BECKHOFF New Automation Technology

Documentation | EN

EK1322

2-port EtherCAT P junction with feed-in



2026-07-01 | Version: 1.3.0

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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.
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

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1.2 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

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

1.3 Documentation issue status

Version	Modifications
1.3.0	• Update chapter “Notes on the documentation” • Update chapter “Technical data” • Update structure
1.2.0	• Addenda chapter “Guide through documentation” • Update chapter “Version identification of EtherCAT devices” • Update chapter “Technical data” • Update chapter “Mounting and wiring” • Update chapter “EK1322 – Configuration by means of TwinCAT System Manager” • Update structure
1.1	• Addenda within „Firmware Update EL/ES/ELM/EM/EPxxxx" • Addenda within chapter „Version identification of EtherCAT devices“ of chapter „Beckhoff Identification Code (BIC)“ • Addenda within chapter „Support and Service“ (appendix) • Chapter „Safety instructions“ updated • Chapter „EtherCAT P cable conductor losses M8“ updated • Chapter „ATEX - Special conditions“ updated
1.0	• 1st public issue
0.1	• 1st version

1.4 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 • EtherCAT basics • Cable redundancy • Hot Connect • EtherCAT devices configuration
I/O Configuration in TwinCAT (PDF)	Quick start guide for EtherCAT Box Modules and EtherCAT P Box modules
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

1.5 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. *“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.

1.5.2 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 Version identification of IP67 modules

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

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

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

Syntax: D ww yy x y z u

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

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

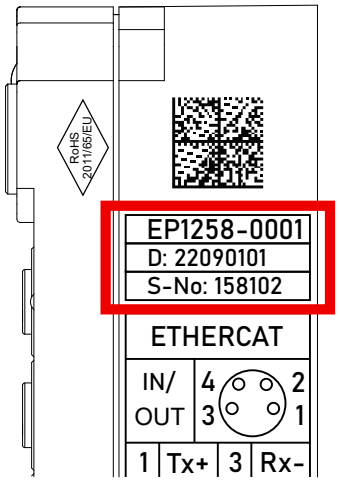


Fig. 2: EP1258-00001 IP67 EtherCAT Box with batch number/DateCode 22090101 and unique serial number 158102

1.5.4 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.

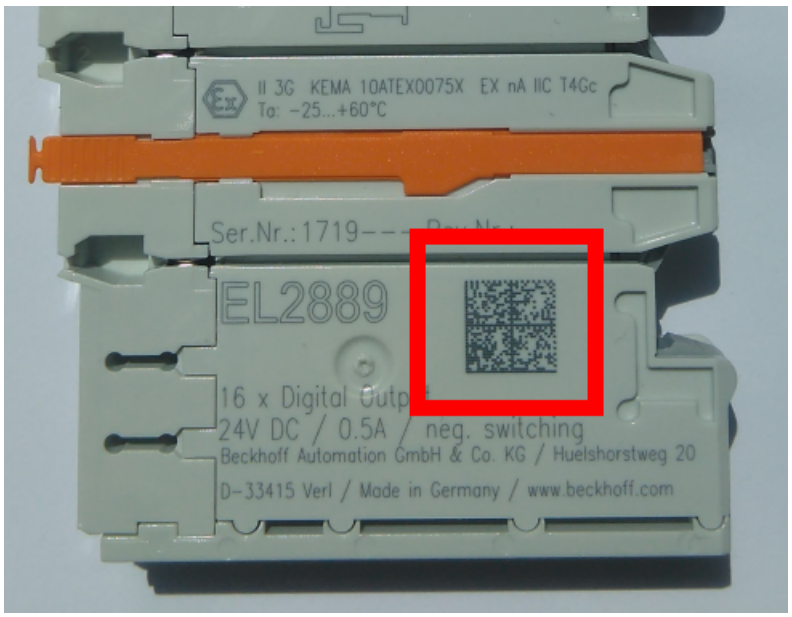


Fig. 3: BIC as data matrix code (DMC, code scheme ECC200)

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

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

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

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

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

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

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

Position	Type of information	Explanation	Data identifier	Number of digits incl. data identifier	Example
7	Variant number	Optional: Product variant number on the basis of standard products	30P	12	**30P**F971, 2*K183
...					

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

Structure of the BIC

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

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

Accordingly as DMC:



Fig. 4: Example DMC **1P**072222**SBTN**k4p562d7**1K**EL1809 **Q**1 **51S**678294

BTN

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

NOTICE

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

1.5.5 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.

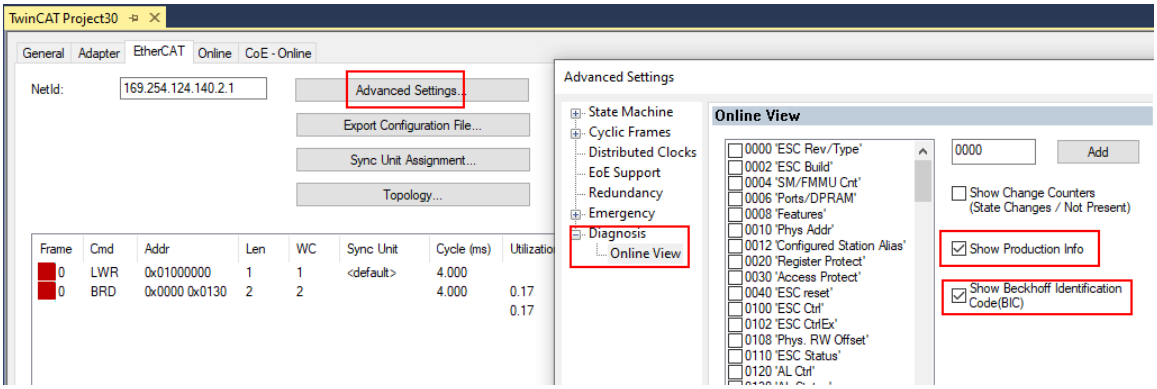
EtherCAT devices (IP20, IP67)

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.

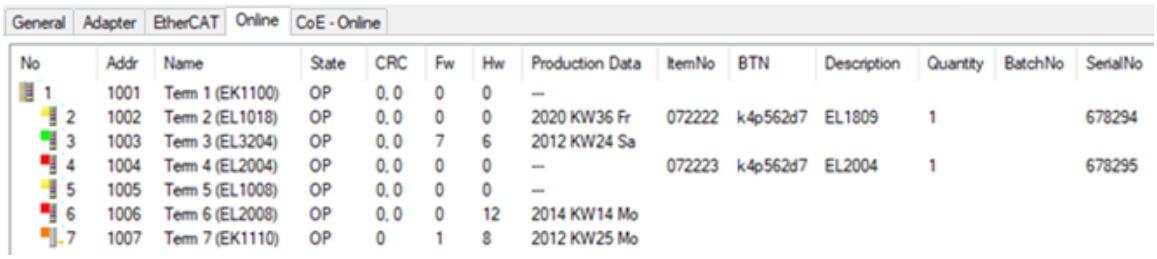
Beckhoff also stores the eBIC in the ESI-EEPROM. The eBIC was introduced into Beckhoff IO production (terminals, box modules) in 2020; as of 2023, implementation is largely complete.

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:

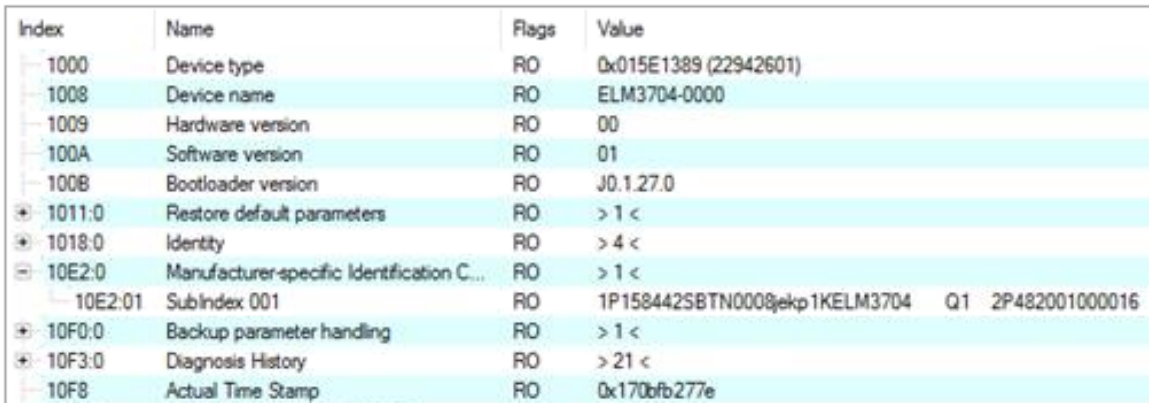


  - The BTN and its contents are then displayed:



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

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



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

  - The object 0x10E2 will be preferentially introduced into stock products in the course of necessary firmware revision.
  - From TwinCAT 3.1. build 4024.24, the functions *FB_EcCoEReadBIC* and *FB_EcCoEReadBTN* for reading into the PLC are available in the Tc2_EtherCAT library from v3.3.19.0
- The following auxiliary functions are available for processing the BIC/BTN data in the PLC in *Tc2_Utilities* as of TwinCAT 3.1 build 4024.24
  - F_SplitBIC: The function splits the Beckhoff Identification Code (BIC) sBICValue into its components using known identifiers and returns the recognized substrings in the ST_SplittedBIC structure as a return value
  - BIC_TO_BTN: The function extracts the BTN from the BIC and returns it as a return value
- Note: If there is further electronic processing, the BTN is to be handled as a string(8); the identifier "SBTN" is not part of the BTN.
- Technical background
  The new BIC information is written as an additional category in the ESI-EEPROM during device production. The structure of the ESI content is largely dictated by the ETG specifications, therefore the additional vendor-specific content is stored using a category in accordance with the ETG.2010. ID 03 tells all EtherCAT masters that they may not overwrite these data in the event of an update or restore the data after an ESI update.
  The structure follows the content of the BIC, see here. The EEPROM therefore requires approx. 50..200 bytes of memory.
- Special cases
  - If multiple hierarchically arranged ESCs are installed in a device, only the top-level ESC carries the eBIC information.
  - If multiple non-hierarchically arranged ESCs are installed in a device, all ESCs carry the eBIC information.
  - If the device consists of several sub-devices which each have their own identity, but only the top-level device is accessible via EtherCAT, the eBIC of the top-level device is located in the CoE object directory 0x10E2:01 and the eBICs of the sub-devices follow in 0x10E2:nn.

PROFIBUS, PROFINET, and DeviceNet® devices

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

2 Product description

2.1 Introduction

EK1322 | 2-port EtherCAT P junction with feed-in

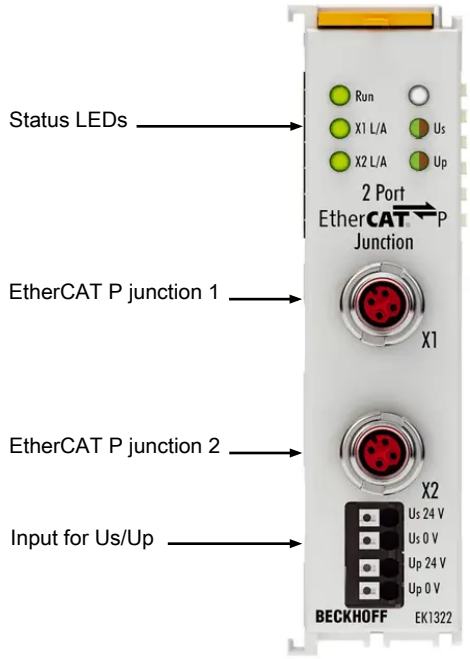


Fig. 5: EK1322

The 2-port EK1322 EtherCAT P junction enables configuration of EtherCAT P star topologies. The ports can be used to connect individual EtherCAT P devices or whole EtherCAT P strands.

The EK1322 can be installed at any point in an EtherCAT strand between the EtherCAT Terminals (ELxxxx).

The front terminal points are used for the system and sensor supply U_S and the peripheral voltage for actuators U_P for the EtherCAT P outputs.

In addition to the Run LED and the link and activity status of the respective port, two status LEDs indicate the state of the U_S and U_P voltages, as well as overload and short-circuit events.

2.2 EtherCAT P

EtherCAT P combines communication and power in a single 4-wire standard Ethernet cable. The 24 V DC supply of the EtherCAT P slaves and the connected sensors and actors is integrated within this bus system: U_S (system- and Sensor supply) and U_P (peripheral voltage for actors) are electrical isolated with 3 A current available for the connected components. All the benefits of EtherCAT, such as freedom in topology design, high speed, optimum bandwidth utilization, telegram processing on-the-fly, highly precise synchronization, extensive diagnostics functionality, etc. are all retained while integrating the voltages.

With EtherCAT P technology, the currents are coupled directly into the wires of the 100 Mbit line, enabling the realization of a highly cost-effective and compact connection. In order to rule out the possibility of incorrect connections to standard EtherCAT slaves and, thus possible defects, a new plug family has been specially developed for EtherCAT P. The plug family covers all applications from the 24 V I/O level up to drives with 400 V AC or 600 V DC and a current of up to 64 A.

EtherCAT P offers extensive savings potential:

- elimination of separate supply cables
- low wiring effort and significant time savings
- sources of error are reduced
- minimization of installation space for drag-chains and control cabinets
- smaller and tidier cable trays
- smaller sensors and actuators through the elimination of separate supply cables

As is typical with EtherCAT, the user benefits from the wide choice in topology and can combine line, star and tree architectures with one another in order to achieve the least expensive and best possible system layouts. Unlike the traditional Power over Ethernet (PoE), devices can also be cascaded using EtherCAT P and supplied with power from one power supply unit.

When designing a machine, the individual consumers, cable lengths and cable types are configured with tool assistance and this information is used to create the optimum layout of the EtherCAT P network. Since it is known what sensors and actuators will be connected and which ones will be operated simultaneously, the power consumption can be accounted for accordingly. For example, if two actuators never switch simultaneously from a logical point of view, they also never need the full load simultaneously. The result is further savings potential in terms of the required supplies and power supply units.

Also see about this

EtherCAT P introduction [▶ 24]

2.3 Technical data

Technical data	EK1322
Task in the EtherCAT system	coupling of EtherCAT P junctions
Data transfer medium	EtherCAT P cable, shielded, to 100BASE-TX EtherCAT P networks
Businterface	2 x M8 socket, shielded, screw type, EtherCAT P-coded
Power supply	external feed-in: 24 V DC (-15%/+20%) for U_S and U_P
Total current	max. 3 A each U_S and U_P for feed-in
Current consumption from U_S	typ. 3 mA
Current consumption from U_P	typ. 3 mA
Current rating per port	max. 3 A each U_S and U_P (note the total current, see chapter Commissioning [▶ 44])
Current consumption E-bus	typ. 200 mA
Electrical isolation	500 V (supply voltage U_S / supply voltage U_P / EtherCAT)
Dimensions (W x H x D)	approx. 24 mm x 100 mm x 62 mm
Weight	approx. 100 g
Permissible ambient temperature range during operation	-25 °C ... +55 °C
Permissible ambient temperature range during storage	-40 °C ... + 85 °C
Permissible relative humidity	95%, no condensation
Mounting	on 35 mm mounting rail conforms to EN 60715
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	variable
Approvals/markings*)	CE, UKCA, EAC, cULus [▶ 38]

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

2.4 Start

For commissioning:

- mount the EK1322 as described in the chapter Mounting and wiring [▶ 27]
- configure the EK1322 in TwinCAT as described in chapter Parameterization and commissioning [▶ 44].

3 Basics communication

3.1 System properties

Protocol

The EtherCAT protocol is optimized for process data and is transported directly within the Ethernet frame thanks to a special Ether-type. It may consist of several sub-telegrams, each serving a particular memory area of the logical process images that can be up to 4 gigabytes in size. The data sequence is independent of the physical order of the Ethernet terminals in the network; addressing can be in any order. Broadcast, Multicast and communication between slaves are possible. Transfer directly in the Ethernet frame is used in cases where EtherCAT components are operated in the same subnet as the control computer.

However, EtherCAT applications are not limited to a subnet: EtherCAT UDP packs the EtherCAT protocol into UDP/IP datagrams. This enables any control with Ethernet protocol stack to address EtherCAT systems. Even communication across routers into other subnets is possible. In this variant, system performance obviously depends on the real-time characteristics of the control and its Ethernet protocol implementation. The response times of the EtherCAT network itself are hardly restricted at all: the UDP datagram only has to be unpacked in the first station.

