**Documentation**

# EL95xx

**Power supply terminals**

**Version:** 2.1
**Date:** 2017-05-19

**BECKHOFF**

# 1 Product overview – EtherCAT power supply terminals

EL9505 [▶ 12] (power supply terminal, 5 $V_{DC}$, 0.5 A)

EL9508 [▶ 12] (power supply terminal, 8 $V_{DC}$, 0.5 A)

EL9510 [▶ 12] (power supply terminal, 10 $V_{DC}$, 0.5 A)

EL9512 [▶ 12] (power supply terminal, 12 $V_{DC}$, 0.5 A)

EL9515 [▶ 12] (power supply terminal, 15 $V_{DC}$, 0.5 A)

EL9560 [▶ 12] (power supply terminal, 24 V / 24 $V_{DC}$, 0.1 A)

# Table of contents

# 2 Foreword

## 2.1 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.

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**Patent Pending**

The EtherCAT Technology is covered, including but not limited to the following patent applications and patents: EP1590927, EP1789857, DE102004044764, DE102007017835 with corresponding applications or registrations in various other countries.

The TwinCAT Technology is covered, including but not limited to the following patent applications and patents: EP0851348, US6167425 with corresponding applications or registrations in various other countries.



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# 2.2 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.

**Description of symbols**

In this documentation the following symbols are used with an accompanying safety instruction or note. The safety instructions must be read carefully and followed without fail!

| | |
|---|---|
| ⚠ **DANGER** | **Serious risk of injury!** <br> Failure to follow the safety instructions associated with this symbol directly endangers the life and health of persons. |
| ⚠ **WARNING** | **Risk of injury!** <br> Failure to follow the safety instructions associated with this symbol endangers the life and health of persons. |
| ⚠ **CAUTION** | **Personal injuries!** <br> Failure to follow the safety instructions associated with this symbol can lead to injuries to persons. |
| ! **Attention** | **Damage to the environment or devices** <br> Failure to follow the instructions associated with this symbol can lead to damage to the environment or equipment. |
| i **Note** | **Tip or pointer** <br> This symbol indicates information that contributes to better understanding. |

## 2.3 Documentation issue status

| Version | Comment |
|---------|---------|
| 2.1 | • Update chapter "Notes on the documentation"<br>• Update chapter "Technical data"<br>• Addenda chapter "Instructions for ESD protection"<br>• Addenda chapter "Installation instructions for enhanced mechanical load capacity"<br>• Chapter "ATEX - Special conditions" replaced with chapter "ATEX - Special conditions (standard temperature range)" |
| 2.0 | • Migration<br>• Update structure |
| 1.4 | • Update "Technical data" |
| 1.3 | • Update "Technical data", connection diagram |
| 1.2 | • Note regarding firmware compatibility inserted |
| 1.1 | • EL9560 added |
| 1.0 | • First published |
| 0.2 | • Corrections and addenda |
| 0.1 | • Provisional documentation for EL95xx |

## 2.4 Version identification of EtherCAT devices

**Designation**

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

- family key
- type
- version
- revision

| Example | Family | Type | Version | Revision |
|---------|--------|------|---------|----------|
| EL3314-0000-0016 | EL terminal<br>(12 mm, non-pluggable connection level) | 3314 (4-channel thermocouple terminal) | 0000 (basic type) | 0016 |
| ES3602-0010-0017 | ES terminal<br>(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.

**Identification number**

Beckhoff EtherCAT devices from the different lines have different kinds of identification numbers:

**Production lot/batch number/serial number/date code/D number**

The serial number 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**

KK - week of production (CW, calendar week)
YY - year of production
FF - firmware version
HH - hardware version

Example with
Ser. no.: 12063A02: 12 - production week 12 06 - production year 2006 3A - firmware version 3A 02 - hardware version 02

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

Syntax: D ww yy x y z u

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

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

**Unique serial number/ID, ID number**

In addition, in some series each individual module has its own unique serial number.

See also the further documentation in the area

- IP67: EtherCAT Box

- Safety: TwinSafe

- Terminals with factory calibration certificate and other measuring terminals
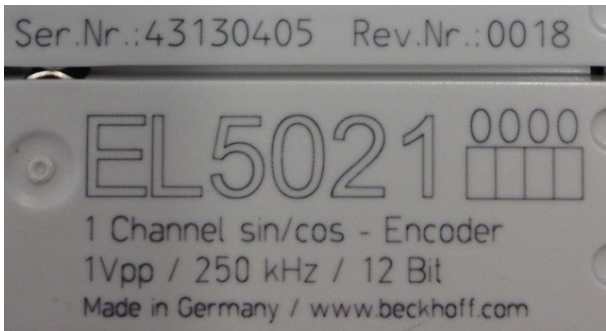
**Examples of markings**



Fig. 1: EL5021 EL terminal, standard IP20 IO device with batch number and revision ID (since 2014/01)



Fig. 2: EK1100 EtherCAT coupler, standard IP20 IO device with batch number



Fig. 3: CU2016 switch with batch number

Fig. 4: EL3202-0020 with batch numbers 26131006 and unique ID-number 204418



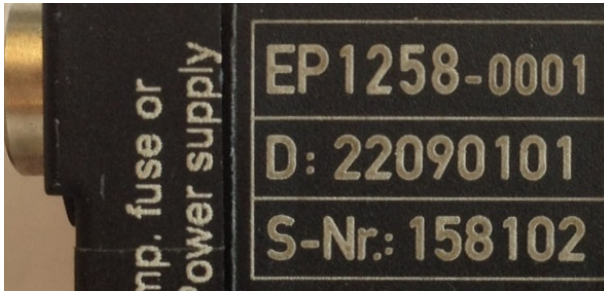Fig. 5: EP1258-00001 IP67 EtherCAT Box with batch number 22090101 and unique serial number 158102



Fig. 6: EP1908-0002 IP67 EtherCAT Safety Box with batch number 071201FF and unique serial number 00346070



Fig. 7: EL2904 IP20 safety terminal with batch number/date code 50110302 and unique serial number 00331701

Fig. 8: ELM3604-0002 terminal with ID number (QR code) 100001051 and unique serial number 44160201
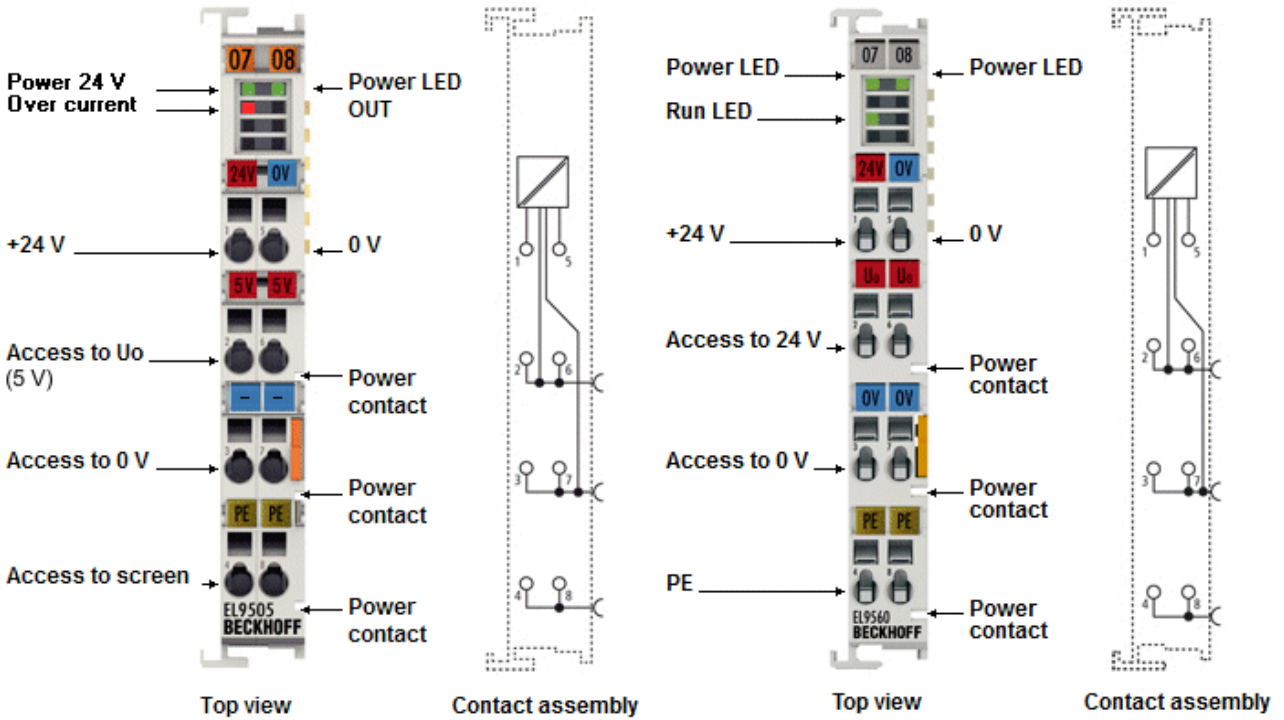
# 3 Product overview

## 3.1 Introduction

Fig. 9: Left: EL9505 (identical pin assignment: EL9508, EL9510, EL9512, EL9515) Right: EL9560

Based on the input voltage (24 $V_{DC}$), the EL9505, EL9508, EL9510, EL9512 and EL9515 power supply terminals generate different output voltages, which can be picked up at the terminals. The following EtherCAT Terminals are also supplied with this voltage via the power contacts. The power LEDs indicate the operating states of the terminals, short-circuits or overloads are indicated by the overcurrent LEDs. The input voltage and the output voltage $U_0$ are not electrically isolated.

