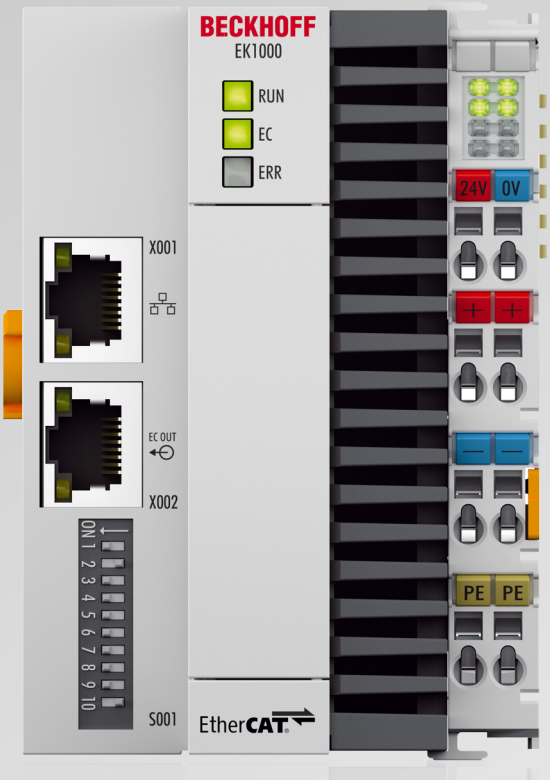
BECKHOFF New Automation Technology

Documentation | EN

EK1000

EtherCAT TSN Bus Coupler



2022-07-15 | Version: 1.1

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1 Foreword

1.1 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.
It is the duty of the technical personnel to use the documentation published at the respective time of each installation and commissioning.

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

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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.

Copyright

1.2 Notes on information security

The products of Beckhoff Automation GmbH & Co. KG (Beckhoff), insofar as they can be accessed online, are equipped with security functions that support the secure operation of plants, systems, machines and networks. Despite the security functions, the creation, implementation and constant updating of a holistic security concept for the operation are necessary to protect the respective plant, system, machine and networks against cyber threats. The products sold by Beckhoff are only part of the overall security concept. The customer is responsible for preventing unauthorized access by third parties to its equipment, systems, machines and networks. The latter should be connected to the corporate network or the Internet only if appropriate protective measures have been set up.

In addition, the recommendations from Beckhoff regarding appropriate protective measures should be observed. Further information regarding information security and industrial security can be found in our https://www.beckhoff.com/secguide.

Beckhoff products and solutions undergo continuous further development. This also applies to security functions. In light of this continuous further development, Beckhoff expressly recommends that the products are kept up to date at all times and that updates are installed for the products once they have been made available. Using outdated or unsupported product versions can increase the risk of cyber threats.

To stay informed about information security for Beckhoff products, subscribe to the RSS feed at https://www.beckhoff.com/secinfo.

1.3 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.

Description of instructions

In this documentation the following instructions are used.
These instructions must be read carefully and followed without fail!

⚠ DANGER

Serious risk of injury!

Failure to follow this safety instruction directly endangers the life and health of persons.

⚠ WARNING

Risk of injury!

Failure to follow this safety instruction endangers the life and health of persons.

⚠ CAUTION

Personal injuries!

Failure to follow this safety instruction can lead to injuries to persons.

NOTE

Damage to environment/equipment or data loss

Failure to follow this instruction can lead to environmental damage, equipment damage or data loss.

Tip or pointer

This symbol indicates information that contributes to better understanding.

1.4 Documentation issue status

Version	Modifications
1.1	• Update chapter “Foreword” • Update structure
1.0	• 1st public issue
0.2	• Addenda, corrections
0.1	• First preliminary version

1.5 Version identification of EtherCAT devices

1.5.1 General notes on marking

Designation

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

- family key
- type
- version
- revision

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

Notes

- The elements mentioned above result in the **technical designation**. EL3314-0000-0016 is used in the example below.
- EL3314-0000 is the order identifier, in the case of “-0000” usually abbreviated to EL3314. “-0016” is the EtherCAT revision.
- The **order identifier** is made up of
  - family key (EL, EP, CU, ES, KL, CX, etc.)
  - type (3314)
  - version (-0000)
- The **revision** -0016 shows the technical progress, such as the extension of features with regard to the EtherCAT communication, and is managed by Beckhoff.
  In principle, a device with a higher revision can replace a device with a lower revision, unless specified otherwise, e.g. in the documentation.
  Associated and synonymous with each revision there is usually a description (ESI, EtherCAT Slave Information) in the form of an XML file, which is available for download from the Beckhoff web site.
  From 2014/01 the revision is shown on the outside of the IP20 terminals, see Fig. *“EL5021 EL terminal, standard IP20 IO device with batch number and revision ID (since 2014/01)”*.
- The type, version and revision are read as decimal numbers, even if they are technically saved in hexadecimal.

1.5.2 Version identification of EK Couplers

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: EK1101 EtherCAT coupler with revision 0815 and serial number 41130206

1.5.3 Beckhoff Identification Code (BIC)

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

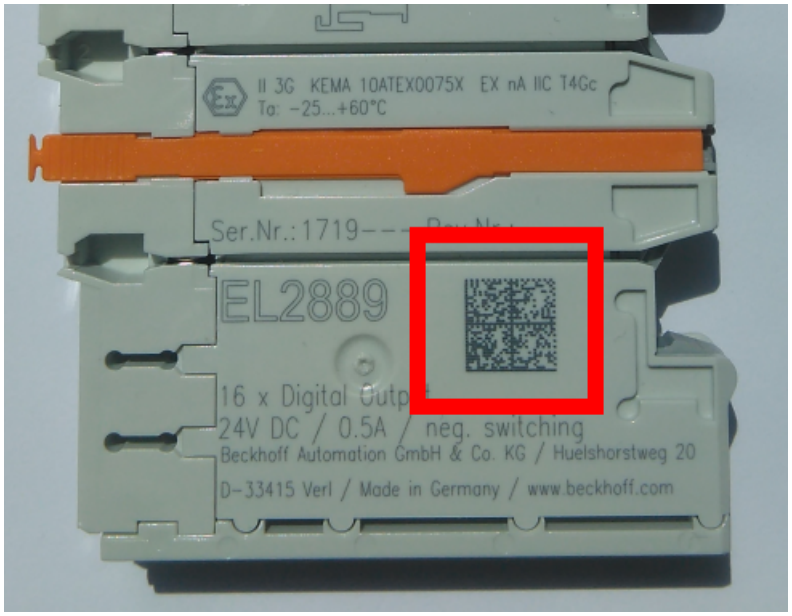


Fig. 2: BIC as data matrix code (DMC, code scheme ECC200)

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:

Position	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:

1P072222**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.

NOTE

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 information.

1.5.4 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.

Decisive for the electronic readout is the interface via which the product can be electronically addressed.

K-bus devices (IP20, IP67)

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

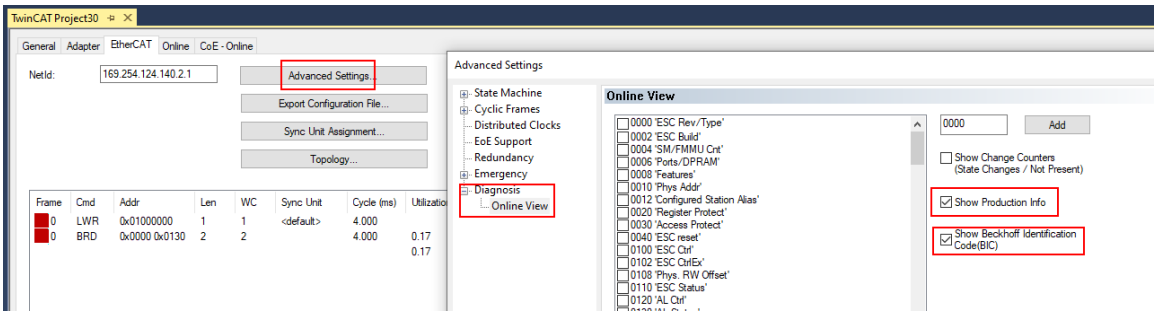
EtherCAT devices (IP20, IP67)

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

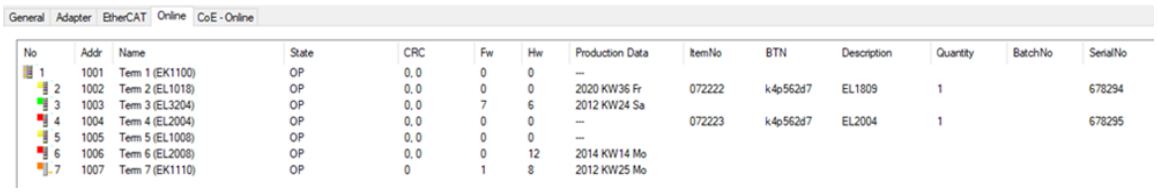
The eBIC is also stored in the ESI-EEPROM. The eBIC was introduced into the Beckhoff I/O production (terminals, box modules) from 2020; widespread implementation is expected in 2021.

The user can electronically access the eBIC (if existent) 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 checkbox "Show Beckhoff Identification Code (BIC)" under
    EtherCAT → Advanced Settings → Diagnostics:



  - The BTN and its contents are then displayed:



  - Note: as can be seen in the illustration, the production data HW version, FW version and production date, which have been programmed since 2012, can also be displayed with "Show Production Info".
  - From TwinCAT 3.1. build 4024.24 the functions *FB_EcReadBIC* and *FB_EcReadBTN* for reading into the PLC and further eBIC auxiliary functions are available in the Tc2_EtherCAT Library from v3.3.19.0.
- In the case of EtherCAT devices with CoE directory, the object 0x10E2:01 can additionally by used to display the device's own eBIC; the PLC can also simply access the information here:

- The device must be in 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 introduced into stock products in the course of a necessary firmware revision.
- From TwinCAT 3.1. build 4024.24 the functions *FB_EcCoEReadBIC* and *FB_EcCoEReadBTN* for reading into the PLC and further eBIC auxiliary functions are available in the Tc2_EtherCAT Library from v3.3.19.0.

- Note: in the case of electronic further 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 additionally written as a category in the ESI-EEPROM during the device production. The structure of the ESI content is largely dictated by the ETG specifications, therefore the additional vendor-specific content is stored with the help of a category according to ETG.2010. ID 03 indicates to all EtherCAT masters that they must not overwrite these data in case of an update or restore the data after an ESI update.
  The structure follows the content of the BIC, see there. This results in a memory requirement of approx. 50..200 bytes in the EEPROM.
- 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 with 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/DeviceNet... Devices

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

2 Product description

2.1 Introduction

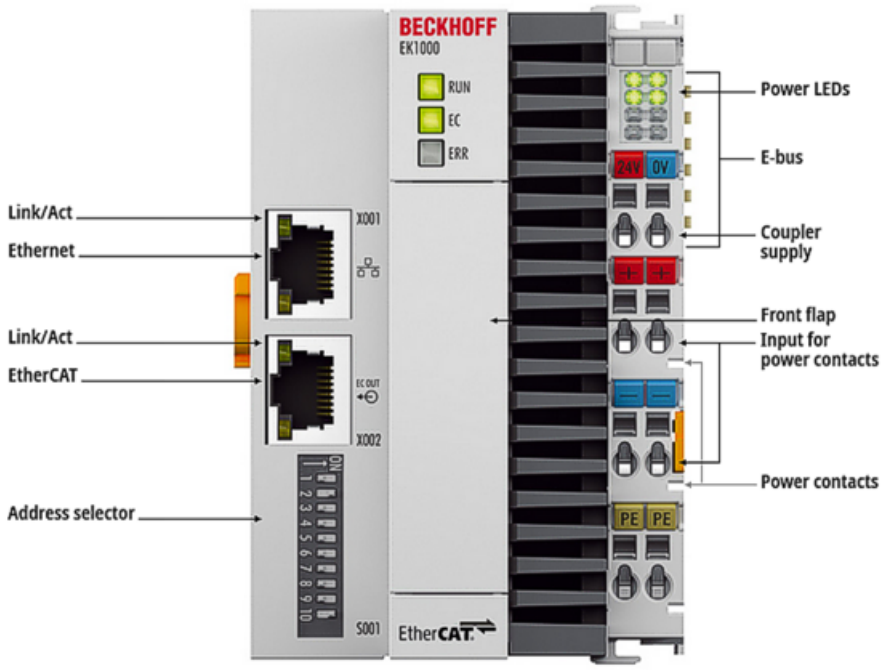


Fig. 4: EK1000

The EK1000 EtherCAT Coupler supports EtherCAT communication via switched Ethernet networks, such as TSN networks (Time-Sensitive Networking), and allows for connecting various EtherCAT Terminals from the wide range of I/Os with standard network technology.

The EtherCAT Open Mode protocol enables communication via a layer 2 or a UDP connection. Via UDP, EtherCAT data can also be addressed across routers. The EK1000 is TSN-ready and can be made TSN-capable by a firmware update when the TSN technology is available. Proven EtherCAT features, such as distributed clocks and XFC, can also be used within a TSN network.

In addition, it allows for connecting EtherCAT-capable drives that do not have a TSN-capable interface. Thus, the EK1000 effectively links EtherCAT and TSN networks, combining their benefits: EtherCAT provides a real-time capable single-device level and is therefore ideally suited to combine the numerous small data packets that come from the digital and analog inputs and are typical of industrial environments into a complete process image. TSN, on the other hand, defines a physical layer, which only relates to the switch layer in switched Ethernet networks.

As a real-time extension of the general Ethernet technology, it controls the procedures and priorities for the transport of Ethernet telegrams through a TSN-capable, switched network.

The EtherCAT Coupler has two RJ45 ports. One of these 100 Mbit/s ports connects the EK1000 to the Ethernet or TSN network. The second port enables EtherCAT network extensions, e.g., via the EK1100 EtherCAT Coupler. The EK1000 extends the TwinCAT automation software with a TSN-capable version of EtherCAT communication. In this way, TSN networks can also be managed seamlessly, and EtherCAT devices located in different terminal strands can be addressed via the TSN network.

2.2 Technical data

Technical data	EK1100
Task in the EtherCAT system	Coupling of EtherCAT slave devices to TSN networks
Networks	Mode 1 for standard networks Mode 2 for TSN networks, in preparation (retrofittable via image update, if available)
Data transfer medium	Ethernet 100BASE-TX (at least Ethernet CAT5 cable)
Cable length between 2 Bus Couplers	max. 100 m (100BASE-TX)
Number of EtherCAT Terminals	up to 65535 in the overall system
Number of peripheral signals	-
Protocol / Baud rate	EtherCAT Open Mode
Delay	-
Data transfer rates	100 Mbit/s
Configuration	≥ TwinCAT v3.1.4024.32
Bus interface	X001 (Rj45) = 100 Mbit/s Ethernet (TSN) X002 (Rj45) = 100 Mbit/s EtherCAT (e.g. EK1100)
Power supply	24 V_{DC} (-15%/+20%)
E-bus power supply (5 V) (at higher current consumption the EL9410 power feed terminal can be used in addition)	max. 2 A (-25 °C ... +60 °C)
Power contacts	max. 24 V_{DC}, max. 10 A
Electrical isolation	500 V (power contact/supply voltage/EtherCAT)
Dimensions (W x H x D)	approx. 71 mm x 100 mm x 73 mm
Weight	approx. 218 g
Permissible ambient temperature range during operation	-25 °C ... +60 °C
Permissible ambient temperature range during storage	-40 °C ... + 85 °C
Permissible relative air humidity	95 %, no condensation
Mounting [▶ 26]	on 35 mm support rail according to EN 60715
Enhanced mechanical load capacity	yes, see also Installation instructions for enhanced mechanical load capacity [▶ 30] for enhanced mechanical load capacity
Vibration / shock resistance	conforms to EN 60068-2-6 / EN 60068-2-27
EMC immunity / emission	conforms to EN 61000-6-2 / EN 61000-6-4
Protection class	IP20
Installation position	See chapter “Mounting [▶ 31]”
Marking	CE, EAC, UKCA

3 Basics communication

3.1 EtherCAT basics

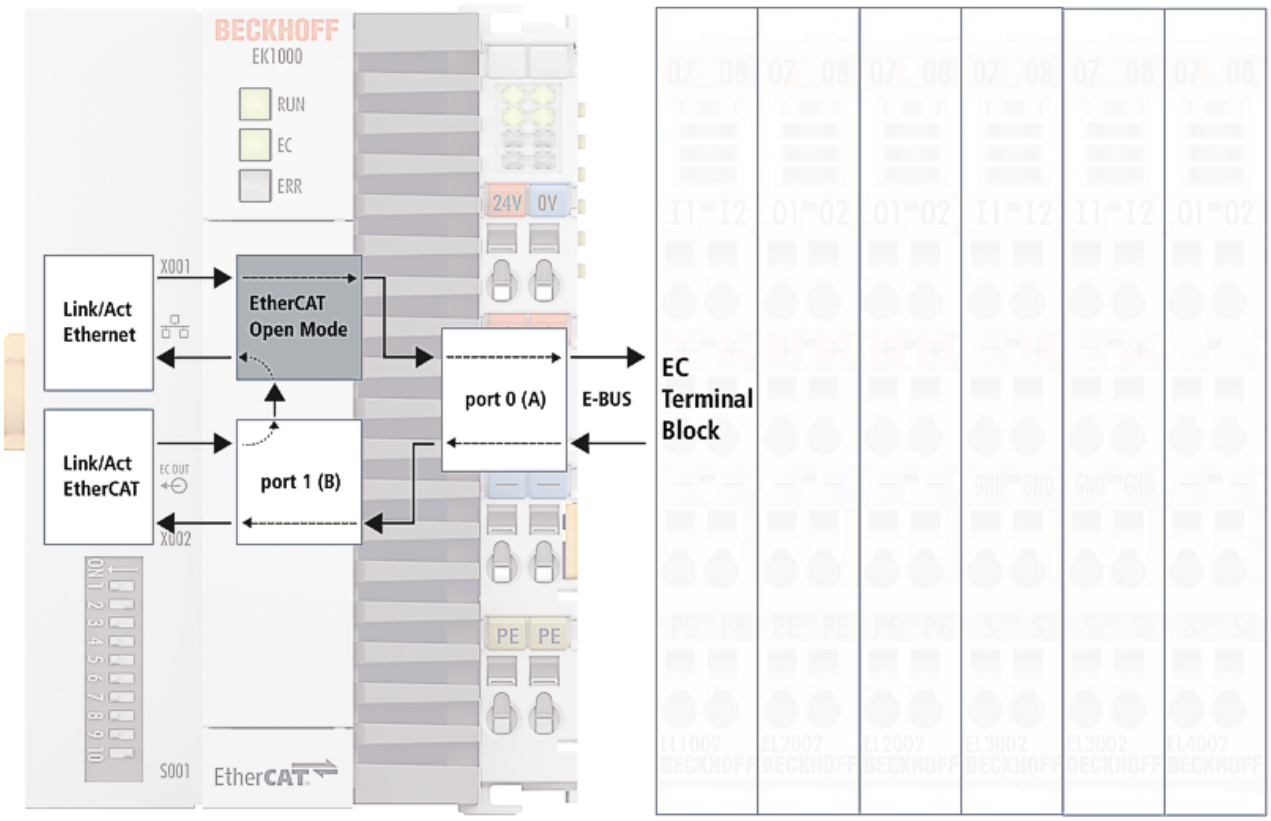
Please refer to the EtherCAT System Documentation for the EtherCAT fieldbus basics.

