is available for download from the Beckhoff website.

The TwinCAT Drive Manager for parameterizing an EL72x1 servo terminal is integrated in the System Manager, so that no separate configuration tool is required. Once a servo terminal has been detected or entered, the TwinCAT Drive Manager is available in the Configuration tab.

The following instructions are intended to enable you to start up the servo terminal relatively quickly. More detailed information on the Drive Manager can be found in the corresponding documentation "AX5000 Introduction in the TC Drivemanager"

### Start-up with the Drive Manager

- The terminal must already have been added manually under I/O devices or have been scanned in by the system (see section "Configuration set-up in TwinCAT [▶ 76]")
- The terminal must already be integrated in the NC (see section "Integration in the NC configuration [▶ 94]")
- Select the *Configuration* tab for the EL72x1.
- Select the connected voltage under *Power Management*.

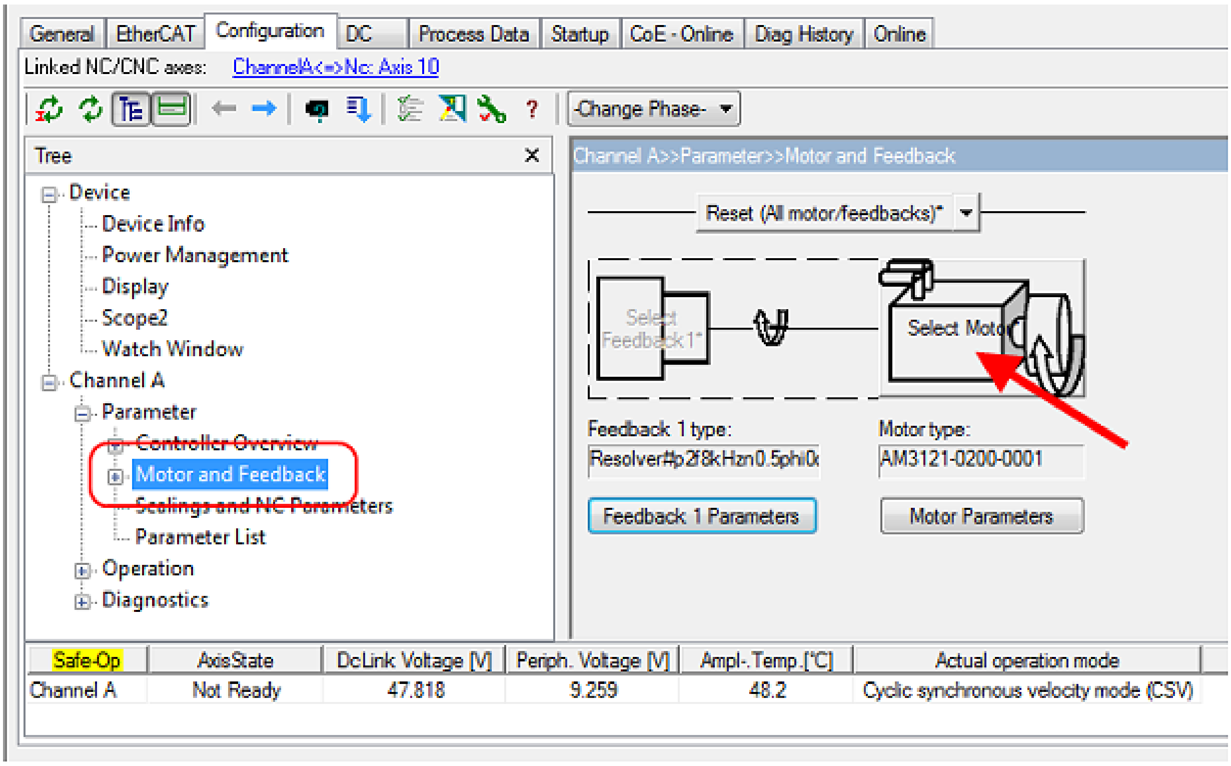


Choose the power supply settings: 48V DC

| Name | ActValue | SetValue | Unit |
|---|---|---|---|
| Nominal DC link voltage | 48.000 | 48.000 | V |
| Min DC link voltage | 6.800 | 6.800 | V |
| Max DC link voltage | 60.000 | 60.000 | V |

Fig. 104: Selecting the connected voltage

- Then select the connected motor under *Motor and Feedback*. Click on *Select Motor*.



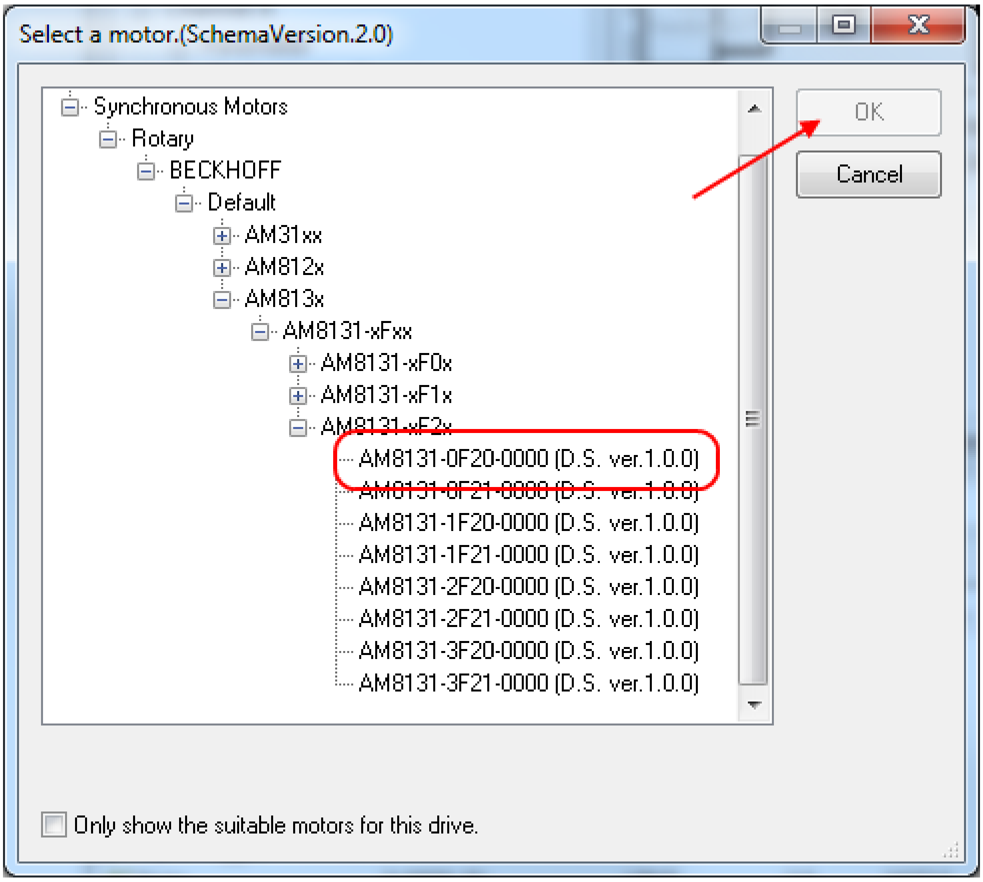
Feedback 1 type: Resolver#p2f8kHzn0.5phi0

Motor type: AM3121-0200-0001

| Safe-Op | AxisState | DcLink Voltage [V] | Periph. Voltage [V] | Ampl.-Temp.[°C] | Actual operation mode |
|---|---|---|---|---|---|
| Channel A | Not Ready | 47.818 | 9.259 | 48.2 | Cyclic synchronous velocity mode (CSV) |

Fig. 105: Selecting the connected motor

- Select the suitable motor in the selection window and confirm with *Ok*.



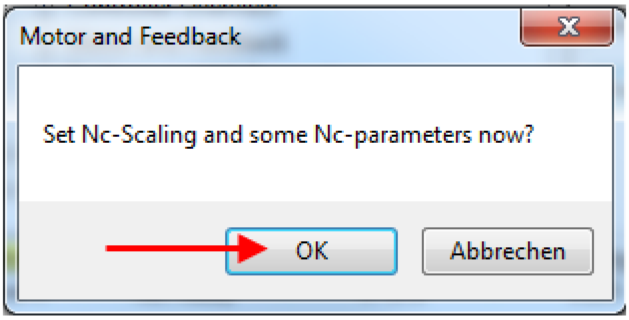
Select a motor.(SchemaVersion.2.0)

```
⊟ Synchronous Motors
  ⊟ Rotary
    ⊟ BECKHOFF
      ⊟ Default
        ⊞ AM31xx
        ⊞ AM812x
        ⊟ AM813x
          ⊟ AM8131-xFxx
            ⊞ AM8131-xF0x
            ⊞ AM8131-xF1x
            ⊟ AM8131-xF2x
                AM8131-0F20-0000 (D.S. ver.1.0.0)
                AM8131-0F21-0000 (D.S. ver.1.0.0)
                AM8131-1F20-0000 (D.S. ver.1.0.0)
                AM8131-1F21-0000 (D.S. ver.1.0.0)
                AM8131-2F20-0000 (D.S. ver.1.0.0)
                AM8131-2F21-0000 (D.S. ver.1.0.0)
                AM8131-3F20-0000 (D.S. ver.1.0.0)
                AM8131-3F21-0000 (D.S. ver.1.0.0)
```

☐ Only show the suitable motors for this drive.

Fig. 106: List of available motors

- Confirm the next dialog box with OK. All required parameters are automatically entered in the NC, and the scaling factor is calculated. If this is not confirmed, these settings have to be entered manually. See section "NC settings [▶ 117]".

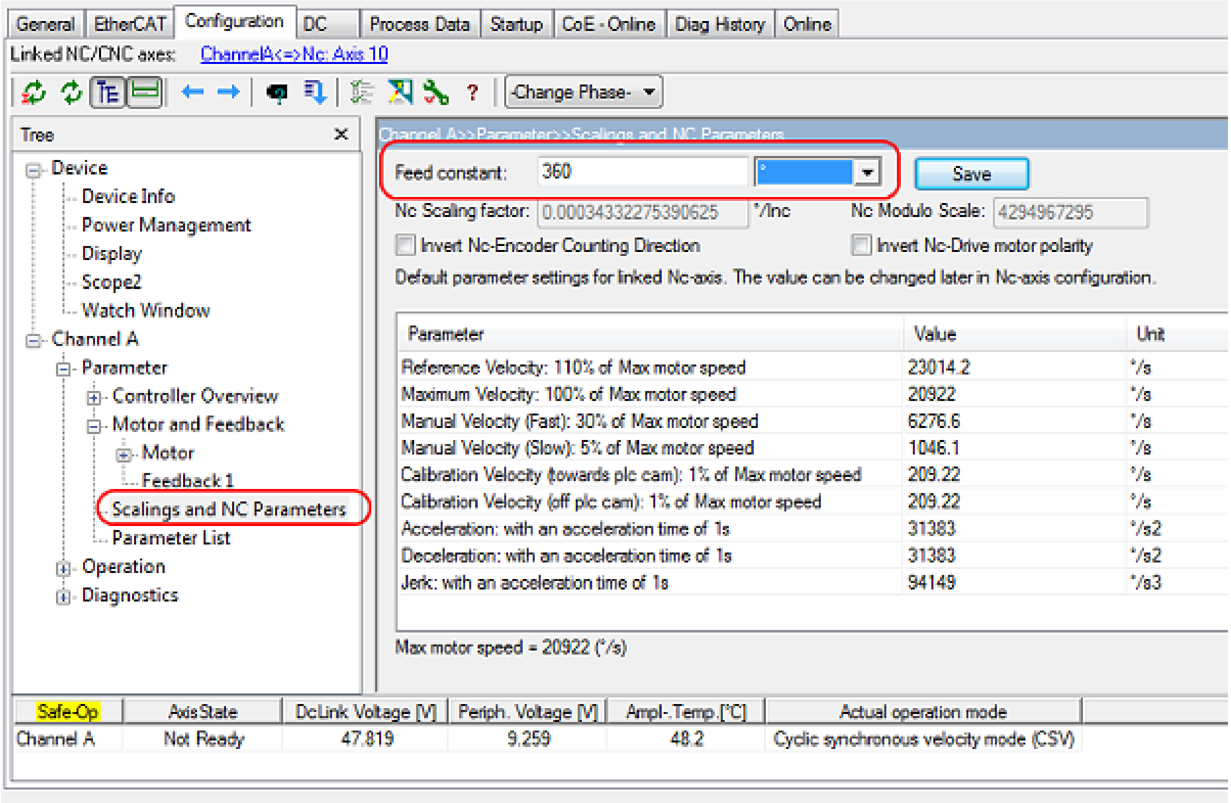


Motor and Feedback

Set Nc-Scaling and some Nc-parameters now?

Fig. 107: Confirmation of the automatic NC settings parameters

- The scaling can be determined under *Scalings and NC Parameters*. A motor revolution is defined as 360° as an example. All required parameters are adjusted automatically. The setting only becomes active once the configuration is activated.



Linked NC/CNC axes: ChannelA<=>Nc: Axis 10

Feed constant: 360 °

Nc Scaling factor: 0.00034332275390625 °/Inc

Nc Modulo Scale: 4294967295

□ Invert Nc-Encoder Counting Direction

□ Invert Nc-Drive motor polarity

Default parameter settings for linked Nc-axis. The value can be changed later in Nc-axis configuration.

| Parameter | Value | Unit |
|---|---|---|
| Reference Velocity: 110% of Max motor speed | 23014.2 | °/s |
| Maximum Velocity: 100% of Max motor speed | 20922 | °/s |
| Manual Velocity (Fast): 30% of Max motor speed | 6276.6 | °/s |
| Manual Velocity (Slow): 5% of Max motor speed | 1046.1 | °/s |
| Calibration Velocity (towards plc cam): 1% of Max motor speed | 209.22 | °/s |
| Calibration Velocity (off plc cam): 1% of Max motor speed | 209.22 | °/s |
| Acceleration: with an acceleration time of 1s | 31383 | °/s2 |
| Deceleration: with an acceleration time of 1s | 31383 | °/s2 |
| Jerk: with an acceleration time of 1s | 94149 | °/s3 |

Max motor speed = 20922 (°/s)

| Safe-Op | Axis State | DcLink Voltage [V] | Periph. Voltage [V] | Ampl.-Temp.[°C] | Actual operation mode |
|---|---|---|---|---|---|
| Channel A | Not Ready | 47.819 | 9.259 | 48.2 | Cyclic synchronous velocity mode (CSV) |

Fig. 108: Adapting the scaling

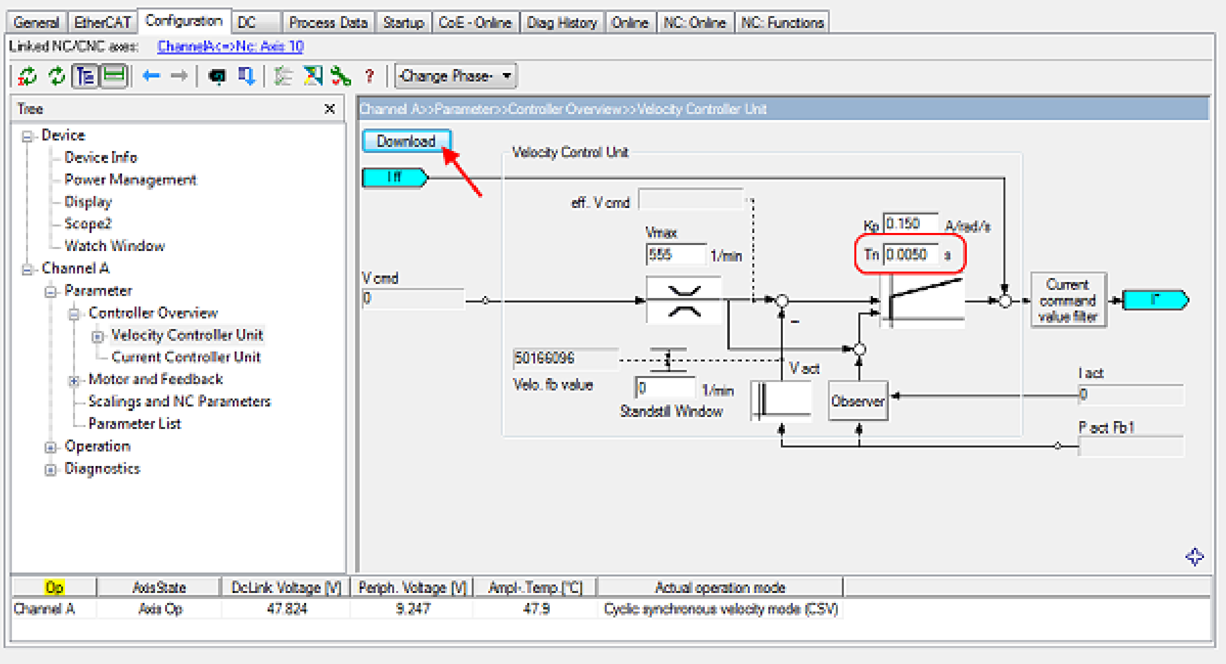
All main parameters for the commissioning the motor are now set. The motor can now be commissioned with the NC, for example. A brief description can be found in section "Commissioning the motor with the NC [▶ 122]". Or the NC can be addressed from the PLC. A small (download: (https://infosys.beckhoff.com/content/1033/el72x1/Resources/1958948107.zip)) is included in the documentation.
Some parameters can be adjusted manually for your particular application.

### Setting further parameters with the Drive Manager

The values specified here are exemplary, although in most cases they have led to excellent results. Depending on the application, other values may yield better results.
These values can be changed during operation. Click on *Download* to apply the values.

### Integral velocity controller component Tn

- Reduce the value, until the motor starts to oscillate slightly. Then increase the value by 10%.



Linked NC/CNC axes: ChannelA<=>Nc: Axis 10

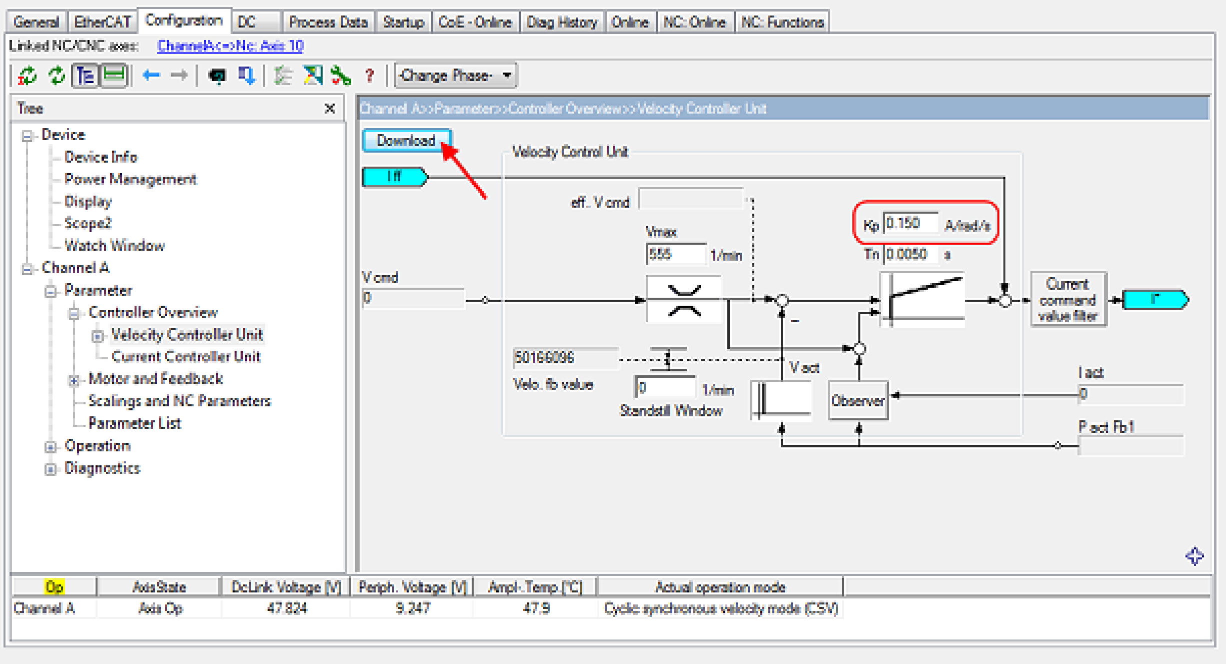
eff. V cmd
Vmax 555 1/min
Kp 0.150 A/rad/s
Tn 0.0050 s
V cmd 0
50166096
Velo. fb value 0 1/min
Standstill Window
V act
I act 0

| Op | AxisState | DcLink Voltage [V] | Periph. Voltage [V] | Ampl.-Temp.[°C] | Actual operation mode |
|---|---|---|---|---|---|
| Channel A | Axis Op | 47.824 | 9.247 | 47.9 | Cyclic synchronous velocity mode (CSV) |

Fig. 109: Adapting Tn

### Proportional velocity controller component Kp

- Increase the value, until the motor starts to oscillate slightly. Then reduce the value by 80%.



Linked NC/CNC axes: ChannelA<=>Nc: Axis 10

eff. V cmd
Vmax 555 1/min
Kp 0.150 A/rad/s
Tn 0.0050 s
V cmd 0
50166096
Velo. fb value 0 1/min
Standstill Window
V act
I act 0

| Op | AxisState | DcLink Voltage [V] | Periph. Voltage [V] | Ampl.-Temp.[°C] | Actual operation mode |
|---|---|---|---|---|---|
| Channel A | Axis Op | 47.824 | 9.247 | 47.9 | Cyclic synchronous velocity mode (CSV) |

Fig. 110: Adapting Kp

## 5.2.3 Settings in the CoE register

(Master TwinCAT 2.11 R3)

The data provided in this section as an example refer to an AM3121-0200-0001 servomotor from Beckhoff Automation. For other motors the values may vary, depending on the application.

**Table of contents**

- Inserting the motor XML file [▶ 102]
  - Adaptation of current and voltage [▶ 104]
- Setting further parameters [▶ 104]
  - Single turn bits / Multi turn bits [▶ 104]
  - Automatic gain control [▶ 105]
  - Torque limitation [▶ 105]
  - Integral velocity controller component Tn [▶ 105]
  - Proportional velocity controller component Kp [▶ 105]

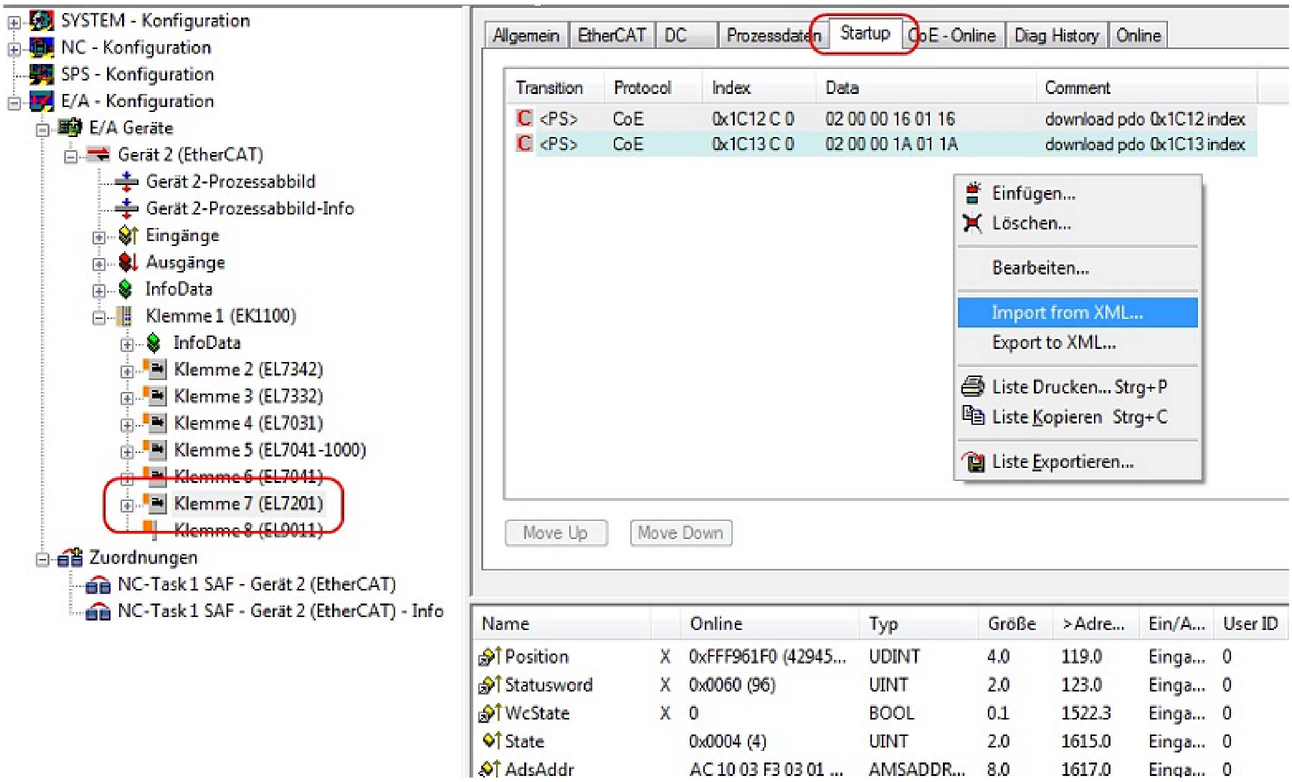
### Inserting the motor XML file

**Downloading the EL72x1 motor XML files**

The motor XML files are available for download from the Beckhoff website.

To facilitate commissioning of the EL72x1 servo terminal, motor XML files are provided for the servomotors that are supported by the EL72x1. The XML files can be read in the System Manager. All CoE parameters and DS402 parameters are then set as required.

- To read the motor XML file select the EL72x1 and open the Startup tab. Right-click in the empty field and select Import from XML... (see Fig. *Importing the motor XML file*).

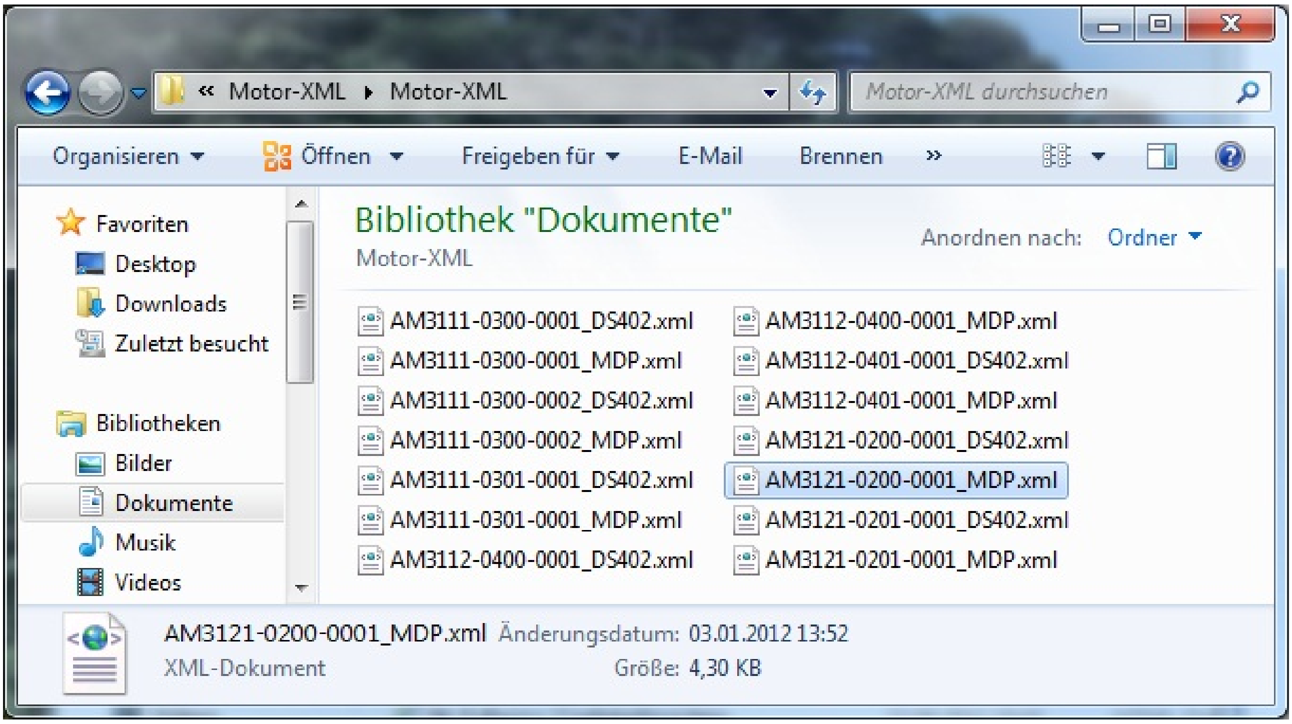


| Transition | Protocol | Index | Data | Comment |
|---|---|---|---|---|
| C <PS> | CoE | 0x1C12 C 0 | 02 00 00 16 01 16 | download pdo 0x1C12 index |
| C <PS> | CoE | 0x1C13 C 0 | 02 00 00 1A 01 1A | download pdo 0x1C13 index |

| Name | | Online | Typ | Größe | >Adre... | Ein/A... | User ID |
|---|---|---|---|---|---|---|---|
| Position | X | 0xFFF961F0 (42945... | UDINT | 4.0 | 119.0 | Einga... | 0 |
| Statusword | X | 0x0060 (96) | UINT | 2.0 | 123.0 | Einga... | 0 |
| WcState | X | 0 | BOOL | 0.1 | 1522.3 | Einga... | 0 |
| State | | 0x0004 (4) | UINT | 2.0 | 1615.0 | Einga... | 0 |
| AdsAddr | | AC 10 03 F3 03 01 ... | AMSADDR... | 8.0 | 1617.0 | Einga... | 0 |

Fig. 111: Importing the motor XML file

- Select the motor XML file that matches the connected motor (see Fig. *Selecting the correct motor XML file*)



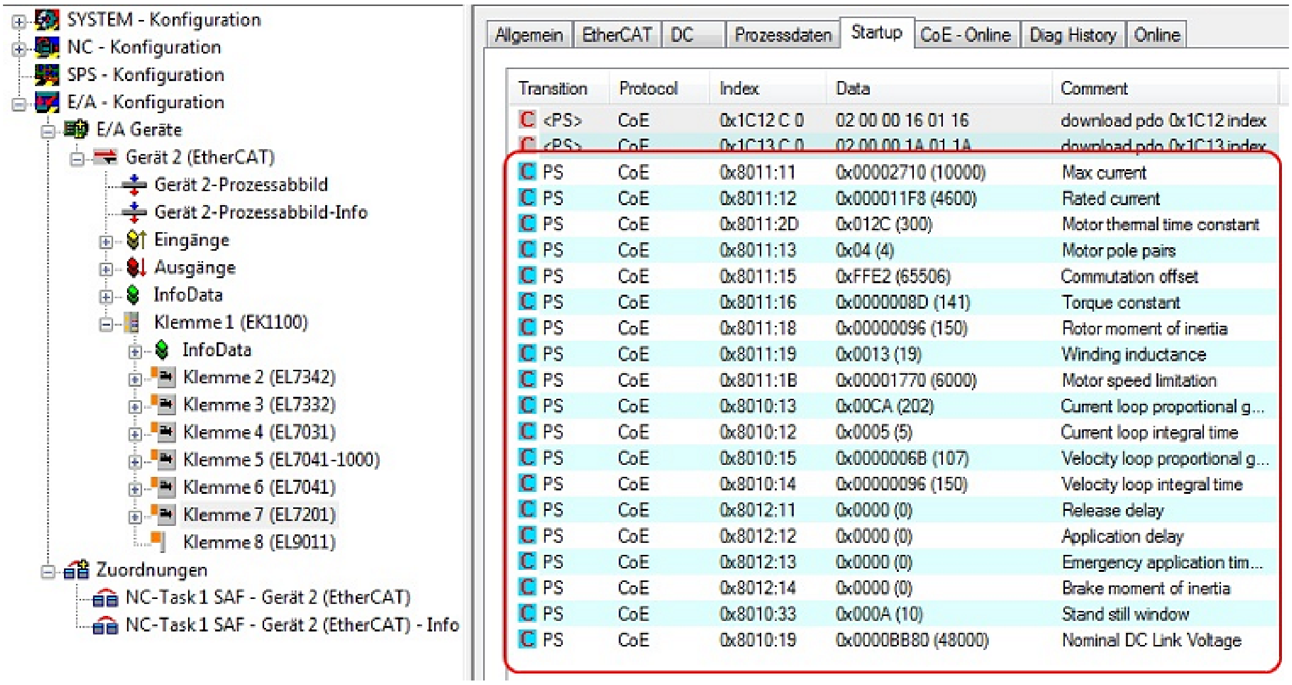
Bibliothek "Dokumente"
Motor-XML

| | |
|---|---|
| AM3111-0300-0001_DS402.xml | AM3112-0400-0001_MDP.xml |
| AM3111-0300-0001_MDP.xml | AM3112-0401-0001_DS402.xml |
| AM3111-0300-0002_DS402.xml | AM3112-0401-0001_MDP.xml |
| AM3111-0300-0002_MDP.xml | AM3121-0200-0001_DS402.xml |
| AM3111-0301-0001_DS402.xml | AM3121-0200-0001_MDP.xml |
| AM3111-0301-0001_MDP.xml | AM3121-0201-0001_DS402.xml |
| AM3112-0400-0001_DS402.xml | AM3121-0201-0001_MDP.xml |

AM3121-0200-0001_MDP.xml Änderungsdatum: 03.01.2012 13:52
XML-Dokument Größe: 4,30 KB

Fig. 112: Selecting the correct motor XML file

- All required parameters are then set, and the motor can be put into operation (see Fig. *CoE parameters of the motor XML file*).



| Transition | Protocol | Index | Data | Comment |
|---|---|---|---|---|
| C <PS> | CoE | 0x1C12 C 0 | 02 00 00 16 01 16 | download pdo 0x1C12 index |
| C <PS> | CoE | 0x1C13 C 0 | 02 00 00 1A 01 1A | download pdo 0x1C13 index |
| C PS | CoE | 0x8011:11 | 0x00002710 (10000) | Max current |
| C PS | CoE | 0x8011:12 | 0x000011F8 (4600) | Rated current |
| C PS | CoE | 0x8011:2D | 0x012C (300) | Motor thermal time constant |
| C PS | CoE | 0x8011:13 | 0x04 (4) | Motor pole pairs |
| C PS | CoE | 0x8011:15 | 0xFFE2 (65506) | Commutation offset |
| C PS | CoE | 0x8011:16 | 0x0000008D (141) | Torque constant |
| C PS | CoE | 0x8011:18 | 0x00000096 (150) | Rotor moment of inertia |
| C PS | CoE | 0x8011:19 | 0x0013 (19) | Winding inductance |
| C PS | CoE | 0x8011:1B | 0x00001770 (6000) | Motor speed limitation |
| C PS | CoE | 0x8010:13 | 0x00CA (202) | Current loop proportional g... |
| C PS | CoE | 0x8010:12 | 0x0005 (5) | Current loop integral time |
| C PS | CoE | 0x8010:15 | 0x0000006B (107) | Velocity loop proportional g... |
| C PS | CoE | 0x8010:14 | 0x00000096 (150) | Velocity loop integral time |
| C PS | CoE | 0x8012:11 | 0x0000 (0) | Release delay |
| C PS | CoE | 0x8012:12 | 0x0000 (0) | Application delay |
| C PS | CoE | 0x8012:13 | 0x0000 (0) | Emergency application tim... |
| C PS | CoE | 0x8012:14 | 0x0000 (0) | Brake moment of inertia |
| C PS | CoE | 0x8010:33 | 0x000A (10) | Stand still window |
| C PS | CoE | 0x8010:19 | 0x0000BB80 (48000) | Nominal DC Link Voltage |

Fig. 113: CoE parameters of the motor XML file

**Startup list**

Any further application-specific settings should also be implemented in the Startup list. Otherwise the modified settings will be overwritten next time the terminal starts up.

### Adaptation of current and voltage

**NOTICE**

**The motor may overheat!**

In order to prevent overheating of the connected motor, it is important to adjust the voltage of the servo terminal to the actually connected voltage.

To this end set the index 0x8010:19 [▸ 146] "Nominal DC Link Voltage" of the connected voltage as required

### Setting further parameters

#### Single-turn Bits (MDP742: Index 0x8000:12 [▸ 145] / DS402: Index 0x2010:12 [▸ 164]) / Multi-turn Bits (MDP742: Index 0x8000:13 [▸ 145] / DS402: Index 0x2010:13 [▸ 164])

Here the user can specify how many single-turn and multi-turn bits the terminal should display. A total of 32 bits are available. These 32 bits can be subdivided as required.
The standard setting is 20 single-turn bits and 12 multi-turn bits.

**Singleturn bits:** number of bits relating to the resolution of one rotor rotation.

**Multiturn bits:** after a rotor rotation the multi-turn bits are incremented by one.

**NOTICE**

**The motor may overheat!**

If the number of single-turn bits is changed, the scaling factor in the NC [▸ 120] has to be adjusted

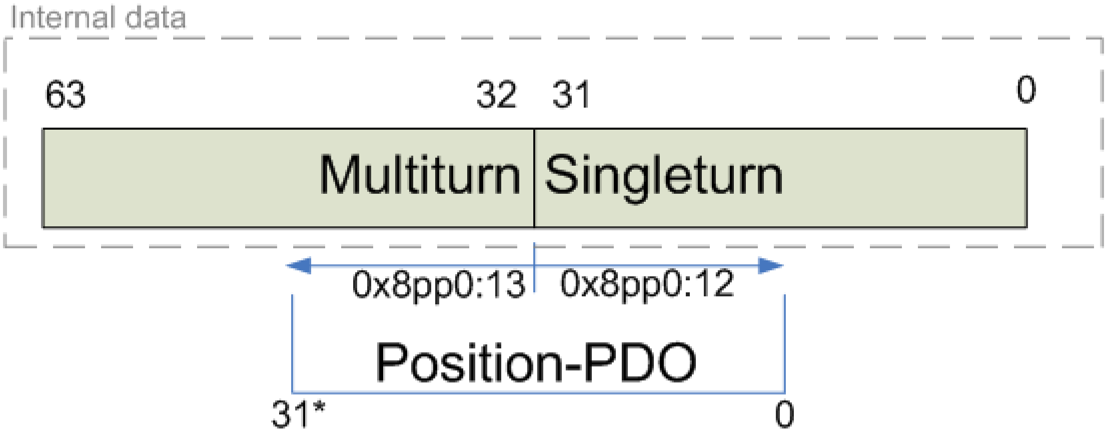


Fig. 114: Multi-turn / single-turn bits

### Automatic gain control

Each resolver has a small difference between the amplitude of the sine and cosine tracks (see Fig. Resolver gain adjustment). This deviation depends on the variance of the components and other factors and may vary from motor to motor.

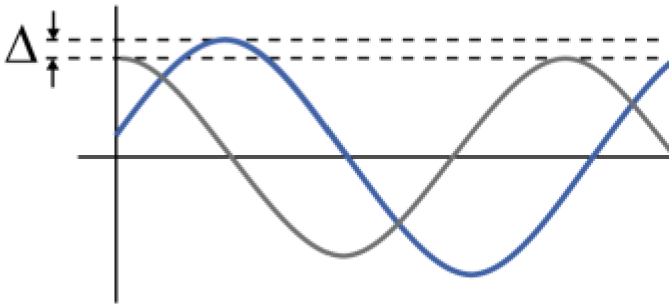


Fig. 115: Resolver gain adjustment

The EL72x1 automatically corrects this small difference in the resolver amplitudes, if the function "Automatic gain control" is active. The correction takes some time, approx. 100 revolutions. The means that the precision during this time is slightly lower than after the correction.
To avoid this small initial inaccuracy, during the commissioning phase, after approx. 100 revolutions, the user can read the "Automatic resolver gain value" determined by the terminal (MDP742: 0x9008:12 [▶ 153] / DS402: Index 0x2058:12 [▶ 171]) and transfer it to "Resolver gain adjustment" (MDP742: Index 0x8008:12 [▶ 146] / DS402: Index 0x2018:12 [▶ 171]). The value entered there is the starting point for the correction. Please note that the value varies from motor to motor. If the motor is replaced, the process must be repeated.
The function "Automatic gain control" can activated or deactivated with "Enable automatic gain control" (MDP742: Index 0x8008:02 [▶ 146] / DS402: Index 0x2018:02 [▶ 165]).

### Torque limitation (MDP742: Index 0x7010:0B [▶ 152] / DS402: Index 0x6072:0 [▶ 168])

Limits the current / torque to this value. The value is specified in 1000th of the rated current.

### Integral velocity controller component Tn (MDP742: Index 0x8010:14 [▶ 146] / DS402: Index 0x2002:14 [▶ 163])

The values specified here are exemplary, although in most cases they have led to excellent results. Depending on the application, other values may yield better results.

- Reduce the value, until the motor starts to oscillate slightly. Then increase the value by 10%.

### Proportional velocity controller component Kp (MDP742: Index 0x8010:15 [▶ 146] / DS402: Index 0x2002:15 [▶ 163])

The values specified here are exemplary, although in most cases they have led to excellent results. Depending on the application, other values may yield better results.

- Increase the value, until the motor starts to oscillate slightly. Then reduce the value by 80%.

## 5.2.4 Application example

**EtherCAT XML Device Description**

The display matches that of the CoE objects from the EtherCAT XML Device Description. We recommend downloading the latest XML file from the download area of the Beckhoff website and installing it according to installation instructions.

**Motor control with visualization**

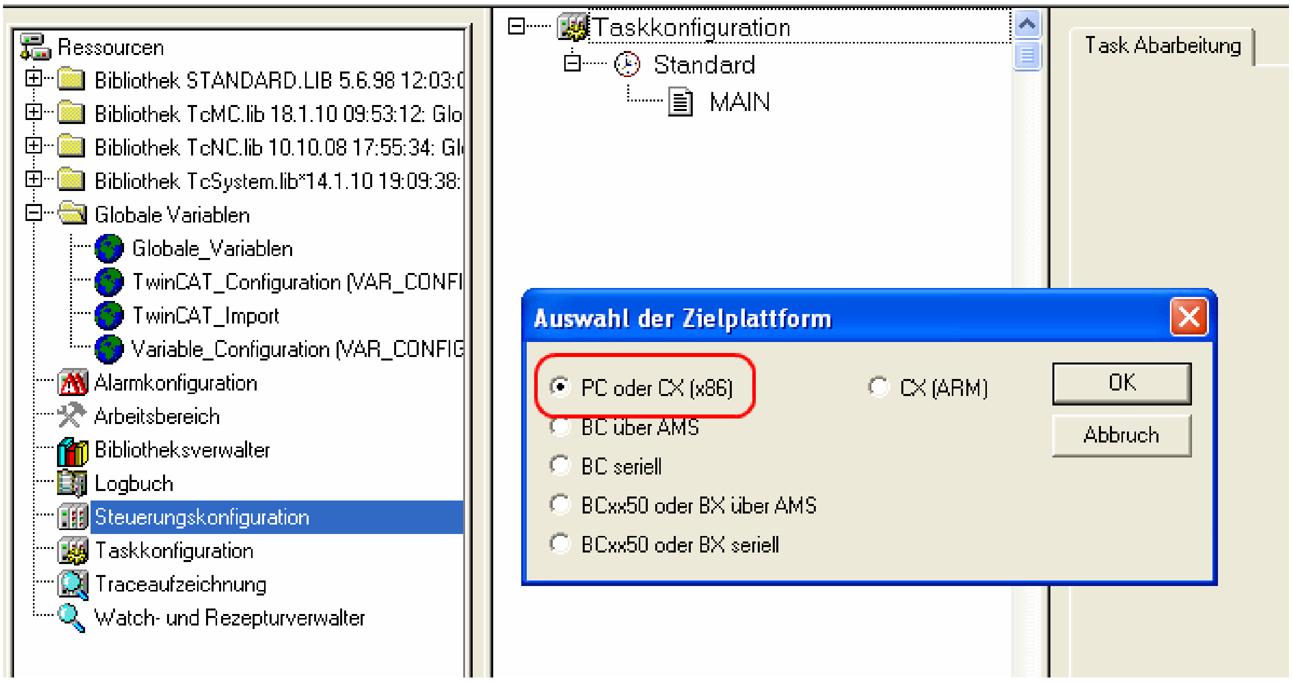
Download (https://infosys.beckhoff.com/content/1033/el72x1/Resources/1958948107.zip):

Used Master: TwinCAT 2.11 (for older versions the control loop has to be programmed manually; in this case it is already implemented in the NC).
This application example demonstrates movement of a motor to any position or in continuous mode with the aid of visualization. The velocity, the starting acceleration and the deceleration can be specified.

The sample program consists of two files (PLC file and System Manager file).

First open the PLC file and compile it so that you have the *.tpy file available that is required for the System Manager.

Please note that you may have to adjust the target platform in the PLC program (default: PC or CX 8x86). If required, you can select the target platform under *Resources* -> *Controller configuration*.


Ressourcen
Bibliothek STANDARD.LIB 5.6.98 12:03:0
Bibliothek TcMC.lib 18.1.10 09:53:12: Glo
Bibliothek TcNC.lib 10.10.08 17:55:34: Gl
Bibliothek TcSystem.lib*14.1.10 19:09:38:
Globale Variablen
Globale_Variablen
TwinCAT_Configuration (VAR_CONFI
TwinCAT_Import
Variable_Configuration (VAR_CONFIG
Alarmkonfiguration
Arbeitsbereich
Bibliotheksverwalter
Logbuch
Steuerungskonfiguration
Taskkonfiguration
Traceaufzeichnung
Watch- und Rezepturverwalter
Taskkonfiguration
Standard
MAIN
Task Abarbeitung
OK
Abbruch

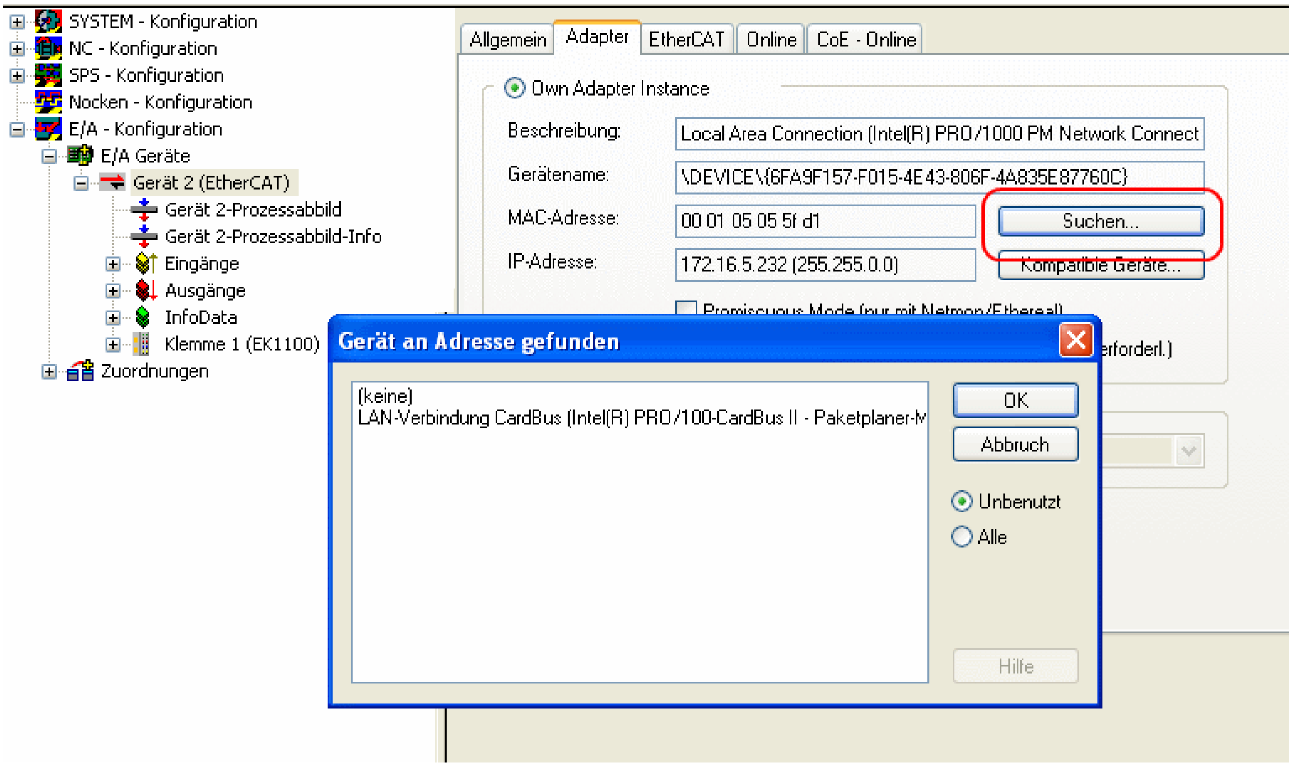
Auswahl der Zielplattform

● PC oder CX (x86)
○ CX (ARM)
○ BC über AMS
○ BC seriell
○ BCxx50 oder BX über AMS
○ BCxx50 oder BX seriell

Fig. 116: Selection of the target platform

Please note the following for the System Manager file:

- Start the System Manager in Config mode.
- Please ensure that the I/O configuration matches your actual configuration. In the sample program only one EL7041 is integrated. If further terminals are connected you have to add them or re-scan your configuration.
- You have to adjust the MAC address. To do this, click on your *EtherCAT device*, then select the *Adapter* tab and click on *Search* after the MAC address (see Fig. *Selecting the MAC address*). Select the right adapter.



● Own Adapter Instance

Beschreibung: Local Area Connection (Intel(R) PRO/1000 PM Network Connect

Gerätename: \DEVICE\{6FA9F157-F015-4E43-806F-4A835E87760C}

MAC-Adresse: 00 01 05 05 5f d1

IP-Adresse: 172.16.5.232 (255.255.0.0)

□ Promiscuous Mode (nur mit Netmon/Ethereal)

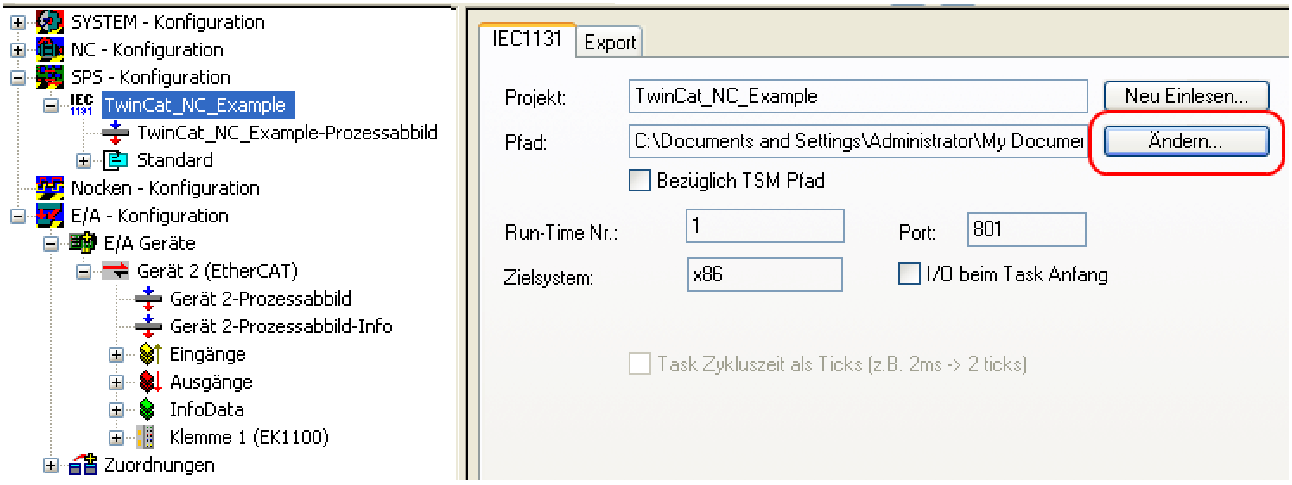
Gerät an Adresse gefunden

(keine)
LAN-Verbindung CardBus (Intel(R) PRO/100-CardBus II - Paketplaner-M

● Unbenutzt
○ Alle

Fig. 117: Selecting the MAC address

- In the PLC configuration you have to adjust the path for the PLC program. Click on the appended PLC program and select the tab *IEC1131* (see Fig. *Changing the PLC path*). Select *Change* and enter the correct path.



Projekt: TwinCat_NC_Example

Pfad: C:\Documents and Settings\Administrator\My Documei

□ Bezüglich TSM Pfad

Run-Time Nr.: 1

Port: 801

Zielsystem: x86

□ I/O beim Task Anfang

□ Task Zykluszeit als Ticks (z.B. 2ms -> 2 ticks)

Fig. 118: Changing the PLC path

- Under NC configuration an EL7041 is already linked to the NC. To change the link or add additional devices proceed as described under “Integration into the NC configuration [▶ 94]”.

The PLC program is configured as follows. The libraries *TcMC.lib* and *TcNC.lib* must be integrated (see Fig. *Required libraries*).

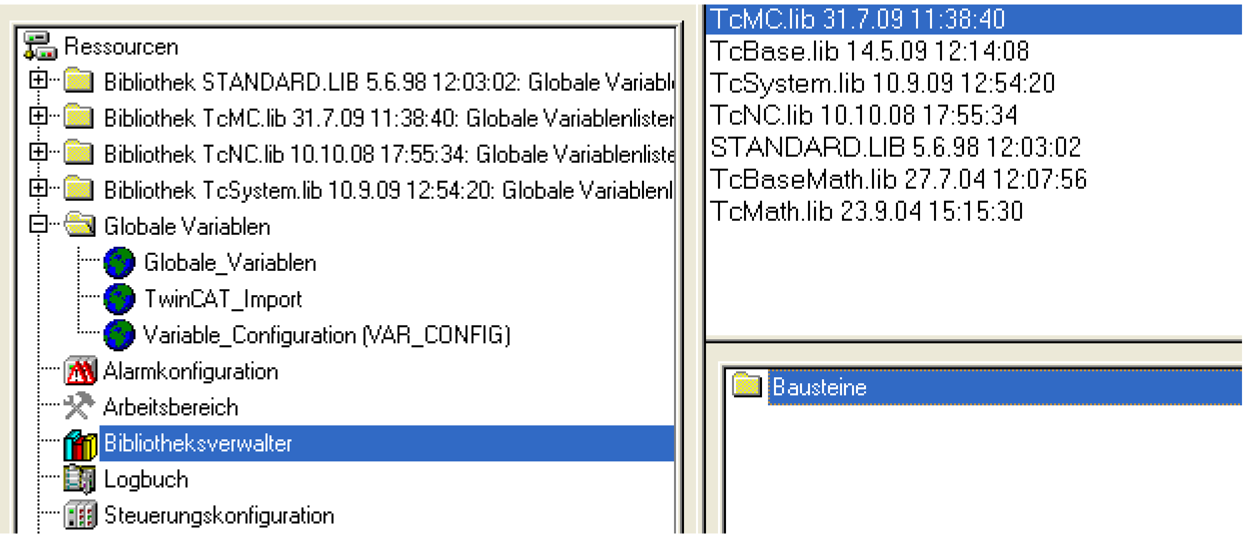
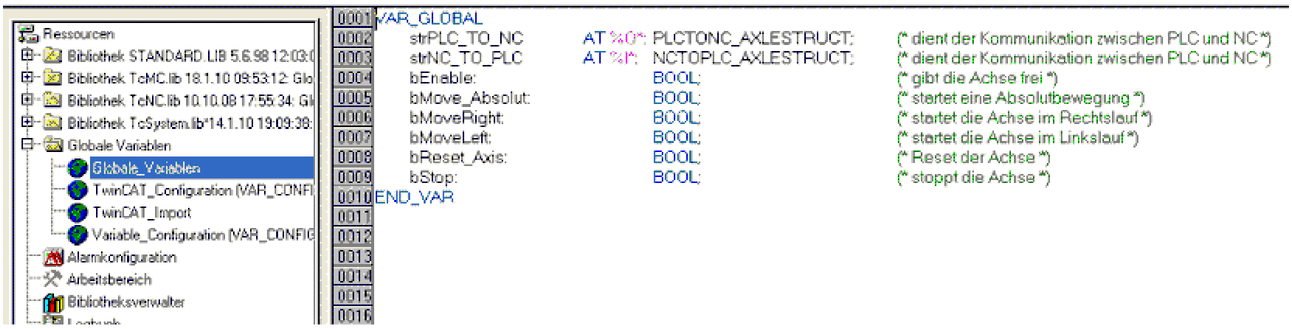

Ressourcen
Bibliothek STANDARD.LIB 5.6.98 12:03:02: Globale Variabl
Bibliothek TcMC.lib 31.7.09 11:38:40: Globale Variablenlisten
Bibliothek TcNC.lib 10.10.08 17:55:34: Globale Variablenliste
Bibliothek TcSystem.lib 10.9.09 12:54:20: Globale Variablenl
Globale Variablen
Globale_Variablen
TwinCAT_Import
Variable_Configuration (VAR_CONFIG)
Alarmkonfiguration
Arbeitsbereich
Bibliotheksverwalter
Logbuch
Steuerungskonfiguration
TcMC.lib 31.7.09 11:38:40
TcBase.lib 14.5.09 12:14:08
TcSystem.lib 10.9.09 12:54:20
TcNC.lib 10.10.08 17:55:34
STANDARD.LIB 5.6.98 12:03:02
TcBaseMath.lib 27.7.04 12:07:56
TcMath.lib 23.9.04 15:15:30
Bausteine

Fig. 119: Required libraries

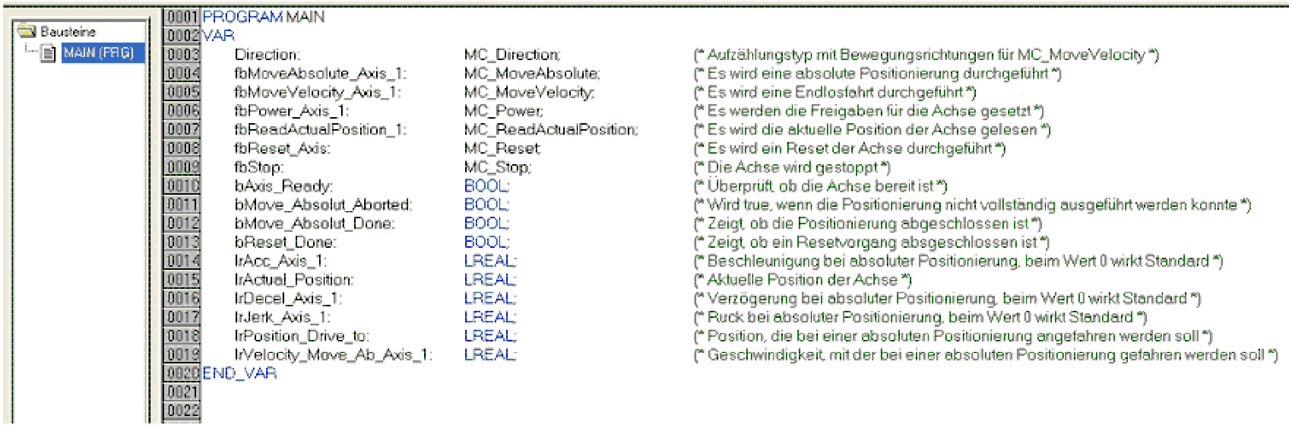
Once this is done, certain global variables are declared (see Fig. *Global variables*). The data types *PLCTONC_AXLESTRUCT* and *NCTOPLC_AXLESTRUCT*deal with the communication between the PLC and the NC.