The EL9560 power supply unit terminal generates an electrically isolated output voltage from the 24 $V_{DC}$ input voltage. The input voltage and the output voltage of 500 V are also electrically isolated.

## 3.2 EL9505, EL9508, EL9510, EL9512, EL9515 - Technical data

| Technical data | EL9505 | EL9508 | EL9510 | EL9512 | EL9515 |
|---|---|---|---|---|---|
| Input voltage | 24 $V_{DC}$ | | | | |
| Output voltage | 5 $V_{DC}$±1% | 8 $V_{DC}$±1% | 10 $V_{DC}$±1% | 12 $V_{DC}$±1% | 15 $V_{DC}$±1% |
| Output current | 0.5 A | | | | |
| Short circuit diagnosis, overload: | Overcurrent LED | | | | |
| Message to E-bus | yes | | | | |
| Power contacts (right) | $U_0$, 0 V, shield | | | | |
| E-Bus current consumption | 90 mA typ. | | | | |
| Bit width in process image | 2 | | | | |
| Electrical connection to mounting rail | - | | | | |
| Residual ripple | <5 mV | | | | |
| Electrical isolation | yes (500 V against field level) | | | | |
| Dimensions (W x H x D) | approx. 15 mm x 100 mm x 70 mm (width aligned: 12 mm) | | | | |
| Configuration | no address or configuration settings required | | | | |
| Weight | approx. 65 g | | | | |
| Permissible ambient temperature range during operation | 0°C ... + 55°C | | | | |
| Permissible ambient temperature range during storage | -25°C ... + 85°C | | | | |
| Permissible relative humidity | 95 %, no condensation | | | | |
| Mounting [▶ 22] | on 35 mm mounting rail conforms to EN 60715 | | | | |
| Vibration/shock resistance | conforms to EN 60068-2-6 / EN 60068-2-27, EN 60068-2-29, see also installation instructions for enhanced mechanical load capacity [▶ 26] | | | | |
| EMC immunity/emission | conforms to EN 61000-6-2 / EN 61000-6-4 | | | | |
| Protection class | IP20 | | | | |
| Installation position | variable | | | | |
| Approval | CE<br>cULus [▶ 39]<br>ATEX [▶ 31] | | | | |

## 3.3 EL9560 - Technical data

| Technical data | EL9560 |
|---|---|
| Input voltage | 24 $V_{DC}$ (-15 %/+20 %) |
| Output voltage | 24 $V_{DC}$ (-15 %/+5 %) |
| Output current | 0.1 A |
| Message to E-bus | yes |
| Power contacts (right) | $U_0$, 0 V, PE |
| E-Bus current consumption | 90 mA typ. |
| Bit width in process image | 1 |
| Electrical connection to mounting rail | - |
| Isolation voltage | 1,500 $V_{AC}$ continuous load, field side/E-bus |
| Insulation voltage input/output | 500 $V_{AC}$ continuous load |
| Dimensions (W x H x D) | approx. 15 mm x 100 mm x 70 mm (width aligned: 12 mm) |
| Configuration | no address or configuration settings required |
| Weight | approx. 65 g |
| Permissible ambient temperature range during operation | 0°C ... + 55°C |
| Permissible ambient temperature range during storage | -25°C ... + 85°C |
| Permissible relative humidity | 95 %, no condensation |
| Mounting [▶ 22] | on 35 mm mounting rail conforms to EN 60715 |
| Vibration/shock resistance | conforms to EN 60068-2-6 / EN 60068-2-27, EN 60068-2-29, see also installation instructions for enhanced mechanical load capacity [▶ 26] |
| EMC immunity/emission | conforms to EN 61000-6-2 / EN 61000-6-4 |
| Protection class | IP20 |
| Installation position | variable |
| Approval | CE cULus [▶ 39] |

# 4 Basics communication

## 4.1 EtherCAT basics

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

## 4.2 EtherCAT cabling – wire-bound

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

**Cables and connectors**

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

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

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

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

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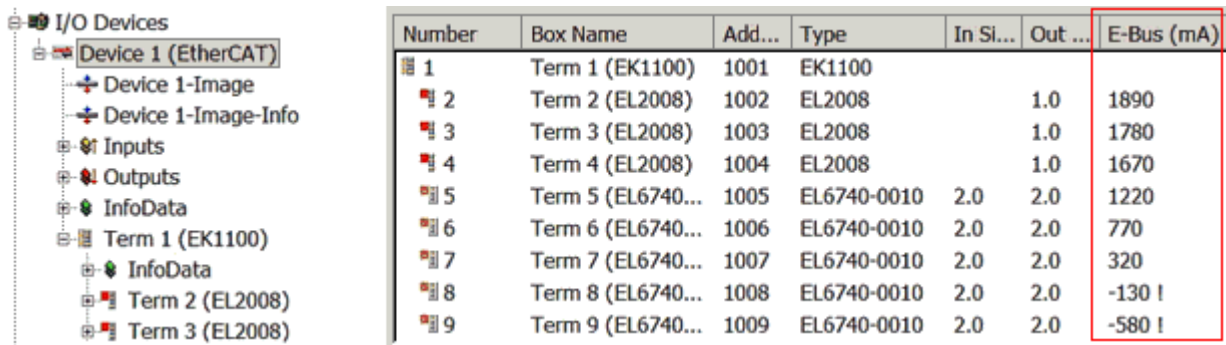
| Number | Box Name | Add... | Type | In Si... | Out ... | E-Bus (mA) |
|---|---|---|---|---|---|---|
| 1 | Term 1 (EK1100) | 1001 | EK1100 | | | |
| 2 | Term 2 (EL2008) | 1002 | EL2008 | | 1.0 | 1890 |
| 3 | Term 3 (EL2008) | 1003 | EL2008 | | 1.0 | 1780 |
| 4 | Term 4 (EL2008) | 1004 | EL2008 | | 1.0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

Fig. 10: *System manager current calculation*

| ! **Attention** | **Malfunction possible!**<br>The same ground potential must be used for the E-Bus supply of all EtherCAT terminals in a terminal block! |
|---|---|

# 4.3 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

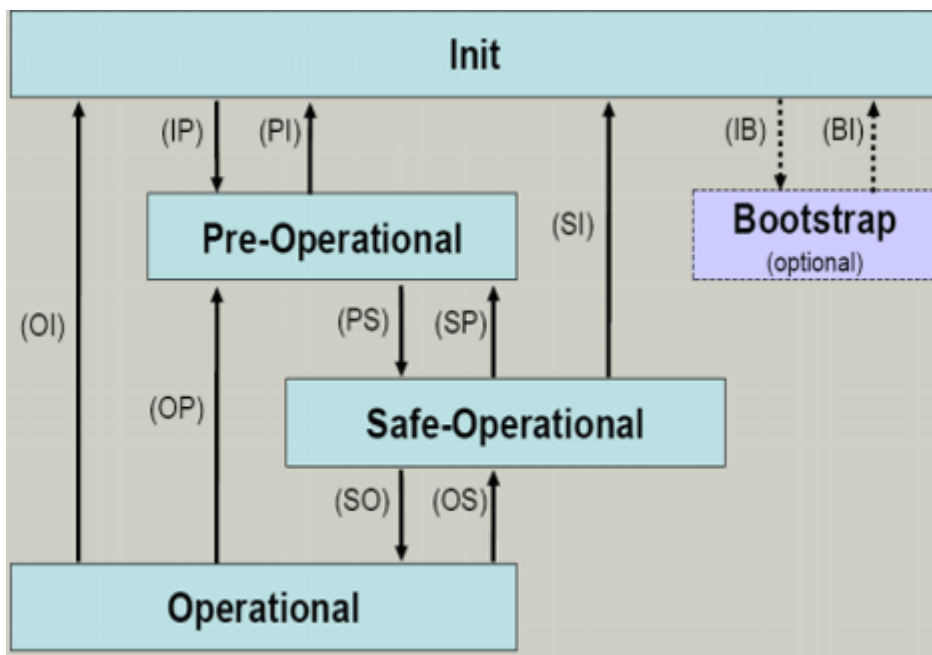The regular state of each EtherCAT slave after bootup is the OP state.