3.2 EtherCAT coupler port allocation

The data flow direction in an EK1000 is shown as an example in the following figure:

Frame processing sequence

- The incoming Ethernet frame at the Ethernet signal input is forwarded to the internal EtherCAT Open Mode port.
- Destination and source addresses are swapped or replaced (for MAC and IP/UDP, if applicable).
- The EOM frame arrives at Port 0 (A) and the data frame departs via Port 0 (A) to the following slave in the EtherCAT terminal network (if a slave is connected there and an active link is detected).
- After the arrival of the data frame at Port 1 (B) from the terminal network, this is forwarded and leaves the coupler at the following EtherCAT output (if a slave is connected there and an active link is detected).
- The data frame arrives at Port 1 (B). This is now forwarded to the EtherCAT Open Mode port and leaves the EK1100 via the Ethernet input.



3.3 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 and
- Operational
- Boot

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

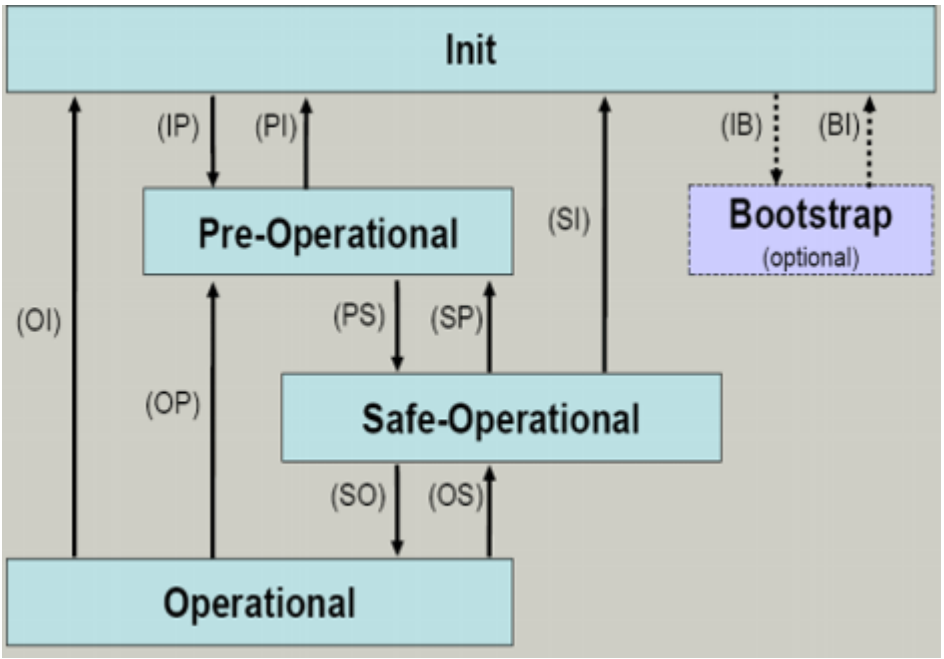


Fig. 5: States of the EtherCAT State Machine

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 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 DP-RAM areas of the EtherCAT slave controller (ECSC).

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 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 watchdog 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.

3.4 CoE Interface

General description

The CoE interface (CAN application protocol over EtherCAT)) 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 read 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 parameter 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 ($0...65535_{dec}$)
- SubIndex: 0x00…0xFF ($0...255_{dec}$)

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 (“input” from the perspective of the EtherCAT master)
- 0x7000: Output PDOs (“output” 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:

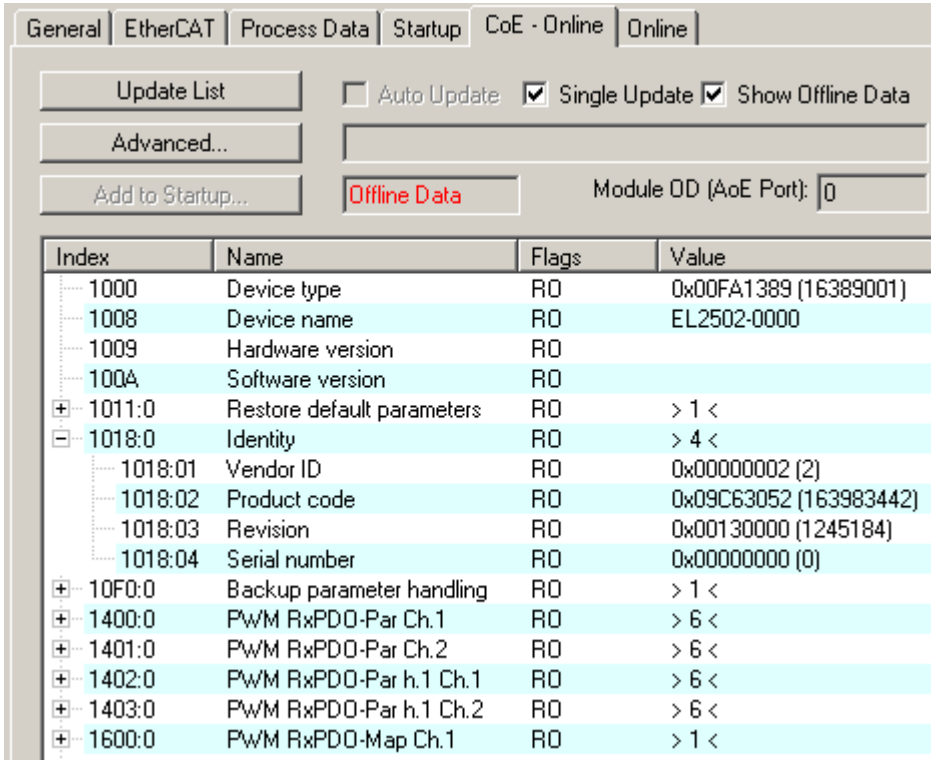


Fig. 6: “CoE Online” tab

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

Data management and function “NoCoeStorage”

Some parameters, particularly the setting parameters of the slave, are configurable and writeable. This can be done in write or read mode

- via the System Manager (Fig. “CoE Online” tab) by clicking
  This is useful for commissioning of the system/slaves. Click on the row of the index to be parameterized and enter a value in the “SetValue” dialog.
- from the control system/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 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.
- 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.

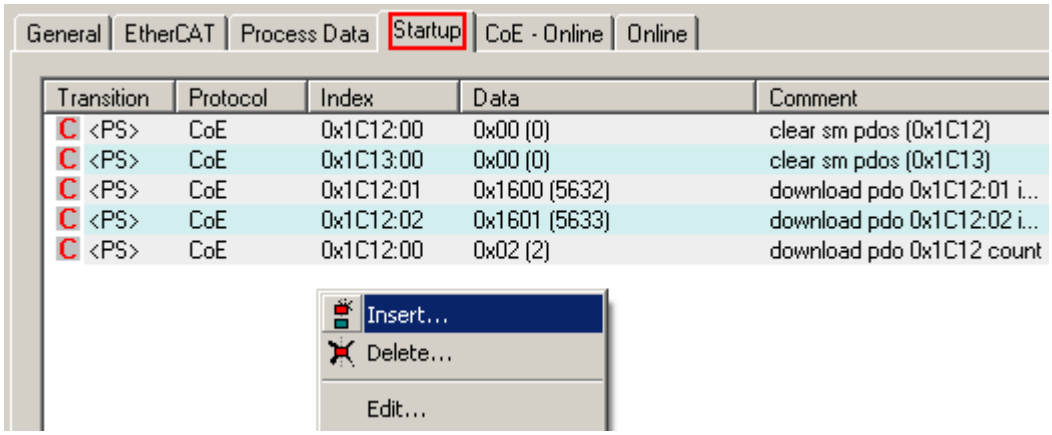


Fig. 7: Startup list in the TwinCAT System Manager

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

Online/offline list

While working with the TwinCAT System Manager, a distinction has to be made whether the EtherCAT device is “available”, i.e. switched on and linked via EtherCAT and therefore **online**, or whether a configuration is created **offline** without connected slaves.

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** is shown in red.

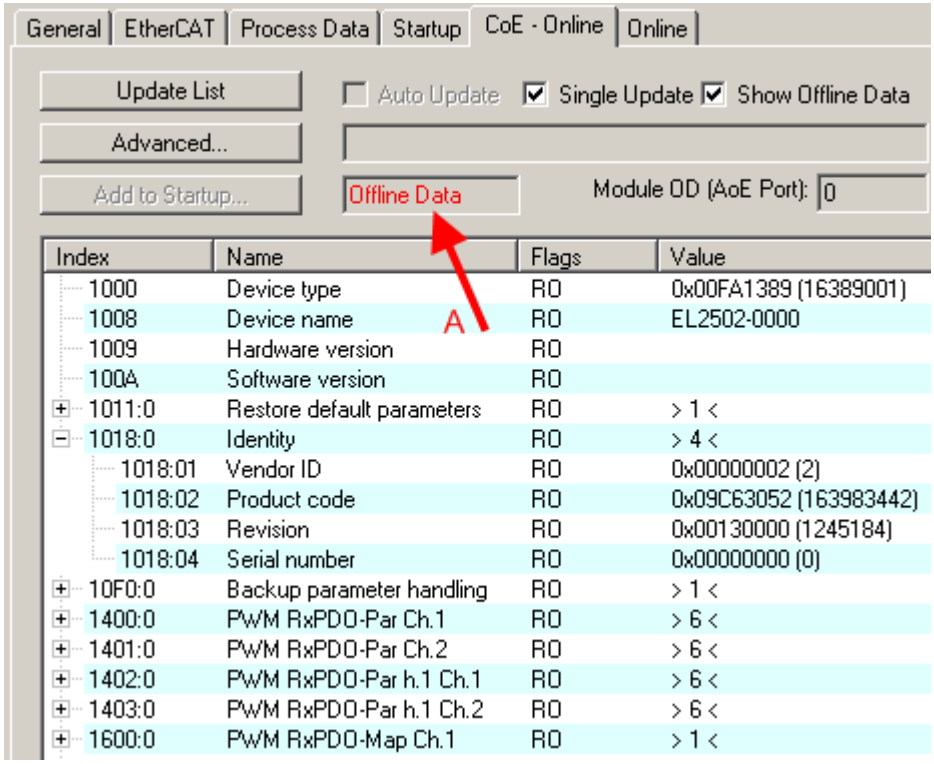


Fig. 8: Offline list

- 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 version of the equipment according to the electronic information is displayed
  - **Online** is shown in green.

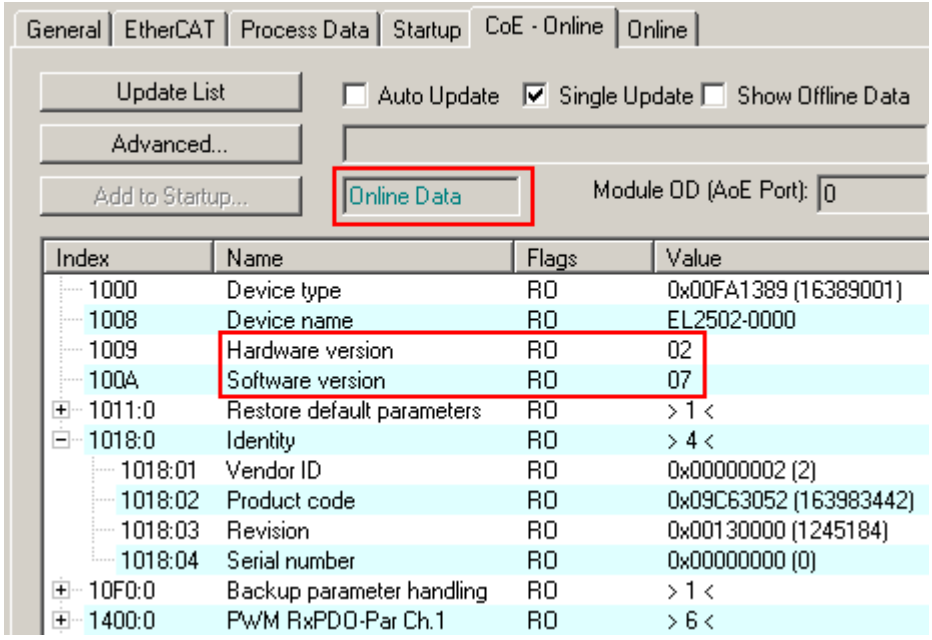


Fig. 9: Online list

Channel-based order

The CoE list is available in EtherCAT devices that usually feature several functionally equivalent channels. For example, a 4-channel analog 0...10 V 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 $16_{dec}/10_{hex}$ 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.

4 Installation

4.1 Instructions for ESD protection

NOTE

Destruction of the devices by electrostatic discharge possible!

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

- Please ensure you are electrostatically discharged and avoid touching the contacts of the device directly.
- Avoid contact with highly insulating materials (synthetic fibers, plastic film etc.).
- Surroundings (working place, packaging and personnel) should by grounded probably, when handling with the devices.
- Each assembly must be terminated at the right hand end with an EL9011 or EL9012 bus end cap, to ensure the protection class and ESD protection.

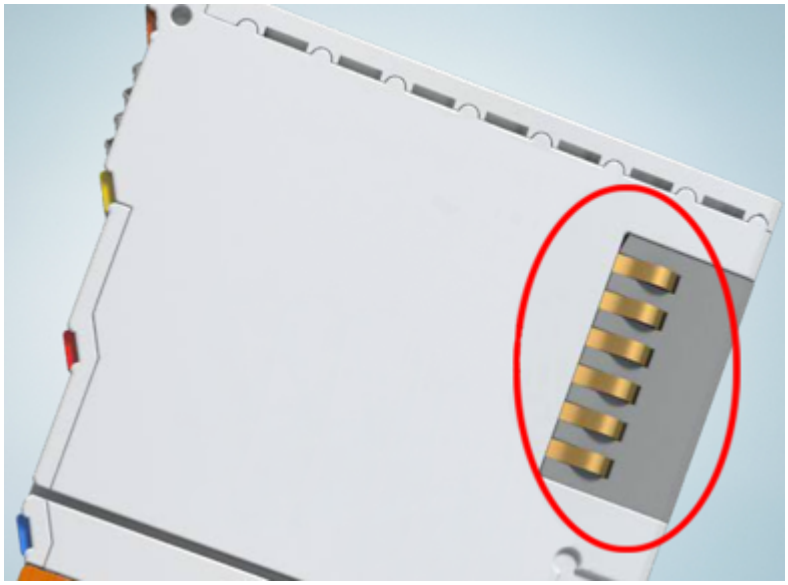


Fig. 10: Spring contacts of the Beckhoff I/O components

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!

Assembly

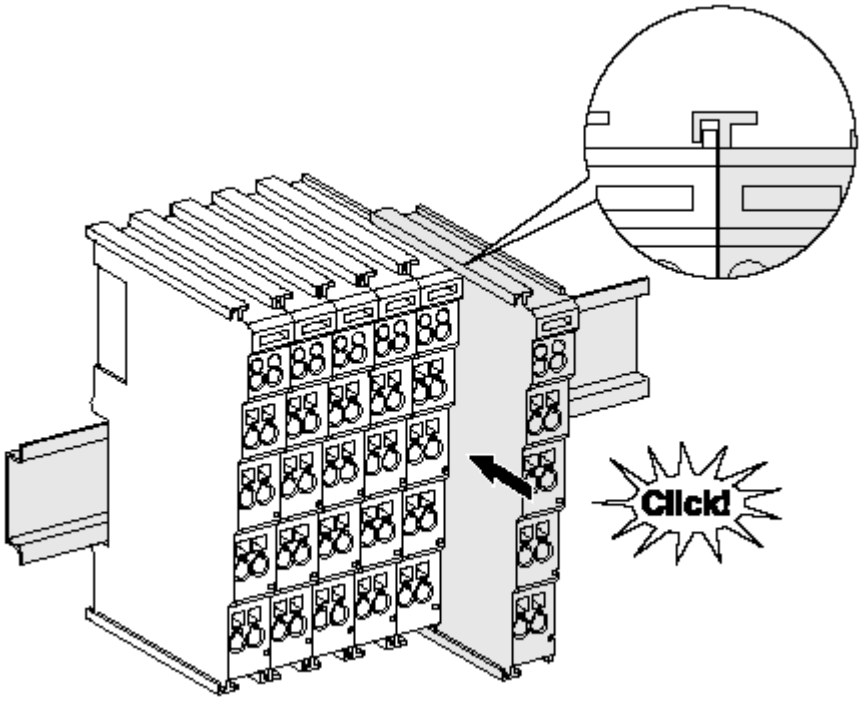


Fig. 11: Attaching on mounting rail

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

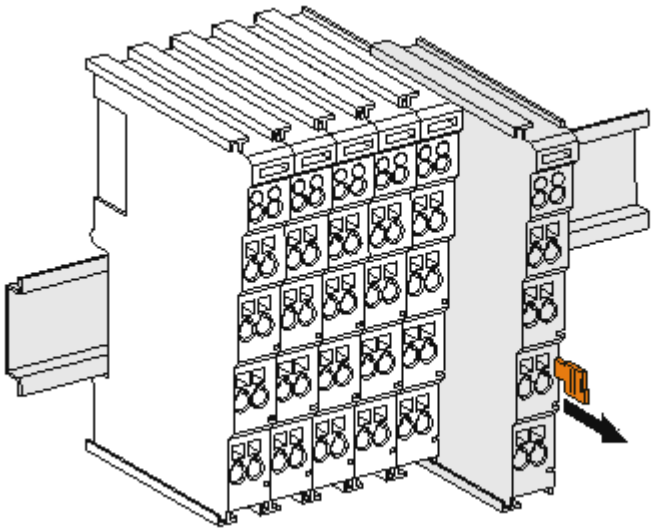


Fig. 12: Disassembling of terminal

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 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.