Ressourcen
Bibliothek STANDARD.LIB 5.6.98 12:03:0
Bibliothek TcMC.lib 18.1.10 09:53:12: Glo
Bibliothek TcNC.lib 10.10.08 17:55:34: Gl
Bibliothek TcSystem.lib*14.1.10 19:09:38:
Globale Variablen
Globale_Variablen
TwinCAT_Configuration (VAR_CONFI
TwinCAT_Import
Variable_Configuration (VAR_CONFIG
Alarmkonfiguration
Arbeitsbereich
Bibliotheksverwalter

```
VAR_GLOBAL
    strPLC_TO_NC        AT %Q*: PLCTONC_AXLESTRUCT;    (* dient der Kommunikation zwischen PLC und NC *)
    strNC_TO_PLC        AT %I*: NCTOPLC_AXLESTRUCT;    (* dient der Kommunikation zwischen PLC und NC *)
    bEnable:                    BOOL;                  (* gibt die Achse frei *)
    bMove_Absolut:              BOOL;                  (* startet eine Absolutbewegung *)
    bMoveRight:                 BOOL;                  (* startet die Achse im Rechtslauf *)
    bMoveLeft:                  BOOL;                  (* startet die Achse im Linkslauf *)
    bReset_Axis:                BOOL;                  (* Reset der Achse *)
    bStop:                      BOOL;                  (* stoppt die Achse *)
END_VAR
```

Fig. 120: Global variables

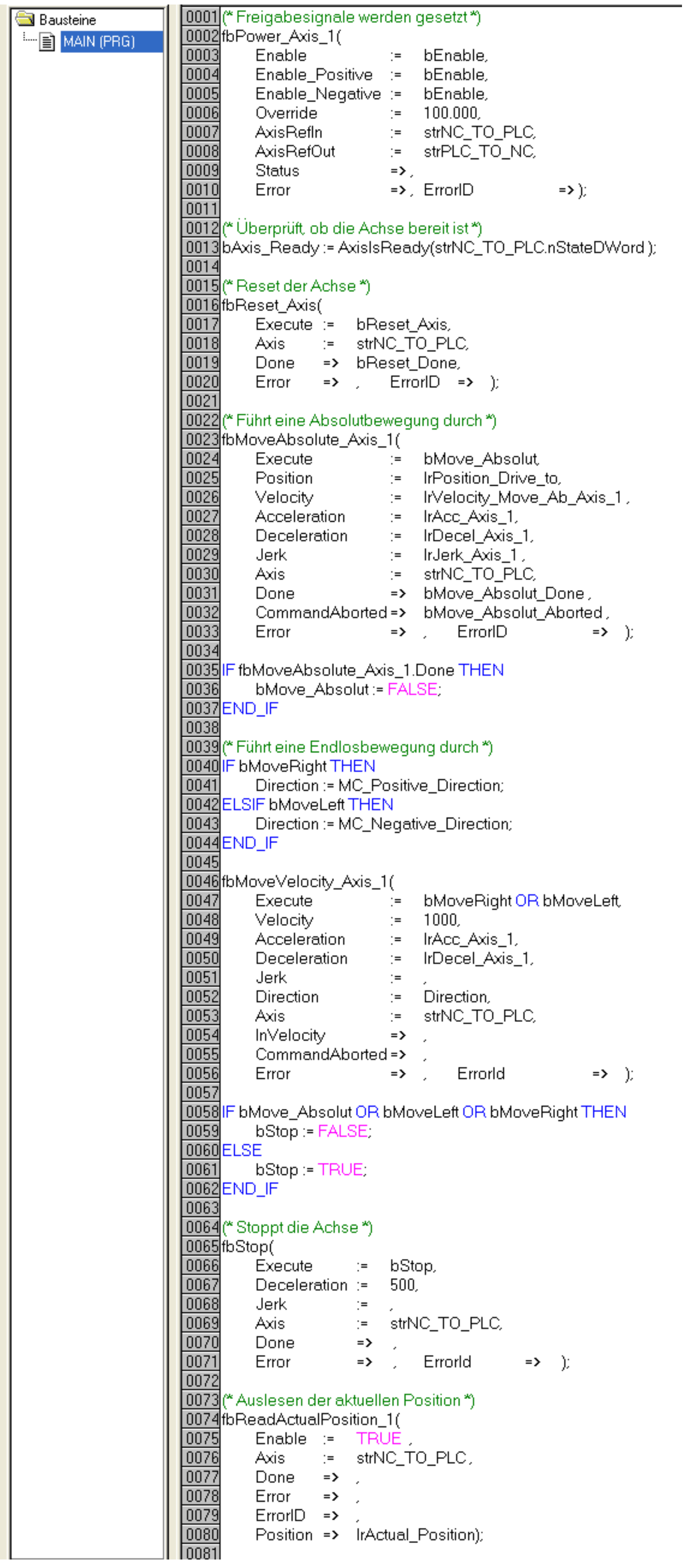
Once the global variables have been declared, programming can commence. Start with declaring local variables (see Fig. *Local variables*).
MC_Direction is an enumeration type that specifies the direction of travel for the block MC_MoveVelocity, which in turn initiates continuous travel of the motor.
An axis reset is carried out with the function block MC_Reset. Absolute positioning is carried out with the function block MC_MoveAbsolute. The current axis position can be read with the function block MC_ActualPosition.
MC_Power enables the axis; MC_Stop is required for stopping the axis.



```
PROGRAM MAIN
VAR
    Direction:                  MC_Direction;               (* Aufzählungstyp mit Bewegungsrichtungen für MC_MoveVelocity *)
    fbMoveAbsolute_Axis_1:      MC_MoveAbsolute;            (* Es wird eine absolute Positionierung durchgeführt *)
    fbMoveVelocity_Axis_1:      MC_MoveVelocity;            (* Es wird eine Endlosfahrt durchgeführt *)
    fbPower_Axis_1:             MC_Power;                   (* Es werden die Freigaben für die Achse gesetzt *)
    fbReadActualPosition_1:     MC_ReadActualPosition;      (* Es wird die aktuelle Position der Achse gelesen *)
    fbReset_Axis:               MC_Reset;                   (* Es wird ein Reset der Achse durchgeführt *)
    fbStop:                     MC_Stop;                    (* Die Achse wird gestoppt *)
    bAxis_Ready:                BOOL;                       (* Überprüft, ob die Achse bereit ist *)
    bMove_Absolut_Aborted:      BOOL;                       (* Wird true, wenn die Positionierung nicht vollständig ausgeführt werden konnte *)
    bMove_Absolut_Done:         BOOL;                       (* Zeigt, ob die Positionierung abgeschlossen ist *)
    bReset_Done:                BOOL;                       (* Zeigt, ob ein Resetvorgang absgeschlossen ist *)
    lrAcc_Axis_1:               LREAL;                      (* Beschleunigung bei absoluter Positionierung, beim Wert 0 wirkt Standard *)
    lrActual_Position:          LREAL;                      (* Aktuelle Position der Achse *)
    lrDecel_Axis_1:             LREAL;                      (* Verzögerung bei absoluter Positionierung, beim Wert 0 wirkt Standard *)
    lrJerk_Axis_1:              LREAL;                      (* Ruck bei absoluter Positionierung, beim Wert 0 wirkt Standard *)
    lrPosition_Drive_to:        LREAL;                      (* Position, die bei einer absoluten Positionierung angefahren werden soll *)
    lrVelocity_Move_Ab_Axis_1:  LREAL;                      (* Geschwindigkeit, mit der bei einer absoluten Positionierung gefahren werden soll *)
END_VAR
```

Fig. 121: Local variables

The program code is as follows (see Fig. *Program code*):



```
(* Freigabesignale werden gesetzt *)
fbPower_Axis_1(
    Enable            :=    bEnable,
    Enable_Positive   :=    bEnable,
    Enable_Negative   :=    bEnable,
    Override          :=    100.000,
    AxisRefIn         :=    strNC_TO_PLC,
    AxisRefOut        :=    strPLC_TO_NC,
    Status            =>,
    Error             =>,   ErrorID            =>);

(* Überprüft, ob die Achse bereit ist *)
bAxis_Ready := AxisIsReady(strNC_TO_PLC.nStateDWord );

(* Reset der Achse *)
fbReset_Axis(
    Execute  :=    bReset_Axis,
    Axis     :=    strNC_TO_PLC,
    Done     =>    bReset_Done,
    Error    =>    ,    ErrorID   =>   );

(* Führt eine Absolutbewegung durch *)
fbMoveAbsolute_Axis_1(
    Execute           :=    bMove_Absolut,
    Position          :=    lrPosition_Drive_to,
    Velocity          :=    lrVelocity_Move_Ab_Axis_1 ,
    Acceleration      :=    lrAcc_Axis_1,
    Deceleration      :=    lrDecel_Axis_1,
    Jerk              :=    lrJerk_Axis_1 ,
    Axis              :=    strNC_TO_PLC,
    Done              =>    bMove_Absolut_Done ,
    CommandAborted    =>    bMove_Absolut_Aborted ,
    Error             =>    ,    ErrorID            =>    );

IF fbMoveAbsolute_Axis_1.Done THEN
    bMove_Absolut := FALSE;
END_IF

(* Führt eine Endlosbewegung durch *)
IF bMoveRight THEN
    Direction := MC_Positive_Direction;
ELSIF bMoveLeft THEN
    Direction := MC_Negative_Direction;
END_IF

fbMoveVelocity_Axis_1(
    Execute           :=    bMoveRight OR bMoveLeft,
    Velocity          :=    1000,
    Acceleration      :=    lrAcc_Axis_1,
    Deceleration      :=    lrDecel_Axis_1,
    Jerk              :=    ,
    Direction         :=    Direction,
    Axis              :=    strNC_TO_PLC,
    InVelocity        =>    ,
    CommandAborted    =>    ,
    Error             =>    ,    ErrorId            =>    );

IF bMove_Absolut OR bMoveLeft OR bMoveRight THEN
    bStop := FALSE;
ELSE
    bStop := TRUE;
END_IF

(* Stoppt die Achse *)
fbStop(
    Execute        :=    bStop,
    Deceleration   :=    500,
    Jerk           :=    ,
    Axis           :=    strNC_TO_PLC,
    Done           =>    ,
    Error          =>    ,    ErrorId       =>    );

(* Auslesen der aktuellen Position *)
fbReadActualPosition_1(
    Enable    :=    TRUE ,
    Axis      :=    strNC_TO_PLC ,
    Done      =>    ,
    Error     =>    ,
    ErrorID   =>    ,
    Position  =>    lrActual_Position);
```

Fig. 122: Program code

The motor can then be operated with the aid of the following visualization (see Fig. *Visualization*).

Press *Enable* to enable the axis. In "Free run mode" you can now use the *Left* or *Right* buttons, and the motor will run with a speed defined under *fbMoveVelocity_Axis_1* in the selected direction. In "Absolute mode" you can specify a *Velocity*, *Acceleration*, *Deceleration* and the *Setpoint Position* and initiate the motion with *Start Job*. If no values are entered for *acceleration* and *deceleration* the default value of the NC is used.

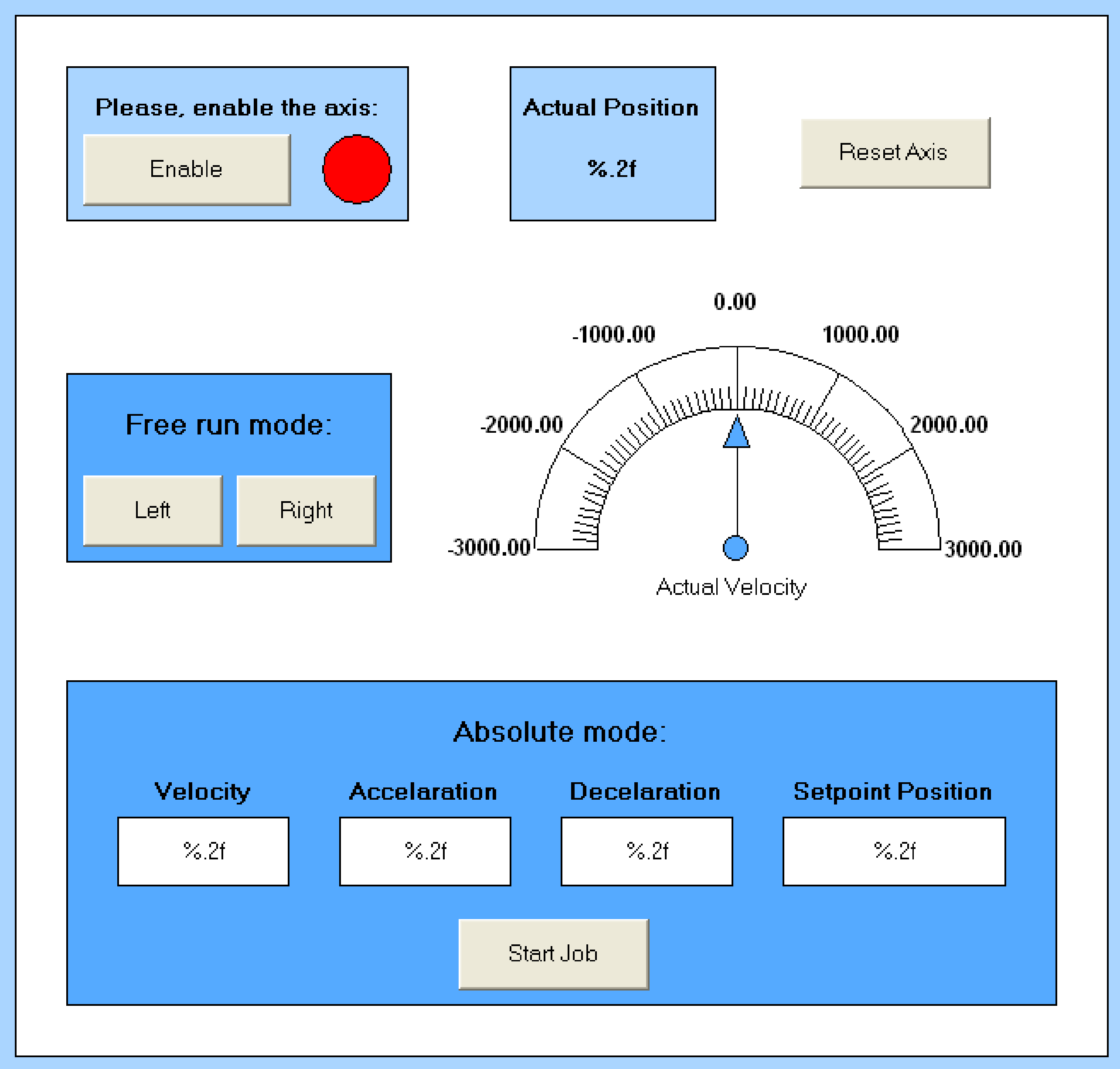


Fig. 123: Visualization

**Information on function blocks and data types**

Further information on the function blocks and data types used can be found in the Beckhoff Information System.

### 5.2.5 Commissioning without NC, status word/control word

(Master: TwinCAT 2.11 R3)

In principle, the operating modes CST, CSTCA, CSV and CSP can be used without TwinCAT NC.

**Output stage enabled via control word**

The output stage has to be enabled for each operating mode. To this end enter the following values in the specified order via the PLC control word (MDP742 [▶ 152] / DS402 [▶ 167]) (see Fig. *DS402 State Machine*). The respective status messages are output in the status word (MDP742 [▶ 151] / DS402 [▶ 167]).

$0_{hex}$
$80_{hex}$ (Fault reset)
$6_{hex}$ (Shutdown)
$7_{hex}$ (Switch on)
$F_{hex}$ (Enable operation)

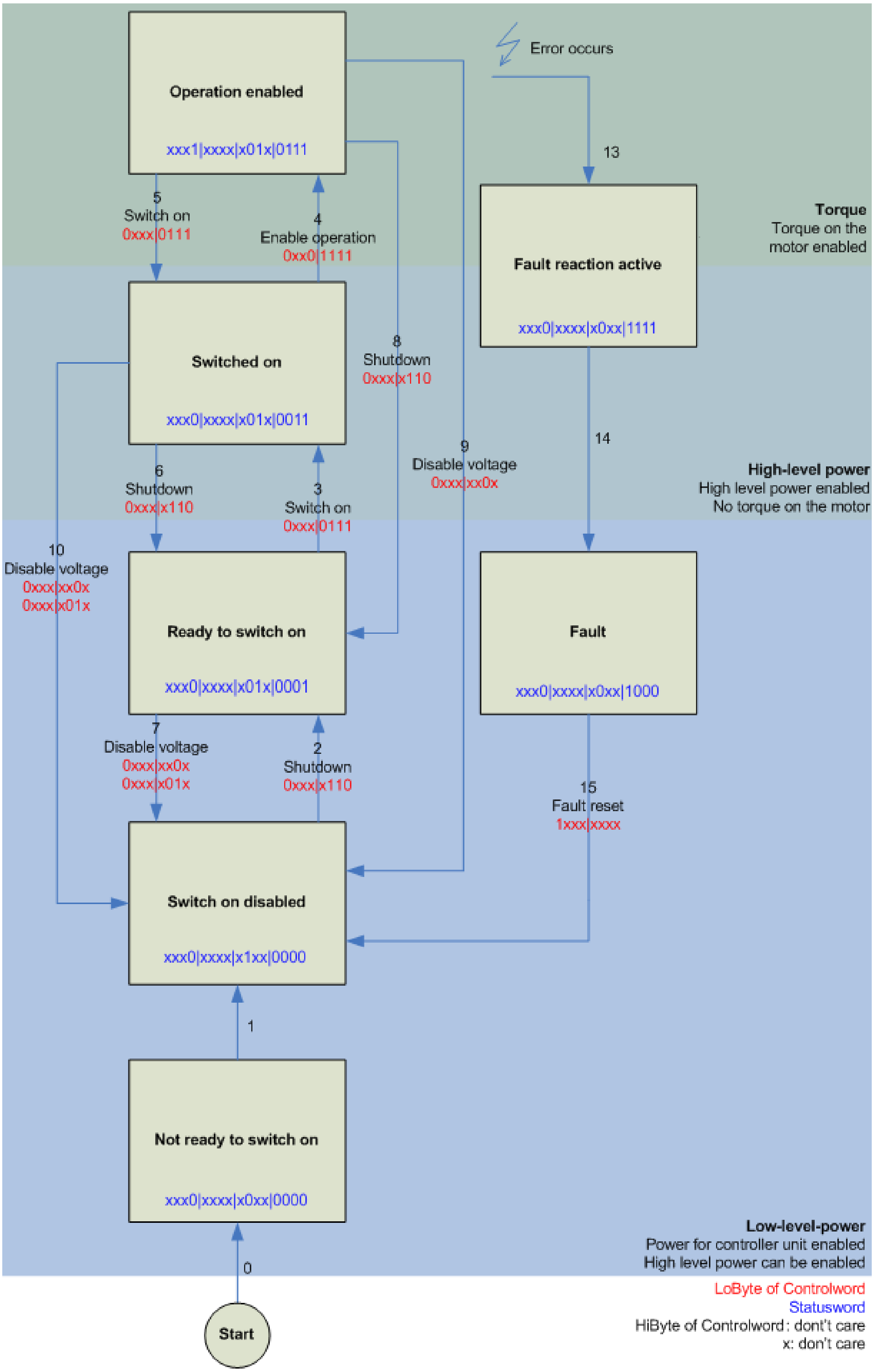


Fig. 124: DS402 State Machine

### CST - cyclic synchronous torque

Select *Cyclic synchronous torque mode* in index 0x7010:03 [▶ 152] *Modes of operation* (MDP) or 0x6060:0 [▶ 167] *Modes of operation* (DS402). The *Predefined PDO Assignment: 'Cyclic synchronous torque mode (CST)'* should also be selected in the respective process data (see CoE process data [▶ 138] or DS402 process data [▶ 141]). The configuration then has to be reloaded in order to activate the selection.
Index 0x6010:03 [▶ 151] *Modes of operation display* (MDP) or 0x6061:0 [▶ 167] *Modes of operation display* (DS402) can be used to check the actual mode of the servo terminal.

Via the PLC a defined torque can be set in the variable *Target torque* as a target value for the servo terminal. The torque is specified in 1000th of the rated current. A value of $1000_{dec}$, for example, corresponds to the set index 0x8011:12 [▶ 148] *Rated current* (MDP) or index 0x6075:0 [▶ 168] *Motor rated current* (DS402). The value $1_{dec}$ corresponds to one 1000th of the rated current.

### CSTCA - cyclic synchronous torque with commutation angle

Select *Cyclic synchronous torque mode with commutation angle* in index 0x7010:03 [▶ 152] *Modes of operation (MDP)* or index 0x6060:0 [▶ 167] *Modes of operation* (DS402). The *Predefined PDO Assignment: 'Cyclic synchronous torque mode with commutation angle mode (CSTCA)'* should also be selected in the respective process data (see CoE process data [▶ 138] or DS402 process data [▶ 141]). The configuration then has to be reloaded in order to activate the selection.
Index 0x6010:03 [▶ 151] *Modes of operation display* (MDP) or 0x6061:0 [▶ 167] Modes of operation display (DS402) can be used to check the actual mode of the servo terminal.

Via the PLC a defined torque can be set in the *Target torque* variable as a basis for the servo terminal control. In the *Commutation angle* variable the angle to be maintained with the set torque can be specified. The torque is specified in 1000th of the rated current. A value of $1000_{dec}$, for example, corresponds to the set index 0x8011:12 [▶ 148] *Rated current* (MDP) or index 0x6075:0 [▶ 168] *Motor rated current* (DS402). The value $1_{dec}$ corresponds to one 1000th of the rated current.
The angle value must be converted, $65536_{dec}$ corresponds to 360°.

### CSV - cyclic synchronous velocity

Select *Cyclic synchronous velocity* in index 0x7010:03 [▶ 152] *Modes of operation* (MDP) or index 0x6060:0 [▶ 167] *Modes of operation* (DS402). The *Predefined PDO Assignment: 'Cyclic synchronous velocity mode (CSV)'* should also be selected in the respective process data (see CoE process data [▶ 138] or DS402 process data [▶ 141]). The configuration then has to be reloaded in order to activate the selection.
Index 0x6010:03 [▶ 151] *Modes of operation display* (MDP) or 0x6061:0 [▶ 167] *Modes of operation display* (DS402) can be used to check the actual mode of the servo terminal.

Via the PLC a defined speed can be set as control parameter for the servo terminal in the variable *Target velocity* 0x7010:06 [▶ 152] (MDP) or 0x60FF:0 [▶ 170] (DS402). The constant value *Velocity encoder resolution* in CoE object 0x9010:14 [▶ 154] (MDP) or 0x6090:0 [▶ 169] (DS402) corresponds to 1 revolution per second. If this value is entered under *Target velocity*, the motor speed is 1 rev. per sec. The velocity can be increased by entering a suitable multiple of the *Velocity encoder resolution* value under *Target velocity*.

### CSP - cyclic synchronous position

Select *Cyclic synchronous position* in index 0x7010:03 [▶ 152] *Modes of operation* (MDP) or index 0x6060:0 [▶ 167] *Modes of operation* (DS402).
Similarly, the *Predefined PDO Assignment: 'Cyclic synchronous position mode (CSP)'* should be selected in the respective process data (see CoE process data [▶ 138] or DS402 process data [▶ 141]). The configuration then has to be reloaded in order to activate the selection.
Index 0x6010:03 [▶ 151] *Modes of operation display* (MDP) or 0x6061:0 [▶ 167] *Modes of operation display* (DS402) can be used to check the actual mode of the servo terminal.

Via the PLC a defined position can be set in the variable *Target position* 0x7010:05 [▶ 152] (MDP) or 0x607A:0 [▶ 169] (DS402) to which the motor is to drive. The calculated scaling factor [▶ 120] is taken as the basis for the calculation of the position. The value entered in the *Target position* variable must be multiplied by the calculated scaling factor.

## 5.2.6 Homing

(Master TwinCAT 2.11 R3)

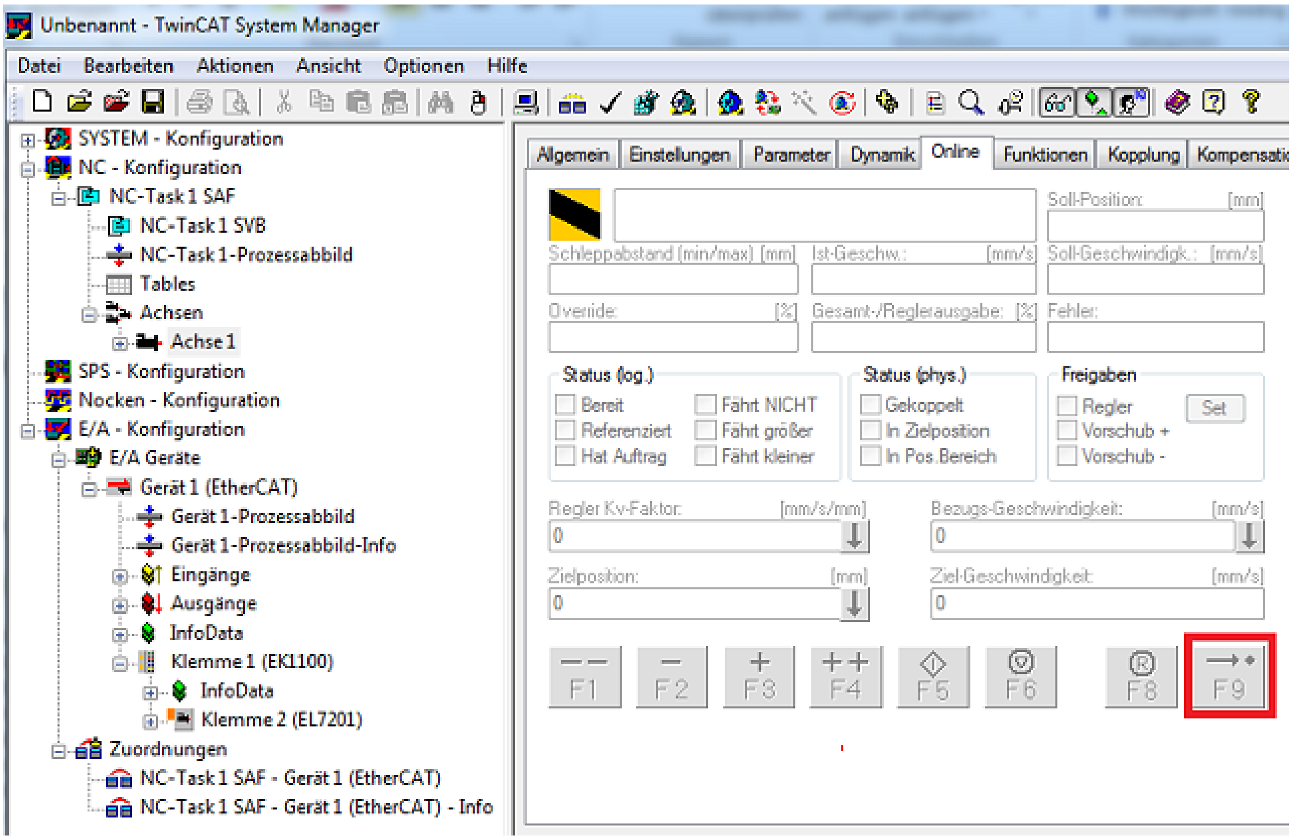
The data provided in this section as an example refer to an AM3121-0200-0001 servomotor from Beckhoff Automation. For other motors the values may vary, depending on the application.

**Table of contents**

- Referencing [▶ 114]
  - Function block "MC_Home" [▶ 115]
  - Reference modes [▶ 116]

### Referencing

Referencing is not available via the online commissioning tab for the axis (see Fig. *Online homing in the NC*), since the reference cam cannot be directly connected to the EL72x1.



Regler Kv-Faktor: [mm/s/mm] 0

Bezugs-Geschwindigkeit: [mm/s] 0

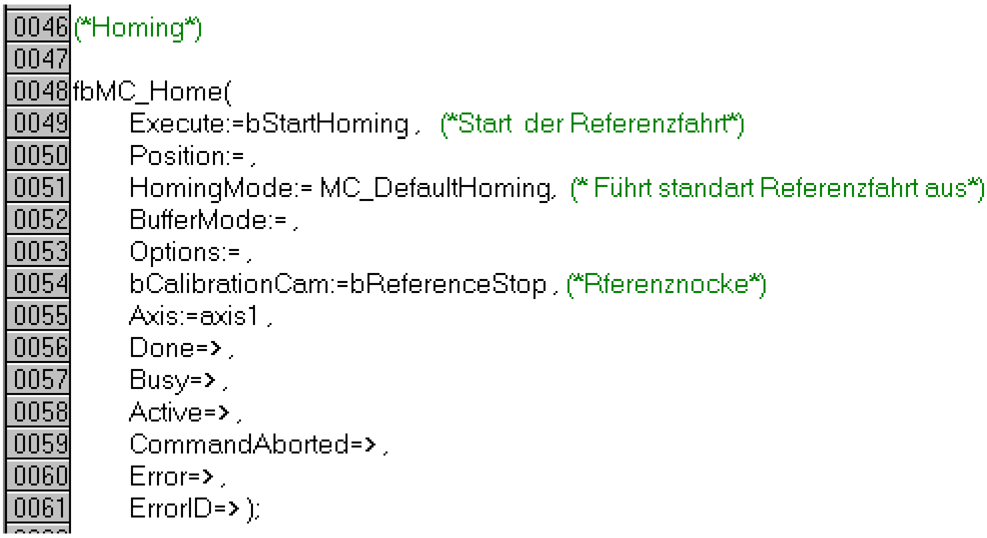
Zielposition: [mm] 0

Ziel-Geschwindigkeit: [mm/s] 0

Fig. 125: Online homing in the NC

### Function block "MC_Home"

- Referencing must be done from the PLC. The function block *MC_Home* from the TC MC2 Lib is used for this purpose.
- The following minimum configuration is required in *MC_Home*.
    - Homing mode enables selection of mode to be used for referencing.
    - Execute is used to initiate homing.
    - bCalibrationCam, which has to be linked with your reference cam, is used to stop homing.

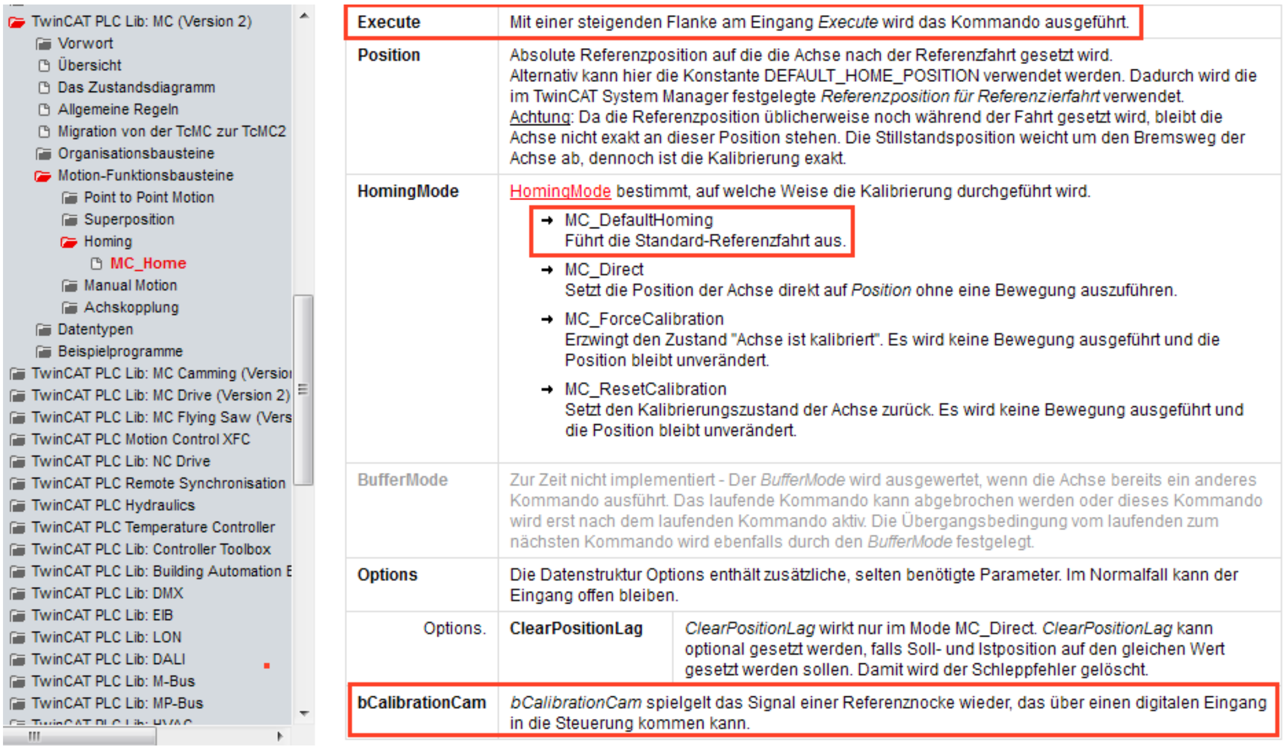


```
(*Homing*)

fbMC_Home(
        Execute:=bStartHoming ,  (*Start  der Referenzfahrt*)
        Position:= ,
        HomingMode:= MC_DefaultHoming,  (* Führt standart Referenzfahrt aus*)
        BufferMode:= ,
        Options:= ,
        bCalibrationCam:=bReferenceStop , (*Rferenznocke*)
        Axis:=axis1 ,
        Done=> ,
        Busy=> ,
        Active=> ,
        CommandAborted=> ,
        Error=> ,
        ErrorID=> );
```

Fig. 126: Configuration of the MC_Home block

- The following figure *Extract from the functional description for MC_Home* shows an extract from the functional description of *MC_Home*. Full information can be found in the corresponding functional description.

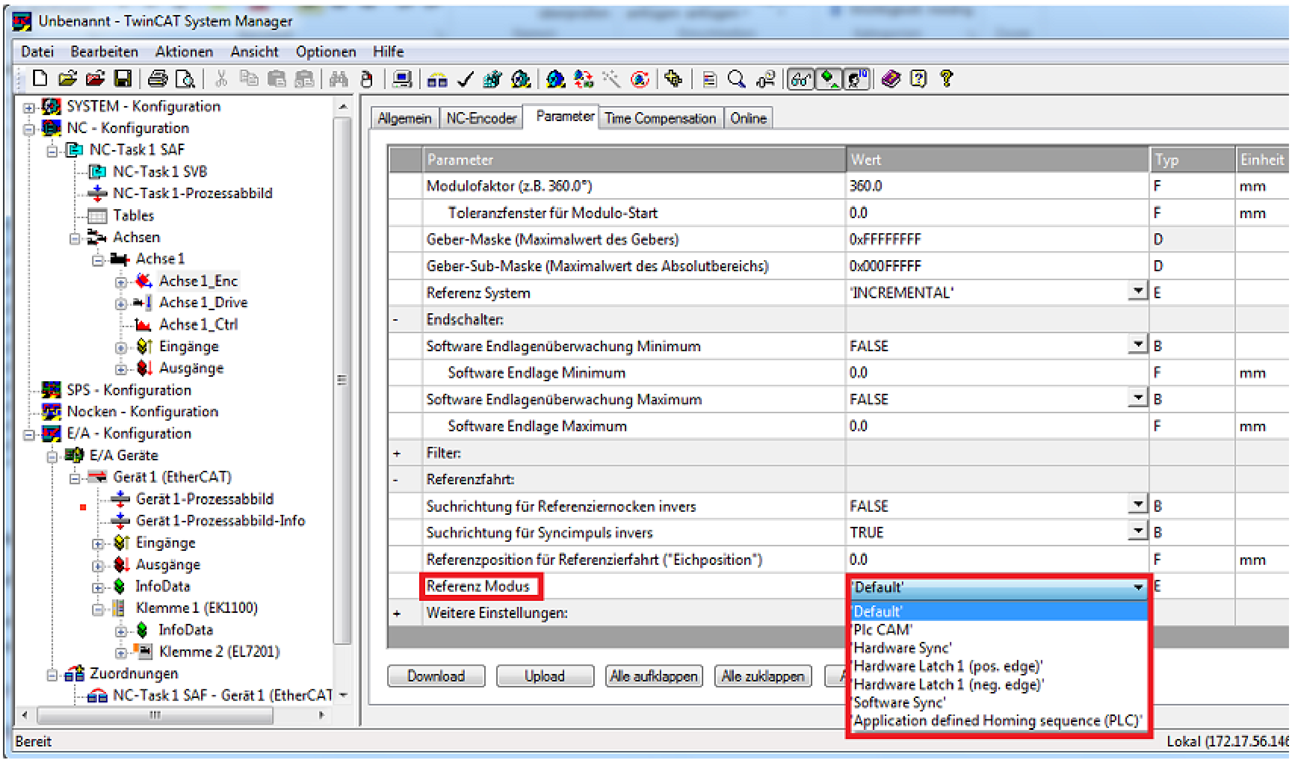

TwinCAT PLC Lib: MC (Version 2)
Vorwort
Übersicht
Das Zustandsdiagramm
Allgemeine Regeln
Migration von der TcMC zur TcMC2
Organisationsbausteine
Motion-Funktionsbausteine
Point to Point Motion
Superposition
Homing
MC_Home
Manual Motion
Achskopplung
Datentypen
Beispielprogramme
TwinCAT PLC Lib: MC Camming (Versio
TwinCAT PLC Lib: MC Drive (Version 2)
TwinCAT PLC Lib: MC Flying Saw (Vers
TwinCAT PLC Motion Control XFC
TwinCAT PLC Lib: NC Drive
TwinCAT PLC Remote Synchronisation
TwinCAT PLC Hydraulics
TwinCAT PLC Temperature Controller
TwinCAT PLC Lib: Controller Toolbox
TwinCAT PLC Lib: Building Automation E
TwinCAT PLC Lib: DMX
TwinCAT PLC Lib: EIB
TwinCAT PLC Lib: LON
TwinCAT PLC Lib: DALI
TwinCAT PLC Lib: M-Bus
TwinCAT PLC Lib: MP-Bus
TwinCAT PLC Lib: HVAC

| | | |
|---|---|---|
| **Execute** | Mit einer steigenden Flanke am Eingang *Execute* wird das Kommando ausgeführt. | |
| **Position** | Absolute Referenzposition auf die die Achse nach der Referenzfahrt gesetzt wird.<br>Alternativ kann hier die Konstante DEFAULT_HOME_POSITION verwendet werden. Dadurch wird die im TwinCAT System Manager festgelegte *Referenzposition für Referenzierfahrt* verwendet.<br>Achtung: Da die Referenzposition üblicherweise noch während der Fahrt gesetzt wird, bleibt die Achse nicht exakt an dieser Position stehen. Die Stillstandsposition weicht um den Bremsweg der Achse ab, dennoch ist die Kalibrierung exakt. | |
| **HomingMode** | HomingMode bestimmt, auf welche Weise die Kalibrierung durchgeführt wird.<br>→ MC_DefaultHoming<br>Führt die Standard-Referenzfahrt aus.<br>→ MC_Direct<br>Setzt die Position der Achse direkt auf *Position* ohne eine Bewegung auszuführen.<br>→ MC_ForceCalibration<br>Erzwingt den Zustand "Achse ist kalibriert". Es wird keine Bewegung ausgeführt und die Position bleibt unverändert.<br>→ MC_ResetCalibration<br>Setzt den Kalibrierungszustand der Achse zurück. Es wird keine Bewegung ausgeführt und die Position bleibt unverändert. | |
| BufferMode | Zur Zeit nicht implementiert - Der *BufferMode* wird ausgewertet, wenn die Achse bereits ein anderes Kommando ausführt. Das laufende Kommando kann abgebrochen werden oder dieses Kommando wird erst nach dem laufenden Kommando aktiv. Die Übergangsbedingung vom laufenden zum nächsten Kommando wird ebenfalls durch den *BufferMode* festgelegt. | |
| **Options** | Die Datenstruktur Options enthält zusätzliche, selten benötigte Parameter. Im Normalfall kann der Eingang offen bleiben. | |
| Options. | **ClearPositionLag** | *ClearPositionLag* wirkt nur im Mode MC_Direct. *ClearPositionLag* kann optional gesetzt werden, falls Soll- und Istposition auf den gleichen Wert gesetzt werden sollen. Damit wird der Schleppfehler gelöscht. |
| **bCalibrationCam** | *bCalibrationCam* spielgelt das Signal einer Referenznocke wieder, das über einen digitalen Eingang in die Steuerung kommen kann. | |

Fig. 127: Extraction from the functional description for MC_Home

### Reference modes

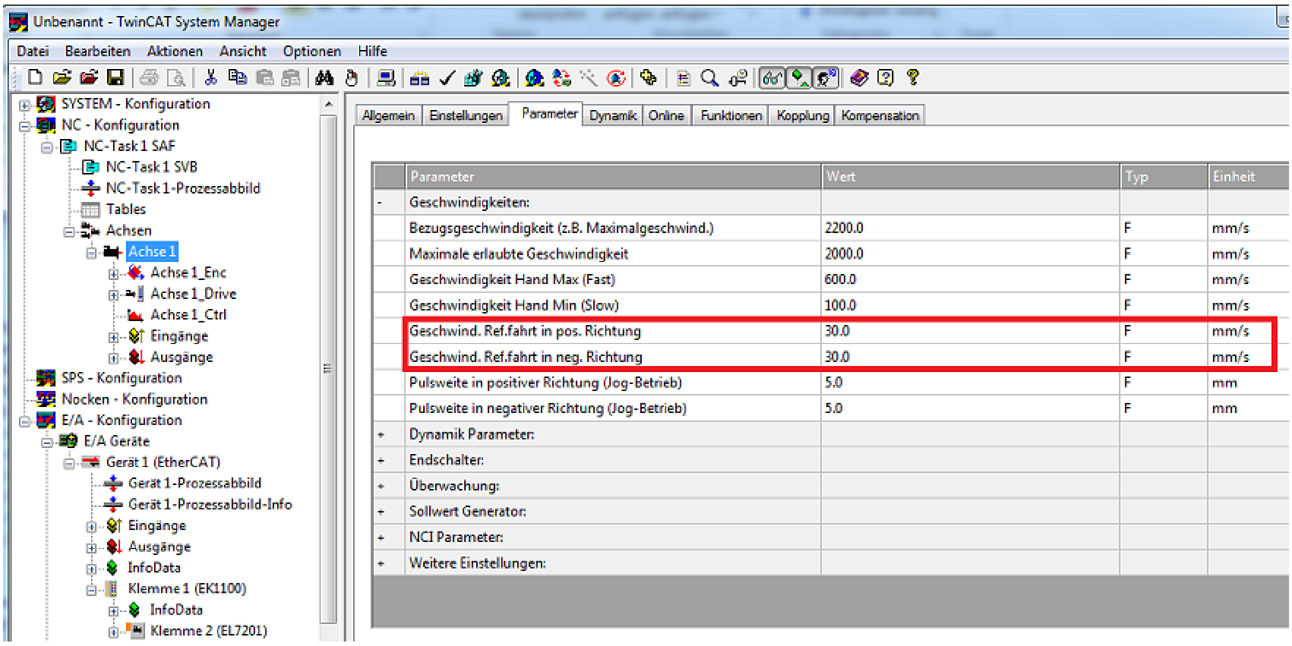
- The EL72x1 can be operated with the following NC reference modes (see Fig. *Selection of the reference modes in the NC*).
- **Default:** Is suitable as a general setting and for most applications.
  Once the motor reaches the reference cam, the direction is reversed. The declining cam signal causes the motor to stop. The reference position is then set.
- **Software Sync:** The C track is modelled virtually.



| | Parameter | Wert | Typ | Einheit |
|---|---|---|---|---|
| | Modulofaktor (z.B. 360.0°) | 360.0 | F | mm |
| | Toleranzfenster für Modulo-Start | 0.0 | F | mm |
| | Geber-Maske (Maximalwert des Gebers) | 0xFFFFFFFF | D | |
| | Geber-Sub-Maske (Maximalwert des Absolutbereichs) | 0x000FFFFF | D | |
| | Referenz System | 'INCREMENTAL' | E | |
| - | Endschalter: | | | |
| | Software Endlagenüberwachung Minimum | FALSE | B | |
| | Software Endlage Minimum | 0.0 | F | mm |
| | Software Endlagenüberwachung Maximum | FALSE | B | |
| | Software Endlage Maximum | 0.0 | F | mm |
| + | Filter: | | | |
| - | Referenzfahrt: | | | |
| | Suchrichtung für Referenziernocken invers | FALSE | B | |
| | Suchrichtung für Syncimpuls invers | TRUE | B | |
| | Referenzposition für Referenzierfahrt ("Eichposition") | 0.0 | F | mm |
| | Referenz Modus | 'Default' | E | |
| + | Weitere Einstellungen: | | | |

Fig. 128: Selection of the reference modes in the NC

The velocity to be used for homing can also be set in the NC (Fig. *Setting the reference velocity*).



| | Parameter | Wert | Typ | Einheit |
|---|---|---|---|---|
| - | Geschwindigkeiten: | | | |
| | Bezugsgeschwindigkeit (z.B. Maximalgeschwind.) | 2200.0 | F | mm/s |
| | Maximale erlaubte Geschwindigkeit | 2000.0 | F | mm/s |
| | Geschwindigkeit Hand Max (Fast) | 600.0 | F | mm/s |
| | Geschwindigkeit Hand Min (Slow) | 100.0 | F | mm/s |
| | Geschwind. Ref.fahrt in pos. Richtung | 30.0 | F | mm/s |
| | Geschwind. Ref.fahrt in neg. Richtung | 30.0 | F | mm/s |
| | Pulsweite in positiver Richtung (Jog-Betrieb) | 5.0 | F | mm |
| | Pulsweite in negativer Richtung (Jog-Betrieb) | 5.0 | F | mm |
| + | Dynamik Parameter: | | | |
| + | Endschalter: | | | |
| + | Überwachung: | | | |
| + | Sollwert Generator: | | | |
| + | NCI Parameter: | | | |
| + | Weitere Einstellungen: | | | |

Fig. 129: Setting the reference velocity

## 5.2.7 NC settings

(Master TwinCAT 2.11 R3)

The data provided in this section as an example refer to an AM3121-0200-0001 servomotor from Beckhoff Automation. For other motors the values may vary, depending on the application.

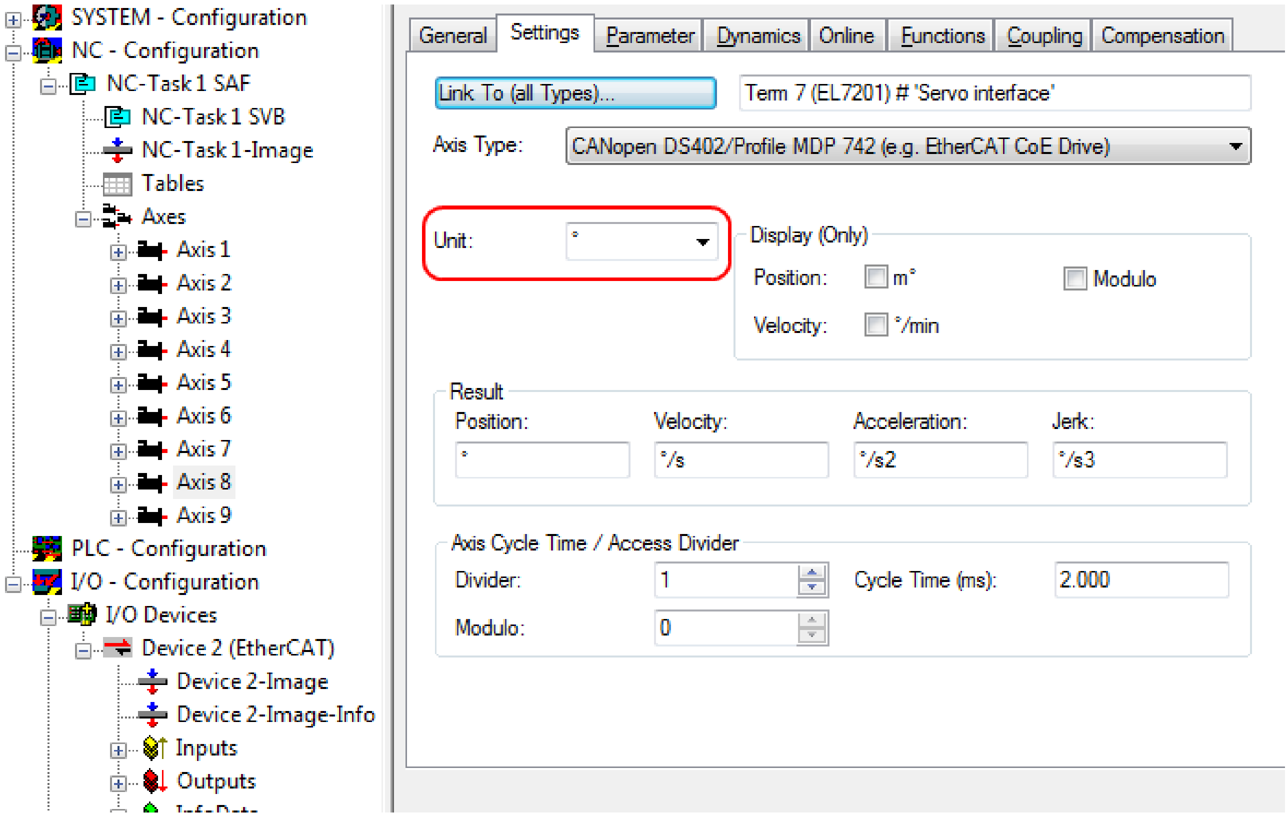
**Table of contents**

- Definition of the unit [▶ 117]
- Selecting the maximum velocity [▶ 118]
- Dead time compensation [▶ 118]
- Setting the encoder mask [▶ 119]
- Scaling factor [▶ 120]
  - Calculation of the scaling factor [▶ 121]
  - Scaling output [▶ 120]
- Position lag monitoring [▶ 121]
- Commissioning the motor with the NC [▶ 122]

Several important parameters are required for the commissioning with the NC. These should be set as follows before commissioning. A fundamental factor for setting the following parameters is the unit in which the NC is set to operate. For the following parameters it was assumed that one revolution corresponds to 360°.

### Definition of the unit

The unit can be defined in the *Settings* tab for the axis.



Term 7 (EL7201) # 'Servo interface'

Axis Type: CANopen DS402/Profile MDP 742 (e.g. EtherCAT CoE Drive)

Unit: °

Display (Only)

Position: □ m° □ Modulo

Velocity: □ °/min

Result

| Position: | Velocity: | Acceleration: | Jerk: |
|---|---|---|---|
| ° | °/s | °/s2 | °/s3 |

Axis Cycle Time / Access Divider

Divider: 1 Cycle Time (ms): 2.000

Modulo: 0

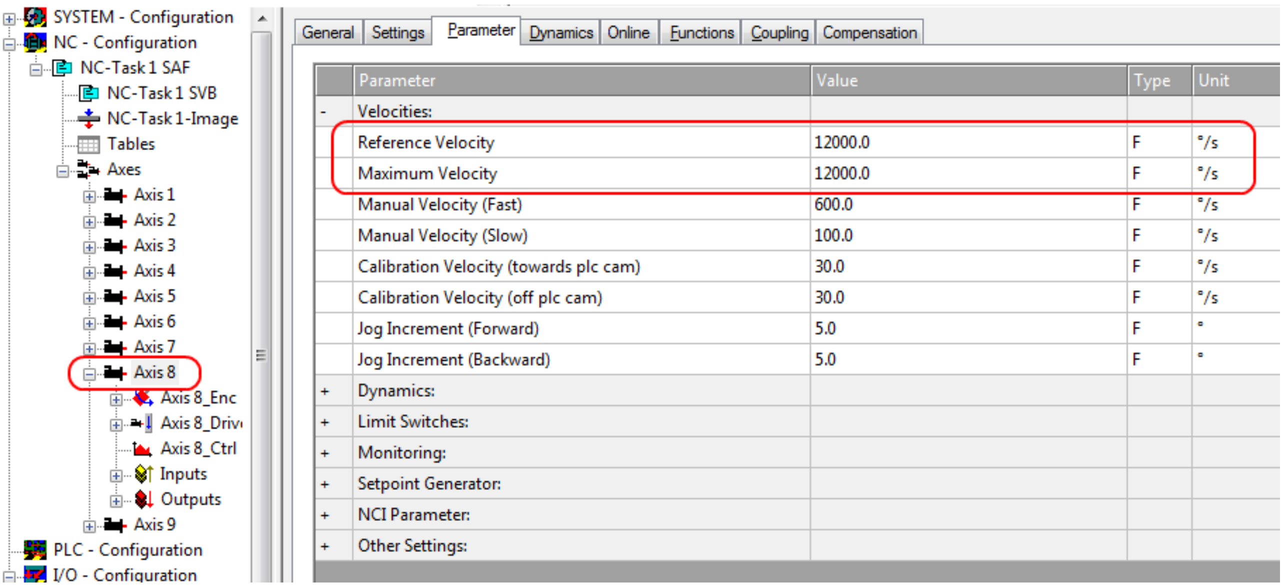
Fig. 130: Definition of the unit

### Selecting the maximum velocity

The *maximum permitted velocity* is calculated based on the maximum motor speed (name plate) and the distance, in this case in relation to 360° per second.

$$v_{Bez} = \frac{v_{maxMotor} \times 360°}{60\ s} = \frac{2000\ {}^{1}/_{min} \times 360°}{60\ s} = 12000\ {}^{°}/_{s}$$

$$v_{max} = \frac{v_{maxMotor} \times 360°}{60\ s} = \frac{2000\ {}^{1}/_{min} \times 360°}{60\ s} = 12000\ {}^{°}/_{s}$$



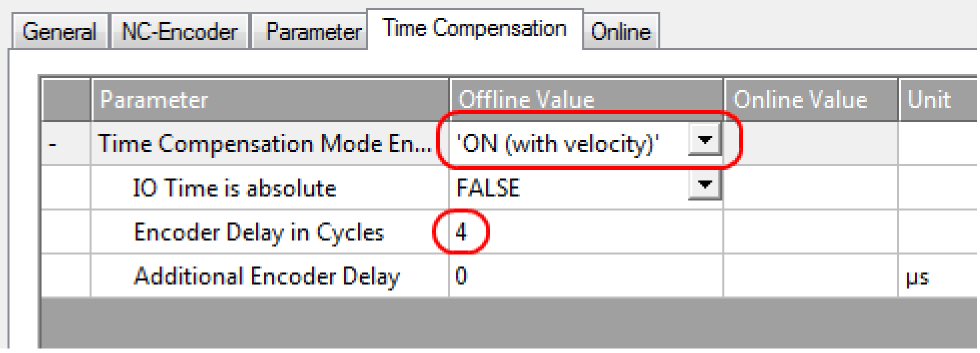
| | Parameter | Value | Type | Unit |
|---|---|---|---|---|
| - | Velocities: | | | |
| | Reference Velocity | 12000.0 | F | °/s |
| | Maximum Velocity | 12000.0 | F | °/s |
| | Manual Velocity (Fast) | 600.0 | F | °/s |
| | Manual Velocity (Slow) | 100.0 | F | °/s |
| | Calibration Velocity (towards plc cam) | 30.0 | F | °/s |
| | Calibration Velocity (off plc cam) | 30.0 | F | °/s |
| | Jog Increment (Forward) | 5.0 | F | ° |
| | Jog Increment (Backward) | 5.0 | F | ° |
| + | Dynamics: | | | |
| + | Limit Switches: | | | |
| + | Monitoring: | | | |
| + | Setpoint Generator: | | | |
| + | NCI Parameter: | | | |
| + | Other Settings: | | | |

Fig. 131: Adjusting the reference velocity

The *reference velocity* matches the *maximum permitted velocity*.
Below that separate values for the maximum and minimum velocity for manual NC mode can be set.