Fig. 11: *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.

| | |
|---|---|
| **i**<br><br>**Note** | **Outputs in SAFEOP state**<br><br>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.

# 4.4    CoE Interface

**General description**

The CoE interface (CANopen 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 2 levels via hexadecimal numbering: (main)index, followed by subindex. The value ranges are

- Index: 0x0000 …0xFFFF (0...65535$_{dez}$)
- SubIndex: 0x00…0xFF (0...255$_{dez}$)

A parameter localized in this way is normally written as 0x8010:07, with preceding "x" 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: In some EtherCAT devices the channel parameters are stored here (as an alternative to the 0x8000 range).
- 0x6000: Input PDOs ("input" from the perspective of the EtherCAT master)
- 0x7000: Output PDOs ("output" from the perspective of the EtherCAT master)

| | **Availability** |
|---|---|
| **i**<br>**Note** | 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:
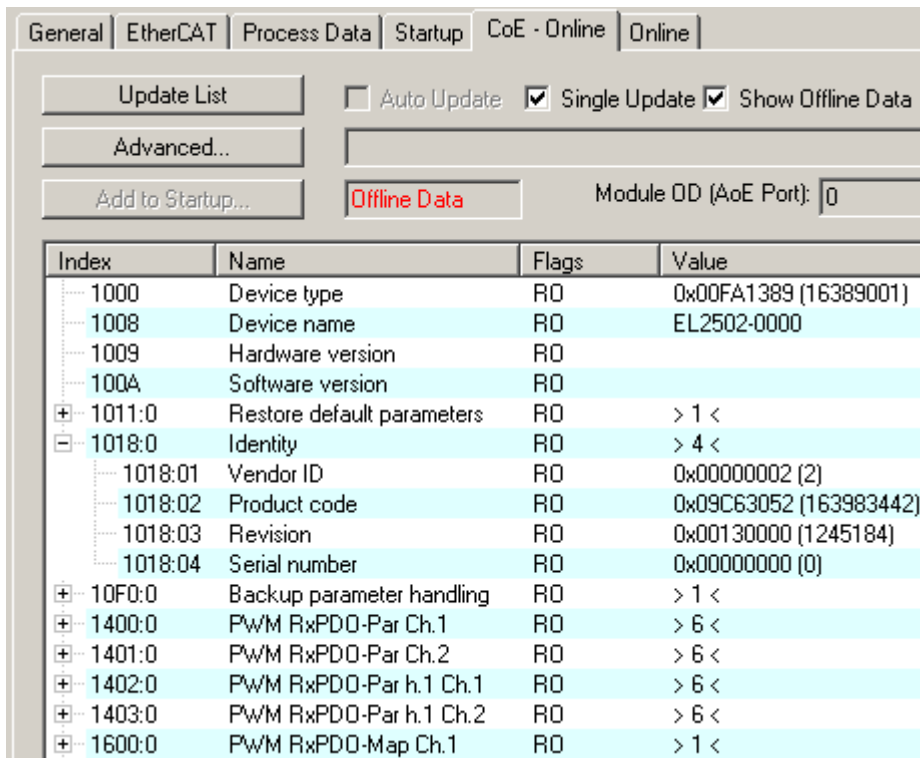


Fig. 12: *"CoE Online " tab*

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 parameterised 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.

| | |
|---|---|
| **i**<br>**Note** | **Data management**<br>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.<br>The situation may be different with other manufacturers.<br><br>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.<br>Please refer to the technical data in this documentation as to whether this applies to the respective device.<br>• 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.<br>• Function is not supported: continuous changing of CoE values is not permissible in view of the lifetime limit. |
| **i**<br>**Note** | **Startup list**<br>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.<br><br>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.
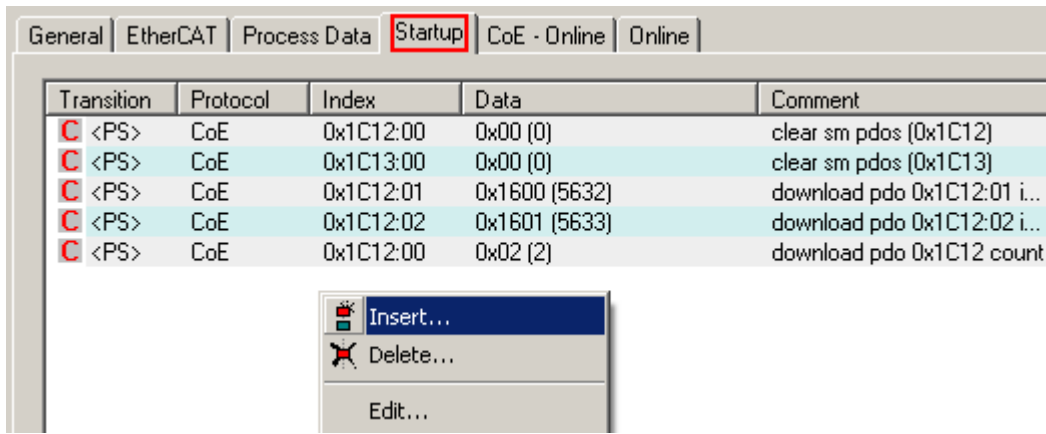  The order of the Startup entries is usually irrelevant.

Fig. 13: *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.
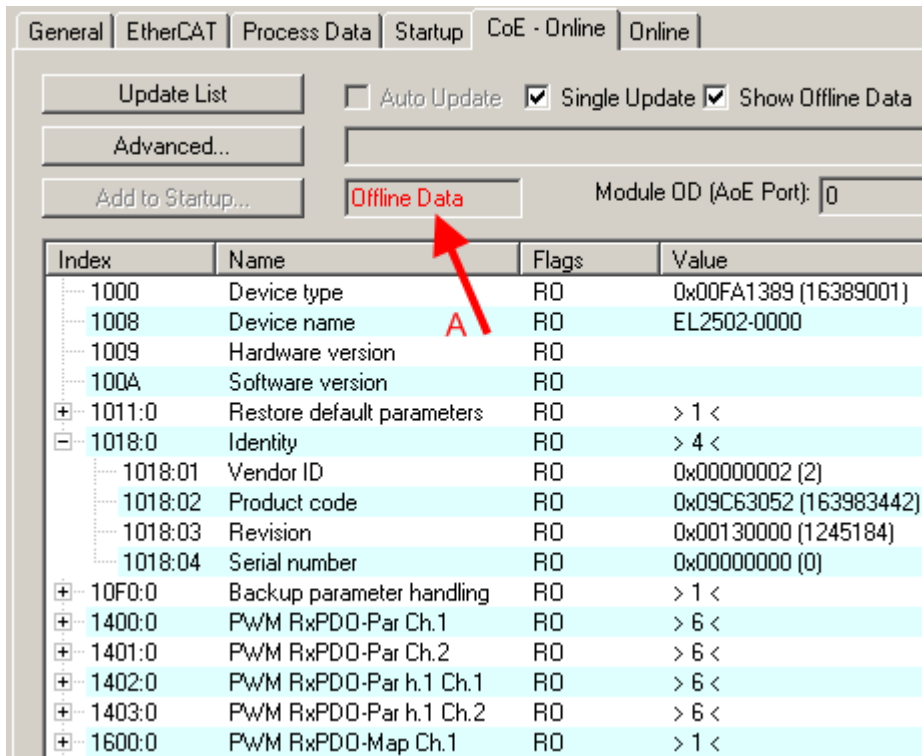


