Dokumentation

EP9128

EtherCAT Junction with protection class IP67

Version	2.2.0
Date	2015-07-13

BECKHOFF

Table of contents

1 Foreword

1.1 Notes on the documentation

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 following notes and explanations are followed when installing and commissioning these components.

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.
For that reason the documentation is not in every case checked for consistency with performance data, standards or other characteristics.
In the event that it contains technical or editorial errors, we retain the right to make alterations at any time and without warning.
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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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.

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

1.3 Documentation issue status

Version	Comment
2.2.0	• Power Connection updated
2.1.0	• Nut torque for connectors extended
2.0.0	• Migration
1.1.0	• Chapter *Basic Function Principles* updated • English translation available
1.0.0	• First release
0.1.0	• preliminary version

Firm and hardware versions

The documentation refers to the firm and hardware status that was valid at the time it was prepared.

The properties of the modules are subject to continuous development and improvement. Modules having earlier production statuses cannot have the same properties as modules with the latest status. Existing properties, however, are always retained and are not changed, so that these modules can always be replaced by new ones.

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

Syntax of the batch number (D number):

D: WW YY FF HH

WW - week of production (calendar week)
YY - year of production
FF - firmware version
HH - hardware version

Example with D-Nr. 29 10 02 01:

29 - week of production 29
10 - year of production 2010
02 - firmware version
01 - hardware version

2 Product overview

2.1 EtherCAT Box - Introduction

The EtherCAT system has been extended with EtherCAT Box modules with protection class IP 67. Through the integrated EtherCAT interface the modules can be connected directly to an EtherCAT network without an additional Coupler Box. The high-performance of EtherCAT is thus maintained into each module.

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

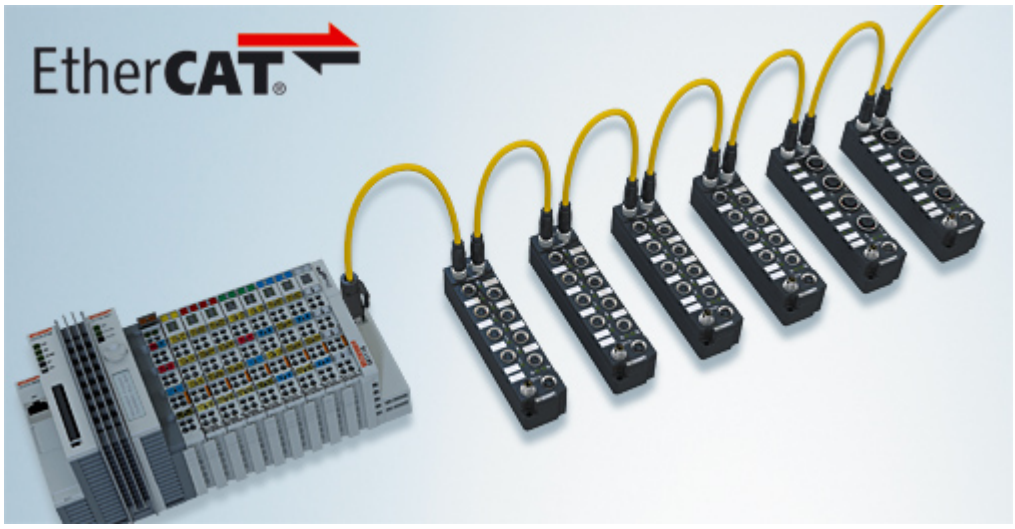

Fig. 1: EtherCAT Box Modules within an EtherCAT network

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

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

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

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

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

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

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

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

Note	**XML files** You will find XML files (XML Device Description Files) for Beckhoff EtherCAT modules on our website (www.beckhoff.com) under Downloads, in the Configuration Files area.

2.2 EP9128-0021- Introduction

Fig. 4: EP9128

8 channel EtherCAT junction with protection class IP67

Line, tree or star: EtherCAT supports virtually any topologies, which can also be directly branched in the field using the EtherCAT Box modules

If several junctions are required at one point in the star topology, an EtherCAT junction EP9128 with eight sockets can be used instead of several EP1122.

The EtherCAT network is connected to the input port 1 of the EP9128-0021 and can be extended at ports 2 to 8.
EtherCAT topologies can be arranged even more flexibly with the EP9128 EtherCAT junction in IP67, since connection to the IP20 world is also possible via the ports.

The EtherCAT junctions are connected via shielded M8 sockets with direct display of link and activity status.

In conjunction with TwinCAT or other suitable EtherCAT masters the EP9128-0021 also supports coupling and uncoupling of EtherCAT strands during operation (Hot Connect).

The device cannot be used as a standard Ethernet switch.

Quick links

Installation [▶ 23]

UL requirements [▶ 38] for UL-approved modules

2.3 Technical data

Technical data	EP9128-0021
Fieldbus	EtherCAT
Functionality EtherCAT	coupling of EtherCAT junctions
Data transfer medium	Ethernet/EtherCAT cable (CAT 5 min.), shielded
Fieldbus connector copper	8 x M8 socket (green)
Cable length	100 m, twisted pair or in star quad formation CAT 5 (e)
Protocol	EtherCAT
Configuration	not necessary
Distributed clocks	yes
Delay	app. 1 µsec / Port
Supply voltage	24 V_{DC} (18 V_{DC} to 30 V_{DC})
Supply of module electronic	from control voltage Us
Current consumption of module electronic	typical 150 mA
Permissible ambient temperature at operation	-25°C ... +60°C 0°C ... +55°C (according to cULus, see UL requirements [▶ 38])
Permissible ambient temperature at storage	-40°C ... +85°C
Dimensions (B x H x T)	60 mm x 126 mm x 26.5 mm (without connectors)
Vibration / shock resistance	according to EN 60068-2-6 / EN 60068-2-27
EMC immunity / emission	according to EN 61000-6-2 / EN 61000-6-4
Protection class	IP65, IP66, IP67 (according to EN 60529)
Installation position	any
Weight	app. 300 g
Approvals	CE cULus (in preparation)

3 Basic functioin principles

3.1 Basic function principles of EtherCAT junctions

Some Beckhoff EtherCAT devices can be used for junctions in the EtherCAT segment. These include EK1122, EK1521, EP1122, CU1128 and EP9128. In the following examples only the EK1122 is used. The technical and system characteristics of the other devices are similar.

EtherCAT handling in the slaves

With EtherCAT as fieldbus protocol a wide range of bus topologies can be used: line, star and tree topology, with redundancy support even ring topology. The simplest topology is the line topology, in which each EtherCAT slave hands data over to the **only** available next slave.

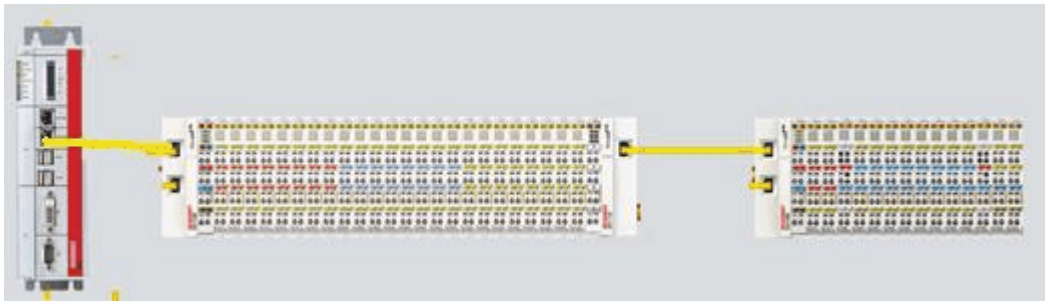

Fig. 5: EtherCAT line topology

If EK1100 EtherCAT couplers are used, for example, junctions and therefore a kind of tree topology is possible.