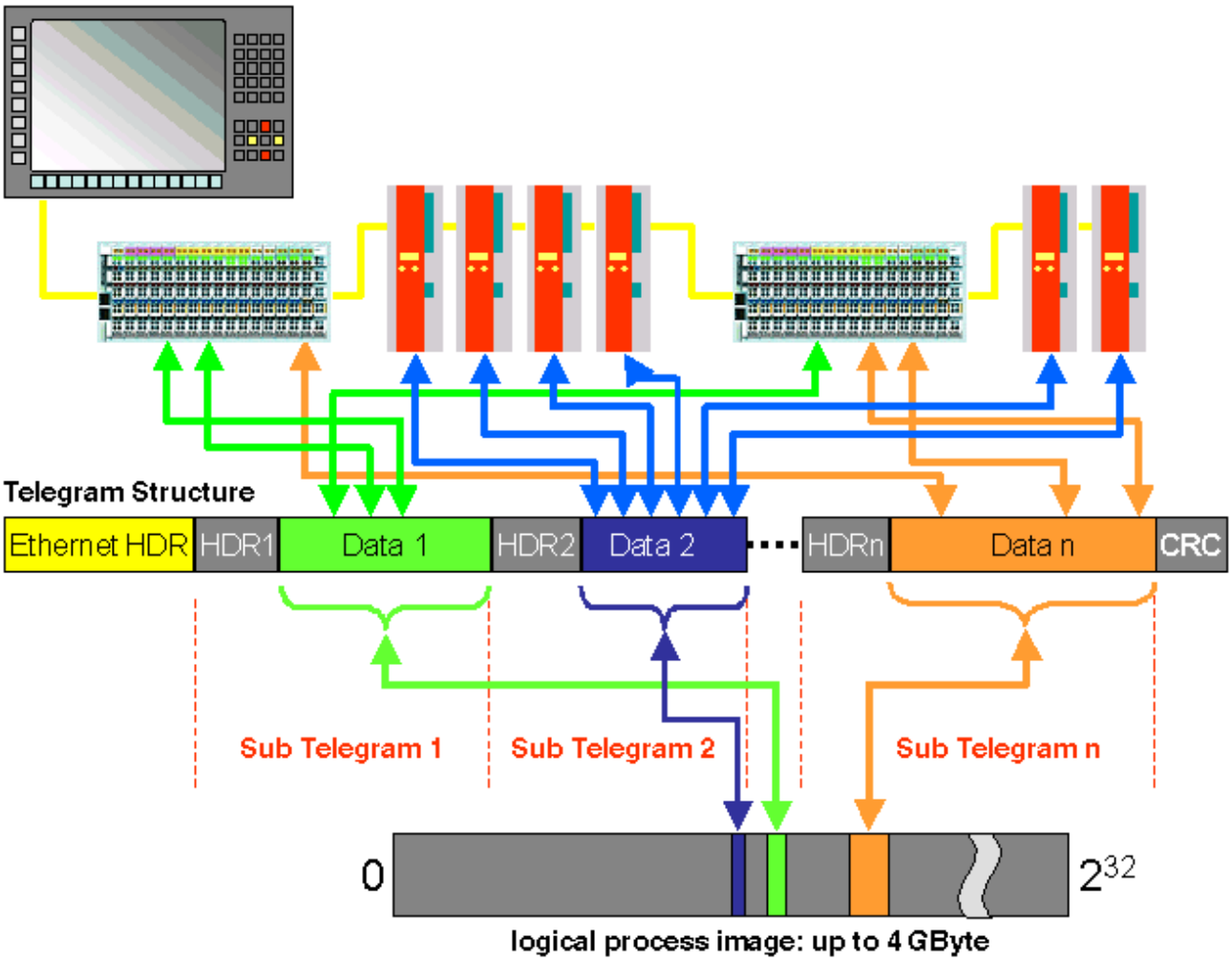


Fig. 6: EtherCAT Telegram Structure

Protocol structure: The process image allocation is freely configurable. Data are copied directly in the I/O terminal to the desired location within the process image: no additional mapping is required. The available logical address space is with very large (4 GB).

Topology

Line, tree or star: EtherCAT supports almost any topology. The bus or line structure known from the fieldbuses thus also becomes available for Ethernet. Particularly useful for system wiring is the combination of line and junctions or stubs. The required interfaces exist on the couplers; no additional switches are required. Naturally, the classic switch-based Ethernet star topology can also be used.

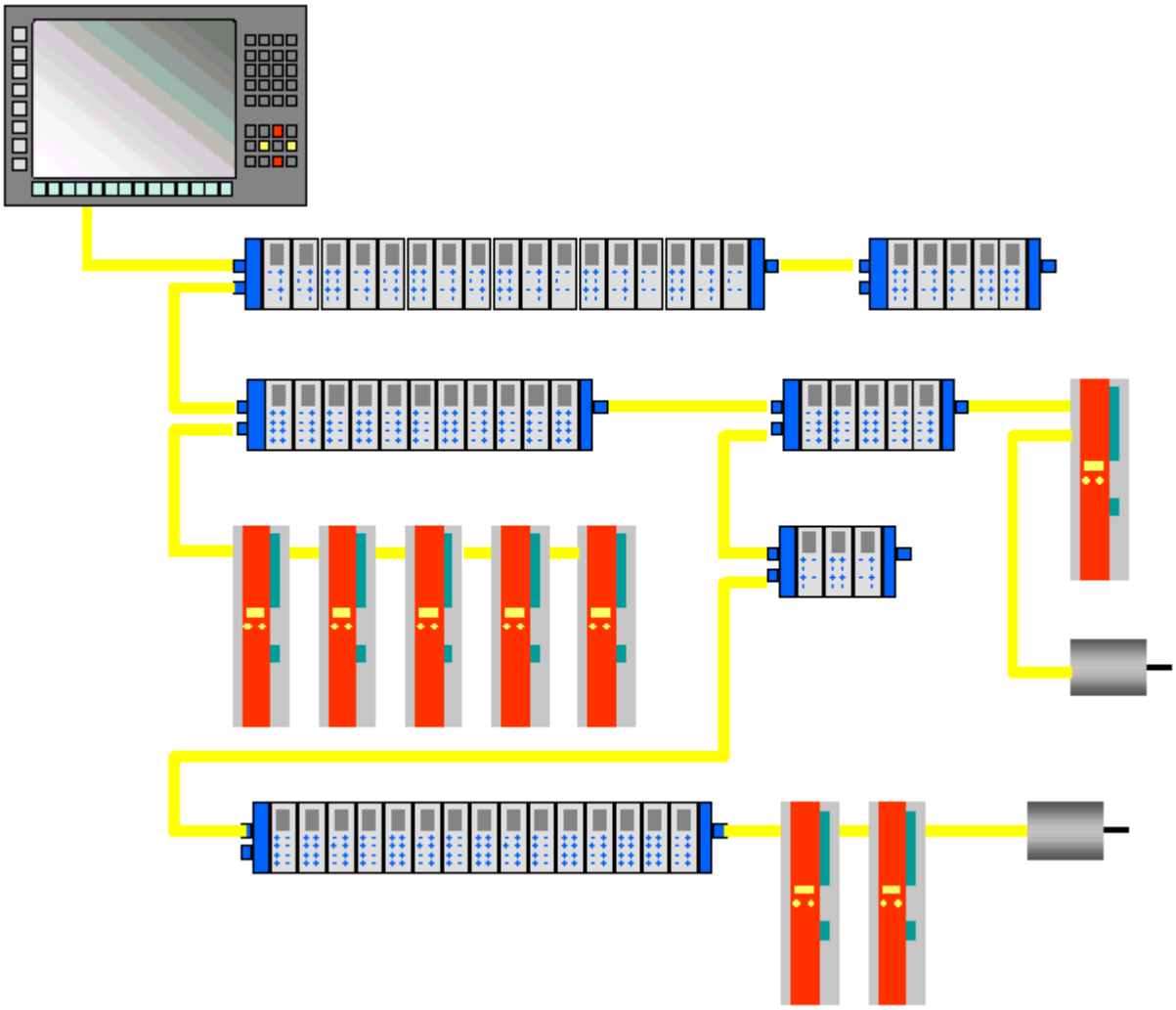


Fig. 7: EtherCAT Topology

Maximum wiring flexibility:
with or without switch, line or tree topologies, can be freely selected and combined.

Wiring flexibility is further maximized through the choice of different cables. Flexible and cost-effective standard Ethernet patch cables transfer the signals in Ethernet mode (100Base-TX). The complete bandwidth of the Ethernet network - such as different optical fibers and copper cables - can be used in combination with switches or media converters.

Distributed Clocks

Accurate synchronization is particularly important in cases where spatially distributed processes require simultaneous actions. This may be the case, for example, in applications where several servo axes carry out coordinated movements simultaneously.

The most powerful approach for synchronization is the accurate alignment of distributed clocks, as described in the new IEEE 1588 standard. In contrast to fully synchronous communication, where synchronization quality suffers immediately in the event of a communication fault, distributed aligned clocks have a high degree of tolerance vis-à-vis possible fault-related delays within the communication system.

With EtherCAT, the data exchange is fully based on a pure hardware machine. Since the communication utilizes a logical (and thanks to full-duplex Fast Ethernet also physical) ring structure, the mother clock can determine the run-time offset to the individual daughter clocks simply and accurately - and vice versa. The distributed clocks are adjusted based on this value, which means that a very precise network-wide timebase with a jitter of significantly less than 1 microsecond is available.

However, high-resolution distributed clocks are not only used for synchronization, but can also provide accurate information about the local timing of the data acquisition. For example, controls frequently calculate velocities from sequentially measured positions. Particularly with very short sampling times, even a small temporal jitter in the displacement measurement leads to large step changes in velocity. With EtherCAT new, extended data types are introduced as a logical extension (time stamp and oversampling data type). The local time is linked to the measured value with a resolution of up to 10 ns, which is made possible by the large bandwidth offered by Ethernet. The accuracy of a velocity calculation then no longer depends on the jitter of the communication system. It is orders of magnitude better than that of measuring techniques based on jitter-free communication.

Performance

EtherCAT reaches new dimensions in network performance. Protocol processing is purely hardware-based through an FMMU chip in the terminal and DMA access to the network card of the master. It is thus independent of protocol stack run-times, CPU performance and software implementation. The update time for 1000 I/Os is only 30 µs - including terminal cycle time. Up to 1486 bytes of process data can be exchanged with a single Ethernet frame - this is equivalent to almost 12000 digital inputs and outputs. The transfer of this data quantity only takes 300 µs.

The communication with 100 servo axes only takes 100 µs. During this time, all axes are provided with set values and control data and report their actual position and status. Distributed clocks enable the axes to be synchronized with a deviation of significantly less than 1 microsecond.

The extremely high performance of the EtherCAT technology enables control concepts that could not be realized with classic fieldbus systems. For example, the Ethernet system can now not only deal with velocity control, but also with the current control of distributed drives. The tremendous bandwidth enables status information to be transferred with each data item. With EtherCAT, a communication technology is available that matches the superior computing power of modern Industrial PCs. The bus system is no longer the bottleneck of the control concept. Distributed I/Os are recorded faster than is possible with most local I/O interfaces. The EtherCAT technology principle is scalable and not bound to the baud rate of 100 Mbaud – extension to Gbit Ethernet is possible.

Diagnostics

Experience with fieldbus systems shows that availability and commissioning times crucially depend on the diagnostic capability. Only faults that are detected quickly and accurately and which can be precisely located can be corrected quickly. Therefore, special attention was paid to exemplary diagnostic features during the development of EtherCAT.

During commissioning, the actual configuration of the I/O terminals should be checked for consistency with the specified configuration. The topology should also match the saved configuration. Due to the built-in topology recognition down to the individual terminals, this verification can not only take place during system start-up, automatic reading in of the network is also possible (configuration upload).

Bit faults during the transfer are reliably detected through evaluation of the CRC checksum: The 32 bit CRC polynomial has a minimum hamming distance of 4. Apart from breaking point detection and localization, the protocol, physical transfer behavior and topology of the EtherCAT system enable individual quality monitoring of each individual transmission segment. The automatic evaluation of the associated error counters enables precise localization of critical network sections. Gradual or changing sources of error such as EMC influences, defective push-in connectors or cable damage are detected and located, even if they do not yet overstrain the self-healing capacity of the network.

Integration of standard Bus Terminals from Beckhoff

In addition to the new Bus Terminals with E-Bus connection (ELxxxx), all Bus Terminals from the familiar standard range with K-bus connection (KLxxxx) can be connected via the BK1120 or BK1250 Bus Coupler. This ensures compatibility and continuity with the existing Beckhoff Bus Terminal systems. Existing investments are protected.

3.2 EtherCAT basics

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

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
- Operational
- Bootstrap

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

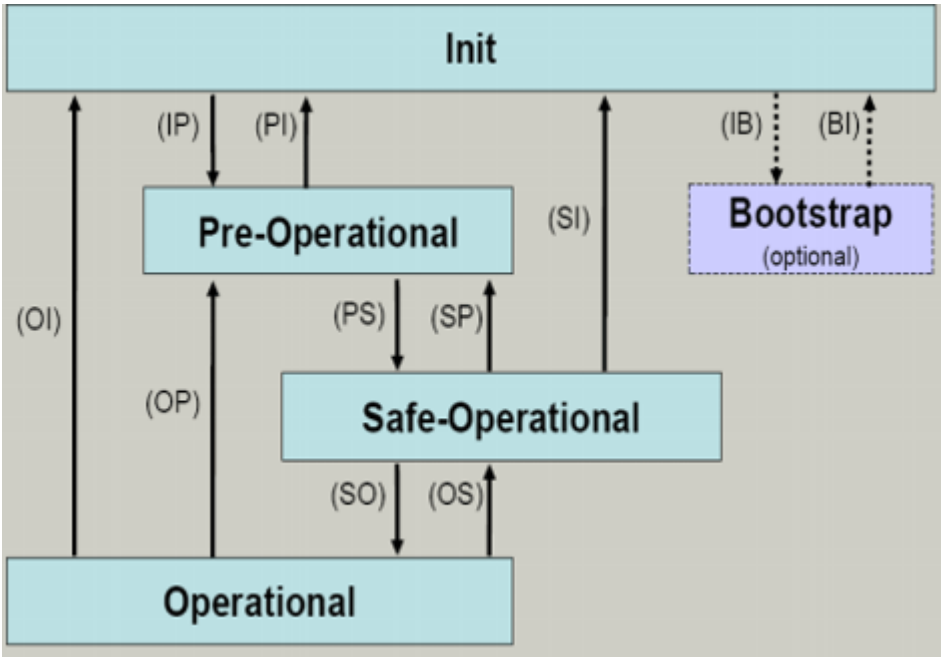


Fig. 8: States of the EtherCAT State Machine

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.

3.4 CoE - Interface: notes

This device has no CoE.

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

3.5 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.

3.6 EtherCAT P introduction

One cable solution for the field level

With EtherCAT P, Beckhoff combines communication and power in a single 4-wire standard Ethernet cable. The 24 V DC supply of the EtherCAT P slaves and of the connected sensors and actuators is integrated: U_S (system and sensor supply) and U_P (peripheral voltage for actuators) are electrically isolated from each other and can each supply a current of up to 3 A to the connected components. At the same time, all the benefits of EtherCAT, such as: Cascadable in all topologies (star, line, tree), telegram processing on-the-fly, high data transfer rate 100 Mbit/s full duplex, optimum bandwidth utilization, highly precise synchronization, extensive diagnostics functionality, etc., are all retained.

The currents of U_S and U_P are coupled directly into the wires of the 100 Mbit/s line, enabling the realization of a highly cost-effective and compact connection. EtherCAT P offers benefits both for connection of remote, smaller I/O stations in the terminal box and for decentralized I/O components locally in the process. The function principle of the one cable solution for the field is shown in the following figure.

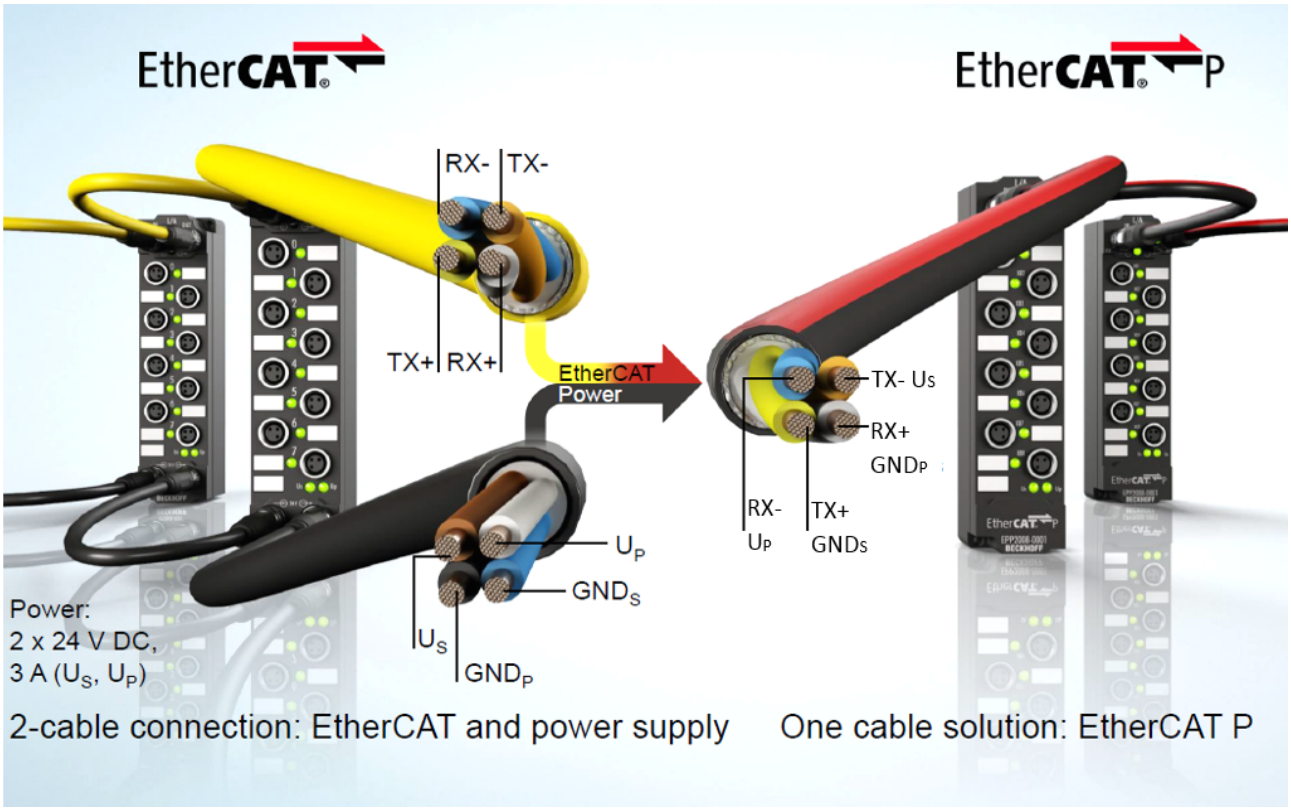


Fig. 9: From EtherCAT to EtherCAT P

The mechanical EtherCAT P coding (see figure below) was developed to prevent potential damage caused by incorrect connection with standard EtherCAT modules. The connector face consists of a centrally located T-piece and a nose and a triangle outside, also the 4 contacts are arranged symmetrically.