### 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’.



| | Parameter | Offline Value | Online Value | Unit |
|---|---|---|---|---|
| - | Time Compensation Mode En... | 'ON (with velocity)' | | |
| | IO Time is absolute | FALSE | | |
| | Encoder Delay in Cycles | 4 | | |
| | Additional Encoder Delay | 0 | | µs |

Fig. 132: Dead time compensation parameter

### Setting the encoder mask

The maximum values for the encoder mask can be set in the *Parameter* tab for the *Axis1_ENC* encoder settings. The EL72x1 provides a maximum of 32 bits for the encoder.
The parameter Encoder Mask (maximum encoder value) can be used to set the maximum number of available bits. By default this is set to 0xFFFF FFFF, which corresponds to 32 bits (20 single-turn bits and 12 multi-turn bits). The calculation is based on the following equation.

$$GM_{max} = 2^{Singleturn\,Bits+Multiturn\,Bits} - 1 = 2^{20+12} - 1 = 4\,294\,967\,295 => 0x\ FFFF\ FFFF$$

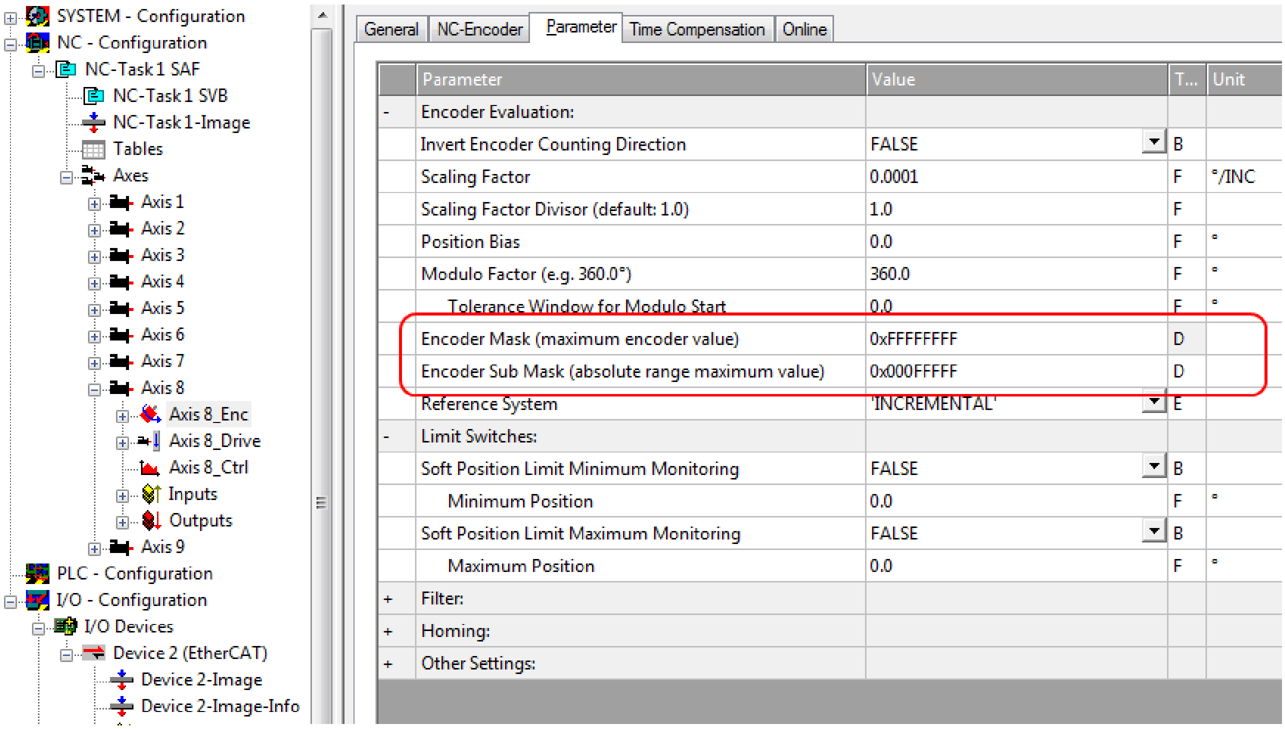
The parameter Encoder Sub Mask (absolute range maximum value) indicates how many bits of the maximum encoder value are single-turn bits. The default setting is 20 (and therefore 12 multi-turn bits). The calculation is based on the following equation.

$$GM_{ST} = 2^{Singleturn\,Bits} - 1 = 2^{20} - 1 = 1\,048\,575 => 0x\ 000F\ FFFF$$

Further calculation example with 13 single-turn bits and 8 multi-turn bits.

$$GM_{max} = 2^{Singleturn\,Bits+Multiturn\,Bits} - 1 = 2^{13+8} - 1 = 2\,097\,151 => 0x\ 001F\ FFFF$$

$$GM_{ST} = 2^{Singleturn\,Bits} - 1 = 2^{13} - 1 = 8\,191 => 0x\ 0000\ 1FFF$$



| | Parameter | Value | T... | Unit |
|---|---|---|---|---|
| - | Encoder Evaluation: | | | |
| | Invert Encoder Counting Direction | FALSE | B | |
| | Scaling Factor | 0.0001 | F | °/INC |
| | Scaling Factor Divisor (default: 1.0) | 1.0 | F | |
| | Position Bias | 0.0 | F | ° |
| | Modulo Factor (e.g. 360.0°) | 360.0 | F | ° |
| | Tolerance Window for Modulo Start | 0.0 | F | ° |
| | Encoder Mask (maximum encoder value) | 0xFFFFFFFF | D | |
| | Encoder Sub Mask (absolute range maximum value) | 0x000FFFFF | D | |
| | Reference System | 'INCREMENTAL' | E | |
| - | Limit Switches: | | | |
| | Soft Position Limit Minimum Monitoring | FALSE | B | |
| | Minimum Position | 0.0 | F | ° |
| | Soft Position Limit Maximum Monitoring | FALSE | B | |
| | Maximum Position | 0.0 | F | ° |
| + | Filter: | | | |
| + | Homing: | | | |
| + | Other Settings: | | | |

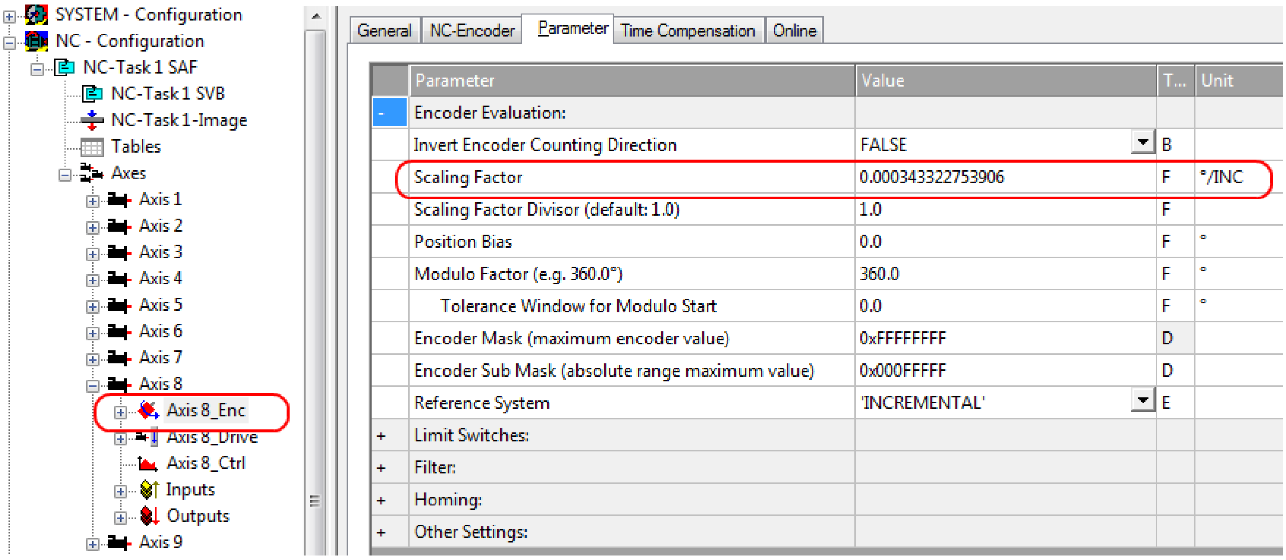
Fig. 133: Setting the encoder mask

### Scaling factor

The scaling factor can be changed by selecting "Axis 1_Enc" and tab "Parameter" in the NC (see *Setting the Scaling Factor*). The value can be calculated with the formulas specified below. The calculation is based on the assumption that one revolution corresponds to 360°.
The number of single-turn bits is taken into account in the calculation of the scaling factor. As indicated above, the default setting for the EL72x1 is 20 single-turn bits. This value is also used for calculating the scaling factor. If the single-turn bit value is changed, the scaling factor must be adjusted.

### Calculation of the scaling factor:

$$SF = \frac{distance\ per\ round}{2^{Singleturn\ Bits}} = \frac{360^{\circ}}{2^{20}} = 0{,}000343322753906\ {}^{\circ}/_{INC}$$

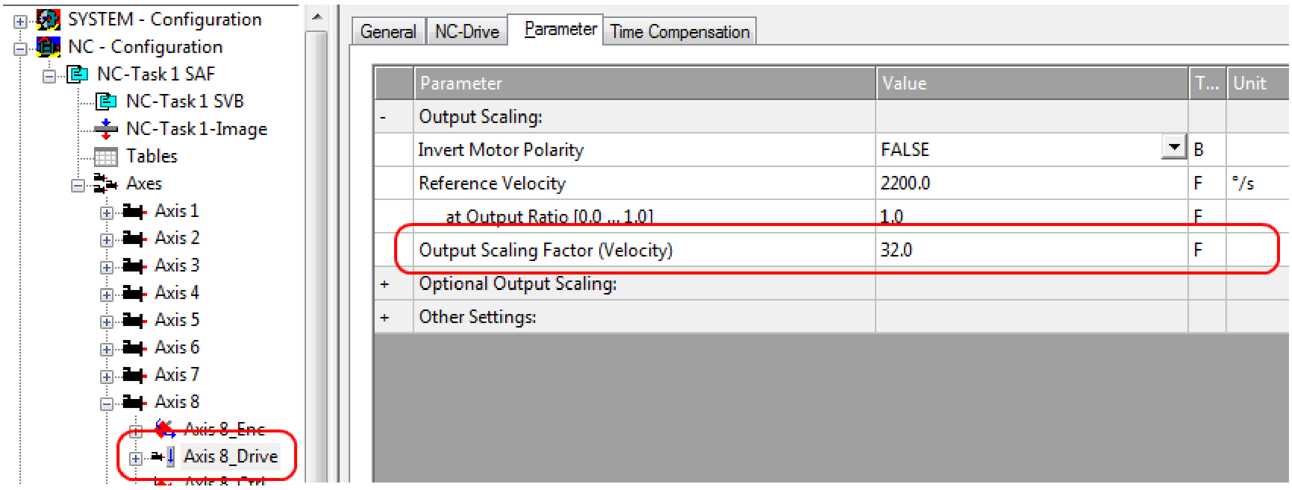


| | Parameter | Value | T... | Unit |
|---|---|---|---|---|
| - | Encoder Evaluation: | | | |
| | Invert Encoder Counting Direction | FALSE | B | |
| | Scaling Factor | 0.000343322753906 | F | °/INC |
| | Scaling Factor Divisor (default: 1.0) | 1.0 | F | |
| | Position Bias | 0.0 | F | ° |
| | Modulo Factor (e.g. 360.0°) | 360.0 | F | ° |
| | Tolerance Window for Modulo Start | 0.0 | F | ° |
| | Encoder Mask (maximum encoder value) | 0xFFFFFFFF | D | |
| | Encoder Sub Mask (absolute range maximum value) | 0x000FFFFF | D | |
| | Reference System | 'INCREMENTAL' | E | |
| + | Limit Switches: | | | |
| + | Filter: | | | |
| + | Homing: | | | |
| + | Other Settings: | | | |

Fig. 134: Setting the Scaling Factor

### Scaling output

Enter the value 32 in the *Parameter* tab for the drive settings under *Output Scaling Factor (Velocity)*.



| | Parameter | Value | T... | Unit |
|---|---|---|---|---|
| - | Output Scaling: | | | |
| | Invert Motor Polarity | FALSE | B | |
| | Reference Velocity | 2200.0 | F | °/s |
| | at Output Ratio [0.0 ... 1.0] | 1.0 | F | |
| | Output Scaling Factor (Velocity) | 32.0 | F | |
| + | Optional Output Scaling: | | | |
| + | Other Settings: | | | |

Fig. 135: Output scaling

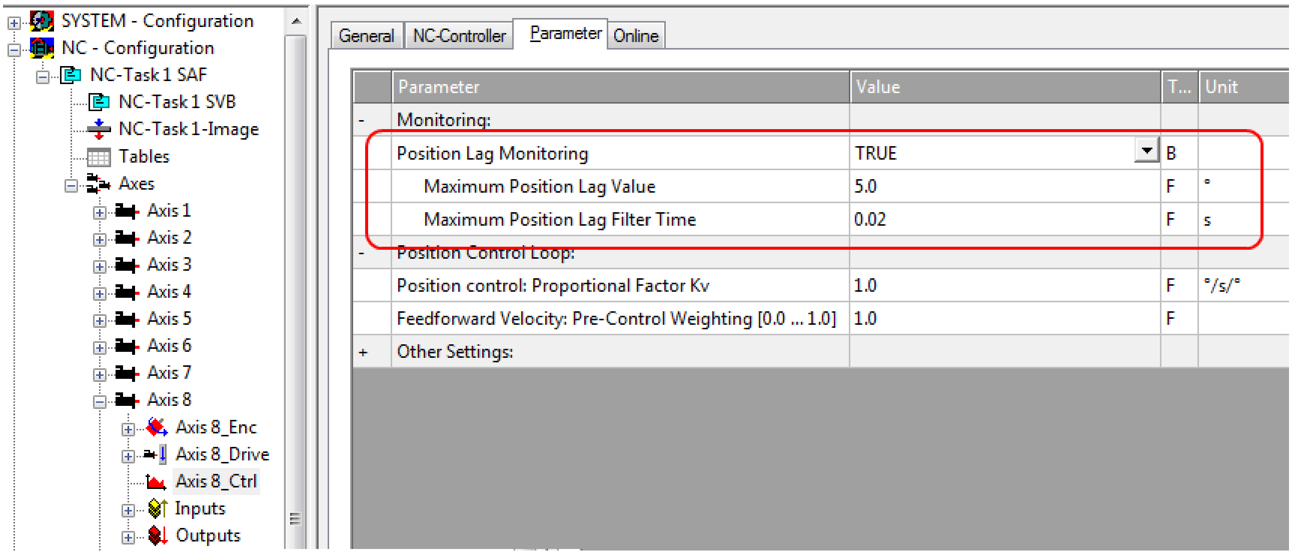
### Position lag monitoring

The position lag monitoring function checks whether the current position lag of an axis has exceeded the limit value. The position lag is the difference between the set value (control value) and the actual value reported back. If the terminal parameters are set inadequately, the position lag monitoring function may report an error when the axis is moved. During commissioning it may therefore be advisable to increase the limits of the *Position lag monitoring* slightly.

**NOTICE**

**Damage to equipment, machines and peripheral components possible!**

Setting the position lag monitoring parameters too high may result in damage to equipment, machines and peripheral components.

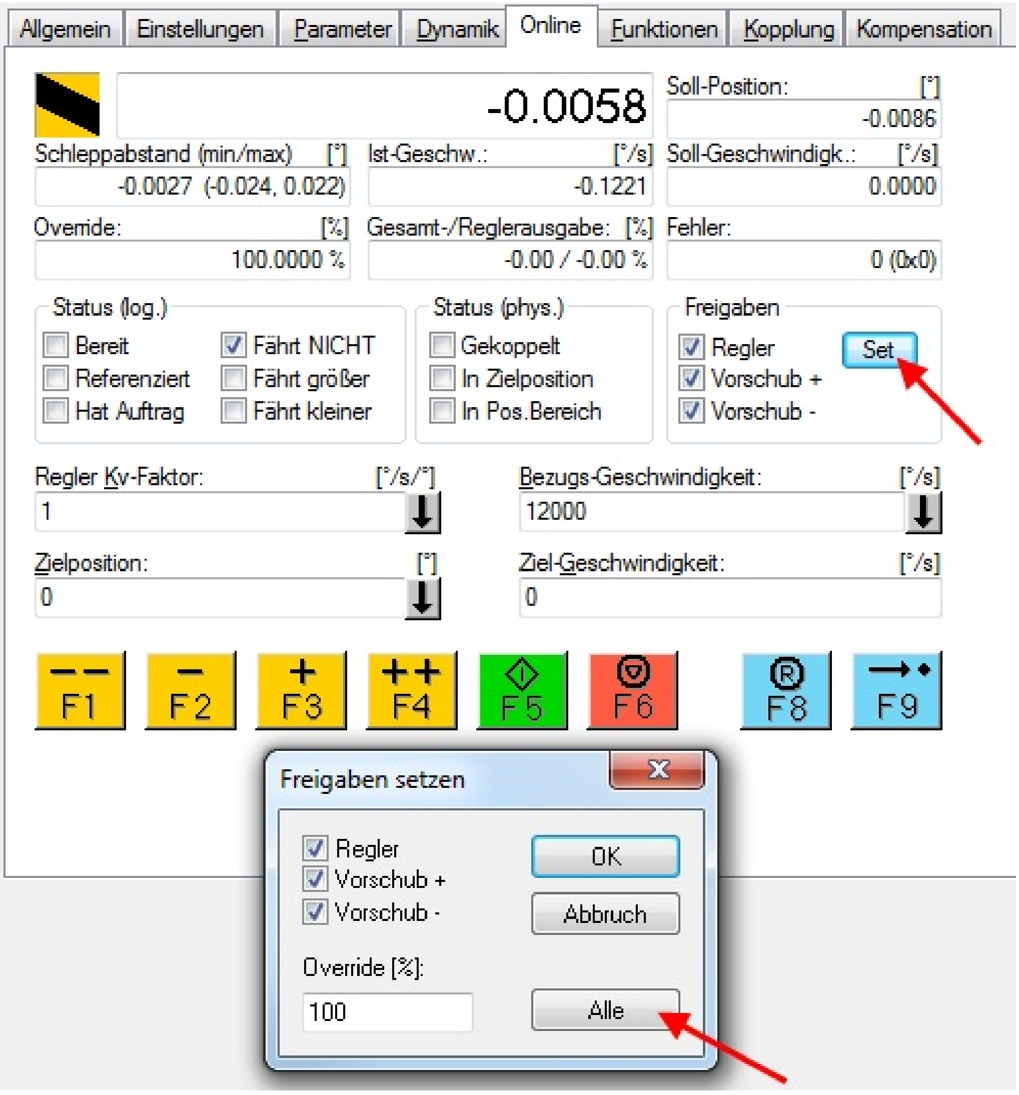


| | Parameter | Value | T... | Unit |
|---|---|---|---|---|
| - | Monitoring: | | | |
| | Position Lag Monitoring | TRUE | B | |
| | Maximum Position Lag Value | 5.0 | F | ° |
| | Maximum Position Lag Filter Time | 0.02 | F | s |
| - | Position Control Loop: | | | |
| | Position control: Proportional Factor Kv | 1.0 | F | °/s/° |
| | Feedforward Velocity: Pre-Control Weighting [0.0 ... 1.0] | 1.0 | F | |
| + | Other Settings: | | | |

Fig. 136: Lag monitoring

## Commissioning the motor with the NC

- Once the parameters are set, the motor is basically ready for operation. Individual further parameters have to be adapted to the respective application.
- To commission the axis, activate the configuration (Ctrl+Shift+F4), select the axis, select tab Online and enable the axis under Set.
- Set all tick marks and set Override to 100% (see Fig. *Enabling an axis*). The axis can then be moved.



-0.0058

Soll-Position: [°] -0.0086

Schleppabstand (min/max) [°] -0.0027 (-0.024, 0.022)

Ist-Geschw.: [°/s] -0.1221

Soll-Geschwindigk.: [°/s] 0.0000

Override: [%] 100.0000 %

Gesamt-/Reglerausgabe: [%] -0.00 / -0.00 %

Fehler: 0 (0x0)

Status (log.)
□ Bereit ☑ Fährt NICHT
□ Referenziert □ Fährt größer
□ Hat Auftrag □ Fährt kleiner

Status (phys.)
□ Gekoppelt
□ In Zielposition
□ In Pos.Bereich

Freigaben
☑ Regler
☑ Vorschub +
☑ Vorschub -

Regler Kv-Faktor: [°/s/°] 1

Bezugs-Geschwindigkeit: [°/s] 12000

Zielposition: [°] 0

Ziel-Geschwindigkeit: [°/s] 0

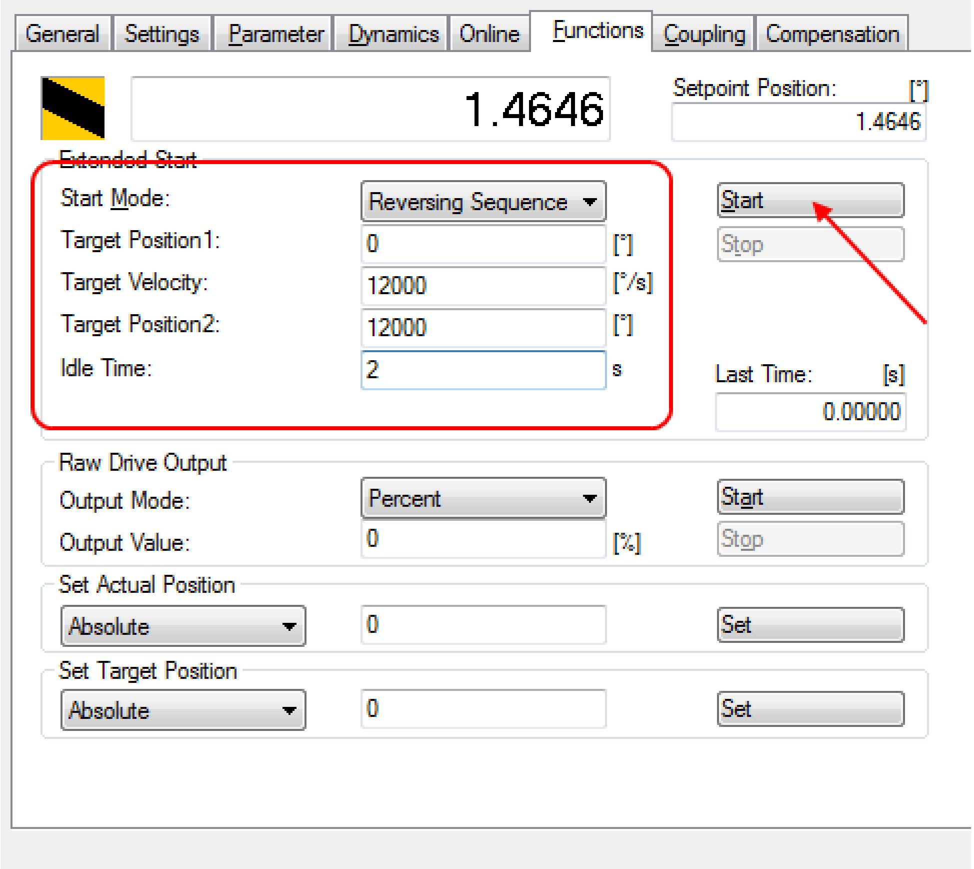
Freigaben setzen
☑ Regler
☑ Vorschub +
☑ Vorschub -
Override [%]: 100

Fig. 137: Enabling an axis

You can now move the axis with the function keys F1, F2 (Backward) or F3, F4 (Forward).
You can adjust the Kv factor in order to approach a suitable factor. Set the value to 0 initially in order to set the correct reference velocity. For calculating the reference velocity please refer to section "Selecting the maximum velocity [▶ 118]". The calculation provides a relatively precise value, although the value may have to be corrected slightly. To this end move the motor with a Kv factor of 0 until the actual velocity matches the setpoint velocity.

Alternatively you can control the axis via the Functions tab. An example is provided below.

- Select as Reversing Sequence as the start type.
- Enter the required *Target Position2*, e.g. 12000°.
- Enter the required Target Velocity, e.g. 12000°/s.
- Enter the required Target Position1, e.g. 0°.
- Enter the required *Idle Time*, e.g. 2 s.
- Select Start.



1.4646

Setpoint Position: [°] 1.4646

Extended Start

Start Mode: Reversing Sequence

Target Position1: 0 [°]

Target Velocity: 12000 [°/s]

Target Position2: 12000 [°]

Idle Time: 2 s

Last Time: [s] 0.00000

Raw Drive Output

Output Mode: Percent

Output Value: 0 [%]

Set Actual Position

Absolute 0

Set Target Position

Absolute 0

Fig. 138: Reversing Sequence

The motor now turns to position 2, remains there for 2 seconds and returns to position 1. This is repeated until Stop is pressed.

# 5.3 Operating modes

## 5.3.1 Overview

Operating modes CST, CSTCA, CSV and CSP are supported. The operating mode is set in the CoE list in index 0x7010:03 [▸ 152] Modes of operation (MDP) or index 0x6060:0 [▸ 167] Modes of operation (DS402). In the respective process data the user can additionally select the respective *Predefined PDO Assignment*. All required variables are then in the process data.

**CSV [▸ 125] - cyclic synchronous velocity (velocity control)**

In CSV mode the EL72x1-xxxx operates with the cyclic velocity interface. A defined velocity can be set via the *Target velocity* variable.

**CST [▸ 128] - cyclic synchronous torque (torque control)**

In CST mode the EL72x1-xxxx operates in the cyclic torque interface. A defined torque can be set via the *Target torque* variable.

**CSTCA [▸ 131] - cyclic synchronous torque with commutation angle (torque control with commutation angle)**

This operating mode is also intended for use with the cyclic torque interface. In addition the user can specify the commutation angle. The variable *Commutation angle* can be used to set an angle which is to be maintained with a defined torque set in variable *Target torque*.

**CSP [▸ 134] - cyclic synchronous position (position control)**

In the CSP operating mode the EL72x1-xxxx operates in the cyclic position interface. A defined position can be set via the *Target position* variable.

For further information on the three operating modes described above please refer to section “Commissioning without NC”.

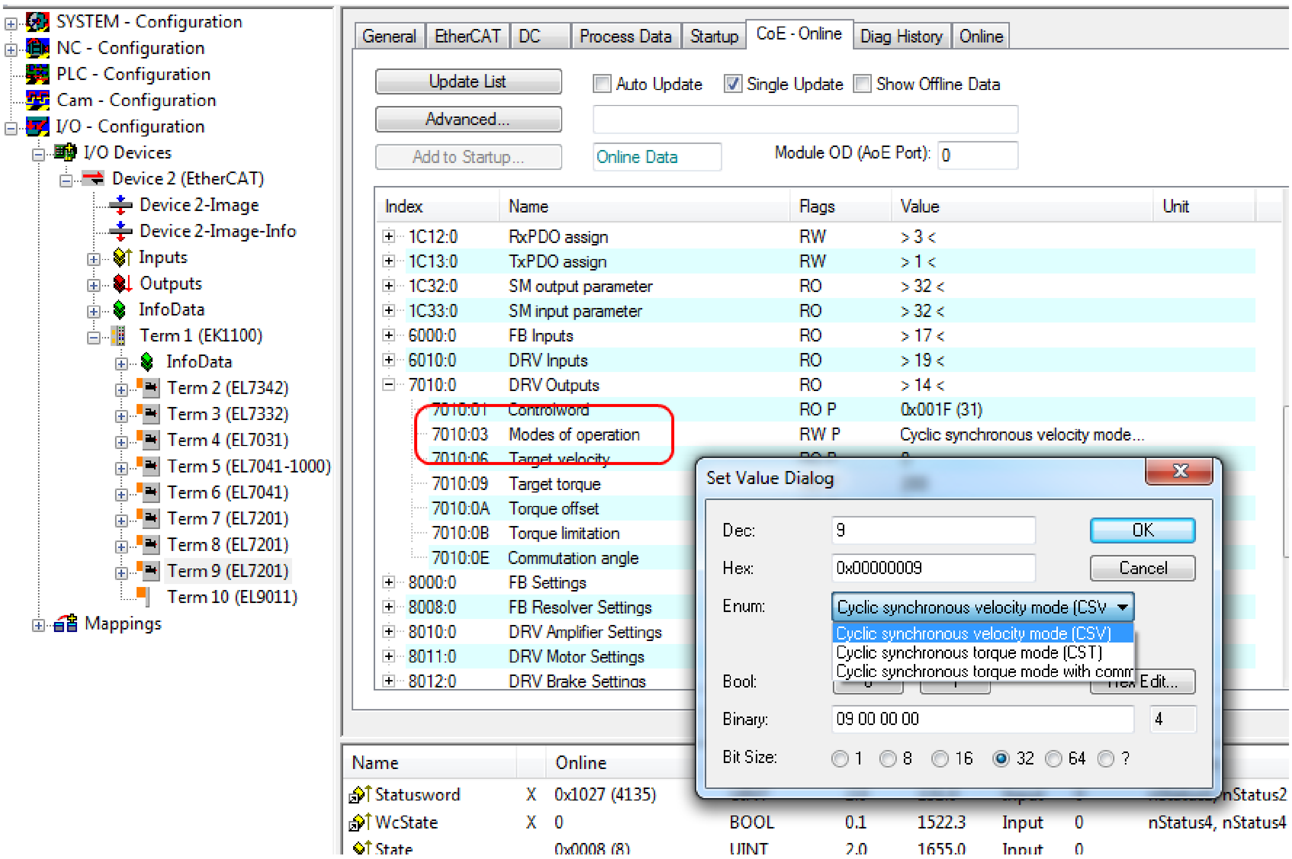
## 5.3.2 CSV

### CSV - cyclic synchronous velocity (velocity control)

In CSV mode the EL72x1-xxxx operates with the cyclic velocity interface. A defined velocity can be set via the *Target velocity* variable.

### Step-by-Step

- Add the terminal to the configuration as described in the chapter TwinCAT configuration settings [▶ 71] - manual or - Online scan [▶ 76].
- Link the terminal with the NC as described in the chapter Integration in the NC configuration [▶ 94].
- Import the motor XML file into the Startup directory as described in the chapter Settings in the CoE [▶ 102].
- Set the mode of operation in the CoE directory to *Cyclic synchronous velocity mode (CSV), Fig. Selection of the mode of operation*.



☐ Auto Update ☑ Single Update ☐ Show Offline Data

Module OD (AoE Port): 0

| Index | Name | Flags | Value | Unit |
|---|---|---|---|---|
| 1C12:0 | RxPDO assign | RW | > 3 < | |
| 1C13:0 | TxPDO assign | RW | > 1 < | |
| 1C32:0 | SM output parameter | RO | > 32 < | |
| 1C33:0 | SM input parameter | RO | > 32 < | |
| 6000:0 | FB Inputs | RO | > 17 < | |
| 6010:0 | DRV Inputs | RO | > 19 < | |
| 7010:0 | DRV Outputs | RO | > 14 < | |
| 7010:01 | Controlword | RO P | 0x001F (31) | |
| 7010:03 | Modes of operation | RW P | Cyclic synchronous velocity mode... | |
| 7010:06 | Target velocity | RO P | 0 | |
| 7010:09 | Target torque | | | |
| 7010:0A | Torque offset | | | |
| 7010:0B | Torque limitation | | | |
| 7010:0E | Commutation angle | | | |
| 8000:0 | FB Settings | | | |
| 8008:0 | FB Resolver Settings | | | |
| 8010:0 | DRV Amplifier Settings | | | |
| 8011:0 | DRV Motor Settings | | | |
| 8012:0 | DRV Brake Settings | | | |

Set Value Dialog

Dec: 9

Hex: 0x00000009

Enum: Cyclic synchronous velocity mode (CSV

- Cyclic synchronous velocity mode (CSV)
- Cyclic synchronous torque mode (CST)
- Cyclic synchronous torque mode with comm

Bool:

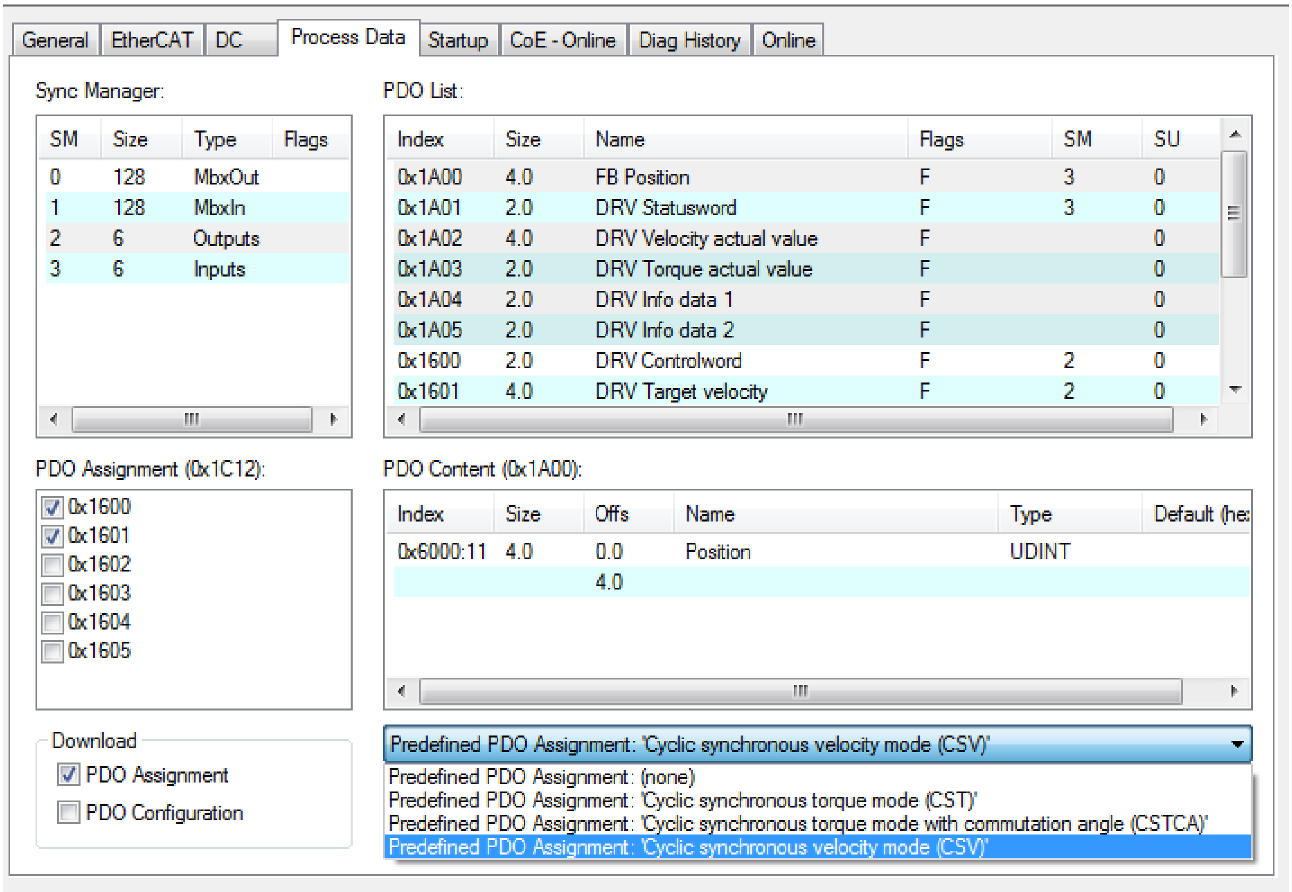
Binary: 09 00 00 00 | 4

Bit Size: ○ 1 ○ 8 ○ 16 ● 32 ○ 64 ○ ?

| Name | | Online | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Statusword | X | 0x1027 (4135) | | | | | | nStatus2 |
| WcState | X | 0 | BOOL | 0.1 | 1522.3 | Input | 0 | nStatus4, nStatus4 |
| State | | 0x0008 (8) | UINT | 2.0 | 1655.0 | Input | 0 | |

Fig. 139: Selection of the mode of operation

- Under Predefined PDO assignment, also select *Cyclic synchronous velocity mode (CSV)*, Fig. *Selecting a predefined PDO assignment*.



Sync Manager:

| SM | Size | Type | Flags |
|---|---|---|---|
| 0 | 128 | MbxOut | |
| 1 | 128 | MbxIn | |
| 2 | 6 | Outputs | |
| 3 | 6 | Inputs | |

PDO List:

| Index | Size | Name | Flags | SM | SU |
|---|---|---|---|---|---|
| 0x1A00 | 4.0 | FB Position | F | 3 | 0 |
| 0x1A01 | 2.0 | DRV Statusword | F | 3 | 0 |
| 0x1A02 | 4.0 | DRV Velocity actual value | F | | 0 |
| 0x1A03 | 2.0 | DRV Torque actual value | F | | 0 |
| 0x1A04 | 2.0 | DRV Info data 1 | F | | 0 |
| 0x1A05 | 2.0 | DRV Info data 2 | F | | 0 |
| 0x1600 | 2.0 | DRV Controlword | F | 2 | 0 |
| 0x1601 | 4.0 | DRV Target velocity | F | 2 | 0 |

PDO Assignment (0x1C12):

- ☑ 0x1600
- ☑ 0x1601
- □ 0x1602
- □ 0x1603
- □ 0x1604
- □ 0x1605

PDO Content (0x1A00):

| Index | Size | Offs | Name | Type | Default (he: |
|---|---|---|---|---|---|
| 0x6000:11 | 4.0 | 0.0 | Position | UDINT | |
| | | 4.0 | | | |

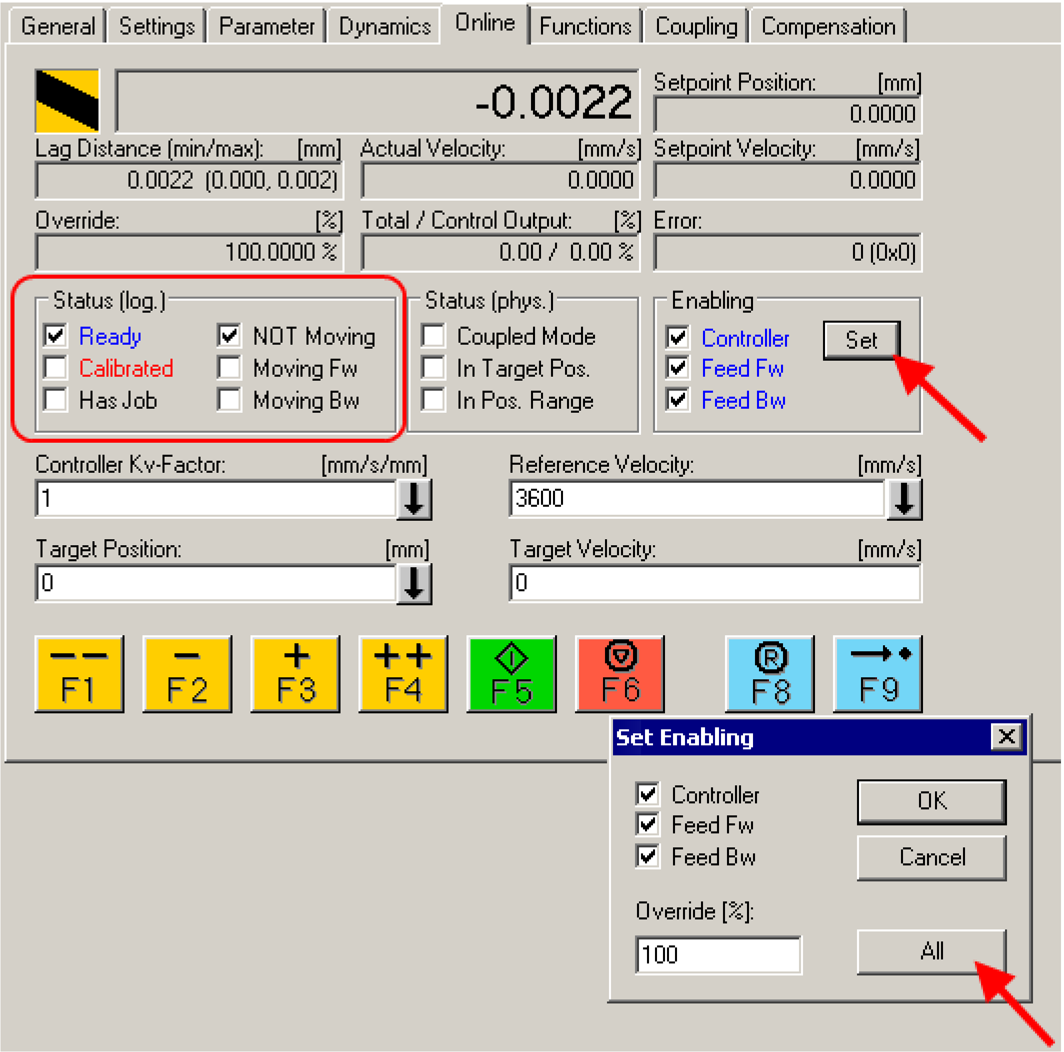
Download
- ☑ PDO Assignment
- □ PDO Configuration

Predefined PDO Assignment: 'Cyclic synchronous velocity mode (CSV)'

- Predefined PDO Assignment: (none)
- Predefined PDO Assignment: 'Cyclic synchronous torque mode (CST)'
- Predefined PDO Assignment: 'Cyclic synchronous torque mode with commutation angle (CSTCA)'
- Predefined PDO Assignment: 'Cyclic synchronous velocity mode (CSV)'

Fig. 140: Selecting a predefined PDO assignment

- Activate the configuration (Ctrl+Shift+F4).
- Run through the State Machine of the terminal. There are two ways to do this:
    - If you use the TwinCAT NC.
      The State Machine is run through automatically by the NC. You can enable the axis in the *Online* tab of the axis.
      Set all tick marks and set *Override* to 100% (see Fig. *Set enables*). The axis can then be moved.



-0.0022

Setpoint Position: [mm] 0.0000

Lag Distance (min/max): [mm] 0.0022 (0.000, 0.002)

Actual Velocity: [mm/s] 0.0000

Setpoint Velocity: [mm/s] 0.0000

Override: [%] 100.0000 %

Total / Control Output: [%] 0.00 / 0.00 %

Error: 0 (0x0)

Status (log.)
☑ Ready ☑ NOT Moving
☐ Calibrated ☐ Moving Fw
☐ Has Job ☐ Moving Bw

Status (phys.)
☐ Coupled Mode
☐ In Target Pos.
☐ In Pos. Range

Enabling
☑ Controller Set
☑ Feed Fw
☑ Feed Bw

Controller Kv-Factor: [mm/s/mm] 1

Reference Velocity: [mm/s] 3600

Target Position: [mm] 0

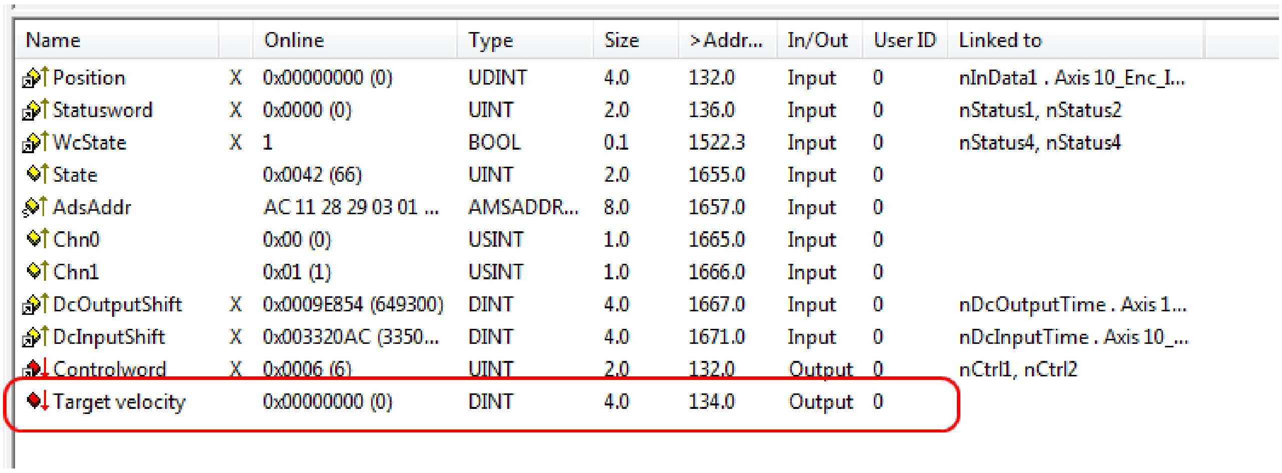
Target Velocity: [mm/s] 0

Set Enabling
☑ Controller OK
☑ Feed Fw Cancel
☑ Feed Bw
Override [%]: 100 All

Fig. 141: Set enables

- ◦ If you don’t use the TwinCAT NC.
  In this case you must run through the State Machine manually. To do this, follow the instructions in the chapter Commissioning without the NC [▶ 111].

- The cyclic variable *Target velocity* (Fig. *Torque specification*) can be used to specify a defined velocity. The value in the index 0x9010:14 (0x6090:0, DS402)*Velocity encoder resolution* corresponds to 1 rpm.



| Name | | Online | Type | Size | >Addr... | In/Out | User ID | Linked to |
|---|---|---|---|---|---|---|---|---|
| Position | X | 0x00000000 (0) | UDINT | 4.0 | 132.0 | Input | 0 | nInData1 . Axis 10_Enc_I... |
| Statusword | X | 0x0000 (0) | UINT | 2.0 | 136.0 | Input | 0 | nStatus1, nStatus2 |
| WcState | X | 1 | BOOL | 0.1 | 1522.3 | Input | 0 | nStatus4, nStatus4 |
| State | | 0x0042 (66) | UINT | 2.0 | 1655.0 | Input | 0 | |
| AdsAddr | | AC 11 28 29 03 01 ... | AMSADDR... | 8.0 | 1657.0 | Input | 0 | |
| Chn0 | | 0x00 (0) | USINT | 1.0 | 1665.0 | Input | 0 | |
| Chn1 | | 0x01 (1) | USINT | 1.0 | 1666.0 | Input | 0 | |
| DcOutputShift | X | 0x0009E854 (649300) | DINT | 4.0 | 1667.0 | Input | 0 | nDcOutputTime . Axis 1... |
| DcInputShift | X | 0x003320AC (3350... | DINT | 4.0 | 1671.0 | Input | 0 | nDcInputTime . Axis 10_... |
| Controlword | X | 0x0006 (6) | UINT | 2.0 | 132.0 | Output | 0 | nCtrl1, nCtrl2 |
| Target velocity | | 0x00000000 (0) | DINT | 4.0 | 134.0 | Output | 0 | |

Fig. 142: Torque specification

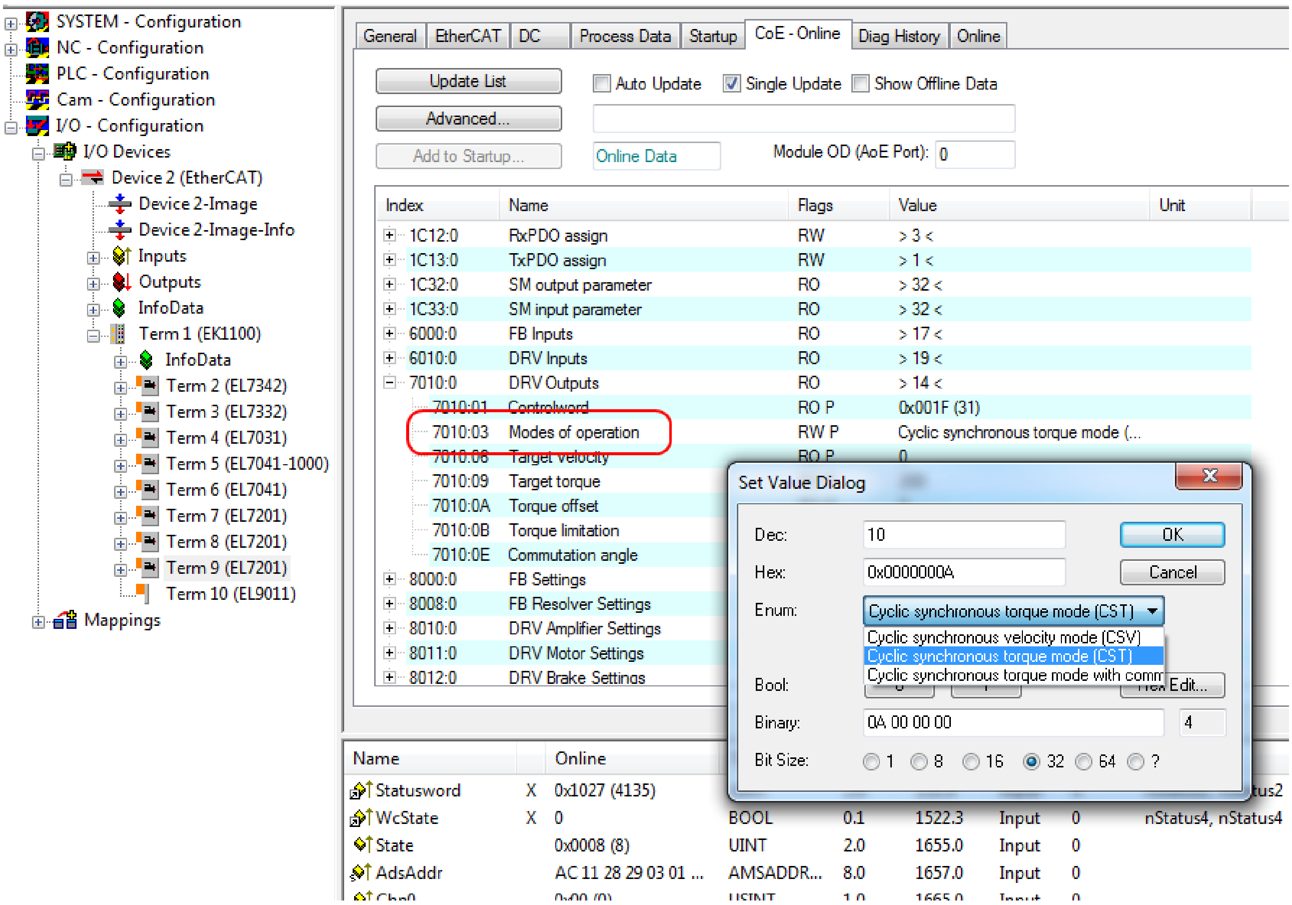
## 5.3.3 CST

### CST - cyclic synchronous torque (torque control)

In CST mode the EL72x1-xxxx operates in the cyclic torque interface. A defined torque can be set via the *Target torque* variable.

### Step-by-Step

- Add the terminal to the configuration as described in the chapter TwinCAT configuration settings [▶ 71] - manual or - Online scan [▶ 76].
- Link the terminal with the NC as described in the chapter Integration in the NC configuration [▶ 94].
- Import the motor XML file into the Startup directory as described in the chapter Settings in the CoE [▶ 102].
- Set the mode of operation in the CoE directory to *Cyclic synchronous torque mode (CST)*, Fig. *Selection of the mode of operation*.



☐ Auto Update ☑ Single Update ☐ Show Offline Data

Module OD (AoE Port): 0

| Index | Name | Flags | Value | Unit |
|---|---|---|---|---|
| 1C12:0 | RxPDO assign | RW | > 3 < | |
| 1C13:0 | TxPDO assign | RW | > 1 < | |
| 1C32:0 | SM output parameter | RO | > 32 < | |
| 1C33:0 | SM input parameter | RO | > 32 < | |
| 6000:0 | FB Inputs | RO | > 17 < | |
| 6010:0 | DRV Inputs | RO | > 19 < | |
| 7010:0 | DRV Outputs | RO | > 14 < | |
| 7010:01 | Controlword | RO P | 0x001F (31) | |
| 7010:03 | Modes of operation | RW P | Cyclic synchronous torque mode (... | |
| 7010:06 | Target velocity | RO P | 0 | |
| 7010:09 | Target torque | | | |
| 7010:0A | Torque offset | | | |
| 7010:0B | Torque limitation | | | |
| 7010:0E | Commutation angle | | | |
| 8000:0 | FB Settings | | | |
| 8008:0 | FB Resolver Settings | | | |
| 8010:0 | DRV Amplifier Settings | | | |
| 8011:0 | DRV Motor Settings | | | |
| 8012:0 | DRV Brake Settings | | | |

Set Value Dialog

Dec: 10

Hex: 0x0000000A

Enum: Cyclic synchronous torque mode (CST)

- Cyclic synchronous velocity mode (CSV)
- Cyclic synchronous torque mode (CST)
- Cyclic synchronous torque mode with comm

Bool:

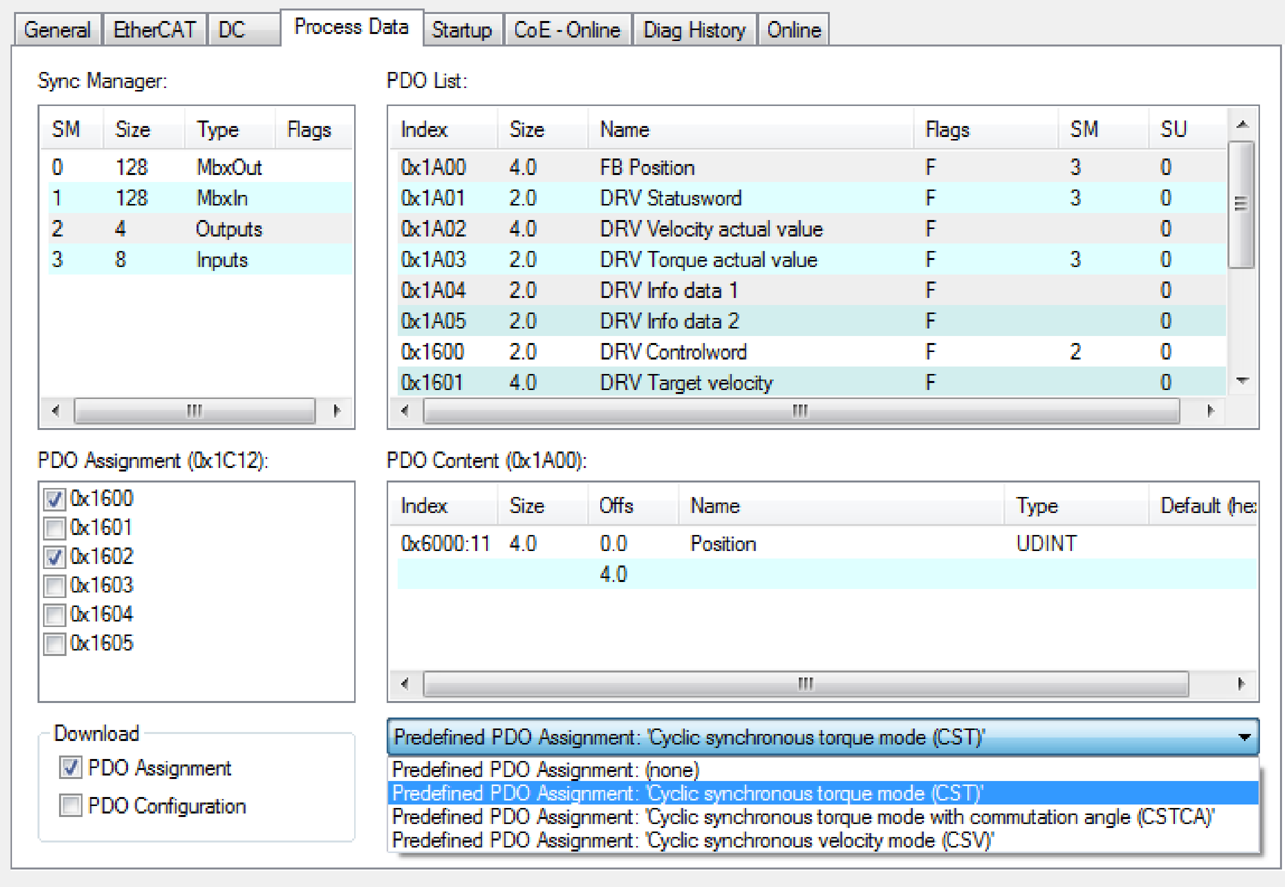
Binary: 0A 00 00 00 4

Bit Size: ○ 1 ○ 8 ○ 16 ● 32 ○ 64 ○ ?

| Name | Online | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | | | | | | tus2 |
| Statusword | X | 0x1027 (4135) | | | | | | |
| WcState | X | 0 | BOOL | 0.1 | 1522.3 | Input | 0 | nStatus4, nStatus4 |
| State | | 0x0008 (8) | UINT | 2.0 | 1655.0 | Input | 0 | |
| AdsAddr | | AC 11 28 29 03 01 ... | AMSADDR... | 8.0 | 1657.0 | Input | 0 | |
| Chn0 | | 0x00 (0) | USINT | 1.0 | 1665.0 | Input | 0 | |

Fig. 143: Selection of the mode of operation

- Under Predefined PDO assignment, also select *Cyclic synchronous torque mode (CST)*, Fig. *Selecting a predefined PDO assignment*.