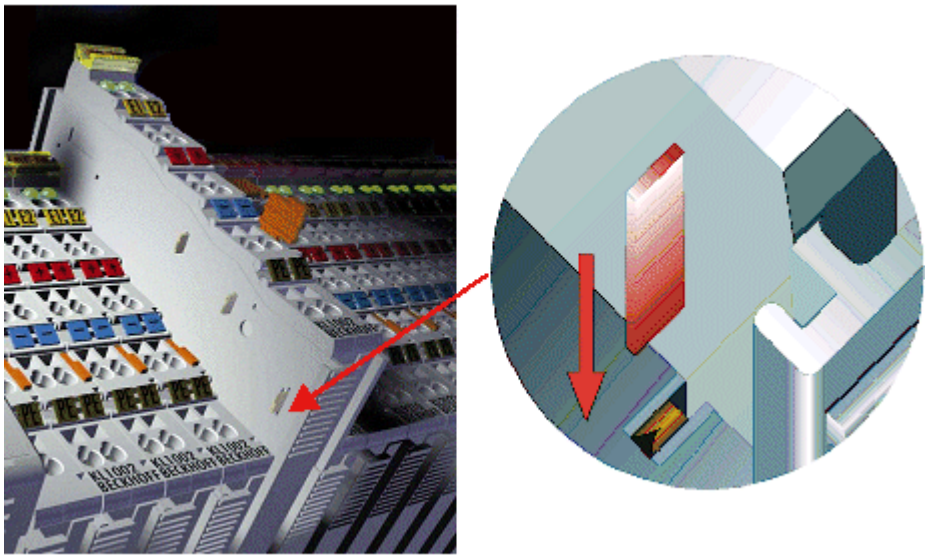


Fig. 13: Power contact on left side

NOTE

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

For terminals with enhanced mechanical load capacity, the following additional installation instructions 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 with) or 32 terminals (24 mm mounting with)
- 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 Mounting

4.4.1 Dimensions

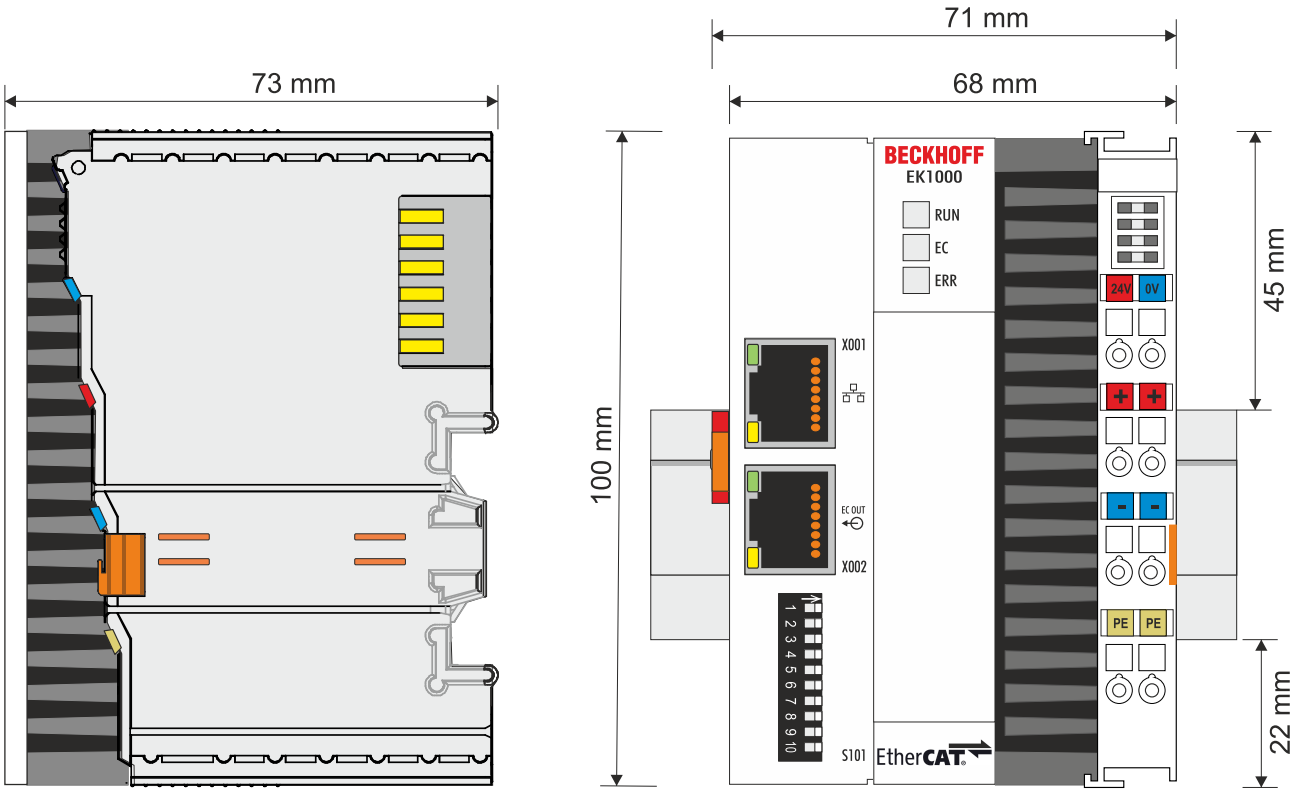


Fig. 14: Dimensions of the EK1000

Technical drawings in DWG format and in STP formats can be found at:

https://www.beckhoff.com/en-us/support/download-finder/technical-documentations/

4.4.2 Note permissible mounting positions

Increased heat generation

If the installation position is incorrectly selected and the minimum distances are not observed, the EK1000 may overheat.
Ensure sufficient ventilation. A horizontal mounting position is optimal. Leave a clearance of at least 30 mm above and below the EK1000.

Please note the following specifications for the control cabinet:

- Adhere to the specified ambient temperature. For this measure the temperature at a distance of 30 mm to the cooling fins to determine the ambient temperature correctly.
- Keep the minimum distance of 30 mm above and below the EtherCAT coupler.
- Further electrical devices influence the heat development in the control cabinet. Select a suitable control cabinet size depending on the application or ensure that excess heat is removed from the control cabinet.

Prescribed mounting position for temperatures up to 60°C

Mount the EK1000 horizontally in the control cabinet on a mounting rail to ensure optimum heat dissipation.

The ventilation openings are located on the bottom and top of the housing. In this way, an optimum air flow is achieved, which flows through the EK1000 in a vertical direction. In addition, a free space of at least 30 mm above and below the EtherCAT coupler is required to ensure sufficient ventilation.

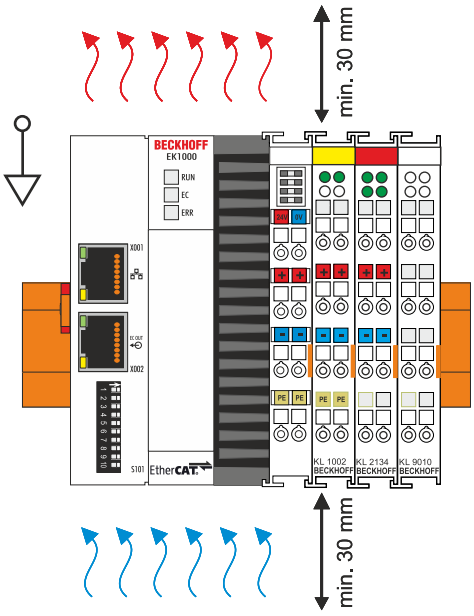


Fig. 15: EK1000, horizontal mounting position

Mounting positions with restricted temperature range up to 50°C

You can also mount the EK1000 vertically or horizontally on the mounting rail. Please note that you can then only operate the EK1000 up to an ambient temperature of 50°C.

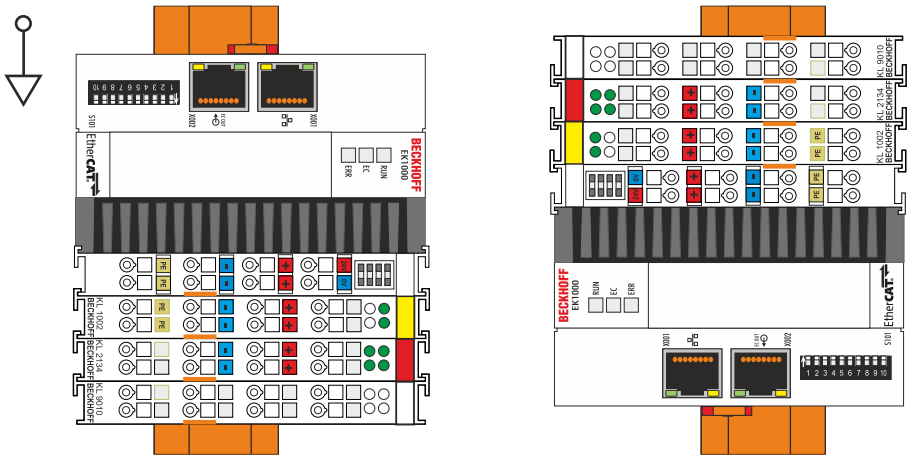


Fig. 16: EK1000, vertical mounting position

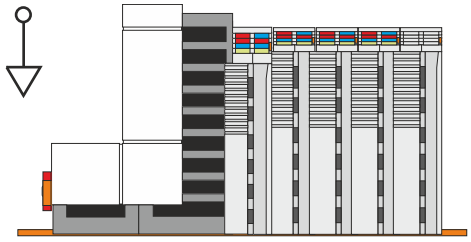


Fig. 17: EK1000, lying mounting position

Make sure that Bus Terminals connected to the EK1000 are designed for vertical or horizontal operation.

4.4.3 Fasten on mounting rail

The housing is designed so that the EK1000 can be held against the mounting rail and snapped onto it. A lock on the left side of the EK1000 secures it to the mounting rail

Requirements::

- Mounting rail of type TS35/7.5 or TS35/15 according to DIN EN 60715

Attach the EK1000 to the mounting rail as follows:

1. Place the EK1000 frontally on the mounting rail. Press the EK1000 lightly against the mounting rail until it clicks quietly and the EK1000 is engaged.

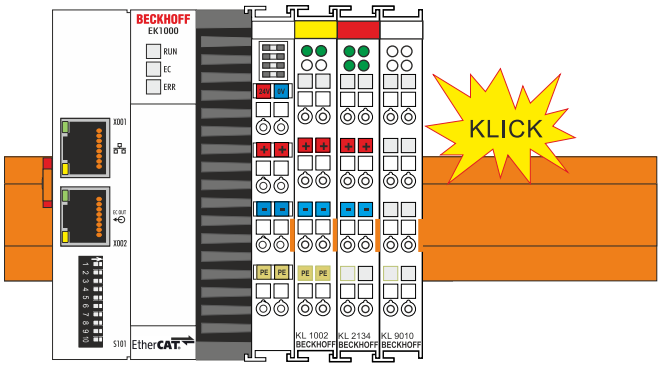


Fig. 18: EK1000 mounting on mounting rail

2. Then lock the latch on the left side of the EtherCAT coupler. Use a screwdriver to do this.

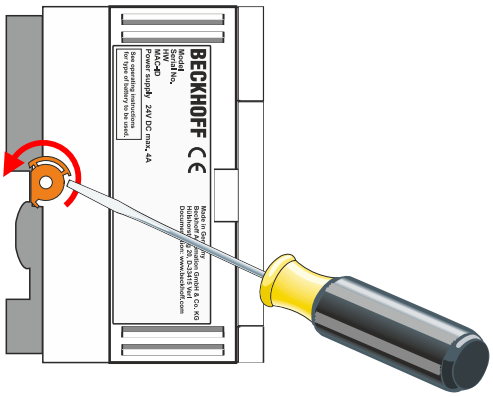


Fig. 19: Locking the latch

⇨ Check that the EK1000 has been correctly mounted and that it has latched onto the mounting rail.

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 (Safety Extra Low Voltage) supply provides safe electrical isolation and limitation of the voltage without a connection to the protective conductor,
  a PELV (Protective Extra Low Voltage) supply also requires a safe connection to the protective conductor.

4.6 Connecting the power supply

NOTE

Damage to the EK1000 possible!

The EK1000 may be damaged during wiring.

- The cables for the power supply should only be connected in de-energized state!

An external voltage source [▶ 35] providing a 24 V DC voltage (-15 % / +20 %) is required for the power supply terminal.
The power supply terminal must supply 4 A at 24 V to ensure operation of the EK1000 in all cases.

The cabling of the EK1000 in the control cabinet must be done in accordance with the standard EN 60204-1:2006 PELV = Protective Extra Low Voltage:

- The "PE" and "0 V" conductors of the voltage source for a basic CPU module must be on the same potential (connected in the control cabinet).
- Standard EN 60204-1:2006, section 6.4.1:b stipulates that one side of the circuit, or a point of the energy source for this circuit must be connected to the protective earth conductor system.

Connection example

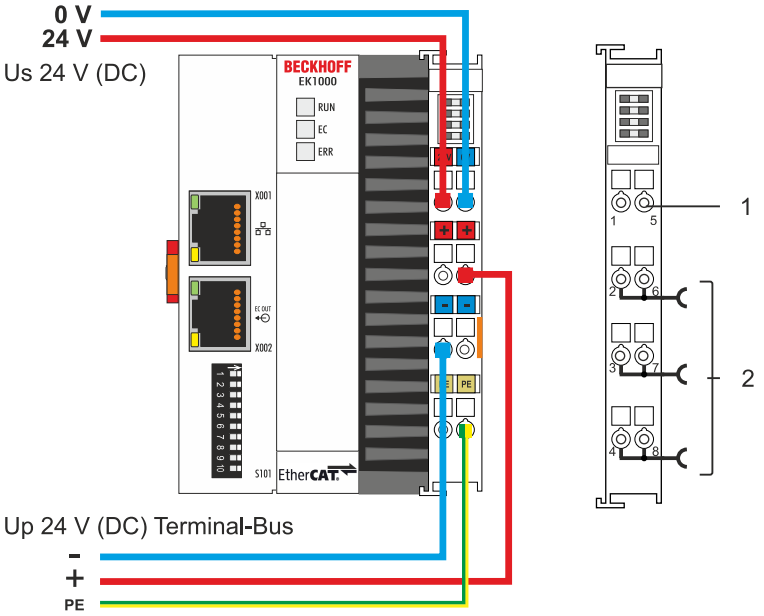


Fig. 20: Connection example EK 1000

No.	Description
1	The upper spring terminals labeled "24 V" and "0 V" supply the EK1000 and the terminal bus (data transmission via K- or E-bus) with voltage.
2	The spring terminals labeled "+", "-" and "PE" supply the Bus Terminals with voltage via the power contacts and the sensors or actuators connected to the Bus Terminals.

Open and close spring terminals

The leads of an external voltage source are connected to spring terminals on the power supply. Connect the lines as follows::

Cable cross section	0,5 ... 2,5 mm²	AWG 20 .. AWG 14
Stripping length	8 ... 9 mm	0.33 inch

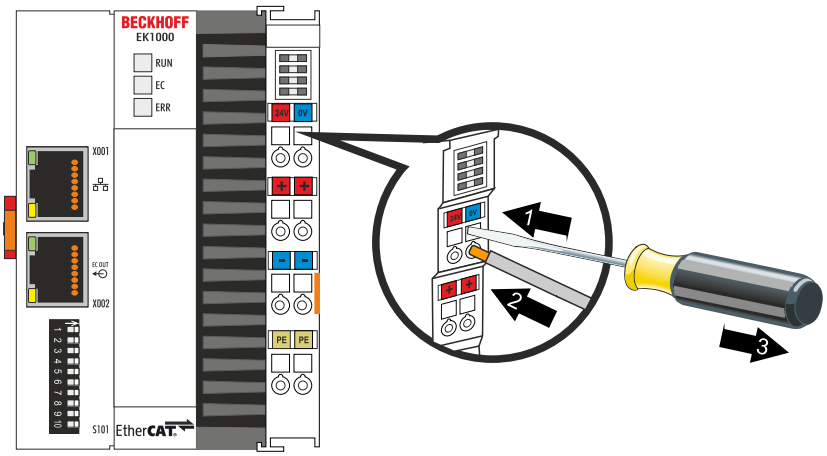
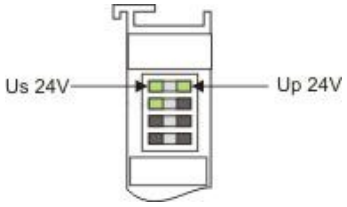


Fig. 21: (1) Insertion screwdriver, (2) Insertion of the cable, (3) Loosen the screwdriver.

The voltage source has been connected to the power supply unit successfully when the two upper power supply terminal LEDs light up in green.

- The left LED (Us) indicates the supply of the basic CPU module and terminal bus.
- The red LED (Up) indicates the Bus Terminal supply via the power contacts.



NOTE

Damage of device possible while interrupting / switching off the power supply

To switch off the EK1000, do not disconnect the ground (0 V), because otherwise current may continue to flow via the shielding, depending on the device, and damage the EK1000 or peripheral devices.

- Always disconnect the 24 V line. Devices connected to the EK1000, which have their own power supply (e.g. a Panel) must have the same potential for "PE" and "0 V" as the EK1000 have (no potential difference).