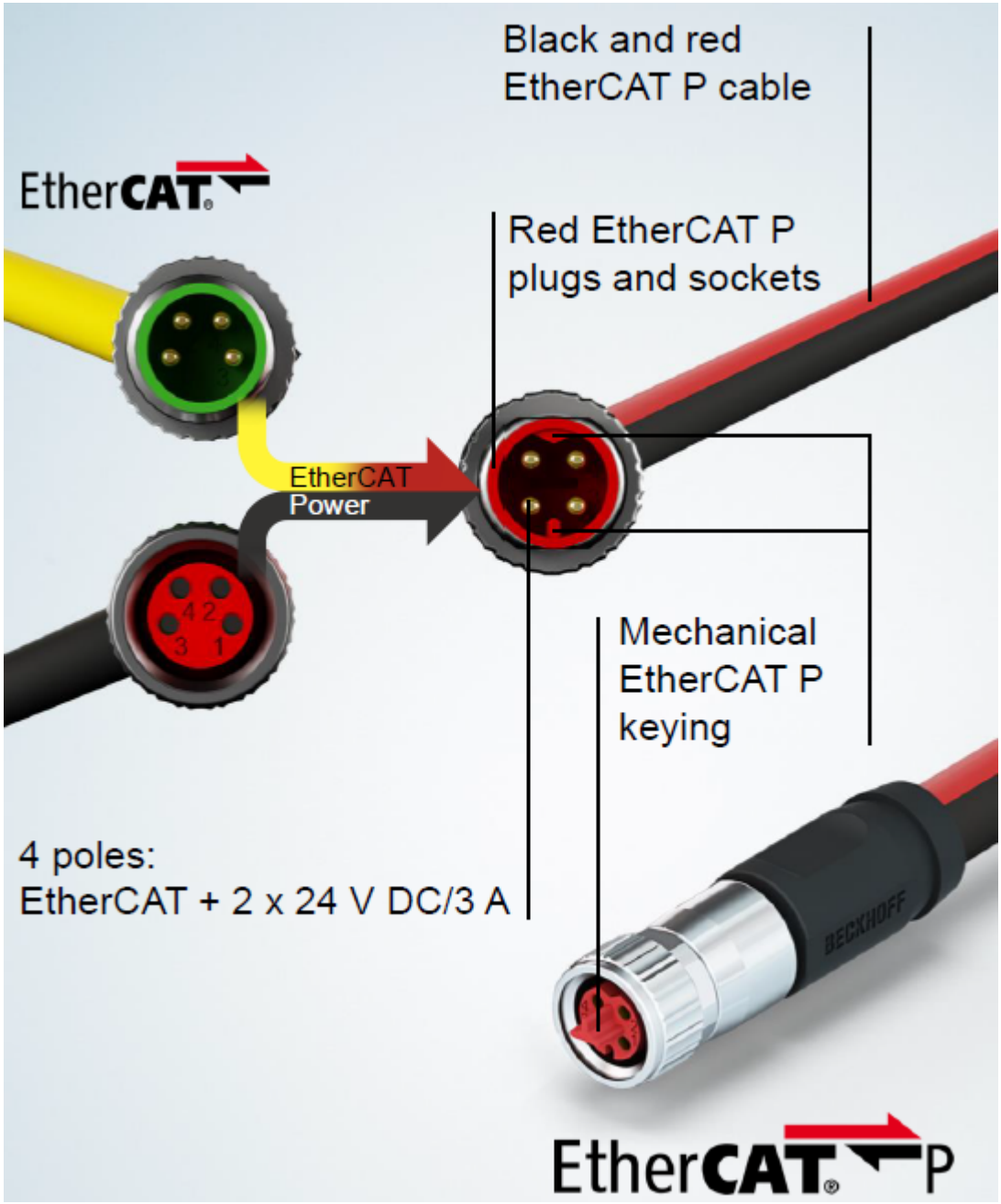


Fig. 10: Connector face: EtherCAT, Power and EtherCAT P

System overview

The system overview (see following figure) shows the free choice of topology with IP20 and IP67 products. Also the wide range of modules for different types of signals is significantly. EtherCAT P can directly supply the sensors/actuators. The sensors/actuators can be supplied directly with power via EtherCAT P.

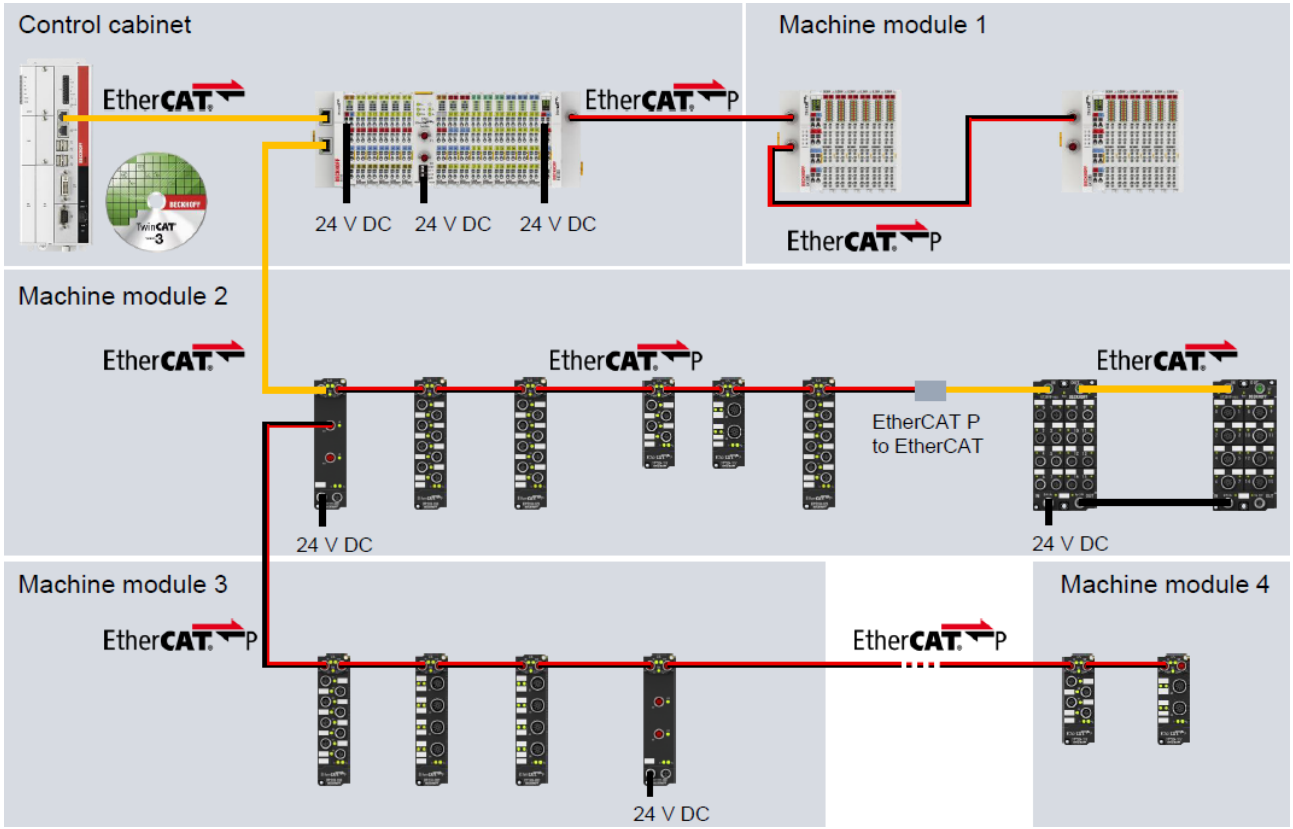


Fig. 11: EtherCAT P: System overview for IP20 and IP67

4 Mounting and wiring

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.

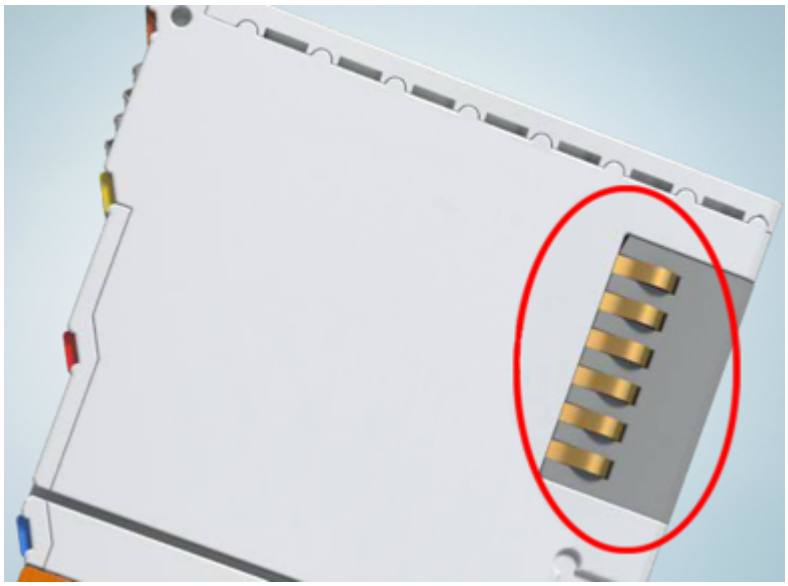


Fig. 12: Spring contacts of the Beckhoff I/O components

4.2 Mounting and demounting - top front unlocking

The terminal modules are fastened to the assembly surface with the aid of a 35 mm mounting rail (e. g. mounting rail TH 35-15).

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 recommended mounting rails under the terminals and couplers, you should use flat mounting connections (e.g. countersunk screws or blind rivets).

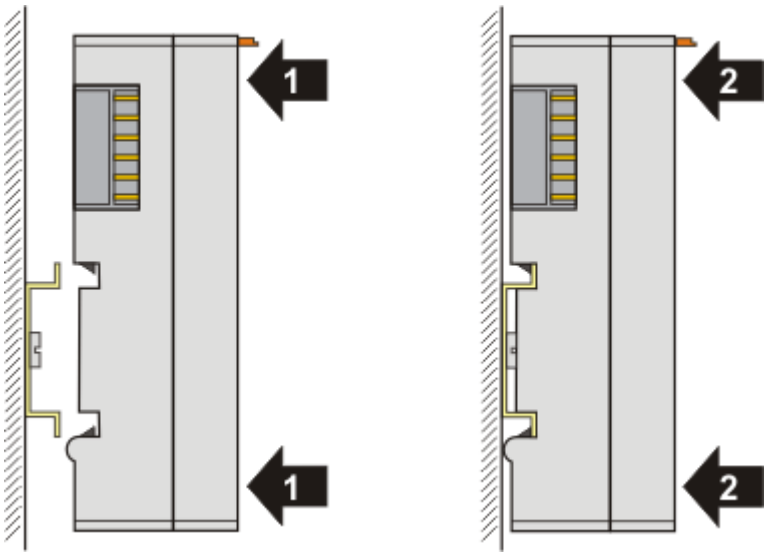
⚠ WARNING

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!

Mounting

- Fit the mounting rail to the planned assembly location.

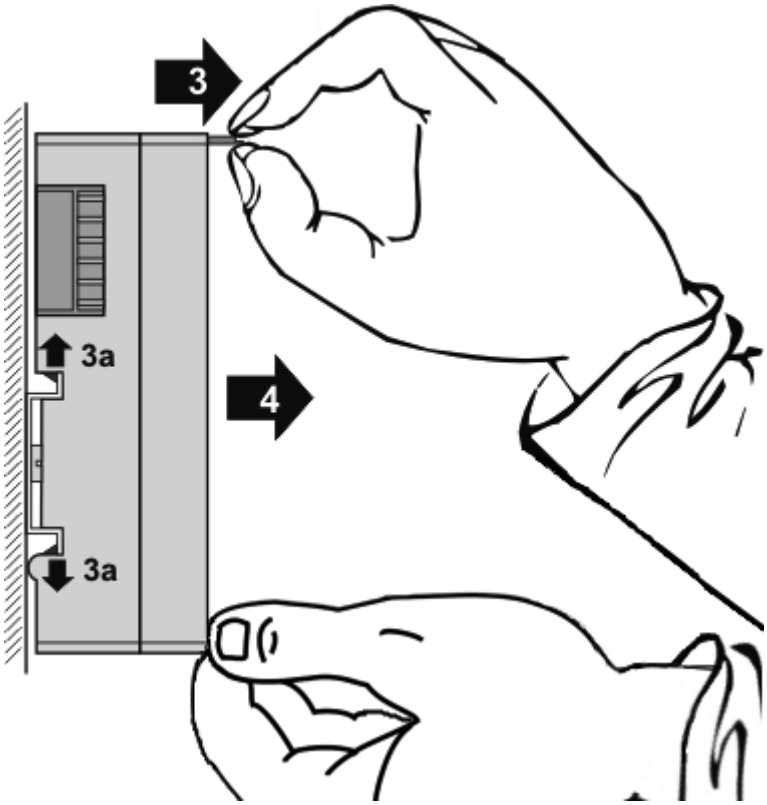


and press (1) the terminal module against the mounting rail until it latches in place on the mounting rail (2).

- Attach the cables.

Demounting

- Remove all the cables.
- Lever the unlatching hook back with thumb and forefinger (3). An internal mechanism pulls the two latching lugs (3a) from the top hat rail back into the terminal module.



- Pull (4) the terminal module away from the mounting surface.
  Avoid canting of the module; you should stabilize the module with the other hand, if required.

4.3 Installation positions

NOTICE

Constraints regarding installation position and operating temperature range

- Please refer to the technical data of the device to ascertain whether any restrictions regarding the installation position and/or the operating temperature range have been specified.
- When installing devices with increased heat dissipation, ensure that there is sufficient space above and below the devices during operation to guarantee adequate ventilation!

The installation positions and their names for mounting devices on mounting rails are specified below. The illustration of the devices in the following figures is an example.
The following applies to all installation positions: The reference direction "down" (see arrow) is the acceleration of gravity.

Horizontal installation (standard installation)

The mounting rail is mounted horizontally on a vertical mounting plate.
The connection level of the devices points to the front.

The devices are ventilated from below, which enables optimum cooling of the electronics through convection. This is therefore also the recommended installation position.

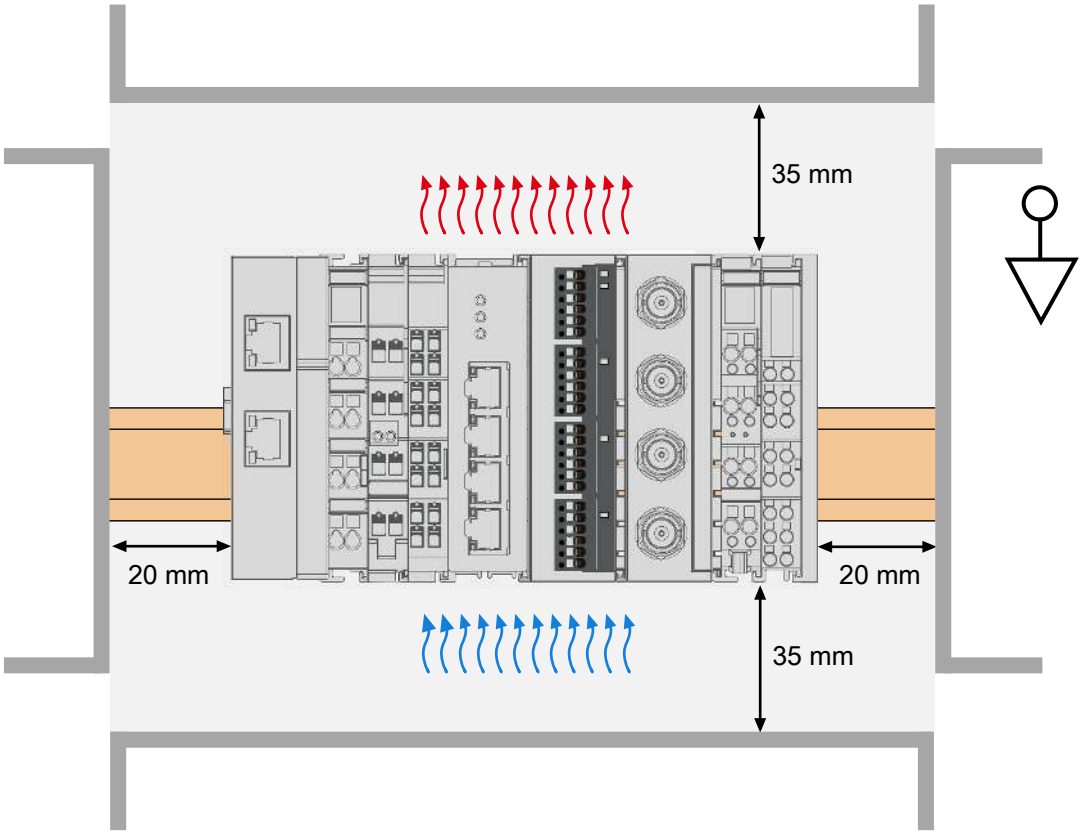


Fig. 13: Recommended minimum distances for standard installation position

NOTICE

Compliance with the minimum distances

Compliance with the minimum distances shown in the figure "Recommended minimum distances for standard installation position" is strongly recommended in all installation positions.

Vertical installation

The mounting rail is mounted vertically on a vertical mounting plate.
The connection level of the devices points to the front.
The devices can be arranged as follows:

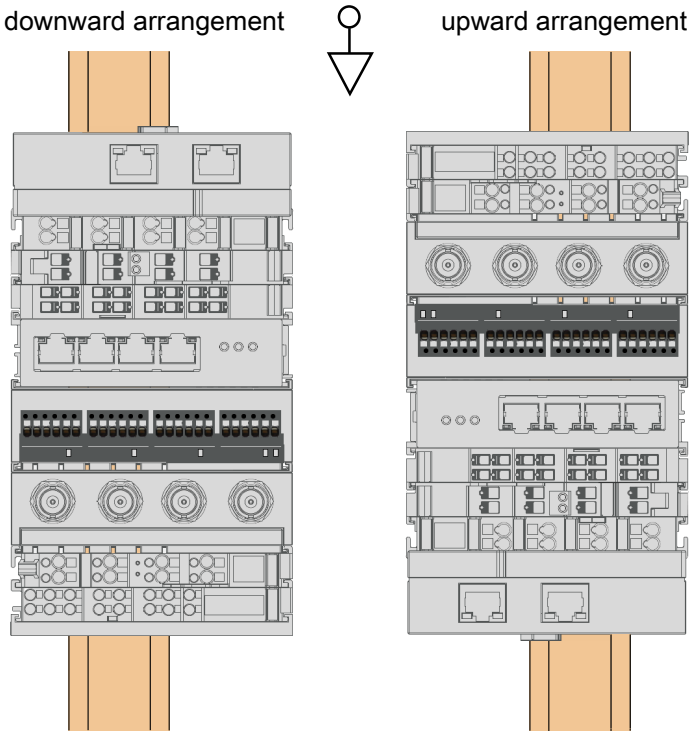


Fig. 14: Installation position Vertical, downward arrangement (left) / upward arrangement (right)

Flat installation

In the flat installation position, the mounting rail is laid on a horizontal mounting plate.
The connection level of the devices points upwards.