Fig. 14: *Offline list*

- 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.
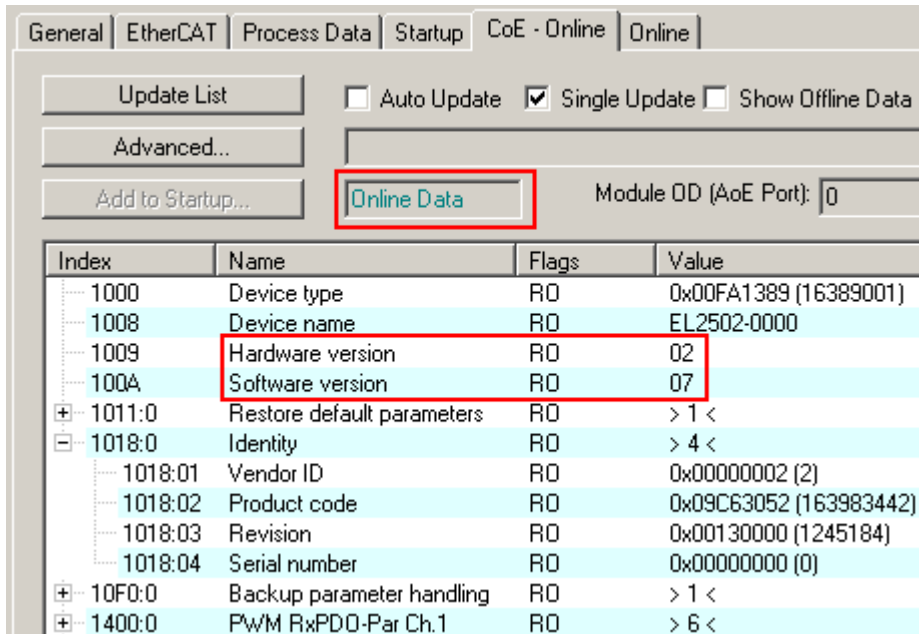


Fig. 15: *Online list*

**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 4 logical channels and therefore 4 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.

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# 5 Mounting and wiring

## 5.1 Instructions for ESD protection

| ⚠️ **Attention** | **Destruction of the devices by electrostatic discharge possible!**<br>The devices contain components at risk from electrostatic discharge caused by improper handling.<br>✓ Please ensure you are electrostatically discharged and avoid touching the contacts of the device directly.<br>a) Avoid contact with highly insulating materials (synthetic fibers, plastic film etc.).<br>b) Surroundings (working place, packaging and personnel) should by grounded probably, when handling with the devices.<br>c) Each assembly must be terminated at the right hand end with an EL9011 bus end cap, to ensure the protection class and ESD protection. |
|---|---|



Fig. 16: Spring contacts of the Beckhoff I/O components

## 5.2 Installation on mounting rails

| ⚠️ **WARNING** | **Risk of electric shock and damage of device!**<br>Bring the bus terminal system into a safe, powered down state before starting installation, disassembly or wiring of the Bus Terminals! |
|---|---|

**Assembly**



Fig. 17: 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.

| | |
|---|---|
| **i**<br>**Note** | **Fixing of mounting rails**<br><br>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**
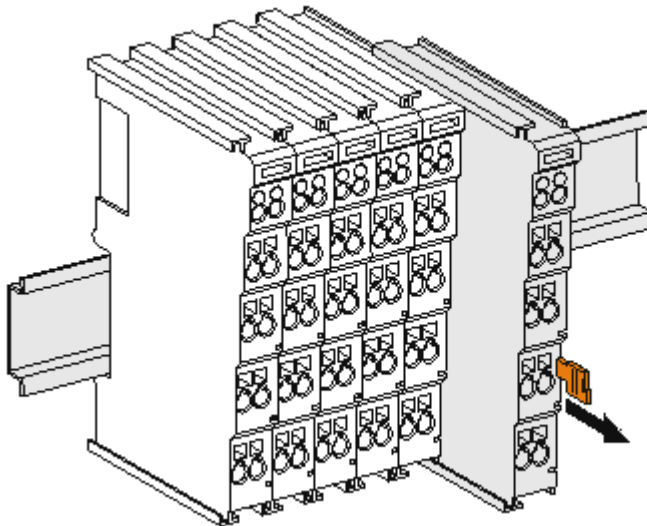


Fig. 18: Disassembling of terminal

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.

| | |
|---|---|
| ![i] **Note** | **Power Contacts** <br> 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.
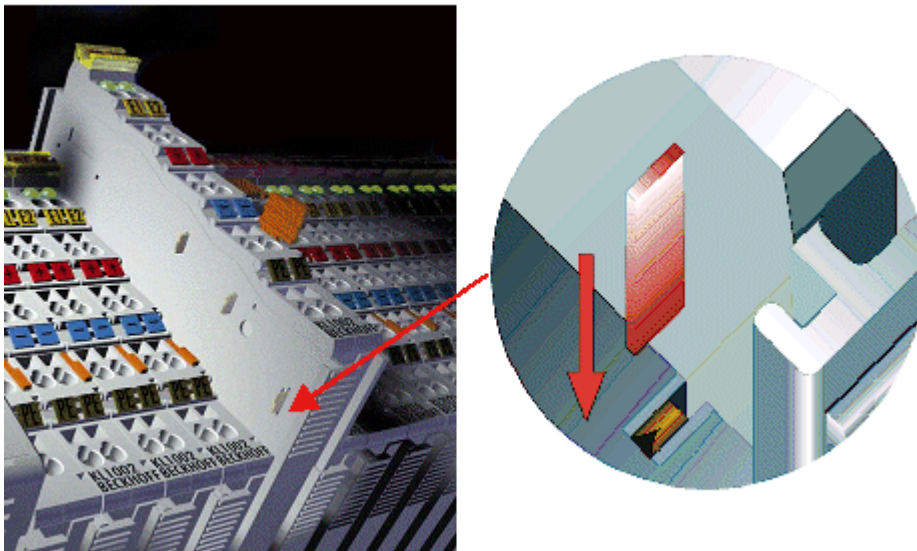
Fig. 19: *Power contact on left side*

| ! **Attention** | **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! |

## 5.3 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.

## 5.4 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 KLxxxx and ELxxxx series with standard wiring include electronics and connection level in a single enclosure.
- The terminals of KSxxxx and ESxxxx 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.
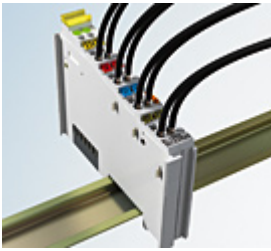
**Standard wiring**



Fig. 20: Standard wiring

The terminals of KLxxxx and ELxxxx series have been tried and tested for years.
They feature integrated screwless spring force technology for fast and simple assembly.

**Pluggable wiring**



Fig. 21: Pluggable wiring

The terminals of KSxxxx and ESxxxx series feature a pluggable connection level.
The assembly and wiring procedure for the KS series is the same as for the KLxxxx and ELxxxx series.
The KS/ES series terminals enable 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 KSxxxx and ESxxxx series has been retained as known from KLxxxx and ELxxxx series.

**High Density Terminals (HD Terminals)**



Fig. 22: *High Density Terminals*

The Bus Terminals from these series with 16 connection 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** |
|---|---|
| **i** <br> **Note** | The High Density (HD) Terminals of the KLx8xx and ELx8xx series doesn't support steady wiring. |

**Ultrasonically "bonded" (ultrasonically welded) conductors**

| | **Ultrasonically "bonded" conductors** |
|---|---|
| **i** <br> **Note** | It is also possible to connect the Standard and High Density Terminals with ultrasonically "bonded" (ultrasonically welded) conductors. In this case, please note the tables concerning the wire-size width [▶ 28] below! |