4.7 Power supply, potential groups

Bus Coupler power supply

The Bus Couplers require a 24 V_{DC} supply for their operation. The connection is made by means of the upper spring-loaded terminals labelled 24 V and 0 V. The supply voltage is used by the Bus Coupler electronics and for direct voltage generation for the E-bus. The voltage generation for the E-bus takes place in a DC/DC converter without electrical isolation.

The EK1xxx units supply the E-bus with max. 2,000 mA E-bus current. Power feed terminals are to be inserted if the added terminals require more current.

Input for power contacts

The bottom six connections with spring-loaded terminals can be used to feed the supply for the peripherals. The spring-loaded terminals are joined in pairs to a power contact. The feed for the power contacts has no connection to the voltage supply for the Bus Coupler. The design of the feed permits voltages of up to 24 V. The assignment in pairs and the electrical connection between feed terminal contacts allows the connection wires to be looped through to various terminal points. The current load via the power contacts may not permanently exceed 10 A; the supply line must therefore be protected by a 10 A fuse (slow-blow).

Power contacts

On the right hand face of the Bus Coupler there are three spring contacts for the power contact connections. The spring contacts are hidden in slots so that they can not be accidentally touched. By attaching a Bus Terminal the blade contacts on the left hand side of the Bus Terminal are connected to the spring contacts. The tongue and groove guides on the top and bottom of the Bus Coupler and of the Bus Terminals guarantees that the power contacts mate securely.

The current load of the power contacts may not permanently exceed 10 A.

Electrical isolation

The bus couplers operate by means of three independent potential groups. The supply voltage feeds the E-bus electronics in the bus coupler and the E-bus itself, which are electrically isolated. The supply voltage is also used to generate the operating voltage for the fieldbus.

Note: All the Bus Terminals are electrically isolated from the E-bus. The E-bus is thus electrically isolated from everything else.

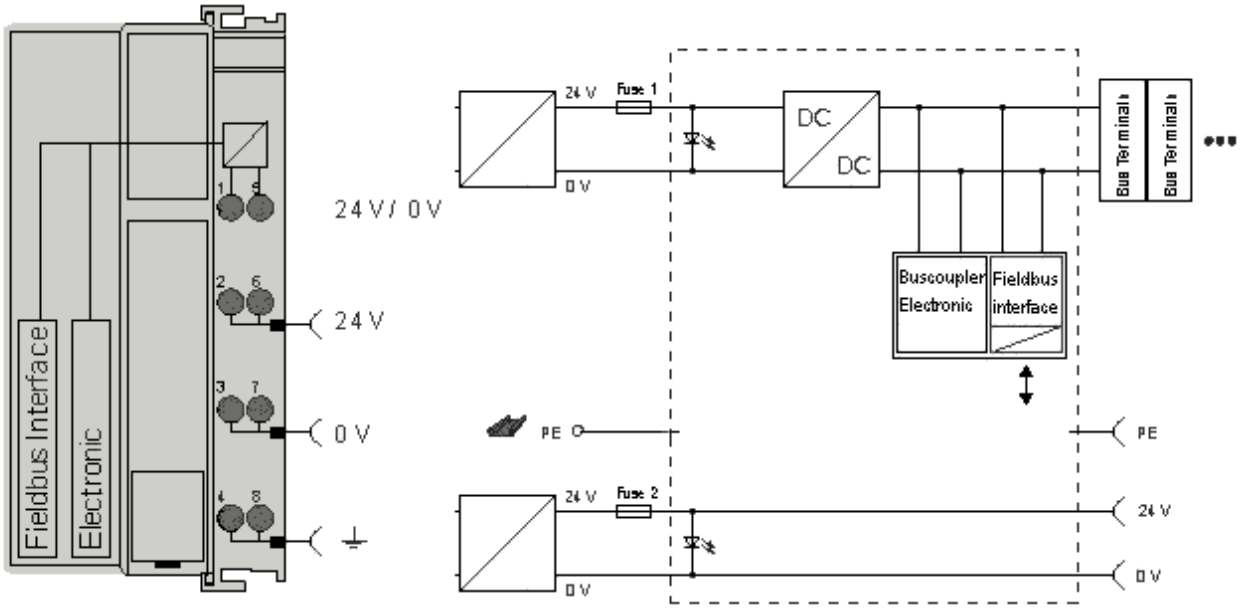


Fig. 22: Potential diagram EKxxxx

GND concept

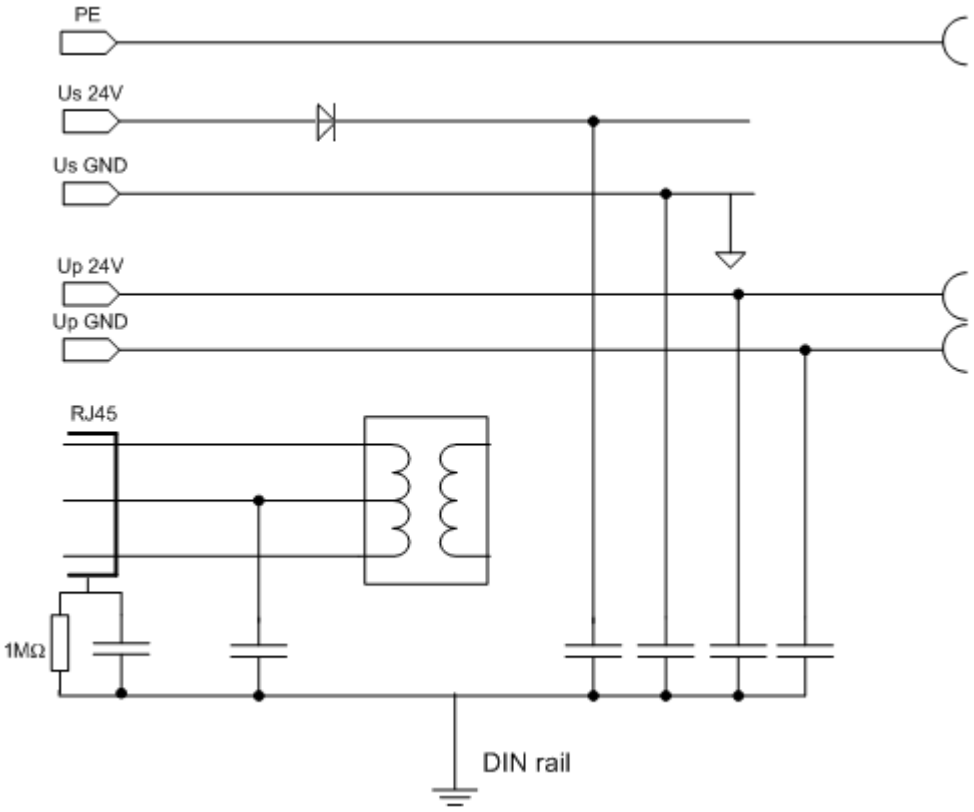


Fig. 23: GND concept EKxxxx

Fuse protection

Coupler supply, fuse 1:

depending on the required current consumption and hence the configured terminals
typical max. 1 A

Power contacts, fuse 2:

permitted max. 10 A (slow-blow)

The coupler electronics and the power contacts can be supplied together from the same source. In this case the fuse should be dimensioned for 10 A max.

4.8 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.

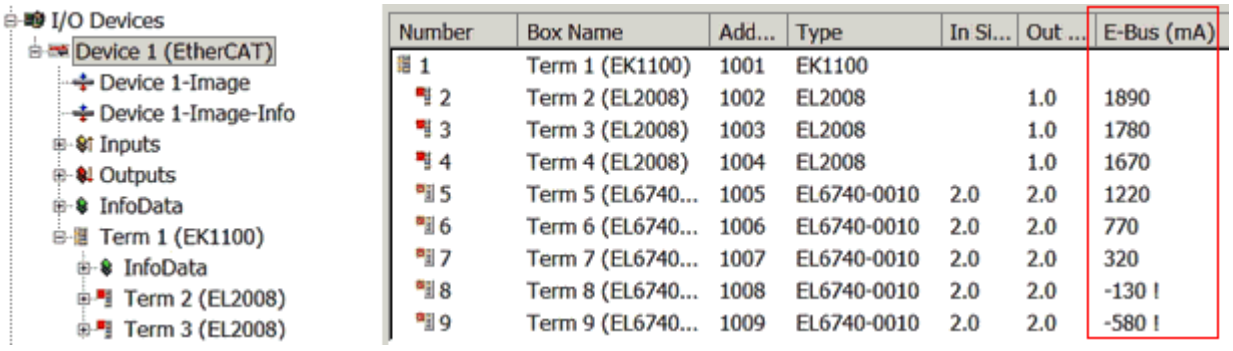


Fig. 24: System manager current calculation

NOTE

Malfunction possible!

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

4.9 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/application notes

In order to operate an EK1000 on an EtherCAT master, an EOM (EtherCAT Open Mode) adapter must first be added directly to **Devices**. Subsequently, it is possible via this adapter to add EOM devices offline or online to the configuration, to make settings and more.

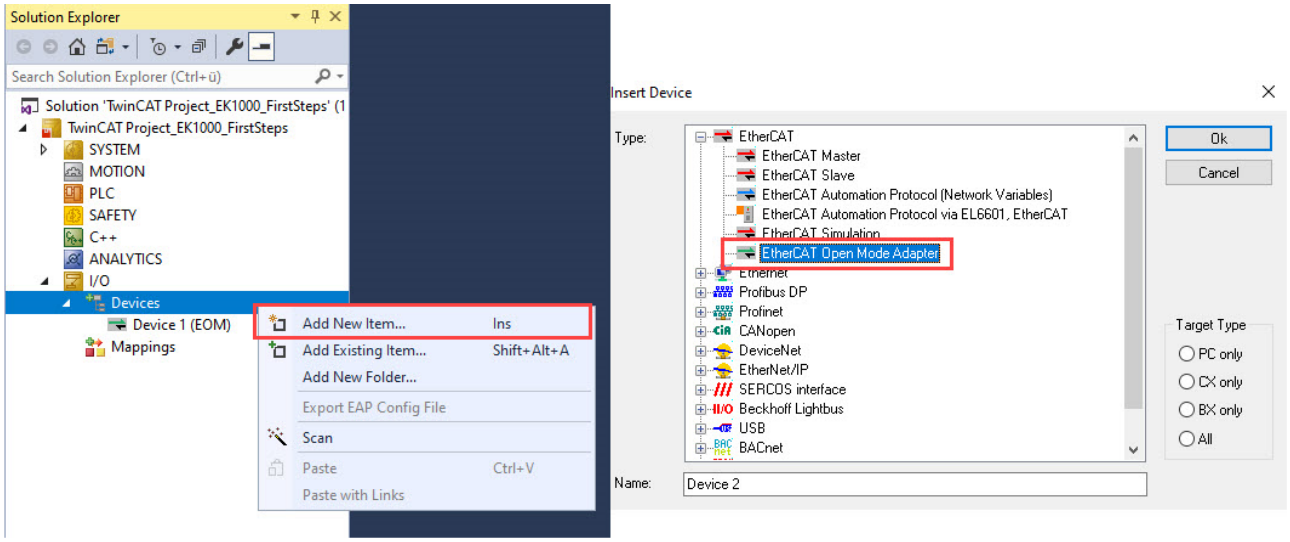


Fig. 25: Adding an EtherCAT Open Mode adapter

NOTE

Installation of the TwinCAT Realtime driver

For the operation of the EtherCAT Open Mode the installation of the TwinCAT Realtime driver on the interface of the connected host PC is necessary!

Further information, see EtherCAT System Documentation.

5.1 Offline configuration

Via **EOM Device Count** in the tab **EOM Devices** of the attached EOM adapter it is possible to add EOM devices like the EK1000 to the configuration. For each device, adjustments such as device name, IP address and communication can be made individually. A mixed operation with communication between "RAW" and "UDP" is possible. The advanced settings of the individual devices can be accessed by right-clicking on the corresponding **EOM device > Advanced Settings.**

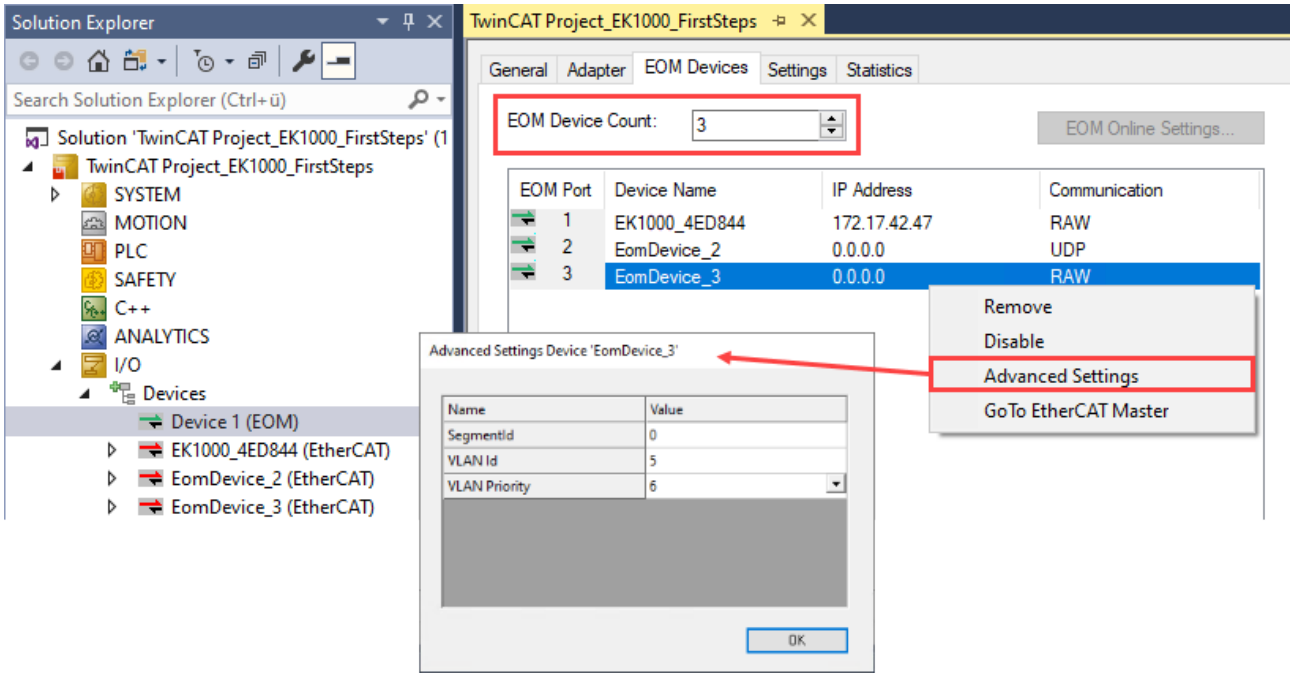


Fig. 26: Dialog "Advanced settings"

By adding EOM devices, associated EtherCAT masters are automatically created on the left in the project tree. You can use this to add EK1000 and other EtherCAT devices to the configuration with a click of the right mouse button.

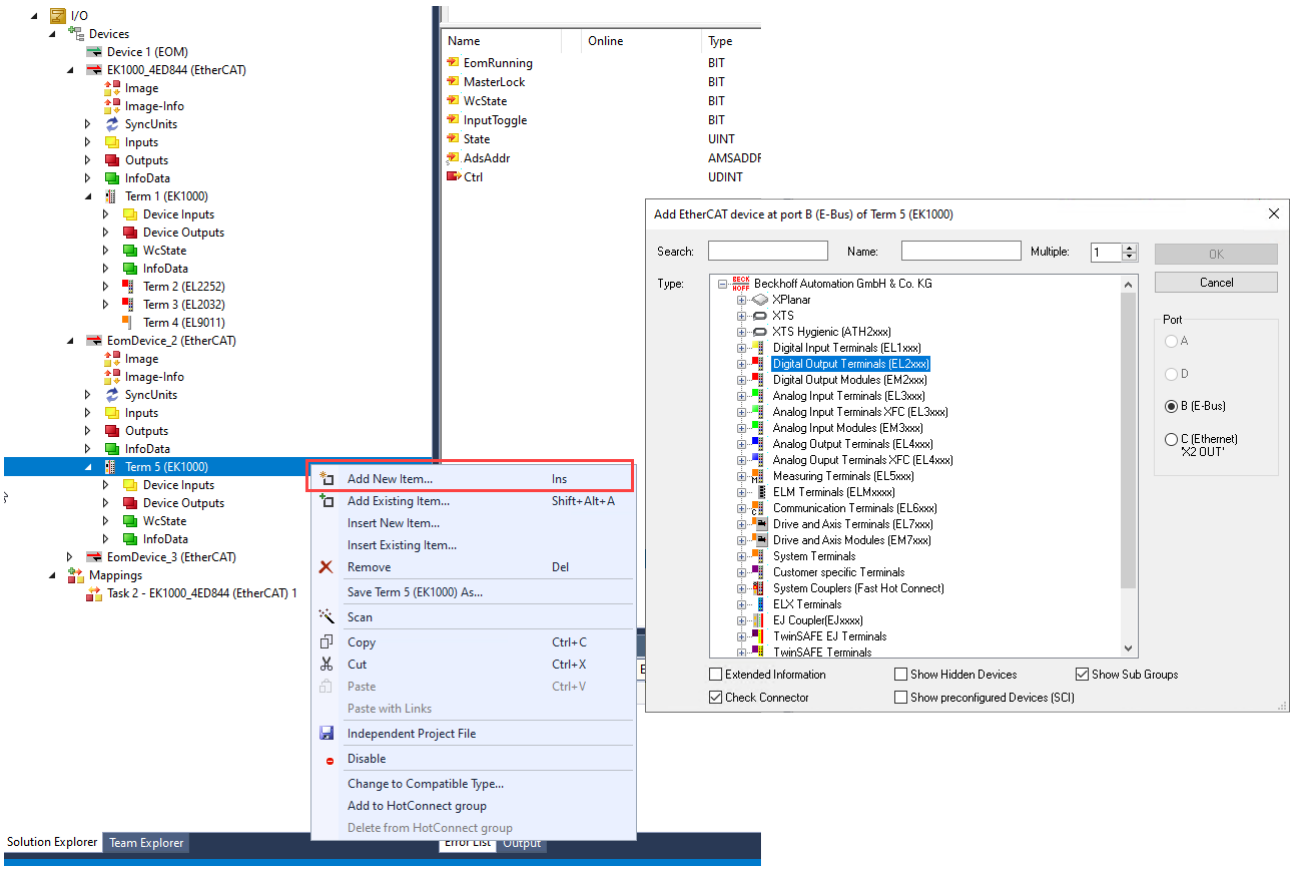


Fig. 27: Add new items

5.2 Online configuration

In order to add EOM devices located in the network to the configuration, it is possible to find them via a broadcast search. To do this, right-click on the attached **EOM adapter - Device x (EOM) > Scan** or via the **EOM Devices > EOM Online Settings** tab.