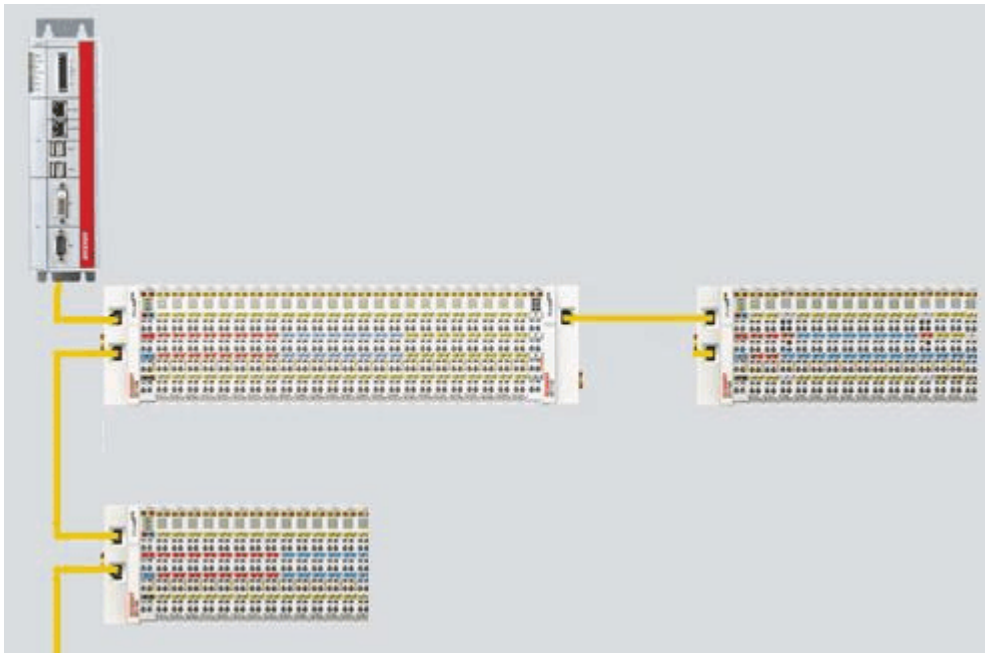

Fig. 6: Line topology with extensions

The basic principle is that internally the Ethernet frame(s) with the EtherCAT protocol data continue to be transported in a logical ring:

- the EtherCAT master sends the frame on the two outgoing lines of the Ethernet cable
- this frame passes each slave once,
- is reversed by the last slave in the logical sequence and

- is returned to the master through each EtherCAT slave via two return lines of the Ethernet cable without further processing.

At short cycle times in the order of 50 µs at 20,000 Ethernet frames are in transit in the EtherCAT system every second, plus acyclic organizational frames. The master awaits the return of the sent frames, which return the device input data to the master, for example. Telegram transfer between slaves is link-based: An EtherCAT slave will only forward a frame if a 'link' signal to the next device is present. Normally it can be assumed that the downstream device correctly processes each EtherCAT telegram and returns or process it at the end.

The crucial factor for forwarding EtherCAT telegrams is that a link signal is reported only from one slave to the next if both slaves are actually ready for real-time participation in data processing. Specifically, this means that an EtherCAT slave should not open the respective Ethernet port until it is ready to receive and forward an Ethernet frame immediately.

A switch or router is usually used for standard Ethernet traffic forwarding. Any collisions or frame losses are compensated through frame repetition in the higher level protocol layers (e.g. TCP). This mode is generally not used for EtherCAT due to the short cycle times and the real-time requirement. Some Ethernet devices such as special switches, for example, report a link to the remote terminal even if they will only be ready for data processing in a few milliseconds. This behavior is particularly noticeable in media converters from 100Base-TX (copper) to 100Base-Fx (optical fiber), which may report a link to the preceding EtherCAT slave even if the optical fiber connection is interrupted, depending on the setting on the copper side.

Fast link detection is therefore a central component of each ESC (EtherCAT slave controller, hardware processing unit for the EtherCAT protocol). According to the EtherCAT specification an ESC can have and control 1 to 4 ports. Via an open port it can handle outgoing and incoming Ethernet traffic. Fig. 3 shows the direction of the data flow in a fully configured ESC. In the EtherCAT datagrams the data are only processed between ports 0 (A) and 3 (D) in the EtherCAT processing unit.