**Wiring**

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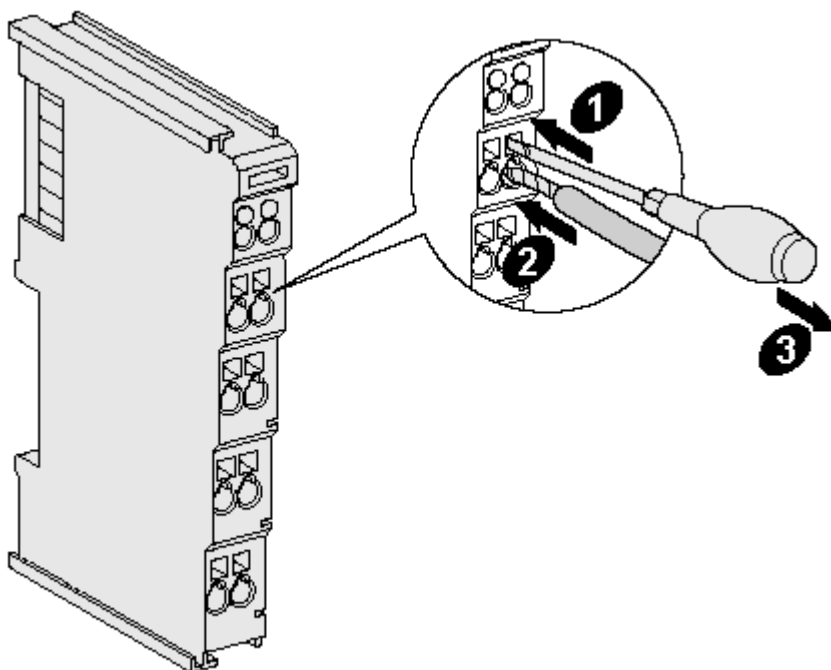


Fig. 23: Mounting a cable on a terminal connection

Up to eight connections enable the connection of solid or finely stranded cables to the Bus Terminals. The terminals are implemented in spring force technology. Connect the cables as follows:

1. Open a spring-loaded terminal by slightly pushing with a screwdriver or a rod into the square opening above the terminal.
2. The wire can now be inserted into the round terminal opening without any force.
3. The terminal closes automatically when the pressure is released, holding the wire securely and permanently.

| Terminal housing | ELxxxx, KLxxxx | ESxxxx, KSxxxx |
|---|---|---|
| Wire size width | 0.08 ... 2,5 mm$^2$ | 0.08 ... 2.5 mm$^2$ |
| Wire stripping length | 8 ... 9 mm | 9 ... 10 mm |

**High Density Terminals ELx8xx, KLx8xx (HD)**

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 contact 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 (conductors with a wire end sleeve)** | 0.14... 0.75 mm$^2$ |
| **Wire size width (single core wires)** | 0.08 ... 1.5 mm$^2$ |
| **Wire size width (fine-wire conductors)** | 0.25 ... 1.5 mm$^2$ |
| **Wire size width (ultrasonically "bonded" conductors)** | only 1.5 mm$^2$ (see notice [▶ 28]!) |
| **Wire stripping length** | 8 ... 9 mm |

**Shielding**

| | **Shielding** |
|---|---|
| **i**<br>**Note** | Analog sensors and actors should always be connected with shielded, twisted paired wires. |

## 5.5 Mounting of Passive Terminals

| | **Hint for mounting passive terminals** |
|---|---|
| **i** **Note** | EtherCAT Terminals (ELxxxx / ESxxxx), which do not take an active part in data transfer within the bus terminal block are so called Passive Terminals. The Passive Terminals have no current consumption out of the E-Bus To ensure an optimal data transfer, you must not directly string together more than 2 Passive Terminals! |

**Examples for mounting passive terminals (highlighted)**
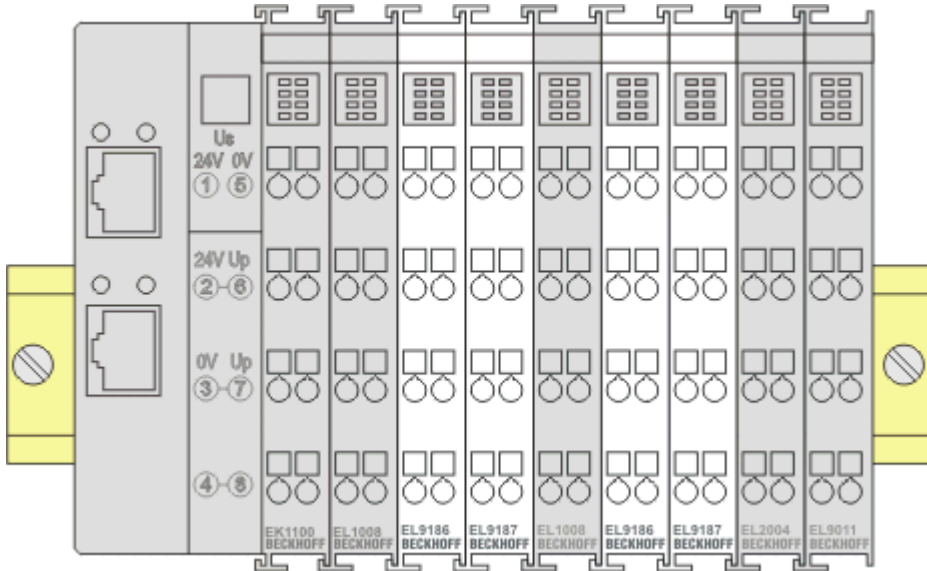


Fig. 24: *Correct configuration*
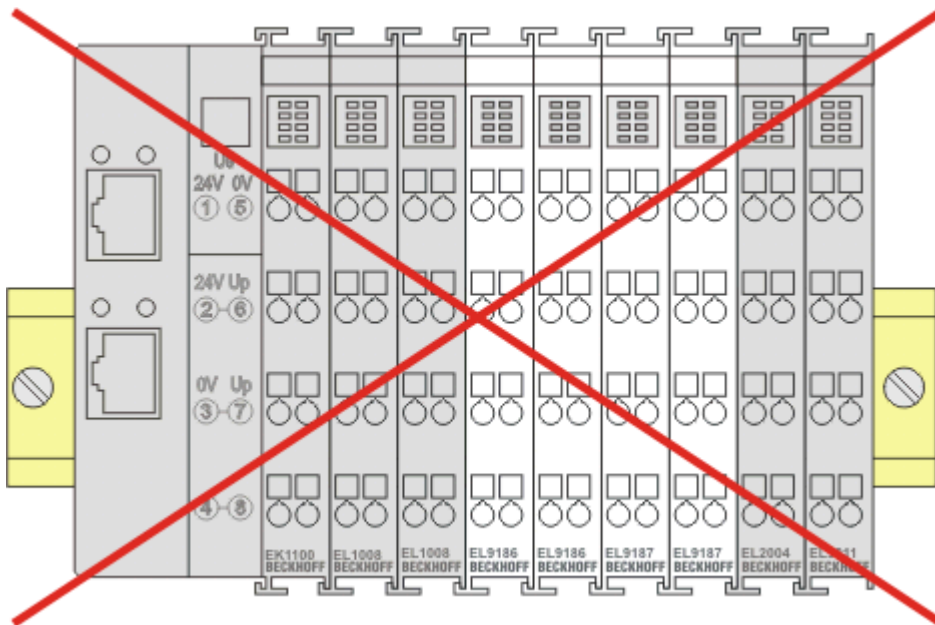


Fig. 25: *Incorrect configuration*

## 5.6 ATEX - Special conditions (standard temperature range)

| | |
|---|---|
| ⚠️ **WARNING** | **Observe the special conditions for the intended use of Beckhoff fieldbus components with standard temperature range in potentially explosive areas (directive 94/9/EU)!**<br><br>• The certified components are to be installed in a suitable housing that guarantees a protection class of at least IP54 in accordance with EN 60529! The environmental conditions during use are thereby to be taken into account!<br><br>• If the temperatures during rated operation are higher than 70°C at the feed-in points of cables, lines or pipes, or higher than 80°C at the wire branching points, then cables must be selected whose temperature data correspond to the actual measured temperature values!<br><br>• Observe the permissible ambient temperature range of 0 to 55°C for the use of Beckhoff fieldbus components standard temperature range in potentially explosive areas!<br><br>• Measures must be taken to protect against the rated operating voltage being exceeded by more than 40% due to short-term interference voltages!<br><br>• The individual terminals may only be unplugged or removed from the Bus Terminal system if the supply voltage has been switched off or if a non-explosive atmosphere is ensured!<br><br>• The connections of the certified components may only be connected or disconnected if the supply voltage has been switched off or if a non-explosive atmosphere is ensured!<br><br>• The fuses of the KL92xx/EL92xx power feed terminals may only be exchanged if the supply voltage has been switched off or if a non-explosive atmosphere is ensured!<br><br>• Address selectors and ID switches may only be adjusted if the supply voltage has been switched off or if a non-explosive atmosphere is ensured! |

**Standards**

The fundamental health and safety requirements are fulfilled by compliance with the following standards:

• EN 60079-0:2012+A11:2013
• EN 60079-15:2010

**Marking**

The Beckhoff fieldbus components with standard temperature range certified for potentially explosive areas bear one of the following markings:

⬡Ex **II 3G   KEMA 10ATEX0075 X Ex nA IIC T4 Gc   Ta: 0 … 55°C**

or

⬡Ex **II 3G   KEMA 10ATEX0075 X Ex nC IIC T4 Gc   Ta: 0 … 55°C**

## 5.7    ATEX Documentation

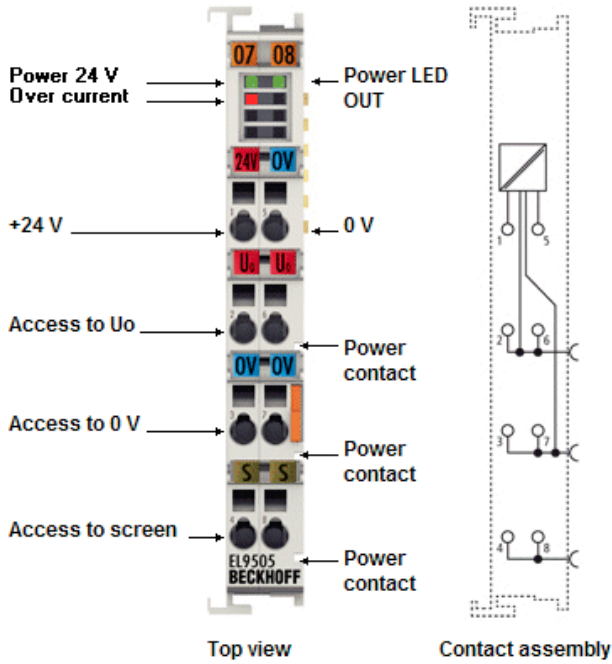| | |
|---|---|
| **i**<br><br>**Note** | **Notes about operation of the Beckhoff terminal systems in potentially explosive areas (ATEX)**<br><br>Pay also attention to the continuative documentation<br><br>Notes about operation of the Beckhoff terminal systems in potentially explosive areas (ATEX)<br><br>that is available in the download area of the Beckhoff homepage http:\\www.beckhoff.com! |

# 5.8 Pin assignment



Fig. 26: Pin assignment based on EL9505 as an example

| Terminal point | | Description |
|---|---|---|
| **Name** | **No.** | |
| +24 V | 1 | +24 V input voltage |
| Output $U_0$ | 2 | Pickup of output voltage $U_0$ (linked to terminal point 6 and power contact $U_0$) |
| Output 0 V | 3 | Pickup of output voltage 0 V (linked to terminal point 7 and power contact 0 V) |
| Shield / PE | 4 | Pickup of shielding / PE (linked to terminal point 8 and power contact shielding / PE) |
| 0 V | 5 | 0 V input voltage |
| Output $U_0$ | 6 | Pickup of output voltage $U_0$ (linked to terminal point 2 and power contact $U_0$) |
| Output 0 V | 7 | Pickup of output voltage 0 V (linked to terminal point 3 and power contact 0 V) |
| Shield / PE | 8 | Pickup of shielding / PE (linked to terminal point 4 and power contact shielding / PE) |

# 6 Commissioning

## 6.1 Inserting the terminal in the EtherCAT terminal network

(Master: TwinCAT 2.1x)

| | **Installation of the latest XML device description** |
|---|---|
| **i** <br> **Note** | Please ensure that you have installed the corresponding latest <u>XML</u> device description in TwinCAT. This can be downloaded from the Beckhoff Website and installed according to the installation instructions. |

The configuration tree in the Beckhoff TwinCAT System Manager can be created in 2 ways:

- by scanning of existing hardware (referred to as "online"), or
- by manually inserting/appending fieldbus devices, couplers and slaves.

**Automatic scanning in of the terminal**

- The Bus Terminal system must be in a safe, de-energized state before the terminals are inserted into the terminal network as described in section <u>Mounting rail installation [▶ 22]</u>.
- Once the operating voltage has been switched on, open the TwinCAT System Manager (Config mode) and scan in the terminal (see Fig. *Scanning in the EtherCAT configuration (I/O Devices -> right click -> Scan Devices…*). Acknowledge all dialogs with "*OK*", so that the configuration is in "FreeRun" mode.
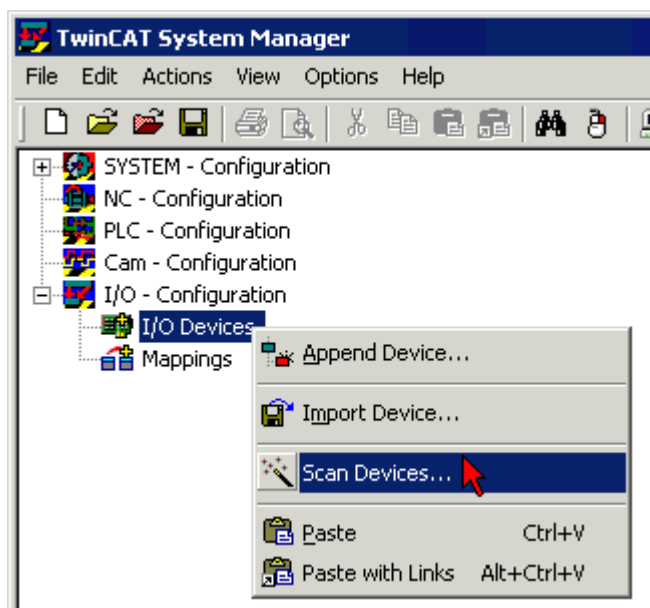


Fig. 27: Scanning in the EtherCAT configuration (I/O Devices-> right-click -> Scan Devices...)

**Appending a terminal manually**

- The Bus Terminal system must be in a safe, de-energized state before the terminals are inserted into the terminal network as described in section <u>Mounting rail installation [▶ 22]</u>.
- Switch on the operating voltage, open the TwinCAT System Manager (Config mode)
- Appending a new I/O device (see Fig. *Appending a new I/O device (I/O Devices -> right click -> Append Device…*). In the dialog that follows select the device *EtherCAT (Direct Mode)*, see Fig. *Selecting the device EtherCAT (Direct Mode)* and confirm with OK.
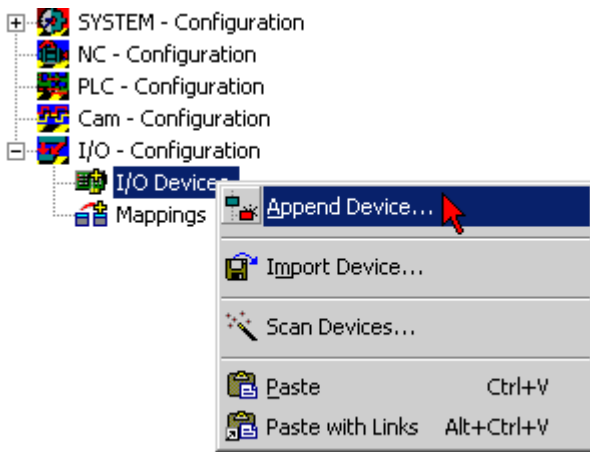
Fig. 28: Appending a new I/O device (I/O Devices-> right-click -> Append Device...)
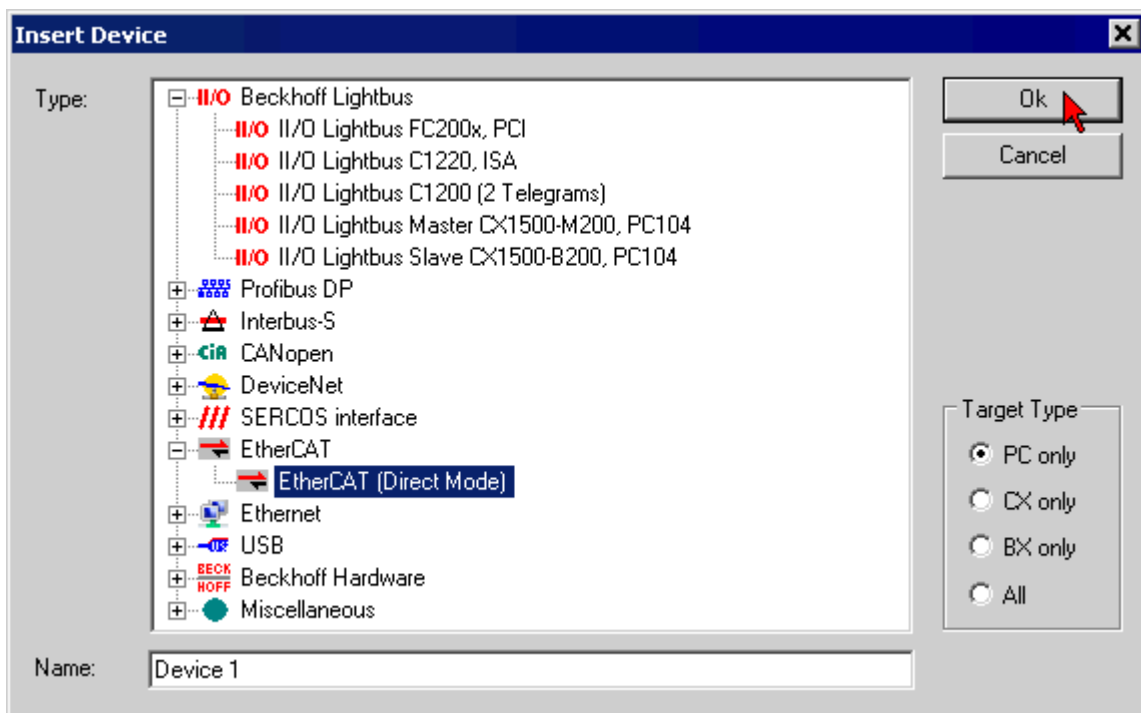