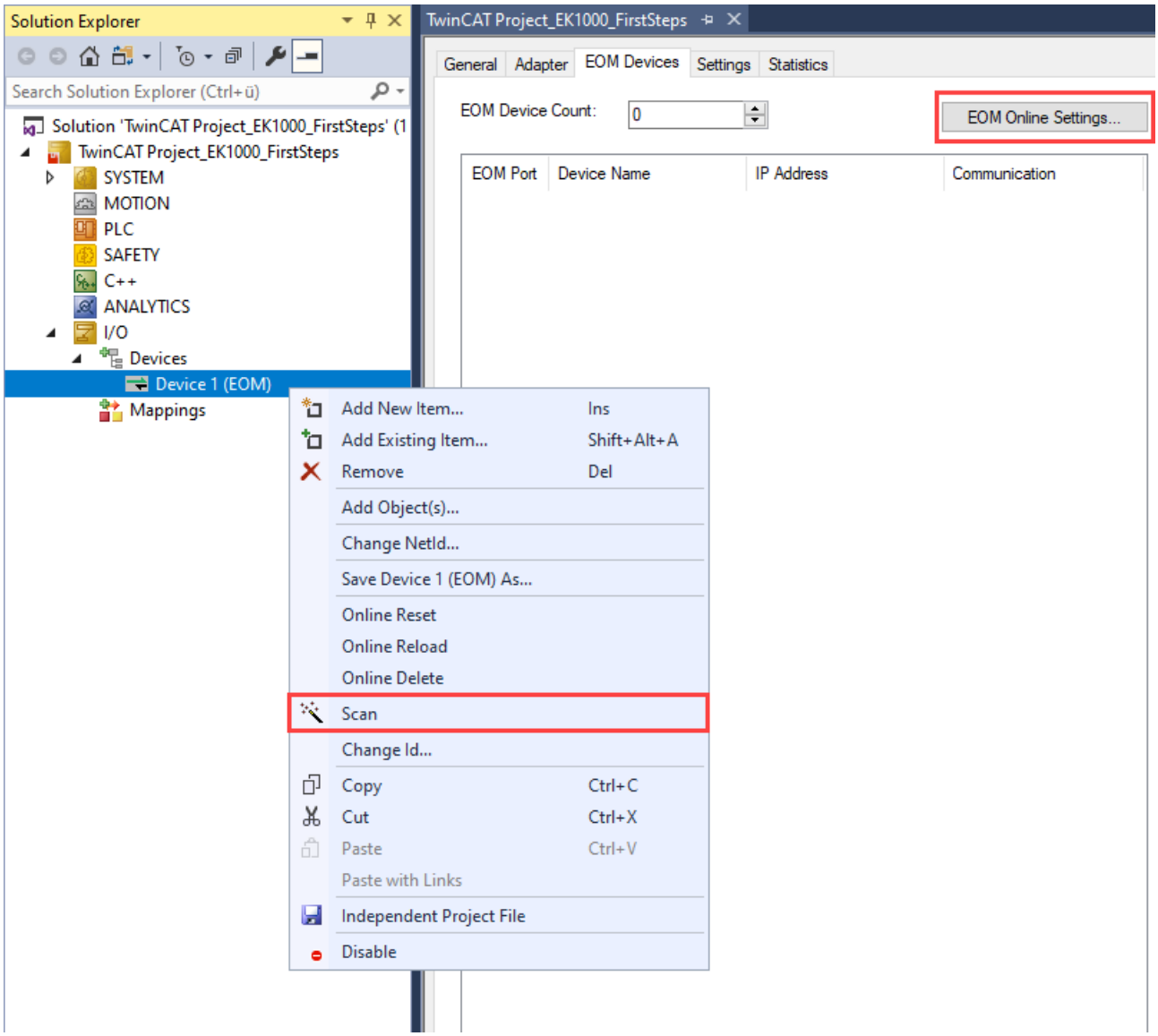


Fig. 28: Scan for EOM Devices

The following dialog should open. After successful scanning, all devices found are listed and settings and configuration can be carried out on the devices. A lock in the icon of a device indicates that it is already communicating with another EOM master and is therefore locked.

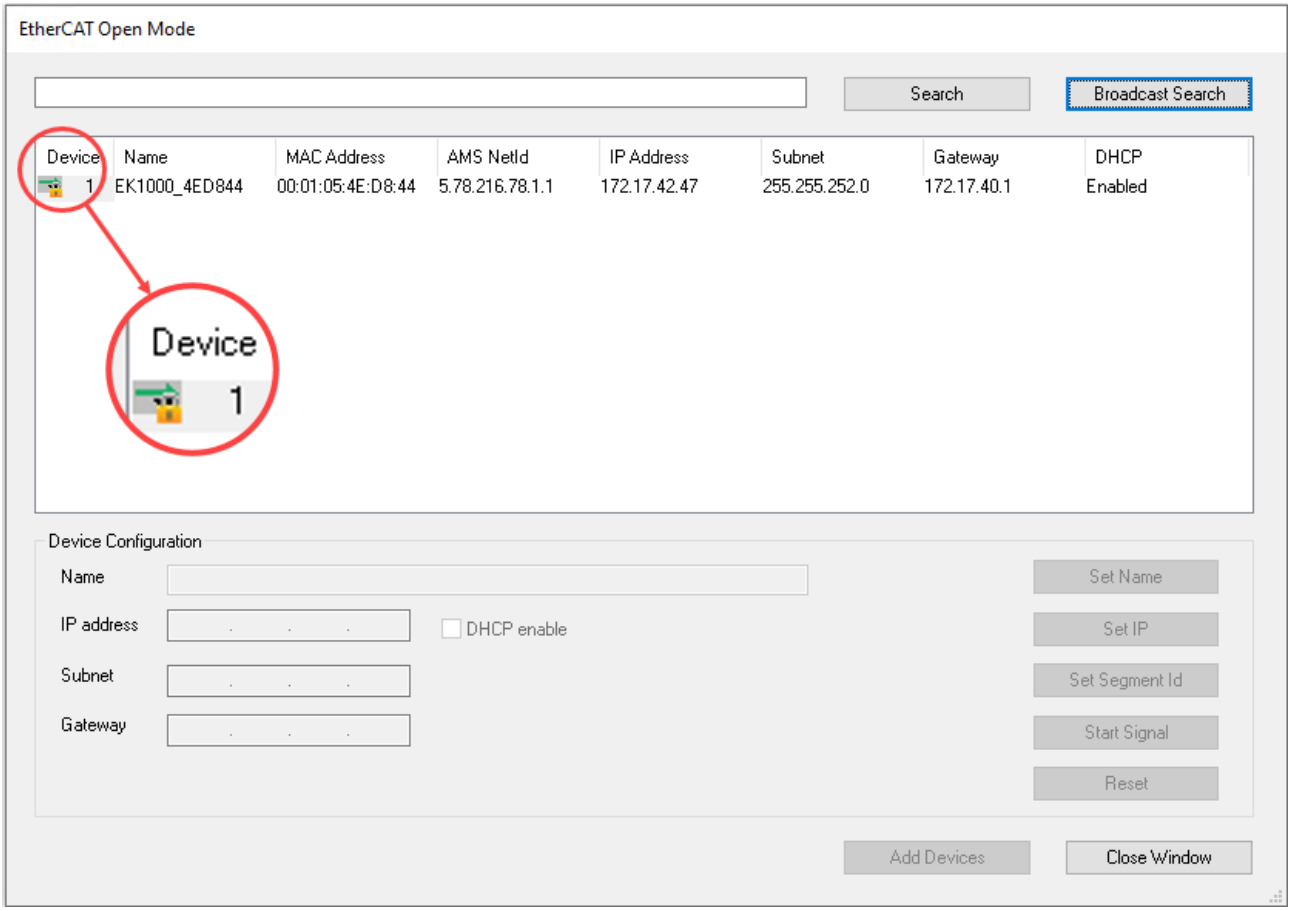


Fig. 29: Device locked, communication with EOM master

When adding the devices, an EtherCAT master is automatically added for each. On closing the dialog, the following query opens:

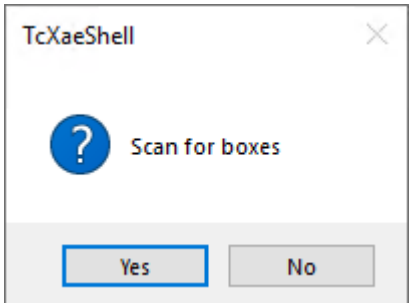


Fig. 30: Scan for futher devices

When the query is confirmed, all devices in the EtherCAT network are automatically added to the configuration. If rejected, only the EtherCAT master is included.

5.3 Meaning of the DIP switch

The DIP switch has the following meaning for interface X001

DIP 9	DIP 10	DIP 1-8	Restart behavior	Behavior with factory settings
0	1	-	• Device name from memory • DHCP= active	• Device name= EK1000_MAC[3..5] • DHCP= active
1	1	0	• Device name from memory • IP settings from memory	• Device name= EK1000_MAC[3..5] • DHCP= active
		≠0	• Device name= EK1000_DIP1-8 • IP settings from memory	• Device name= EK1000_DIP1-8 • DHCP= active

5.4 Configuration overview

More detailed information on the configuration settings can be found in the EtherCAT System Documentation on the Beckhoff website.

6 Settings and Parameterization

6.1 Settings at the EtherCAT Open Mode adapter

6.1.1 General

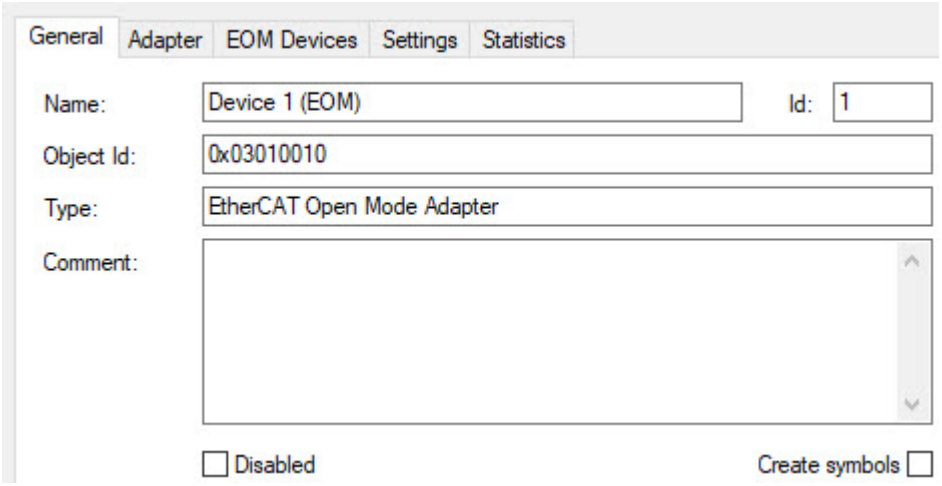


Fig. 31: “General” tab

Name

Identifier for the EtherCAT Open Mode adapter.

Id

The device ID is set by the TwinCAT System Manager during configuration and cannot be configured by the user.

Object Id

Identification number of the EtherCAT Open Mode adapter object in the TwinCAT object context.

Type

Shows the selected object type and its property.

Comment

Freely editable comment to describe the object used.

Disabled

This option sets the EOM adapter to inactive (transparent) for the current configuration. If this option is activated, the corresponding object is ignored in the I/O configuration.

Create symbols

Creating variables as symbolic names.

6.1.2 Adapter

This dialog is used to select the network card to be used for communication with the EtherCAT Open Mode.

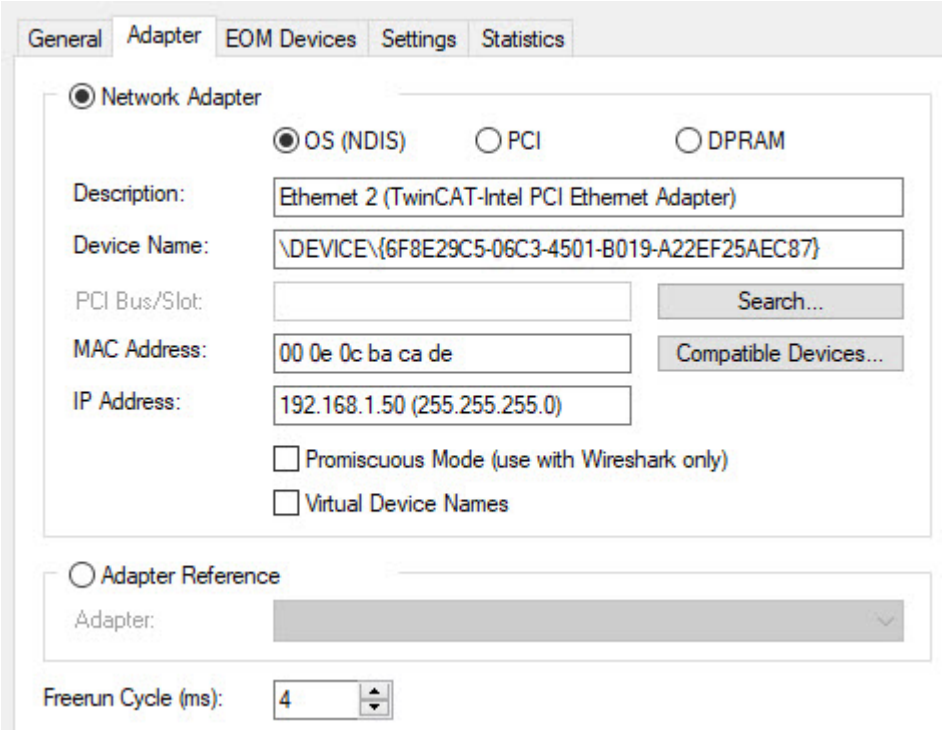


Fig. 32: “Adapter” tab

OS (NDIS)

This option uses the operating system (OS) settings for installed network cards. In Description the name of the network card is displayed. Device Name contains the Device Manager path of the installed network card.

PCI

This option controls the network card via the PCI bus address, which is specified in the PCI Bus/Slot field.

The PCI Bus/Slot field is not enabled until the PCI option is selected.

DPRAM

This option controls the network card via the DPRAM address, which is specified in the Address field.

The Address field is not enabled until the DPRAM option is selected.

Search… button

This button opens a dialog in which all unused or all compatible devices (adapters) can be selected.

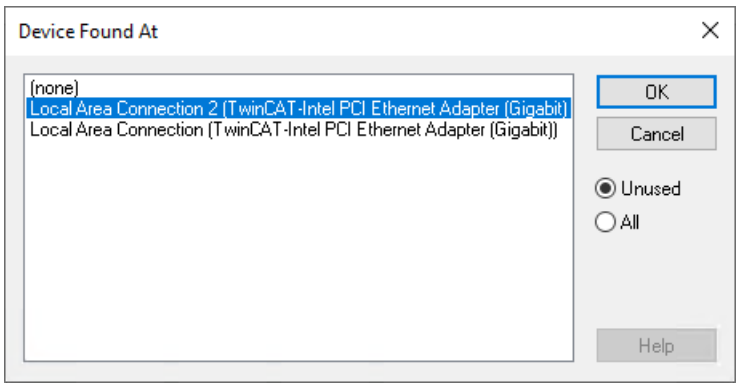


Fig. 33: Dialog “Device Found At”

Compatible Device… button

The button opens the same dialog as "TWINCAT\Show Realtime Compatible Devices…" in the main menu. Here you can determine whether compatible Ethernet adapters are available in the system.

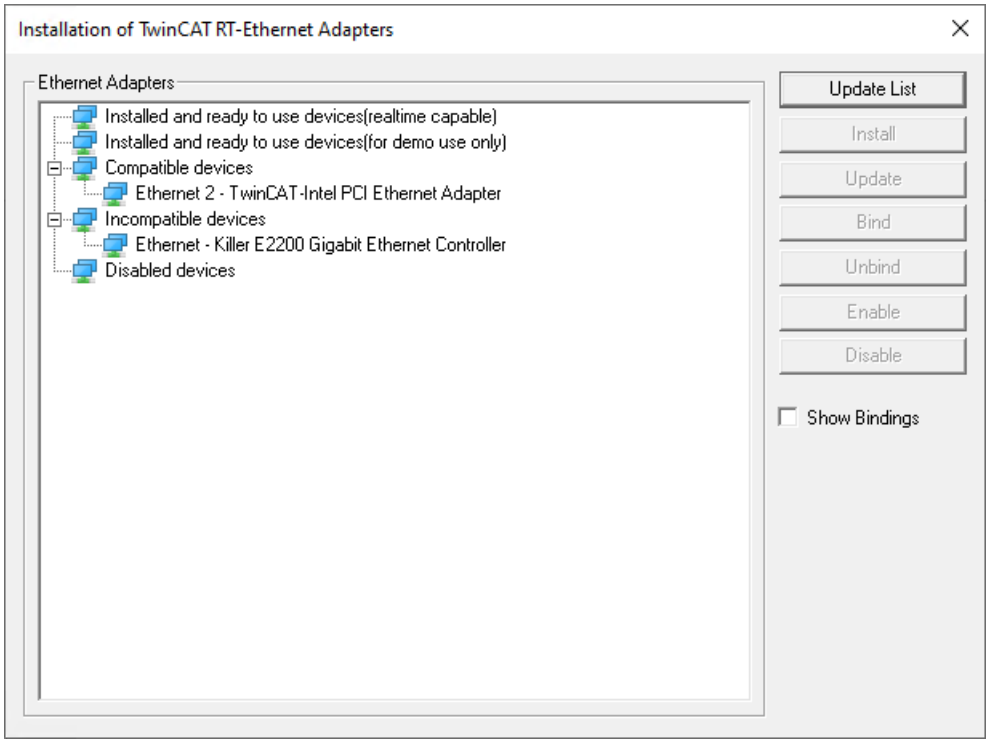


Fig. 34: Dialog “Installation of TwinCAT RT-Ethernet Adapters”

MAC Address

MAC address of the Ethernet card (read-only).