Sync Manager:

| SM | Size | Type | Flags |
|---|---|---|---|
| 0 | 128 | MbxOut | |
| 1 | 128 | MbxIn | |
| 2 | 4 | Outputs | |
| 3 | 8 | Inputs | |

PDO List:

| Index | Size | Name | Flags | SM | SU |
|---|---|---|---|---|---|
| 0x1A00 | 4.0 | FB Position | F | 3 | 0 |
| 0x1A01 | 2.0 | DRV Statusword | F | 3 | 0 |
| 0x1A02 | 4.0 | DRV Velocity actual value | F | | 0 |
| 0x1A03 | 2.0 | DRV Torque actual value | F | 3 | 0 |
| 0x1A04 | 2.0 | DRV Info data 1 | F | | 0 |
| 0x1A05 | 2.0 | DRV Info data 2 | F | | 0 |
| 0x1600 | 2.0 | DRV Controlword | F | 2 | 0 |
| 0x1601 | 4.0 | DRV Target velocity | F | | 0 |

PDO Assignment (0x1C12):

☑ 0x1600
☐ 0x1601
☑ 0x1602
☐ 0x1603
☐ 0x1604
☐ 0x1605

PDO Content (0x1A00):

| Index | Size | Offs | Name | Type | Default (he: |
|---|---|---|---|---|---|
| 0x6000:11 | 4.0 | 0.0 | Position | UDINT | |
| | | 4.0 | | | |

Download

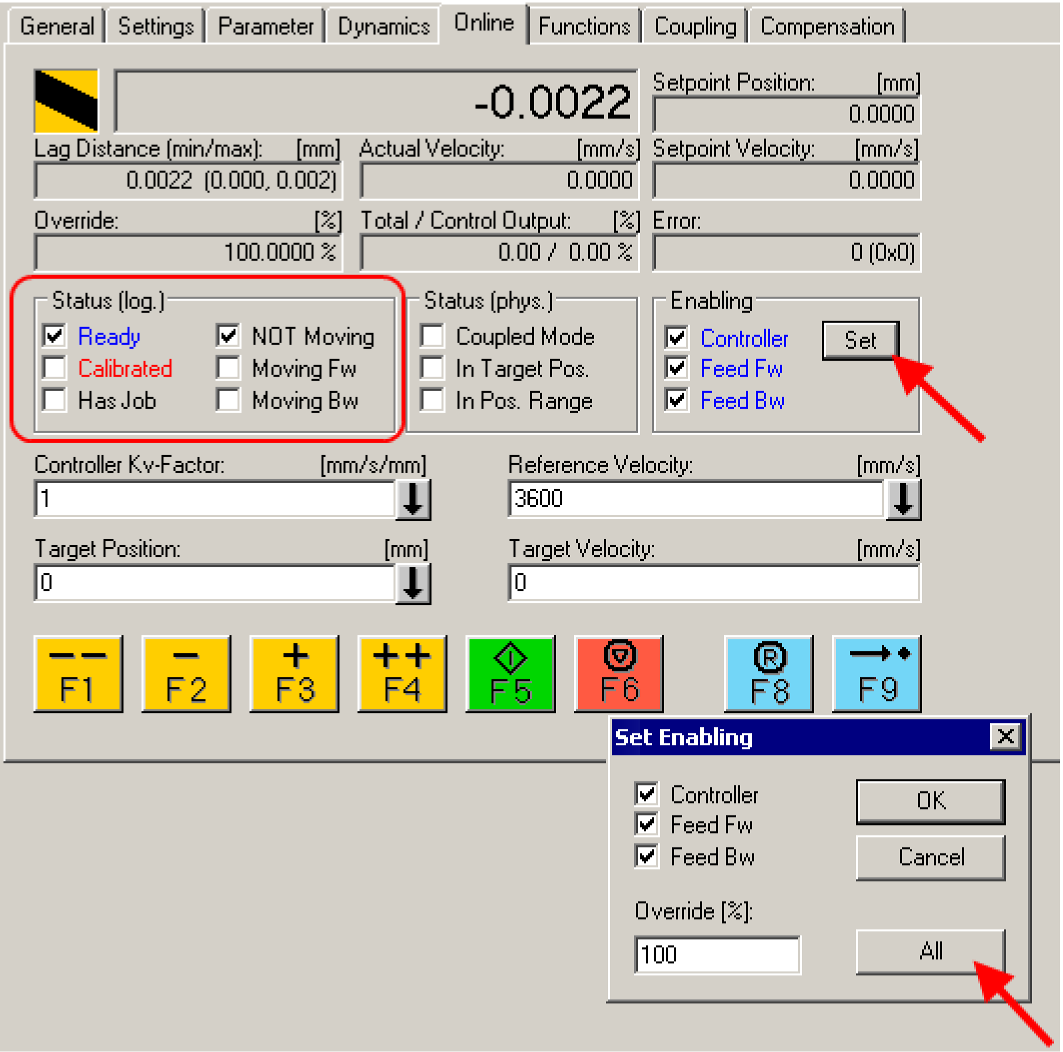
☑ PDO Assignment
☐ PDO Configuration

Predefined PDO Assignment: 'Cyclic synchronous torque mode (CST)'

Predefined PDO Assignment: (none)
Predefined PDO Assignment: 'Cyclic synchronous torque mode (CST)'
Predefined PDO Assignment: 'Cyclic synchronous torque mode with commutation angle (CSTCA)'
Predefined PDO Assignment: 'Cyclic synchronous velocity mode (CSV)'

Fig. 144: Selecting a predefined PDO assignment

- Activate the configuration (Ctrl+Shift+F4).
- Run through the State Machine of the terminal. There are two ways to do this:
  - If you use the TwinCAT NC.
    The State Machine is run through automatically by the NC. You can enable the axis in the *Online* tab of the axis.
    Set all tick marks and set *Override* to 100% (see Fig. *Set enables*). The axis can then be moved.



-0.0022

Setpoint Position: [mm] 0.0000

Lag Distance (min/max): [mm] 0.0022 (0.000, 0.002)

Actual Velocity: [mm/s] 0.0000

Setpoint Velocity: [mm/s] 0.0000

Override: [%] 100.0000 %

Total / Control Output: [%] 0.00 / 0.00 %

Error: 0 (0x0)

Status (log.)
☑ Ready ☑ NOT Moving
☐ Calibrated ☐ Moving Fw
☐ Has Job ☐ Moving Bw

Status (phys.)
☐ Coupled Mode
☐ In Target Pos.
☐ In Pos. Range

Enabling
☑ Controller
☑ Feed Fw
☑ Feed Bw

Controller Kv-Factor: [mm/s/mm] 1

Reference Velocity: [mm/s] 3600

Target Position: [mm] 0

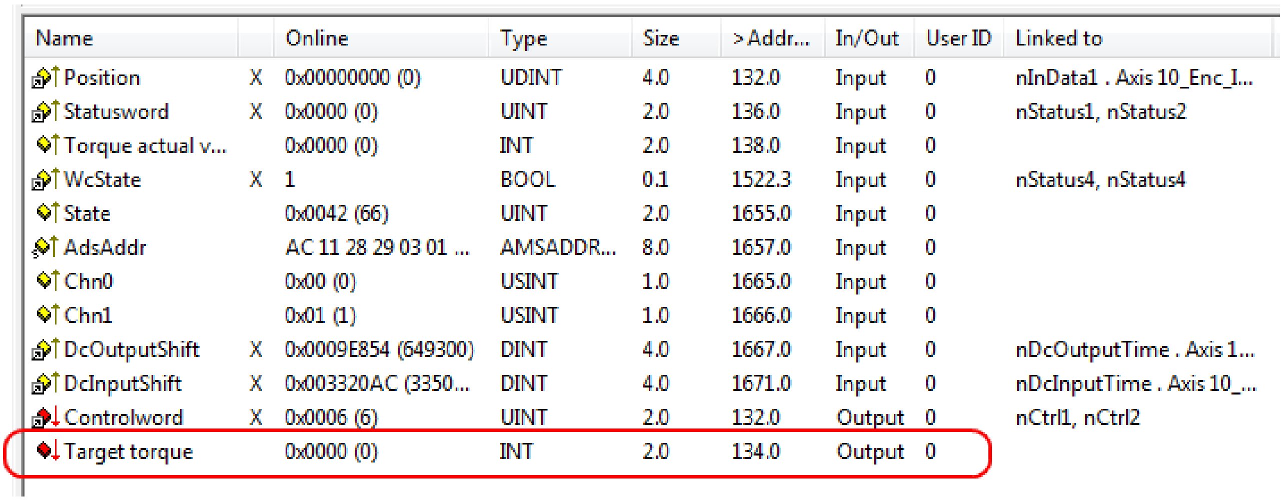
Target Velocity: [mm/s] 0

Set Enabling
☑ Controller
☑ Feed Fw
☑ Feed Bw
Override [%]: 100

Fig. 145: Set enables

- ◦ If you don't use the TwinCAT NC.
  In this case you must run through the State Machine manually. To do this, follow the instructions in the chapter Commissioning without the NC [▶ 111].

- The cyclic variable *Target torque* (Fig. *Torque specification*) can be used to specify a defined torque. The value is specified in 1000ths of the *rated current* and the torque is calculated according to the following equation, where the *rated current* refers to the value in the index 0x8011:12 (*rated current*).



| Name | | Online | Type | Size | >Addr... | In/Out | User ID | Linked to |
|---|---|---|---|---|---|---|---|---|
| Position | X | 0x00000000 (0) | UDINT | 4.0 | 132.0 | Input | 0 | nInData1 . Axis 10_Enc_I... |
| Statusword | X | 0x0000 (0) | UINT | 2.0 | 136.0 | Input | 0 | nStatus1, nStatus2 |
| Torque actual v... | | 0x0000 (0) | INT | 2.0 | 138.0 | Input | 0 | |
| WcState | X | 1 | BOOL | 0.1 | 1522.3 | Input | 0 | nStatus4, nStatus4 |
| State | | 0x0042 (66) | UINT | 2.0 | 1655.0 | Input | 0 | |
| AdsAddr | | AC 11 28 29 03 01 ... | AMSADDR... | 8.0 | 1657.0 | Input | 0 | |
| Chn0 | | 0x00 (0) | USINT | 1.0 | 1665.0 | Input | 0 | |
| Chn1 | | 0x01 (1) | USINT | 1.0 | 1666.0 | Input | 0 | |
| DcOutputShift | X | 0x0009E854 (649300) | DINT | 4.0 | 1667.0 | Input | 0 | nDcOutputTime . Axis 1... |
| DcInputShift | X | 0x003320AC (3350... | DINT | 4.0 | 1671.0 | Input | 0 | nDcInputTime . Axis 10_... |
| Controlword | X | 0x0006 (6) | UINT | 2.0 | 132.0 | Output | 0 | nCtrl1, nCtrl2 |
| Target torque | | 0x0000 (0) | INT | 2.0 | 134.0 | Output | 0 | |

Fig. 146: Torque specification

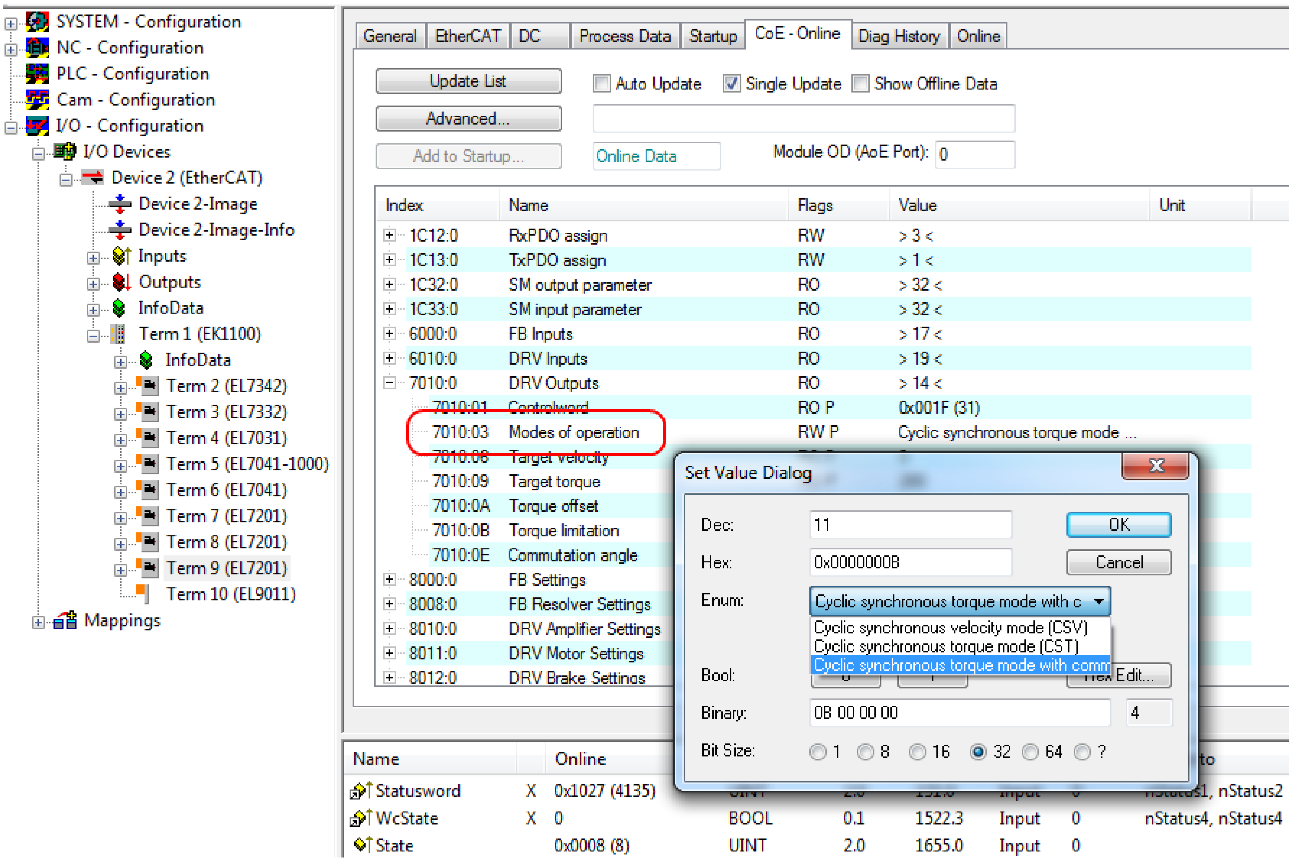
## 5.3.4 CSTCA

### CSTCA - cyclic synchronous torque with commutation angle (torque control with commutation angle)

This mode of operation is also intended for use with the cyclic torque interface. In addition the user can specify the commutation angle. The variable *Commutation angle* can be used to set an angle which is to be maintained with a defined torque set in variable *Target torque*.

### Step-by-Step

- Add the terminal to the configuration as described in the chapter TwinCAT configuration settings [▶ 71] - manual or - Online scan [▶ 76].
- Link the terminal with the NC as described in the chapter Integration in the NC configuration [▶ 94].
- Import the motor XML file into the Startup directory as described in the chapter Settings in the CoE [▶ 102].
- Set the mode of operation in the CoE directory to *Cyclic synchronous torque mode with commutation angle (CSTCA),* Fig. *Selection of the mode of operation*



□ Auto Update ☑ Single Update □ Show Offline Data

Module OD (AoE Port): 0

| Index | Name | Flags | Value | Unit |
|---|---|---|---|---|
| 1C12:0 | RxPDO assign | RW | > 3 < | |
| 1C13:0 | TxPDO assign | RW | > 1 < | |
| 1C32:0 | SM output parameter | RO | > 32 < | |
| 1C33:0 | SM input parameter | RO | > 32 < | |
| 6000:0 | FB Inputs | RO | > 17 < | |
| 6010:0 | DRV Inputs | RO | > 19 < | |
| 7010:0 | DRV Outputs | RO | > 14 < | |
| 7010:01 | Controlword | RO P | 0x001F (31) | |
| 7010:03 | Modes of operation | RW P | Cyclic synchronous torque mode ... | |
| 7010:06 | Target velocity | | | |
| 7010:09 | Target torque | | | |
| 7010:0A | Torque offset | | | |
| 7010:0B | Torque limitation | | | |
| 7010:0E | Commutation angle | | | |
| 8000:0 | FB Settings | | | |
| 8008:0 | FB Resolver Settings | | | |
| 8010:0 | DRV Amplifier Settings | | | |
| 8011:0 | DRV Motor Settings | | | |
| 8012:0 | DRV Brake Settings | | | |

Set Value Dialog

Dec: 11

Hex: 0x0000000B

Enum: Cyclic synchronous torque mode with c
- Cyclic synchronous velocity mode (CSV)
- Cyclic synchronous torque mode (CST)
- Cyclic synchronous torque mode with comm

Bool:

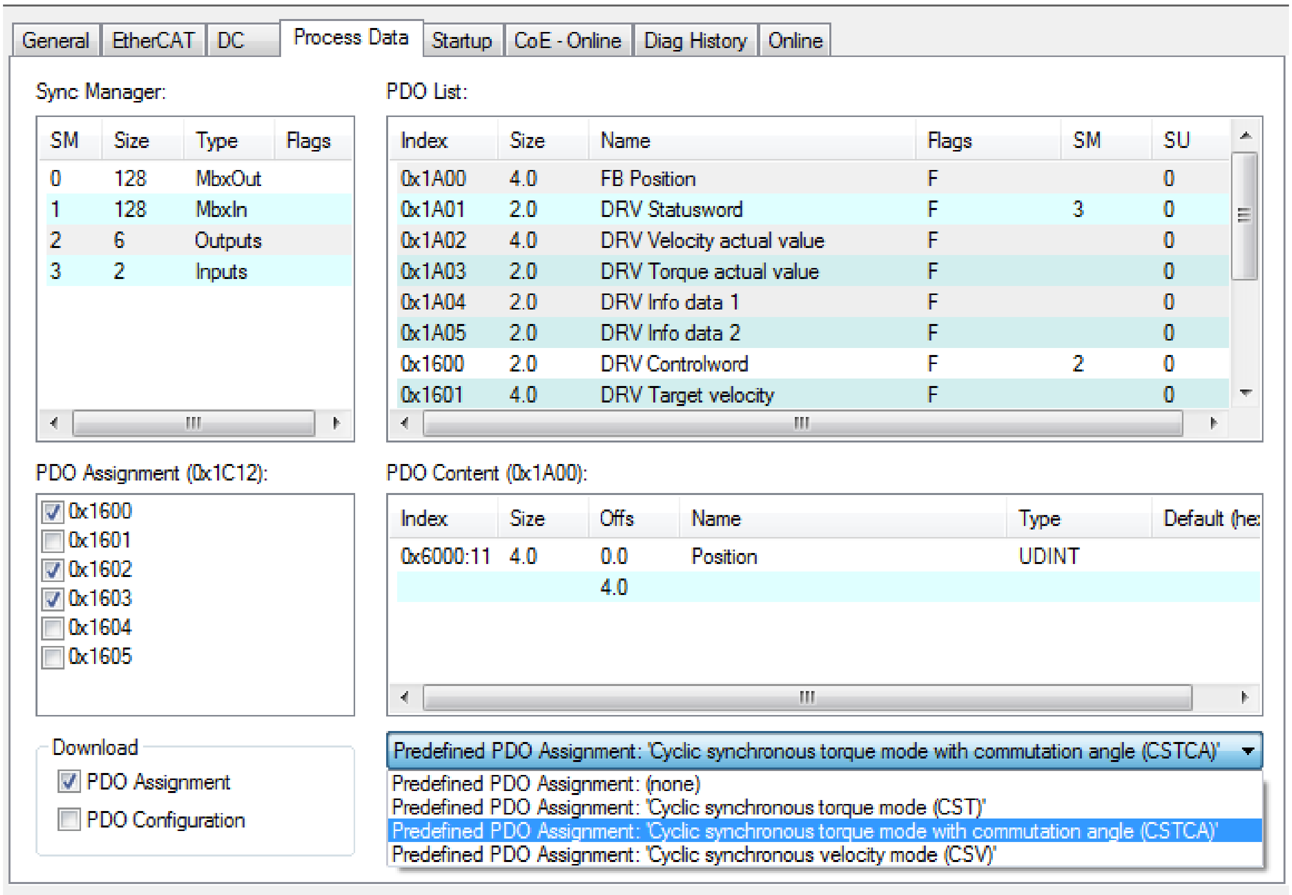
Binary: 0B 00 00 00 4

Bit Size: ○ 1 ○ 8 ○ 16 ● 32 ○ 64 ○ ?

| Name | | Online | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Statusword | X | 0x1027 (4135) | | | | | | nStatus1, nStatus2 |
| WcState | X | 0 | BOOL | 0.1 | 1522.3 | Input | 0 | nStatus4, nStatus4 |
| State | | 0x0008 (8) | UINT | 2.0 | 1655.0 | Input | 0 | |

Fig. 147: Selection of the mode of operation

- Under Predefined PDO assignment, also select *Cyclic synchronous torque mode with commutation angle (CSTCA*), Fig. *Selecting a predefined PDO assignment*.



Sync Manager:

| SM | Size | Type | Flags |
|---|---|---|---|
| 0 | 128 | MbxOut | |
| 1 | 128 | MbxIn | |
| 2 | 6 | Outputs | |
| 3 | 2 | Inputs | |

PDO List:

| Index | Size | Name | Flags | SM | SU |
|---|---|---|---|---|---|
| 0x1A00 | 4.0 | FB Position | F | | 0 |
| 0x1A01 | 2.0 | DRV Statusword | F | 3 | 0 |
| 0x1A02 | 4.0 | DRV Velocity actual value | F | | 0 |
| 0x1A03 | 2.0 | DRV Torque actual value | F | | 0 |
| 0x1A04 | 2.0 | DRV Info data 1 | F | | 0 |
| 0x1A05 | 2.0 | DRV Info data 2 | F | | 0 |
| 0x1600 | 2.0 | DRV Controlword | F | 2 | 0 |
| 0x1601 | 4.0 | DRV Target velocity | F | | 0 |

PDO Assignment (0x1C12):

☑ 0x1600
☐ 0x1601
☑ 0x1602
☑ 0x1603
☐ 0x1604
☐ 0x1605

PDO Content (0x1A00):

| Index | Size | Offs | Name | Type | Default (he: |
|---|---|---|---|---|---|
| 0x6000:11 | 4.0 | 0.0 | Position | UDINT | |
| | | 4.0 | | | |

Download

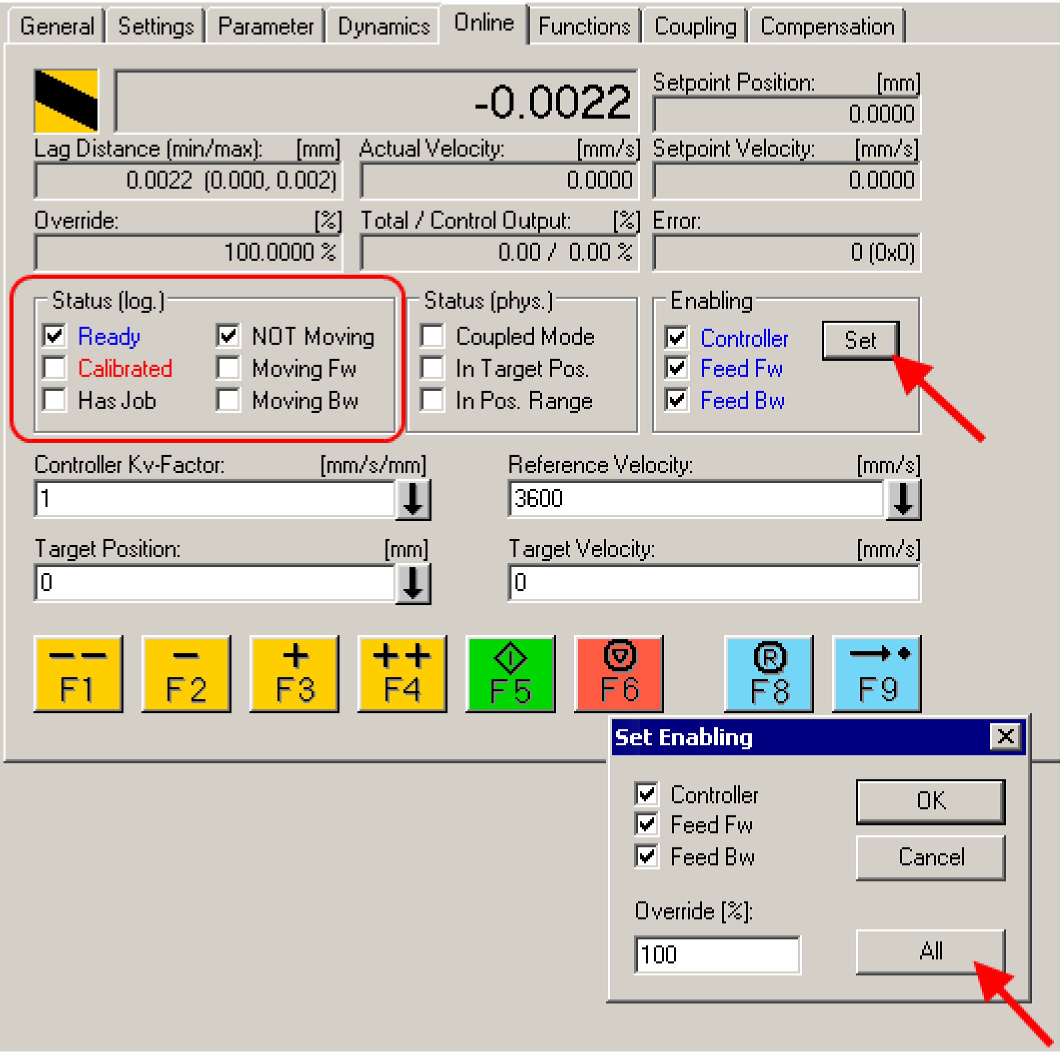
☑ PDO Assignment
☐ PDO Configuration

Predefined PDO Assignment: 'Cyclic synchronous torque mode with commutation angle (CSTCA)'

- Predefined PDO Assignment: (none)
- Predefined PDO Assignment: 'Cyclic synchronous torque mode (CST)'
- Predefined PDO Assignment: 'Cyclic synchronous torque mode with commutation angle (CSTCA)'
- Predefined PDO Assignment: 'Cyclic synchronous velocity mode (CSV)'

Fig. 148: Selecting a predefined PDO assignment

- Activate the configuration (Ctrl+Shift+F4).
- Run through the State Machine of the terminal. There are two ways to do this:
  - If you use the TwinCAT NC.
    The State Machine is run through automatically by the NC. You can enable the axis in the *Online* tab of the axis.
    Set all tick marks and set *Override* to 100% (see Fig. *Set enables*). The axis can then be moved.



General | Settings | Parameter | Dynamics | Online | Functions | Coupling | Compensation

-0.0022

Setpoint Position: [mm] 0.0000

Lag Distance (min/max): [mm] 0.0022 (0.000, 0.002)

Actual Velocity: [mm/s] 0.0000

Setpoint Velocity: [mm/s] 0.0000

Override: [%] 100.0000 %

Total / Control Output: [%] 0.00 / 0.00 %

Error: 0 (0x0)

Status (log.)
☑ Ready ☑ NOT Moving
□ Calibrated □ Moving Fw
□ Has Job □ Moving Bw

Status (phys.)
□ Coupled Mode
□ In Target Pos.
□ In Pos. Range

Enabling
☑ Controller
☑ Feed Fw
☑ Feed Bw
Set

Controller Kv-Factor: [mm/s/mm] 1

Reference Velocity: [mm/s] 3600

Target Position: [mm] 0

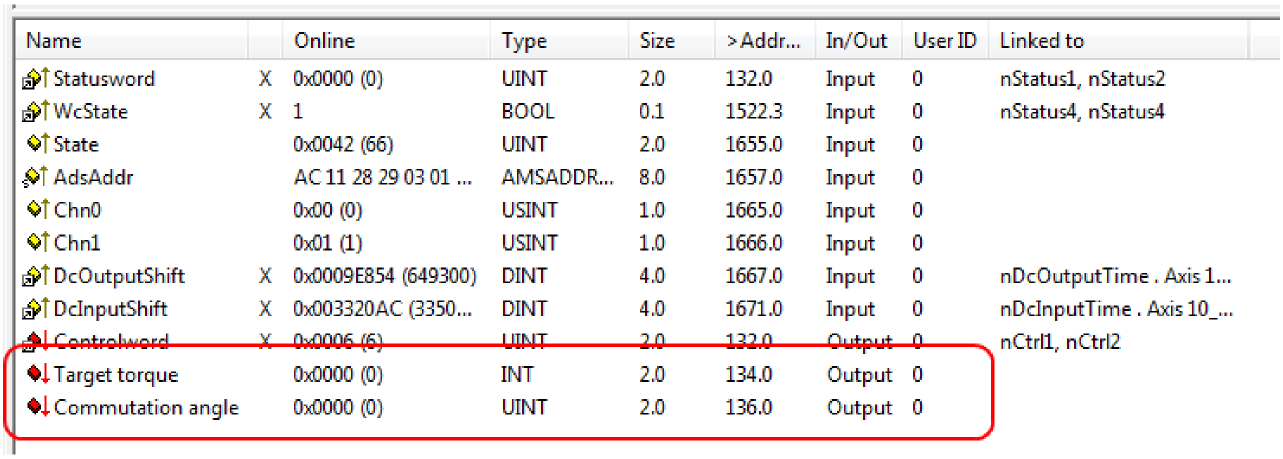
Target Velocity: [mm/s] 0

Set Enabling
☑ Controller
☑ Feed Fw
☑ Feed Bw
OK
Cancel
Override [%]: 100
All

Fig. 149: Set enables

- ◦ If you don’t use the TwinCAT NC.
  In this case you must run through the State Machine manually. To do this, follow the instructions in the chapter Commissioning without the NC [▶ 111].
- You can specify a defined torque via the cyclic variable *Target torque*. The value is specified in 1000ths of the *rated current* and the torque is calculated according to the following equation, where the rated current refers to the value in the index 0x8011:12 (*rated current*).

You can specify a defined angle via the cyclic variable *Commutation angle*. The value is specified in 360°/$2^{16}$.



| Name | | Online | Type | Size | >Addr... | In/Out | User ID | Linked to |
|---|---|---|---|---|---|---|---|---|
| Statusword | X | 0x0000 (0) | UINT | 2.0 | 132.0 | Input | 0 | nStatus1, nStatus2 |
| WcState | X | 1 | BOOL | 0.1 | 1522.3 | Input | 0 | nStatus4, nStatus4 |
| State | | 0x0042 (66) | UINT | 2.0 | 1655.0 | Input | 0 | |
| AdsAddr | | AC 11 28 29 03 01 ... | AMSADDR... | 8.0 | 1657.0 | Input | 0 | |
| Chn0 | | 0x00 (0) | USINT | 1.0 | 1665.0 | Input | 0 | |
| Chn1 | | 0x01 (1) | USINT | 1.0 | 1666.0 | Input | 0 | |
| DcOutputShift | X | 0x0009E854 (649300) | DINT | 4.0 | 1667.0 | Input | 0 | nDcOutputTime . Axis 1... |
| DcInputShift | X | 0x003320AC (3350... | DINT | 4.0 | 1671.0 | Input | 0 | nDcInputTime . Axis 10_... |
| Controlword | X | 0x0006 (6) | UINT | 2.0 | 132.0 | Output | 0 | nCtrl1, nCtrl2 |
| Target torque | | 0x0000 (0) | INT | 2.0 | 134.0 | Output | 0 | |
| Commutation angle | | 0x0000 (0) | UINT | 2.0 | 136.0 | Output | 0 | |

Fig. 150: Specification of torque and commutation angle

## 5.3.5 CSP

### CSP - cyclic synchronous position (position control)

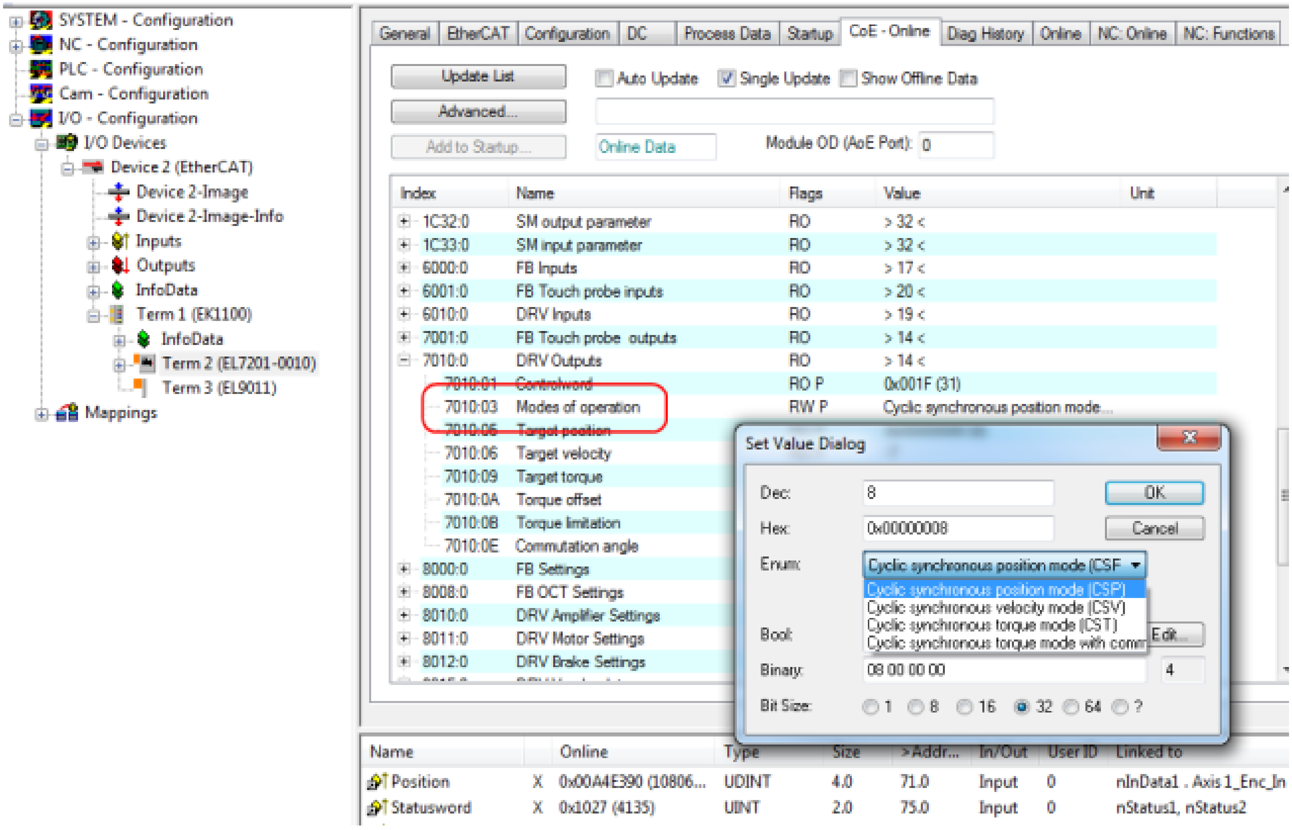
In the CSP operating mode the EL72x1-xxxx operates in the cyclic position interface. A defined position can be set via the *Target position* variable.

**Minimum cycle time**

The cycle times in CSP mode with 2^n * 125 µs (for n =1 to 8) are:
250 µs, 500 µs, 1 ms, 2 ms, 4 ms, 8 ms, 16 ms or 32 ms.

### Step-by-Step

- Add the terminal to the configuration as described in the chapter TwinCAT configuration settings [▶ 71] - manual or - Online scan [▶ 76].
- Link the terminal with the NC as described in the chapter Integration in the NC configuration [▶ 94].
- Configure the motor with the help of the automatic configuration (only OCT types), using the Drive Manager [▶ 97] or import the motor XML file into the Start-up directory as described in the chapter Settings in the CoE [▶ 102].
- Set the mode of operation in the CoE directory to *Cyclic synchronous position mode (CSP), Fig. Selection of the mode of operation*.



- SYSTEM - Configuration
- NC - Configuration
- PLC - Configuration
- Cam - Configuration
- I/O - Configuration
  - I/O Devices
    - Device 2 (EtherCAT)
      - Device 2-Image
      - Device 2-Image-Info
      - Inputs
      - Outputs
      - InfoData
      - Term 1 (EK1100)
        - InfoData
        - Term 2 (EL7201-0010)
        - Term 3 (EL9011)
  - Mappings

☐ Auto Update ☑ Single Update ☐ Show Offline Data

Online Data

Module OD (AoE Port): 0

| Index | Name | Flags | Value | Unit |
|---|---|---|---|---|
| 1C32:0 | SM output parameter | RO | > 32 < | |
| 1C33:0 | SM input parameter | RO | > 32 < | |
| 6000:0 | FB Inputs | RO | > 17 < | |
| 6001:0 | FB Touch probe inputs | RO | > 20 < | |
| 6010:0 | DRV Inputs | RO | > 19 < | |
| 7001:0 | FB Touch probe outputs | RO | > 14 < | |
| 7010:0 | DRV Outputs | RO | > 14 < | |
| 7010:01 | Controlword | RO P | 0x001F (31) | |
| 7010:03 | Modes of operation | RW P | Cyclic synchronous position mode... | |
| 7010:05 | Target position | | | |
| 7010:06 | Target velocity | | | |
| 7010:09 | Target torque | | | |
| 7010:0A | Torque offset | | | |
| 7010:0B | Torque limitation | | | |
| 7010:0E | Commutation angle | | | |
| 8000:0 | FB Settings | | | |
| 8008:0 | FB OCT Settings | | | |
| 8010:0 | DRV Amplifier Settings | | | |
| 8011:0 | DRV Motor Settings | | | |
| 8012:0 | DRV Brake Settings | | | |

Set Value Dialog

Dec: 8

Hex: 0x00000008

Enum: Cyclic synchronous position mode (CSF

- Cyclic synchronous position mode (CSP)
- Cyclic synchronous velocity mode (CSV)
- Cyclic synchronous torque mode (CST)
- Cyclic synchronous torque mode with comm

Bool:

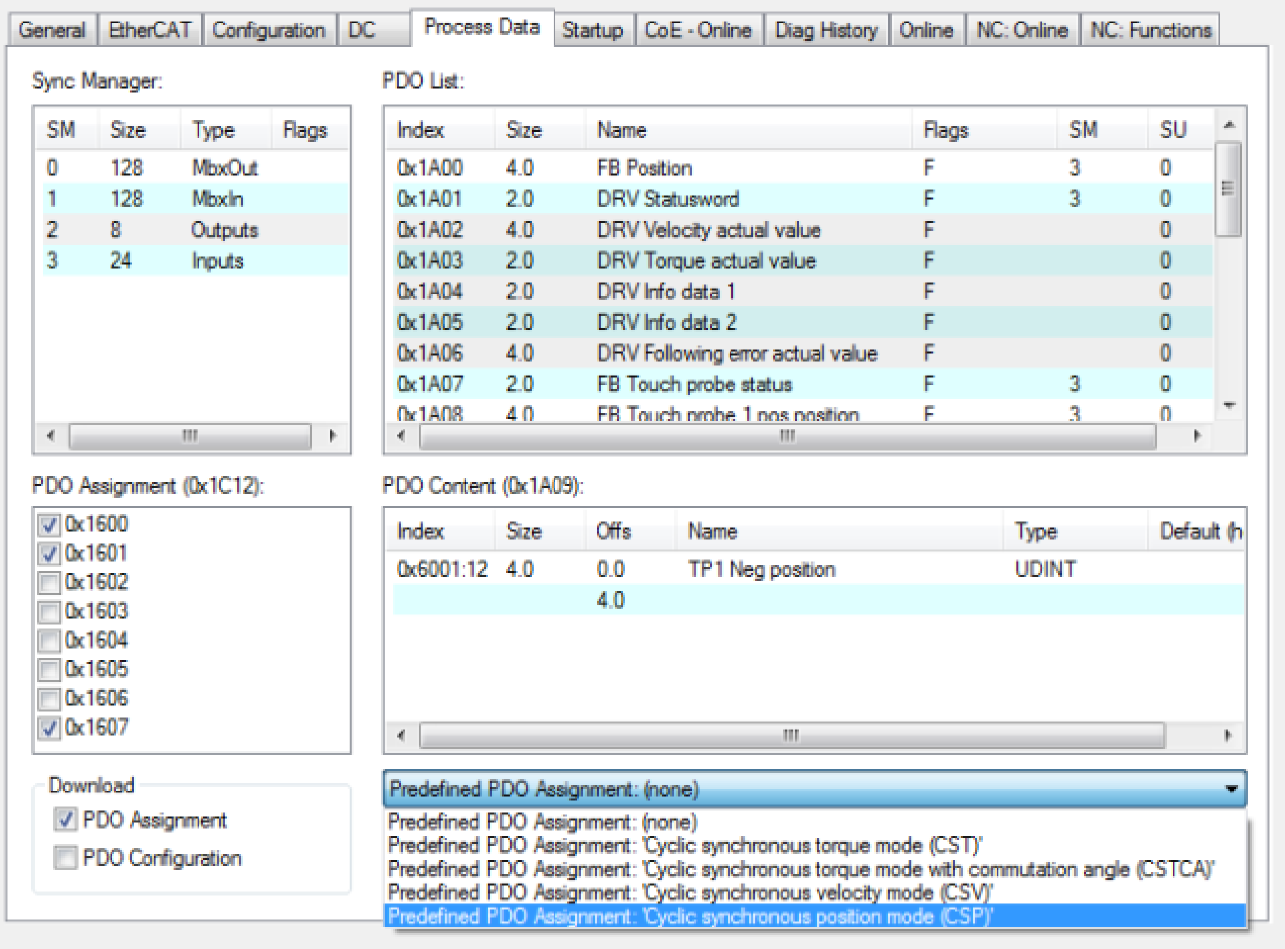
Binary: 08 00 00 00 4

Bit Size: ○ 1 ○ 8 ○ 16 ● 32 ○ 64 ○ ?

| Name | | Online | Type | Size | >Addr... | In/Out | User ID | Linked to |
|---|---|---|---|---|---|---|---|---|
| Position | X | 0x00A4E390 (10806... | UDINT | 4.0 | 71.0 | Input | 0 | nInData1 . Axis 1_Enc_In |
| Statusword | X | 0x1027 (4135) | UINT | 2.0 | 75.0 | Input | 0 | nStatus1, nStatus2 |

Fig. 151: Selection of the mode of operation

- Under Predefined PDO assignment, also select *Cyclic synchronous position mode (CSP)*, Fig. *Selecting a predefined PDO assignment*.



Sync Manager:

| SM | Size | Type | Flags |
|---|---|---|---|
| 0 | 128 | MbxOut | |
| 1 | 128 | MbxIn | |
| 2 | 8 | Outputs | |
| 3 | 24 | Inputs | |

PDO List:

| Index | Size | Name | Flags | SM | SU |
|---|---|---|---|---|---|
| 0x1A00 | 4.0 | FB Position | F | 3 | 0 |
| 0x1A01 | 2.0 | DRV Statusword | F | 3 | 0 |
| 0x1A02 | 4.0 | DRV Velocity actual value | F | | 0 |
| 0x1A03 | 2.0 | DRV Torque actual value | F | | 0 |
| 0x1A04 | 2.0 | DRV Info data 1 | F | | 0 |
| 0x1A05 | 2.0 | DRV Info data 2 | F | | 0 |
| 0x1A06 | 4.0 | DRV Following error actual value | F | | 0 |
| 0x1A07 | 2.0 | FB Touch probe status | F | 3 | 0 |
| 0x1A08 | 4.0 | FB Touch probe 1 pos position | F | 3 | 0 |

PDO Assignment (0x1C12):

☑ 0x1600
☑ 0x1601
□ 0x1602
□ 0x1603
□ 0x1604
□ 0x1605
□ 0x1606
☑ 0x1607

PDO Content (0x1A09):

| Index | Size | Offs | Name | Type | Default (h |
|---|---|---|---|---|---|
| 0x6001:12 | 4.0 | 0.0 | TP1 Neg position | UDINT | |
| | | 4.0 | | | |

Download

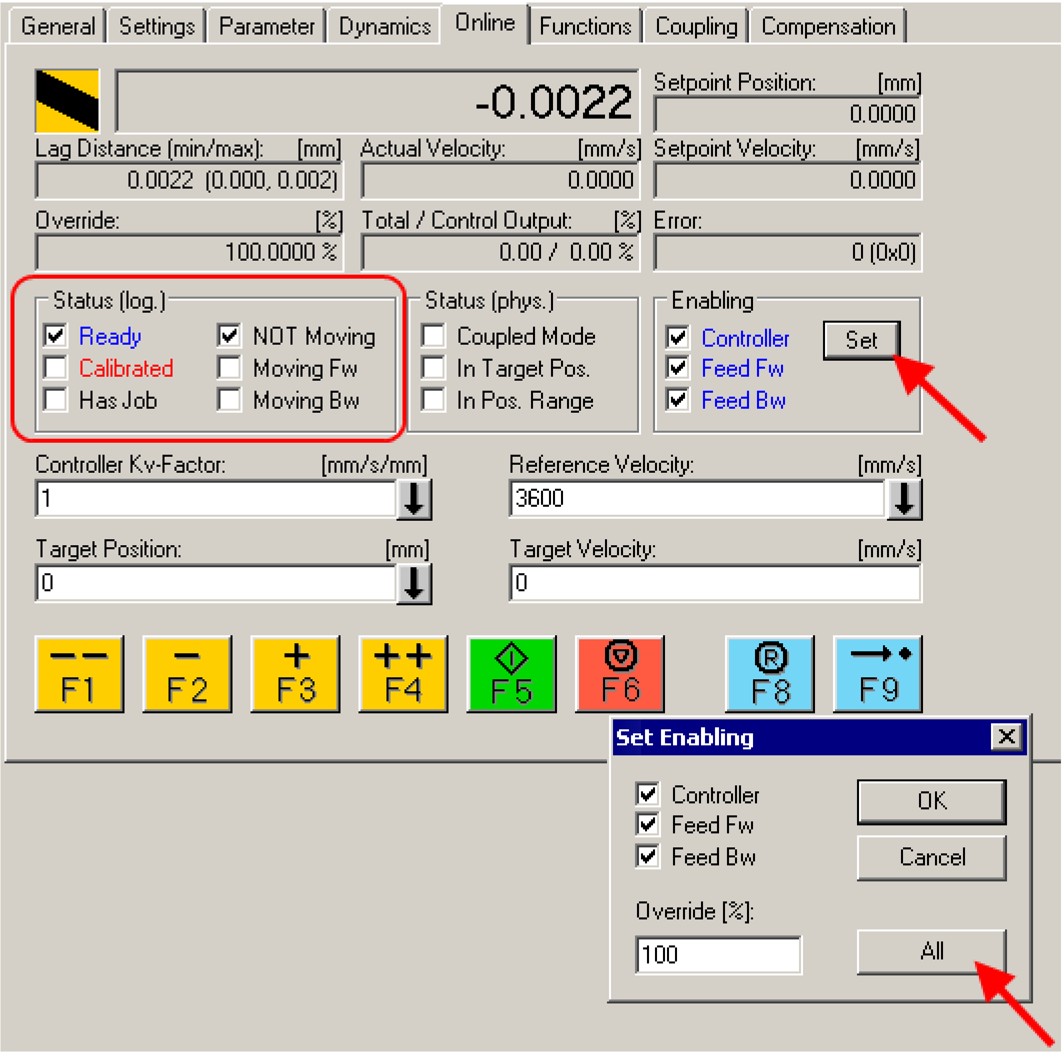
☑ PDO Assignment
□ PDO Configuration

Predefined PDO Assignment: (none)

Predefined PDO Assignment: (none)
Predefined PDO Assignment: 'Cyclic synchronous torque mode (CST)'
Predefined PDO Assignment: 'Cyclic synchronous torque mode with commutation angle (CSTCA)'
Predefined PDO Assignment: 'Cyclic synchronous velocity mode (CSV)'
Predefined PDO Assignment: 'Cyclic synchronous position mode (CSP)'

Fig. 152: Selecting a predefined PDO assignment

- Activate the configuration (Ctrl+Shift+F4).
- Run through the State Machine of the terminal. There are two ways to do this:
    - If you use the TwinCAT NC.
      The State Machine is run through automatically by the NC. You can enable the axis in the “Online” tab of the axis.
      Set all tick marks and set Override to 100% (see Fig. *Set enables*). The axis can then be moved.



-0.0022

Setpoint Position: [mm] 0.0000

Lag Distance (min/max): [mm] 0.0022 (0.000, 0.002)

Actual Velocity: [mm/s] 0.0000

Setpoint Velocity: [mm/s] 0.0000

Override: [%] 100.0000 %

Total / Control Output: [%] 0.00 / 0.00 %

Error: 0 (0x0)

Status (log.)
☑ Ready ☑ NOT Moving
□ Calibrated □ Moving Fw
□ Has Job □ Moving Bw

Status (phys.)
□ Coupled Mode
□ In Target Pos.
□ In Pos. Range

Enabling
☑ Controller
☑ Feed Fw
☑ Feed Bw
Set

Controller Kv-Factor: [mm/s/mm] 1

Reference Velocity: [mm/s] 3600

Target Position: [mm] 0

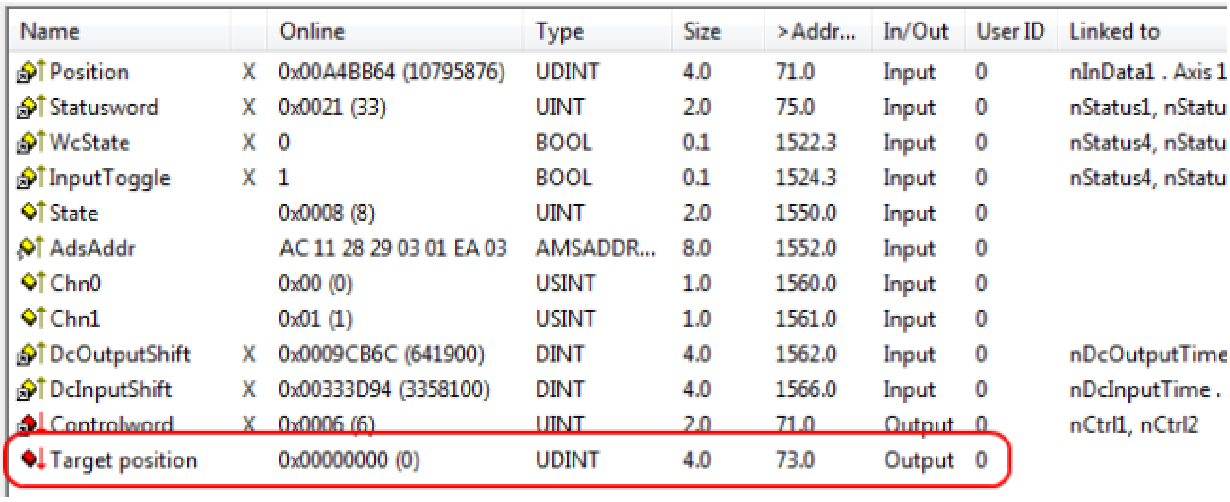
Target Velocity: [mm/s] 0

Set Enabling
☑ Controller
☑ Feed Fw
☑ Feed Bw
OK
Cancel
Override [%]: 100
All

Fig. 153: Set enables

- ◦ If you don’t use the TwinCAT NC.
  In this case you must run through the State Machine manually. To do this, follow the instructions in the chapter Commissioning without the NC [▶ 111].

- You can specify a defined position via the cyclic variable *Target position* (fig. *Position specification*). The value must be multiplied by the calculated scaling factor [▶ 120] in order to obtain the correct position.



| Name | | Online | Type | Size | >Addr... | In/Out | User ID | Linked to |
|---|---|---|---|---|---|---|---|---|
| Position | X | 0x00A4BB64 (10795876) | UDINT | 4.0 | 71.0 | Input | 0 | nInData1 . Axis 1 |
| Statusword | X | 0x0021 (33) | UINT | 2.0 | 75.0 | Input | 0 | nStatus1, nStatu |
| WcState | X | 0 | BOOL | 0.1 | 1522.3 | Input | 0 | nStatus4, nStatu |
| InputToggle | X | 1 | BOOL | 0.1 | 1524.3 | Input | 0 | nStatus4, nStatu |
| State | | 0x0008 (8) | UINT | 2.0 | 1550.0 | Input | 0 | |
| AdsAddr | | AC 11 28 29 03 01 EA 03 | AMSADDR... | 8.0 | 1552.0 | Input | 0 | |
| Chn0 | | 0x00 (0) | USINT | 1.0 | 1560.0 | Input | 0 | |
| Chn1 | | 0x01 (1) | USINT | 1.0 | 1561.0 | Input | 0 | |
| DcOutputShift | X | 0x0009CB6C (641900) | DINT | 4.0 | 1562.0 | Input | 0 | nDcOutputTime |
| DcInputShift | X | 0x00333D94 (3358100) | DINT | 4.0 | 1566.0 | Input | 0 | nDcInputTime . |
| Controlword | X | 0x0006 (6) | UINT | 2.0 | 71.0 | Output | 0 | nCtrl1, nCtrl2 |
| Target position | | 0x00000000 (0) | UDINT | 4.0 | 73.0 | Output | 0 | |

Fig. 154: Position specification

**Following error monitor**

Furthermore, there is an option in *CSP* mode to activate a following error monitor. The following error monitor is switched off on delivery. In all other modes this is not used and is ignored.

- The window of the following error monitor can be adjusted with the *Following error window* (Index 0x8010:50 MDP742 / Index 0x6065 DS402). The value set here – multiplied by the scaling factor – specifies by what position the actual position may differ from the set position, positively and negatively. The total accepted tolerance is thus twice as large as the position entered in the *Following error window* (see fig. *Following error window*).

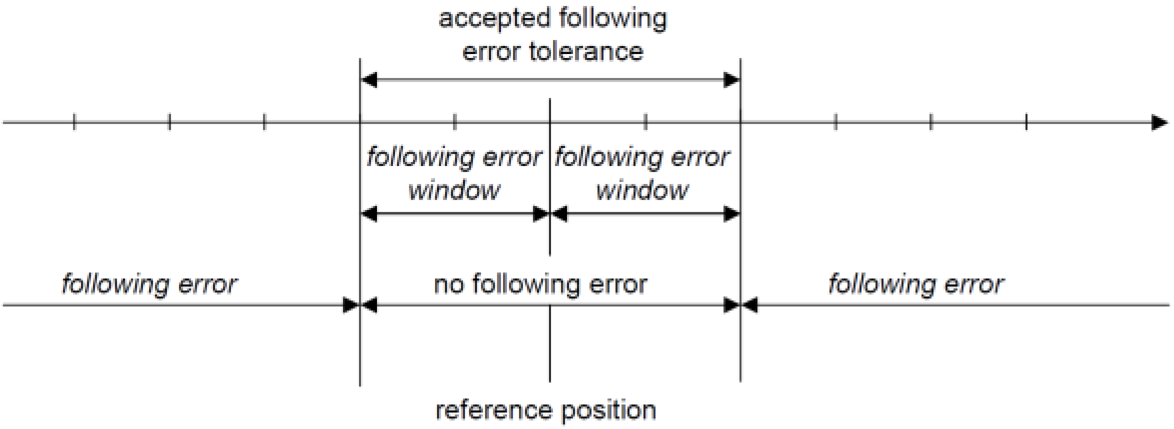


Fig. 155: Following error window

- The time (in ms) allowed for a following error exceedance can be set with the *Following error time out* (Index 0x8010:51 MDP742 / Index 0x6066 DS402). As soon as the target position is exceeded by more than the position entered in the *Following error window* for the time entered in the *Following error time out*, the terminal outputs an error and stops immediately.
- The current following error can be read in the *Following error actual value* (Index 0x6010:09 MDP742 / Index 0x60F4 DS402).