Fig. 29: Selecting the device EtherCAT (Direct Mode)

- Appending a new box (see Fig. *Appending a new box (Device -> right click -> Append Box…)*). In the dialog that follows select an EK1100 system coupler, for example (see Fig. *Selecting a system coupler (e.g. EK1100))* and confirm with OK.
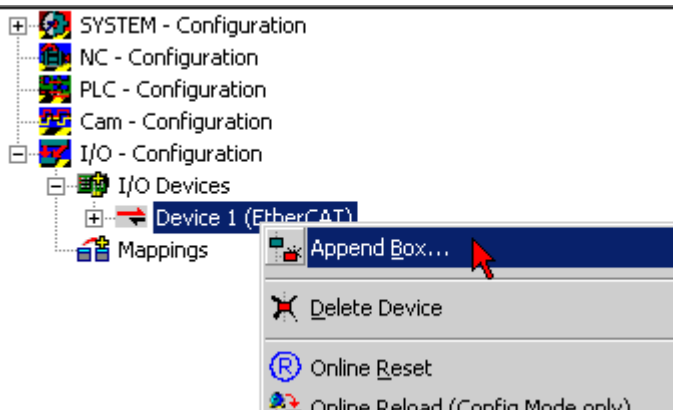


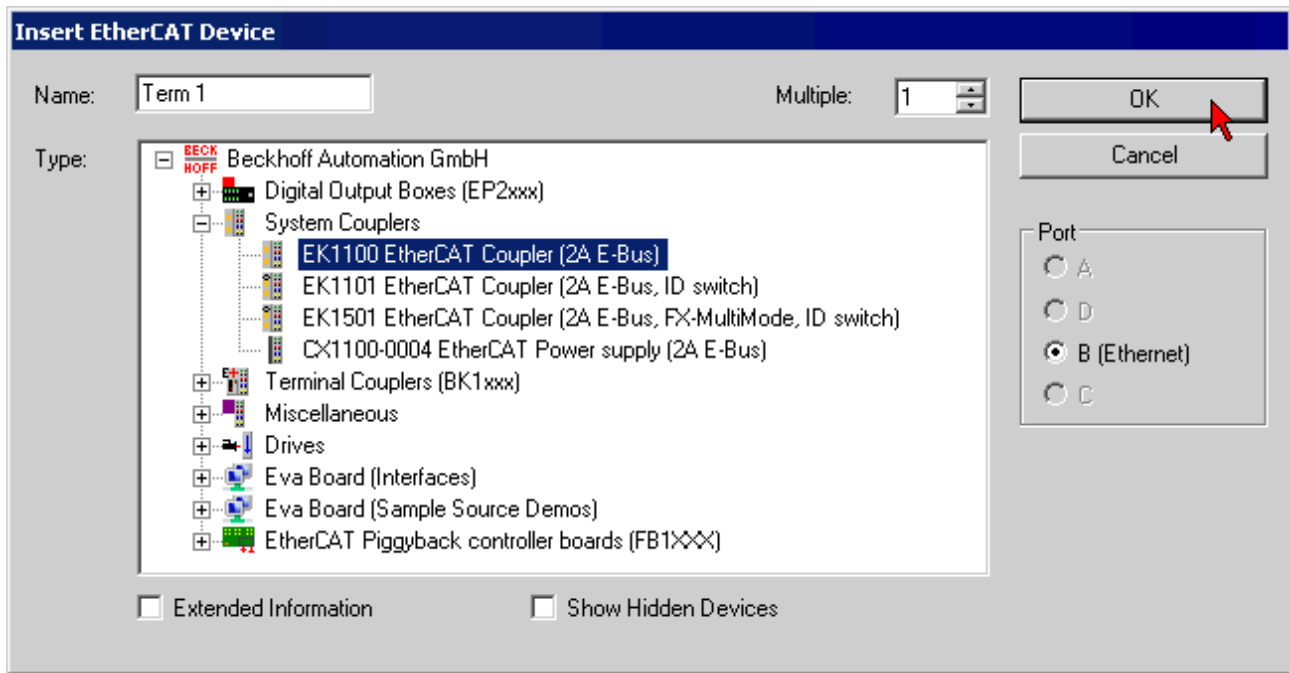Fig. 30: Appending a new box (Device -> right-click -> Append Box... )

**BECKHOFF**



Fig. 31: Selecting a system coupler (e.g. EK1100)

- Appending a new box (see Fig. *Appending a new box (Device -> right click -> Append Box…)*). In the dialog that follows select the EL95xx, (see Fig. *Selecting the terminal, e.g. EL9505*) and confirm with OK.
- The terminal is added in the TwinCAT tree (see Fig. *Terminal in the TwinCAT tree*).
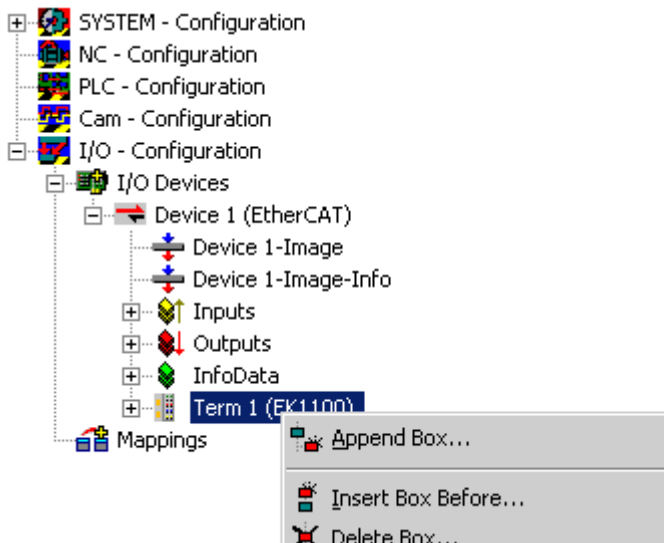