IP Address

IP address of the card (read-only). The IP address is read from the operating system.

Promiscuous Mode

This is required in order to record Ethernet frames, and should normally be switched off.

Virtual Device Names

A virtual name is used for the network card.

Adapter Reference

If the network adapter is referenced to another device, this option must be selected. This is used, for example, when using the "Multiple Protocol Handler".

Free Cycle

Cycle time in Config mode (no real-time).

6.1.3 EOM Devices

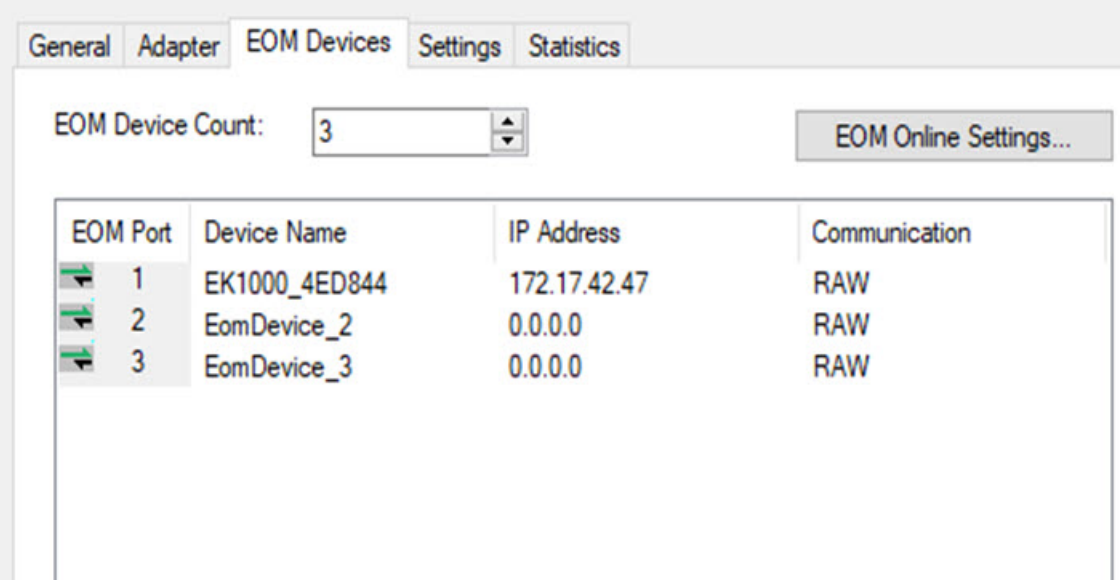


Fig. 35: “EOM Devices” tab

EOM Device Count

Shows the number of EOM devices in the current configuration. Use the arrow keys to edit the number.

EOM Online Settings… Button

1. Search for an implicit device, e.g. by entering the IP address
2. Starting a broadcast search for the network
3. Listing of the devices found
4. The settings made are applied by pressing these buttons
5. Used to locate the selected device: when pressed, the **ERR LED** flashes at a frequency of 2 Hz.
6. The selected device is reset to factory settings
7. Automatically adds EtherCAT master for the selected devices
8. For future TSN functionalities
9. Current settings of the selected devices

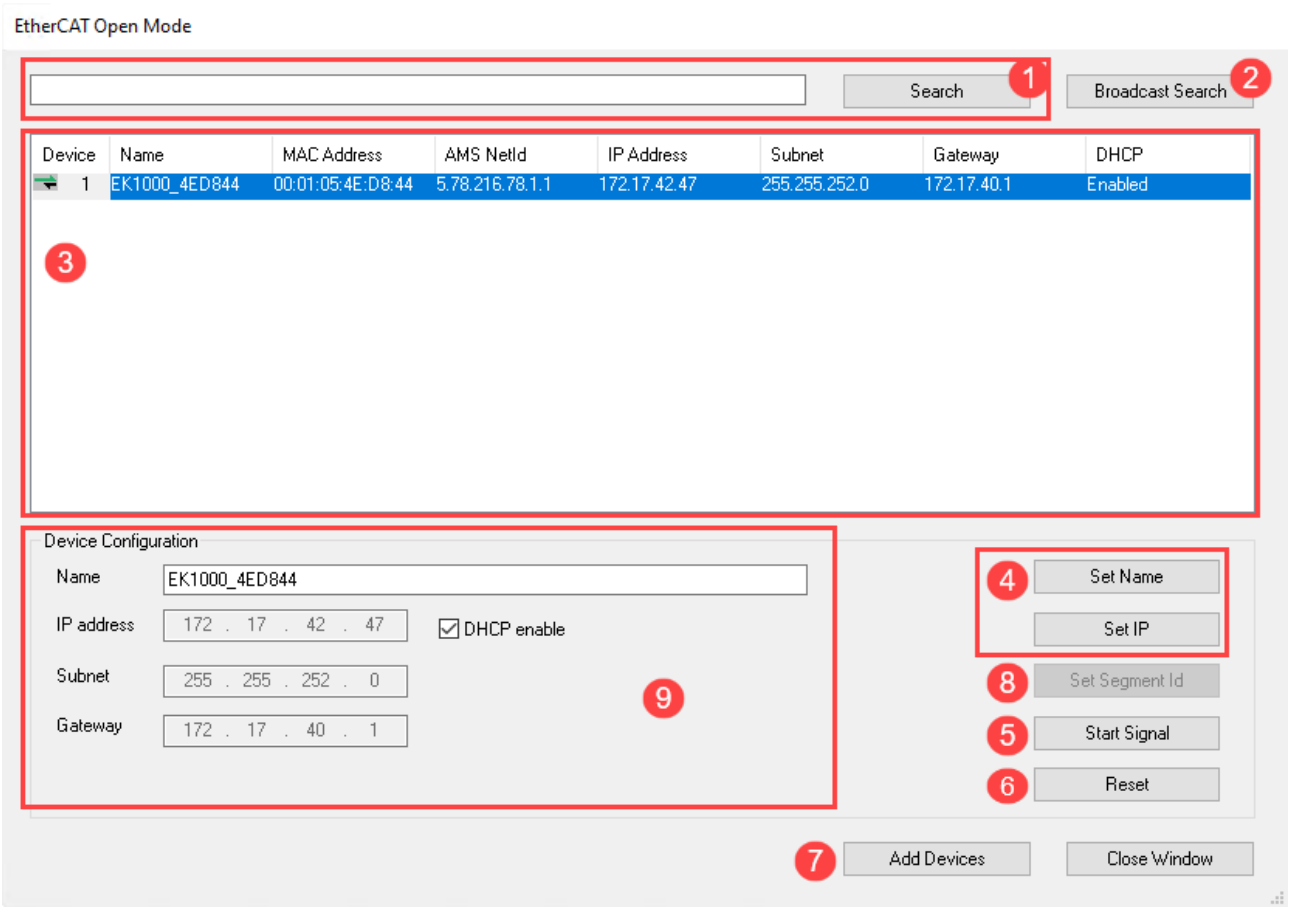


Fig. 36: Dialog “EtherCAT Open Mode”

EOM Port

The port ID is the unique assignment for the respective port and cannot be changed. It is included in the generation of the TCCOM OID.

Device Name

Identifier for the EOM device can be edited.

IP Address

IP address for the EOM device can be edited.

Communication

Communication type for the EOM device can be set to "RAW" or to "UDP". Mixed operation among the EOM devices is possible.

6.1.4 Settings

This dialog is used to specify and parameterize the network adapter to be used for communication with the EtherCAT Open Mode.

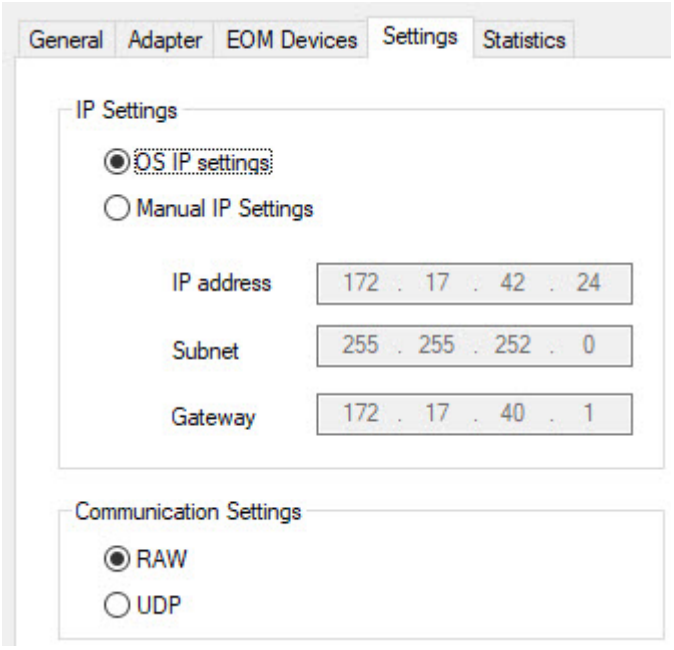


Fig. 37: “Settings” tab

OS IP settings

The settings used by the operating system are adopted and used for the network adapter.

Manual IP Settings

Changes can be made to the network settings.

Communication Settings

This option controls the communication type.

The "RAW" setting is intended for local networks and communicates on layer 2. We recommend cycle times between 1...45 ms.

The setting "UDP" communicates on layer 4 and should be used for routing-capable and WLAN networks. We recommend cycle times between 5...45 ms. For WLAN networks it is recommended that the cycle times do not fall below 10 ms.

In addition, the SM watchdog time of EtherCAT devices must be taken into account when setting the cycle time.

6.1.5 Statistics

This dialog contains various (frame) statistics for the EOM master and its EOM devices

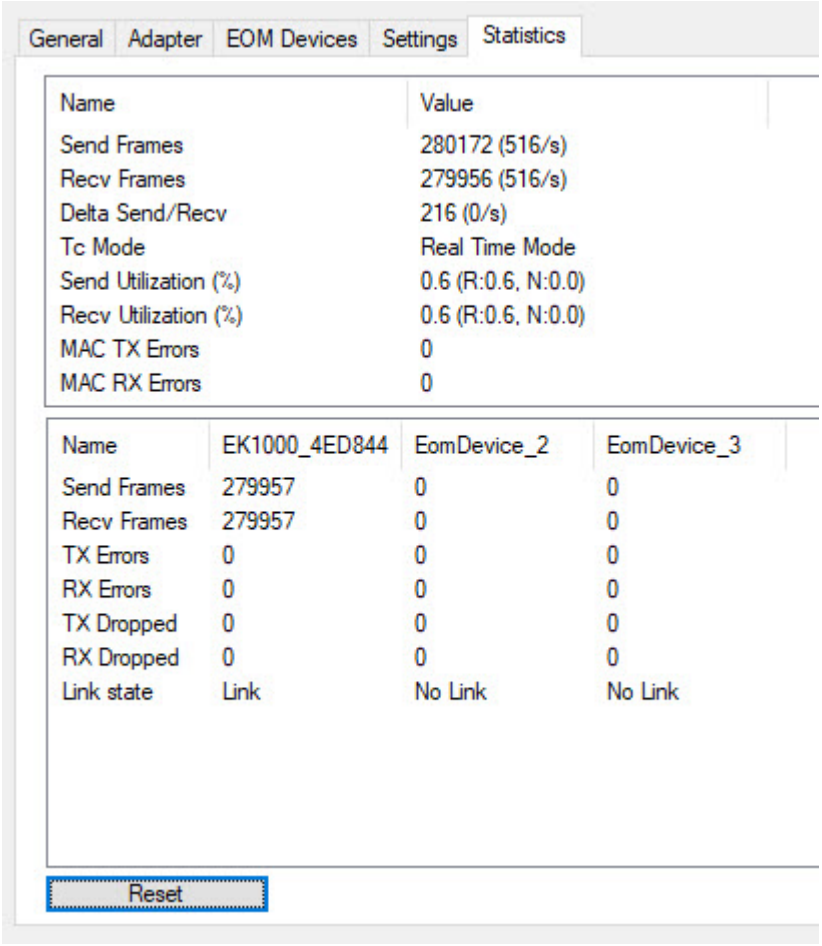


Fig. 38: “Statistics” tab

Name	Explanation
Send Utilization (%)	Utilization of the ESL transmission in transmit direction R: real-time data, N: non-real-time data
Recv Utilization (%)	Utilization of the ESL transmission in receive direction R: real-time data, N: non-real-time data

NOTE

The utilization of the EK1000 should not exceed 50% in transmit/receive direction

In the event of a high network load or an expansion, this provides sufficient buffering.

- No action is required if the network load is ≤ 20%.
- With a network load between 20...50%, this should be investigated and optimized
- If the network load is ≥ 50%, it should be mandatory to implement measures to reduce the network load.

6.2 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 EtherCAT device 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 notes [▶ 21] 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

6.2.1 Profile-specific objects

Index F100 Diagnosis State

Index (hex)	Name	Meaning	Data type	Flags	Default
F100:0	Diagnosis State	Max. Subindex	UINT8	RO	0x02
F100:01	EomRunning	Is set to TRUE as soon as the coupler reaches the EtherCAT state Operational	BOOLEAN	RO	0x00
F100:02	MasterLock	Set to TRUE as soon as the EOM master accesses via EtherCAT	BOOLEAN	RO	0x00

Index F200 Diagnosis Control

Index (hex)	Name	Meaning	Data type	Flags	Default
F200:0	Diagnosis Control	Max. Subindex	UINT8	RO	0x01
F200:01	Ctrl		UINT32	RO	0x00000000

Index F800 EK1000 settings

Index (hex)	Name	Meaning	Data type	Flags	Default
F800:0	EK1000 settings	Max. Subindex	UINT8	RO	0x05
F800:01	Station name	Device name of the EOM device	STRING	RW	EK1000_MAC[3..5]
F800:02	IP Data	IP settings Byte 0..3 = IP Address Byte 4..7 = Subnet Byte 8..11 = Gateway	OCTET-STRING[12]	RW	{0}
F800:03	DHCPEnable	If TRUE, then DHCP is activated	BOOLEAN	RW	0x00
F800:05	SegmentId	For future TSN use	UINT16	RW	0x0003

Index F883 Vendor data

Index (hex)	Name	Meaning	Data type	Flags	Default
F883:0	Vendor data	Max. Subindex	UINT8	RO	0x04
F883:01	Serial number	Serial number	STRING	RW	-
F883:02	Model Number	Model number	STRING	RW	-
F883:03	Production date	Date of manufacture	STRING	RW	0
F883:04	Hardware Revision	Hardware revision	STRING	RW	0

Index F8F0 MAC address

Index (hex)	Name	Meaning	Data type	Flags	Default
F883:0	MAC address	Max. Subindex	UINT8	RO	0x01
F883:01	MAC	MAC address of the EK1000	OCTET-STRING[6]	RW	{0}

Index FA00 EK1000 diagnosis

Index (hex)	Name	Meaning	Data type	Flags	Default
FA00:0	EK1000 diagnosis	Max. Subindex	UINT8	RO	0x03
FA00:01	EomMasterMac	MAC address of the currently associated EOM master	OCTET-STRING[6]	RO	{0}
FA00:02	EomMasterIp	IP address of the currently associated EOM master	OCTET-STRING[6]	RO	{0}
FA00:03	EomMasterUdpPort	UDP port of the currently associated EOM master	UINT16	RO	0x0000

7 Error handling and diagnostics

7.1 Diagnostic LEDs

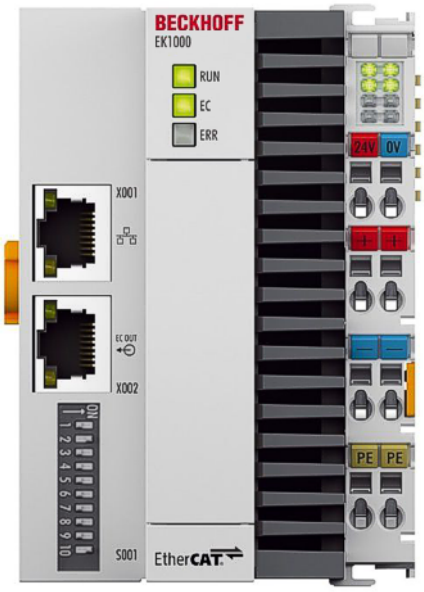


Fig. 39: EK1000 LEDs

Ethernet interface X001

LED		Display	State	Description
LINK / ACT (X001 IN)	green	off	-	Link not available/no activity
		on	linked	Link available/activity

LED power supply terminal

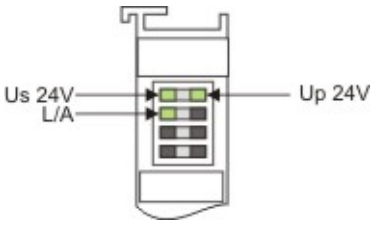


Fig. 40: Diagnostic LEDs

LED		Display	State	Description
Us	green	off	-	No operating voltage present at the Bus Coupler
		on	-	24 V_{DC} operating voltage present at the Bus Coupler
Up	green	off	-	No power supply present at the power contacts
		on	-	24 V_{DC} power supply present at the power contacts
LINK / ACT (X002 OUT)	green	off	-	No EtherCAT device connected
		on	linked	EtherCAT device connected / data communication not active
		flashes	active	EtherCAT device connected / data communication active

LED coupler

LED		Display	State	Description
RUN	green	on	-	Coupler is ready
EC	green	off	Init	The Bus Coupler is in initialization state
		flashes	Pre-Operational	The Bus Coupler is in *pre-operational* state
		Single flash	Safe-Operational	The Bus Coupler is in *safe-operational* state
		on	Operational	The Bus Coupler is in *operational* state
		flickering	Bootstrap	Firmware is being loaded.
ERR	red	off	-	No error
		flashes at 2 Hz	-	Used to visually locate the corresponding device. Triggered by "Start Signal" function in the Broadcast Search
		on	-	Error is signaled

8 Appendix

8.1 Image Update

Applies to EK1000.