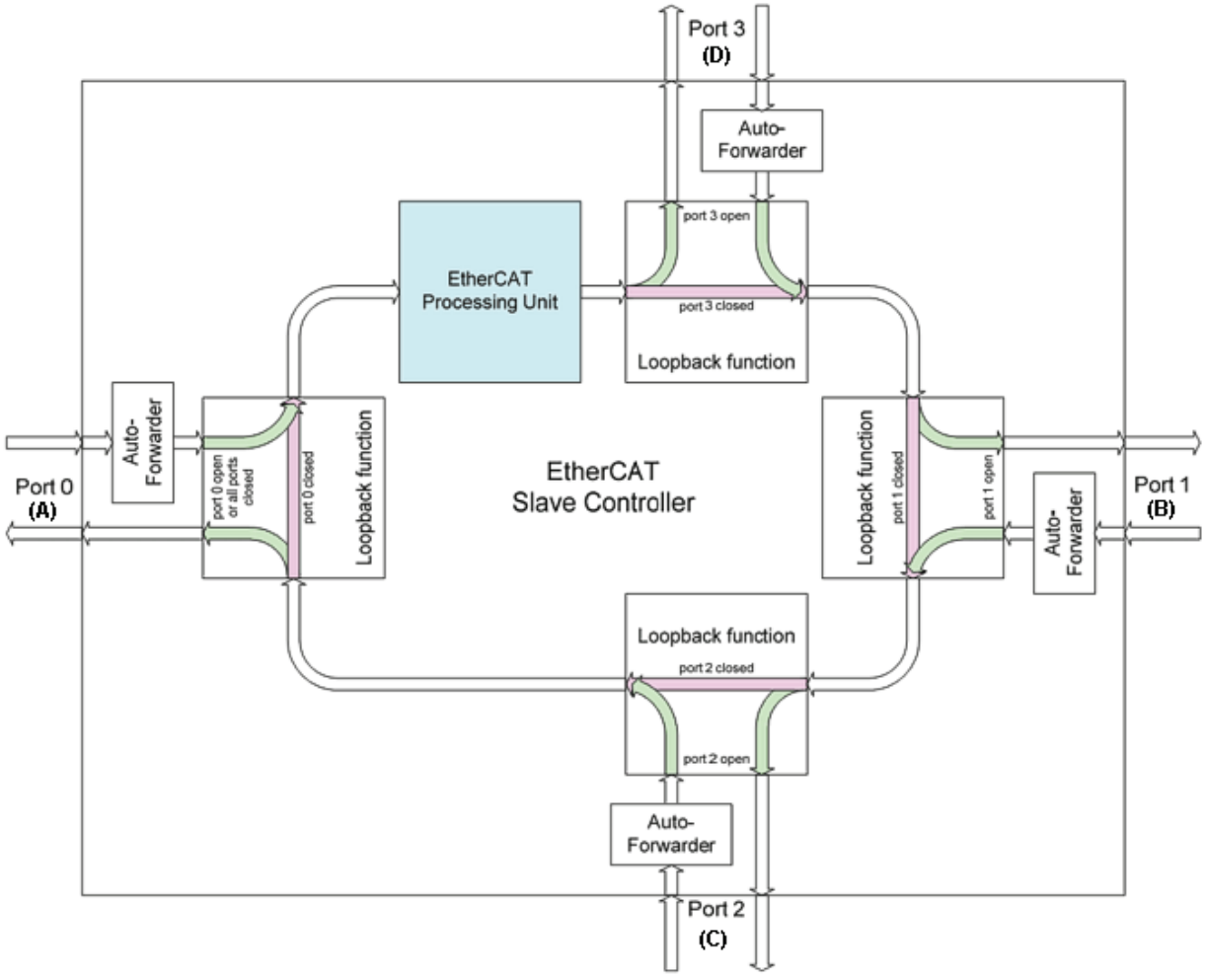

Fig. 7: Direction of data flow in the ESC

Ideally link detection and therefore port handling in the ESC should be fast enough that lost frame events are avoided even at 100 µs cycle time. Nevertheless, at least one lost frame can never be ruled out if a connection is disconnected while an Ethernet frame is in transit on this line and in the bus segment downstream of the separation point.

Implementation: EL terminal

A standard EtherCAT slave such as a Beckhoff EL terminal has 2 ports:

- one for incoming frames (port 0 [A])
- one for outgoing frames (e.g. port [D]).

The other two ports are internally closed in the ESC. An EtherCAT telegram enters the processing unit via port 0 (A)/top and is forwarded to the next slave via port 3 (D)/left, if a link to this port exists - see green arrows. This is the case if a further EL terminal is connected to the right.

If no link exists, the frame is forwarded to port 1(B) via the purple route. This and port 2 (C) have no link and therefore return the frame to port 0 (A), where the frame leaves via the same Ethernet port through which it arrived at the slave. This is the case if the terminal acts as end terminal.

An EtherCAT device with a single port is therefore only of limited use, since it can only be used as end device.

Implementation: EK1100 EtherCAT coupler

In the EK1100 EtherCAT coupler 3 of the 4 available ports are used, so that a connection to the right to terminals and via an RJ45 socket to further couplers is possible, see Fig. 2. In the EK1100 the processing unit is not used for process data exchange.

Implementation: EK1122 EtherCAT junction

In the EK1122 all 4 ESC ports can be connected - two via the internal E-bus and two via the RJ45 sockets with Ethernet configuration. In the TwinCAT System Manager the link statuses of ports 0, 1, 2 and 3 are indicated via the online display as port A, B, C and D, see *Fig. Topology display for interrupted line*.

Implementation: EK1521 / EK1521-0010 / EK1561 EtherCAT junction

As in the EK1100, three ESC ports can be connected in these junctions: Two via E-bus within the terminal and one via the SC socket/versatile link and optical fibre cable/POF line.

Implementation: CU1128 and EP9128 EtherCAT junctions

The CU1128 integrates three ESCs, which means eight ports in total are available to users. The three ESCs are interconnected via E-bus.

Example configuration with EK1122

The following section describes the link characteristics under TwinCAT and its representation in the System Manager.

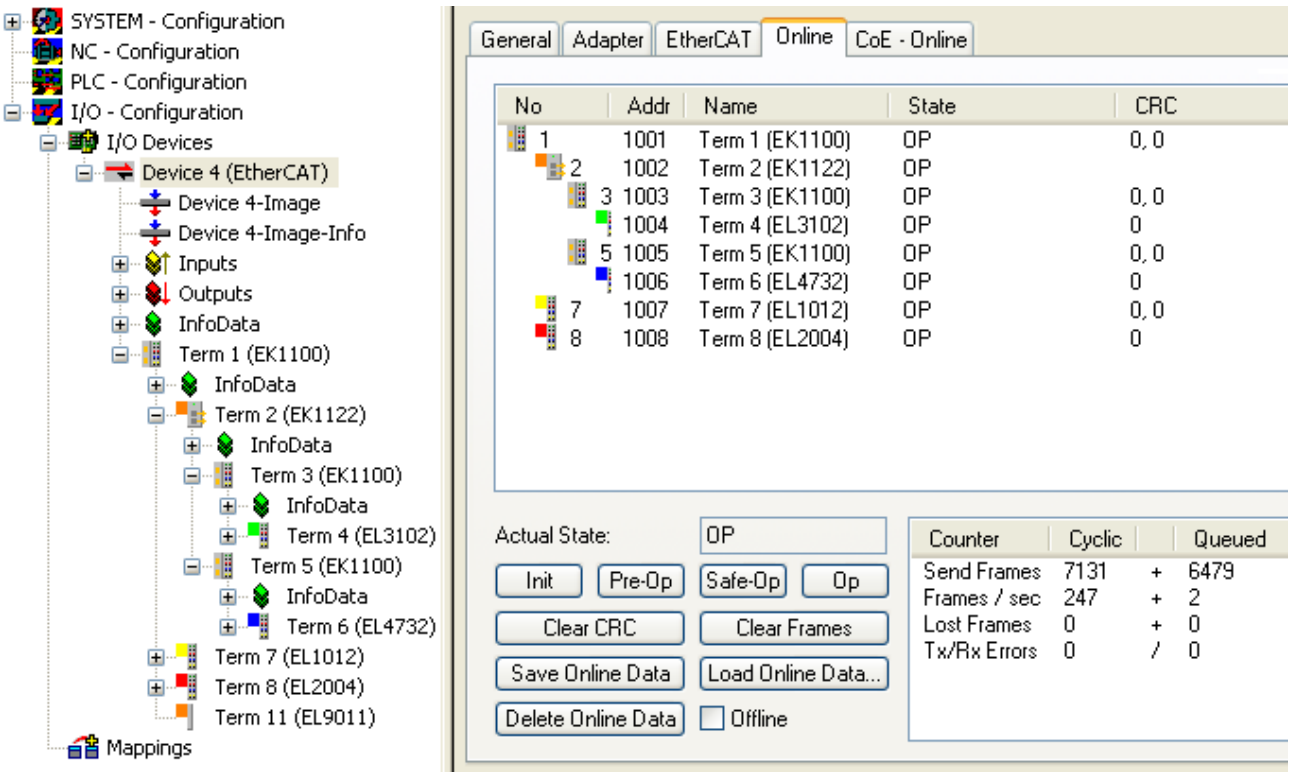

Fig. 8: Example Configuration with EK1122

The TwinCAT online topology shows the wiring scheme, see Fig. 5. The EK1122 is selected, so that further information is shown. The green bars above the slaves indicate the correct RUN state in all slaves.