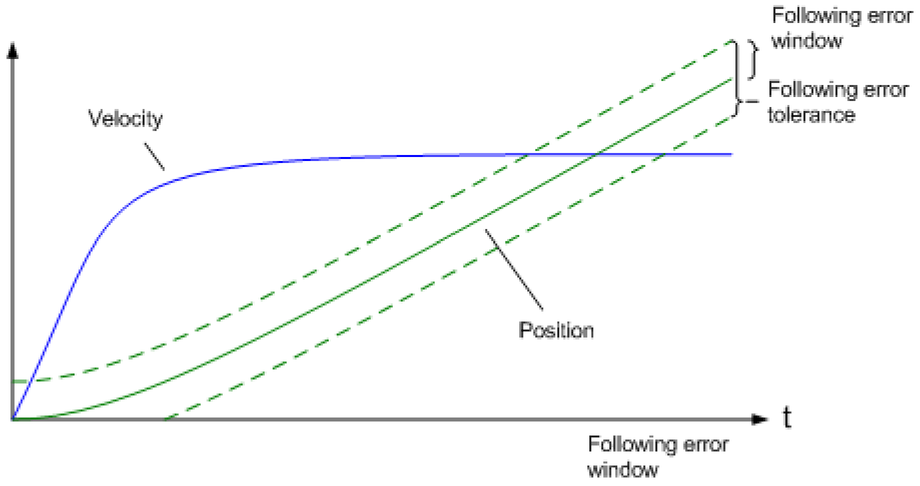


Fig. 156: Following error over time

The value 0xFFFFFF (- 1) in the *Following error window* means that the following error monitor is switched off and corresponds to the delivery status.
The *Following error time out* is 0x0000 (0) on delivery.

## 5.4 Profile MDP742 or DS402

The EL72x1-000x supports the MDP742 and DS402 drive profiles. The profiles define the presentation of parameters for the EtherCAT Terminal and the index, under which the respective parameters are arranged in the object directory.

Both profiles contain the same parameters. They only differ in terms of the specified designations and the parameter index. The CoE objects in the MDP742 profile (Modular Device Profile) are allocated in the way that is common for the Beckhoff EtherCAT Terminals.
The DS402 drive profile is specified in IEC61800-7-200 (CiA402). It uses a different object directory structure.

In both profiles, the drive state machine of the EL72x1-000x is based on the CiA402 State Machine [▶ 111], which means the functional behavior is identical.
The terminals delivered with the MDP742 profile ex factory.

### Changing the profile

After a profile change an EEPROM update [▶ 188] is required. The corresponding ESI description [▶ 188] can then be loaded into the terminal.

Please note that the CoE object description and the process data are different for both profiles. The motor XML files that match the set profile must be used.

**Terminal designation MDP742 and DS402 profile**

Take note that the profile change process described above lead to a change of the type designation of the Servo Motor Terminal in TwinCAT.
The TwinCAT System Manager provide one of these devices:
- Servo Motor Terminal with MDP742 profile: EL72x1[**-0000]**
- Servo Motor Terminal with DS402 profile: EL72x1-**0001**

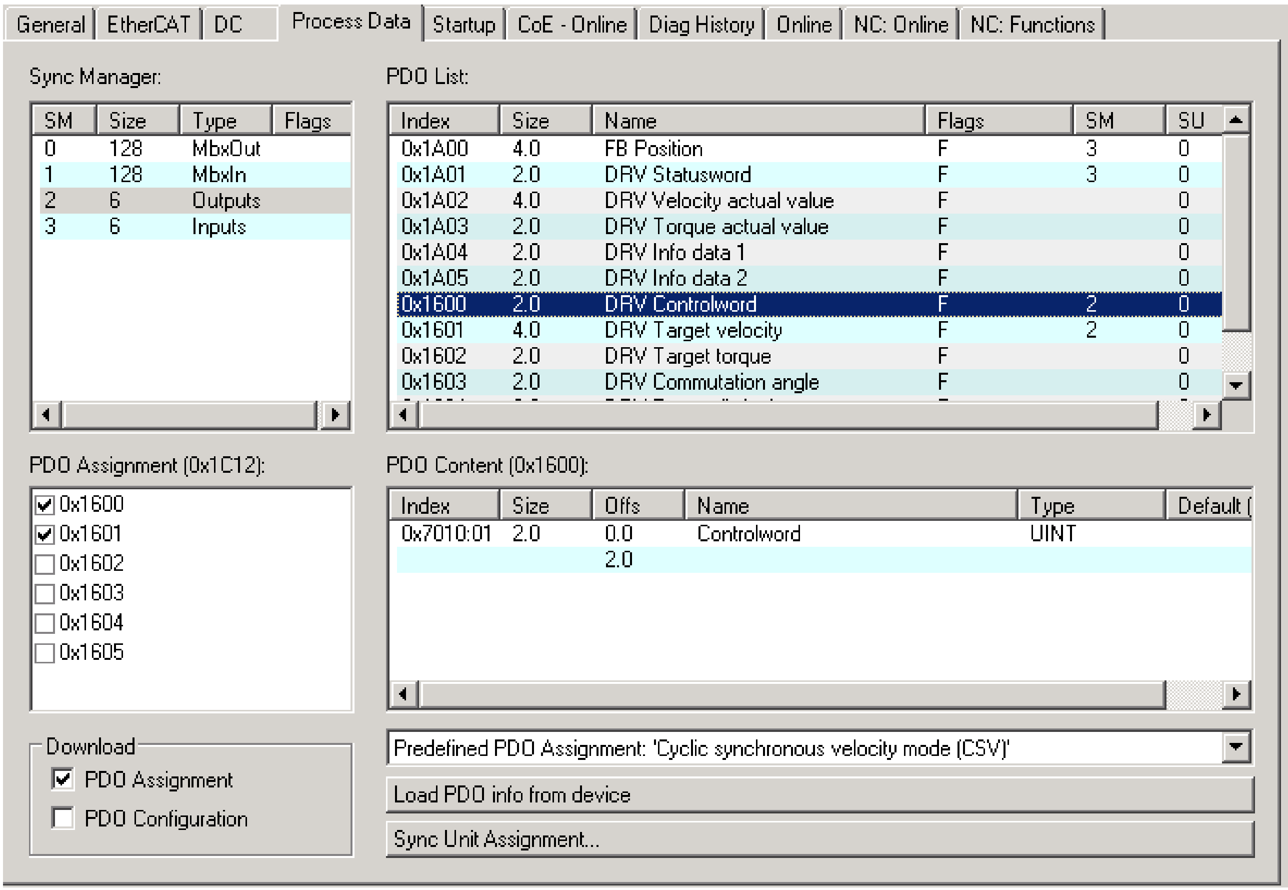
## 5.5 MDP742 process data

**Table of contents**

- Sync Manager [▶ 138]
- PDO Assignment [▶ 140]
- Predefined PDO Assignment [▶ 141]

### Sync Manager (SM)

Sync Manager (SM) The scope of the offered process data can be changed via the "Process Data" tab (see Fig. *"Process Data tab SM2, EL72x1 (default), Process data tab SM3, EL72x1 (default)"*).



Sync Manager:

| SM | Size | Type | Flags |
|---|---|---|---|
| 0 | 128 | MbxOut | |
| 1 | 128 | MbxIn | |
| 2 | 6 | Outputs | |
| 3 | 6 | Inputs | |

PDO List:

| Index | Size | Name | Flags | SM | SU |
|---|---|---|---|---|---|
| 0x1A00 | 4.0 | FB Position | F | 3 | 0 |
| 0x1A01 | 2.0 | DRV Statusword | F | 3 | 0 |
| 0x1A02 | 4.0 | DRV Velocity actual value | F | | 0 |
| 0x1A03 | 2.0 | DRV Torque actual value | F | | 0 |
| 0x1A04 | 2.0 | DRV Info data 1 | F | | 0 |
| 0x1A05 | 2.0 | DRV Info data 2 | F | | 0 |
| 0x1600 | 2.0 | DRV Controlword | F | 2 | 0 |
| 0x1601 | 4.0 | DRV Target velocity | F | 2 | 0 |
| 0x1602 | 2.0 | DRV Target torque | F | | 0 |
| 0x1603 | 2.0 | DRV Commutation angle | F | | 0 |

PDO Assignment (0x1C12):

- ☑ 0x1600
- ☑ 0x1601
- □ 0x1602
- □ 0x1603
- □ 0x1604
- □ 0x1605

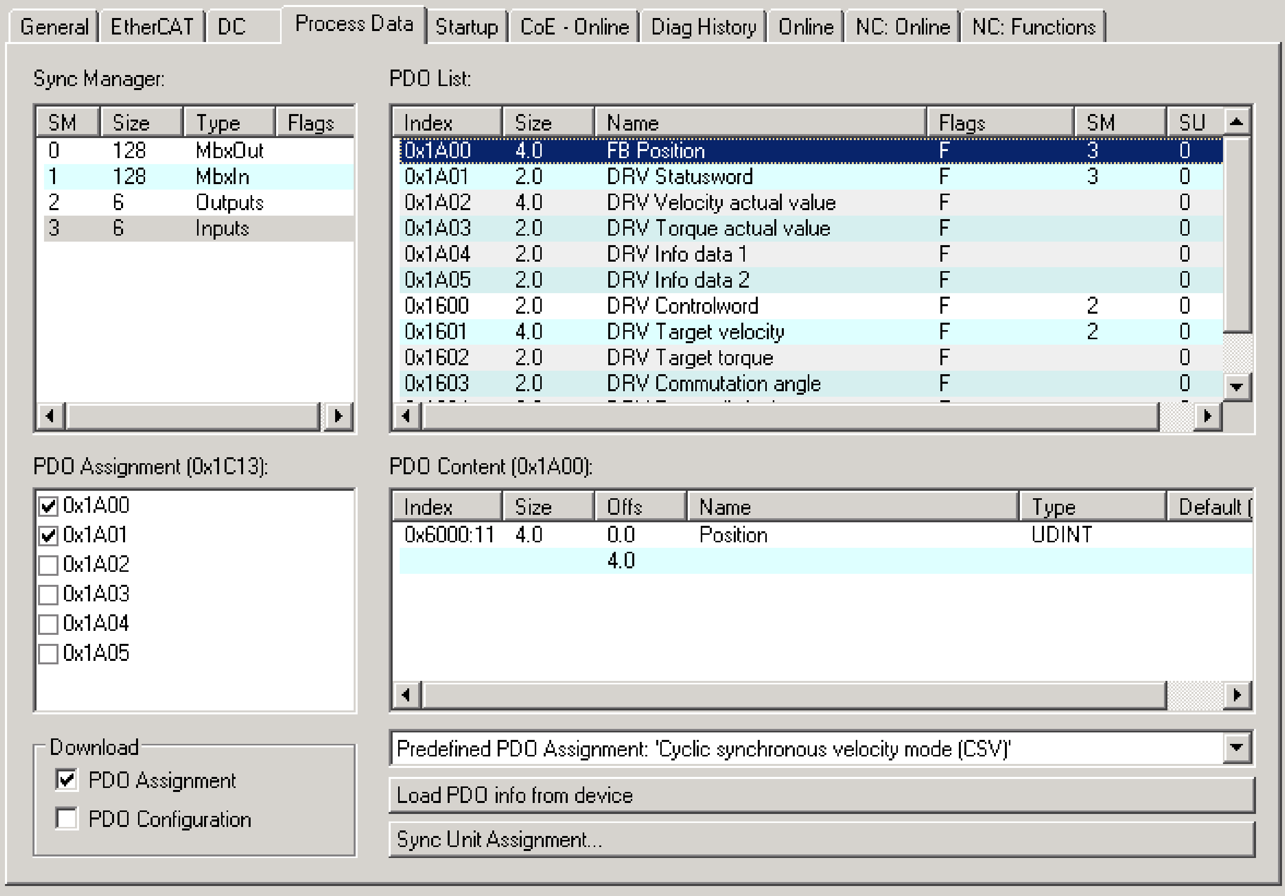
PDO Content (0x1600):

| Index | Size | Offs | Name | Type | Default ( |
|---|---|---|---|---|---|
| 0x7010:01 | 2.0 | 0.0 | Controlword | UINT | |
| | | 2.0 | | | |

Download
- ☑ PDO Assignment
- □ PDO Configuration

Predefined PDO Assignment: 'Cyclic synchronous velocity mode (CSV)'

Fig. 157: Process Data tab SM2, EL72x1 (default)



Sync Manager:

| SM | Size | Type | Flags |
|---|---|---|---|
| 0 | 128 | MbxOut | |
| 1 | 128 | MbxIn | |
| 2 | 6 | Outputs | |
| 3 | 6 | Inputs | |

PDO List:

| Index | Size | Name | Flags | SM | SU |
|---|---|---|---|---|---|
| 0x1A00 | 4.0 | FB Position | F | 3 | 0 |
| 0x1A01 | 2.0 | DRV Statusword | F | 3 | 0 |
| 0x1A02 | 4.0 | DRV Velocity actual value | F | | 0 |
| 0x1A03 | 2.0 | DRV Torque actual value | F | | 0 |
| 0x1A04 | 2.0 | DRV Info data 1 | F | | 0 |
| 0x1A05 | 2.0 | DRV Info data 2 | F | | 0 |
| 0x1600 | 2.0 | DRV Controlword | F | 2 | 0 |
| 0x1601 | 4.0 | DRV Target velocity | F | 2 | 0 |
| 0x1602 | 2.0 | DRV Target torque | F | | 0 |
| 0x1603 | 2.0 | DRV Commutation angle | F | | 0 |

PDO Assignment (0x1C13):

- ☑ 0x1A00
- ☑ 0x1A01
- □ 0x1A02
- □ 0x1A03
- □ 0x1A04
- □ 0x1A05

PDO Content (0x1A00):

| Index | Size | Offs | Name | Type | Default ( |
|---|---|---|---|---|---|
| 0x6000:11 | 4.0 | 0.0 | Position | UDINT | |
| | | 4.0 | | | |

Download
- ☑ PDO Assignment
- □ PDO Configuration

Predefined PDO Assignment: 'Cyclic synchronous velocity mode (CSV)'

Fig. 158: Process Data tab SM3, EL72x1 (default)

### PDO Assignment

- In order to configure the process data, select the desired Sync Manager (SM2 and SM3 can be edited) in the upper left-hand "Sync Manager" box (see fig.).
- The process data assigned to this Sync Manager can then be switched on or off in the “PDO Assignment” box underneath.
- Restarting the EtherCAT system, or reloading the configuration in configuration mode (F4), causes the EtherCAT communication to restart, and the process data is transferred from the terminal.

### PDO assignment of sync managers, EL72x1

| SM2, PDO assignment 0x1C12 | | | |
|---|---|---|---|
| **Index** | **Size (byte.bit)** | **Name** | **PDO content** |
| 0x1600 (default) | 2.0 | DRV Controlword | Index 0x7010:01 [▸ 152] |
| 0x1601 (default) | 4.0 | DRV Target velocity | Index 0x7010:06 [▸ 152] |
| 0x1602 | 2.0 | DRV Target torque | Index 0x7010:09 [▸ 152] |
| 0x1603 | 2.0 | DRV Commutation angle | Index 0x7010:0E [▸ 152] |
| 0x1604 | 2.0 | DRV Torque limitation | Index 0x7010:0B [▸ 152] |
| 0x1605 | 2.0 | DRV Torque offset | Index 0x7010:0A [▸ 152] |
| 0x1606 | 4.0 | DRV Target position | Index 0x7010:05 [▸ 152] |

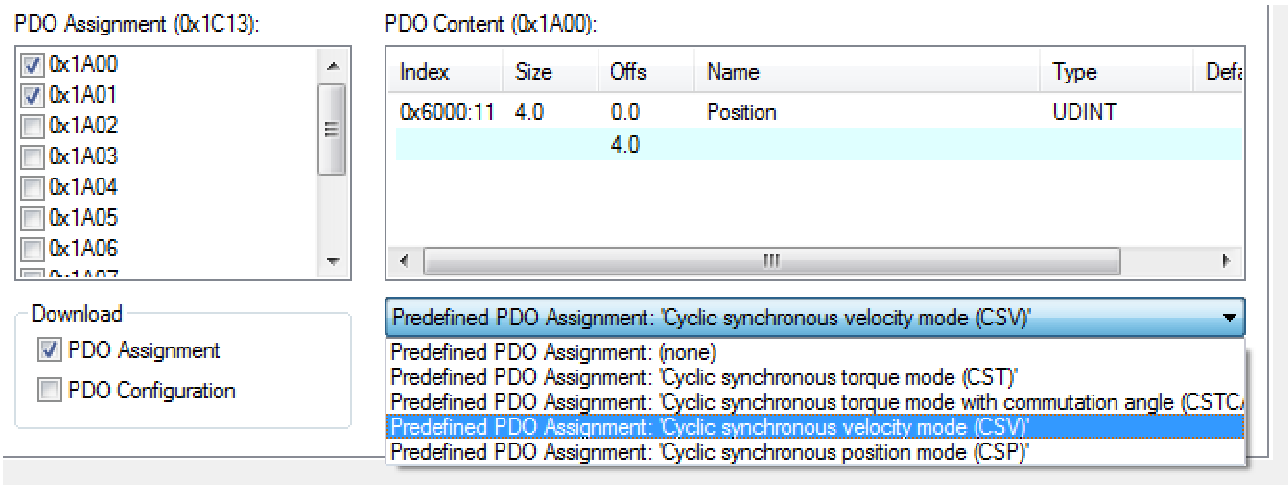
| SM3, PDO Assignment 0x1C13 | | | |
|---|---|---|---|
| **Index** | **Size (byte.bit)** | **Name** | **PDO content** |
| 0x1A00 (default) | 4.0 | FB Position | Index 0x6000:11 [▸ 150] |
| 0x1A01 (default) | 2.0 | DRV Statusword | Index 0x6010:01 [▸ 151] |
| 0x1A02 | 4.0 | DRV Velocity actual value | Index 0x6010:07 [▸ 151] |
| 0x1A03 | 2.0 | DRV Torque actual value | Index 0x6010:08 [▸ 151] |
| 0x1A04 | 2.0 | DRV Info data 1 | Index 0x6010:12 [▸ 151] |
| 0x1A05 | 2.0 | DRV Info data 2 | Index 0x6010:13 [▸ 151] |
| 0x1A06 | 4.0 | DRV Following error actual value | Index 0x6010:09 [▸ 151] |

### Predefined PDO Assignment

The "Predefined PDO Assignment" enables a simplified selection of the process data. The desired function is selected on the lower part of the "Process Data" tab. As a result, all necessary PDOs are automatically activated and the unnecessary PDOs are deactivated.

Four PDO assignments are available:

| Name | SM2, PDO assignment | SM3, PDO assignment |
|---|---|---|
| Cyclic synchronous velocity mode (CSV) | 0x1600 [▸ 155] (DRV Controlword)<br>0x1601 [▸ 155] (DRV Target velocity) | 0x1A00 [▸ 156] (FB Position)<br>0x1A01 [▸ 156] (DRV Statusword) |
| Cyclic synchronous torque mode (CST) | 0x1600 [▸ 155] (DRV Controlword)<br>0x1602 [▸ 156] (DRV Target torque) | 0x1A00 [▸ 156] (FB Position)<br>0x1A01 [▸ 156] (DRV Statusword)<br>0x1A03 [▸ 157] (DRV Torque actual value) |
| Cyclic synchronous torque mode with commutation angel (CSTCA) | 0x1600 [▸ 155] (DRV Controlword)<br>0x1602 [▸ 156] (DRV Target torque)<br>0x1603 [▸ 156] (DRV Commutation angle) | 0x1A01 [▸ 156] (DRV Statusword) |
| Cyclic synchronous position mode (CSP) | 0x1600 [▸ 155] (DRV Controlword)<br>0x1606 [▸ 156] (DRV Target position) | 0x1A00 [▸ 156] (FB Position)<br>0x1A01 [▸ 156] (DRV Statusword)<br>0x1A06 [▸ 157] (DRV Following error actual value) |



PDO Assignment (0x1C13):

☑ 0x1A00
☑ 0x1A01
□ 0x1A02
□ 0x1A03
□ 0x1A04
□ 0x1A05
□ 0x1A06

PDO Content (0x1A00):

| Index | Size | Offs | Name | Type | Defa |
|---|---|---|---|---|---|
| 0x6000:11 | 4.0 | 0.0 | Position | UDINT | |
| | | 4.0 | | | |

Download
☑ PDO Assignment
□ PDO Configuration

Predefined PDO Assignment: 'Cyclic synchronous velocity mode (CSV)'

Predefined PDO Assignment: (none)
Predefined PDO Assignment: 'Cyclic synchronous torque mode (CST)'
Predefined PDO Assignment: 'Cyclic synchronous torque mode with commutation angle (CSTC
Predefined PDO Assignment: 'Cyclic synchronous velocity mode (CSV)'
Predefined PDO Assignment: 'Cyclic synchronous position mode (CSP)'

Fig. 159: Process data tab Predefined PDO Assignment, EL72x1

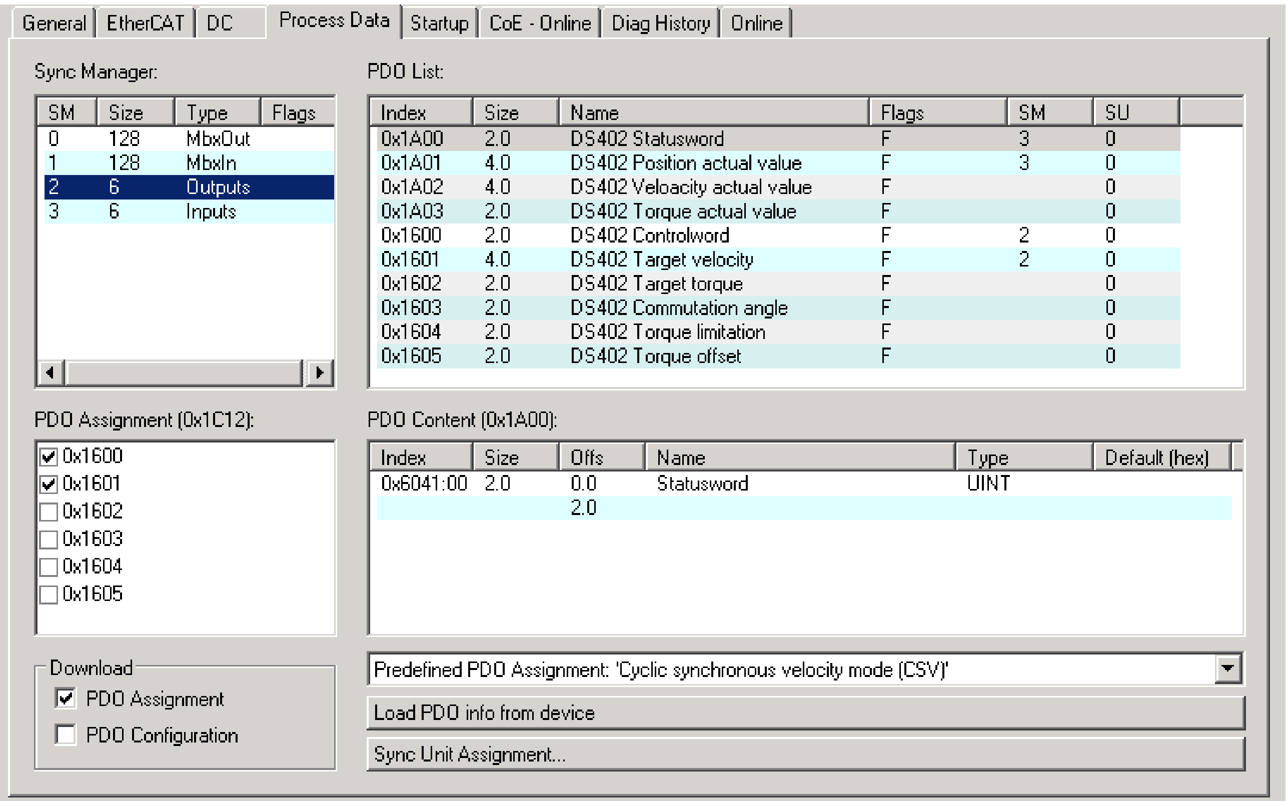
## 5.6 DS402 process data

**Table of contents**

- Sync Manager [▸ 141]
- PDO Assignment [▸ 143]
- Predefined PDO Assignment [▸ 144]

### Sync Manager (SM)

Sync Manager (SM) The scope of the offered process data can be changed via the "Process Data" tab (see Fig. *"Process Data tab SM2, EL72x1 (default), Process data tab SM3, EL72x1 (default)"*).



Sync Manager:

| SM | Size | Type | Flags |
|---|---|---|---|
| 0 | 128 | MbxOut | |
| 1 | 128 | MbxIn | |
| 2 | 6 | Outputs | |
| 3 | 6 | Inputs | |

PDO List:

| Index | Size | Name | Flags | SM | SU |
|---|---|---|---|---|---|
| 0x1A00 | 2.0 | DS402 Statusword | F | 3 | 0 |
| 0x1A01 | 4.0 | DS402 Position actual value | F | 3 | 0 |
| 0x1A02 | 4.0 | DS402 Veloacity actual value | F | | 0 |
| 0x1A03 | 2.0 | DS402 Torque actual value | F | | 0 |
| 0x1600 | 2.0 | DS402 Controlword | F | 2 | 0 |
| 0x1601 | 4.0 | DS402 Target velocity | F | 2 | 0 |
| 0x1602 | 2.0 | DS402 Target torque | F | | 0 |
| 0x1603 | 2.0 | DS402 Commutation angle | F | | 0 |
| 0x1604 | 2.0 | DS402 Torque limitation | F | | 0 |
| 0x1605 | 2.0 | DS402 Torque offset | F | | 0 |

PDO Assignment (0x1C12):

☑ 0x1600
☑ 0x1601
☐ 0x1602
☐ 0x1603
☐ 0x1604
☐ 0x1605

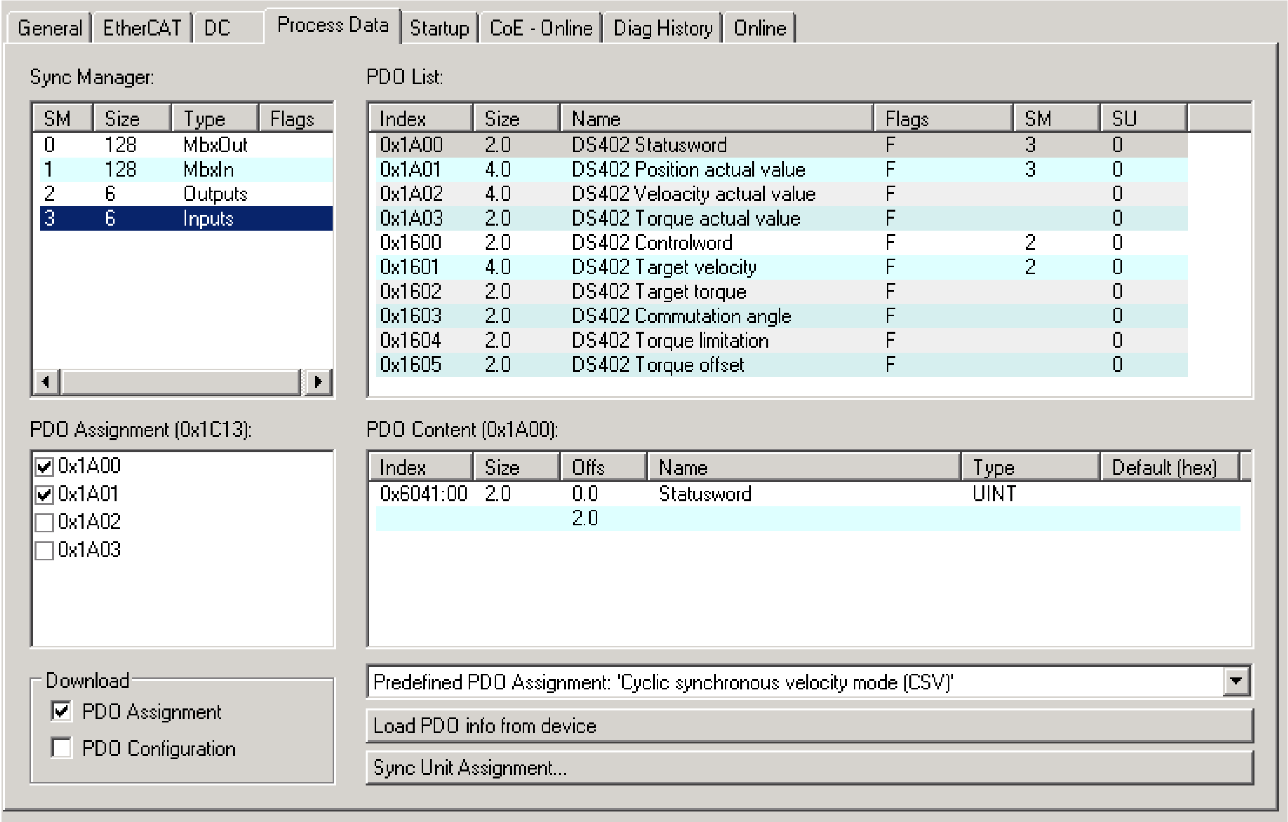
PDO Content (0x1A00):

| Index | Size | Offs | Name | Type | Default (hex) |
|---|---|---|---|---|---|
| 0x6041:00 | 2.0 | 0.0 | Statusword | UINT | |
| | | 2.0 | | | |

Download
☑ PDO Assignment
☐ PDO Configuration

Predefined PDO Assignment: 'Cyclic synchronous velocity mode (CSV)'

Fig. 160: Process Data tab SM2, EL72x1 (default)



Sync Manager:

| SM | Size | Type | Flags |
|---|---|---|---|
| 0 | 128 | MbxOut | |
| 1 | 128 | MbxIn | |
| 2 | 6 | Outputs | |
| 3 | 6 | Inputs | |

PDO List:

| Index | Size | Name | Flags | SM | SU |
|---|---|---|---|---|---|
| 0x1A00 | 2.0 | DS402 Statusword | F | 3 | 0 |
| 0x1A01 | 4.0 | DS402 Position actual value | F | 3 | 0 |
| 0x1A02 | 4.0 | DS402 Veloacity actual value | F | | 0 |
| 0x1A03 | 2.0 | DS402 Torque actual value | F | | 0 |
| 0x1600 | 2.0 | DS402 Controlword | F | 2 | 0 |
| 0x1601 | 4.0 | DS402 Target velocity | F | 2 | 0 |
| 0x1602 | 2.0 | DS402 Target torque | F | | 0 |
| 0x1603 | 2.0 | DS402 Commutation angle | F | | 0 |
| 0x1604 | 2.0 | DS402 Torque limitation | F | | 0 |
| 0x1605 | 2.0 | DS402 Torque offset | F | | 0 |

PDO Assignment (0x1C13):

☑ 0x1A00
☑ 0x1A01
☐ 0x1A02
☐ 0x1A03

PDO Content (0x1A00):

| Index | Size | Offs | Name | Type | Default (hex) |
|---|---|---|---|---|---|
| 0x6041:00 | 2.0 | 0.0 | Statusword | UINT | |
| | | 2.0 | | | |

Download
☑ PDO Assignment
☐ PDO Configuration

Predefined PDO Assignment: 'Cyclic synchronous velocity mode (CSV)'

Fig. 161: Process Data tab SM3, EL72x1 (default)

### PDO Assignment

- In order to configure the process data, select the desired Sync Manager (SM2 and SM3 can be edited) in the upper left-hand "Sync Manager" box (see fig.).
- The process data assigned to this Sync Manager can then be switched on or off in the “PDO Assignment” box underneath.
- Restarting the EtherCAT system, or reloading the configuration in configuration mode (F4), causes the EtherCAT communication to restart, and the process data is transferred from the terminal.

### PDO assignment of sync managers, EL72x1

| SM2, PDO assignment 0x1C12 | | | |
|---|---|---|---|
| **Index** | **Size (byte.bit)** | **Name** | **PDO content** |
| 0x1600 (default) | 2.0 | DS402 Controlword | Index 0x6040 [▶ 167] |
| 0x1601 (default) | 4.0 | DS402 Target velocity | Index 0x60FF [▶ 170] |
| 0x1602 | 2.0 | DS402 Target torque | Index 0x6071 [▶ 168] |
| 0x1603 | 2.0 | DS402 Commutation angle | Index 0x60EA [▶ 170] |
| 0x1604 | 2.0 | DS402 Torque limitation | Index 0x6072 [▶ 168] |
| 0x1605 | 2.0 | DS402 Torque offset | Index 0x2001:11 [▶ 166] |
| 0x1606 | 4.0 | DS402 Target position | Index 0x607A [▶ 169] |

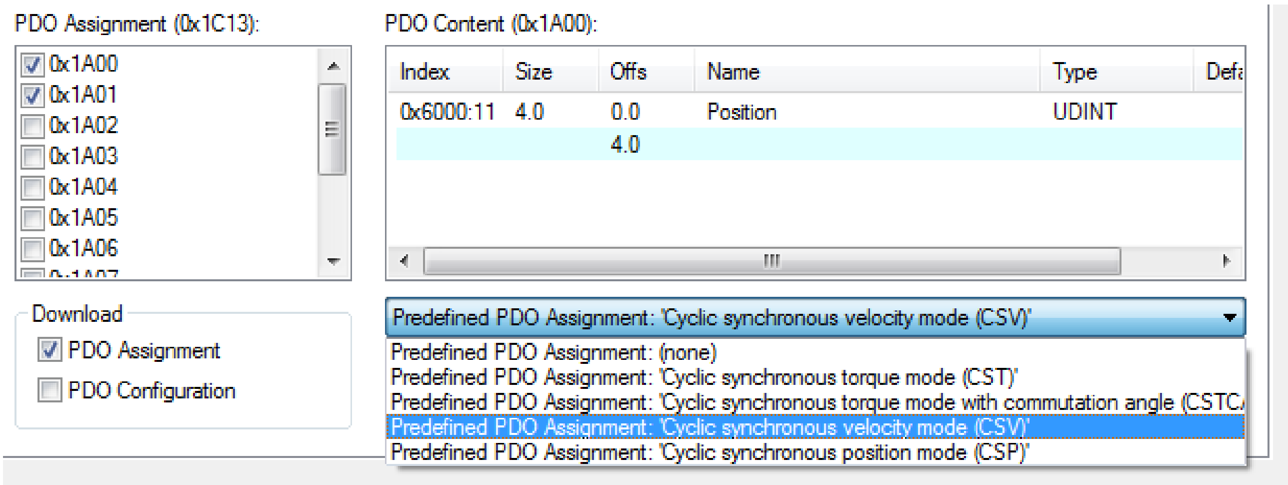
| SM3, PDO Assignment 0x1C13 | | | |
|---|---|---|---|
| **Index** | **Size (byte.bit)** | **Name** | **PDO content** |
| 0x1A00 (default) | 4.0 | DS402 Statusword | Index 0x6041 [▶ 167] |
| 0x1A01 (default) | 2.0 | DS402 Position actual value | Index 0x6064 [▶ 167] |
| 0x1A02 | 4.0 | DS402 Velocity actual value | Index 0x606C [▶ 168] |
| 0x1A03 | 2.0 | DS402 Torque actual value | Index 0x6077 [▶ 168] |
| 0x1A04 | 4.0 | DS402 Following error actual value | Index 0x60F4 [▶ 170] |
| 0x1A0A | 2.0 | DS402 TxPDO Data Invalid | Index 0x603E:02 [▶ 166] |

### Predefined PDO Assignment

The "Predefined PDO Assignment" enables a simplified selection of the process data. The desired function is selected on the lower part of the "Process Data" tab. As a result, all necessary PDOs are automatically activated and the unnecessary PDOs are deactivated.

Four PDO assignments are available:

| Name | SM2, PDO assignment | SM3, PDO assignment |
|---|---|---|
| Cyclic synchronous velocity mode (CSV) | 0x1600 [▶ 172] (DS402 Controlword)<br>0x1601 [▶ 172] (DS402 Target velocity) | 0x1A00 [▶ 173] (DS402 Statusword)<br>0x1A01 [▶ 173] (DS402 Position actual value) |
| Cyclic synchronous torque mode (CST) | 0x1600 [▶ 172] (DS402 Controlword)<br>0x1602 [▶ 172] (DS402 Target torque) | 0x1A00 [▶ 173] (DS402 Statusword)<br>0x1A01 [▶ 173] (DS402 Position actual value)<br>0x1A03 [▶ 173] (DS402 Torque actual value) |
| Cyclic synchronous torque mode with commutation angel (CSTCA) | 0x1600 [▶ 172] (DS402 Controlword)<br>0x1602 [▶ 172] (DS402 Target torque)<br>0x1603 [▶ 172] (DS402 Commutation angle) | 0x1A00 [▶ 173] (DS402 Statusword) |
| Cyclic synchronous position mode (CSP) | 0x1600 [▶ 172] (DS402 Controlword)<br>0x1606 [▶ 173] (DS402 Target position) | 0x1A00 [▶ 173] (DS402 Statusword)<br>0x1A01 [▶ 173] (DS402 Position actual value)<br>0x1A04 [▶ 173] (DS402 Following error actual value) |



PDO Assignment (0x1C13):

☑ 0x1A00
☑ 0x1A01
□ 0x1A02
□ 0x1A03
□ 0x1A04
□ 0x1A05
□ 0x1A06

PDO Content (0x1A00):

| Index | Size | Offs | Name | Type | Defa |
|---|---|---|---|---|---|
| 0x6000:11 | 4.0 | 0.0 | Position | UDINT | |
| | | 4.0 | | | |

Download
☑ PDO Assignment
□ PDO Configuration

Predefined PDO Assignment: 'Cyclic synchronous velocity mode (CSV)'

Predefined PDO Assignment: (none)
Predefined PDO Assignment: 'Cyclic synchronous torque mode (CST)'
Predefined PDO Assignment: 'Cyclic synchronous torque mode with commutation angle (CSTC
Predefined PDO Assignment: 'Cyclic synchronous velocity mode (CSV)'
Predefined PDO Assignment: 'Cyclic synchronous position mode (CSP)'

Fig. 162: Process data tab Predefined PDO Assignment, EL72x1

# 6 EL72x1 (MDP742) - Object description and parameterization

**EtherCAT XML Device Description**

The display matches that of the CoE objects from the EtherCAT XML Device Description. We recommend downloading the latest XML file from the download area of the Beckhoff website and installing it according to installation instructions.

**Parameterization via the CoE list (CAN over EtherCAT)**

The terminal is parameterized via the CoE - Online tab (double-click on the respective object) or via the Process Data tab (allocation of PDOs).
Please note the following general CoE information [▸ 28] when using/manipulating the CoE parameters:
- Keep a **startup list** if components have to be replaced
- Differentiation between online/offline dictionary, existence of current XML description
- use “CoE reload” for resetting changes

***NOTICE***

**Risk of damage to the device!**

We strongly advise not to change settings in the CoE objects while the axis is active, since this could impair the control.

## 6.1 Restore object

### Index 1011 Restore default parameters

| Index (hex) | Name | Meaning | Data type | Flags | Default |
|---|---|---|---|---|---|
| 1011:0 | Restore default parameters | Maximum subindex | UINT8 | RO | 0x01 ($1_{dec}$) |
| 1011:01 | SubIndex 001 | If this object is set to “**0x64616F6C**” in the set value dialog, all backup objects are reset to their delivery state. | UINT32 | RW | 0x00000000 ($0_{dec}$) |

## 6.2 Configuration data

### Index 8000 FB Settings

| Index (hex) | Name | Meaning | Data type | Flags | Default |
|---|---|---|---|---|---|
| 8000:0 | FB Settings | Maximum subindex | UINT8 | RO | 0x13 ($19_{dec}$) |
| 8000:01 | Invert feedback direction | Inverting the count direction | BOOLEAN | RW | 0x00 ($0_{dec}$) |
| 8000:11 | Device type | 1: Resolver (cannot be changed) | UINT32 | RO | 0x00000001 ($1_{dec}$) |
| 8000:12 | Singleturn bits | Number of single- and multi-turn-bits [▸ 104] | UINT8 | RW | 0x14 ($20_{dec}$) |
| 8000:13 | Multiturn bits | | UINT8 | RW | 0x0C ($12_{dec}$) |

### Index 8008 FB Resolver Settings

| Index (hex) | Name | Meaning | Data type | Flags | Default |
|---|---|---|---|---|---|
| 8008:0 | FB Resolver Settings | Maximum subindex | UINT8 | RO | 0x14 (20$_{dec}$) |
| 8008:01 | Invert feedback direction | Inverting the count direction | BOOLEAN | RW | 0x00 (0$_{dec}$) |
| 8008:02 | Enable automatic gain control | Activate automatic gain adjustment [▶ 105]. | BOOLEAN | RW | 0x01 (1$_{dec}$) |
| 8008:11 | Bandwidth | Resolver bandwidth [1 Hz] | UINT16 | RW | 0x01F4 (500$_{dec}$) |
| 8008:12 | Resolver gain adjustment | Sine and cosine signal level adaptation [▶ 105] | REAL32 | RW | 0x3F800000 (1065353216$_{dec}$) |
| 8008:13 | Resolver phase shift | Nominal resolver phase shift | INT8 | RW | 0x00 (0$_{dec}$) |
| 8008:14 | Observer feed-forward | Pre-control for speed monitor<br>**Unit:** % | UINT8 | RW | 0x32 (50$_{dec}$) |

### Index 8010 DRV Amplifier Settings

| Index (hex) | Name | Meaning | Data type | Flags | Default |
|---|---|---|---|---|---|
| 8010:0 | DRV Amplifier Settings | Maximum subindex | UINT8 | RO | 0x54 (84$_{dec}$) |
| 8010:01 | Enable TxPDOToggle | Show TxPDO toggle in status word (bit 10) | BOOLEAN | RW | 0x00 (0$_{dec}$) |
| 8010:02 | Enable input cycle counter | 1: active<br>A two bit counter is incremented with each process data cycle and switches to 0 after its maximum value of 3.<br>The low bit is displayed in bit 10 and the high bit is displayed in bit 14 of the status word. | BOOLEAN | RW | 0x00 (0$_{dez}$) |
| 8010:03 | Enable output cycle counter | reserved | BOOLEAN | RW | 0x00 (0$_{dez}$) |
| 8010:11 | Device type | 1: Servo drive (cannot be changed) | UINT32 | RO | 0x00000001 (1$_{dec}$) |
| 8010:12 | Current loop integral time | Current controller integral action time (Tn)<br>**Unit:** 0.1 ms | UINT16 | RW | 0x000A (10$_{dec}$) |
| 8010:13 | Current loop proportional gain | Proportional component of current controller<br>**Unit:** 0.1 V/A | UINT16 | RW | 0x0064 (100$_{dec}$) |
| 8010:14 | Velocity loop integral time | Speed controller integral action time (Tn)<br>**Unit:** 0.1 ms | UINT32 | RW | 0x00000032 (50$_{dec}$) |
| 8010:15 | Velocity loop proportional gain | Proportional component of velocity controller<br>**Unit:** mA / (rad/s) | UINT32 | RW | 0x00000096 (150$_{dec}$) |
| 8010:19 | Nominal DC link voltage | Nominal DC link voltage<br>**Unit:** mV | UINT32 | RW | 0x0000BB80 (48000$_{dec}$) |
| 8010:1A | Min DC link voltage | Minimum DC link voltage<br>**Unit:** mV | UINT32 | RW | 0x00004FB0 (20400$_{dec}$) |
| 8010:1B | Max DC link voltage | Maximum DC link voltage<br>**Unit:** mV | UINT32 | RW | 0x0000EA60 (60000$_{dec}$) |
| 8010:29 | Amplifier I2T warn level | I$^2$T model warning threshold<br>**Unit:** % | UINT8 | RW | 0x50 (80$_{dec}$) |
| 8010:2A | Amplifier I2T error level | I$^2$T model error threshold<br>**Unit:** % | UINT8 | RW | 0x69 (105$_{dec}$) |
| 8010:2B | Amplifier Temperature warn level | Overtemperature warning threshold<br>**Unit:** 0.1 °C | UINT16 | RW | 0x02BC (700$_{dec}$) |
| 8010:2C | Amplifier Temperature error level | Overtemperature error threshold<br>**Unit:** 0.1 °C | UINT16 | RW | 0x0352 (850$_{dec}$) |
| 8010:31 | Velocity limitation | Velocity limitation<br>**Unit:** rpm | UINT32 | RW | 0x00040000 (262144$_{dec}$) |
| 8010:32 | Short-Circuit Brake duration max | Max. duration of armature short circuit brake<br>**Unit:** ms | UINT16 | RW | 0x03E8 (1000$_{dec}$) |
| 8010:33 | Stand still window | Standstill window<br>**Unit:** rpm | UINT16 | RW | 0x0000 (0$_{dec}$) |

### Index 8010 DRV Amplifier Settings

| Index (hex) | Name | Meaning | Data type | Flags | Default |
|---|---|---|---|---|---|
| 8010:39 | Select info data 1 | Selection "Info data 1"<br>Optional display of additional information in the cyclic process data. The following parameters are available. | UINT8 | RW | 0x01 ($1_{dec}$) |
| | | Torque current (filtered 1 ms) | | | |
| | | DC link voltage [mV] | | | |
| | | PCB temperature [0,1 °C] | | | |
| | | Errors:<br>Bit0: ADC Error<br>Bit1: Overcurrent<br>Bit2: Undervoltage<br>Bit3: Overvoltage<br>Bit4: Overtemperature<br>Bit5: I2T Amplifier<br>Bit6: I2T Motor<br>Bit7: Encoder<br>Bit8: Watchdog | | | |
| | | Warnings:<br>Bit2: Undervoltage<br>Bit3: Overvoltage<br>Bit4: Overtemperature<br>Bit5: I2T Amplifier<br>Bit6: I2T Motor<br>Bit7: Encoder | | | |
| 8010:3A | Select info data 2 | Selection "Info data 2"<br>Optional display of additional information in the cyclic process data. The following parameters are available. | UINT8 | RW | 0x01 ($1_{dec}$) |
| | | Torque current (filtered 1 ms) | | | |
| | | DC link voltage [mV] | | | |
| | | PCB temperature [0,1 °C] | | | |
| | | Errors:<br>Bit0: ADC Error<br>Bit1: Overcurrent<br>Bit2: Undervoltage<br>Bit3: Overvoltage<br>Bit4: Overtemperature<br>Bit5: I2T Amplifier<br>Bit6: I2T Motor<br>Bit7: Encoder<br>Bit8: Watchdog | | | |
| | | Warnings:<br>Bit2: Undervoltage<br>Bit3: Overvoltage<br>Bit4: Overtemperature<br>Bit5: I2T Amplifier<br>Bit6: I2T Motor<br>Bit7: Encoder | | | |
| 8010:41 | Low-pass filter frequency | Low-pass filter frequency<br>**Unit:** Hz<br>The following values can be set:<br>0 Hz = off<br>320 Hz<br>640 Hz | UINT16 | RW | 0x0140 ($320_{dec}$) |
| 8010:49 | Halt ramp deceleration | Halt ramp deceleration<br>**Unit**: 0.1 rad / s² | UINT32 | RW | 0x0000F570 ($62832_{dec}$) |
| 8010:50 | Following error window | Following error monitor: Following error window<br>**Unit**: the given value must be multiplied by the corresponding scaling factor<br>0xFFFFFFFF ($-1_{dec}$) = following error monitor off<br>Any other value = following error monitor on | UINT32 | RW | 0xFFFFFFFF (-1) |

### Index 8010 DRV Amplifier Settings

| Index (hex) | Name | Meaning | Data type | Flags | Default |
|---|---|---|---|---|---|
| 8010:51 | Following error time out | Following error monitor: Timeout<br>**Unit:** ms<br>If the following error is larger than the following error window for a time that exceeds the timeout, this leads to an error reaction | UINT16 | RW | 0x0000 |
| 8010:52 | Fault reaction option code | Possible values:<br>0: Disable drive function, motor is free to rotate<br>1: Slow down on slow down ramp | UINT16 | RW | 0x0000 ($0_{dec}$) |
| 8010:53 | Position loop proportional gain | Proportional part of position controller<br>**Unit:** mA / (rad/s) | UINT32 | RW | 0x00000000 ($0_{dec}$) |
| 8010:54 | Feature bits | The feature bit switches:<br>Peak value → Bit 0 = 0 (default for EL7201-000x)<br>RMS value → Bit 0 = 1 (default for EL7211-000x)<br>With the help of the fan cartridge ZB8610, it is possible to increase the output current of the EL7201-000x<br>rated output current (2.8 $A_{rms}$) → Bit 1 = 0 (default)<br>increased output current (4.5 $A_{rms}$) → Bit 1 = 1<br>The following combination are possible:<br>$0_{dec}$ → rated output current, interpretation as peak value<br>$1_{dec}$ → rated output current, interpretation as RMS value<br>$2_{dec}$ →increased output current, interpretation as peak value<br>$3_{dec}$ → increased output current, interpretation as RMS value | UINT32 | RW | 0x00000000 ($0_{dec}$) |

### Index 8011 DRV Motor Settings

| Index (hex) | Name | Meaning | Data type | Flags | Default |
|---|---|---|---|---|---|
| 8011:0 | DRV Motor Settings | Maximum subindex | UINT8 | RO | 0x2D ($45_{dec}$) |
| 8011:11 | Max current | Peak current<br>**Unit:** mA<br>The adjustable motor current values can be interpreted as a peak value or RMS value.<br>The feature bit (0x8010:54 [▶ 146]) switches:<br>Peak value → Bit 0 = 0 (default for EL7201)<br>RMS value → Bit 0 = 1 (default for EL7211) | UINT32 | RW | 0x00001770 ($6000_{dec}$) |
| 8011:12 | Rated current | Rated current<br>**Unit:** mA<br>The adjustable motor current values can be interpreted as a peak value or RMS value.<br>The feature bit (0x8010:54 [▶ 146]) switches:<br>Peak value → Bit 0 = 0 (default for EL7201)<br>RMS value → Bit 0 = 1 (default for EL7211) | UINT32 | RW | 0x000003E8 ($1000_{dec}$) |
| 8011:13 | Motor pole pairs | Number of pole pairs | UINT8 | RW | 0x03 ($3_{dec}$) |
| 8011:15 | Commutation offset | Commutation offset (between electrical zero position and mechanical single-turn zero position)<br>**Unit:** ° | INT16 | RW | 0x0000 ($0_{dec}$) |
| 8011:16 | Torque constant | Torque constant<br>**Unit:** mNm / A | UINT32 | RW | 0x00000000 ($0_{dec}$) |
| 8011:18 | Rotor moment of inertia | Mass moment of inertia of the motor<br>**Unit:** g cm^2 | UINT32 | RW | 0x00000000 ($0_{dec}$) |
| 8011:19 | Winding inductance | Inductance<br>**Unit:** 0.1 mH | UINT16 | RW | 0x000E ($14_{dec}$) |
| 8011:1B | Motor speed limitation | Velocity limitation<br>**Unit:** rpm | UINT32 | RW | 0x00040000 ($262144_{dec}$) |
| 8011:29 | I2T warn level | I2T model warning threshold<br>**Unit:** % | UINT8 | RW | 0x50 ($80_{dec}$) |
| 8011:2A | I2T error level | I2T model error threshold<br>**Unit:** % | UINT8 | RW | 0x69 ($105_{dec}$) |
| 8011:2D | Motor thermal time constant | Thermal time constant<br>**Unit:** 0.1 s | UINT16 | RW | 0x0028 ($40_{dec}$) |

### Index 8012 DRV Brake Settings

| Index (hex) | Name | Meaning | Data type | Flags | Default |
|---|---|---|---|---|---|
| 8012:0 | DRV Brake Settings | Maximum subindex | UINT8 | RO | 0x14 ($20_{dec}$) |
| 8012:01 | Manual override (release) | Manual release of the motor holding brake | BOOLEAN | RW | 0x00 ($0_{dec}$) |
| 8012:11 | Release delay | Time the holding brake requires for opening (releasing) after the current was applied. | UINT16 | RW | 0x0000 ($0_{dec}$) |
| 8012:12 | Application delay | Time the holding brake requires for closing (holding) after the current was switched off. | UINT16 | RW | 0x0000 ($0_{dec}$) |
| 8012:13 | Emergency application timeout | Time the amplifier waits, until the rotation speed reaches the stand still window after stop request (set rotation speed 0 or Torque off). If the set waiting time is exceeded, the holding brake is triggered independently of the rotation speed.<br>**Note:**<br>For rotatory axes and the setting „torque off“ in error case, this parameter has to be set at least to the „coast to the stop“ time of the axis.<br>For suspended (hanging) axes and the setting „torque off“ in error case, this parameter has to be set to an appropriate short time, to prevent the axis/load from drop/fall. | UINT16 | RW | 0x0000 ($0_{dec}$) |
| 8012:14 | Brake moment of inertia | Mass moment of inertia of the brake<br>**Unit:** g cm^2 | UINT16 | RW | 0x0000 ($0_{dec}$) |

## 6.3 Configuration data (vendor-specific)

### Index 801F DRV Vendor data

| Index (hex) | Name | Meaning | Data type | Flags | Default |
|---|---|---|---|---|---|
| 801F:0 | DRV Vendor data | Maximum subindex | UINT8 | RO | 0x15 ($21_{dec}$) |
| 801F:11 | Amplifier peak current | Peak current of the amplifier<br>**Unit:** mA | UINT32 | RO | 0x00001F40 ($8000_{dec}$) |
| 801F:12 | Amplifier rated current | Rated current of the amplifier<br>**Unit:** mA | UINT32 | RO | 0x00000FA0 ($4000_{dec}$) |
| 801F:13 | Amplifier thermal time constant | Thermal time constant of the amplifier<br>**Unit:** 0.1 ms | UINT16 | RO | 0x0023 ($35_{dec}$) |
| 801F:14 | Amplifier overcurrent threshold | Threshold value for short-circuit detection<br>**Unit:** mA | UINT32 | RO | 0x00002EE0 ($12000_{dec}$) |
| 801F:15 | Max rotary field frequency | Max. rotary field frequency in Hz | UINT16 | RO | 0x0257 ($599_{dec}$) |

# 6.4 Command object

### Index FB00 DCM Command

| Index (hex) | Name | Meaning | | | Data type | Flags | Default |
|---|---|---|---|---|---|---|---|
| FB00:0 | DCM Command | Max. subindex | | | UINT8 | RO | 0x03 ($3_{\text{dec}}$) |
| FB00:01 | Request | 0x1000 | Clear diag history | Clear the Diag History | OCTET-STRING[2] | RW | {0} |
| | | 0x1100 | Get build number | Read out the build number | | | |
| | | 0x1101 | Get build date | Read out the build date | | | |
| | | 0x1102 | Get build time | Read out the build time | | | |
| | | 0x8000 | Software reset | Perform a software reset (hardware is re-initialized with the current CoE configuration; this otherwise happens only during the transition to INIT) | | | |
| FB00:02 | Status | 0 | Finished, no error, no response | Command terminated without error and without response | UINT8 | RO | 0x00 ($0_{\text{dec}}$) |
| | | 1 | Finished, no error, response | Command terminated without error and with response | | | |
| | | 2 | Finished, error, no response | Command terminated with error and without response | | | |
| | | 3 | Finished, error, response | Command terminated with error and with response | | | |
| | | 255 | Executing | Command is being executed | | | |
| FB00:03 | Response | dependent on the request | | | OCTET-STRING[4] | RO | {0} |

# 6.5 Input data

### Index 6000 FB Inputs

| Index (hex) | Name | Meaning | Data type | Flags | Default |
|---|---|---|---|---|---|
| 6000:0 | FB Inputs | Maximum subindex | UINT8 | RO | 0x11 ($17_{\text{dec}}$) |
| 6000:0E | TxPDO State | TRUE:<br>position data not valid<br>FALSE:<br>position data valid | BOOLEAN | RO | 0x00 ($0_{\text{dez}}$) |
| 6000:0F | Input Cycle Counter | Is incremented with each process data cycle and switches to 0 after its maximum value of 3. | BIT2 | RO | 0x00 ($0_{\text{dez}}$) |
| 6000:11 | Position | Position | UINT32 | RO | 0x00000000 ($0_{\text{dec}}$) |