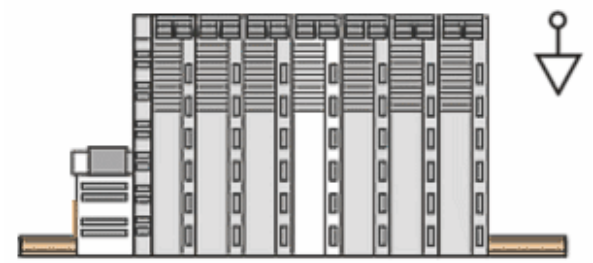


Fig. 15: Flat installation position

NOTICE

Danger of sliding off the mounting rail

Particularly in the "vertical" installation position, but also in other installation positions under corresponding mechanical load, the terminal segment may move on the mounting rail. These can lead to undesirable malfunctions.

- If this risk exists, secure the terminal segment with appropriate locking devices, e.g. by clamping it to the mounting rail.

NOTICE

Compliance with the minimum distances

Compliance with the minimum distances shown in the figure "Recommended minimum distances for standard installation position" is strongly recommended in all installation positions.

Installation positions with ZB8610 fan cartridge

If the cooling should or must be increased for the intended application, the ZB8610 fan cartridge can be mounted on the underside of the device. In the horizontal installation position, the devices are ventilated from bottom to top by the fan cartridge. The optimum cooling is further enhanced by convection ventilation (see following figure).

The fan cartridge can be used in any installation position.

Further information on operation with and without a fan can be found in the technical data for the device (e.g. derating, information on installation positions, etc.).

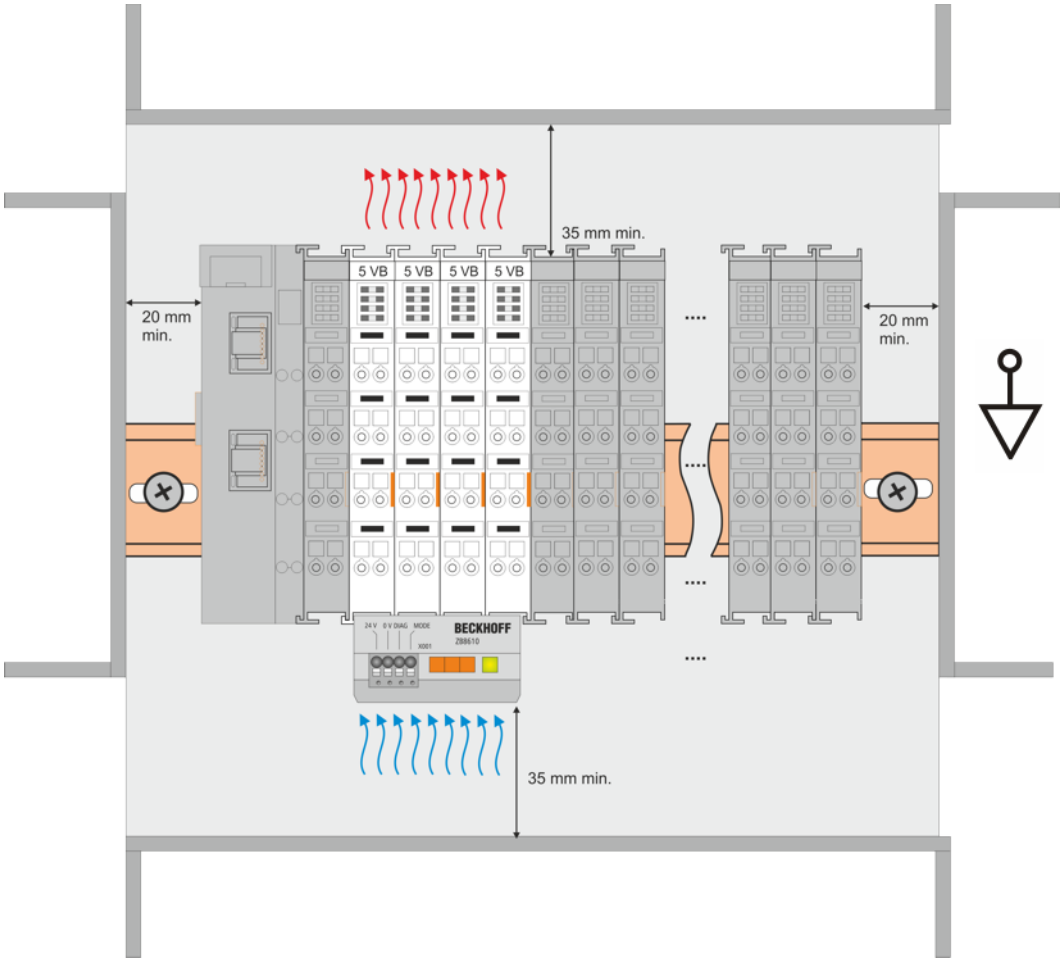


Fig. 16: Recommended minimum distances for operation with fan, using horizontal installation position as an example

NOTICE

Compliance with the minimum distances

Compliance with the minimum distances as shown in the figure "Recommended minimum distances for operation with fan" is strongly recommended.

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)

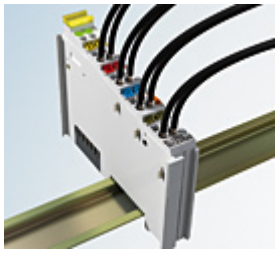


Fig. 17: Standard wiring

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

Pluggable wiring (ESxxxx / KSxxxx)

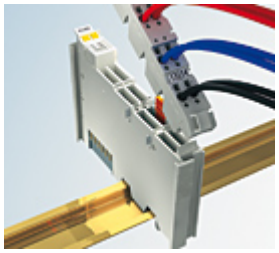


Fig. 18: Pluggable wiring

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. 19: High Density Terminals

The terminals from these series with 16/32 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 [▶ 36]!

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

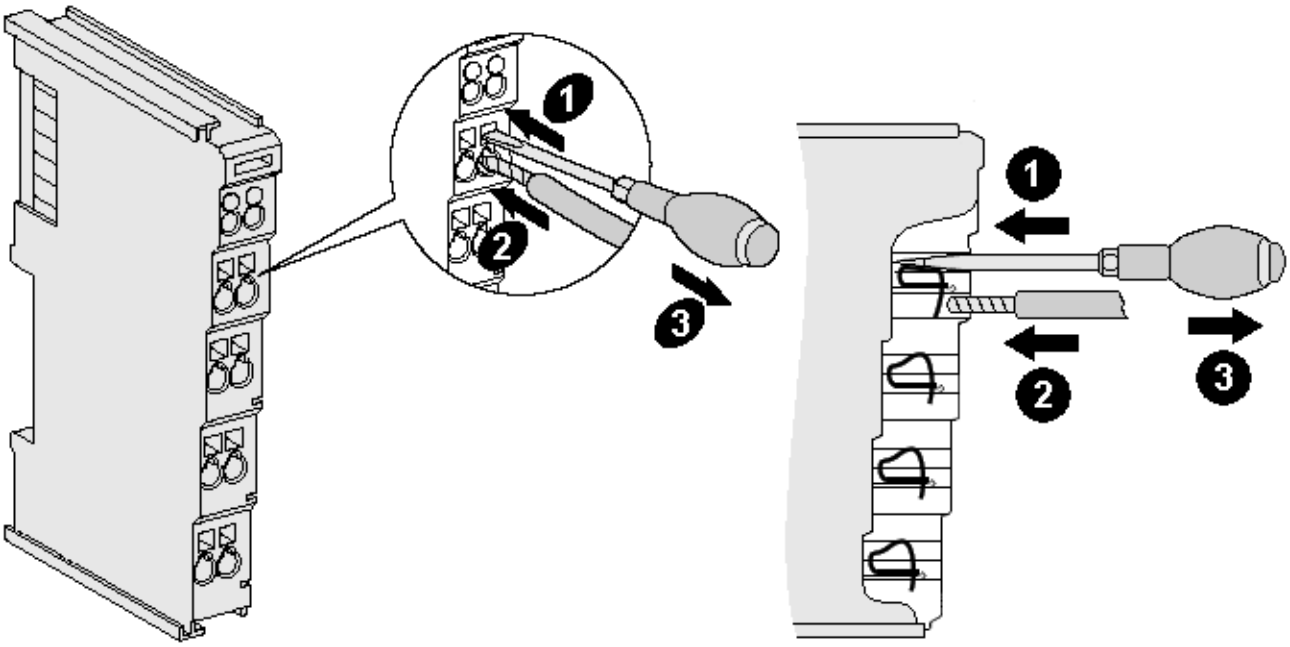


Fig. 20: Connecting a cable on a terminal point

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 mm²	0.08 ... 2.5 mm²
Wire size width (fine-wire conductors)	0.08 ... 2.5 mm²	0.08 ... 2.5 mm²
Wire size width (conductors with a wire end sleeve)	0.14 ... 1.5 mm²	0.14 ... 1.5 mm²
Wire stripping length	8 ... 9 mm	9 ... 10 mm

High Density Terminals (HD Terminals [▶ 34]) with 16/32 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 mm²
Wire size width (fine-wire conductors)	0.25 ... 1.5 mm²
Wire size width (conductors with a wire end sleeve)	0.14 ... 0.75 mm²
Wire size width (ultrasonically compacted [ultrasonically welded] strands)	only 1.5 mm² (see notice [▶ 34])
Wire stripping length	8 ... 9 mm

4.4.3 Shielding

Shielding

Encoder, analog 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 Positioning of passive Terminals

Hint for positioning of passive terminals in the bus terminal block

EtherCAT Terminals, 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)

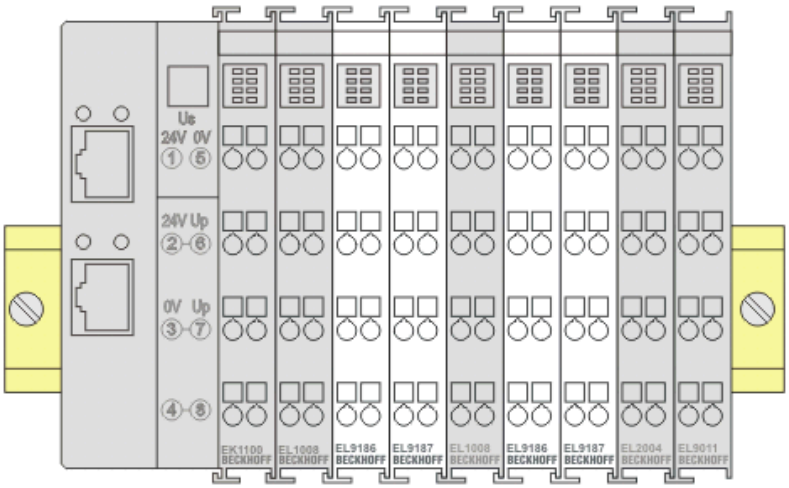


Fig. 21: Correct positioning

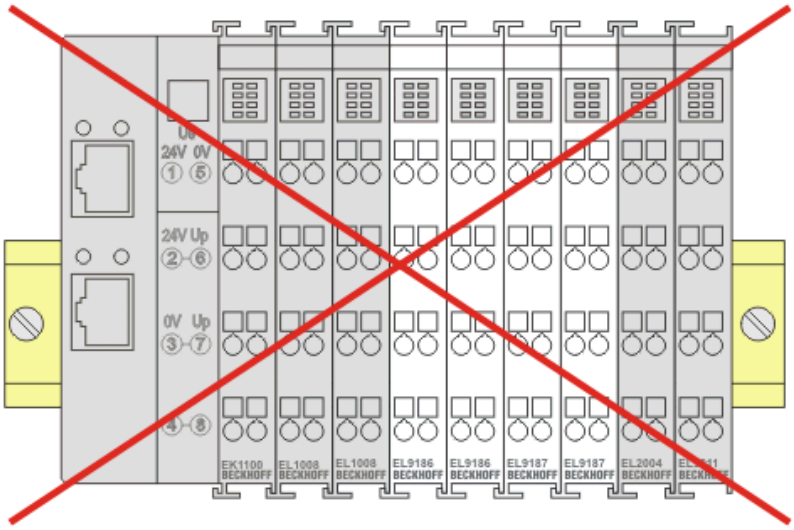


Fig. 22: Incorrect positioning

4.7 UL notice

⚠ 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.

Basic principles

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



4.8 Connection EK1322

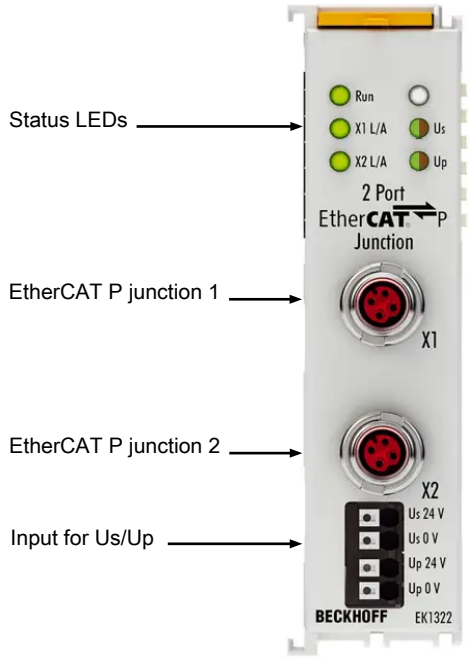


Fig. 23: EK1322 feed-in connections

Terminal point		Description
Name	No.	
U_S 24 V	1	+24 V Feed-In U_S (System- and Sensor supply)
U_S 0 V	2	0 V of System- and Sensor supply U_S
U_P 24 V	3	+24 V Feed-In U_P (Peripheral voltage for Actors)
U_P 0 V	4	0 V of Peripheral voltage for Actors U_P

Permitted conductor cross-sections of the terminal points for input U_S/U_P

The permitted conductor cross-sections and the strip length are shown in the following table.

Terminal points, clamping range	0.13 ... 1.5 mm²
Wire cross-section (AWG)	28 – 14
Solid wire H05(07) V-U	0.2 ... 1.5 mm²
Stranded wire H05(07) V-K	0.2 ... 1.5 mm²
Stranded wire (with ferrule with collar DIN46 228/4)	0.25 ... 0.75 mm²
Stranded wire (with ferrule DIN 46 228/1)	0.25 ... 1.5 mm²
Strip length	approx. 8 ... 9 mm

4.9 EtherCAT P connection

NOTICE

Risk of damage to the device!

Bring the EtherCAT/EtherCAT P system into a safe, powered down state before starting installation, disassembly or wiring of the modules!

The feeding and forwarding of EtherCAT P is done via two EtherCAT P-coded M8 connectors at the top of the modules:

- IN: left M8 connector with EtherCAT P-coding for feeding EtherCAT P
- OUT: right M8 connector with EtherCAT P for forwarding the supply voltages



Fig. 24: EtherCAT P-Box, Connectors for EtherCAT P



Fig. 25: Pin assignment M8, EtherCAT P In and EtherCAT P Out

The pins M8 connectors carry a maximum current of 3 A.

Two LEDs display the status of the supply voltages.

Control voltage U_S 24 V_{DC}

Power is supplied to the fieldbus, the processor logic, the inputs and the sensors from the 24 V_{DC} control voltage U_S.

Auxiliary voltage Up 24 V_{DC}

The Auxiliary voltage U_P supplies the digital outputs; it can be brought in separately. If the load voltage is switched off, the fieldbus functions and the power supply and functionality of the inputs are retained.

NOTICE

Pay attention to the maximum permissible current!

Pay attention also for the redirection of EtherCAT P, the maximum permissible current for M8 connectors of 3 A must not be exceeded!

4.10 Nut torque for connectors



Fig. 26: M8 EtherCAT P connector

For mounting of the M8 EtherCAT P connector the following have to be noticed:

M8 connectors

It is recommended to pull the M8 connectors tight with a nut torque of **0.4 Nm**. When using the torque control screwdriver ZB8800 is also a max. torque of **0.5 Nm** permissible.



Fig. 27: EtherCAT Box with M8 connectors

4.11 EtherCAT P cable conductor losses M8

When using ZK700x-xxxx-0xxx EtherCAT P cables it must be ensured that the voltage at the last device is not less than the minimum rated voltage of 20.4 V according to the standard. Variations in the output voltage from the power supply unit must also be taken into account. This ensures that the connected consumers, sensors and actuators are operated within the permitted voltage range.

The voltage calculation tool [▶ 46] integrated in TwinCAT can be used for the offline calculation of the cable lengths.

The EPP9022-0060 box with diagnostics can be used for checking during operation.