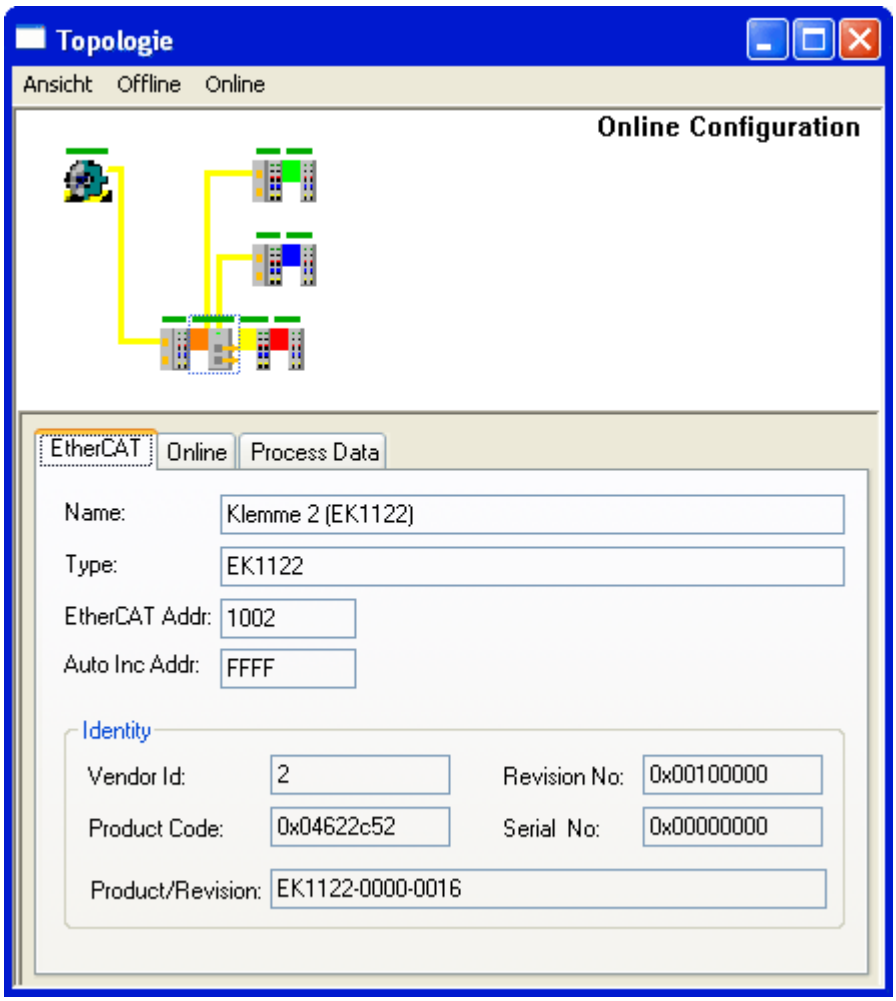

Fig. 9: Online topology

An error is now generated by disconnecting the connection between the upper RJ45 socket (X1) and the EL3102 device. Within a few µs the ESC in the EK1122 detects the lost link and automatically closes the affected port. This has the effect that the next incoming EtherCAT telegram is immediately forwarded to port D (port 3) and the EL4732. The link is therefore missing and the System Manager indicates this in the online display, see Fig. 6.

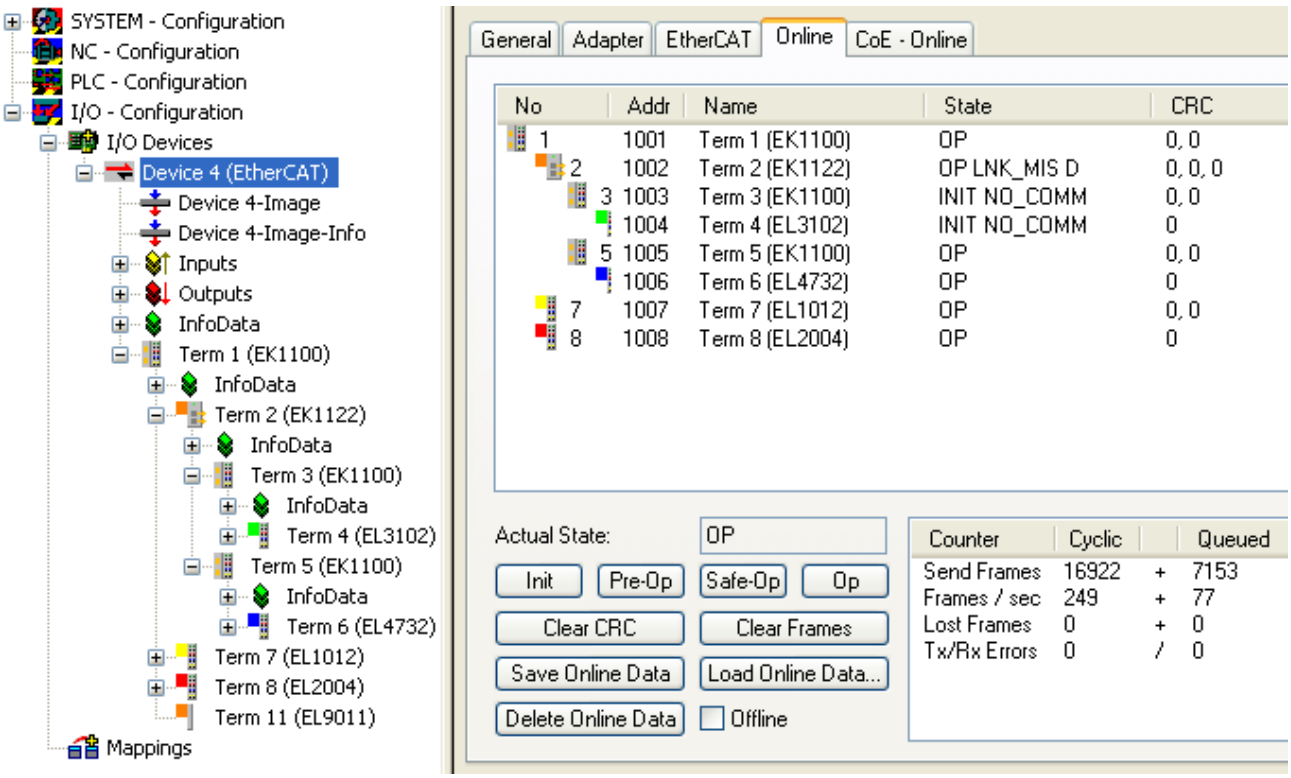

Fig. 10: Example configuration with interrupted cable

The System Manager messages can be interpreted as follows:

- Address 1002 - EK1122: "OP LNK:MIS D": The slave is in OP state, although a link is missing at port D (3) that should be present according to the configuration
- Address 1003 - EK1100: "INIT NO_COMM": Since communication with this slave is interrupted its state is shown as INIT
- Address 1004 - EL3104: ditto

Note	**Logger output** The logger output can be displayed in the lower part of the System Manager (Display--> Show Logger Output). This may be helpful for diagnostic purposes (for link interruptions and other situations).