Fig. 32: Appending a new box (Device -> right-click -> Append Box... )
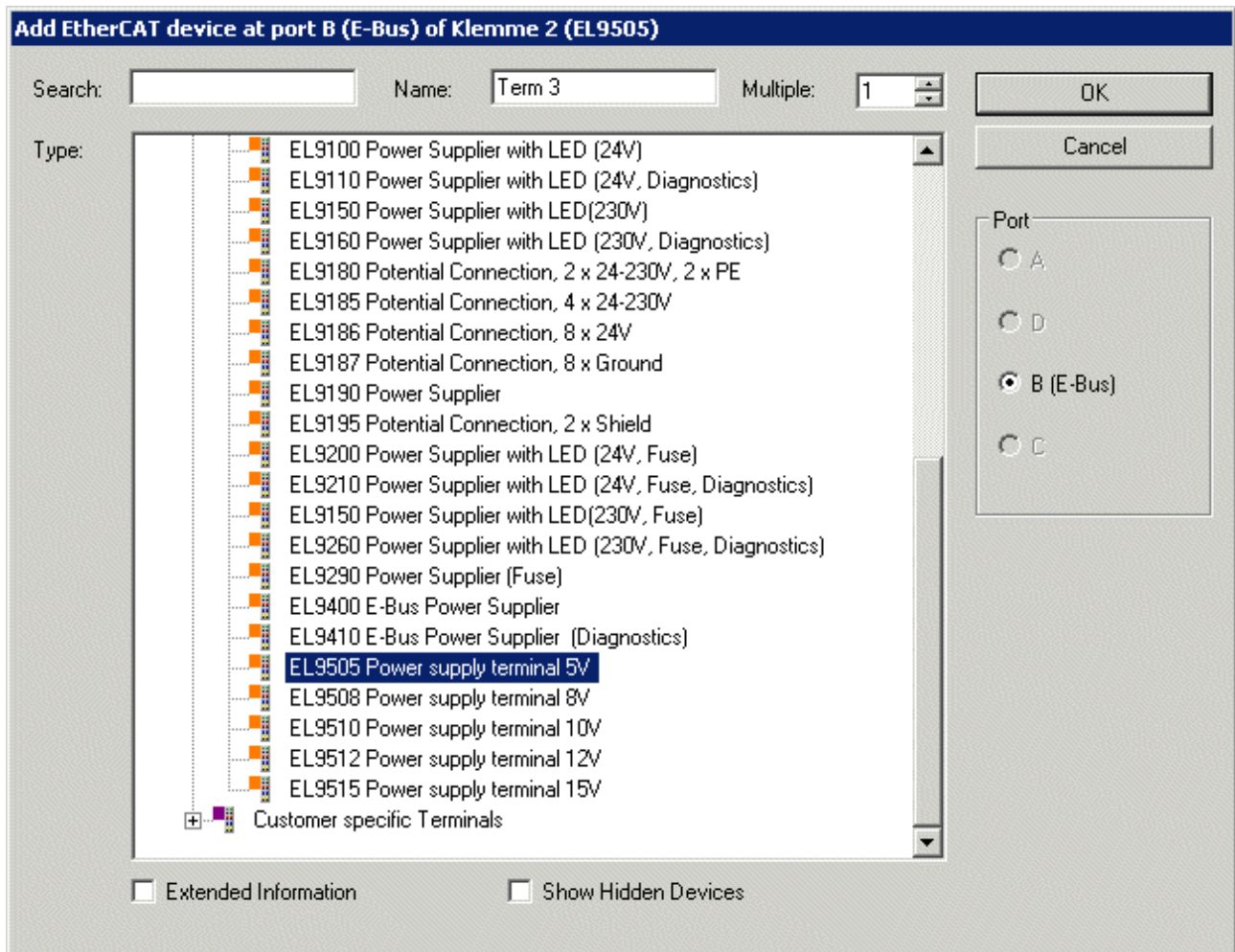
Fig. 33: Selecting the terminal, e.g. EL9505
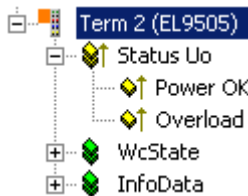


Fig. 34: Terminal in the TwinCAT tree

## 6.2 Process data

The "Process Data" tab of the EL95xx in the TwinCAT System Manager shows the PDO list of the EL95xx with the corresponding input objects. The width in the process image is 2 bits.
The index 0x1A00 ("Status $U_0$") contains the two boolean input objects "Power OK" (0x6000:01) for checking the output voltage and "Overload" (0x6000:02) for the overvoltage display.
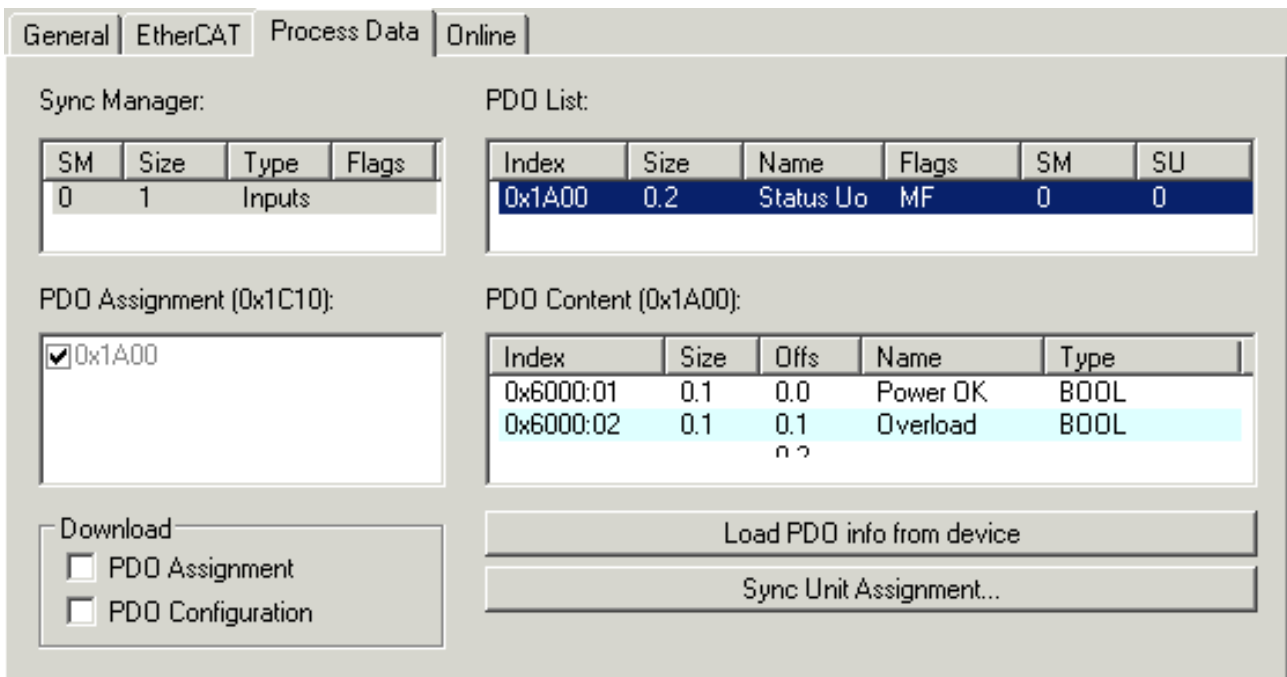
**BECKHOFF**



Fig. 35: EL95xx – "Process Data" tab

# 7 Appendix

## 7.1 UL notice

| | **Application** |
|---|---|
| c(UL)US | Beckhoff EtherCAT modules are intended for use with Beckhoff's UL Listed EtherCAT System only. |

| | **Examination** |
|---|---|
| c(UL)US | 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). |

| | **For devices with Ethernet connectors** |
|---|---|
| c(UL)US | Not for connection to telecommunication circuits. |

**Basic principles**

Two UL certificates are met in the Beckhoff EtherCAT product range, depending upon the components:

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

c(UL)US

Almost all current EtherCAT products (as at 2010/05) are UL certified without restrictions.

- UL certification according to UL508 with limited power consumption
  The current consumed by the device is limited to a max. possible current consumption of 4 A. Devices with this kind of certification are marked by this sign:

c(UL)US LISTED
Ind. Cont. Eq.: 24TB
Use 4 Amp. fuse or
Class 2 power supply.
See instructions.
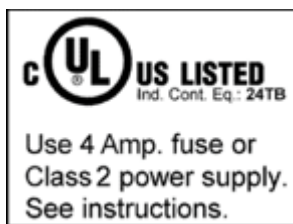
Almost all current EtherCAT products (as at 2010/05) are UL certified without restrictions.

**Application**

If terminals certified *with restrictions* are used, then the current consumption at 24 V $_{DC}$ must be limited accordingly by means of supply

- from an isolated source protected by a fuse of max. 4A (according to UL248) or
- from a voltage supply complying with *NEC class 2*.
  A voltage source complying with *NEC class 2* may not be connected in series or parallel with another *NEC class 2* compliant voltage supply!

These requirements apply to the supply of all EtherCAT bus couplers, power adaptor terminals, Bus Terminals and their power contacts.

## 7.2    Firmware compatibility

The terminals of the EL95xx series have no firmware.

# 7.3 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:
http://www.beckhoff.com

You will also find further documentation for Beckhoff components there.

**Beckhoff Headquarters**

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| e-mail: | info@beckhoff.com |

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- and extensive training program for Beckhoff system components

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- spare parts service
- hotline service

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| Fax: | +49(0)5246/963-479 |
| e-mail: | service@beckhoff.com |

# List of illustrations