Conductor losses on the EtherCAT P cables

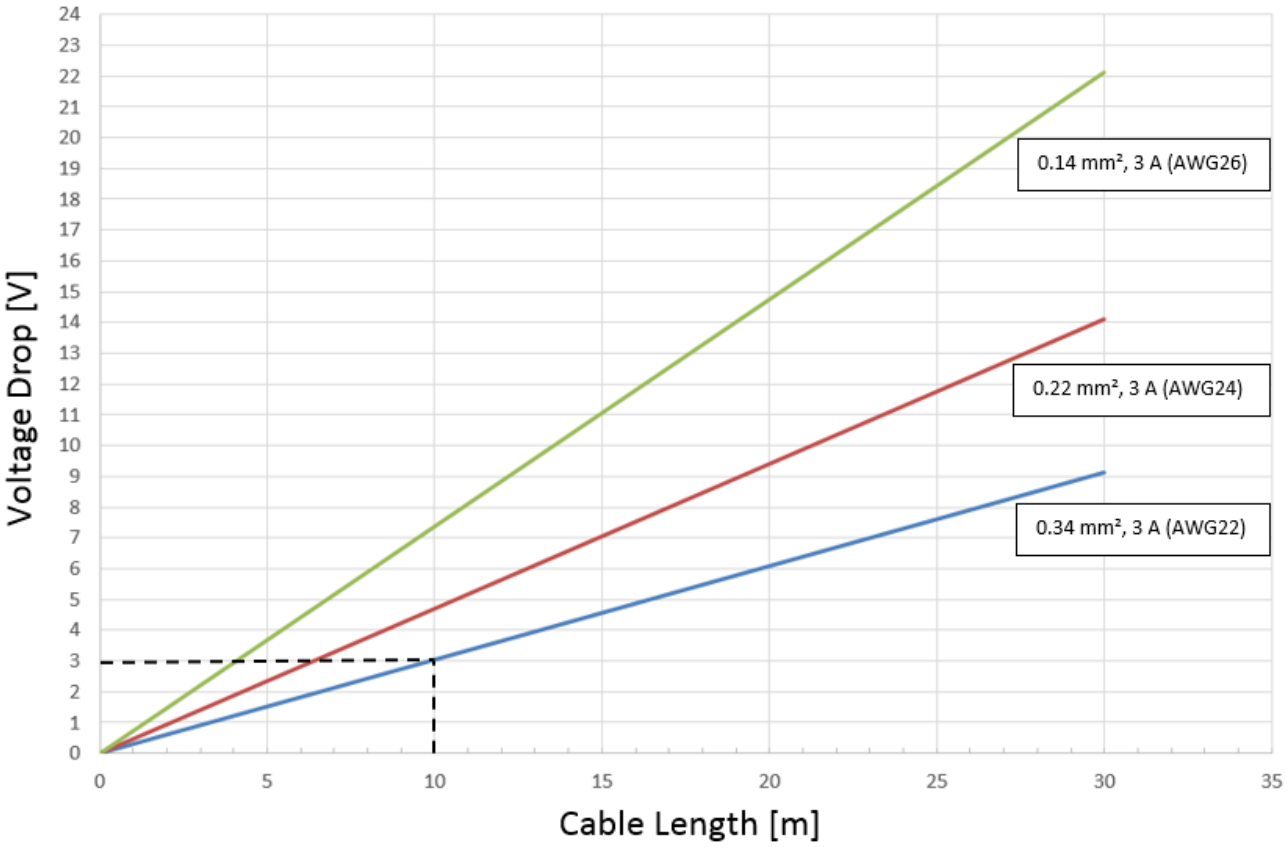


Fig. 28: Conductor losses on the EtherCAT P cables

Example

A 10 meter-long EtherCAT P cable with a cross section of 0.34 mm² has a voltage drop of ~3.0 V with a load of 3 A.

4.12 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

Note the total current of the device

The max. permissible total current applies to both ports X1 and X2 together.
I.e. the feed in of U_S as for U_P the max. permissible current of 3 A must not be exceeded (e.g. current of U_S for port X1 is 1.7 A; then the max. permissible current of U_S for port X2 is equal or less than 1.3 A).

5.1 EK1322 - Configuration by means of the TwinCAT System Manager

TwinCAT tree

Enter the EK1322 EtherCAT P extension as an EtherCAT device in the TwinCAT System Manager in Config mode under Devices. Any Terminals already connected to the network can also be read. This will cause all the Bus Couplers with Bus Terminals and their configurations to be loaded. You can then adapt these to meet your requirements.

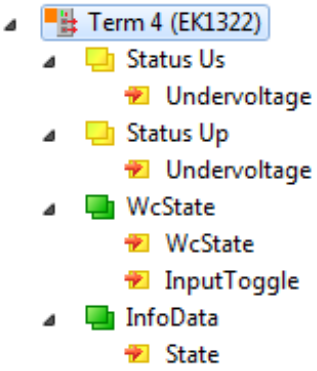
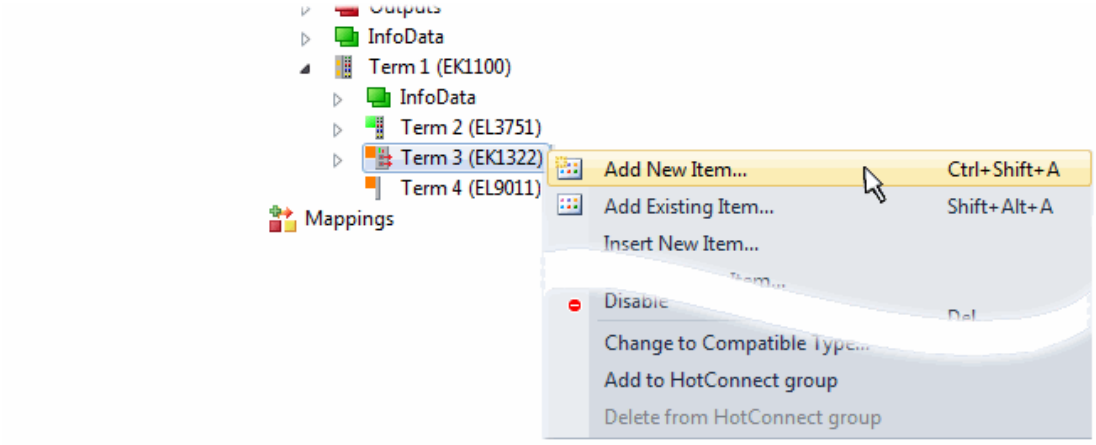


Fig. 29: TwinCAT tree EK1322

Meaning of the PDO identifier

PDO identifier	Typ	State	Description
Status U_P (Undervoltage)	Bit	0	Peripheral voltage for Actors U_P >= 19.4 V, no overload/ no case of short circuit
		1	Peripheral voltage for Actors U_P < 19.4 V or overload/ case of short circuit (output current > 3 A)
Status U_S (Undervoltage)	Bit	0	System- and Sensor supply U_S >= 19.4 V, no overload/ no case of short circuit
		1	System- and Sensor supply U_S < 19.4 V or overload/ case of short circuit (output current > 3 A)
WcState	Bit	0/1	Each datagram of the device indicates its processing state here. This allows monitoring for correct process data communication.
InputToggle	Bit	0/1	Toggles whenever new valid EtherCAT telegram was received
State	UINT	-	Status display of the “EtherCAT state machine” (see State, Online tab [▶ 50])

To add an EtherCAT P device to one of the two ports of the junction, right - click on the device in the Tree in the subsequently opened context menu "Add New Item...":



In the window that opens therefore, the component to be inserted and the respective port (X1 or X2) on the right side can be selected:

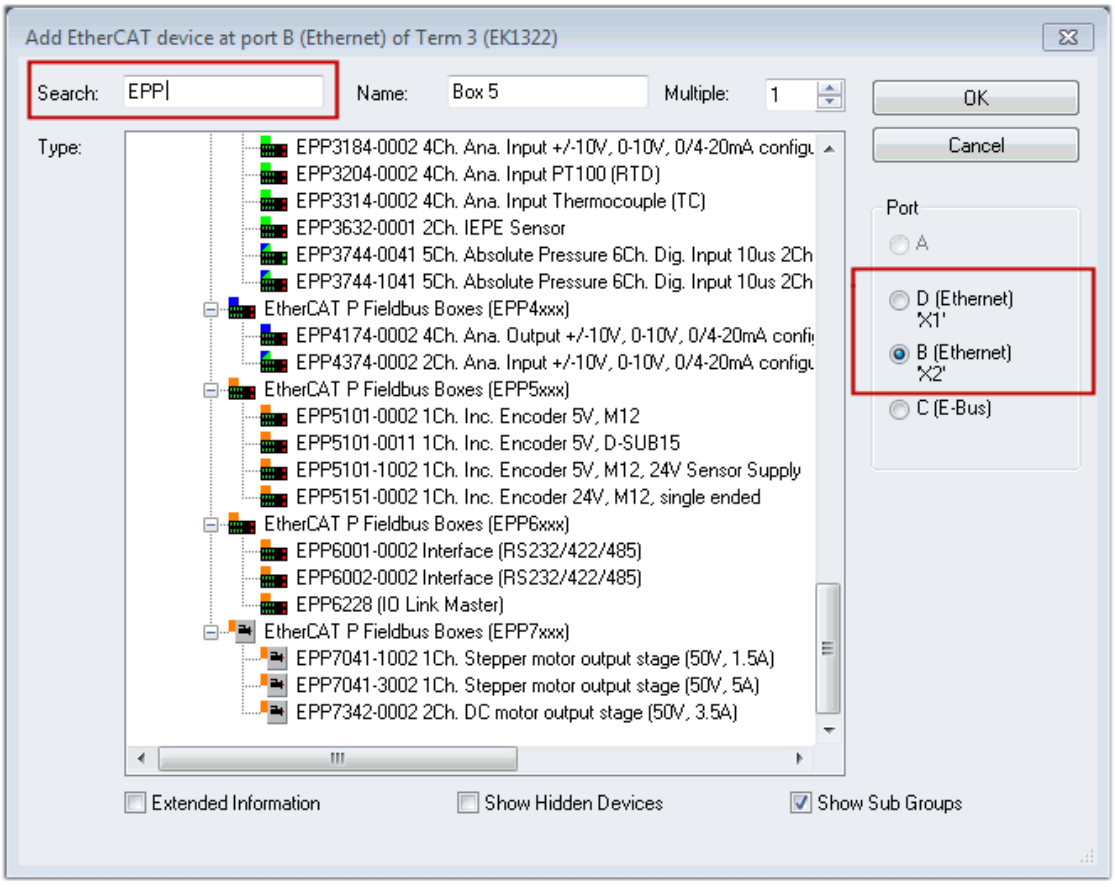


Fig. 30: Add an EtherCAT P device to EK1322 in the TwinCAT tree

EtherCAT P tab

From TwinCAT 3 Build 4020 TwinCAT has the tab „EtherCAT P“. This tab contains a planning tool to calculate voltages, currents and cable lengths of EtherCAT P system. The figure below shows the tab EtherCAT P when no device is connected to the junction device (A).

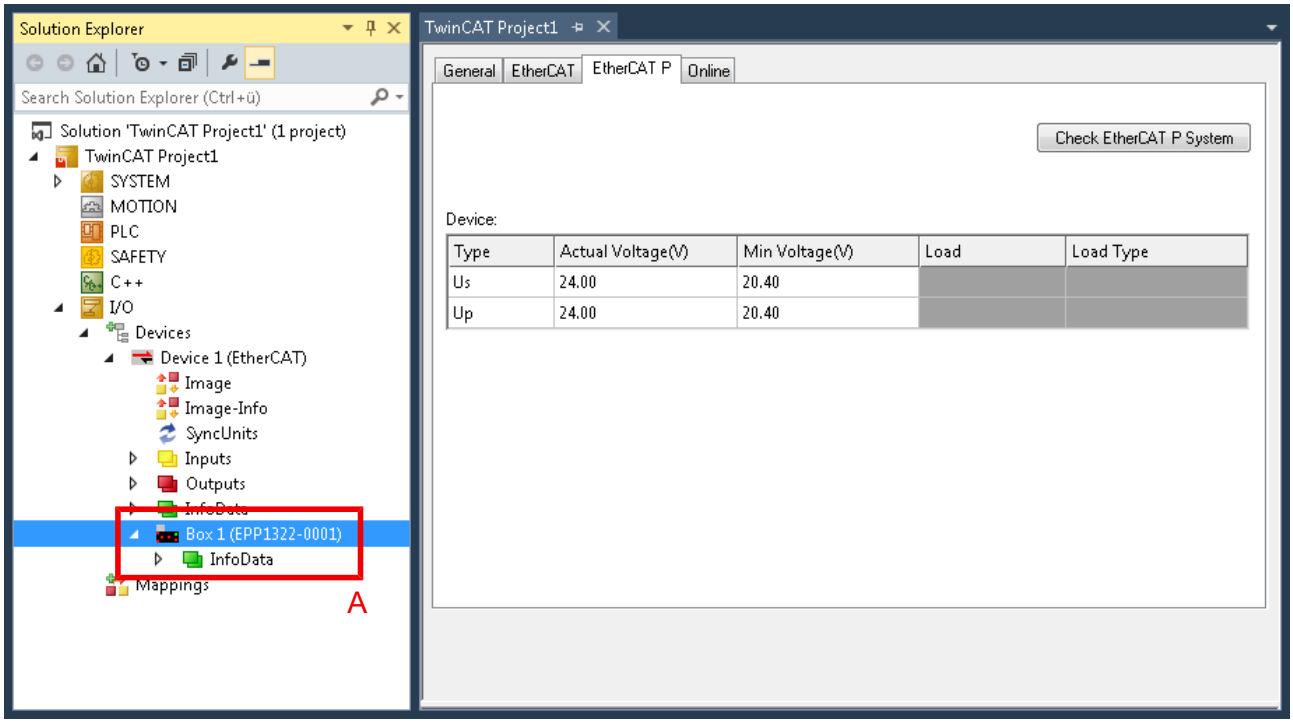


Fig. 31: Tab EtherCAT P: No device connected to junction device

If a device is connected to the junction device (A), you can set the cross-section and the length of the EtherCAT P cable in the tab “EtherCAT P“ of the device. See figure below, B).

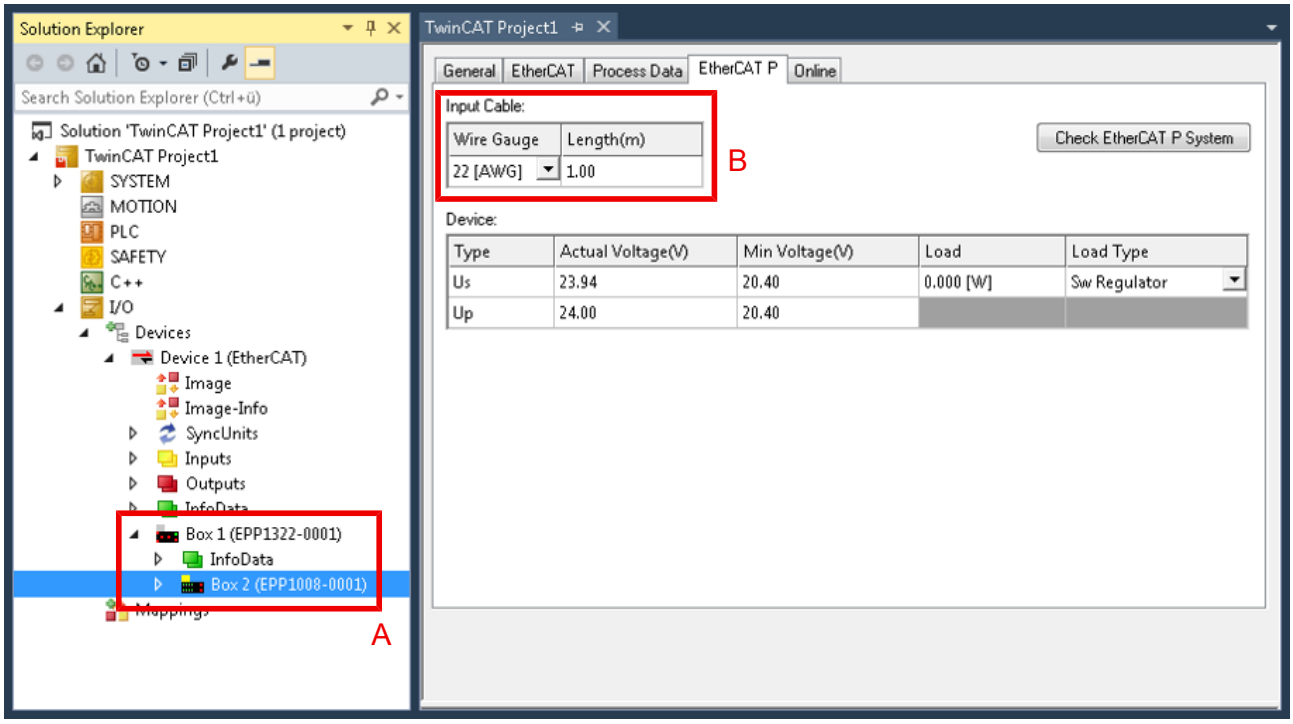


Fig. 32: Tab EtherCAT P: One device connected to junction device

Are three devices connected to the three ports of the junction device (A), they are displayed as shown in the figure below.