In the topology display any slaves affected by interruption are shown with a red border, see following Fig.

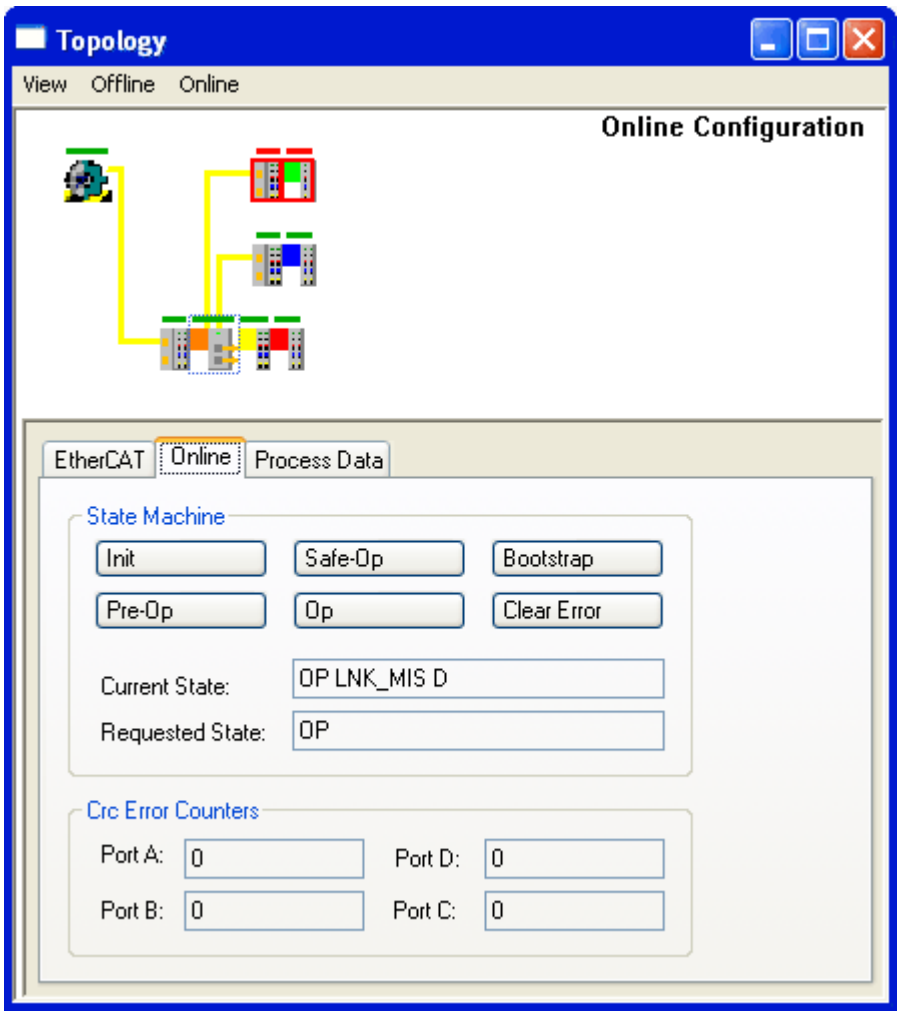

Fig. 11: Topology display for interrupted line

Please note the acyclic frame display for *Fig. Example Configuration with EK1122* and for *Fig. Example configuration with interrupted cable*.

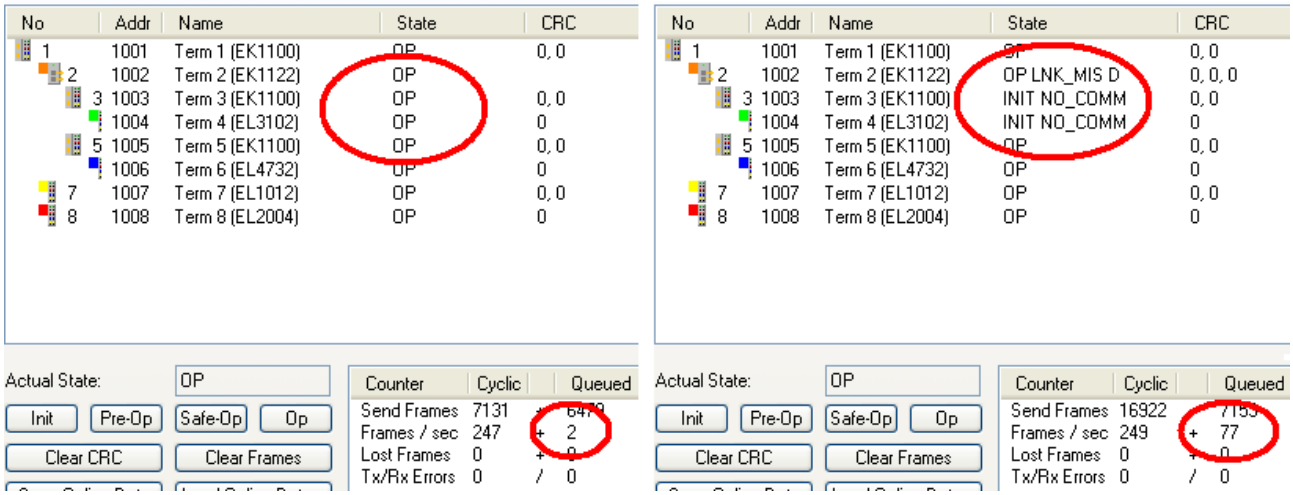

Fig. 12: Comparison of the frame displays

The image on the left shows a small number (2) of acyclic frames sent by the master during the respective second - all slaves are operating properly. The image on the right shows a significant increase (currently 77 acyclic frames/sec): The EtherCAT master has quickly detected that not all slaves are properly taking part in the data exchange. Once the master has located the fault, it continuously tries to restore the connection.

Reconnection

Once the connection has been restored, the EK1122 reports to the master that a link is present again at port D (3). The EtherCAT master will then make its process data available again for this section. One the preparations are complete, it will instruct the EK1122 to re-open port D (3) for regular data exchange. Cyclic and acyclic data traffic with the other EtherCAT slaves continues normally.

Note	**External access to EtherCAT diagnostics** The system offers a wide range of options for accessing status and diagnostic information and EtherCAT master functions from the PLC. Almost all information displayed by the System Manager online can also be retrieved via ADS (see figures on this page). System Manager functions can also be triggered via PLC or ADS. Please refer to the relevant sections in the Beckhoff Information System and the notes on EtherCAT diagnostics.

3.2 Basic function principles

The EtherCAT star hub EP9128 is an infrastructure device without controllable input/output data (I/O). It can be used

- as a junction point for conducted Fast Ethernet, in order to connect EtherCAT terminal stations, drives or any other EtherCAT slaves to drop lines
- as distributed clocks reference clock (see EtherCAT System Documentation)

It has no I/O and no CoE directory and is not parameterizable. The core functions of the link control and distributed clocks synchronization are mapped by the ESCs.