### Index 6010 DRV Inputs

| Index (hex) | Name | Meaning | Data type | Flags | Default |
|---|---|---|---|---|---|
| 6010:0 | DRV Inputs | Maximum subindex | UINT8 | RO | 0x13 (19$_{dec}$) |
| 6010:01 | Statusword | Statusword [▶ 111]<br>Bit 0 : Ready to switch on<br>Bit 1 : Switched on<br>Bit 2 : Operation enabled<br>Bit 3 : Fault<br>Bit 4 : reserved<br>Bit 5 : reserved<br>Bit 6 : Switch on disabled<br>Bit 7 : Warning<br>Bit 8 + 9 : reserved<br>Bit 10: TxPDOToggle (selection/deselection via 0x8010:01 [▶ 146])<br>Bit 11 : Internal limit active<br>Bit 12 : Drive follows the command value<br>Bit 13 - 15 : reserved | UINT16 | RO | 0x0000 (0$_{dec}$) |
| 6010:03 | Modes of operation display | Display of the operating mode | UINT8 | RO | 0x00 (0$_{dec}$) |
| 6010:07 | Velocity actual value | Display of the current velocity value<br>**Unit**: see Index 0x9010:14 [▶ 154] | INT32 | RO | 0x00000000 (0$_{dec}$) |
| 6010:08 | Torque actual value | Display of current torque value<br>The value is specified in 1000th of the *rated current* (0x8011:12 [▶ 148])<br>Formula for Index 8010:54 [▶ 146] = 0 :<br>M = ((Torque actual value / 1000) x (rated current / √2)) x torque constant (0x8011:16 [▶ 148])<br>Formula for Index 0x8010:54 [▶ 146] = 1 :<br>M = ((Torque actual value / 1000) x rated current)) x torque constant (0x8011:16 [▶ 148]) | INT16 | RO | 0x0000 (0$_{dec}$) |
| 6010:09 | Following error actual value | Following error<br>**Unit**: the given value must be multiplied by the corresponding scaling factor [▶ 120] | INT32 | RO | 0x00000000 (0$_{dec}$) |
| 6010:12 | Info data 1 | Synchronous information (selection via subindex 0x8010:39) | UINT16 | RO | 0x0000 (0$_{dec}$) |
| 6010:13 | Info data 2 | Synchronous information (selection via subindex 0x8010:3A) | UINT16 | RO | 0x0000 (0$_{dec}$) |

# 6.6 Output data

### Index 7010 DRV Outputs

| Index (hex) | Name | Meaning | Data type | Flags | Default |
|---|---|---|---|---|---|
| 7010:0 | DRV Outputs | Maximum subindex | UINT8 | RO | 0x0E ($14_{dec}$) |
| 7010:01 | Controlword | Controlword [▶ 111]<br>Bit 0 : Switch on<br>Bit 1 : Enable voltage<br>Bit 2 : reserved<br>Bit 3 : Enable operation<br>Bit 4 - 6 : reserved<br>Bit 7 : Fault reset<br>Bit 8 - 15 : reserved | UINT16 | RO | 0x0000 ($0_{dec}$) |
| 7010:03 | Modes of operation | Setting the operating mode<br>0x08: Cyclic synchronous position mode (CSP)<br>0x09: Cyclic synchronous velocity mode (CSV)<br>0x0A: Cyclic synchronous torque mode (CST)<br>0x0B: Cyclic synchronous torque mode with commutation angle (CSTCA) | UINT8 | RW | 0x00 ($0_{dec}$) |
| 7010:05 | Target position | Configured target position<br>**Unit**: the value must be multiplied by the corresponding scaling factor [▶ 120] | UINT32 | RW | 0x00000000 ($0_{dec}$) |
| 7010:06 | Target velocity | Configured target velocity<br>The velocity scaling can be found in object 0x9010:14 [▶ 154] (Velocity encoder resolution) | INT32 | RO | 0x00000000 ($0_{dec}$) |
| 7010:09 | Target torque | Configured input value for torque monitoring<br>The value is specified in 1000th of the *rated current* (0x8011:12 [▶ 148])<br>Formula for Index 8010:54 [▶ 146] = 0 :<br>M = ((Torque actual value / 1000) x (rated current / √2)) x torque constant (0x8011:16 [▶ 148])<br>Formula for Index 8010:54 [▶ 146] = 1 :<br>M = ((Torque actual value / 1000) x rated current)) x torque constant (0x8011:16 [▶ 148]) | INT16 | RO | 0x0000 ($0_{dec}$) |
| 7010:0A | Torque offset | Torque value offset<br>The value is specified in 1000th of the *rated current* (0x8011:12 [▶ 148])<br>Formula for Index 0x8010:54 [▶ 146] = 0 :<br>M = ((Torque actual value / 1000) x (rated current / √2)) x torque constant (0x8011:16 [▶ 148])<br>Formula for Index 0x8010:54 [▶ 146] = 1 :<br>M = ((Torque actual value / 1000) x rated current)) x torque constant (0x8011:16 [▶ 148]) | INT16 | RO | 0x0000 ($0_{dec}$) |
| 7010:0B | Torque limitation | Torque threshold value for torque monitoring (bipolar limit)<br>The value is specified in 1000th of the *rated current* (0x8011:12 [▶ 148])<br>Formula for Index 0x8010:54 [▶ 146] = 0 :<br>M = ((Torque actual value / 1000) x (rated current / √2)) x torque constant (0x8011:16 [▶ 148])<br>Formula for Index 8010:54 [▶ 146] = 1 :<br>M = ((Torque actual value / 1000) x rated current)) x torque constant (0x8011:16 [▶ 148]) | UINT16 | RW | 0x7FFF ($32767_{dec}$) |
| 7010:0E | Commutation angle | Commutation angle (for CSTCA mode)<br>**Unit:** 360° / $2^{16}$ | UINT16 | RO | 0x0000 ($0_{dec}$) |

## 6.7 Information / diagnosis data

### Index 10F3 Diagnosis History

| Index (hex) | Name | Meaning | Data type | Flags | Default |
|---|---|---|---|---|---|
| 10F3:0 | Diagnosis History | Maximum subindex | UINT8 | RO | 0x37 (55$_{dec}$) |
| 10F3:01 | Maximum Messages | Maximum number of stored messages<br>A maximum of 50 messages can be stored | UINT8 | RO | 0x32 (50$_{dec}$) |
| 10F3:02 | Newest Message | Subindex of the latest message | UINT8 | RO | 0x00 (0$_{dec}$) |
| 10F3:03 | Newest Acknowledged Message | Subindex of the last confirmed message | UINT8 | RW | 0x00 (0$_{dec}$) |
| 10F3:04 | New Messages Available | Indicates that a new message is available | BOOLEAN | RO | 0x00 (0$_{dec}$) |
| 10F3:05 | Flags | not used | UINT16 | RW | 0x0000 (0$_{dec}$) |
| 10F3:06 | Diagnosis Message 001 | Message 1 | OCTET-STRING[28] | RO | {0} |
| … | … | … | … | … | … |
| 10F3:37 | Diagnosis Message 050 | Message 50 | OCTET-STRING[28] | RO | {0} |

### Index 10F8 Actual Time Stamp

| Index (hex) | Name | Meaning | Data type | Flags | Default |
|---|---|---|---|---|---|
| 10F8:0 | Actual Time Stamp | Time stamp | UINT64 | RO | |

### Index 9008 FB Resolver Info data

| Index (hex) | Name | Meaning | Data type | Flags | Default |
|---|---|---|---|---|---|
| 9008:0 | FB Resolver Info data | Maximum subindex | UINT8 | RO | 0x12 (18$_{dec}$) |
| 9008:12 | Automatic resolver gain value | Current value for the sine and cosine signal level adaptation (only if "Enable automatic gain control" is active) | REAL32 | RO | 0x00000000 (0$_{dec}$) |

## Index 9010 DRV Info data

| Index (hex) | Name | Meaning | Data type | Flags | Default |
|---|---|---|---|---|---|
| 9010:0 | DRV Info data | Maximum subindex | UINT8 | RO | 0x16 (22$_{dec}$) |
| 9010:11 | Amplifier temperature | Internal terminal temperature<br>**Unit:** 0.1 °C | UINT16 | RO | 0x0000 (0$_{dec}$) |
| 9010:12 | DC link voltage | DC link voltage<br>**Unit:** mV | UINT32 | RO | 0x00000000 (0$_{dec}$) |
| 9010:13 | Supported drive modes | Information on supported operation modes (DS402: object 0x6502)<br>Only modes *CSV*, *CST* and *CSTCA* are supported<br>Bit 0: PP<br>Bit 1: VL<br>Bit 2: PV<br>Bit 3: TQ<br>Bit 4: R<br>Bit 5: HM<br>Bit 6: IP<br>Bit 7: CSP<br>Bit 8: CSV<br>Bit 9: CST<br>Bit 10: CSTCA<br>Bit 11-15: reserved<br>Bit 16-31: Manufacturer specific | UINT32 | RO | 0x00000700 (1792$_{dec}$) |
| 9010:14 | Velocity encoder resolution | Display of configured encoder increments/s and motor revolutions/s.<br>The velocity encoder resolution is calculated according to the following formula:<br>Velocity Encoder Resolution = (encoder_increments / s ) / (motor_revolutions / s) | UINT32 | RO | 0x00041893 (268435$_{dec}$) |
| 9010:15 | Position encoder resolution increments | Feedback increments per motor turn | UINT32 | RO | 0x00000000 (0$_{dez}$) |
| 9010:16 | Position encoder resolution revolutions | Motor revolutions<br>Position encoder resolution = encoder increments (Index 0x9010:15) / motor revolutions (Index 0x9010:16) | UINT32 | RO | 0x00000000 (0$_{dez}$) |

## Index 9018 DRV Info data

| Index (hex) | Name | Meaning | Data type | Flags | Default |
|---|---|---|---|---|---|
| 9018:0 | DRV Info data | Maximum subindex | UINT8 | RO | 0x11 (17$_{dec}$) |
| 9018:11 | Auxiliary voltage (10 V) | Auxiliary voltage<br>**Unit:** mV | UINT322 | RO | 0x00000000 (0$_{dec}$) |

## Index A010 DRV Amplifier Diag data

| Index (hex) | Name | Meaning | Data type | Flags | Default |
|---|---|---|---|---|---|
| A010:0 | DRV Amplifier Diag data | Maximum subindex | UINT8 | RO | 0x11 (17$_{dec}$) |
| A010:11 | Amplifier I2T temperature | I2T model load<br>**Unit:** % | UINT8 | RO | 0x00 (0$_{dec}$) |

## Index A011 DRV Motor Diag data

| Index (hex) | Name | Meaning | Data type | Flags | Default |
|---|---|---|---|---|---|
| A011:0 | DRV Motor Diag data | Maximum subindex | UINT8 | RO | 0x11 (17$_{dec}$) |
| A011:11 | Motor I2T temperature | I2T model load<br>**Unit:** % | UINT8 | RO | 0x00 (0$_{dec}$) |

## Index FB40 Memory interface

| Index (hex) | Name | Meaning | Data type | Flags | Default |
|---|---|---|---|---|---|
| FB40:0 | Memory interface | Maximum subindex | UINT8 | RO | 0x03 (3$_{dec}$) |
| FB40:01 | Address | reserved | UINT32 | RW | 0x00000000 (0$_{dec}$) |
| FB40:02 | Length | reserved | UINT16 | RW | 0x0000 (0$_{dec}$) |
| FB40:03 | Data | reserved | OCTET-STRING[8] | RW | {0} |

## 6.8 Standard objects

The standard objects have the same meaning for all EtherCAT slaves.

### Index 1000 Device type

| Index (hex) | Name | Meaning | Data type | Flags | Default |
|---|---|---|---|---|---|
| 1000:0 | Device type | Device type of the EtherCAT slave: the Lo-Word contains the CoE profile used (5001). The Hi-Word contains the module profile according to the modular device profile. | UINT32 | RO | 0x00001389 ($5001_{dec}$) |

### Index 1008 Device name

| Index (hex) | Name | Meaning | Data type | Flags | Default |
|---|---|---|---|---|---|
| 1008:0 | Device name | Device name of the EtherCAT slave | STRING | RO | EL72x1 |

### Index 1009 Hardware version

| Index (hex) | Name | Meaning | Data type | Flags | Default |
|---|---|---|---|---|---|
| 1009:0 | Hardware version | Hardware version of the EtherCAT slave | STRING | RO | 00 |

### Index 100A Software version

| Index (hex) | Name | Meaning | Data type | Flags | Default |
|---|---|---|---|---|---|
| 100A:0 | Software version | Firmware version of the EtherCAT slave | STRING | RO | 01 |

### Index 1018 Identity

| Index (hex) | Name | Meaning | Data type | Flags | Default |
|---|---|---|---|---|---|
| 1018:0 | Identity | Maximum subindex | UINT8 | RO | 0x04 ($4_{dec}$) |
| 1018:01 | Vendor ID | Vendor ID of the EtherCAT slave | UINT32 | RO | 0x00000002 ($2_{dec}$) |
| 1018:02 | Product code | Product code of the EtherCAT slave | UINT32 | RO | 0x1C213052 ($471937106_{dec}$) |
| 1018:03 | Revision | Revision number of the EtherCAT slave; the low word (bit 0-15) indicates the special terminal number, the high word (bit 16-31) refers to the device description | UINT32 | RO | 0x00110000 ($1114112_{dec}$) |
| 1018:04 | Serial number | Unique serial number | UINT32 | RO | 0x00000000 ($0_{dec}$) |

### Index 10F0 Backup parameter handling

| Index (hex) | Name | Meaning | Data type | Flags | Default |
|---|---|---|---|---|---|
| 10F0:0 | Backup parameter handling | Information for standardized loading and saving of backup entries | UINT8 | RO | 0x01 ($1_{dec}$) |
| 10F0:01 | Checksum | Checksum across all backup entries of the EtherCAT slave | UINT32 | RO | 0x00000000 ($0_{dec}$) |

### Index 1600 DRV RxPDO-Map Controlword

| Index (hex) | Name | Meaning | Data type | Flags | Default |
|---|---|---|---|---|---|
| 1600:0 | DRV RxPDO-Map Controlword | PDO Mapping RxPDO 1 | UINT8 | RO | 0x01 ($1_{dec}$) |
| 1600:01 | SubIndex 001 | 1. PDO Mapping entry (object 0x7010 (DRV Outputs), entry 0x01 (Controlword)) | UINT32 | RO | 0x7010:01, 16 |

### Index 1601 DRV RxPDO-Map Target velocity

| Index (hex) | Name | Meaning | Data type | Flags | Default |
|---|---|---|---|---|---|
| 1601:0 | DRV RxPDO-Map Target velocity | PDO Mapping RxPDO 2 | UINT8 | RO | 0x01 ($1_{dec}$) |
| 1601:01 | SubIndex 001 | 1. PDO Mapping entry (object 0x7010 (DRV Outputs), entry 0x05 (Target position)) | UINT32 | RO | 0x7010:06, 32 |

### Index 1602 DRV RxPDO-Map Target torque

| Index (hex) | Name | Meaning | Data type | Flags | Default |
|---|---|---|---|---|---|
| 1602:0 | DRV RxPDO-Map Target torque | PDO Mapping RxPDO 3 | UINT8 | RO | 0x01 ($1_{dec}$) |
| 1602:01 | SubIndex 001 | 1. PDO Mapping entry (object 0x7010 (DRV Outputs), entry 0x09 (Target torque)) | UINT32 | RO | 0x7010:09, 16 |

### Index 1603 DRV RxPDO-Map Commutation angle

| Index (hex) | Name | Meaning | Data type | Flags | Default |
|---|---|---|---|---|---|
| 1603:0 | DRV RxPDO-Map Commutation angle | PDO Mapping RxPDO 4 | UINT8 | RO | 0x01 ($1_{dec}$) |
| 1603:01 | SubIndex 001 | 1. PDO Mapping entry (object 0x7010 (DRV Outputs), entry 0x0E (Commutation angle)) | UINT32 | RO | 0x7010:0E, 16 |

### Index 1604 DRV RxPDO-Map Torque limitation

| Index (hex) | Name | Meaning | Data type | Flags | Default |
|---|---|---|---|---|---|
| 1604:0 | DRV RxPDO-Map Torque limitation | PDO Mapping RxPDO 5 | UINT8 | RO | 0x01 ($1_{dec}$) |
| 1604:01 | SubIndex 001 | 1. PDO Mapping entry (object 0x7010 (DRV Outputs), entry 0x0B (Torque limitation)) | UINT32 | RO | 0x7010:0B, 16 |

### Index 1605 DRV RxPDO-Map Torque offset

| Index (hex) | Name | Meaning | Data type | Flags | Default |
|---|---|---|---|---|---|
| 1605:0 | DRV RxPDO-Map Torque offset | PDO Mapping RxPDO 6 | UINT8 | RO | 0x01 ($1_{dec}$) |
| 1605:01 | SubIndex 001 | 1. PDO Mapping entry (object 0x7010 (DRV Outputs), entry 0x0A (Torque offset)) | UINT32 | RO | 0x7010:0A, 16 |

### Index 1606 DRV RxPDO-Map Target position

| Index (hex) | Name | Meaning | Data type | Flags | Default |
|---|---|---|---|---|---|
| 1606:0 | DRV RxPDO-Map Target position | PDO Mapping RxPDO 7 | UINT8 | RO | 0x01 ($1_{dec}$) |
| 1606:01 | SubIndex 001 | 1. PDO Mapping entry (object 0x7010 (DRV Outputs), entry 0x0A (Torque offset)) | UINT32 | RO | 0x7010:05, 32 |

### Index 1A00 FB TxPDO-Map Position

| Index (hex) | Name | Meaning | Data type | Flags | Default |
|---|---|---|---|---|---|
| 1A00:0 | FB TxPDO-Map Position | PDO Mapping TxPDO 1 | UINT8 | RO | 0x01 ($1_{dec}$) |
| 1A00:01 | SubIndex 001 | 1. PDO Mapping entry (object 0x6041 (Statusword), entry 0x00 (Statusword)) | UINT32 | RO | 0x6000:11, 32 |

### Index 1A01 DRV TxPDO-Map Statusword

| Index (hex) | Name | Meaning | Data type | Flags | Default |
|---|---|---|---|---|---|
| 1A01:0 | DRV TxPDO-Map Statusword | PDO Mapping TxPDO 2 | UINT8 | RO | 0x01 ($1_{dec}$) |
| 1A01:01 | SubIndex 001 | 1. PDO Mapping entry (object 0x6010 (DRV Inputs), entry 0x01 (Statusword)) | UINT32 | RO | 0x6010:01, 16 |

### Index 1A02 DRV TxPDO-Map Velocity actual value

| Index (hex) | Name | Meaning | Data type | Flags | Default |
|---|---|---|---|---|---|
| 1A02:0 | DRV TxPDO-Map Velocity actual value | PDO Mapping TxPDO 3 | UINT8 | RO | 0x01 ($1_{dec}$) |
| 1A02:01 | SubIndex 001 | 1. PDO Mapping entry (object 0x6010 (DRV Inputs), entry 0x07 (Velocity actual value)) | UINT32 | RO | 0x6010:07, 32 |

### Index 1A03 DRV TxPDO-Map Torque actual value

| Index (hex) | Name | Meaning | Data type | Flags | Default |
|---|---|---|---|---|---|
| 1A03:0 | DRV TxPDO-Map Torque actual value | PDO Mapping TxPDO 4 | UINT8 | RO | 0x01 ($1_{dec}$) |
| 1A03:01 | SubIndex 001 | 1. PDO Mapping entry (object 0x6010 (DRV Inputs), entry 0x08 (Torque actual value)) | UINT32 | RO | 0x6010:08, 16 |

### Index 1A04 DRV TxPDO-Map Info data 1

| Index (hex) | Name | Meaning | Data type | Flags | Default |
|---|---|---|---|---|---|
| 1A04:0 | DRV TxPDO-Map Info data 1 | PDO Mapping TxPDO 5 | UINT8 | RO | 0x01 ($1_{dec}$) |
| 1A04:01 | SubIndex 001 | 1. PDO Mapping entry (object 0x6010 (DRV Inputs), entry 0x12 (Info data 1)) | UINT32 | RO | 0x6010:12, 16 |

### Index 1A05 DRV TxPDO-Map Info data 2

| Index (hex) | Name | Meaning | Data type | Flags | Default |
|---|---|---|---|---|---|
| 1A05:0 | DRV TxPDO-Map Info data 2 | PDO Mapping TxPDO 6 | UINT8 | RO | 0x01 ($1_{dec}$) |
| 1A05:01 | SubIndex 001 | 1. PDO Mapping entry (object 0x6010 (DRV Inputs), entry 0x13 (Info data 2)) | UINT32 | RO | 0x6010:13, 16 |

### Index 1A06 DRV TxPDO-Map Following error actual value

| Index (hex) | Name | Meaning | Data type | Flags | Default |
|---|---|---|---|---|---|
| 1A06:0 | DRV TxPDO-Map Following error actual value | PDO Mapping TxPDO 7 | UINT8 | RO | 0x01 ($1_{dec}$) |
| 1A06:01 | SubIndex 001 | 1. PDO Mapping entry (object 0x6010 (DRV Inputs), entry 0x01 (Statusword)) | UINT32 | RO | 0x6010:09, 32 |

### Index 1A0C FB TxPDO-Map Status

| Index (hex) | Name | Meaning | Data type | Flags | Default |
|---|---|---|---|---|---|
| 1A0C:0 | FB TxPDO-Map Status | PDO Mapping TxPDO 1 | UINT8 | RO | 0x03 ($3_{dec}$) |
| 1A0C:01 | SubIndex 001 | 1. PDO Mapping entry (13 bits align) | UINT32 | RO | 0x0000:00, 13 |
| 1A0C:02 | SubIndex 002 | 2. PDO Mapping entry (object 0x6000 (FB Inputs), entry 0x0E (TxPDO State)) | UINT32 | RO | 0x6000:0E, 1 |
| 1A0C:03 | SubIndex 003 | 3. PDO Mapping entry (object 0x6000 (FB Inputs), entry 0x0F (Input Cycle Counter)) | UINT32 | RO | 0x6000:0F, 2 |

### Index 1C00 Sync manager type

| Index (hex) | Name | Meaning | Data type | Flags | Default |
|---|---|---|---|---|---|
| 1C00:0 | Sync manager type | Using the sync managers | UINT8 | RO | 0x04 ($4_{dec}$) |
| 1C00:01 | SubIndex 001 | Sync-Manager Type Channel 1: Mailbox Write | UINT8 | RO | 0x01 ($1_{dec}$) |
| 1C00:02 | SubIndex 002 | Sync-Manager Type Channel 2: Mailbox Read | UINT8 | RO | 0x02 ($2_{dec}$) |
| 1C00:03 | SubIndex 003 | Sync-Manager Type Channel 3: Process Data Write (Outputs) | UINT8 | RO | 0x03 ($3_{dec}$) |
| 1C00:04 | SubIndex 004 | Sync-Manager Type Channel 4: Process Data Read (Inputs) | UINT8 | RO | 0x04 ($4_{dec}$) |

### Index 1C12 RxPDO assign

| Index (hex) | Name | Meaning | Data type | Flags | Default |
|---|---|---|---|---|---|
| 1C12:0 | RxPDO assign | PDO Assign Outputs | UINT8 | RW | 0x02 (2$_{dec}$) |
| 1C12:01 | Subindex 001 | 1. allocated RxPDO (contains the index of the associated RxPDO mapping object) | UINT16 | RW | 0x1600 (5632$_{dec}$) |
| 1C12:02 | Subindex 002 | 2. allocated RxPDO (contains the index of the associated RxPDO mapping object) | UINT16 | RW | 0x1601 (5633$_{dec}$) |
| 1C12:03 | SubIndex 003 | 3. allocated RxPDO (contains the index of the associated RxPDO mapping object) | UINT16 | RW | 0x0000 (0$_{dec}$) |
| 1C12:04 | SubIndex 004 | 4. allocated RxPDO (contains the index of the associated RxPDO mapping object) | UINT16 | RW | 0x0000 (0$_{dec}$) |
| 1C12:05 | SubIndex 005 | 5. allocated RxPDO (contains the index of the associated RxPDO mapping object) | UINT16 | RW | 0x0000 (0$_{dec}$) |
| 1C12:06 | SubIndex 006 | 6. allocated RxPDO (contains the index of the associated RxPDO mapping object) | UINT16 | RW | 0x0000 (0$_{dec}$) |

### Index 1C13 TxPDO assign

| Index (hex) | Name | Meaning | Data type | Flags | Default |
|---|---|---|---|---|---|
| 1C13:0 | TxPDO assign | PDO Assign Inputs | UINT8 | RW | 0x02 (2$_{dec}$) |
| 1C13:01 | Subindex 001 | 1. allocated TxPDO (contains the index of the associated TxPDO mapping object) | UINT16 | RW | 0x1A00 (6656$_{dec}$) |
| 1C13:02 | Subindex 002 | 2. allocated TxPDO (contains the index of the associated TxPDO mapping object) | UINT16 | RW | 0x1A01 (6657$_{dec}$) |
| 1C13:03 | SubIndex 003 | 3. allocated TxPDO (contains the index of the associated TxPDO mapping object) | UINT16 | RW | 0x0000 (0$_{dec}$) |
| 1C13:04 | SubIndex 004 | 4. allocated TxPDO (contains the index of the associated TxPDO mapping object) | UINT16 | RW | 0x0000 (0$_{dec}$) |
| 1C13:05 | SubIndex 005 | 5. allocated TxPDO (contains the index of the associated TxPDO mapping object) | UINT16 | RW | 0x0000 (0$_{dec}$) |
| 1C13:06 | SubIndex 006 | 6. allocated TxPDO (contains the index of the associated TxPDO mapping object) | UINT16 | RW | 0x0000 (0$_{dec}$) |

### Index 1C32 SM output parameter

| Index (hex) | Name | Meaning | Data type | Flags | Default |
|---|---|---|---|---|---|
| 1C32:0 | SM output parameter | Synchronization parameters for the outputs | UINT8 | RO | 0x20 (32$_{dec}$) |
| 1C32:01 | Sync mode | Current synchronization mode:<br>• 3: DC-Mode - Synchronous with SYNC1 event | UINT16 | RW | 0x0001 (1$_{dec}$) |
| 1C32:02 | Cycle time | Cycle time (in ns):<br>• Free Run: Cycle time of the local timer<br>• Synchronous with SM 2 event: Master cycle time<br>• DC mode: SYNC0/SYNC1 Cycle Time | UINT32 | RW | 0x000F4240 (1000000$_{dec}$) |
| 1C32:03 | Shift time | Time between SYNC0 event and output of the outputs (in ns, DC mode only) | UINT32 | RO | 0x00000000 (0$_{dec}$) |
| 1C32:04 | Sync modes supported | Supported synchronization modes:<br>• Bit 0 = 1: free run is supported<br>• Bit 1 = 1: Synchronous with SM 2 event is supported<br>• Bit 2-3 = 01: DC mode is supported<br>• Bit 4-5 = 10: Output shift with SYNC1 event (only DC mode)<br>• Bit 14 = 1: dynamic times (measurement through writing of 0x1C32:08 [▶ 159]) | UINT16 | RO | 0xC007 (49159$_{dec}$) |
| 1C32:05 | Minimum cycle time | Minimum cycle time (in ns) | UINT32 | RO | 0x000249F0 (150000$_{dec}$) |
| 1C32:06 | Calc and copy time | Minimum time between SYNC0 and SYNC1 event (in ns, DC mode only) | UINT32 | RO | 0x00000000 (0$_{dec}$) |
| 1C32:07 | Minimum delay time | | UINT32 | RO | 0x00000000 (0$_{dec}$) |
| 1C32:08 | Command | • 0: Measurement of the local cycle time is stopped<br>• 1: Measurement of the local cycle time is started<br>The entries 0x1C32:03 [▶ 159], 0x1C32:05 [▶ 159], 0x1C32:06 [▶ 159], 0x1C32:09 [▶ 159], 0x1C33:03 [▶ 160], 0x1C33:06 [▶ 159], 0x1C33:09 [▶ 160] are updated with the maximum measured values.<br>For a subsequent measurement the measured values are reset | UINT16 | RW | 0x0000 (0$_{dec}$) |
| 1C32:09 | Maximum Delay time | Time between SYNC1 event and output of the outputs (in ns, DC mode only) | UINT32 | RO | 0x00000000 (0$_{dec}$) |
| 1C32:0B | SM event missed counter | Number of missed SM events in OPERATIONAL (DC mode only) | UINT16 | RO | 0x0000 (0$_{dec}$) |
| 1C32:0C | Cycle exceeded counter | Number of occasions the cycle time was exceeded in OPERATIONAL (cycle was not completed in time or the next cycle began too early) | UINT16 | RO | 0x0000 (0$_{dec}$) |
| 1C32:0D | Shift too short counter | Number of occasions that the interval between SYNC0 and SYNC1 event was too short (DC mode only) | UINT16 | RO | 0x0000 (0$_{dec}$) |
| 1C32:20 | Sync error | The synchronization was not correct in the last cycle (outputs were output too late; DC mode only) | BOOLEAN | RO | 0x00 (0$_{dec}$) |

### Index 1C33 SM input parameter

| Index (hex) | Name | Meaning | Data type | Flags | Default |
|---|---|---|---|---|---|
| 1C33:0 | SM input parameter | Synchronization parameters for the inputs | UINT8 | RO | 0x20 (32$_{dec}$) |
| 1C33:01 | Sync mode | Current synchronization mode:<br>• 3: DC - Synchronous with SYNC1 Event | UINT16 | RW | 0x0000 (0$_{dec}$) |
| 1C33:02 | Cycle time | as 0x1C32:02 [▸ 159] | UINT32 | RW | 0x0003D090 (250000$_{dec}$) |
| 1C33:03 | Shift time | Time between SYNC0 event and reading of the inputs (in ns, only DC mode) | UINT32 | RO | 0x00001C52 (7250$_{dec}$) |
| 1C33:04 | Sync modes supported | Supported synchronization modes:<br>• Bit 0: free run is supported<br>• Bit 1: synchronous with SM 2 event is supported (outputs available)<br>• Bit 1: synchronous with SM 3 event is supported (no outputs available)<br>• Bit 2-3 = 01: DC mode is supported<br>• Bit 4-5 = 01: input shift through local event (outputs available)<br>• Bit 4-5 = 10: input shift with SYNC1 event (no outputs available)<br>• Bit 14 = 1: dynamic times (measurement through writing of 0x1C32:08 [▸ 159] or 0x1C33:08 [▸ 160]) | UINT16 | RO | 0xC007 (49159$_{dec}$) |
| 1C33:05 | Minimum cycle time | as 0x1C32:05 [▸ 159] | UINT32 | RO | 0x0001E848 (125000$_{dec}$) |
| 1C33:06 | Calc and copy time | Time between reading of the inputs and availability of the inputs for the master (in ns, only DC mode) | UINT32 | RO | 0x00000000 (0$_{dec}$) |
| 1C33:07 | Minimum delay time | | UINT322 | RO | 0x00001C52 (7250$_{dec}$) |
| 1C33:08 | Command | as 0x1C32:08 [▸ 159] | UINT16 | RW | 0x0000 (0$_{dec}$) |
| 1C33:09 | Maximum delay time | Time between SYNC1 event and reading of the inputs (in ns, only DC mode) | UINT32 | RO | 0x00001C52 (7250$_{dec}$) |
| 1C33:0B | SM event missed counter | as 0x1C32:11 [▸ 159] | UINT16 | RO | 0x0000 (0$_{dec}$) |
| 1C33:0C | Cycle exceeded counter | as 0x1C32:12 [▸ 159] | UINT16 | RO | 0x0000 (0$_{dec}$) |
| 1C33:0D | Shift too short counter | as 0x1C32:13 [▸ 159] | UINT16 | RO | 0x0000 (0$_{dec}$) |
| 1C33:20 | Sync error | as 0x1C32:32 [▸ 159] | BOOLEAN | ROO | 0x00 (0$_{dec}$) |

### Index F000 Modular device profile

| Index (hex) | Name | Meaning | Data type | Flags | Default |
|---|---|---|---|---|---|
| F000:0 | Modular device profile | General information for the modular device profile | UINT8 | RO | 0x02 (2$_{dec}$) |
| F000:01 | Module index distance | Index spacing of the objects of the individual channels | UINT16 | RO | 0x0010 (16$_{dec}$) |
| F000:02 | Maximum number of modules | Number of channels | UINT16 | RO | 0x0002 (2$_{dec}$) |

### Index F008 Code word

| Index (hex) | Name | Meaning | Data type | Flags | Default |
|---|---|---|---|---|---|
| F008:0 | Code word | see note [▸ 28]! | UINT32 | RW | 0x00000000 (0$_{dec}$) |

### Index F010 Module list

| Index (hex) | Name | Meaning | Data type | Flags | Default |
|---|---|---|---|---|---|
| F010:0 | Module list | Maximum subindex | UINT8 | RW | 0x02 (2$_{dec}$) |
| F010:01 | SubIndex 001 | Encoder profile number | UINT32 | RW | 0x00000201 (513$_{dec}$) |
| F010:02 | SubIndex 002 | Servo drive profile number | UINT32 | RW | 0x000002E6 (742$_{dec}$) |

### Index F081 Download revision

| Index (hex) | Name | Meaning | Data type | Flags | Default |
|---|---|---|---|---|---|
| F081:0 | Download revision | Max. Subindex | UINT8 | RO | 0x01 ($1_{dec}$) |
| F010:01 | Revision number | Configured revision of the terminal, see note [▶ 102] | UINT32 | RW | 0x00000000 ($0_{dec}$) |

# 7 EL72x1-0001 (DS402) - Object description and parameterization

**EtherCAT XML Device Description**

The display matches that of the CoE objects from the EtherCAT XML Device Description. We recommend downloading the latest XML file from the download area of the Beckhoff website and installing it according to installation instructions.

**Parameterization via the CoE list (CAN over EtherCAT)**

The terminal is parameterized via the CoE - Online tab (double-click on the respective object) or via the Process Data tab (allocation of PDOs).
Please note the following general CoE information [▶ 28] when using/manipulating the CoE parameters:
- Keep a startup list if components have to be replaced
- Differentiation between online/offline dictionary, existence of current XML description
- use “CoE reload” for resetting changes

***NOTICE***

**Risk of damage to the device!**

We strongly advise not to change settings in the CoE objects while the axis is active, since this could impair the control.

## 7.1 Configuration data

### Index 2002 Amplifier Settings

| Index (hex) | Name | Meaning | Data type | Flags | Default |
|---|---|---|---|---|---|
| 2002:0 | Amplifier Settings | Maximum subindex | UINT8 | RO | 0x54 ($84_{dec}$) |
| 2002:11 | Device type | 1: Servo drive (cannot be changed) | UINT32 | RO | 0x00000001 ($1_{dec}$) |
| 2002:12 | Current loop integral time | Current controller integral action time (Tn)<br>**Unit:** 0.1 ms | UINT16 | RW | 0x000A ($10_{dec}$) |
| 2002:13 | Current loop proportional gain | Proportional component of current controller<br>**Unit:** 0.1 V/A | UINT16 | RW | 0x0064 ($100_{dec}$) |
| 2002:14 | Velocity loop integral time | Speed controller integral action time (Tn)<br>**Unit:** 0.1 ms | UINT32 | RW | 0x00000032 ($50_{dez}$) |
| 2002:15 | Velocity loop proportional gain | Proportional component of velocity controller<br>**Unit:** mA / (rad/s) | UINT32 | RW | 0x00000096 ($150_{dec}$) |
| 2002:19 | Nominal DC link voltage | Nominal DC link voltage<br>**Unit:** mV | UINT32 | RW | 0x0000BB80 ($48000_{dec}$) |
| 2002:1A | Min DC link voltage | Minimum DC link voltage<br>**Unit:** mV | UINT32 | RW | 0x00001A90 ($6800_{dec}$) |
| 2002:1B | Max DC link voltage | Maximum DC link voltage<br>**Unit:** mV | UINT32 | RW | 0x0000EA60 ($60000_{dec}$) |
| 2002:29 | Amplifier I2T warn level | $I^2T$ model warning threshold<br>**Unit:** % | UINT8 | RW | 0x50 ($80_{dec}$) |
| 2002:2A | Amplifier I2T error level | $I^2T$ model error threshold<br>**Unit:** % | UINT8 | RW | 0x69 ($105_{dec}$) |
| 2002:2B | Amplifier temperature warn level | Overtemperature warning threshold<br>**Unit:** 0.1 °C | UINT16 | RW | 0x0320 ($800_{dec}$) |
| 2002:2C | Amplifier temperature error level | Overtemperature error threshold<br>**Unit:** 0.1 °C | UINT16 | RW | 0x03E8 ($1000_{dec}$) |
| 2002:31 | Velocity limitation | Velocity limitation<br>**Unit:** rpm | UINT32 | RW | 0x00040000 ($262144_{dec}$) |
| 2002:32 | Short circuit brake duration max | Max. duration of armature short circuit brake<br>**Unit:** ms | UINT16 | RW | 0x03E8 ($1000_{dec}$) |
| 2002:33 | Stand still window | Standstill window<br>**Unit:** rpm | UINT16 | RW | 0x0000 ($0_{dec}$) |
| 2002:41 | Low-pass filter frequency | Low-pass filter frequency<br>**Unit:** Hz<br>The following values can be set:<br>0 Hz = off<br>320 Hz<br>640 Hz | UINT16 | RW | 0x0140 ($320_{dec}$) |
| 2002:49 | Halt ramp deceleration | Halt ramp deceleration<br>**Unit**: 0.1 rad / $s^2$ | UINT32 | RW | 0x0000F570 ($62832_{dec}$) |
| 2002:53 | Position loop proportional gain | Proportional part of position controller<br>**Unit:** mA / (rad/s) | UINT32 | RW | 0x00000000 ($0_{dec}$) |
| 2002:54 | Feature bits | The feature bit switches:<br>Peak value → Bit 0 = 0 (default for EL7201-000x)<br>RMS value → Bit 0 = 1 (default for EL7211-000x)<br>With the help of the fan cartridge ZB8610, it is possible to increase the output current of the EL7201-000x<br>rated output current (2.8 $A_{rms)}$ → Bit 1 = 0 (default)<br>increased output current (4.5 $A_{rms)}$ → Bit 1 = 1<br>The following combination are possible:<br>$0_{dec}$ → rated output current, interpretation as peak value<br>$1_{dec}$ → rated output current, interpretation as RMS value<br>$2_{dec}$ →increased output current, interpretation as peak value<br>$3_{dec}$ → increased output current, interpretation as RMS value | UINT32 | RW | 0x00000000 ($0_{dec}$) |

### Index 2003 Motor Settings

| Index (hex) | Name | Meaning | Data type | Flags | Default |
|---|---|---|---|---|---|
| 2003:0 | Motor Settings | Maximum subindex | UINT8 | RO | 0x2D ($45_{dec}$) |
| 2003:11 | Max current | Peak current<br>**Unit:** mA<br>The adjustable motor current values can be interpreted as a peak value or RMS value.<br>The feature bit (0x2002:54 [▶ 163]) switches:<br>Peak value → Bit 0 = 0 (default for EL7201)<br>RMS value → Bit 0 = 1 (default for EL7201) | UINT32 | RW | 0x00001770 ($6000_{dec}$) |
| 2003:13 | Motor pole pairs | Number of pole pairs | UINT8 | RW | 0x03 ($3_{dec}$) |
| 2003:15 | Commutation offset | Commutation offset (between electrical zero position and mechanical single-turn zero position)<br>**Unit:** ° | INT16 | RW | 0x0000 ($0_{dec}$) |
| 2003:16 | Torque constant | Torque constant<br>**Unit:** mNm / A | UINT32 | RW | 0x00000000 ($0_{dec}$) |
| 2003:18 | Rotor moment of inertia | Mass moment of inertia of the motor<br>**Unit:** g cm^2 | UINT32 | RW | 0x00000000 ($0_{dec}$) |
| 2003:19 | Winding inductance | Inductance<br>**Unit:** 0.1 mH | UINT16 | RW | 0x000E ($14_{dec}$) |
| 2003:29 | Motor I2T warn level | I2T model warning threshold<br>**Unit:** % | UINT8 | RW | 0x50 ($80_{dec}$) |
| 2003:2A | Motor I2T error level | I2T model error threshold<br>**Unit:** % | UINT8 | RW | 0x69 ($105_{dec}$) |
| 2003:2D | Motor thermal time constant | Thermal time constant<br>**Unit:** 0.1 s | UINT16 | RW | 0x0028 ($40_{dec}$) |

### Index 2004 Brake Settings

| Index (hex) | Name | Meaning | Data type | Flags | Default |
|---|---|---|---|---|---|
| 2004:0 | Brake Settings | Maximum subindex | UINT8 | RO | 0x14 ($20_{dec}$) |
| 2004:01 | Manual override (release) | Release the motor holding brake manually | BOOLEAN | RW | 0x00 ($0_{dec}$) |
| 2004:11 | Release delay | This object describes the time that the holding brake needs to open (to be released) after voltage is applied | UINT16 | RW | 0x0000 ($0_{dec}$) |
| 2004:12 | Application delay | This object describes the time that the holding brake needs to close (to be applied) after voltage is removed | UINT16 | RW | 0x0000 ($0_{dec}$) |
| 2004:13 | Emergency application timeout | Time the amplifier waits, until the rotation speed reaches the stand still window after stop request (set rotation speed 0 or Torque off). If the set waiting time is exceeded, the holding brake is triggered independently of the rotation speed.<br>**Note:**<br>For rotatory axes and the setting „torque off“ in error case, this parameter has to be set at least to the „coast to the stop“ time of the axis.<br>For suspended (hanging) axes and the setting „torque off“ in error case, this parameter has to be set to an appropriate short time, to prevent the axis/load from drop/fall. | UINT16 | RW | 0x0000 ($0_{dec}$) |
| 2004:14 | Brake moment of inertia | Mass moment of inertia of the brake<br>**Unit:** g cm^2 | UINT16 | RW | 0x0000 ($0_{dec}$) |

### Index 2010 Feedback Settings

| Index (hex) | Name | Meaning | Data type | Flags | Default |
|---|---|---|---|---|---|
| 2010:0 | Feedback Settings | Maximum subindex | UINT8 | RO | 0x13 ($19_{dec}$) |
| 2010:01 | Invert feedback direction | Inverting the count direction | BOOLEAN | RW | 0x00 ($0_{dec}$) |
| 2010:11 | Device type | 1: Resolver (cannot be changed) | UINT32 | RO | 0x00000001 ($1_{dec}$) |
| 2010:12 | Singleturn bits | Number of single- and multi-turn-bits [▶ 104] | UINT8 | RW | 0x14 ($20_{dec}$) |
| 2010:13 | Multiturn bits | | UINT8 | RW | 0x0C ($12_{dec}$) |

### Index 2018 Resolver Settings

| Index (hex) | Name | Meaning | Data type | Flags | Default |
|---|---|---|---|---|---|
| 2018:0 | Resolver Settings | Maximum subindex | UINT8 | RO | 0x14 (20$_{dec}$) |
| 2018:01 | Invert feedback direction | Inverting the count direction | BOOLEAN | RW | 0x00 (0$_{dec}$) |
| 2018:02 | Enable automatic gain control | Activate automatic gain adjustment [▶ 105] | BOOLEAN | RW | 0x01 (1$_{dec}$) |
| 2018:11 | Bandwith | Resolver bandwidth [1 Hz] | UINT16 | RW | 0x01F4 (500$_{dec}$) |
| 2018:12 | Resolver gain adjustment | Sine and cosine signal level adaptation [▶ 105] | REAL32 | RW | 0x3F800000 (1065353216$_{dec}$) |
| 2018:13 | Resolver phase shift | Nominal resolver phase shift | INT8 | RW | 0x00 (0$_{dec}$) |
| 2018:14 | Observer feed-forward | Pre-control for speed monitor<br>**Unit:** % | UINT8 | RW | 0x32 (50$_{dec}$) |

## 7.2 Configuration data (vendor-specific)

### Index 2020 Vendor data

| Index (hex) | Name | Meaning | Data type | Flags | Default |
|---|---|---|---|---|---|
| 2020:0 | Vendor data | Maximum subindex | UINT8 | RO | 0x15 (21$_{dec}$) |
| 2020:11 | Amplifier peak current | Peak current of the amplifier<br>**Unit:** mA | UINT32 | RO | 0x00001F40 (8000$_{dec}$) |
| 2020:12 | Amplifier rated current | Rated current of the amplifier<br>**Unit:** mA | UINT32 | RO | 0x00000FA0 (4000$_{dec}$) |
| 2020:13 | Amplifier thermal time constant | Thermal time constant of the amplifier<br>**Unit:** 0.1 ms | UINT16 | RO | 0x0023 (35$_{dec}$) |
| 2020:14 | Amplifier overcurrent threshold | Threshold value for short-circuit detection<br>**Unit:** mA | UINT32 | RO | 0x00002EE0 (12000$_{dec}$) |
| 2020:15 | Max rotary field frequency | Max rotary field frequency<br>**Unit:** Hz | UINT16 | RW | 0x0257 (599$_{dec}$) |

## 7.3 Command object

### Index FB00 Command

| Index (hex) | Name | Meaning | | | Data type | Flags | Default |
|---|---|---|---|---|---|---|---|
| FB00:0 | DCM Command | Max. subindex | | | UINT8 | RO | 0x03 ($3_{dec}$) |
| FB00:01 | Request | 0x1000 | Clear diag history | Clear the Diag History | OCTET-STRING[2] | RW | {0} |
| | | 0x1100 | Get build number | Read out the build number | | | |
| | | 0x1101 | Get build date | Read out the build date | | | |
| | | 0x1102 | Get build time | Read out the build time | | | |
| | | 0x8000 | Software reset | Perform a software reset (hardware is re-initialized with the current CoE configuration; this otherwise happens only during the transition to INIT) | | | |
| FB00:02 | Status | 0 | Finished,<br>no error,<br>no response | Command terminated without error and without response | UINT8 | RO | 0x00 ($0_{dec}$) |
| | | 1 | Finished,<br>no error,<br>response | Command terminated without error and with response | | | |
| | | 2 | Finished,<br>error,<br>no response | Command terminated with error and without response | | | |
| | | 3 | Finished,<br>error,<br>response | Command terminated with error and with response | | | |
| | | 255 | Executing | Command is being executed | | | |
| FB00:03 | Response | dependent on the request | | | OCTET-STRING[4] | RO | {0} |

## 7.4 Input/output data

### Index 2001 Outputs

| Index (hex) | Name | Meaning | Data type | Flags | Default |
|---|---|---|---|---|---|
| 2001:0 | Outputs | Maximum subindex | UINT8 | RO | 0x11 ($17_{dec}$) |
| 2001:11 | Torque offset | Torque value offset<br>The value is specified in 1000th of the *rated current*<br>Formula for Index 0x2002:54 [▶ 163] = 0 :<br>M = ((Torque actual value / 1000) x (rated current / √2)) x torque constant (0x2003:16 [▶ 164])<br>Formula for Index 0x2002:54 [▶ 163] = 1 :<br>M = ((Torque actual value / 1000) x rated current)) x torque constant (0x2003:16 [▶ 164]) | INT16 | RO | 0x0000 ($0_{dec}$) |

### Index 603E TxPDO Data invalid

| Index (hex) | Name | Meaning | Data type | Flags | Default |
|---|---|---|---|---|---|
| 603E:0 | TxPDO Data invalid | Max. Subindex | UINT8 | RO | 0x02 ($2_{dec}$) |
| 603E:02 | Position actual value | 0: The current position is valid<br>1: The current position is invalid | BOOLEAN | RO P | 0 |

### Index 6040 Controlword

| Index (hex) | Name | Meaning | Data type | Flags | Default |
|---|---|---|---|---|---|
| 6040:0 | Controlword | DS402 Controlword [▶ 111]<br>Bit 0 : Switch on<br>Bit 1 : Enable voltage<br>Bit 2 : reserved<br>Bit 3 : Enable operation<br>Bit 4 - 6 : reserved<br>Bit 7 : Fault reset<br>Bit 8 - 15 : reserved | UINT16 | RO | 0x0000 ($0_{dec}$) |

### Index 6041 Statusword

| Index (hex) | Name | Meaning | Data type | Flags | Default |
|---|---|---|---|---|---|
| 6041:0 | Statusword | DS402 Statusword [▶ 111]<br>Bit 0 : Ready to switch on<br>Bit 1 : Switched on<br>Bit 2 : Operation enabled<br>Bit 3 : Fault<br>Bit 4 : reserved<br>Bit 5 : reserved<br>Bit 6 : Switch on disabled<br>Bit 7 : Warning<br>Bit 8 + 9 : reserved<br>Bit 10: TxPDOToggle (selection/deselection via 0x60DA [▶ 169])<br>Bit 11 : Internal limit active<br>Bit 12 : Drive follows the command value<br>Bit 13 - 15 : reserved | UINT16 | RO | 0x0000 ($0_{dec}$) |

### Index 605E Fault reaction option code

| Index (hex) | Name | Meaning | Data type | Flags | Default |
|---|---|---|---|---|---|
| 605E:0 | Fault reaction option code | 0: Disable drive function, motor is free to rotate<br>1: Slow down by slow down ramp | ENUM16BIT | RW | 0 |

### Index 6060 Modes of operation

| Index (hex) | Name | Meaning | Data type | Flags | Default |
|---|---|---|---|---|---|
| 6060:0 | Modes of operation | This object shall indicate the requested operation mode<br>0x08: Cyclic synchronous position mode (CSP)<br>0x09: Cyclic synchronous velocity mode (CSV)<br>0x0A: Cyclic synchronous torque mode (CST)<br>0x0B: Cyclic synchronous torque mode with commutation angle (CSTCA) | UINT8 | RW | 0x00 ($0_{dec}$) |

### Index 6061 Modes of operation display

| Index (hex) | Name | Meaning | Data type | Flags | Default |
|---|---|---|---|---|---|
| 6061:0 | Modes of operation display | This object shall provide the actual operation mode | UINT8 | RO | 0x00 ($0_{dec}$) |

### Index 6064 Position actual value

| Index (hex) | Name | Meaning | Data type | Flags | Default |
|---|---|---|---|---|---|
| 6064:0 | Position actual value | Position | UINT32 | RO | 0x00000000 ($0_{dec}$) |

### Index 6065 Following error window

| Index (hex) | Name | Meaning | Data type | Flags | Default |
|---|---|---|---|---|---|
| 6065:0 | Following error window |  |  | RW |  |

### Index 6066 Following error time out

| Index (hex) | Name | Meaning | Data type | Flags | Default |
|---|---|---|---|---|---|
| 6066:0 | Following error time out | | | RW | |

### Index 606C Velocity actual value

| Index (hex) | Name | Meaning | Data type | Flags | Default |
|---|---|---|---|---|---|
| 606C:0 | Velocity actual value | This object shall provide the actual velocity value | INT32 | RO | 0x00000000 ($0_{dec}$) |

### Index 6071 Target torque

| Index (hex) | Name | Meaning | Data type | Flags | Default |
|---|---|---|---|---|---|
| 6071:0 | Target torque | This object shall indicate the configured input value for the torque controller.<br>The value is specified in 1000th of the *rated current*<br>Equation for Index 0x2002:54 [▶ 163] = 0 :<br>M = ((Torque actual value / 1000) x (rated current / √2)) x torque constant (0x2003:16 [▶ 164])<br>Equation for Index 0x2002:54 [▶ 163] = 1 :<br>M = ((Torque actual value / 1000) x rated current)) x torque constant (0x2003:16 [▶ 164]) | INT16 | RO | 0x0000 ($0_{dec}$) |

### Index 6072 Max torque

| Index (hex) | Name | Meaning | Data type | Flags | Default |
|---|---|---|---|---|---|
| 6072:0 | Max torque | This object limits the target torque for the torque controller (bipolar limit).<br>The value is specified in 1000th of the *rated current*<br>Equation for Index 0x2002:54 [▶ 163] = 0 :<br>M = ((Torque actual value / 1000) x (rated current / √2)) x torque constant (0x2003:16 [▶ 164])<br>Equation for Index 0x2002:54 [▶ 163] = 1 :<br>M = ((Torque actual value / 1000) x rated current)) x torque constant (0x2003:16 [▶ 164]) | UINT16 | RW | 0x7FFF ($32767_{dec}$) |

### Index 6075 Motor rated current

| Index (hex) | Name | Meaning | Data type | Flags | Default |
|---|---|---|---|---|---|
| 6075:0 | Motor rated current | Rated motor current<br>**Unit:** mA | UINT32 | RW | 0x000003E8 ($1000_{dec}$) |

### Index 6077 Torque actual value

| Index (hex) | Name | Meaning | Data type | Flags | Default |
|---|---|---|---|---|---|
| 6077:0 | Torque actual value | This object shall provide the actual value of the torque.<br>The value is specified in 1000th of the *rated current*<br>Equation for Index 0x2002:54 [▶ 163] = 0 :<br>M = ((Torque actual value / 1000) x (rated current / √2)) x torque constant (0x2003:16 [▶ 164])<br>Equation for Index 0x2002:54 [▶ 163] = 1 :<br>M = ((Torque actual value / 1000) x rated current)) x torque constant (0x2003:16 [▶ 164]) | INT16 | RO | 0x0000 ($0_{dec}$) |

### Index 6079 DC link circuit voltage

| Index (hex) | Name | Meaning | Data type | Flags | Default |
|---|---|---|---|---|---|
| 6079:0 | DC link circuit voltage | DC link voltage<br>**Unit:** mV | UINT32 | RO | 0x00000000 ($0_{dec}$) |

### Index 607A Target position

| Index (hex) | Name | Meaning | Data type | Flags | Default |
|---|---|---|---|---|---|
| 607A:0 | Target position | Objects represents absolute position.<br>**Unit**: the given value must be multiplied by the corresponding scaling factor [▸ 120] | UINT32 | RO | 0x00000000 ($0_{\text{dec}}$) |

### Index 6080 Max motor speed

| Index (hex) | Name | Meaning | Data type | Flags | Default |
|---|---|---|---|---|---|
| 6080:0 | Max motor speed | Velocity limitation<br>**Unit:** rpm | UINT32 | RW | 0x00040000 ($262144_{\text{dec}}$) |

### Index 608F Position encoder resolution

| Index (hex) | Name | Meaning | Data type | Flags | Default |
|---|---|---|---|---|---|
| 608F:0 | Position encoder resolution | This object shall indicate the configured encoder increments and number of motor revolutions. The position encoder resolution shall be calculated by the following formula: | UINT8 | RO | 0x02 ($2_{\text{dec}}$) |
| 608F:01 | SubIndex 001 | Encoder increments | UINT32 | RO | 0x00000000 ($0_{\text{dec}}$) |
| 608F:02 | SubIndex 002 | Motor revolutions | UINT32 | RO | 0x00000000 ($0_{\text{dec}}$) |

### Index 6090 Velocity Encoder Resolution

| Index (hex) | Name | Meaning | Data type | Flags | Default |
|---|---|---|---|---|---|
| 6090:0 | Velocity Encoder Resolution | Display of configured encoder increments / s and motor revolutions / s.<br>The velocity encoder resolution is calculated according to the following formula:<br>Velocity Encoder Resolution = (encoder_increments / s ) / (motor_revolutions / s) | UINT32 | RO | 0x00041893 ($268435_{\text{dec}}$) |

### Index 60C2 Interpolation time period

| Index (hex) | Name | Meaning | Data type | Flags | Default |
|---|---|---|---|---|---|
| 60C2:0 | Interpolation time period | Maximum subindex | UINT8 | RO | 0x02 ($2_{\text{dec}}$) |
| 60C2:01 | Interpolation time period value | This object shall indicate the configured interpolation cycle time. The interpolation time period (sub-index 0x01) value shall be given in $10^{\text{(interpolation time index)}}$ (second).<br>The interpolation time index (sub-index 0x02) shall be dimensionless. | UINT8 | RO | 0x00 ($0_{\text{dec}}$) |
| 60C2:02 | Interpolation time index | | INT8 | RO | 0x00 ($0_{\text{dec}}$) |

### Index 60D9 Supported functions

| Index (hex) | Name | Meaning | Data type | Flags | Default |
|---|---|---|---|---|---|
| 60D9:0 | Supported functions | This object shall provide information on the supported functions in the device. | UINT32 | RO | 0x00000000 ($0_{\text{dec}}$) |

### Index 60DA Synchronization function settings

| Index (hex) | Name | Meaning | Data type | Flags | Default |
|---|---|---|---|---|---|
| 60DA:0 | Synchronization function settings | This object shall enable/disable supported functions in the device.<br>Bit 0: Enable TxPDOToggle-Bit in Statusword: Bit 10<br>Bit 1: Enable input cycle counter in Statusword: Bit 13<br>Bit 2-31: reserved | UINT32 | RW | 0x00000000 ($0_{\text{dec}}$) |

### Index 60EA Commutation angle

| Index (hex) | Name | Meaning | Data type | Flags | Default |
|---|---|---|---|---|---|
| 60EA:0 | Commutation angle | Electrical commutation angle (for the CSTCA mode)<br>**Unit:** 5.49 * $10^{-3}$ ° | UINT16 | RO | 0x0000 ($0_{dec}$) |

### Index 60F4 Following error actual value

| Index (hex) | Name | Meaning | Data type | Flags | Default |
|---|---|---|---|---|---|
| 60F4:0 | Following error actual value | Following error<br>**Unit**: the given value must be multiplied by the corresponding scaling factor [▸ 120] | INT32 | RO | 0x00000000 ($0_{dec}$) |

### Index 60FF Target velocity

| Index (hex) | Name | Meaning | Data type | Flags | Default |
|---|---|---|---|---|---|
| 60FF:0 | Target velocity | This object shall indicate the configured target velocity<br>The velocity scaling can be found in object 0x6090 (Velocity encoder resolution) | INT32 | RO | 0x00000000 ($0_{dec}$) |

### Index 6502 Supported drive modes

| Index (hex) | Name | Meaning | Data type | Flags | Default |
|---|---|---|---|---|---|
| 6502:0 | Supported drive modes | This object shall provide information on the supported drive modes. (DS402 Object 0x6502)<br>Only modes *CSV*, *CST* and *CSTCA* are supported<br>Bit 0 : PP<br>Bit 1 : VL<br>Bit 2: PV<br>Bit 3: TQ<br>Bit 4: R<br>Bit 5: HM<br>Bit 6: IP<br>Bit 7: CSP<br>Bit 8: CSV<br>Bit 9: CST<br>Bit 10: CSTCA<br>Bit 11-15: reserved<br>Bit 16-31: Manufacturer specific | UINT32 | RO | 0x00000000 ($0_{dec}$) |

# 7.5 Information / diagnosis data

### Index 10F3 Diagnosis History

| Index (hex) | Name | Meaning | Data type | Flags | Default |
|---|---|---|---|---|---|
| 10F3:0 | Diagnosis History | Maximum subindex | UINT8 | RO | 0x37 ($55_{dec}$) |
| 10F3:01 | Maximum Messages | Maximum number of stored messages<br>A maximum of 50 messages can be stored | UINT8 | RO | 0x00 ($0_{dec}$) |
| 10F3:02 | Newest Message | Subindex of the latest message | UINT8 | RO | 0x00 ($0_{dec}$) |
| 10F3:03 | Newest Acknowledged Message | Subindex of the last confirmed message | UINT8 | RW | 0x00 ($0_{dec}$) |
| 10F3:04 | New Messages Available | Indicates that a new message is available | BOOLEAN | RO | 0x00 ($0_{dec}$) |
| 10F3:05 | Flags | not used | UINT16 | RW | 0x0000 ($0_{dec}$) |
| 10F3:06 | Diagnosis Message 001 | Message 1 | OCTET-STRING[28] | RO | {0} |
| ... | ... | ... | | | |
| 10F3:37 | Diagnosis Message 050 | Message 50 | OCTET-STRING[28] | RO | {0} |

### Index 10F8 Actual Time Stamp

| Index (hex) | Name | Meaning | Data type | Flags | Default |
|---|---|---|---|---|---|
| 10F8:0 | Actual Time Stamp | Time stamp | UINT64 | RO | |

### Index 2030 Amplifier Diag data

| Index (hex) | Name | Meaning | Data type | Flags | Default |
|---|---|---|---|---|---|
| 2030:0 | Amplifier Diag data | Maximum subindex | UINT8 | RO | 0x11 (17$_{dec}$) |
| 2030:11 | Amplifier I2T temperature | I2T model load<br>**Unit:** % | UINT8 | RO | 0x00 (0$_{dec}$) |

### Index 2031 Motor Diag data

| Index (hex) | Name | Meaning | Data type | Flags | Default |
|---|---|---|---|---|---|
| 2031:0 | Motor Diag data | Maximum subindex | UINT8 | RO | 0x11 (17$_{dec}$) |
| 2031:11 | Motor I2T temperature | I2T model load<br>**Unit:** % | UINT8 | RO | 0x00 (0$_{dec}$) |

### Index 2040 Amplifier Info data

| Index (hex) | Name | Meaning | Data type | Flags | Default |
|---|---|---|---|---|---|
| 2040:0 | Amplifier Info data | Maximum subindex | UINT8 | RO | 0x12 (18$_{dec}$) |
| 2040:11 | Amplifier temperature | Internal terminal temperature<br>**Unit:** 0.1 °C | UINT16 | RO | 0x0000 (0$_{dec}$) |
| 2040:12 | DC link voltage | DC link voltage<br>**Unit:** mV | UINT32 | RO | 0x00000000 (0$_{dec}$) |

### Index 2041 Info data

| Index (hex) | Name | Meaning | Data type | Flags | Default |
|---|---|---|---|---|---|
| 2041:0 | Info data | Maximum subindex | UINT8 | RO | 0x11 (17$_{dec}$) |
| 2041:11 | Auxiliary voltage (10 V) | Auxiliary voltage<br>**Unit:** mV | UINT32 | RO | 0x00000000 (0$_{dec}$) |

### Index 2058 Resolver info data

| Index (hex) | Name | Meaning | Data type | Flags | Default |
|---|---|---|---|---|---|
| 2058:0 | Resolver info data | Maximum subindex | UINT8 | RO | 0x12 (18$_{dec}$) |
| 2058:12 | Automatic resolver gain value | Index 0x9008 Current value for the sine and cosine signal level adaptation (only if "Enable automatic gain control" is active") | REAL32 | RO | 0x01F80000 (33030144$_{dec}$) |

### Index FB40 Memory interface

| Index (hex) | Name | Meaning | Data type | Flags | Default |
|---|---|---|---|---|---|
| FB40:0 | Memory interface | Maximum subindex | UINT8 | RO | 0x03 (3$_{dec}$) |
| FB40:01 | Address | reserved | UINT32 | RW | 0x00000000 (0$_{dec}$) |
| FB40:02 | Length | reserved | UINT16 | RW | 0x0000 (0$_{dec}$) |
| FB40:03 | Data | reserved | OCTET-STRING[8] | RW | {0} |

## 7.6 Standard objects

The standard objects have the same meaning for all EtherCAT slaves.