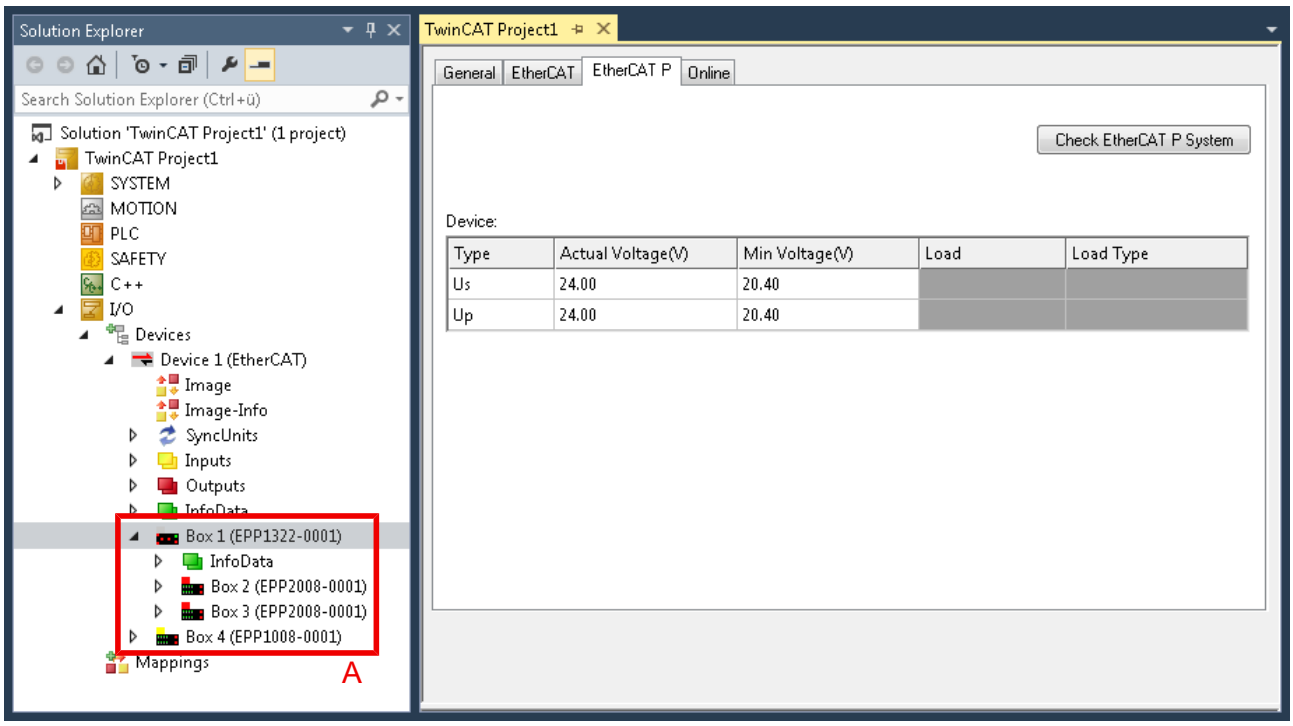


Fig. 33: Tab EtherCAT P: Three devices connected to junction device

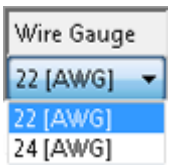
You can display the topology of your EtherCAT P system [▶ 51].

Wire Gauge

Selection of the wire cross-sectional area of the cable which is to be used

AWG 22 = 0.34 mm²

AWG 24 = 0.22 mm²



Length (m)

Indication of the cable length which is to be used

Check EtherCAT P System

At least one device is connected to the controller, the connected EtherCAT P system can be checked

Type

Listing of two voltages: Box supply U_S, Auxiliary voltage U_P

Actual Voltage (V)

The respective voltage at which the system is powered, can be entered manually. The default setting is 24.00 V.

Min Voltage (V)

The minimum voltage is preset by the device and described in the ESI file. The EtherCAT P system is to be interpreted after this voltage. It is valid not to fall short this voltage.

Load (A)

The total consumption of the connected sensors / actuators at the device can be specified here, e.g. 100 mA.

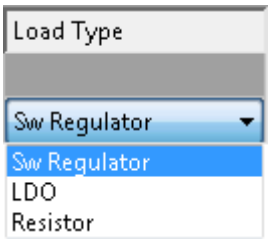
Load Type

The characteristic of the load which is connected to the devices can be selected here. Which of the three options is right for the connected load (Sw regulator, LDO, Resistor), must be taken from the datasheet. In case of doubt please select the default value "Sw Regulator".

Sw Regulator: Switching regulators, consume more energy and therefore require an efficient power supply.

LDO: Low drop voltage regulator, the energy demand is often small and the heat dissipation is not a problem, e.g. proximity sensor.

Resistor: electronic, passive components e.g. relay, coil



If you click on the button “Check EtherCAT P System”, all devices that are attached to your TwinCAT tree are listed as shown in the following figure.

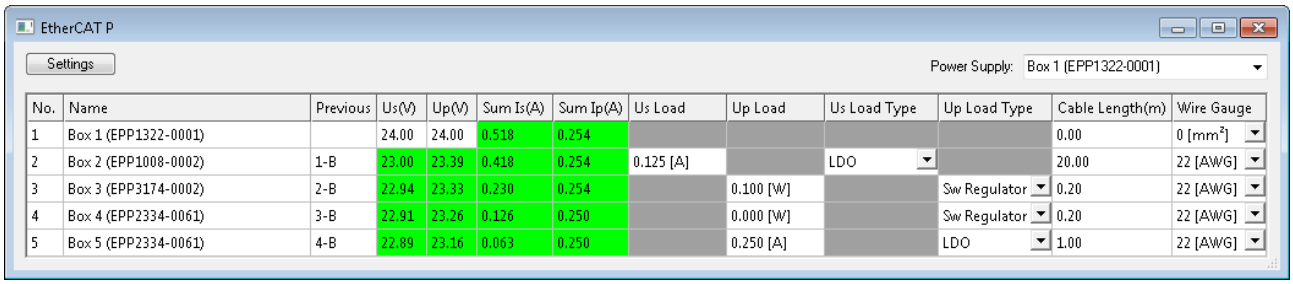


Fig. 34: Check EtherCAT P System

No. The automatically assigned number of the device according to its position in the EtherCAT P strand.

Name Designation of the device in TwinCAT.

Previous Number of the previous device in the EtherCAT P strand and the output port used (A/B/C/D).

Us (V), Up (V) Supply voltage which is present at the input of the device. For device No. 1 You can enter the voltages manually.

Sum Is(A), Sum Ip(A) Sum currents of the supply voltages at the input of the device.

Us Load, Up Load Enter here the total load at the IO ports of the device.
The unit of this value is set by the choice of "Us Load Type" and "Up Load Type".

Us Load Type, Up Load Type Choose here the characteristic of the load [▶ 47], which is connected to the IO ports of the device.

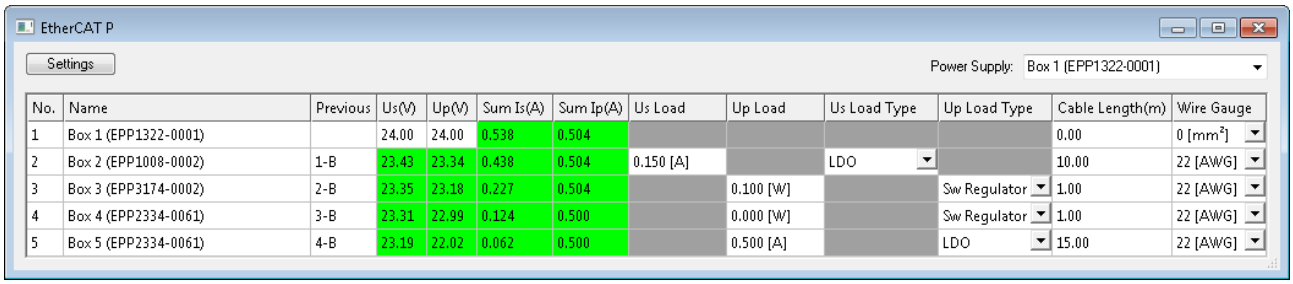
Cable Length (m) Enter here the length of the EtherCAT P cable, which is connected to the input of the device.

Wire Gauge Choose here the wire cross-section of the EtherCAT P cable, which is connected to the input of the device.

- AWG 22 = 0.34 mm²
- AWG 24 = 0.22 mm²

Example with problem case and troubleshooting

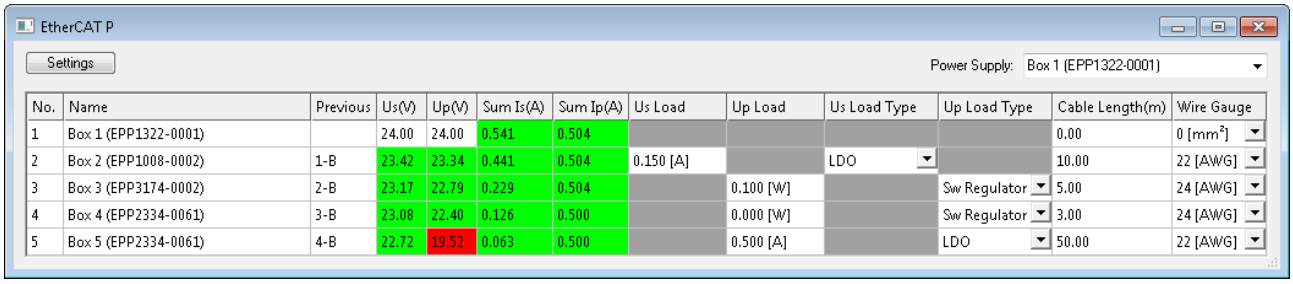
The following figure shows the planning of the EtherCAT P system without a problem. All voltages in the column “Supply Voltage (V)” are highlighted in green.



No.	Name	Previous	Us(V)	Up(V)	Sum Is(A)	Sum Ip(A)	Us Load	Up Load	Us Load Type	Up Load Type	Cable Length(m)	Wire Gauge
1	Box 1 (EPP1322-0001)		24.00	24.00	0.538	0.504					0.00	0 [mm²]
2	Box 2 (EPP1008-0002)	1-B	23.43	23.34	0.438	0.504	0.150 [A]		LDO		10.00	22 [AWG]
3	Box 3 (EPP3174-0002)	2-B	23.35	23.18	0.227	0.504		0.100 [W]		Sw Regulator	1.00	22 [AWG]
4	Box 4 (EPP2334-0061)	3-B	23.31	22.99	0.124	0.500		0.000 [W]		Sw Regulator	1.00	22 [AWG]
5	Box 5 (EPP2334-0061)	4-B	23.19	22.02	0.062	0.500		0.500 [A]		LDO	15.00	22 [AWG]

Fig. 35: Check EtherCAT P system without problem

The following figure shows the planning of the EtherCAT P system with a problem. The “Supply Voltage (V)” of Box 5 drops below the “Min. voltage (V)”. The corresponding field is highlighted in red. The error occurs because longer cables (adjustable in “Cable Length (m)”) and also AWG 24 instead of AWG 22 cables (adjustable in “Wire Gauge”) be used.



No.	Name	Previous	Us(V)	Up(V)	Sum Is(A)	Sum Ip(A)	Us Load	Up Load	Us Load Type	Up Load Type	Cable Length(m)	Wire Gauge
1	Box 1 (EPP1322-0001)		24.00	24.00	0.541	0.504					0.00	0 [mm²]
2	Box 2 (EPP1008-0002)	1-B	23.42	23.34	0.441	0.504	0.150 [A]		LDO		10.00	22 [AWG]
3	Box 3 (EPP3174-0002)	2-B	23.17	22.79	0.229	0.504		0.100 [W]		Sw Regulator	5.00	24 [AWG]
4	Box 4 (EPP2334-0061)	3-B	23.08	22.40	0.126	0.500		0.000 [W]		Sw Regulator	3.00	24 [AWG]
5	Box 5 (EPP2334-0061)	4-B	22.72	19.52	0.063	0.500		0.500 [A]		LDO	50.00	22 [AWG]

Fig. 36: Check EtherCAT P System with problem

This area offers the following three options to adjust the system so that there is no error:

- Provide a higher voltage: There are max. 28.8 V possible.
- Use an EtherCAT P cable with a larger wire cross sectional area (AWG 22 instead of AWG 24).
- New voltage feed.

State, "Online" tab

Indicates the online status of the terminal.

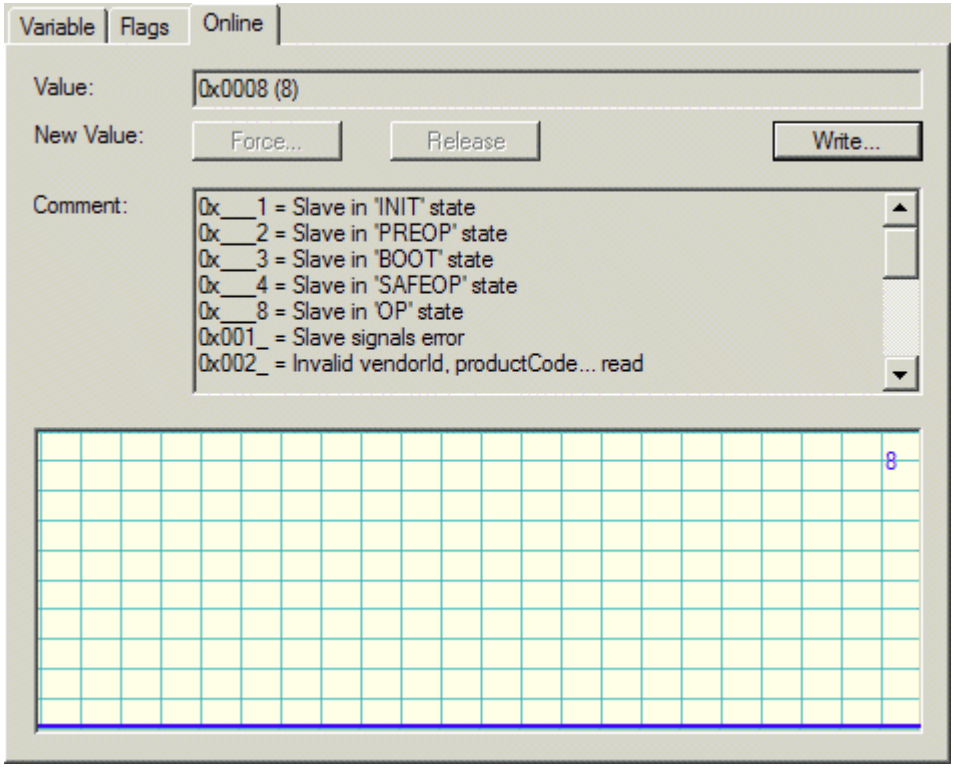


Fig. 37: State, "Online" tab

Value	Description
0x___1	Slave in 'INIT' state
0x___2	Slave in 'PREOP' state
0x___3	Slave in 'BOOT' state
0x___4	Slave in 'SAFEOP' state
0x___8	Slave in 'OP' state
0x001_	Slave signals error
0x002_	Invalid vendorId, productCode... read
0x004_	Initialization error occurred
0x010_	Slave not present
0x020_	Slave signals link error
0x040_	Slave signals missing link
0x080_	Slave signals unexpected link
0x100_	Communication port A
0x200_	Communication port B
0x400_	Communication port C
0x800_	Communication port D

Topology of the EtherCAT P system

You can view the topology of your EtherCAT P system, as described in the figure below:

1. In the Click on "Device 1 (EtherCAT)" in the "Solution Explorer"
2. Click on the "EtherCAT" tab
3. Click on the "Topology" button

⇨ The topology of your EtherCAT P system is displayed.

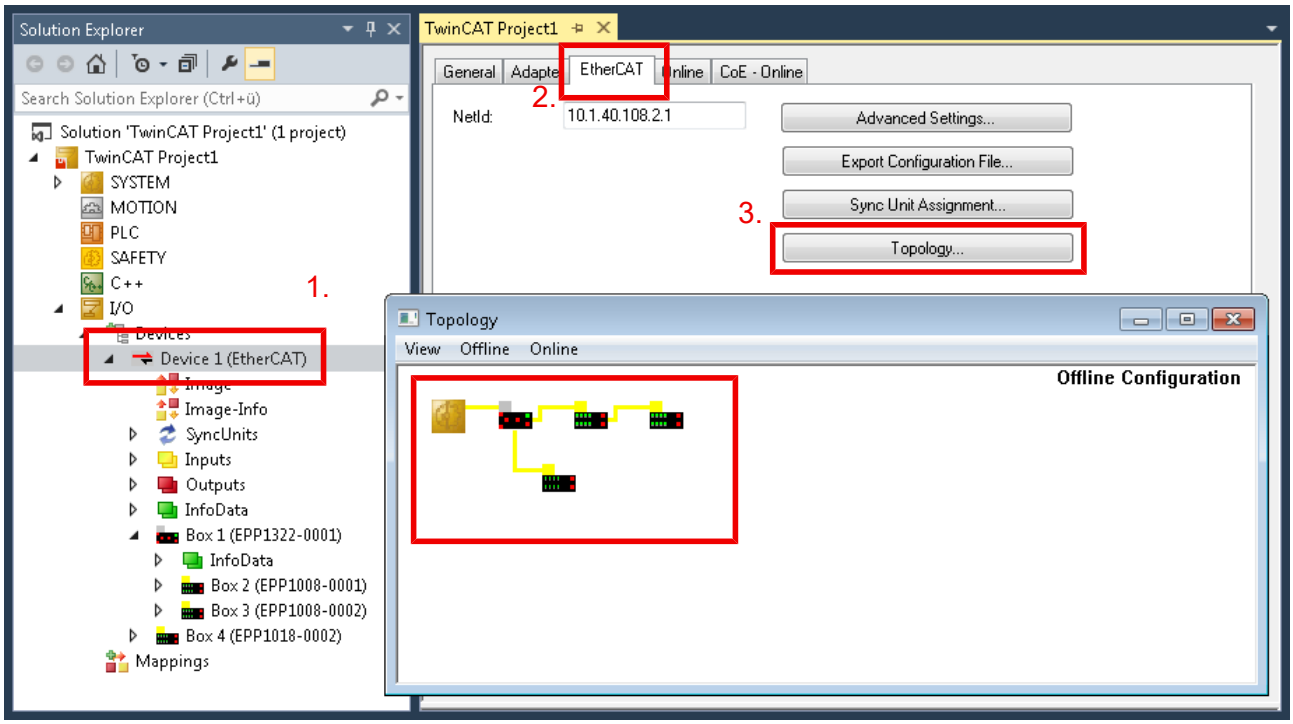


Fig. 38: Example: Three devices are connected to the three ports of the distributor device.