Structure

In order to provide 8 EtherCAT ports, the EP9128 has three internal communication ICs (ESCs), which are connected in series internally. For this reason the EP9128 appears as three individual slaves in the EtherCAT configurator, although they are located in one housing. The interrelationship between the internal ESC ports (A, B, C, D) and the descriptions of the connection sockets (1 to 8) is as follows:

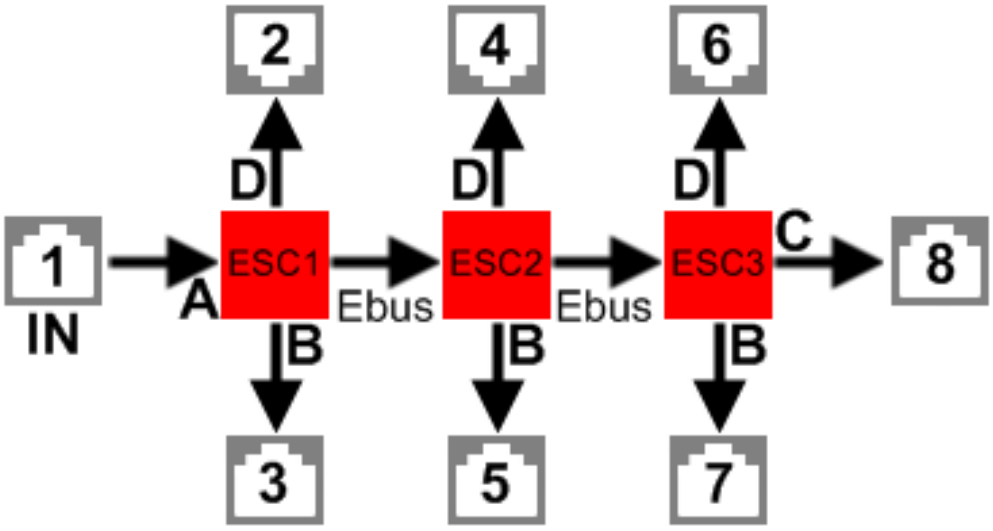

Fig. 13: EP9128 diagram

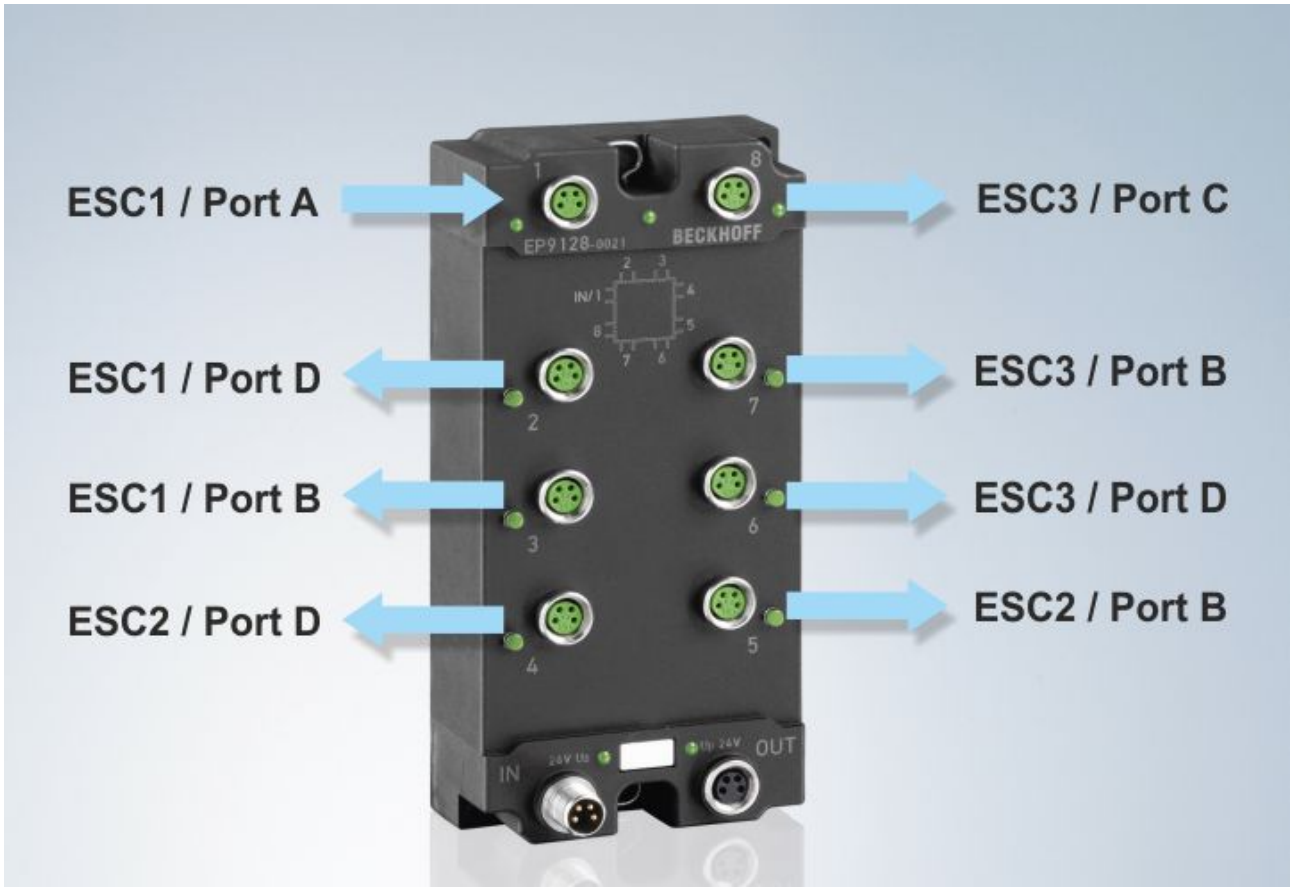

Fig. 14: Physical arrangement of the EP9128's ports

Accordingly, 3 devices are displayed in the TwinCAT System Manager:

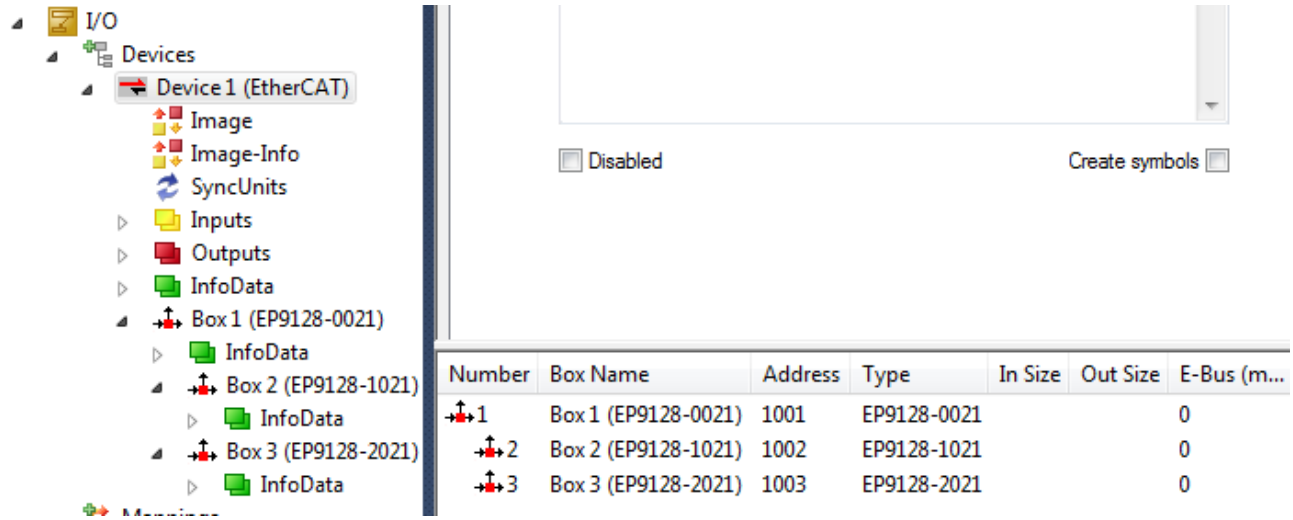

Fig. 15: Slaves in the TwinCAT System Manager

Please note:

- port 1 is always the input for the EtherCAT traffic in the EP9128
- the other ports (2 to 7) should be used as outputs
- it is not permitted to delete sub devices once the EP9128 has been configured

For differentiation see also EEPROM Update [▶ 41].