### Index 1000 Device type

| Index (hex) | Name | Meaning | Data type | Flags | Default |
|---|---|---|---|---|---|
| 1000:0 | Device type | Device type of the EtherCAT slave: the Lo-Word contains the CoE profile used (5001). The Hi-Word contains the module profile according to the modular device profile. | UINT32 | RO | 0x00000192 (402$_{dec}$) |

### Index 1001 Error register

| Index (hex) | Name | Meaning | Data type | Flags | Default |
|---|---|---|---|---|---|
| 1001:0 | Error register | | UINT8 | RO | 0x00 (0$_{dec}$) |

### Index 1008 Device name

| Index (hex) | Name | Meaning | Data type | Flags | Default |
|---|---|---|---|---|---|
| 1008:0 | Device name | Device name of the EtherCAT slave | STRING | RO | EL72x1-0001 |

### Index 1009 Hardware version

| Index (hex) | Name | Meaning | Data type | Flags | Default |
|---|---|---|---|---|---|
| 1009:0 | Hardware version | Hardware version of the EtherCAT slave | STRING | RO | 00 |

### Index 100A Software version

| Index (hex) | Name | Meaning | Data type | Flags | Default |
|---|---|---|---|---|---|
| 100A:0 | Software version | Firmware version of the EtherCAT slave | STRING | RO | 01 |

### Index 1018 Identity

| Index (hex) | Name | Meaning | Data type | Flags | Default |
|---|---|---|---|---|---|
| 1018:0 | Identity | Information for identifying the slave | UINT8 | RO | 0x04 ($4_{dec}$) |
| 1018:01 | Vendor ID | Vendor ID of the EtherCAT slave | UINT32 | RO | 0x00000002 ($2_{dec}$) |
| 1018:02 | Product code | Product code of the EtherCAT slave | UINT32 | RO | 0x1C213052 ($471937106_{dec}$) |
| 1018:03 | Revision | Revision number of the EtherCAT slave; the low word (bit 0-15) indicates the special terminal number, the high word (bit 16-31) refers to the device description | UINT32 | RO | 0x00110001 ($1114113_{dec}$) |
| 1018:04 | Serial number | Unique serial number | UINT32 | RO | 0x00000000 ($0_{dec}$) |

### Index 1600 DS402 RxPDO-Map Controlword

| Index (hex) | Name | Meaning | Data type | Flags | Default |
|---|---|---|---|---|---|
| 1600:0 | DS402 RxPDO-Map Controlword | PDO Mapping RxPDO 1 | UINT8 | RO | 0x01 ($1_{dec}$) |
| 1600:01 | SubIndex 001 | 1. PDO Mapping entry (object 0x6040 (Controlword), entry 0x00 (Controlword)) | UINT32 | RO | 0x6040:00, 16 |

### Index 1601 DS402 RxPDO-Map Target velocity

| Index (hex) | Name | Meaning | Data type | Flags | Default |
|---|---|---|---|---|---|
| 1601:0 | DS402 RxPDO-Map Target velocity | PDO Mapping RxPDO 2 | UINT8 | RO | 0x01 ($1_{dec}$) |
| 1601:01 | SubIndex 001 | 1. PDO Mapping entry (object 0x60FF (Target velocity), entry 0x00 (Target velocity)) | UINT32 | RO | 0x60FF:00, 32 |

### Index 1602 DS402 RxPDO-Map Target torque

| Index (hex) | Name | Meaning | Data type | Flags | Default |
|---|---|---|---|---|---|
| 1602:0 | DS402 RxPDO-Map Target torque | PDO Mapping RxPDO 3 | UINT8 | RO | 0x01 ($1_{dec}$) |
| 1602:01 | SubIndex 001 | 1. PDO Mapping entry (object 0x6071 (Target torque), entry 0x00 (Target torque)) | UINT32 | RO | 0x6071:00, 16 |

### Index 1603 DS402 RxPDO-Map Commutation angle

| Index (hex) | Name | Meaning | Data type | Flags | Default |
|---|---|---|---|---|---|
| 1603:0 | DS402 RxPDO-Map Commutation angle | PDO Mapping RxPDO 4 | UINT8 | RO | 0x01 ($1_{dec}$) |
| 1603:01 | SubIndex 001 | 1. PDO Mapping entry (object 0x60EA (Commutation angle), entry 0x00 (Commutation angle)) | UINT32 | RO | 0x60EA:00, 16 |

### Index 1604 DS402 RxPDO-Map Torque limitation

| Index (hex) | Name | Meaning | Data type | Flags | Default |
|---|---|---|---|---|---|
| 1604:0 | DS402 RxPDO-Map Torque limitation | PDO Mapping RxPDO 5 | UINT8 | RO | 0x01 ($1_{dec}$) |
| 1604:01 | SubIndex 001 | 1. PDO Mapping entry (object 0x6072 (Max torque), entry 0x00 (Max torque)) | UINT32 | RO | 0x6072:00, 16 |

### Index 1605 DS402 RxPDO-Map Torque offset

| Index (hex) | Name | Meaning | Data type | Flags | Default |
|---|---|---|---|---|---|
| 1605:0 | DS402 RxPDO-Map Torque offset | PDO Mapping RxPDO 6 | UINT8 | RO | 0x01 ($1_{dec}$) |
| 1605:01 | SubIndex 001 | 1. PDO Mapping entry (object 0x2001 (Outputs), entry 0x11 (Torque offset)) | UINT32 | RO | 0x2001:11, 16 |

### Index 1606 DS402 RxPDO-Map Target position

| Index (hex) | Name | Meaning | Data type | Flags | Default |
|---|---|---|---|---|---|
| 1606:0 | DS402 RxPDO-Map Target position | PDO Mapping RxPDO 7 | UINT8 | RO | 0x01 ($1_{dec}$) |
| 1606:01 | SubIndex 001 | 1. PDO Mapping entry | UINT32 | RO | 0x607A:00, 32 |

### Index 1A00 DS402 TxPDO-Map Statusword

| Index (hex) | Name | Meaning | Data type | Flags | Default |
|---|---|---|---|---|---|
| 1A00:0 | DS402 TxPDO-Map Statusword | PDO Mapping TxPDO 1 | UINT8 | RO | 0x01 ($1_{dec}$) |
| 1A00:01 | SubIndex 001 | 1. PDO Mapping entry (object 0x6041 (Statusword), entry 0x00 (Statusword)) | UINT32 | RO | 0x6041:00, 16 |

### Index 1A01 DS402 TxPDO-Map Position actual value

| Index (hex) | Name | Meaning | Data type | Flags | Default |
|---|---|---|---|---|---|
| 1A01:0 | DS402 TxPDO-Map Position actual value | PDO Mapping TxPDO 2 | UINT8 | RO | 0x01 ($1_{dec}$) |
| 1A01:01 | SubIndex 001 | 1. PDO Mapping entry (object 0x6064 (Position actual value), entry 0x00 (Position actual value)) | UINT32 | RO | 0x6064:00, 32 |

### Index 1A02 DS402 TxPDO-Map Veloacity actual value

| Index (hex) | Name | Meaning | Data type | Flags | Default |
|---|---|---|---|---|---|
| 1A02:0 | DS402 TxPDO-Map Veloacity actual value | PDO Mapping TxPDO 3 | UINT8 | RO | 0x01 ($1_{dec}$) |
| 1A02:01 | SubIndex 001 | 1. PDO Mapping entry (object 0x606C (Velocity actual value), entry 0x00 (Velocity actual value)) | UINT32 | RO | 0x606C:00, 32 |

### Index 1A03 DS402 TxPDO-Map Torque actual value

| Index (hex) | Name | Meaning | Data type | Flags | Default |
|---|---|---|---|---|---|
| 1A03:0 | DS402 TxPDO-Map Torque actual value | PDO Mapping TxPDO 4 | UINT8 | RO | 0x01 ($1_{dec}$) |
| 1A03:01 | SubIndex 001 | 1. PDO Mapping entry (object 0x6077 (Torque actual value), entry 0x00 (Torque actual value)) | UINT32 | RO | 0x6077:00, 16 |

### Index 1A04 DS402 TxPDO-Map Following error actual value

| Index (hex) | Name | Meaning | Data type | Flags | Default |
|---|---|---|---|---|---|
| 1A04:0 | DS402 TxPDO-Map Following error actual value | PDO Mapping TxPDO 5 | UINT8 | RO | 0x01 ($1_{dec}$) |
| 1A04:01 | SubIndex 001 | 1. PDO Mapping entry | UINT32 | RO | 0x60F4:00, 32 |

### Index 1A0A DS402 TxPDO-Map TxPDO Data Invalid

| Index (hex) | Name | Meaning | Data type | Flags | Default |
|---|---|---|---|---|---|
| 1A0A:0 | DS402 TxPDO-Map TxPDO Data Invalid | PDO Mapping TxPDO 6 | UINT8 | RO | 0x03 ($3_{dec}$) |
| 1A0A:01 | SubIndex 001 | 1. PDO Mapping entry (1 bit align) | UINT32 | RO | 0x0000:00, 1 |
| 1A0A:02 | SubIndex 002 | 2. PDO Mapping entry (object 0x603E (TxPDO Data Invalid), entry 0x02 (TxPDO Data invalid__Position actual value)) | UINT32 | RO | 0x603E:02, 1 |
| 1A0A:03 | SubIndex 003 | 3. PDO Mapping entry (14 bits align) | UINT32 | RO | 0x0000:00, 14 |

### Index 1C00 Sync manager type

| Index (hex) | Name | Meaning | Data type | Flags | Default |
|---|---|---|---|---|---|
| 1C00:0 | Sync manager type | Using the sync managers | UINT8 | RO | 0x04 ($4_{dec}$) |
| 1C00:01 | SubIndex 001 | Sync-Manager Type Channel 1: Mailbox Write | UINT8 | RO | 0x01 ($1_{dec}$) |
| 1C00:02 | SubIndex 002 | Sync-Manager Type Channel 2: Mailbox Read | UINT8 | RO | 0x02 ($2_{dec}$) |
| 1C00:03 | SubIndex 003 | Sync-Manager Type Channel 3: Process Data Write (Outputs) | UINT8 | RO | 0x03 ($3_{dec}$) |
| 1C00:04 | SubIndex 004 | Sync-Manager Type Channel 4: Process Data Read (Inputs) | UINT8 | RO | 0x04 ($4_{dec}$) |

### Index 1C12 RxPDO assign

| Index (hex) | Name | Meaning | Data type | Flags | Default |
|---|---|---|---|---|---|
| 1C12:0 | RxPDO assign | PDO Assign Outputs | UINT8 | RW | 0x02 ($2_{dec}$) |
| 1C12:01 | SubIndex 001 | 1. allocated RxPDO (contains the index of the associated RxPDO mapping object) | UINT16 | RW | 0x1600 ($5632_{dec}$) |
| 1C12:02 | SubIndex 002 | 2. allocated RxPDO (contains the index of the associated RxPDO mapping object) | UINT16 | RW | 0x1601 ($5633_{dec}$) |
| 1C12:03 | SubIndex 003 | 3. allocated RxPDO (contains the index of the associated RxPDO mapping object) | UINT16 | RW | 0x0000 ($0_{dec}$) |
| 1C12:04 | SubIndex 004 | 4. allocated RxPDO (contains the index of the associated RxPDO mapping object) | UINT16 | RW | 0x0000 ($0_{dec}$) |
| 1C12:05 | SubIndex 005 | 5. allocated RxPDO (contains the index of the associated RxPDO mapping object) | UINT16 | RW | 0x0000 ($0_{dec}$) |
| 1C12:06 | SubIndex 006 | 6. allocated RxPDO (contains the index of the associated RxPDO mapping object) | UINT16 | RW | 0x0000 ($0_{dec}$) |

### Index 1C13 TxPDO assign

| Index (hex) | Name | Meaning | Data type | Flags | Default |
|---|---|---|---|---|---|
| 1C13:0 | TxPDO assign | PDO Assign Inputs | UINT8 | RW | 0x02 ($2_{dec}$) |
| 1C13:01 | SubIndex 001 | 1. allocated TxPDO (contains the index of the associated TxPDO mapping object) | UINT16 | RW | 0x1A00 ($6656_{dec}$) |
| 1C13:02 | SubIndex 002 | 2. allocated TxPDO (contains the index of the associated TxPDO mapping object) | UINT16 | RW | 0x1A01 ($6657_{dec}$) |
| 1C13:03 | SubIndex 003 | 3. allocated TxPDO (contains the index of the associated TxPDO mapping object) | UINT16 | RW | 0x0000 ($0_{dec}$) |
| 1C13:04 | SubIndex 004 | 4. allocated TxPDO (contains the index of the associated TxPDO mapping object) | UINT16 | RW | 0x0000 ($0_{dec}$) |

### Index 1C32 SM output parameter

| Index (hex) | Name | Meaning | Data type | Flags | Default |
|---|---|---|---|---|---|
| 1C32:0 | SM output parameter | Synchronization parameters for the outputs | UINT8 | RO | 0x20 ($32_{dec}$) |
| 1C32:01 | Sync mode | Current synchronization mode:<br>• 3: DC-Mode - Synchronous with SYNC1 event | UINT16 | RW | 0x0000 ($0_{dec}$) |
| 1C32:02 | Cycle time | Cycle time (in ns):<br>• Free Run: Cycle time of the local timer<br>• Synchronous with SM 2 event: Master cycle time<br>• DC mode: SYNC0/SYNC1 Cycle Time | UINT32 | RW | 0x0003D090 ($250000_{dec}$) |
| 1C32:03 | Shift time | Time between SYNC0 event and output of the outputs (in ns, DC mode only) | UINT32 | RO | 0x00000000 ($0_{dec}$) |
| 1C32:04 | Sync modes supported | Supported synchronization modes:<br>• Bit 0 = 1: free run is supported<br>• Bit 1 = 1: Synchronous with SM 2 event is supported<br>• Bit 2-3 = 01: DC mode is supported<br>• Bit 4-5 = 10: Output shift with SYNC1 event (only DC mode)<br>• Bit 14 = 1: dynamic times (measurement through writing of 0x1C32:08) | UINT16 | RO | 0xC007 ($49159_{dec}$) |
| 1C32:05 | Minimum cycle time | Minimum cycle time (in ns) | UINT32 | RO | 0x0001E848 ($125000_{dec}$) |
| 1C32:06 | Calc and copy time | Minimum time between SYNC0 and SYNC1 event (in ns, DC mode only) | UINT32 | RO | 0x00000000 ($0_{dec}$) |
| 1C32:07 | Minimum delay time | | UINT32 | RO | 0x00000000 ($0_{dec}$) |
| 1C32:08 | Command | • 0: Measurement of the local cycle time is stopped<br>• 1: Measurement of the local cycle time is started<br>The entries 0x1C32:03, 0x1C32:05, 0x1C32:06, 0x1C32:09, 0x1C33:03 [▶ 176], 0x1C33:06, 0x1C33:09 [▶ 176] are updated with the maximum measured values.<br>For a subsequent measurement the measured values are reset | UINT16 | RW | 0x0000 ($0_{dec}$) |
| 1C32:09 | Maximum delay time | Time between SYNC1 event and output of the outputs (in ns, DC mode only) | UINT32 | RO | 0x00000000 ($0_{dec}$) |
| 1C32:0B | SM event missed counter | Number of missed SM events in OPERATIONAL (DC mode only) | UINT16 | RO | 0x0000 ($0_{dec}$) |
| 1C32:0C | Cycle exceeded counter | Number of occasions the cycle time was exceeded in OPERATIONAL (cycle was not completed in time or the next cycle began too early) | UINT16 | RO | 0x0000 ($0_{dec}$) |
| 1C32:0D | Shift too short counter | Number of occasions that the interval between SYNC0 and SYNC1 event was too short (DC mode only) | UINT16 | RO | 0x0000 ($0_{dec}$) |
| 1C32:20 | Sync error | The synchronization was not correct in the last cycle (outputs were output too late; DC mode only) | BOOLEAN | RO | 0x00 ($0_{dec}$) |

### Index 1C33 SM input parameter

| Index (hex) | Name | Meaning | Data type | Flags | Default |
|---|---|---|---|---|---|
| 1C33:0 | SM input parameter | Synchronization parameters for the inputs | UINT8 | RO | 0x20 ($32_{dec}$) |
| 1C33:01 | Sync mode | Current synchronization mode:<br>• 3: DC - Synchronous with SYNC1 Event | UINT16 | RW | 0x0000 ($0_{dec}$) |
| 1C33:02 | Cycle time | as 0x1C32:02 [▸ 175] | UINT32 | RW | 0x0003D090 ($250000_{dec}$) |
| 1C33:03 | Shift time | Time between SYNC0 event and reading of the inputs (in ns, only DC mode) | UINT32 | RO | 0x00001C52 ($7250_{dec}$) |
| 1C33:04 | Sync modes supported | Supported synchronization modes:<br>• Bit 0: free run is supported<br>• Bit 1: synchronous with SM 2 event is supported (outputs available)<br>• Bit 1: synchronous with SM 3 event is supported (no outputs available)<br>• Bit 2-3 = 01: DC mode is supported<br>• Bit 4-5 = 01: input shift through local event (outputs available)<br>• Bit 4-5 = 10: input shift with SYNC1 event (no outputs available)<br>• Bit 14 = 1: dynamic times (measurement through writing of 0x1C32:08 [▸ 175] or 0x1C33:08) | UINT16 | RO | 0xC007 ($49159_{dec}$) |
| 1C33:05 | Minimum cycle time | as 0x1C32:05 [▸ 175] | UINT32 | RO | 0x0001E848 ($125000_{dec}$) |
| 1C33:06 | Calc and copy time | Time between reading of the inputs and availability of the inputs for the master (in ns, only DC mode) | UINT32 | RO | 0x00000000 ($0_{dec}$) |
| 1C33:07 | Minimum delay time | | UINT32 | RO | 0x00001C52 ($7250_{dec}$) |
| 1C33:08 | Command | as 0x1C32:08 [▸ 175] | UINT16 | RW | 0x0000 ($0_{dec}$) |
| 1C33:09 | Maximum delay time | Time between SYNC1 event and reading of the inputs (in ns, only DC mode) | UINT32 | RO | 0x00001C52 ($7250_{dec}$) |
| 1C33:0B | SM event missed counter | as 0x1C32:11 [▸ 175] | UINT16 | RO | 0x0000 ($0_{dec}$) |
| 1C33:0C | Cycle exceeded counter | as 0x1C32:12 [▸ 175] | UINT16 | RO | 0x0000 ($0_{dec}$) |
| 1C33:0D | Shift too short counter | as 0x1C32:13 [▸ 175] | UINT16 | RO | 0x0000 ($0_{dec}$) |
| 1C33:20 | Sync error | as 0x1C32:32 [▸ 175] | BOOLEAN | RO | 0x00 ($0_{dec}$) |

### Index F008 Code word

| Index (hex) | Name | Meaning | Data type | Flags | Default |
|---|---|---|---|---|---|
| F008:0 | Code word | see note [▸ 28]! | UINT32 | RW | 0x00000000 ($0_{dec}$) |

### Index FB00 Command

| Index (hex) | Name | Meaning | Data type | Flags | Default |
|---|---|---|---|---|---|
| FB00:0 | Command | Maximum subindex | UINT8 | RO | 0x03 ($3_{dec}$) |
| FB00:01 | Request | reserved | OCTET-STRING[2] | RW | {0} |
| FB00:02 | Status | reserved | UINT8 | RO | 0x00 ($0_{dec}$) |
| FB00:03 | Response | reserved | OCTET-STRING[4] | RO | {0} |

# 8 Error correction

## 8.1 Diagnostics - basic principles of diag messages

*DiagMessages* designates a system for the transmission of messages from the EtherCAT Slave to the EtherCAT Master/TwinCAT. The messages are stored by the device in its own CoE under 0x10F3 and can be read by the application or the System Manager. An error message referenced via a code is output for each event stored in the device (warning, error, status change).

### Definition

The *DiagMessages* system is defined in the ETG (EtherCAT Technology Group) in the guideline ETG.1020, chapter 13 “Diagnosis handling”. It is used so that pre-defined or flexible diagnostic messages can be conveyed from the EtherCAT Slave to the Master. In accordance with the ETG, the process can therefore be implemented supplier-independently. Support is optional. The firmware can store up to 250 DiagMessages in its own CoE.

Each DiagMessage consists of

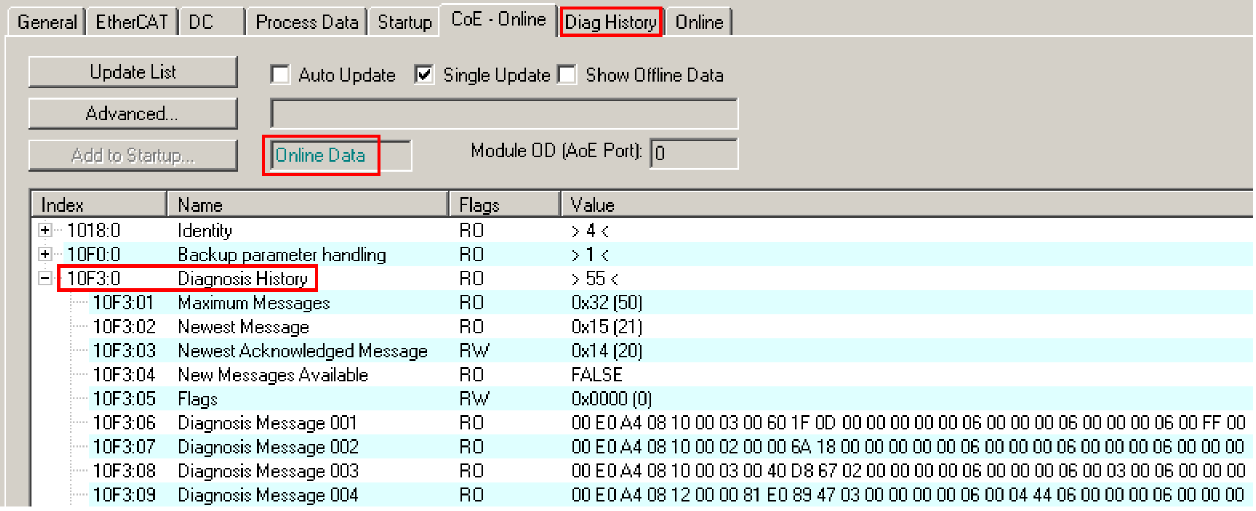
- Diag Code (4-byte)
- Flags (2-byte; info, warning or error)
- Text ID (2-byte; reference to explanatory text from the ESI/XML)
- Timestamp (8-byte, local slave time or 64-bit Distributed Clock time, if available)
- Dynamic parameters added by the firmware

The DiagMessages are explained in text form in the ESI/XML file belonging to the EtherCAT device: on the basis of the Text ID contained in the DiagMessage, the corresponding plain text message can be found in the languages contained in the ESI/XML. In the case of Beckhoff products these are usually German and English.

Via the entry *NewMessagesAvailable* the user receives information that new messages are available.

DiagMessages can be confirmed in the device: the last/latest unconfirmed message can be confirmed by the user.

In the CoE both the control entries and the history itself can be found in the CoE object 0x10F3:



□ Auto Update ☑ Single Update □ Show Offline Data

Module OD (AoE Port): 0

| Index | Name | Flags | Value |
|---|---|---|---|
| 1018:0 | Identity | RO | > 4 < |
| 10F0:0 | Backup parameter handling | RO | > 1 < |
| 10F3:0 | Diagnosis History | RO | > 55 < |
| 10F3:01 | Maximum Messages | RO | 0x32 (50) |
| 10F3:02 | Newest Message | RO | 0x15 (21) |
| 10F3:03 | Newest Acknowledged Message | RW | 0x14 (20) |
| 10F3:04 | New Messages Available | RO | FALSE |
| 10F3:05 | Flags | RW | 0x0000 (0) |
| 10F3:06 | Diagnosis Message 001 | RO | 00 E0 A4 08 10 00 03 00 60 1F 0D 00 00 00 00 00 06 00 00 00 06 00 00 00 06 00 FF 00 |
| 10F3:07 | Diagnosis Message 002 | RO | 00 E0 A4 08 10 00 02 00 00 6A 18 00 00 00 00 00 06 00 00 00 06 00 00 00 06 00 00 00 |
| 10F3:08 | Diagnosis Message 003 | RO | 00 E0 A4 08 10 00 03 00 40 D8 67 02 00 00 00 00 06 00 00 00 06 00 03 00 06 00 00 00 |
| 10F3:09 | Diagnosis Message 004 | RO | 00 E0 A4 08 12 00 00 81 E0 89 47 03 00 00 00 00 06 00 04 44 06 00 00 00 06 00 00 00 |

Fig. 163: DiagMessages in the CoE

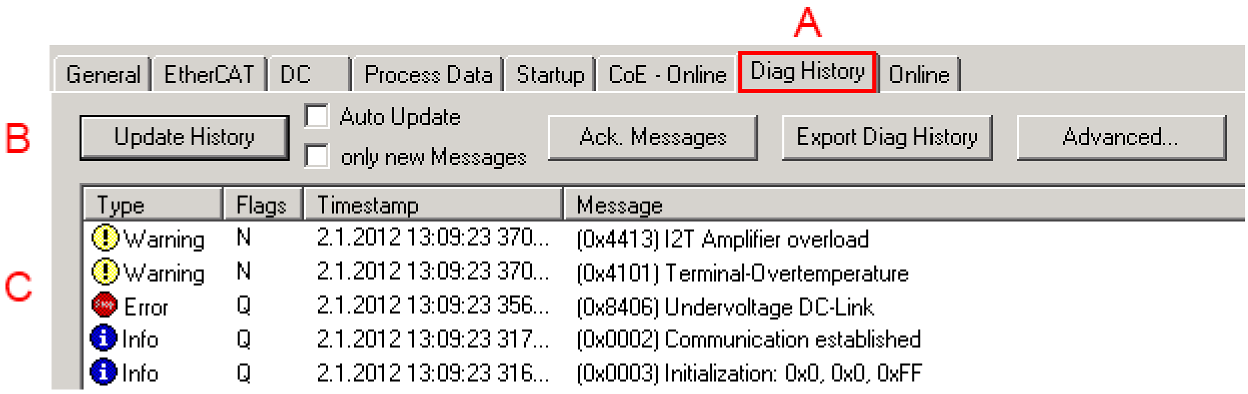
The subindex of the latest *DiagMessage* can be read under 0x10F3:02.

**Support for commissioning**

The DiagMessages system is to be used above all during the commissioning of the plant. The diagnostic values e.g. in the StatusWord of the device (if available) are helpful for online diagnosis during the subsequent continuous operation.

### TwinCAT System Manager implementation

From TwinCAT 2.11 DiagMessages, if available, are displayed in the device’s own interface. Operation (collection, confirmation) also takes place via this interface.



| Type | Flags | Timestamp | Message |
|---|---|---|---|
| Warning | N | 2.1.2012 13:09:23 370... | (0x4413) I2T Amplifier overload |
| Warning | N | 2.1.2012 13:09:23 370... | (0x4101) Terminal-Overtemperature |
| Error | Q | 2.1.2012 13:09:23 356... | (0x8406) Undervoltage DC-Link |
| Info | Q | 2.1.2012 13:09:23 317... | (0x0002) Communication established |
| Info | Q | 2.1.2012 13:09:23 316... | (0x0003) Initialization: 0x0, 0x0, 0xFF |

Fig. 164: Implementation of the DiagMessage system in the TwinCAT System Manager

The operating buttons (B) and the history read out (C) can be seen on the Diag History tab (A). The components of the message:

- Info/Warning/Error
- Acknowledge flag (N = unconfirmed, Q = confirmed)
- Time stamp
- Text ID
- Plain text message according to ESI/XML data

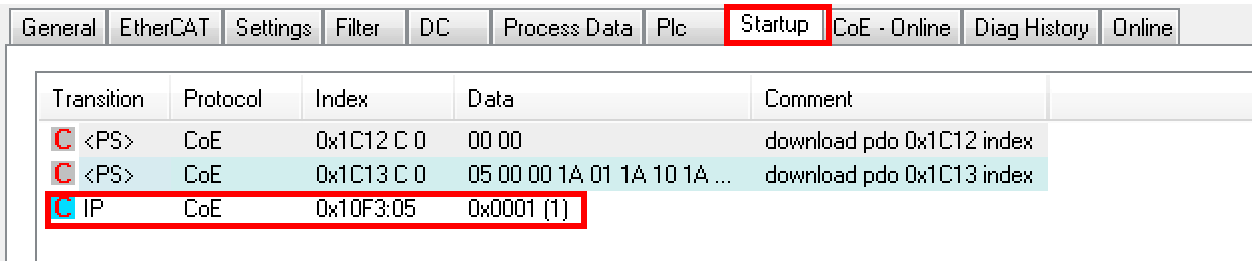
The meanings of the buttons are self-explanatory.

### DiagMessages within the ADS Logger/Eventlogger

From TwinCAT 3.1 build 4022 onwards, DiagMessages sent by the terminal are shown by the TwinCAT ADS Logger. Given that DiagMessages are represented IO- comprehensive at one place, commissioning will be simplified. In addition, the logger output could be stored into a data file – hence DiagMessages are available long-term for analysis.

DiagMessages are actually only available locally in CoE 0x10F3 in the terminal and can be read out manually if required, e.g. via the DiagHistory mentioned above.

In the latest developments, the EtherCAT Terminals are set by default to report the presence of a DiagMessage as emergency via EtherCAT; the event logger can then retrieve the DiagMessage. The function is activated in the terminal via 0x10F3:05, so such terminals have the following entry in the StartUp list by default:



| Transition | Protocol | Index | Data | Comment |
|---|---|---|---|---|
| C <PS> | CoE | 0x1C12 C 0 | 00 00 | download pdo 0x1C12 index |
| C <PS> | CoE | 0x1C13 C 0 | 05 00 00 1A 01 1A 10 1A ... | download pdo 0x1C13 index |
| C IP | CoE | 0x10F3:05 | 0x0001 (1) | |

Fig. 165: Startup List

If the function is to be deactivated because, for example, many messages come in or the EventLogger is not used, the StartUp entry can be deleted or set to 0. The value can then be set back to 1 later from the PLC via CoE access if required.

### Reading messages into the PLC

- In preparation -

### Interpretation

### Time stamp

The time stamp is obtained from the local clock of the terminal at the time of the event. The time is usually the distributed clock time (DC) from register x910.

Please note: When EtherCAT is started, the DC time in the reference clock is set to the same time as the local IPC/TwinCAT time. From this moment the DC time may differ from the IPC time, since the IPC time is not adjusted. Significant time differences may develop after several weeks of operation without a EtherCAT restart. As a remedy, external synchronization of the DC time can be used, or a manual correction calculation can be applied, as required: The current DC time can be determined via the EtherCAT master or from register x901 of the DC slave.

### Structure of the Text ID

The structure of the MessageID is not subject to any standardization and can be supplier-specifically defined. In the case of Beckhoff EtherCAT devices (EL, EP) it usually reads according to **xyzz**:

| x | y | zz |
|---|---|---|
| 0: Systeminfo<br>2: reserved<br>1: Info<br>4: Warning<br>8: Error | 0: System<br>1: General<br>2: Communication<br>3: Encoder<br>4: Drive<br>5: Inputs<br>6: I/O general<br>7: reserved | Error number |

Example: Message 0x4413 --> Drive Warning Number 0x13

### Overview of text IDs

Specific text IDs are listed in the device documentation.

| Text ID | Type | Place | Text Message | Additional comment |
|---|---|---|---|---|
| 0x0001 | Information | System | No error | No error |
| 0x0002 | Information | System | Communication established | Connection established |
| 0x0003 | Information | System | Initialization: 0x%X, 0x%X, 0x%X | General information; parameters depend on event. See device documentation for interpretation. |
| 0x1000 | Information | System | Information: 0x%X, 0x%X, 0x%X | General information; parameters depend on event. See device documentation for interpretation. |
| 0x1012 | Information | System | EtherCAT state change Init - PreOp | |
| 0x1021 | Information | System | EtherCAT state change PreOp - Init | |
| 0x1024 | Information | System | EtherCAT state change PreOp - Safe-Op | |
| 0x1042 | Information | System | EtherCAT state change SafeOp - PreOp | |
| 0x1048 | Information | System | EtherCAT state change SafeOp - Op | |
| 0x1084 | Information | System | EtherCAT state change Op - SafeOp | |
| 0x1100 | Information | General | Detection of operation mode completed: 0x%X, %d | Detection of the mode of operation ended |
| 0x1135 | Information | General | Cycle time o.k.: %d | Cycle time OK |
| 0x1157 | Information | General | Data manually saved (Idx: 0x%X, SubIdx: 0x%X) | Data saved manually |
| 0x1158 | Information | General | Data automatically saved (Idx: 0x%X, SubIdx: 0x%X) | Data saved automatically |
| 0x1159 | Information | General | Data deleted (Idx: 0x%X, SubIdx: 0x%X) | Data deleted |
| 0x117F | Information | General | Information: 0x%X, 0x%X, 0x%X | Information |
| 0x1201 | Information | Communication | Communication re-established | Communication to the field side restored<br>This message appears, for example, if the voltage was removed from the power contacts and re-applied during operation. |
| 0x1300 | Information | Encoder | Position set: %d, %d | Position set - StartInputhandler |
| 0x1303 | Information | Encoder | Encoder Supply ok | Encoder power supply unit OK |
| 0x1304 | Information | Encoder | Encoder initialization successfully, channel: %X | Encoder initialization successfully completed |
| 0x1305 | Information | Encoder | Sent command encoder reset, channel: %X | Send encoder reset command |
| 0x1400 | Information | Drive | Drive is calibrated: %d, %d | Drive is calibrated |
| 0x1401 | Information | Drive | Actual drive state: 0x%X, %d | Current drive status |
| 0x1705 | Information | | CPU usage returns in normal range (< 85%%) | Processor load is back in the normal range |
| 0x1706 | Information | | Channel is not in saturation anymore | Channel is no longer in saturation |
| 0x1707 | Information | | Channel is not in overload anymore | Channel is no longer overloaded |
| 0x170A | Information | | No channel range error anymore | A measuring range error is no longer active |
| 0x170C | Information | | Calibration data saved | Calibration data were saved |
| 0x170D | Information | | Calibration data will be applied and saved after sending the command “0x5AFE” | Calibration data are not applied and saved until the command "0x5AFE" is sent. |

| Text ID | Type | Place | Text Message | Additional comment |
|---|---|---|---|---|
| 0x2000 | Information | System | %s: %s | |
| 0x2001 | Information | System | %s: Network link lost | Network connection lost |
| 0x2002 | Information | System | %s: Network link detected | Network connection found |
| 0x2003 | Information | System | %s: no valid IP Configuration - Dhcp client started | Invalid IP configuration |
| 0x2004 | Information | System | %s: valid IP Configuration (IP: %d.%d.%d.%d) assigned by Dhcp server %d.%d.%d.%d | Valid IP configuration, assigned by the DHCP server |
| 0x2005 | Information | System | %s: Dhcp client timed out | DHCP client timeout |
| 0x2006 | Information | System | %s: Duplicate IP Address detected (%d.%d.%d.%d) | Duplicate IP address found |
| 0x2007 | Information | System | %s: UDP handler initialized | UDP handler initialized |
| 0x2008 | Information | System | %s: TCP handler initialized | TCP handler initialized |
| 0x2009 | Information | System | %s: No more free TCP sockets available | No free TCP sockets available. |

| Text ID | Type | Place | Text Message | Additional comment |
|---|---|---|---|---|
| 0x4000 | Warning | | Warning: 0x%X, 0x%X, 0x%X | General warning; parameters depend on event. See device documentation for interpretation. |
| 0x4001 | Warning | System | Warning: 0x%X, 0x%X, 0x%X | |
| 0x4002 | Warning | System | %s: %s Connection Open (IN:%d OUT:%d API:%dms) from %d.%d.%d.%d successful | |
| 0x4003 | Warning | System | %s: %s Connection Close (IN:%d OUT:%d) from %d.%d.%d.%d successful | |
| 0x4004 | Warning | System | %s: %s Connection (IN:%d OUT:%d) with %d.%d.%d.%d timed out | |
| 0x4005 | Warning | System | %s: %s Connection Open (IN:%d OUT:%d) from %d.%d.%d.%d denied (Error: %u) | |
| 0x4006 | Warning | System | %s: %s Connection Open (IN:%d OUT:%d) from %d.%d.%d.%d denied (Input Data Size expected: %d Byte(s) received: %d Byte(s)) | |
| 0x4007 | Warning | System | %s: %s Connection Open (IN:%d OUT:%d) from %d.%d.%d.%d denied (Output Data Size expected: %d Byte(s) received: %d Byte(s)) | |
| 0x4008 | Warning | System | %s: %s Connection Open (IN:%d OUT:%d) from %d.%d.%d.%d denied (RPI:%dms not supported -> API:%dms) | |
| 0x4101 | Warning | General | Terminal-Overtemperature | Overtemperature. The internal temperature of the terminal exceeds the parameterized warning threshold. |
| 0x4102 | Warning | General | Discrepancy in the PDO-Configuration | The selected PDOs do not match the set operating mode.<br>Sample: Drive operates in velocity mode, but the velocity PDO is but not mapped in the PDOs. |
| 0x417F | Warning | General | Warning: 0x%X, 0x%X, 0x%X | |
| 0x428D | Warning | General | Challenge is not Random | |
| 0x4300 | Warning | Encoder | Subincrements deactivated: %d, %d | Sub-increments deactivated (despite activated configuration) |
| 0x4301 | Warning | Encoder | Encoder-Warning | General encoder error |
| 0x4302 | Warning | Encoder | Maximum frequency of the input signal is nearly reached (channel %d) | |
| 0x4303 | Warning | Encoder | Limit counter value was reduced because of the PDO configuration (channel %d) | |
| 0x4304 | Warning | Encoder | Reset counter value was reduced because of the PDO configuration (channel %d) | |
| 0x4400 | Warning | Drive | Drive is not calibrated: %d, %d | Drive is not calibrated |
| 0x4401 | Warning | Drive | Starttype not supported: 0x%X, %d | Start type is not supported |
| 0x4402 | Warning | Drive | Command rejected: %d, %d | Command rejected |
| 0x4405 | Warning | Drive | Invalid modulo subtype: %d, %d | Modulo sub-type invalid |
| 0x4410 | Warning | Drive | Target overrun: %d, %d | Target position exceeded |
| 0x4411 | Warning | Drive | DC-Link undervoltage (Warning) | The DC link voltage of the terminal is lower than the parameterized minimum voltage. Activation of the output stage is prevented. |
| 0x4412 | Warning | Drive | DC-Link overvoltage (Warning) | The DC link voltage of the terminal is higher than the parameterized maximum voltage. Activation of the output stage is prevented. |
| 0x4413 | Warning | Drive | I2T-Model Amplifier overload (Warning) | • The amplifier is being operated outside the specification.<br>• The I2T-model of the amplifier is incorrectly parameterized. |
| 0x4414 | Warning | Drive | I2T-Model Motor overload (Warning) | • The motor is being operated outside the parameterized rated values. |

| Text ID | Type | Place | Text Message | Additional comment |
|---|---|---|---|---|
| | | | | - The I2T-model of the motor is incorrectly parameterized. |
| 0x4415 | Warning | Drive | Speed limitation active | The maximum speed is limited by the parameterized objects (e.g. velocity limitation, motor speed limitation). This warning is output if the set velocity is higher than one of the parameterized limits. |
| 0x4416 | Warning | Drive | Step lost detected at position: 0x%X%X | Step loss detected |
| 0x4417 | Warning | Drive | Motor overtemperature | The internal temperature of the motor exceeds the parameterized warning threshold |
| 0x4418 | Warning | Drive | Limit: Current | Limit: current is limited |
| 0x4419 | Warning | Drive | Limit: Amplifier I2T-model exceeds 100%% | The threshold values for the maximum current were exceeded. |
| 0x441A | Warning | Drive | Limit: Motor I2T-model exceeds 100%% | Limit: Motor I2T-model exceeds 100% |
| 0x441B | Warning | Drive | Limit: Velocity limitation | The threshold values for the maximum speed were exceeded. |
| 0x441C | Warning | Drive | STO while the axis was enabled | An attempt was made to activate the axis, despite the fact that no voltage is present at the STO input. |
| 0x4600 | Warning | General IO | Wrong supply voltage range | Supply voltage not in the correct range |
| 0x4610 | Warning | General IO | Wrong output voltage range | Output voltage not in the correct range |
| 0x4705 | Warning | | Processor usage at %d %% | Processor load at %d %% |
| 0x470A | Warning | | EtherCAT Frame missed (change Settings or DC Operation Mode or Sync0 Shift Time) | EtherCAT frame missed (change DC Operation Mode or Sync0 Shift Time under Settings) |

| Text ID | Type | Place | Text Message | Additional comment |
|---|---|---|---|---|
| 0x8000 | Error | System | %s: %s | |
| 0x8001 | Error | System | Error: 0x%X, 0x%X, 0x%X | General error; parameters depend on event. See device documentation for interpretation. |
| 0x8002 | Error | System | Communication aborted | Communication aborted |
| 0x8003 | Error | System | Configuration error: 0x%X, 0x%X, 0x%X | General; parameters depend on event.<br>See device documentation for interpretation. |
| 0x8004 | Error | System | %s: Unsuccessful FwdOpen-Response received from %d.%d.%d.%d (%s) (Error: %u) | |
| 0x8005 | Error | System | %s: FwdClose-Request sent to %d.%d.%d.%d (%s) | |
| 0x8006 | Error | System | %s: Unsuccessful FwdClose-Response received from %d.%d.%d.%d (%s) (Error: %u) | |
| 0x8007 | Error | System | %s: Connection with %d.%d.%d.%d (%s) closed | |
| 0x8100 | Error | General | Status word set: 0x%X, %d | Error bit set in the status word |
| 0x8101 | Error | General | Operation mode incompatible to PDO interface: 0x%X, %d | Mode of operation incompatible with the PDO interface |
| 0x8102 | Error | General | Invalid combination of Inputs and Outputs PDOs | Invalid combination of input and output PDOs |
| 0x8103 | Error | General | No variable linkage | No variables linked |
| 0x8104 | Error | General | Terminal-Overtemperature | The internal temperature of the terminal exceeds the parameterized error threshold. Activation of the terminal is prevented |
| 0x8105 | Error | General | PD-Watchdog | Communication between the fieldbus and the output stage is secured by a Watchdog. The axis is stopped automatically if the fieldbus communication is interrupted.<br>• The EtherCAT connection was interrupted during operation.<br>• The Master was switched to Config mode during operation. |
| 0x8135 | Error | General | Cycle time has to be a multiple of 125 µs | The IO or NC cycle time divided by 125 µs does not produce a whole number. |
| 0x8136 | Error | General | Configuration error: invalid sampling rate | Configuration error: Invalid sampling rate |
| 0x8137 | Error | General | Electronic type plate: CRC error | Content of the external name plate memory invalid. |
| 0x8140 | Error | General | Sync Error | Real-time violation |
| 0x8141 | Error | General | Sync%X Interrupt lost | Sync%X Interrupt lost |
| 0x8142 | Error | General | Sync Interrupt asynchronous | Sync Interrupt asynchronous |
| 0x8143 | Error | General | Jitter too big | Jitter limit violation |
| 0x817F | Error | General | Error: 0x%X, 0x%X, 0x%X | |
| 0x8200 | Error | Communication | Write access error: %d, %d | Error while writing |
| 0x8201 | Error | Communication | No communication to field-side (Auxiliary voltage missing) | • There is no voltage applied to the power contacts.<br>• A firmware update has failed. |
| 0x8281 | Error | Communication | Ownership failed: %X | |
| 0x8282 | Error | Communication | To many Keys founded | |
| 0x8283 | Error | Communication | Key Creation failed: %X | |
| 0x8284 | Error | Communication | Key loading failed | |
| 0x8285 | Error | Communication | Reading Public Key failed: %X | |
| 0x8286 | Error | Communication | Reading Public EK failed: %X | |
| 0x8287 | Error | Communication | Reading PCR Value failed: %X | |
| 0x8288 | Error | Communication | Reading Certificate EK failed: %X | |
| 0x8289 | Error | Communication | Challenge could not be hashed: %X | |
| 0x828A | Error | Communication | Tickstamp Process failed | |
| 0x828B | Error | Communication | PCR Process failed: %X | |
| 0x828C | Error | Communication | Quote Process failed: %X | |
| 0x82FF | Error | Communication | Bootmode not activated | Boot mode not activated |
| 0x8300 | Error | Encoder | Set position error: 0x%X, %d | Error while setting the position |

| Text ID | Type | Place | Text Message | Additional comment |
|---|---|---|---|---|
| 0x8301 | Error | Encoder | Encoder increments not configured: 0x%X, %d | Encoder increments not configured |
| 0x8302 | Error | Encoder | Encoder error | The amplitude of the resolver is too small |
| 0x8303 | Error | Encoder | Encoder power missing (channel %d) | |
| 0x8304 | Error | Encoder | Encoder communication error, channel: %X | Encoder communication error |
| 0x8305 | Error | Encoder | EnDat2.2 is not supported, channel: %X | EnDat2.2 is not supported |
| 0x8306 | Error | Encoder | Delay time, tolerance limit exceeded, 0x%X, channel: %X | Runtime measurement, tolerance exceeded |
| 0x8307 | Error | Encoder | Delay time, maximum value exceeded, 0x%X, channel: %X | Runtime measurement, maximum value exceeded |
| 0x8308 | Error | Encoder | Unsupported ordering designation, 0x%X, channel: %X (only 02 and 22 is supported) | Wrong EnDat order ID |
| 0x8309 | Error | Encoder | Encoder CRC error, channel: %X | Encoder CRC error |
| 0x830A | Error | Encoder | Temperature %X could not be read, channel: %X | Temperature cannot be read |
| 0x830C | Error | Encoder | Encoder Single-Cycle-Data Error, channel. %X | CRC error detected. Check the transmission path and the CRC polynomial |
| 0x830D | Error | Encoder | Encoder Watchdog Error, channel. %X | The sensor has not responded within a predefined time period |
| 0x8310 | Error | Encoder | Initialisation error | |
| 0x8311 | Error | Encoder | Maximum frequency of the input signal is exceeded (channel %d) | |
| 0x8312 | Error | Encoder | Encoder plausibility error (channel %d) | |
| 0x8313 | Error | Encoder | Configuration error (channel %d) | |
| 0x8314 | Error | Encoder | Synchronisation error | |
| 0x8315 | Error | Encoder | Error status input (channel %d) | |
| 0x8400 | Error | Drive | Incorrect drive configuration: 0x%X, %d | Drive incorrectly configured |
| 0x8401 | Error | Drive | Limiting of calibration velocity: %d, %d | Limitation of the calibration velocity |
| 0x8402 | Error | Drive | Emergency stop activated: 0x%X, %d | Emergency stop activated |
| 0x8403 | Error | Drive | ADC Error | Error during current measurement in the ADC |
| 0x8404 | Error | Drive | Overcurrent | Overcurrent in phase U, V or W |
| 0x8405 | Error | Drive | Invalid modulo position: %d | Modulo position invalid |
| 0x8406 | Error | Drive | DC-Link undervoltage (Error) | The DC link voltage of the terminal is lower than the parameterized minimum voltage. Activation of the output stage is prevented. |
| 0x8407 | Error | Drive | DC-Link overvoltage (Error) | The DC link voltage of the terminal is higher than the parameterized maximum voltage. Activation of the output stage is prevented. |
| 0x8408 | Error | Drive | I2T-Model Amplifier overload (Error) | • The amplifier is being operated outside the specification.<br>• The I2T-model of the amplifier is incorrectly parameterized. |
| 0x8409 | Error | Drive | I2T-Model motor overload (Error) | • The motor is being operated outside the parameterized rated values.<br>• The I2T-model of the motor is incorrectly parameterized. |
| 0x840A | Error | Drive | Overall current threshold exceeded | Total current exceeded |
| 0x8415 | Error | Drive | Invalid modulo factor: %d | Modulo factor invalid |
| 0x8416 | Error | Drive | Motor overtemperature | The internal temperature of the motor exceeds the parameterized error threshold. The motor stops immediately. Activation of the output stage is prevented. |
| 0x8417 | Error | Drive | Maximum rotating field velocity exceeded | Rotary field speed exceeds the value specified for dual use (EU 1382/2014). |
| 0x841C | Error | Drive | STO while the axis was enabled | An attempt was made to activate the axis, despite the fact that no voltage is present at the STO input. |

| Text ID | Type | Place | Text Message | Additional comment |
|---|---|---|---|---|
| 0x8550 | Error | Inputs | Zero crossing phase %X missing | Zero crossing phase %X missing |
| 0x8551 | Error | Inputs | Phase sequence Error | Wrong direction of rotation |
| 0x8552 | Error | Inputs | Overcurrent phase %X | Overcurrent phase %X |
| 0x8553 | Error | Inputs | Overcurrent neutral wire | Overcurrent neutral wire |
| 0x8581 | Error | Inputs | Wire broken Ch %D | Wire broken Ch %d |
| 0x8600 | Error | General IO | Wrong supply voltage range | Supply voltage not in the correct range |
| 0x8601 | Error | General IO | Supply voltage to low | Supply voltage too low |
| 0x8602 | Error | General IO | Supply voltage to high | Supply voltage too high |
| 0x8603 | Error | General IO | Over current of supply voltage | Overcurrent of supply voltage |
| 0x8610 | Error | General IO | Wrong output voltage range | Output voltage not in the correct range |
| 0x8611 | Error | General IO | Output voltage to low | Output voltage too low |
| 0x8612 | Error | General IO | Output voltage to high | Output voltage too high |
| 0x8613 | Error | General IO | Over current of output voltage | Overcurrent of output voltage |
| 0x8700 | Error | | Channel/Interface not calibrated | Channel/interface not synchronized |
| 0x8701 | Error | | Operating time was manipulated | Operating time was manipulated |
| 0x8702 | Error | | Oversampling setting is not possible | Oversampling setting not possible |
| 0x8703 | Error | | No slave controller found | No slave controller found |
| 0x8704 | Error | | Slave controller is not in Bootstrap | Slave controller is not in bootstrap |
| 0x8705 | Error | | Processor usage to high (>= 100%%) | Processor load too high (>= 100%%) |
| 0x8706 | Error | | Channel in saturation | Channel in saturation |
| 0x8707 | Error | | Channel overload | Channel overload |
| 0x8708 | Error | | Overloadtime was manipulated | Overload time was manipulated |
| 0x8709 | Error | | Saturationtime was manipulated | Saturation time was manipulated |
| 0x870A | Error | | Channel range error | Measuring range error for the channel |
| 0x870B | Error | | no ADC clock | No ADC clock available |
| 0xFFFF | Information | | Debug: 0x%X, 0x%X, 0x%X | Debug: 0x%X, 0x%X, 0x%X |

## 8.2 Notes on Diag Messages associated with Motor Terminals

**„Ack. Message“ Button**

The ‚Ack. Message’ button has no effect on the Drive State Machine of the Motor terminals, pressing the button does not make an axis reset.
The Drive State Machine has no influence on the error list, an axis reset also does not remove any entries from the error list, however, this can be done by pressing the ‚Ack. Message’ button.

# 9 Appendix

## 9.1 EtherCAT AL Status Codes

For detailed information please refer to the EtherCAT system description.

## 9.2 Firmware compatibility

Beckhoff EtherCAT devices are delivered with the latest available firmware version. Compatibility of firmware and hardware is mandatory; not every combination ensures compatibility. The overview below shows the hardware versions on which a firmware can be operated.