Image Update

Please ascertain before the image update whether the hardware supports the image that you wish to load!
When updating the image, please delete all files first and only load the new image after that.

Update via SD card

1. Switch off the EK
2. Remove SD card
3. Insert SD card into PC
4. Delete all files (we recommend that you backup all files first), no formatting
5. Copying the new image
6. Wait until copying has finished, then remove the SD card
7. Switch on the EK1000 with SD card; it is possible that switching on may be delayed a little after the update

8.2 Firmware compatibility

The EK110x and EK15xx Couplers have no firmware.

8.3 Firmware Update EL/ES/EM/ELM/EPxxxx

This section describes the device update for Beckhoff EtherCAT slaves from the EL/ES, ELM, EM, EK and EP series. A firmware update should only be carried out after consultation with Beckhoff support.

NOTE

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 https://www.beckhoff.com/en-us/.

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:

- 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.
- In addition, each EtherCAT slave has a memory chip, a so-called **ESI-EEPROM**, for storing its own device description (ESI: EtherCAT Slave Information). On power-up this description is loaded and the EtherCAT communication is set up accordingly. The device description is available from the download area of the Beckhoff website at (https://www.beckhoff.com). All ESI files are accessible there as zip files.

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

NOTE

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.

8.3.1 Device description ESI file/XML

NOTE

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:

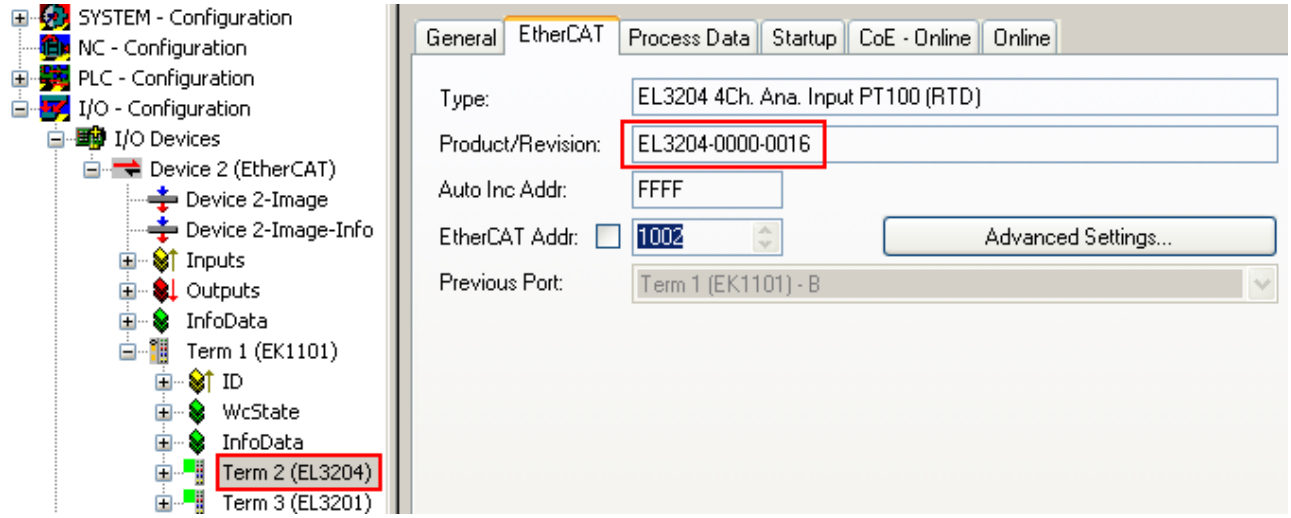


Fig. 41: Device identifier consisting of name EL3204-0000 and revision -0016

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:

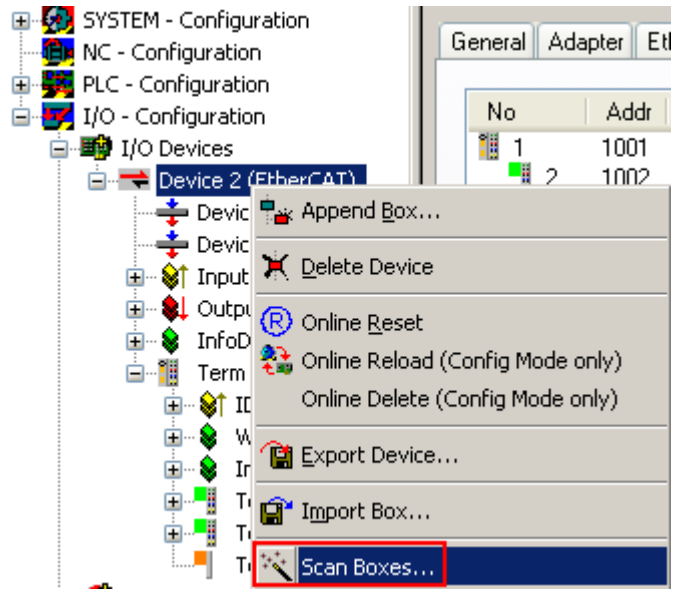


Fig. 42: Scan the subordinate field by right-clicking on the EtherCAT device

If the found field matches the configured field, the display shows

Fig. 43: Configuration is identical

otherwise a change dialog appears for entering the actual data in the configuration.

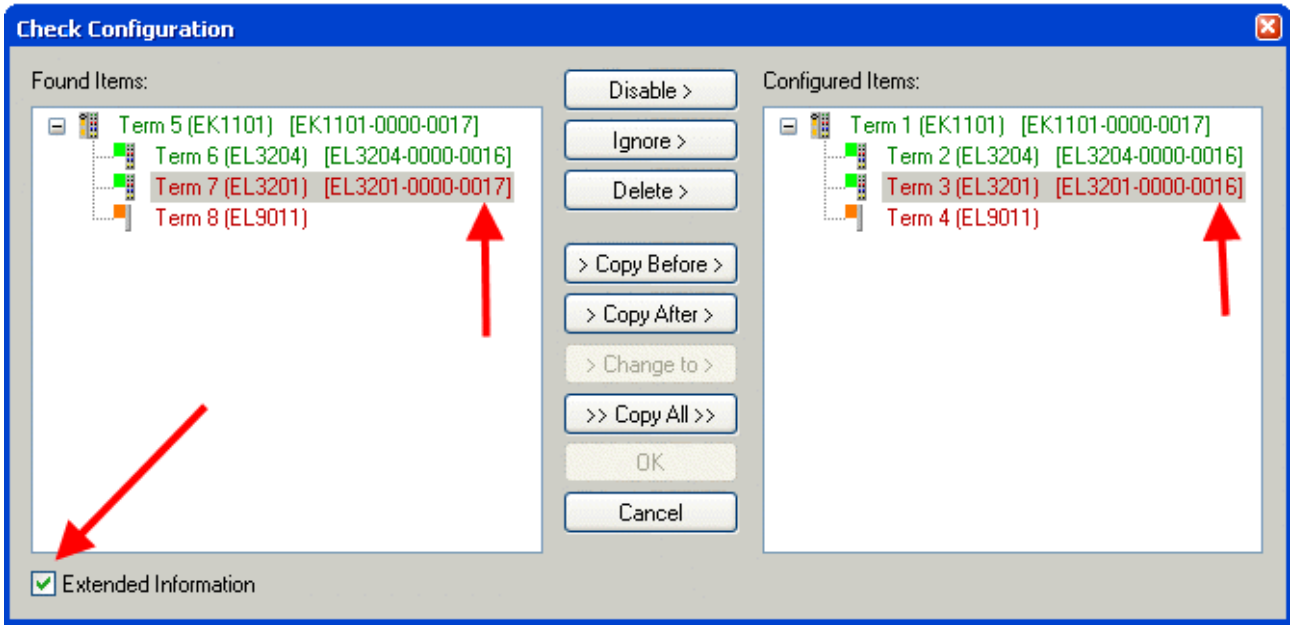


Fig. 44: Change dialog

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*

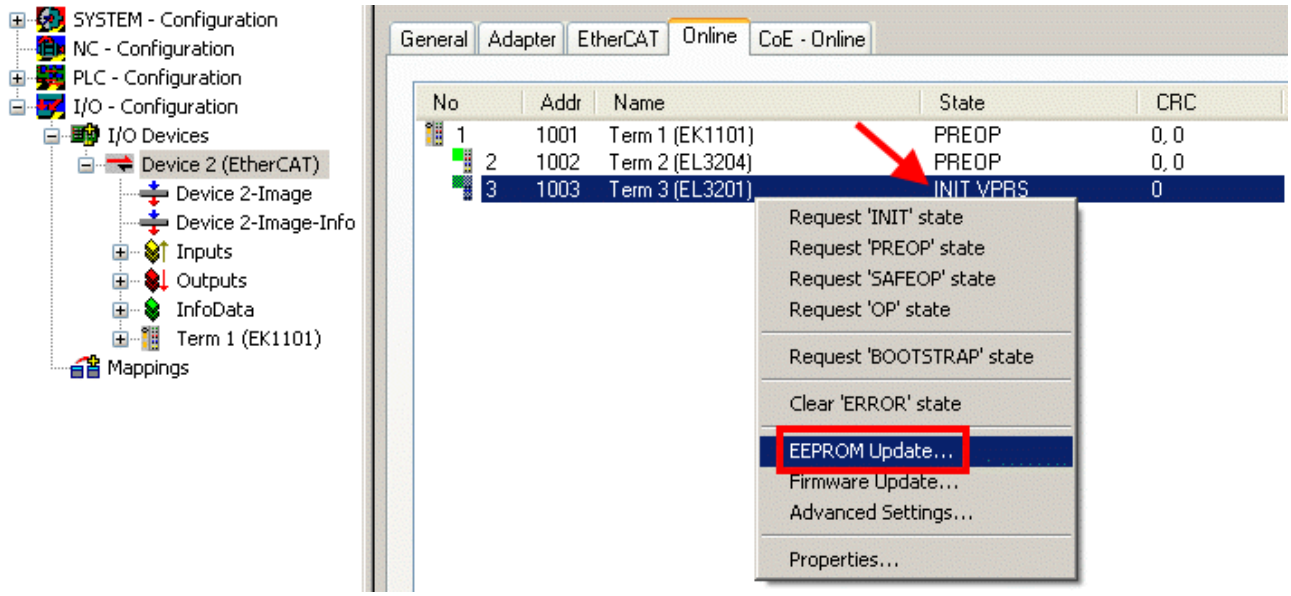


Fig. 45: EEPROM Update

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.

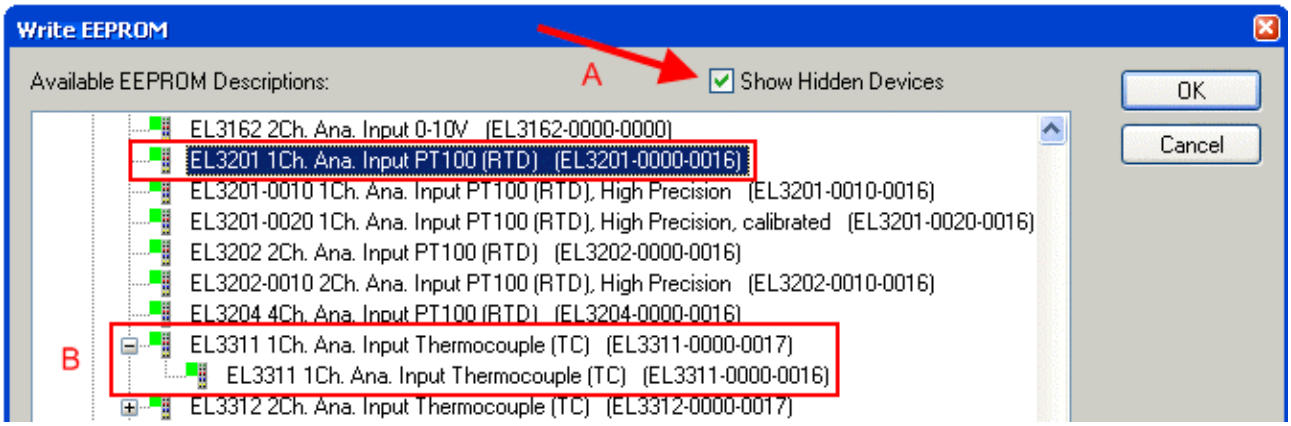


Fig. 46: Selecting the new ESI

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.

8.3.2 Firmware explanation

Determining the firmware version

Determining the version via the 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.

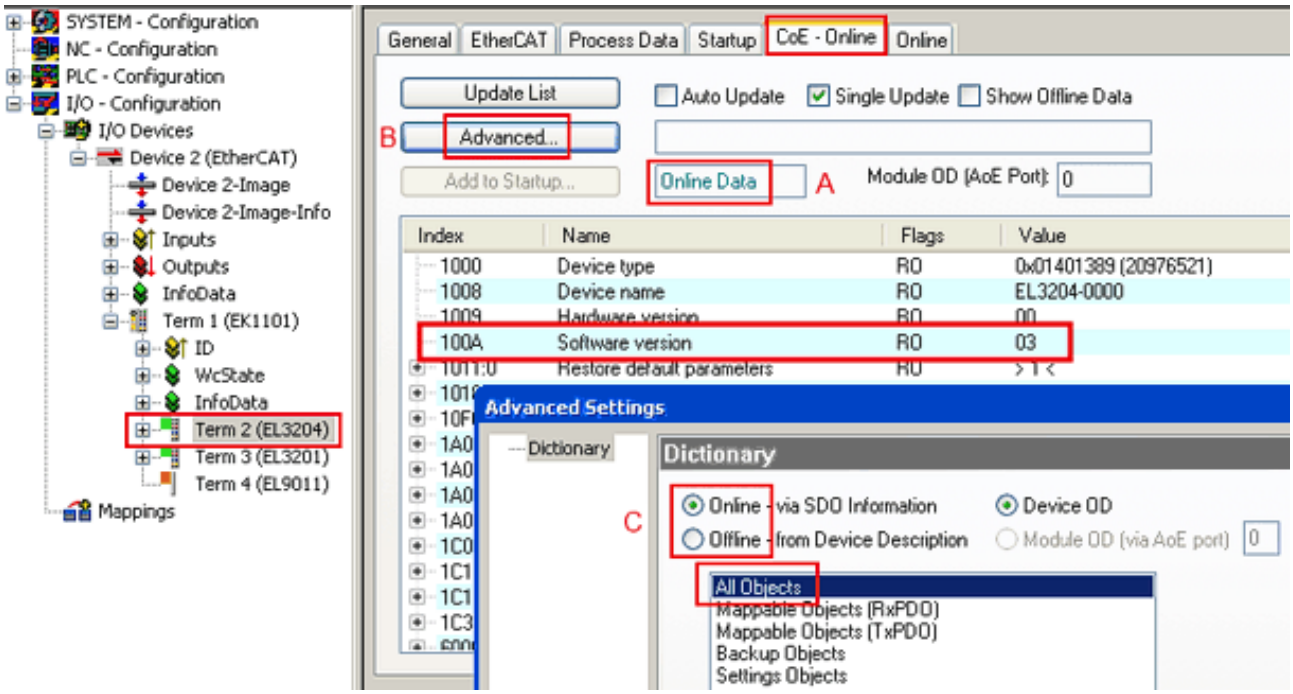


Fig. 47: Display of EL3204 firmware version

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*.