6 Error handling and diagnostics

6.1 Diagnostic LED

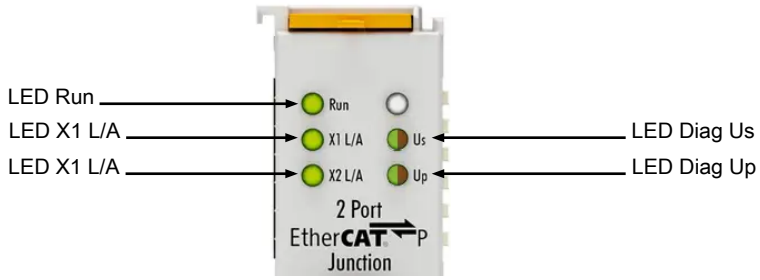


Fig. 39: EK1322 LEDs

LEDs for fieldbus diagnostics

LED		Display	State	Description
Run	green	off	INIT	EtherCAT P module is in state Init
		flashing uniformly	PREOP	EtherCAT P module is in state Pre-Operational
		flashing slowly	SAFEOP	EtherCAT P module is in state Safe-Operational
		on	OP	EtherCAT P module is in state Operational

LEDs for fieldbus diagnostics

LED		Display	State	Description
X1 L/A	green	off	-	No connection on the previous EtherCAT P strand
		on	link	Previous EtherCAT P device connected
		flashing	active	Communication with previous EtherCAT P device
X2 L/A	green	off	-	No connection on the subsequent EtherCAT P strand
		on	link	Subsequent EtherCAT P device connected
		flashing	active	Communication with subsequent EtherCAT P device

LEDs power supply diagnostics

LED		Display	Description
U_S	green	off	System- and Sensor supply U_S not present
		on	System- and Sensor supply U_S present
	red	off	System- and Sensor supply U_S >= 19.4 V, no overload/ no case of short circuit
		on	System- and Sensor supply U_S < 19.4 V or overload/ case of short circuit (output current > 3 A)
U_P	green	off	Peripheral voltage for Actors U_P not present
		on	Peripheral voltage for Actors U_P present
	red	off	Peripheral voltage for Actors U_P >= 19.4 V, no overload/ no case of short circuit
		on	Peripheral voltage for Actors U_P < 19.4 V or overload/ case of short circuit (output current > 3 A)

7 Appendix

7.1 EtherCAT AL Status Codes

For detailed information please refer to the EtherCAT system description.

7.2 Firmware compatibility

The EK1322 has no firmware.

7.3 Firmware Update

This section describes the device update for Beckhoff EtherCAT slaves from the ED/EF, 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.

7.3.1 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:

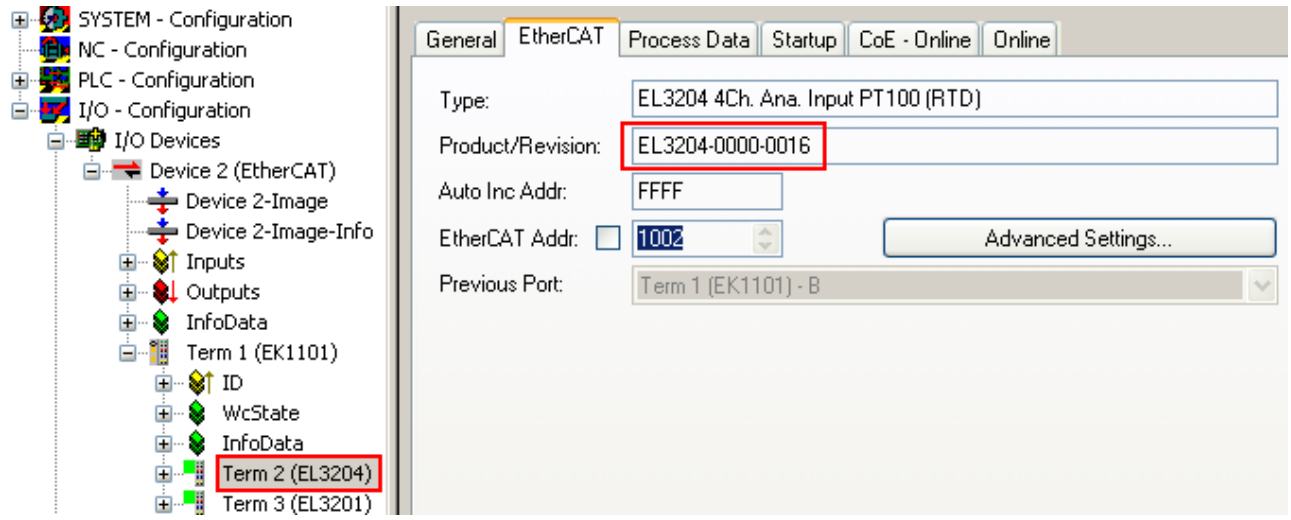


Fig. 40: Device identifier consisting of name EL3204-0000 and revision -0016

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:

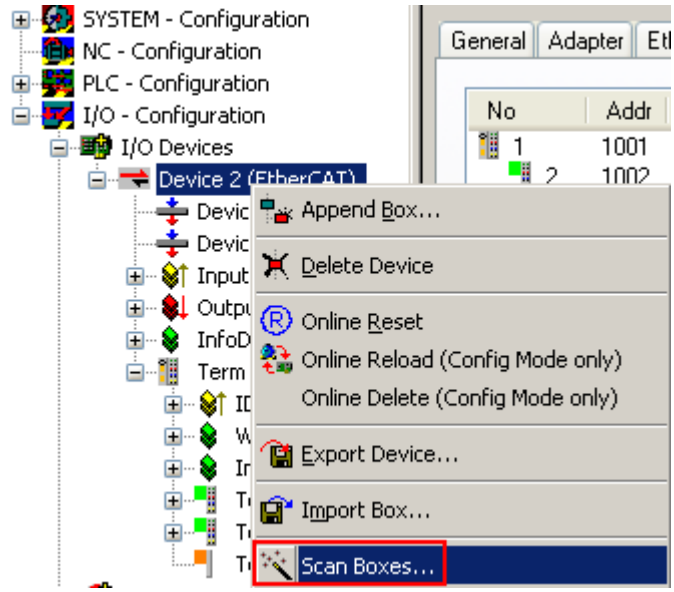


Fig. 41: Scan the subordinate field by right-clicking on the EtherCAT device

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

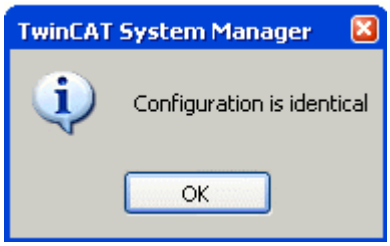


Fig. 42: Configuration is identical

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

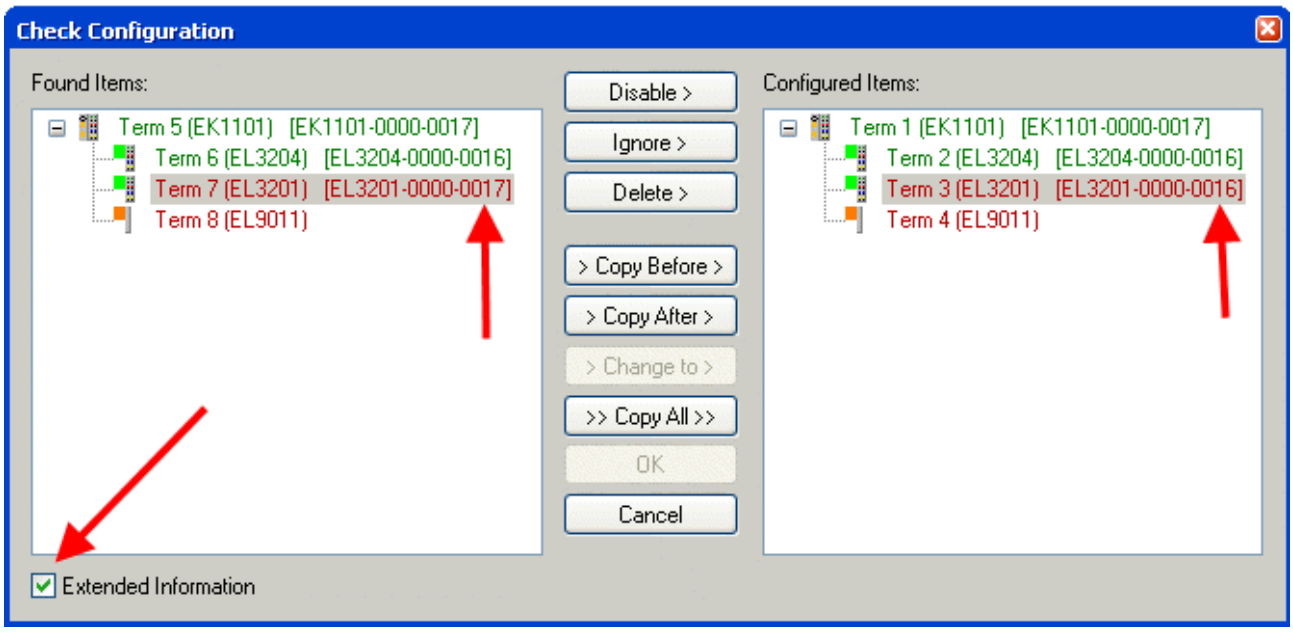


Fig. 43: Change dialog

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*

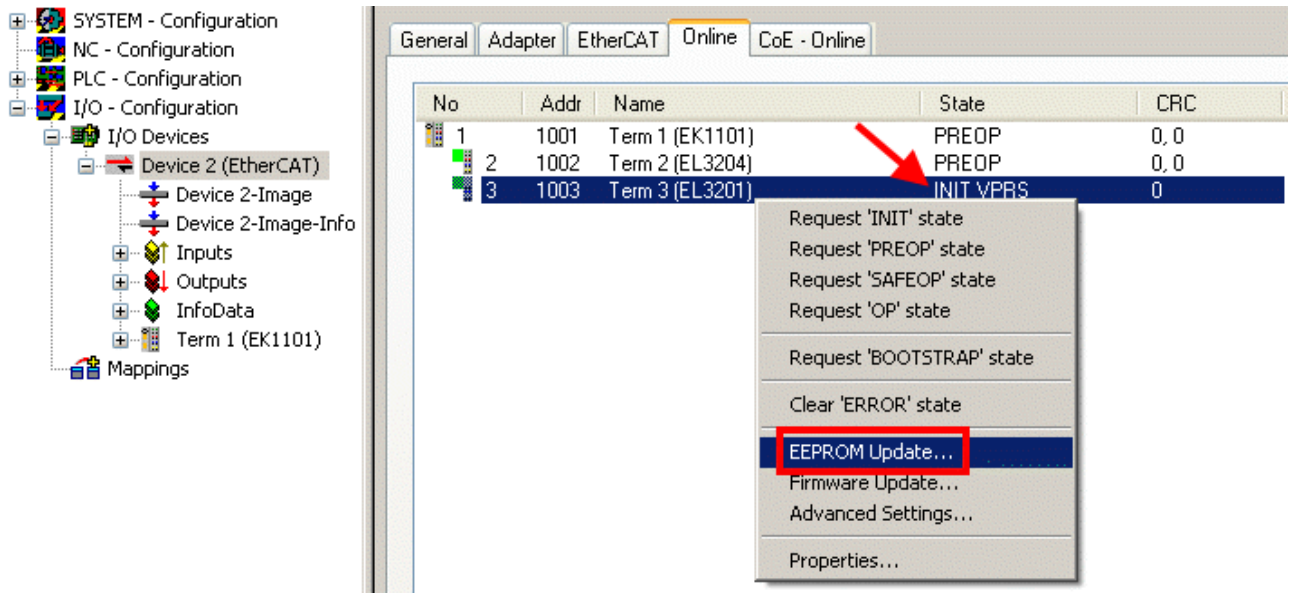


Fig. 44: EEPROM Update

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.

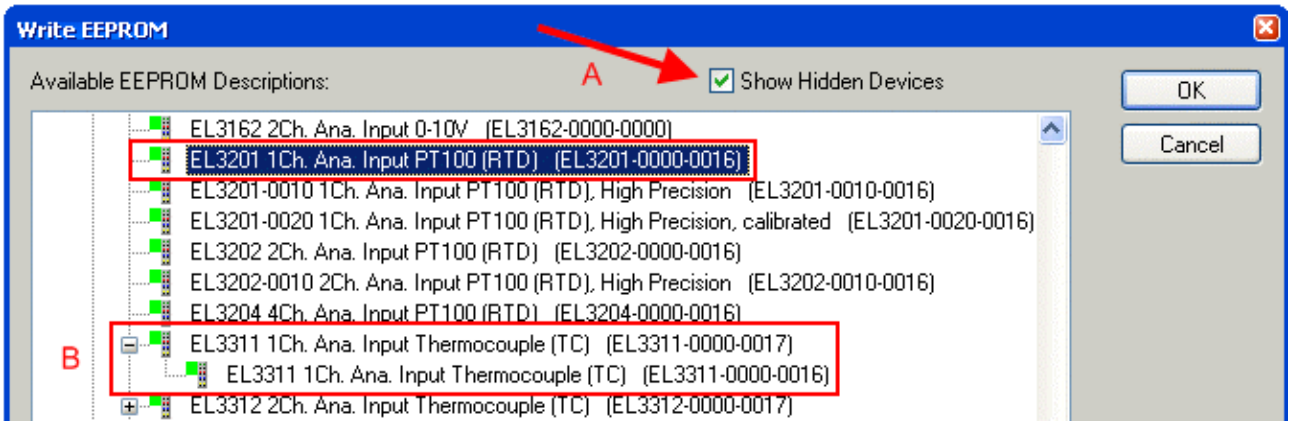


Fig. 45: Selecting the new ESI

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.

7.3.2 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.

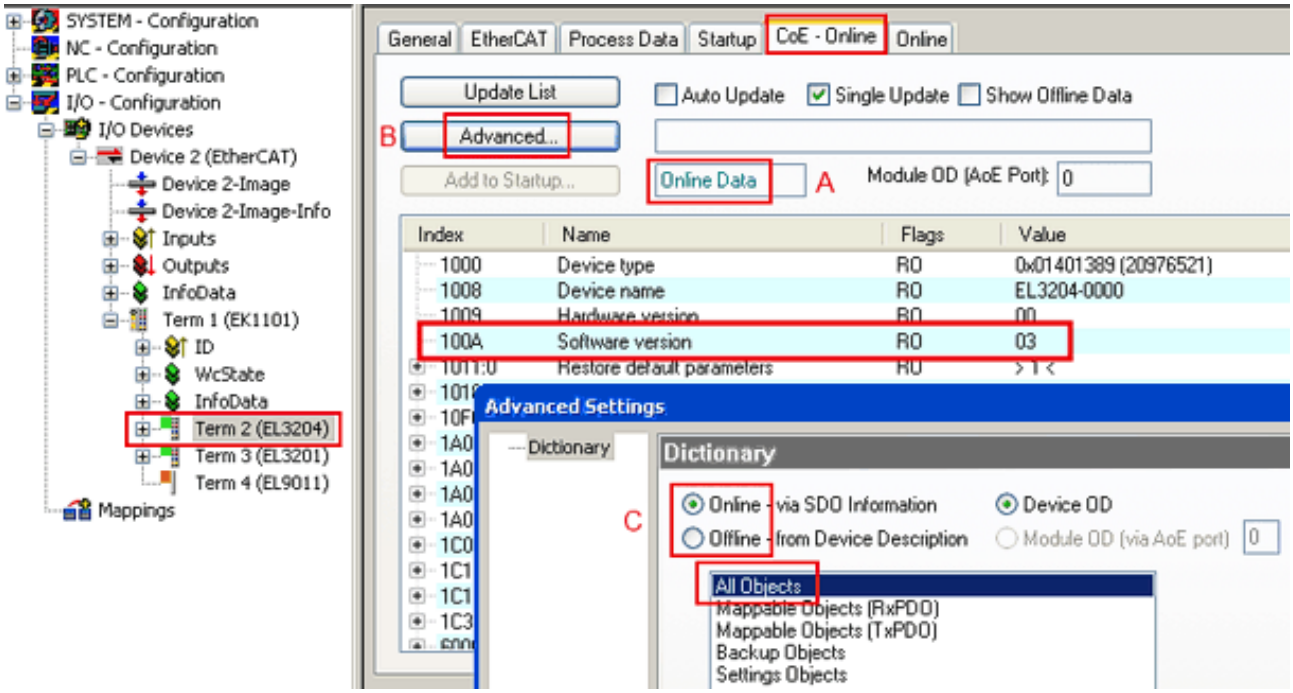


Fig. 46: Display of EL3204 firmware version

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*.