Note	**Connection to the EtherCAT Master** The connection to the EtherCAT Master resp. in the direction of the Master has to be done on port 1! All other ports can be used for outgoing EtherCAT traffic. No special sequence is required.

Topological configuration

With the EP9128, special attention should be paid to the sequence of the EtherCAT slaves. Since the EP9128 has seven junction ports, drop lines connected to ports must and can be clearly identified in practice. If incorrect information is provided in the configuration (TwinCAT System Manager file *.tsm), the system cannot start.

For each EtherCAT device the System Manager indicates at which *PreviousPort* it is connected, i.e. the name of the connected port (B to D) of the previous slave. This also applies for the internal connections between the ESCs in the EP9128:

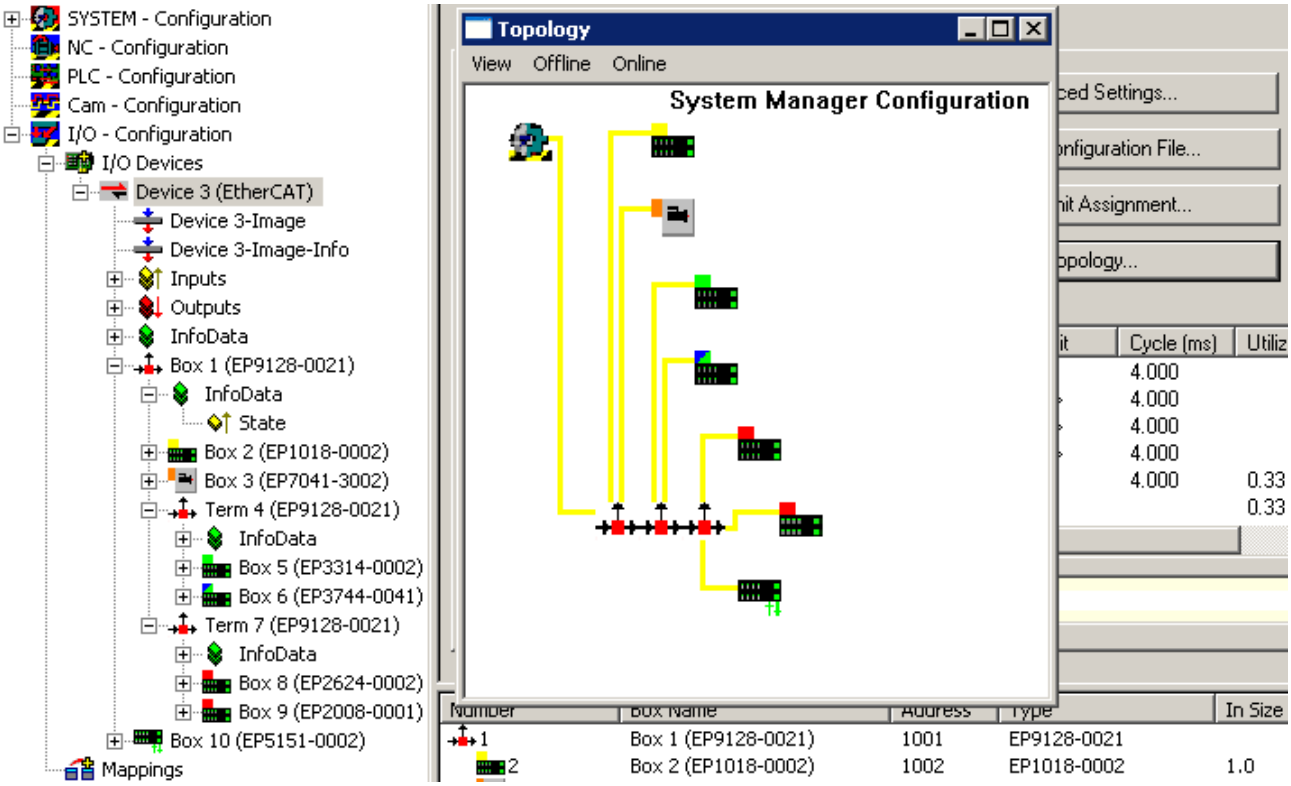

Fig. 16: Previous port of the second ESC in the EP9128

The Fig. above shows a topology as an example, with

- EP1018-0002 at port 2
- EP7041-3002 at port 3
- EP3314-002 at port 4
- EP3744-0041 at port 5
- EP2624-0002 at port 6
- EP2008-0001 at port 7 and
- EP5151-0002 at port 8

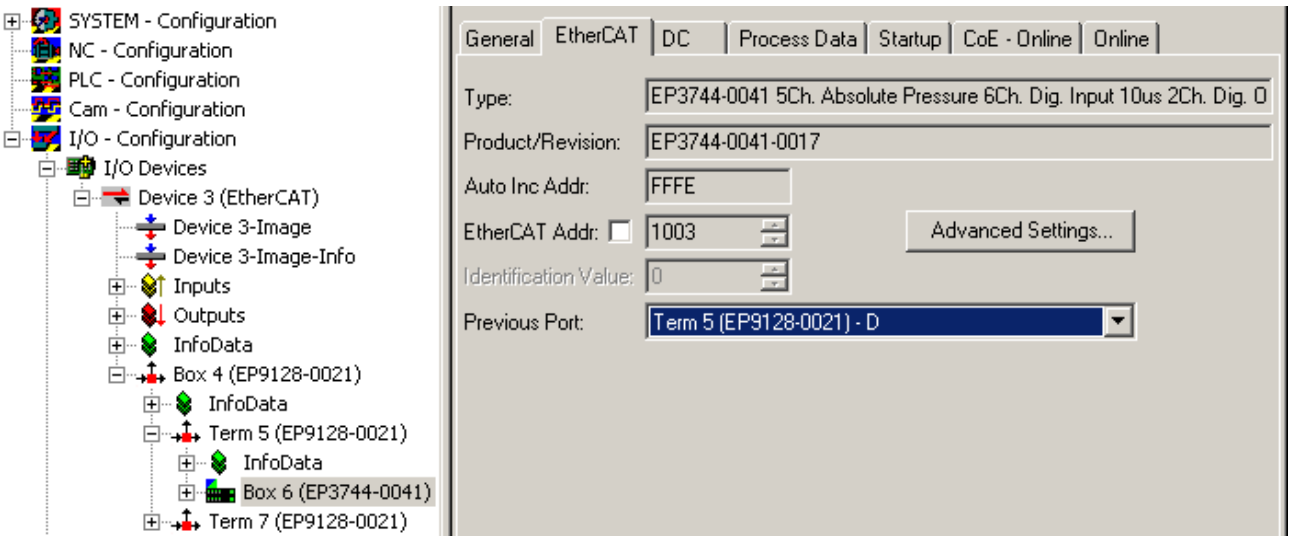

Fig. 17: Setting the PreviousPort for an EP box

In the Fig. above the box 6 successor is set up at port 5, which means the PreviousPort selection of the EP3744 shows the free port D of ESC2 (B and D, see *Fig. EP9128 diagram*).
The internal connections in the EP9128 are E-bus connections, the 8 ports on the other hand are Ethernet, see *Fig. EP9128 diagram*.