8.3.3 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.*

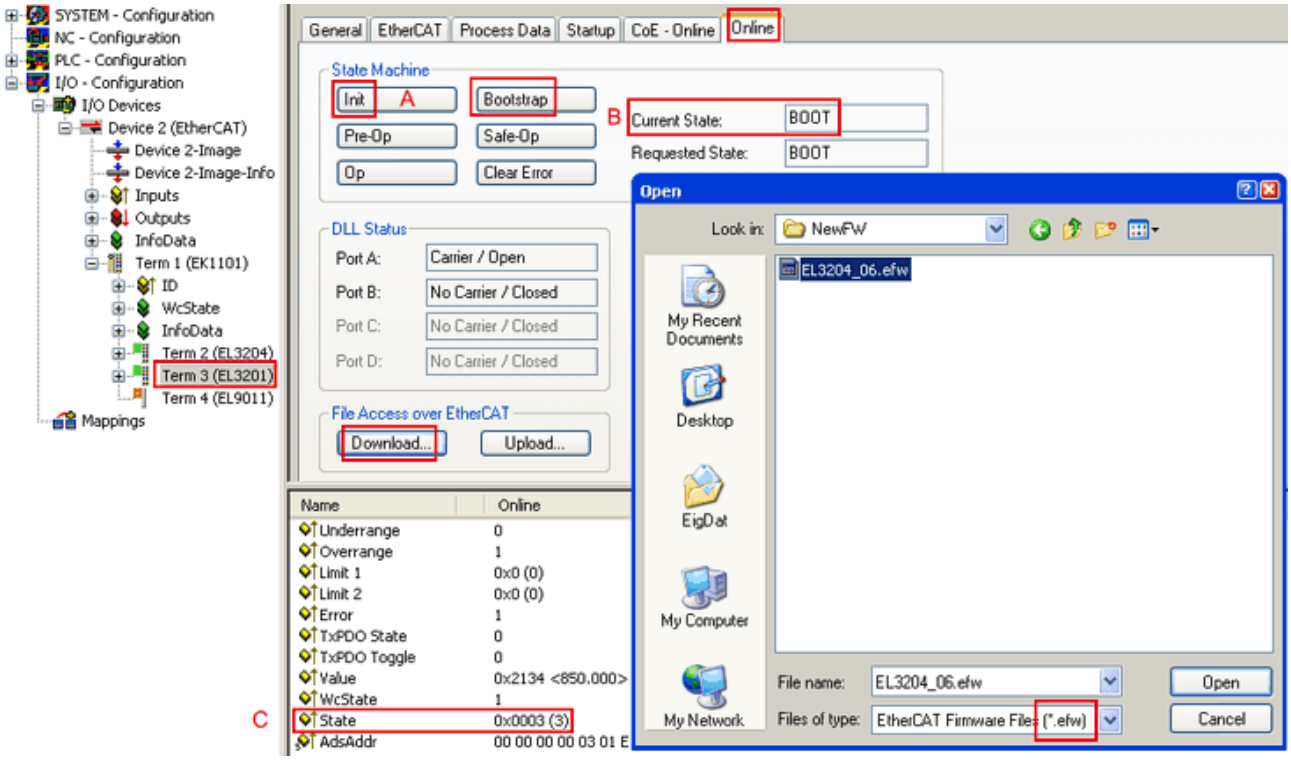
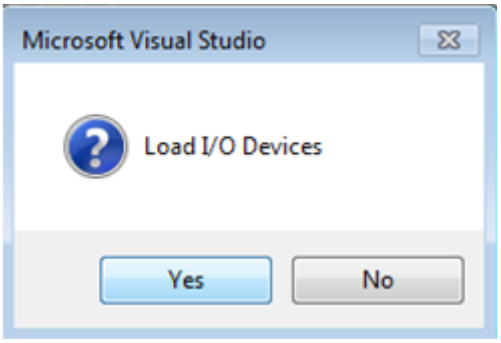
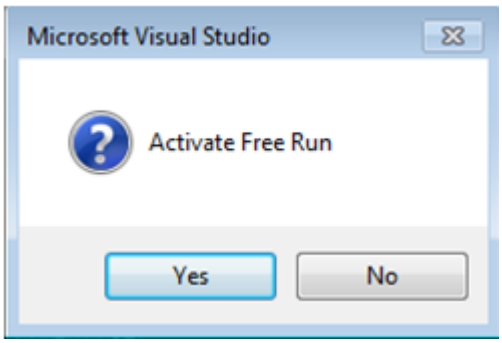


Fig. 48: Firmware Update

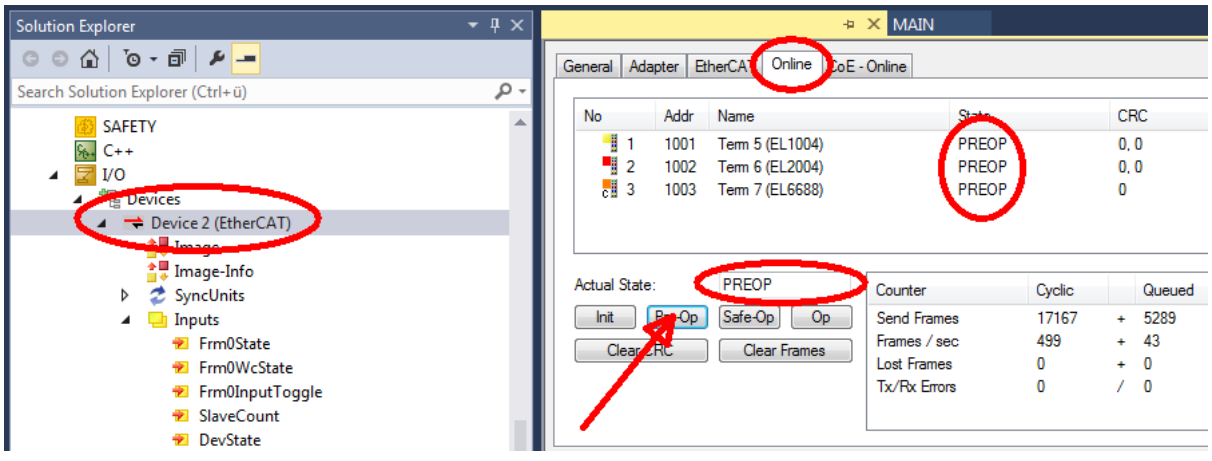
Proceed as follows, unless instructed otherwise by Beckhoff support. Valid for TwinCAT 2 and 3 as EtherCAT master.

- 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.



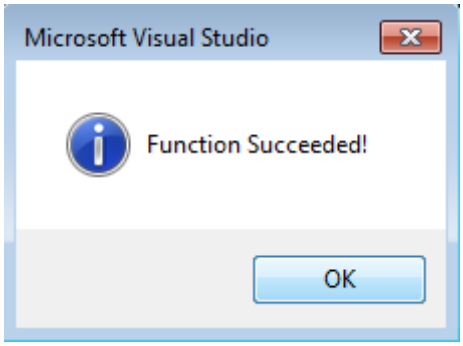


- Switch EtherCAT Master to PreOP



- 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 pass word will not be neccessary usually.



- 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.

8.3.4 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 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.

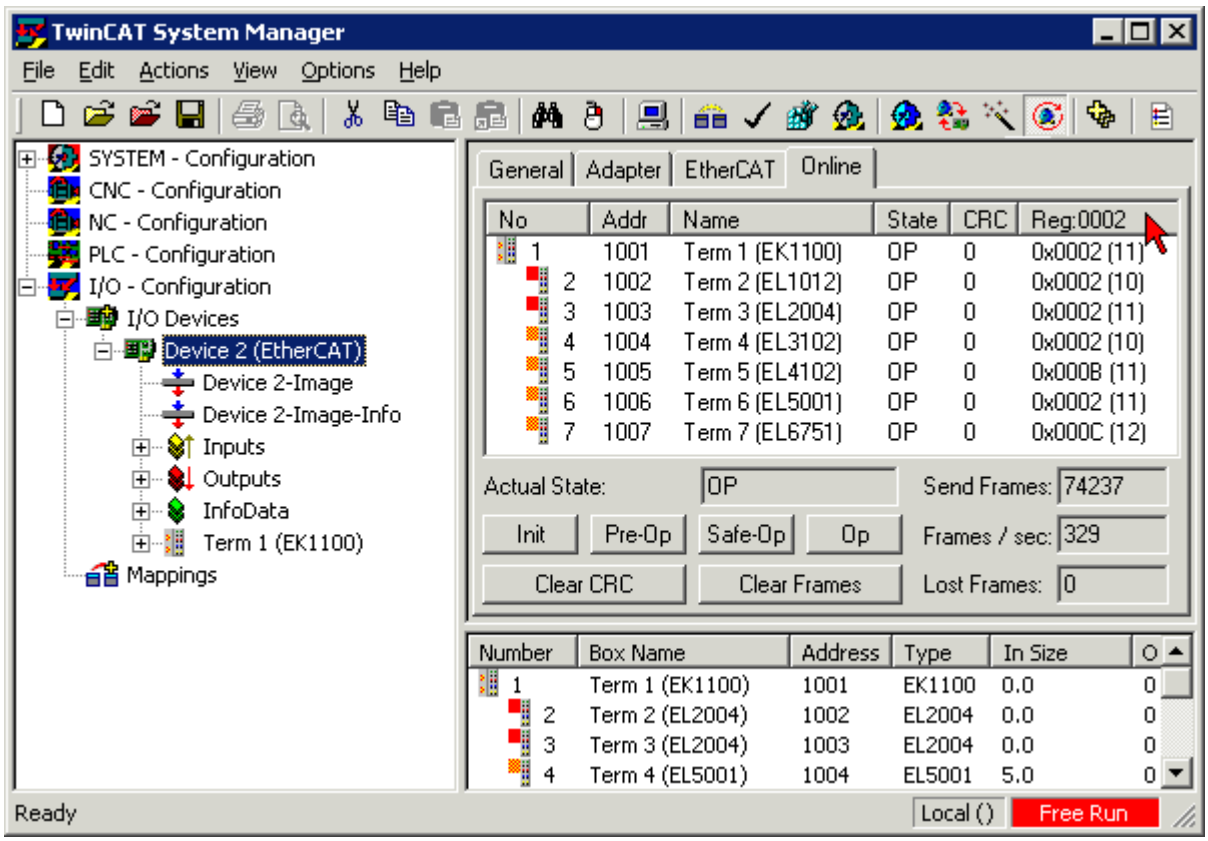


Fig. 49: FPGA firmware version definition

If the column *Reg:0002* is not displayed, right-click the table header and select *Properties* in the context menu.

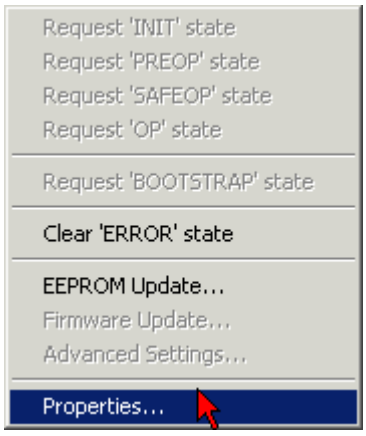


Fig. 50: Context menu *Properties*

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.

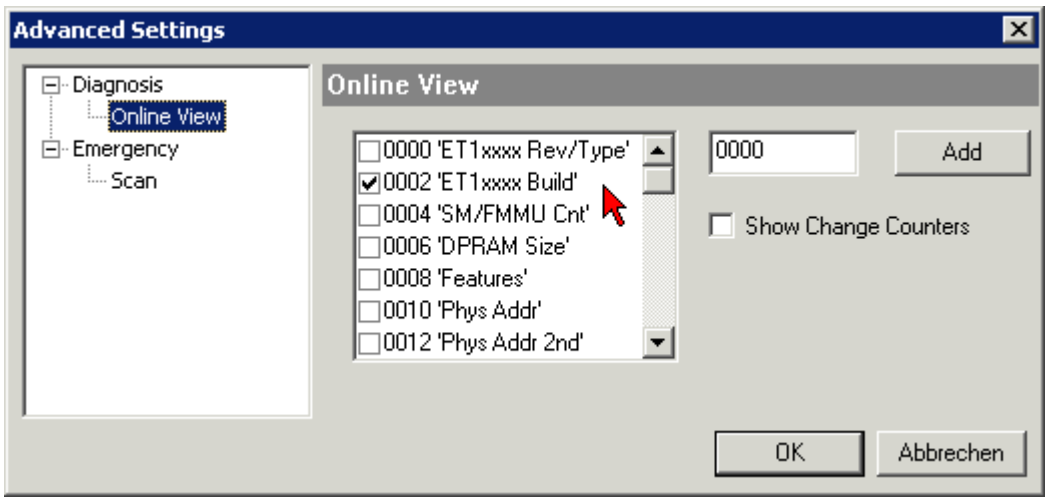


Fig. 51: Dialog *Advanced Settings*

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.

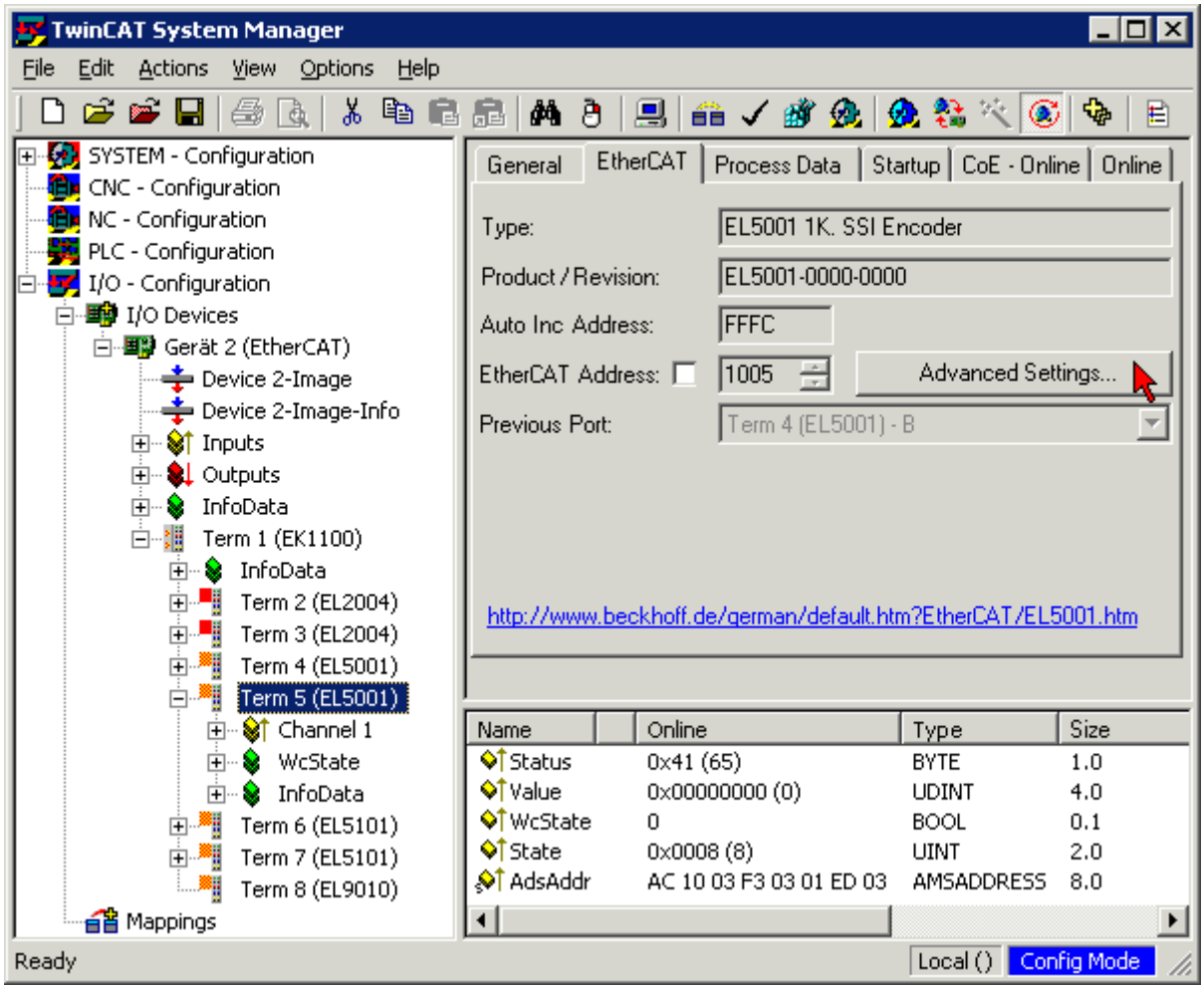
Older firmware versions can only be updated by the manufacturer!

Updating an EtherCAT device

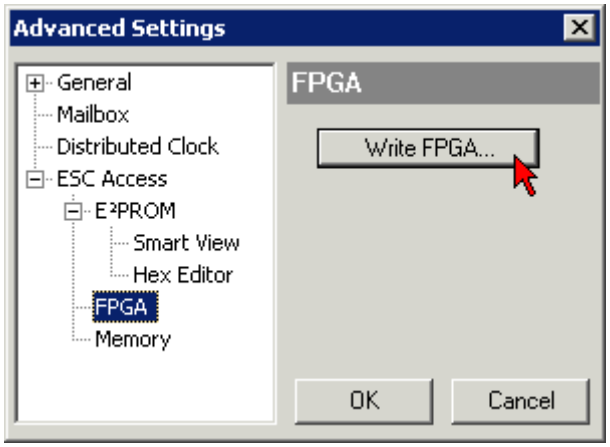
The following sequence order have to be met if no other specifications are given (e.g. by the Beckhoff support):

- 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.

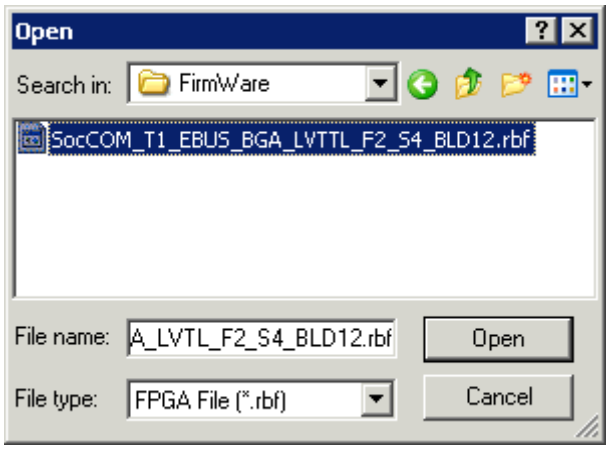
- In the TwinCAT System Manager select the terminal for which the FPGA firmware is to be updated (in the example: Terminal 5: EL5001) and
  click the *Advanced Settings* button in the *EtherCAT* tab:



- 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:



- 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

NOTE

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!

8.3.5 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.

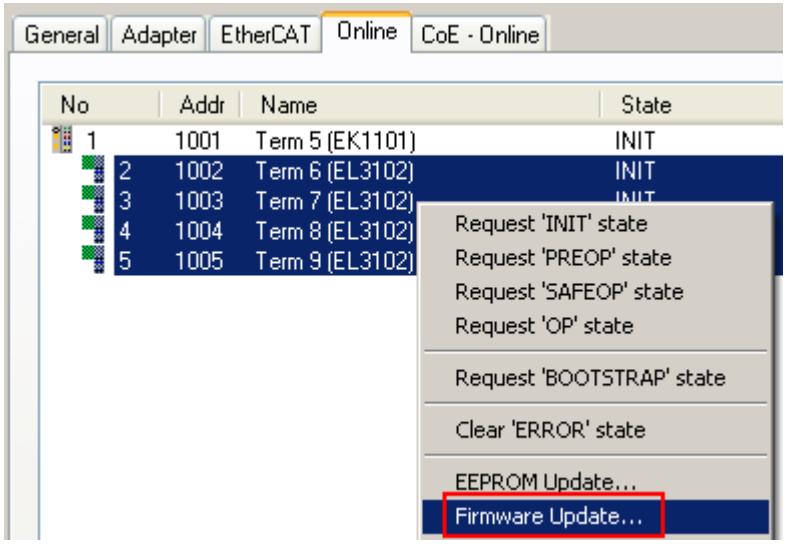


Fig. 52: Multiple selection and firmware update

Select the required slaves and carry out the firmware update in BOOTSTRAP mode as described above.

8.4 Support and Service

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

Beckhoff's branch offices and representatives

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

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

You will also find further documentation for Beckhoff components there.

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

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