7.3.3 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.*

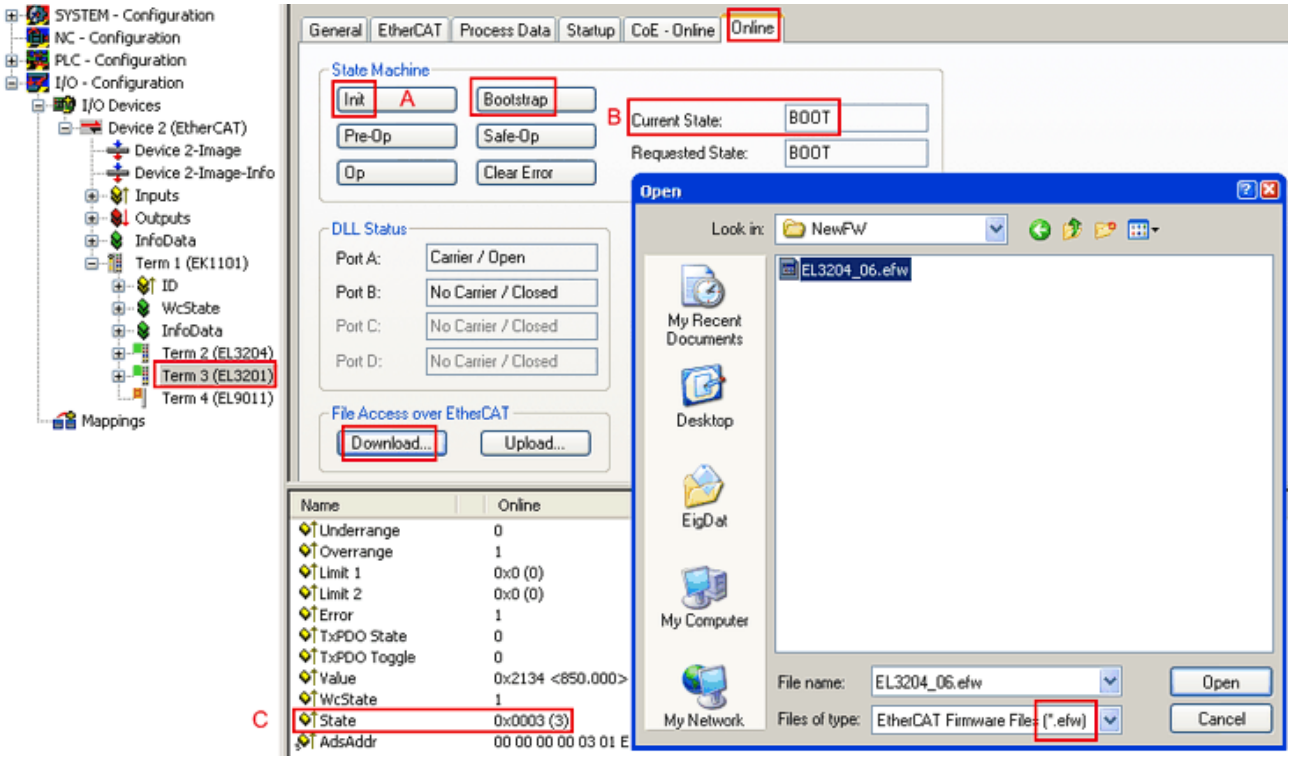
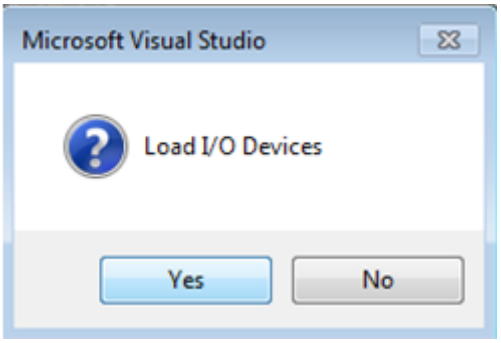
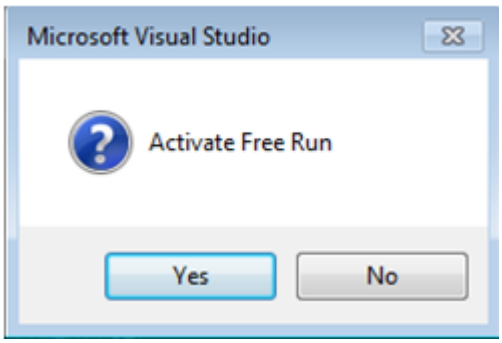


Fig. 47: Firmware Update

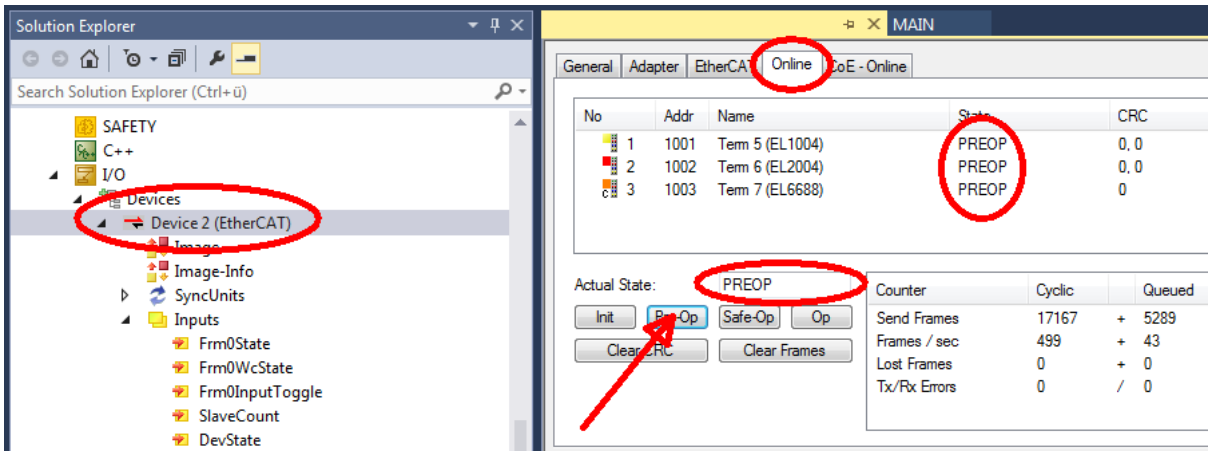
Proceed as follows, unless instructed otherwise by Beckhoff support. Valid for TwinCAT 2 and 3 as EtherCAT master.

- 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.



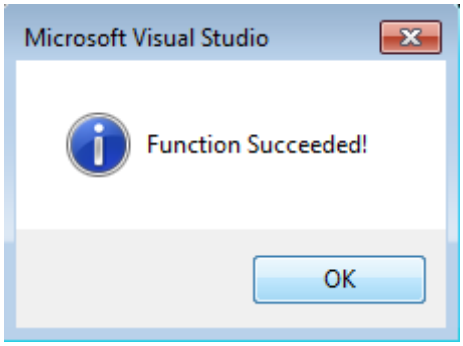


- Switch EtherCAT Master to PreOP



- 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.



- 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.

7.3.4 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.

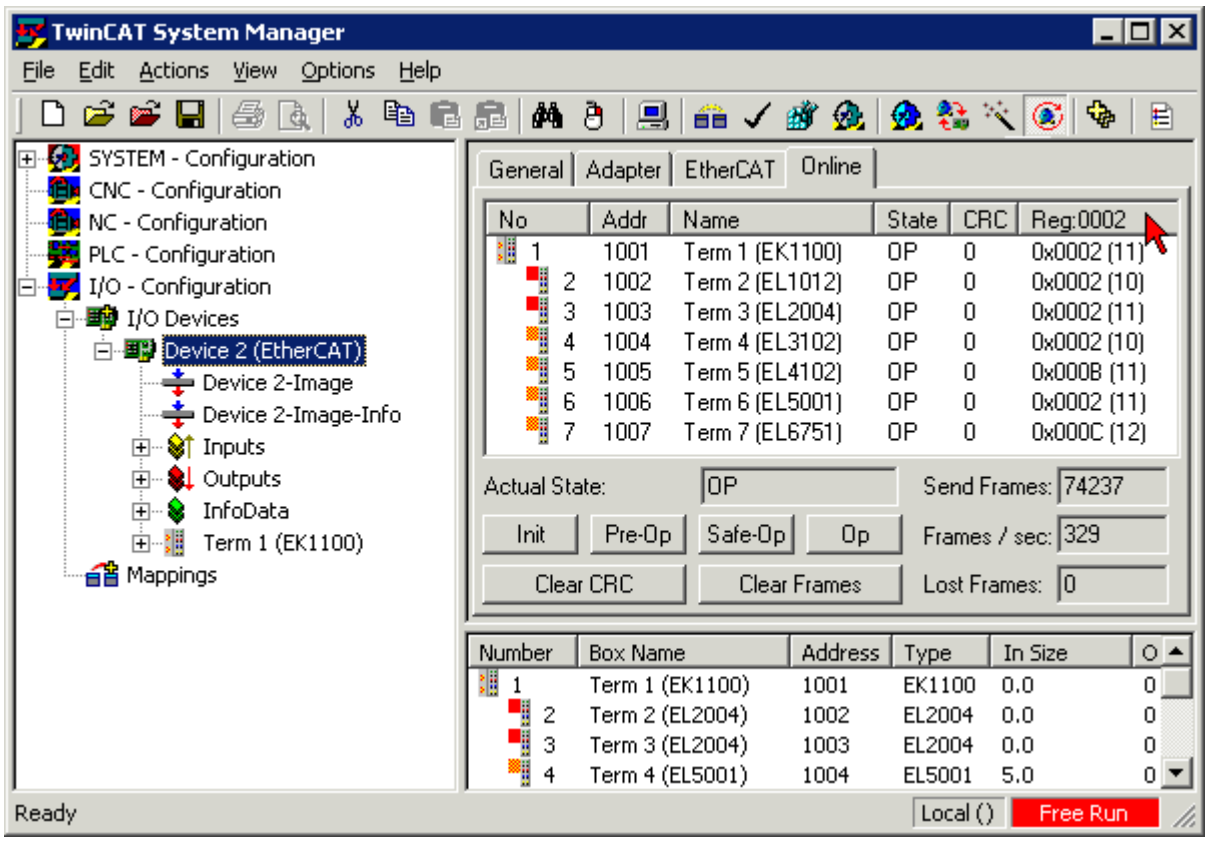


Fig. 48: FPGA firmware version definition

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

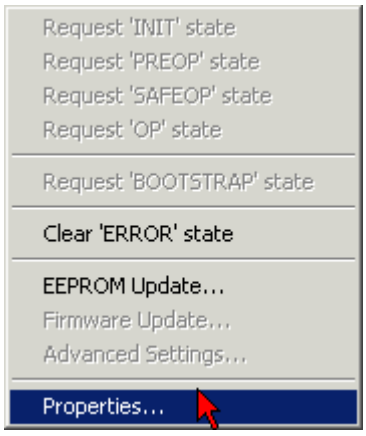


Fig. 49: Context menu *Properties*

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.

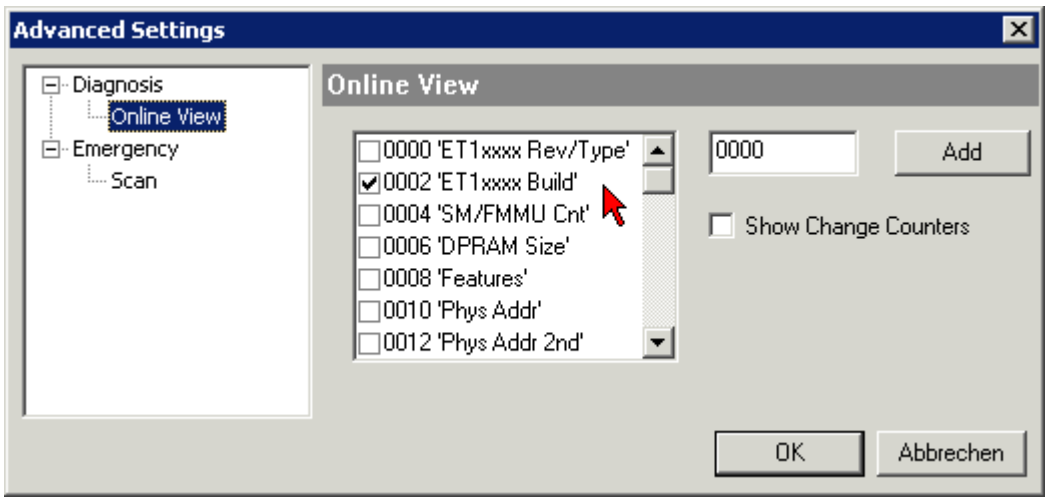


Fig. 50: Dialog *Advanced Settings*

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.

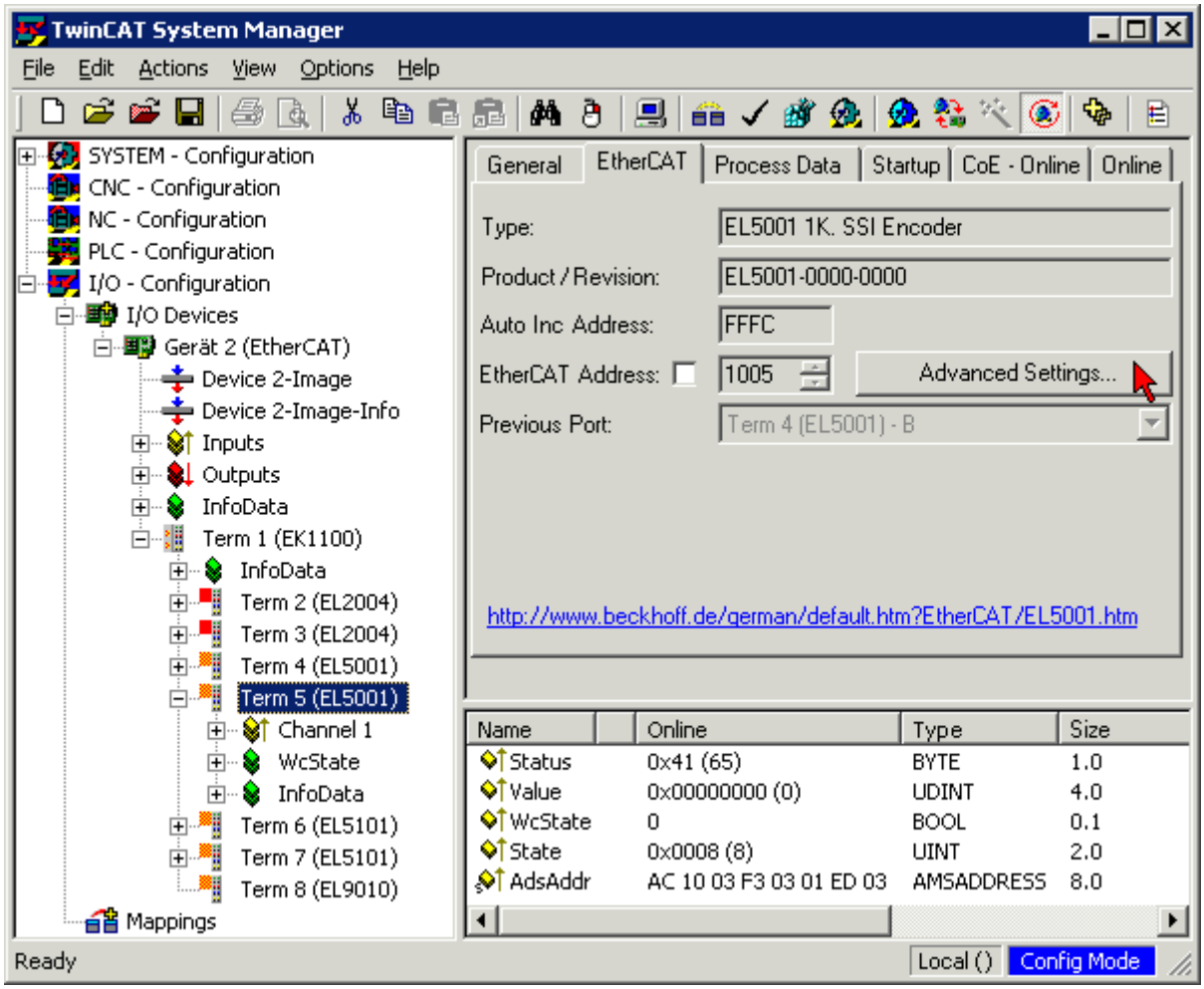
Older firmware versions can only be updated by the manufacturer!

Updating an EtherCAT device

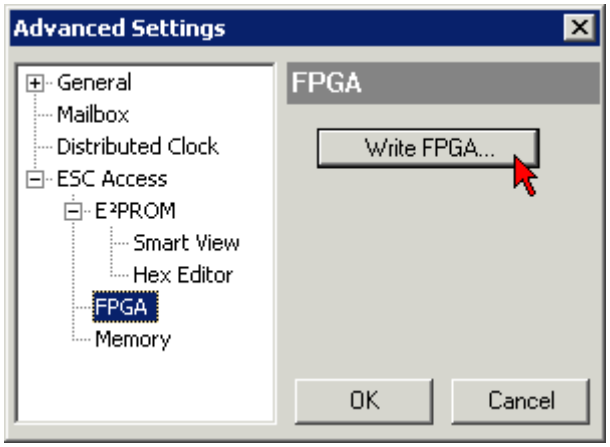
The following sequence order have to be met if no other specifications are given (e.g. by the Beckhoff support):

- 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.

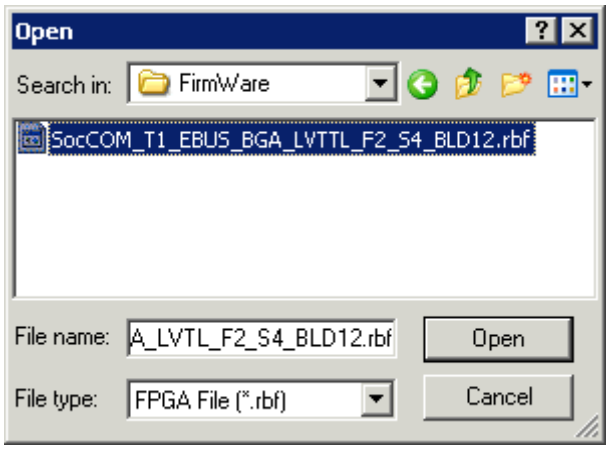
- In the TwinCAT System Manager select the terminal for which the FPGA firmware is to be updated (in the example: Terminal 5: EL5001) and
  click the *Advanced Settings* button in the *EtherCAT* tab:



- 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

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!

7.3.5 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.

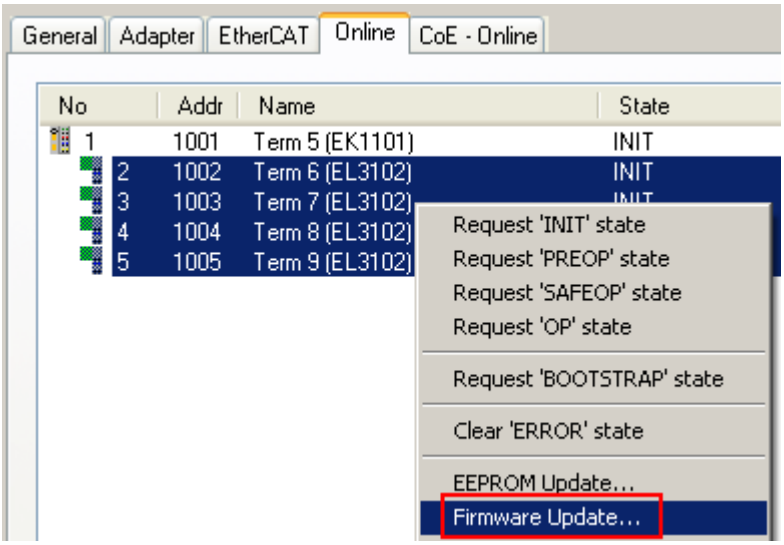


Fig. 51: Multiple selection and firmware update

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

7.4 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!

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