**Note**

- It is recommended to use the newest possible firmware for the respective hardware
- Beckhoff is not under any obligation to provide customers with free firmware updates for delivered products.

***NOTICE***

**Risk of damage to the device!**

Pay attention to the instructions for firmware updates on the separate page [▶ 188].
If a device is placed in BOOTSTRAP mode for a firmware update, it does not check when downloading whether the new firmware is suitable.
This can result in damage to the device! Therefore, always make sure that the firmware is suitable for the hardware version!

| EL7201-0000 | | | |
|---|---|---|---|
| **Hardware (HW)** | **Firmware (FW)** | **Revision no.** | **Date of release** |
| 00 | 00 | EL7201-0000-0016 | 2010/06 |
| 02 - 11* | 01 | EL7201-0000-0017 | 2012/01 |
| | 02 | | 2012/02 |
| | 03 | | 2012/04 |
| | | EL7201-0000-0018 | 2012/08 |
| | | EL7201-0000-0019 | 2013/04 |
| | 04 | EL7201-0000-0020 | 2014/06 |
| | 05 | EL7201-0000-0021 | 2015/03 |
| | 06 | | 2016/05 |
| | 07 | | 2018/08 |
| | 08 | | 2020/03 |
| | 09* | | 2024/09 |

| EL7211-0000 | | | |
|---|---|---|---|
| **Hardware (HW)** | **Firmware (FW)** | **Revision no.** | **Date of release** |
| 06 - 12* | 04 | EL7211-0000-0020 | 2014/06 |
| | 05 | EL7211-0000-0021 | 2015/03 |
| | 06 | | 2016/05 |
| | 07 | | 2018/08 |
| | 08 | | 2020/03 |
| | 09* | | 2024/09 |

*) This is the current compatible firmware/hardware version at the time of the preparing this documentation. Check on the Beckhoff web page whether more up-to-date documentation is available.

## 9.3 Firmware Update EL/ES/EM/ELM/EP/EPP/ERPxxxx

This section describes the device update for Beckhoff EtherCAT slaves from the EL/ES, ELM, EM, EK, EP, EPP and ERP series. A firmware update should only be carried out after consultation with Beckhoff support.

**NOTICE**

**Only use TwinCAT 3 software!**

A firmware update of Beckhoff IO devices must only be performed with a TwinCAT 3 installation. It is recommended to build as up-to-date as possible, available for free download on the Beckhoff website.

To update the firmware, TwinCAT can be operated in the so-called FreeRun mode, a paid license is not required.

The device to be updated can usually remain in the installation location, but TwinCAT has to be operated in the FreeRun. Please make sure that EtherCAT communication is trouble-free (no LostFrames etc.).

Other EtherCAT master software, such as the EtherCAT Configurator, should not be used, as they may not support the complexities of updating firmware, EEPROM and other device components.

### Storage locations

An EtherCAT slave stores operating data in up to three locations:

- Each EtherCAT slave has a device description, consisting of identity (name, product code), timing specifications, communication settings, etc.
  This device description (ESI; EtherCAT Slave Information) can be downloaded from the Beckhoff website in the download area as a zip file and used in EtherCAT masters for offline configuration, e.g. in TwinCAT.
  Above all, each EtherCAT slave carries its device description (ESI) electronically readable in a local memory chip, the so-called **ESI EEPROM**. When the slave is switched on, this description is loaded locally in the slave and informs it of its communication configuration; on the other hand, the EtherCAT master can identify the slave in this way and, among other things, set up the EtherCAT communication accordingly.

**NOTICE**

**Application-specific writing of the ESI-EEPROM**

The ESI is developed by the device manufacturer according to ETG standard and released for the corresponding product.
- Meaning for the ESI file: Modification on the application side (i.e. by the user) is not permitted.
- Meaning for the ESI EEPROM: Even if a writeability is technically given, the ESI parts in the EEPROM and possibly still existing free memory areas must not be changed beyond the normal update process. Especially for cyclic memory processes (operating hours counter etc.), dedicated memory products such as EL6080 or IPC's own NOVRAM must be used.

- Depending on functionality and performance EtherCAT slaves have one or several local controllers for processing I/O data. The corresponding program is the so-called **firmware** in *.efw format.
- In some EtherCAT slaves the EtherCAT communication may also be integrated in these controllers. In this case the controller is usually a so-called **FPGA** chip with *.rbf firmware.

Customers can access the data via the EtherCAT fieldbus and its communication mechanisms. Acyclic mailbox communication or register access to the ESC is used for updating or reading of these data.

The TwinCAT System Manager offers mechanisms for programming all three parts with new data, if the slave is set up for this purpose. Generally the slave does not check whether the new data are suitable, i.e. it may no longer be able to operate if the data are unsuitable.

### Simplified update by bundle firmware

The update using so-called **bundle firmware** is more convenient: in this case the controller firmware and the ESI description are combined in a *.efw file; during the update both the firmware and the ESI are changed in the terminal. For this to happen it is necessary

- for the firmware to be in a packed format: recognizable by the file name, which also contains the revision number, e.g. ELxxxx-xxxx_REV0016_SW01.efw

- for password=1 to be entered in the download dialog. If password=0 (default setting) only the firmware update is carried out, without an ESI update.
- for the device to support this function. The function usually cannot be retrofitted; it is a component of many new developments from year of manufacture 2016.

Following the update, its success should be verified

- ESI/Revision: e.g. by means of an online scan in TwinCAT ConfigMode/FreeRun – this is a convenient way to determine the revision
- Firmware: e.g. by looking in the online CoE of the device

**NOTICE**

**Risk of damage to the device!**

✓ Note the following when downloading new device files

a) Firmware downloads to an EtherCAT device must not be interrupted

b) Flawless EtherCAT communication must be ensured. CRC errors or LostFrames must be avoided.

c) The power supply must adequately dimensioned. The signal level must meet the specification.

⇨ In the event of malfunctions during the update process the EtherCAT device may become unusable and require re-commissioning by the manufacturer.

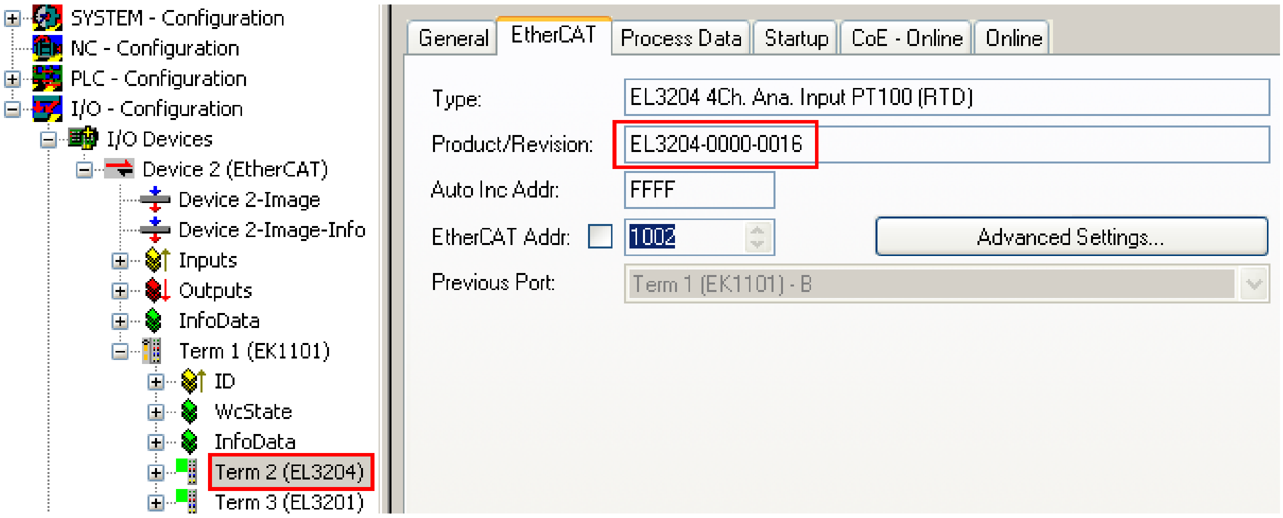
## 9.3.1 Device description ESI file/XML

**NOTICE**

**Attention regarding update of the ESI description/EEPROM**

Some slaves have stored calibration and configuration data from the production in the EEPROM. These are irretrievably overwritten during an update.

The ESI device description is stored locally on the slave and loaded on start-up. Each device description has a unique identifier consisting of slave name (9 characters/digits) and a revision number (4 digits). Each slave configured in the System Manager shows its identifier in the EtherCAT tab:



Type: EL3204 4Ch. Ana. Input PT100 (RTD)

Product/Revision: EL3204-0000-0016

Auto Inc Addr: FFFF

EtherCAT Addr: □ 1002

Previous Port: Term 1 (EK1101) - B

Fig. 166: Device identifier consisting of name EL3204-0000 and revision -0016

The configured identifier must be compatible with the actual device description used as hardware, i.e. the description which the slave has loaded on start-up (in this case EL3204). Normally the configured revision must be the same or lower than that actually present in the terminal network.

For further information on this, please refer to the EtherCAT system documentation.

**Update of XML/ESI description**

The device revision is closely linked to the firmware and hardware used. Incompatible combinations lead to malfunctions or even final shutdown of the device. Corresponding updates should only be carried out in consultation with Beckhoff support.

### Display of ESI slave identifier

The simplest way to ascertain compliance of configured and actual device description is to scan the EtherCAT boxes in TwinCAT mode Config/FreeRun:

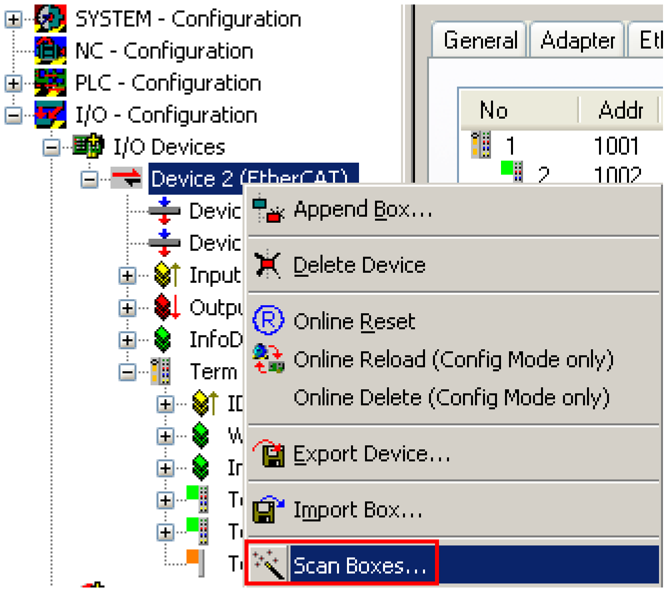
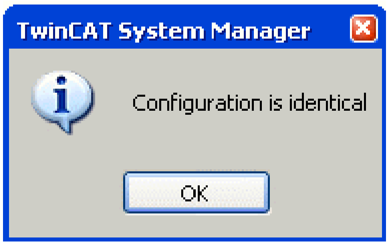


Fig. 167: Scan the subordinate field by right-clicking on the EtherCAT device

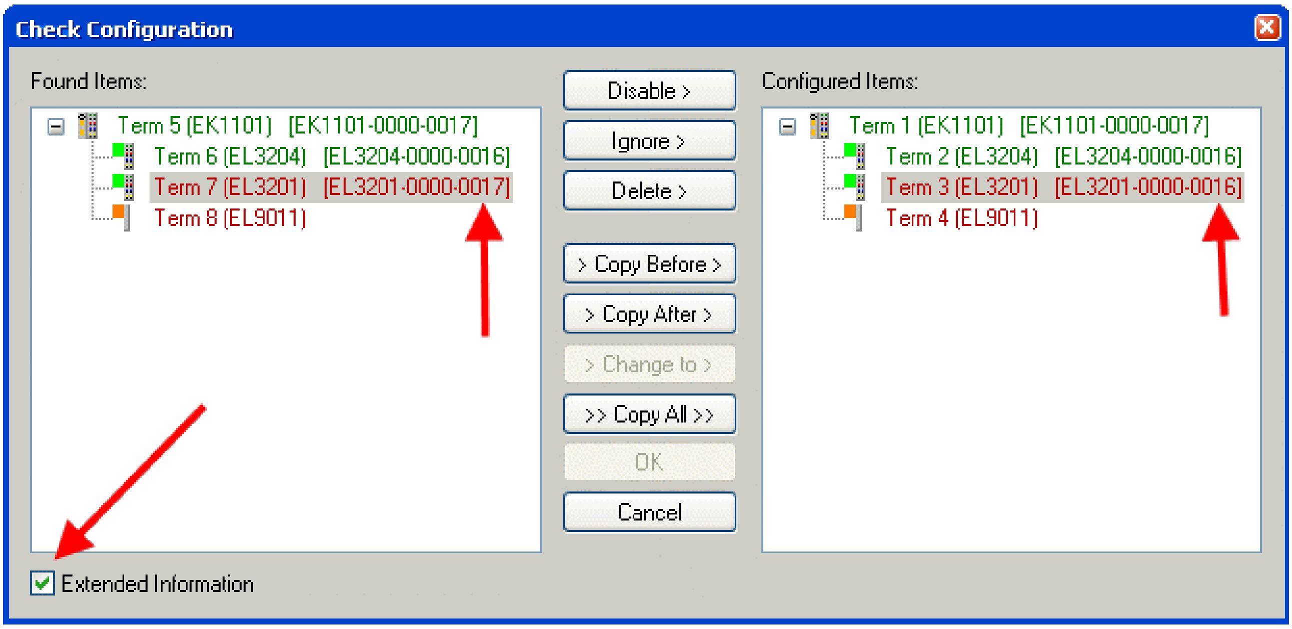
If the found field matches the configured field, the display shows


TwinCAT System Manager

Configuration is identical

Fig. 168: Configuration is identical

otherwise a change dialog appears for entering the actual data in the configuration.



Check Configuration

Found Items:

- Term 5 (EK1101) [EK1101-0000-0017]
  - Term 6 (EL3204) [EL3204-0000-0016]
  - Term 7 (EL3201) [EL3201-0000-0017]
  - Term 8 (EL9011)

Configured Items:

- Term 1 (EK1101) [EK1101-0000-0017]
  - Term 2 (EL3204) [EL3204-0000-0016]
  - Term 3 (EL3201) [EL3201-0000-0016]
  - Term 4 (EL9011)

☑ Extended Information

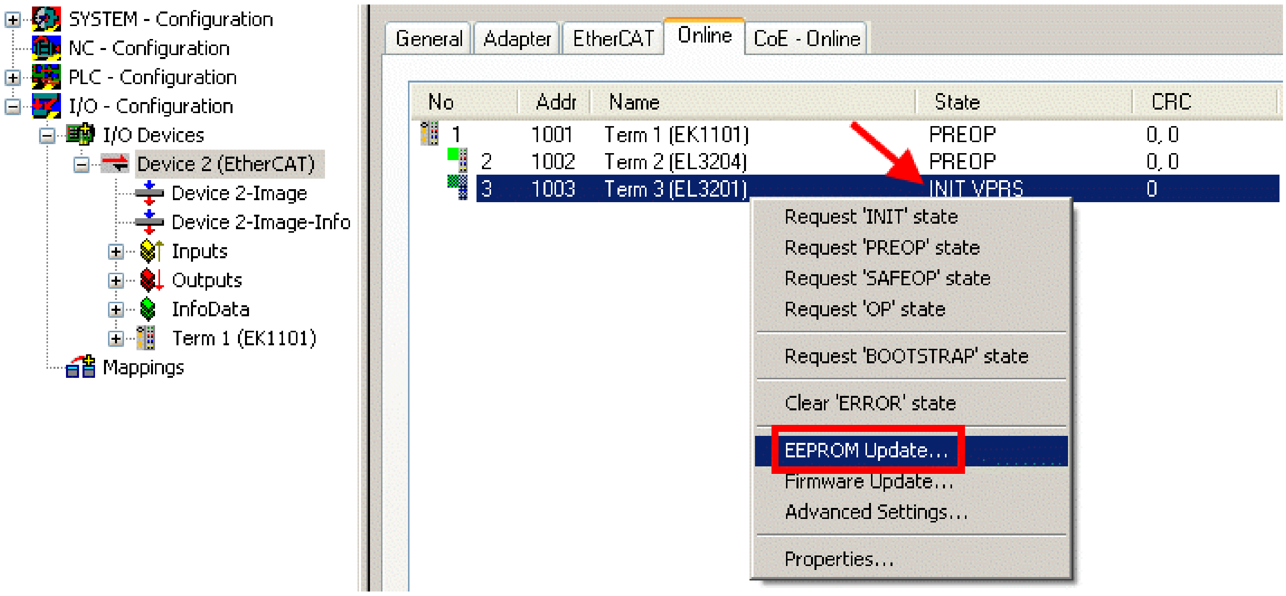
Fig. 169: Change dialog

In this example in Fig. *Change dialog*, an EL3201-0000-**0017** was found, while an EL3201-0000-**0016** was configured. In this case the configuration can be adapted with the *Copy Before* button. The *Extended Information* checkbox must be set in order to display the revision.

### Changing the ESI slave identifier

The ESI/EEPROM identifier can be updated as follows under TwinCAT:

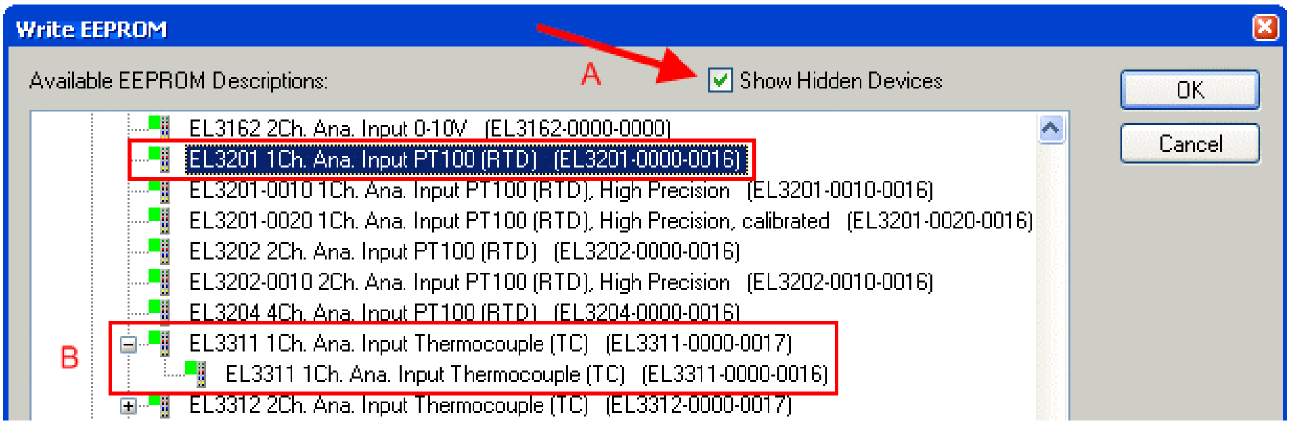
- Trouble-free EtherCAT communication must be established with the slave.
- The state of the slave is irrelevant.
- Right-clicking on the slave in the online display opens the *EEPROM Update* dialog, Fig. *EEPROM Update*



| No | Addr | Name | State | CRC |
|---|---|---|---|---|
| 1 | 1001 | Term 1 (EK1101) | PREOP | 0, 0 |
| 2 | 1002 | Term 2 (EL3204) | PREOP | 0, 0 |
| 3 | 1003 | Term 3 (EL3201) | INIT VPRS | 0 |

Fig. 170: EEPROM Update

The new ESI description is selected in the following dialog, see Fig. *Selecting the new ESI.* The checkbox *Show Hidden Devices* also displays older, normally hidden versions of a slave.



EL3162 2Ch. Ana. Input 0-10V (EL3162-0000-0000)
EL3201 1Ch. Ana. Input PT100 (RTD) (EL3201-0000-0016)
EL3201-0010 1Ch. Ana. Input PT100 (RTD), High Precision (EL3201-0010-0016)
EL3201-0020 1Ch. Ana. Input PT100 (RTD), High Precision, calibrated (EL3201-0020-0016)
EL3202 2Ch. Ana. Input PT100 (RTD) (EL3202-0000-0016)
EL3202-0010 2Ch. Ana. Input PT100 (RTD), High Precision (EL3202-0010-0016)
EL3204 4Ch. Ana. Input PT100 (RTD) (EL3204-0000-0016)
EL3311 1Ch. Ana. Input Thermocouple (TC) (EL3311-0000-0017)
EL3311 1Ch. Ana. Input Thermocouple (TC) (EL3311-0000-0016)
EL3312 2Ch. Ana. Input Thermocouple (TC) (EL3312-0000-0017)

Fig. 171: Selecting the new ESI

A progress bar in the System Manager shows the progress. Data are first written, then verified.

**The change only takes effect after a restart.**

Most EtherCAT devices read a modified ESI description immediately or after startup from the INIT. Some communication settings such as distributed clocks are only read during power-on. The EtherCAT slave therefore has to be switched off briefly in order for the change to take effect.

## 9.3.2 Firmware explanation

### Determining the firmware version

### Determining the version via the TwinCAT System Manager

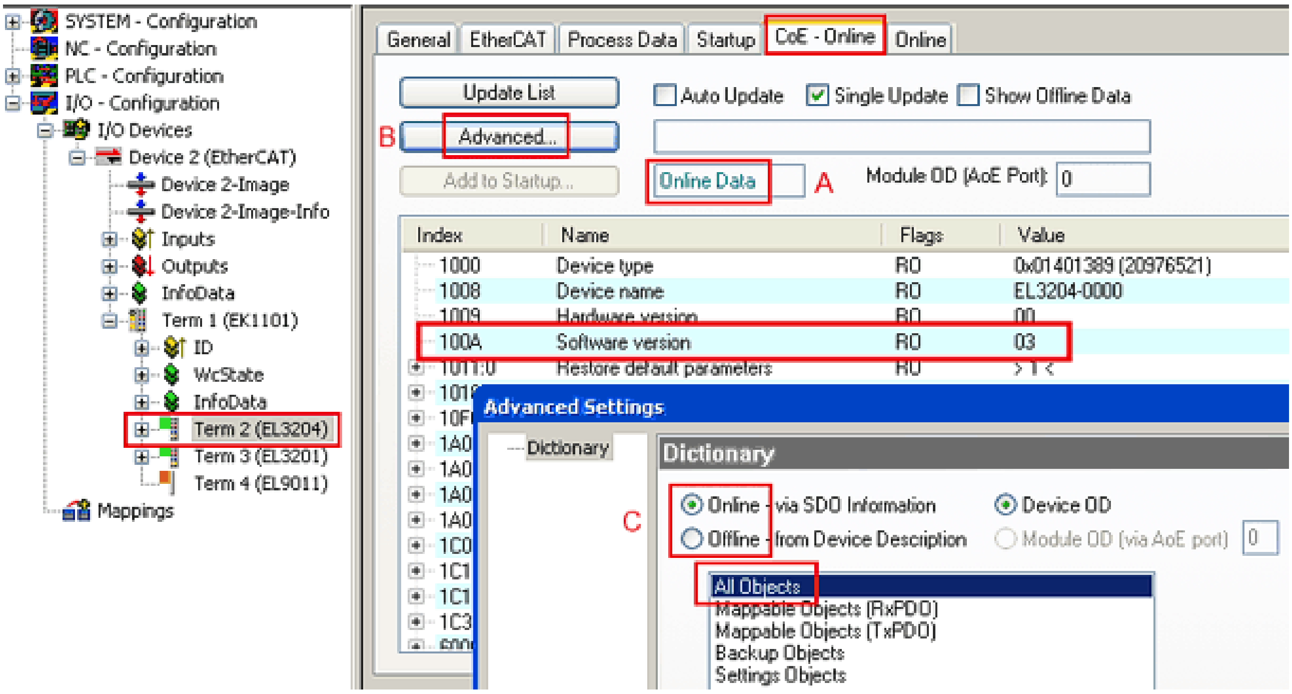
The TwinCAT System Manager shows the version of the controller firmware if the master can access the slave online. Click on the E-Bus Terminal whose controller firmware you want to check (in the example terminal 2 (EL3204)) and select the tab *CoE Online* (CAN over EtherCAT).

**CoE Online and Offline CoE**

Two CoE directories are available:
• **online**: This is offered in the EtherCAT slave by the controller, if the EtherCAT slave supports this. This CoE directory can only be displayed if a slave is connected and operational.
• **offline**: The EtherCAT Slave Information ESI/XML may contain the default content of the CoE. This CoE directory can only be displayed if it is included in the ESI (e.g. “Beckhoff EL5xxx.xml”).

The Advanced button must be used for switching between the two views.

In Fig. *Display of EL3204 firmware version* the firmware version of the selected EL3204 is shown as 03 in CoE entry 0x100A.



| Index | Name | Flags | Value |
|---|---|---|---|
| 1000 | Device type | RO | 0x01401389 (20976521) |
| 1008 | Device name | RO | EL3204-0000 |
| 1009 | Hardware version | RO | 00 |
| 100A | Software version | RO | 03 |
| 1011:0 | Restore default parameters | RO | > 1 < |

Fig. 172: Display of EL3204 firmware version

In (A) TwinCAT 2.11 shows that the Online CoE directory is currently displayed. If this is not the case, the Online directory can be loaded via the *Online* option in Advanced Settings (B) and double-clicking on *AllObjects*.

## 9.3.3 Updating controller firmware *.efw

**CoE directory**

The Online CoE directory is managed by the controller and stored in a dedicated EEPROM, which is generally not changed during a firmware update.

Switch to the *Online* tab to update the controller firmware of a slave, see Fig. *Firmware Update.*

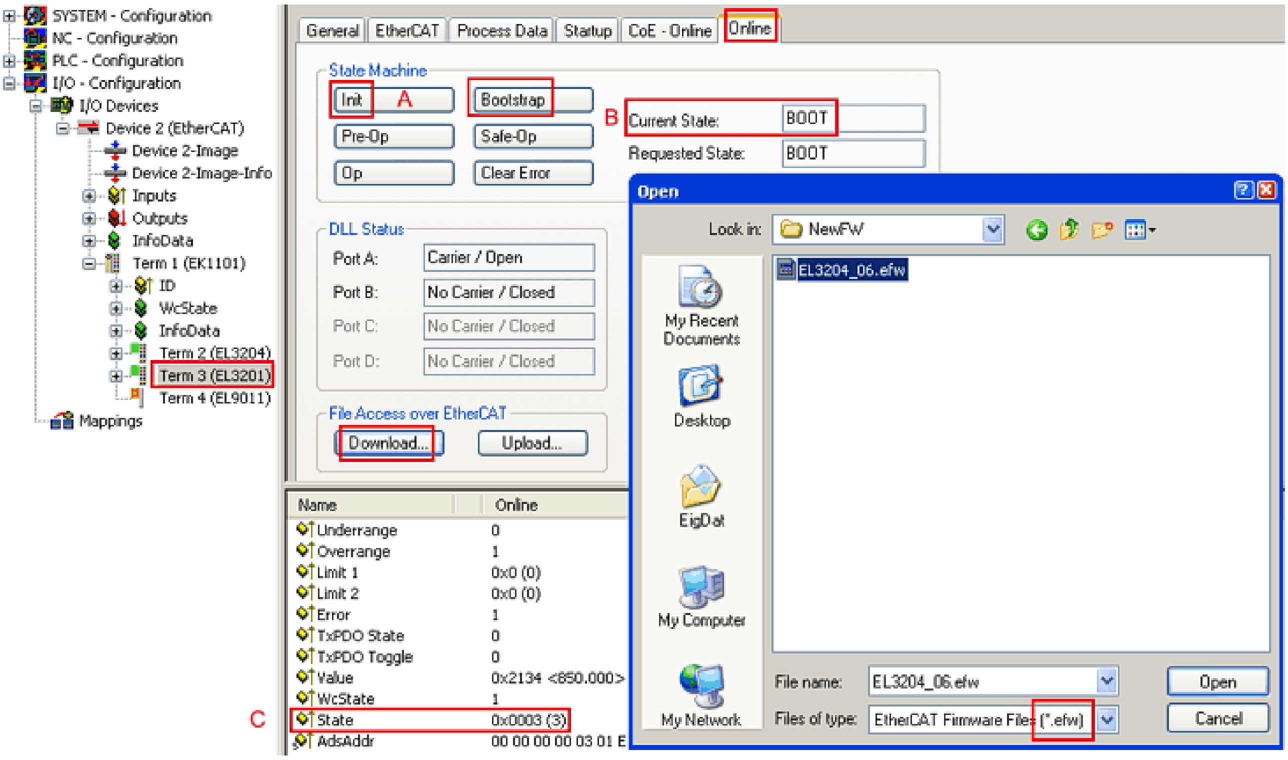
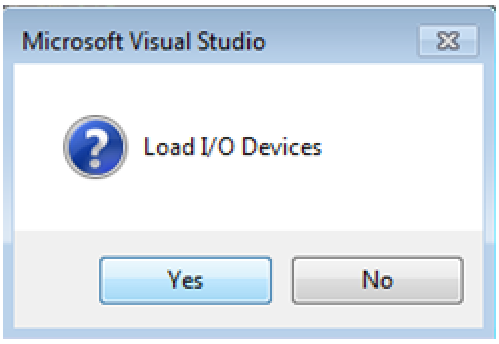
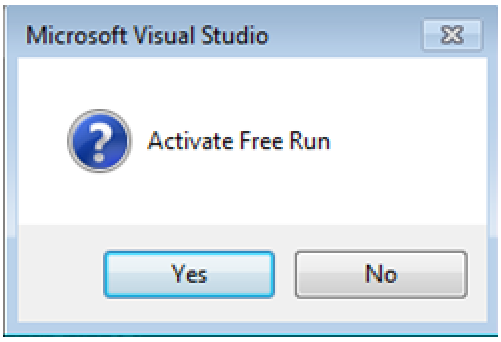


Fig. 173: Firmware Update

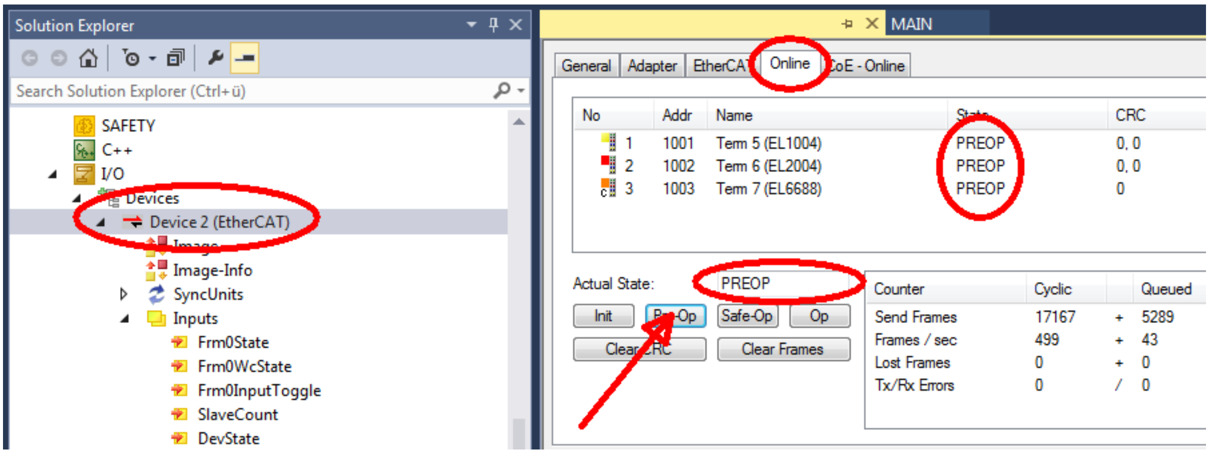
Proceed as follows, unless instructed otherwise by Beckhoff support. Valid for TwinCAT 2 and 3 as EtherCAT master.

- Switch TwinCAT system to ConfigMode/FreeRun with cycle time >= 1 ms (default in ConfigMode is 4 ms). A FW-Update during real time operation is not recommended.



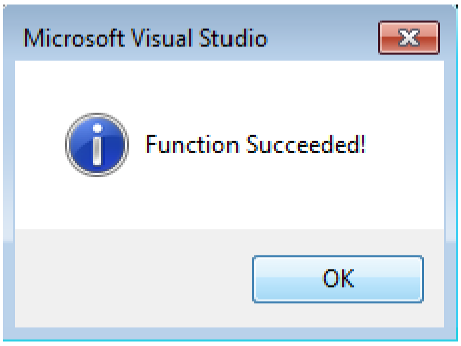


- Switch EtherCAT Master to PreOP



- Switch slave to INIT (A)
- Switch slave to BOOTSTRAP

- Check the current status (B, C)
- Download the new *efw file (wait until it ends). A password will not be necessary usually.



Microsoft Visual Studio

Function Succeeded!

- After the download switch to INIT, then PreOP
- Switch off the slave briefly (don't pull under voltage!)
- Check within CoE 0x100A, if the FW status was correctly overtaken.

## 9.3.4 FPGA firmware *.rbf

If an FPGA chip deals with the EtherCAT communication an update may be accomplished via an *.rbf file.

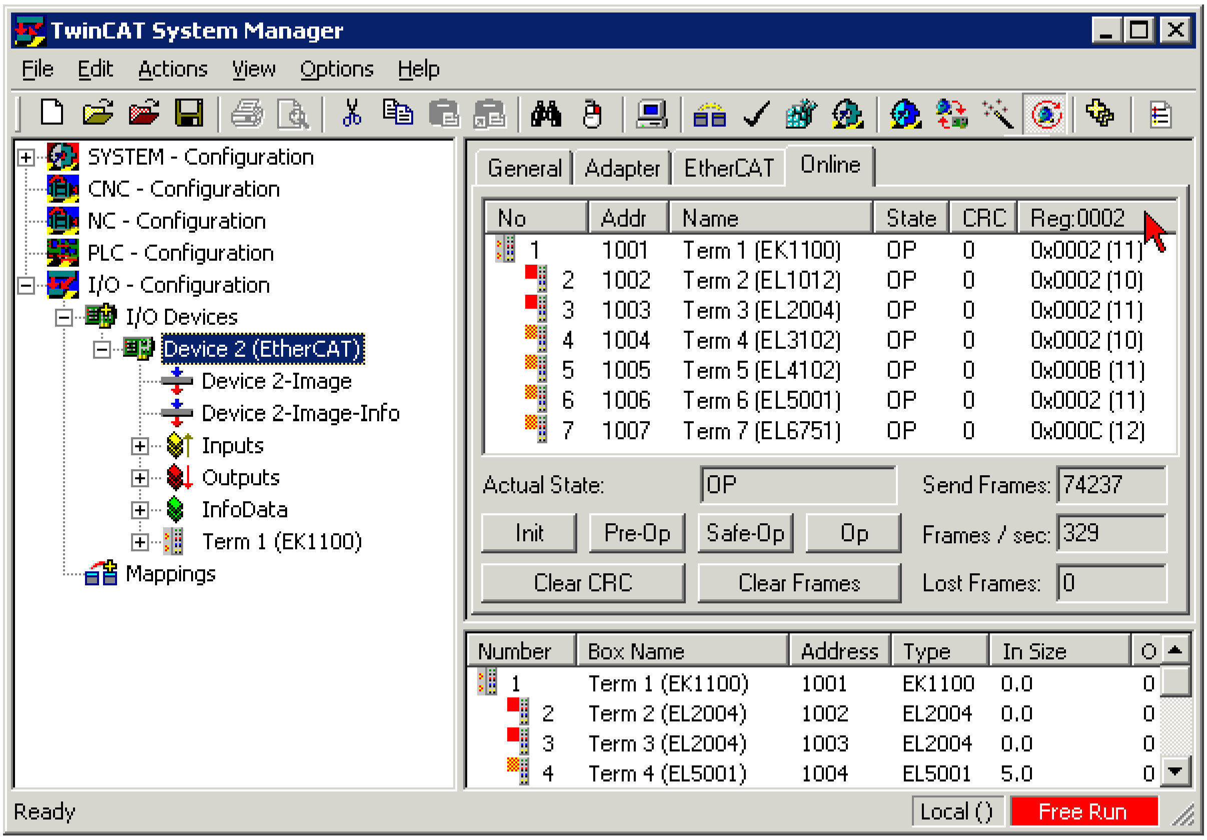
- Controller firmware for processing I/O signals
- FPGA firmware for EtherCAT communication (only for terminals with FPGA)

The firmware version number included in the terminal serial number contains both firmware components. If one of these firmware components is modified this version number is updated.

**Determining the version via the TwinCAT System Manager**

The TwinCAT System Manager indicates the FPGA firmware version. Click on the Ethernet card of your EtherCAT strand (Device 2 in the example) and select the *Online* tab.

The *Reg:0002* column indicates the firmware version of the individual EtherCAT devices in hexadecimal and decimal representation.



| No | Addr | Name | State | CRC | Reg:0002 |
|---|---|---|---|---|---|
| 1 | 1001 | Term 1 (EK1100) | OP | 0 | 0x0002 (11) |
| 2 | 1002 | Term 2 (EL1012) | OP | 0 | 0x0002 (10) |
| 3 | 1003 | Term 3 (EL2004) | OP | 0 | 0x0002 (11) |
| 4 | 1004 | Term 4 (EL3102) | OP | 0 | 0x0002 (10) |
| 5 | 1005 | Term 5 (EL4102) | OP | 0 | 0x000B (11) |
| 6 | 1006 | Term 6 (EL5001) | OP | 0 | 0x0002 (11) |
| 7 | 1007 | Term 7 (EL6751) | OP | 0 | 0x000C (12) |

Actual State: OP
Send Frames: 74237
Frames / sec: 329
Lost Frames: 0

| Number | Box Name | Address | Type | In Size | O |
|---|---|---|---|---|---|
| 1 | Term 1 (EK1100) | 1001 | EK1100 | 0.0 | 0 |
| 2 | Term 2 (EL2004) | 1002 | EL2004 | 0.0 | 0 |
| 3 | Term 3 (EL2004) | 1003 | EL2004 | 0.0 | 0 |
| 4 | Term 4 (EL5001) | 1004 | EL5001 | 5.0 | 0 |

Ready Local () Free Run

Fig. 174: FPGA firmware version definition

If the column *Reg:0002* is not displayed, right-click the table header and select *Properties* in the context menu.

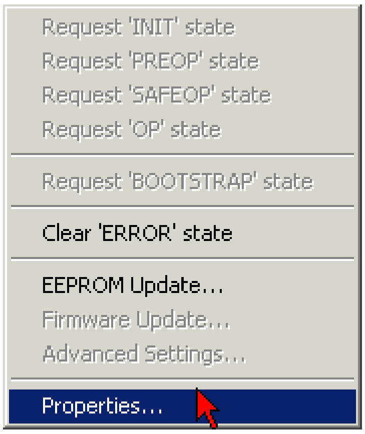
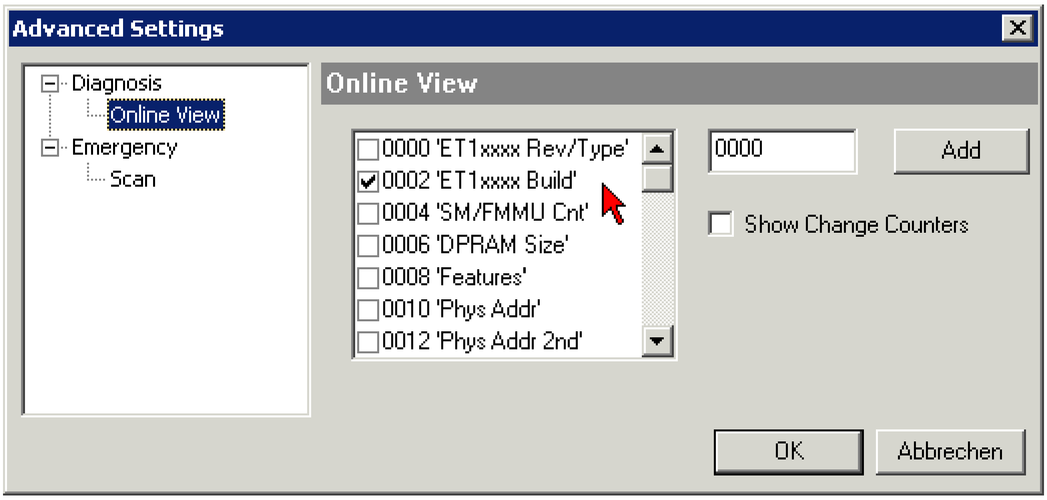


Fig. 175: Context menu *Properties*

The *Advanced Settings* dialog appears where the columns to be displayed can be selected. Under *Diagnosis/***Online View** select the *'0002 ETxxxx Build'* check box in order to activate the FPGA firmware version display.



- ☐ 0000 'ET1xxxx Rev/Type'
- ☑ 0002 'ET1xxxx Build'
- ☐ 0004 'SM/FMMU Cnt'
- ☐ 0006 'DPRAM Size'
- ☐ 0008 'Features'
- ☐ 0010 'Phys Addr'
- ☐ 0012 'Phys Addr 2nd'

0000

☐ Show Change Counters

Fig. 176: Dialog *Advanced Settings*

### Update

For updating the FPGA firmware

- of an EtherCAT coupler the coupler must have FPGA firmware version 11 or higher;
- of an E-Bus Terminal the terminal must have FPGA firmware version 10 or higher.

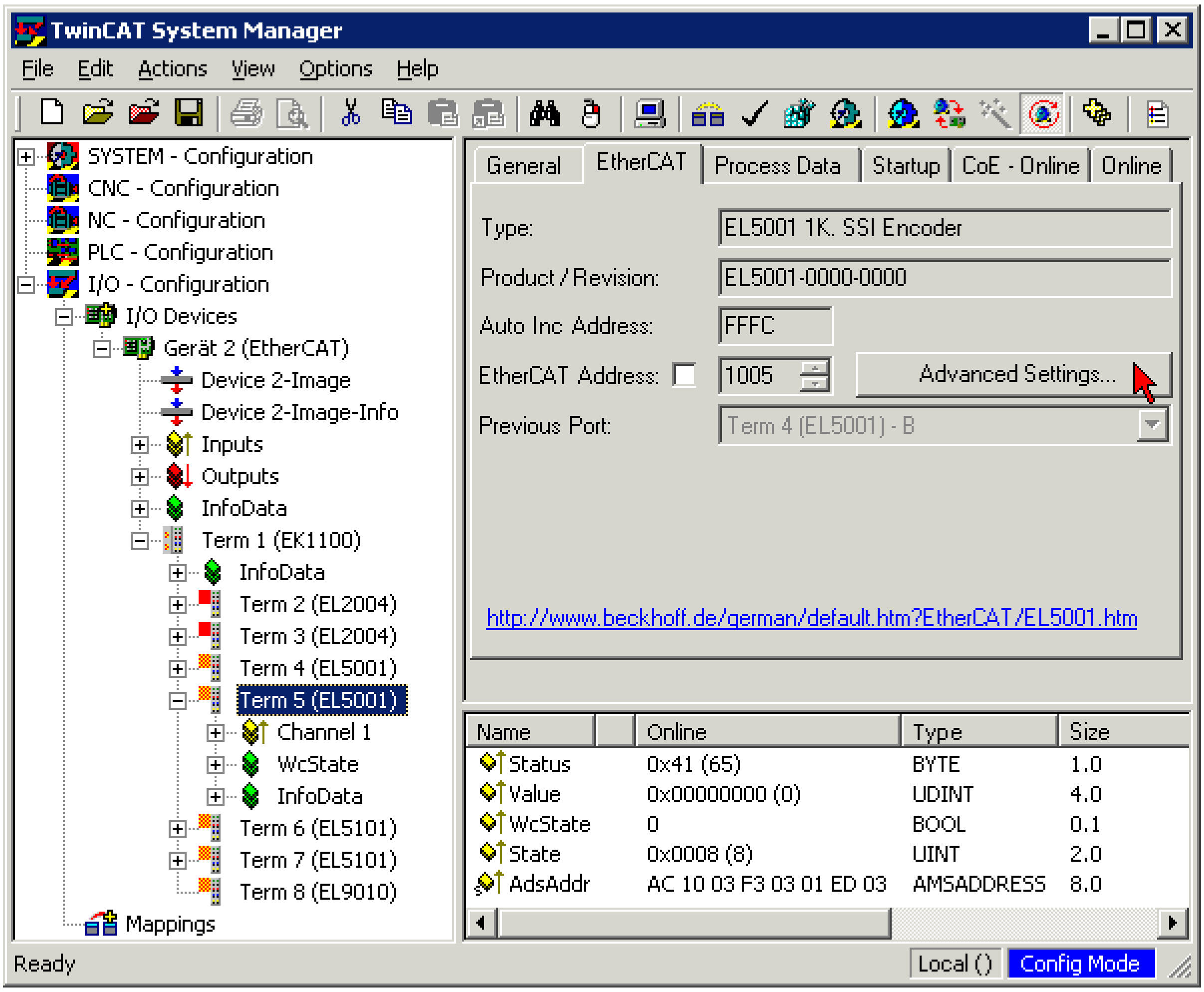
Older firmware versions can only be updated by the manufacturer!

### Updating an EtherCAT device

The following sequence order have to be met if no other specifications are given (e.g. by the Beckhoff support):

- Switch TwinCAT system to ConfigMode/FreeRun with cycle time >= 1 ms (default in ConfigMode is 4 ms). A FW-Update during real time operation is not recommended.

- In the TwinCAT System Manager select the terminal for which the FPGA firmware is to be updated (in the example: Terminal 5: EL5001) and
click the *Advanced Settings* button in the *EtherCAT* tab:



Type: EL5001 1K. SSI Encoder

Product / Revision: EL5001-0000-0000

Auto Inc Address: FFFC

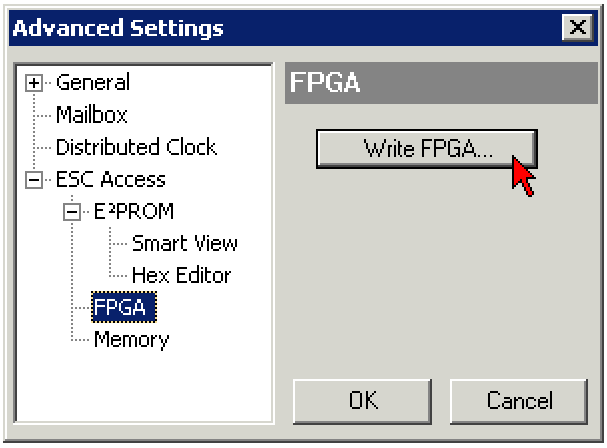
EtherCAT Address: □ 1005

Previous Port: Term 4 (EL5001) - B

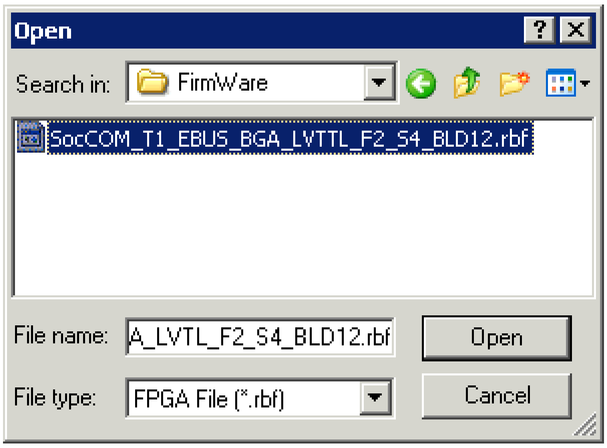
http://www.beckhoff.de/german/default.htm?EtherCAT/EL5001.htm

| Name | Online | Type | Size |
|---|---|---|---|
| Status | 0x41 (65) | BYTE | 1.0 |
| Value | 0x00000000 (0) | UDINT | 4.0 |
| WcState | 0 | BOOL | 0.1 |
| State | 0x0008 (8) | UINT | 2.0 |
| AdsAddr | AC 10 03 F3 03 01 ED 03 | AMSADDRESS | 8.0 |

- The *Advanced Settings* dialog appears. Under *ESC Access/E²PROM*/FPGA click on *Write FPGA* button:



- Select the file (*.rbf) with the new FPGA firmware, and transfer it to the EtherCAT device:



Open

Search in: FirmWare

SocCOM_T1_EBUS_BGA_LVTTL_F2_S4_BLD12.rbf

File name: A_LVTTL_F2_S4_BLD12.rbf

File type: FPGA File (*.rbf)

- Wait until download ends
- Switch slave current less for a short time (don't pull under voltage!). In order to activate the new FPGA firmware a restart (switching the power supply off and on again) of the EtherCAT device is required.
- Check the new FPGA status

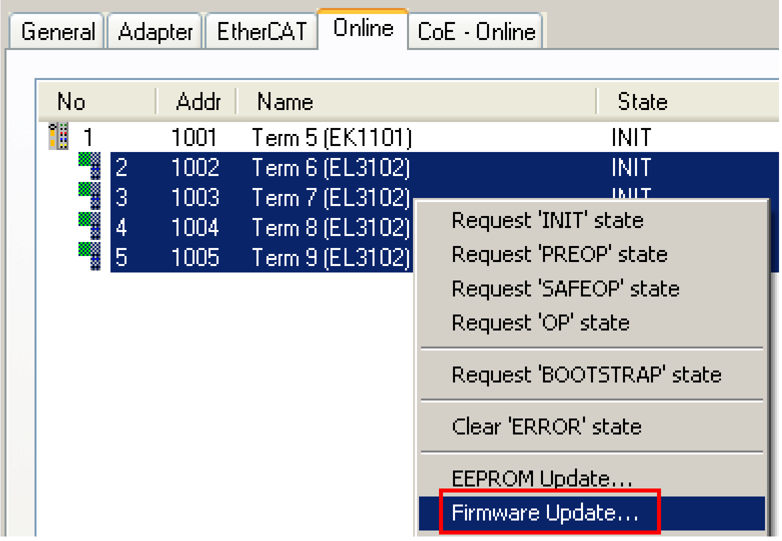
**NOTICE**

**Risk of damage to the device!**

A download of firmware to an EtherCAT device must not be interrupted in any case! If you interrupt this process by switching off power supply or disconnecting the Ethernet link, the EtherCAT device can only be recommissioned by the manufacturer!

## 9.3.5 Simultaneous updating of several EtherCAT devices

The firmware and ESI descriptions of several devices can be updated simultaneously, provided the devices have the same firmware file/ESI.



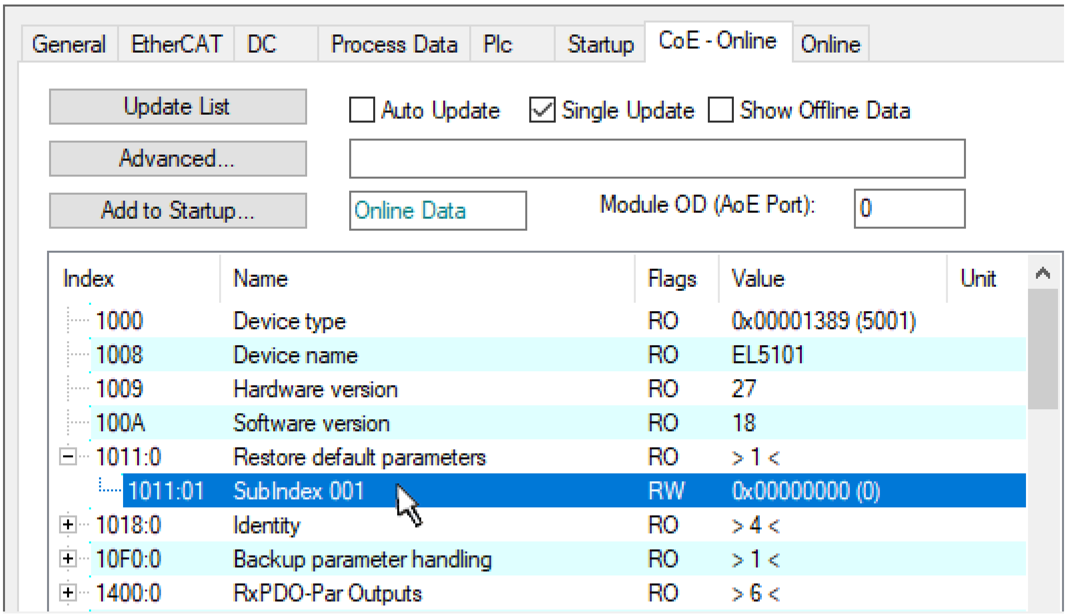
| No | Addr | Name | State |
|---|---|---|---|
| 1 | 1001 | Term 5 (EK1101) | INIT |
| 2 | 1002 | Term 6 (EL3102) | INIT |
| 3 | 1003 | Term 7 (EL3102) | INIT |
| 4 | 1004 | Term 8 (EL3102) | |
| 5 | 1005 | Term 9 (EL3102) | |

Fig. 177: Multiple selection and firmware update

Select the required slaves and carry out the firmware update in BOOTSTRAP mode as described above.

## 9.4 Restoring the delivery state

To restore the delivery state (factory settings) of CoE objects for EtherCAT devices (“slaves”), the CoE object *Restore default parameters*, SubIndex 001 can be used via EtherCAT master (e.g. TwinCAT) (see Fig. *Selecting the Restore default parameters PDO*).

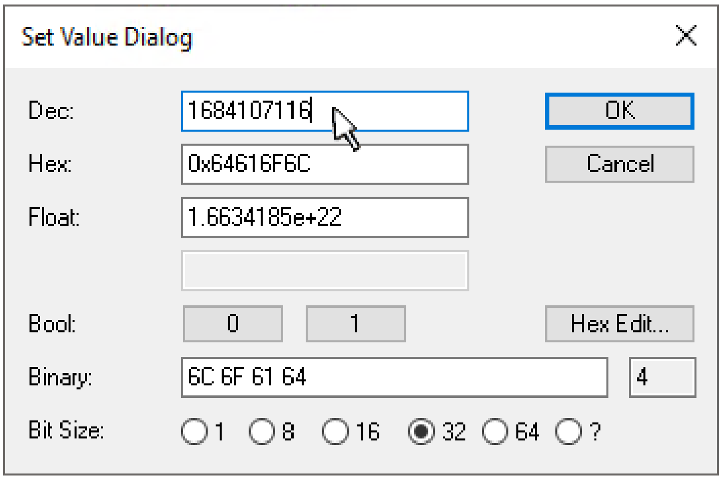


□ Auto Update ☑ Single Update □ Show Offline Data

Module OD (AoE Port): 0

| Index | Name | Flags | Value | Unit |
|---|---|---|---|---|
| 1000 | Device type | RO | 0x00001389 (5001) | |
| 1008 | Device name | RO | EL5101 | |
| 1009 | Hardware version | RO | 27 | |
| 100A | Software version | RO | 18 | |
| 1011:0 | Restore default parameters | RO | > 1 < | |
| 1011:01 | SubIndex 001 | RW | 0x00000000 (0) | |
| 1018:0 | Identity | RO | > 4 < | |
| 10F0:0 | Backup parameter handling | RO | > 1 < | |
| 1400:0 | RxPDO-Par Outputs | RO | > 6 < | |

Fig. 178: Selecting the *Restore default parameters* PDO



Dec: 1684107116

Hex: 0x64616F6C

Float: 1.6634185e+22

Bool: 0 1

Binary: 6C 6F 61 64 4

Bit Size: ○ 1 ○ 8 ○ 16 ● 32 ○ 64 ○ ?

Fig. 179: Entering a restore value in the Set Value dialog

Double-click on *SubIndex 001* to enter the Set Value dialog. Enter the reset value **1684107116** in field *Dec* or the value **0x64616F6C** in field *Hex* (ASCII: “load”) and confirm with *OK* (Fig. *Entering a restore value in the Set Value dialog*).

- All changeable entries in the slave are reset to the default values.
- The values can only be successfully restored if the reset is directly applied to the online CoE, i.e. to the slave. No values can be changed in the offline CoE.
- TwinCAT must be in the RUN or CONFIG/Freerun state for this; that means EtherCAT data exchange takes place. Ensure error-free EtherCAT transmission.
- No separate confirmation takes place due to the reset. A changeable object can be manipulated beforehand for the purposes of checking.
- This reset procedure can also be adopted as the first entry in the startup list of the slave, e.g. in the state transition PREOP->SAFEOP or, as in Fig. *CoE reset as a startup entry*, in SAFEOP->OP.

All backup objects are reset to the delivery state.

**Alternative restore value**

In some older terminals (FW creation approx. before 2007) the backup objects can be switched with an alternative restore value: Decimal value: 1819238756, Hexadecimal value: 0x6C6F6164.

An incorrect entry for the restore value has no effect.

## 9.5 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.

### Support

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:

- support
- design, programming and commissioning of complex automation systems
- and extensive training program for Beckhoff system components

| | |
|---|---|
| Hotline: | +49 5246 963 157 |
| e-mail: | support@beckhoff.com |
| web: | www.beckhoff.com/support |

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The Beckhoff Service Center supports you in all matters of after-sales service:

- on-site service
- repair service
- spare parts service
- hotline service

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| e-mail: | service@beckhoff.com |
| web: | www.beckhoff.com/service |

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