See also *notes for configuration setup*.

3.3 LED displays

EtherCAT

For each channel an LED indicates the current status (example port2).

Fig. 18: LED display per channel

LED	Display	
Link Act	off	No connection
	on	Connection available (link)
	flashing	Data transfer (act)

Power supply

The presence of the supply voltages (24 V_{DC}) is indicated by the two green Power LEDs.

Us is used for the module electronics, Up is passed through.

Fig. 19: LED display for the supply voltages

4 Mounting and cabling

4.1 Mounting

4.1.1 Dimensions

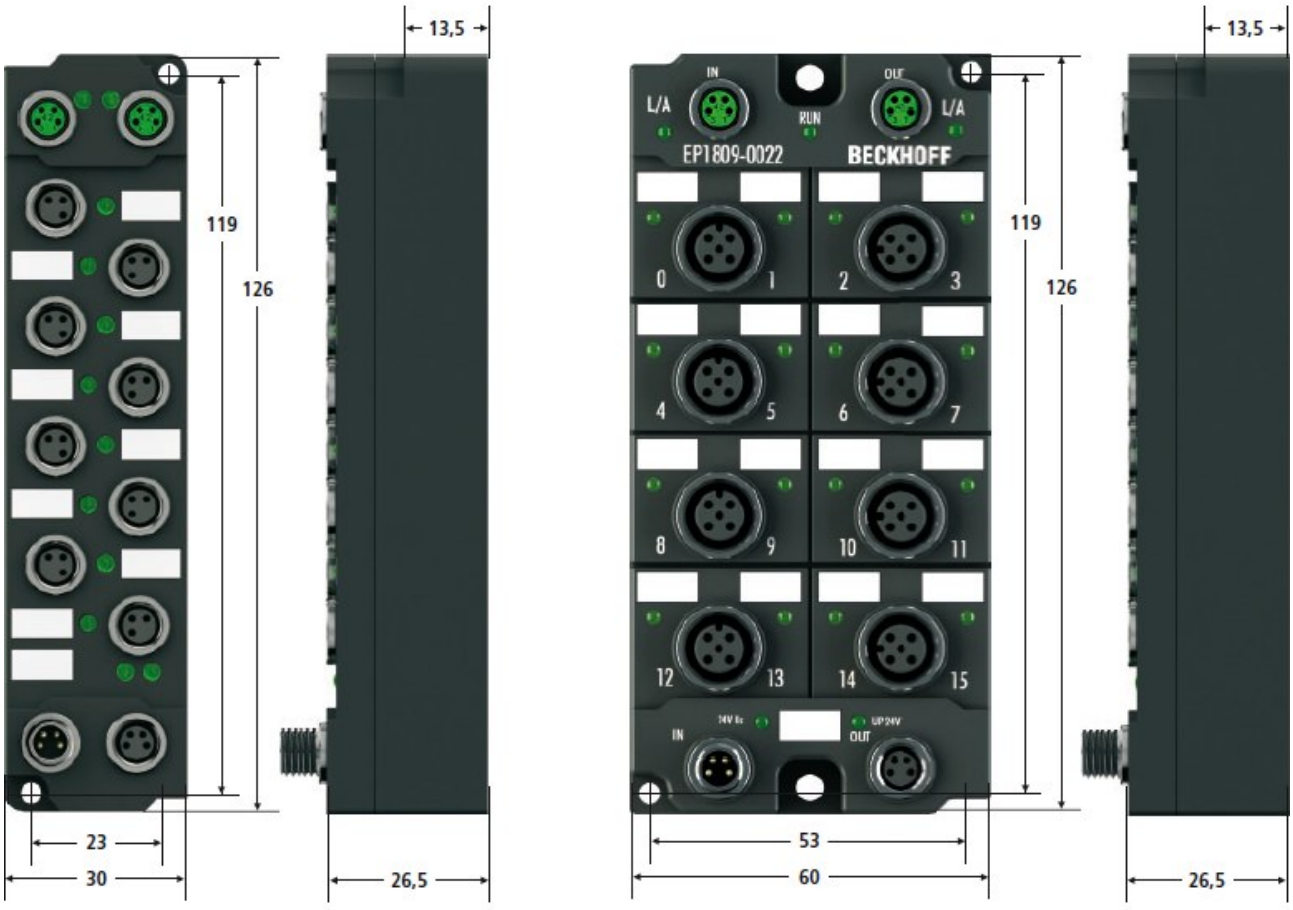

Fig. 20: Dimensions of the EtherCAT Box Modules

All dimensions are given in millimeters.

Housing properties

EtherCAT Box	lean body	wide body
Housing material	PA6 (polyamide)	
Casting compound	Polyurethane	
Mounting	two fastening holes Ø 3 mm for M3	two fastening holes Ø 3 mm for M3 two fastening holes Ø 4,5 mm for M4
Metal parts	Brass, nickel-plated	
Contacts	CuZn, gold-plated	
Power feed through	max. 4 A	
Installation position	variable	
Protection class	IP65, IP66, IP67 (conforms to EN 60529) when screwed together	
Dimensions (H x W x D)	ca. 126 x 30 x 26,5 mm	ca. 126 x 60 x 26,5 mm
Weight	approx. 125 g, depending on module type	approx. 250 g, depending on module type

4.1.2 Fixing

Note	**Note or pointer** While mounting the modules, protect all connectors, especially the IP-Link, against contamination! Only with connected cables or plugs the protection class IP67 is guaranteed! Unused connectors have to be protected with the right plugs! See for plug sets in the catalogue.

Modules with narrow housing are mounted with two M3 bolts.
Modules with wide housing are mounted with two M3 bolts to the fixing holes located at the corners or mounted with two M4 bolts to the fixing holes located centrally.

The bolts must be longer than 15 mm. The fixing holes of the modules are not threaded.

When assembling, remember that the fieldbus connectors increases the overall height. See chapter accessories.

Mounting Rail ZS5300-0001

The mounting rail ZS5300-0001 (500 mm x 129 mm) allows the time saving assembly of modules.

The rail is made of stainless steel, 1.5 mm thick, with already pre-made M3 threads for the modules. The rail has got 5.3 mm slots to mount it via M5 screws to the machine.

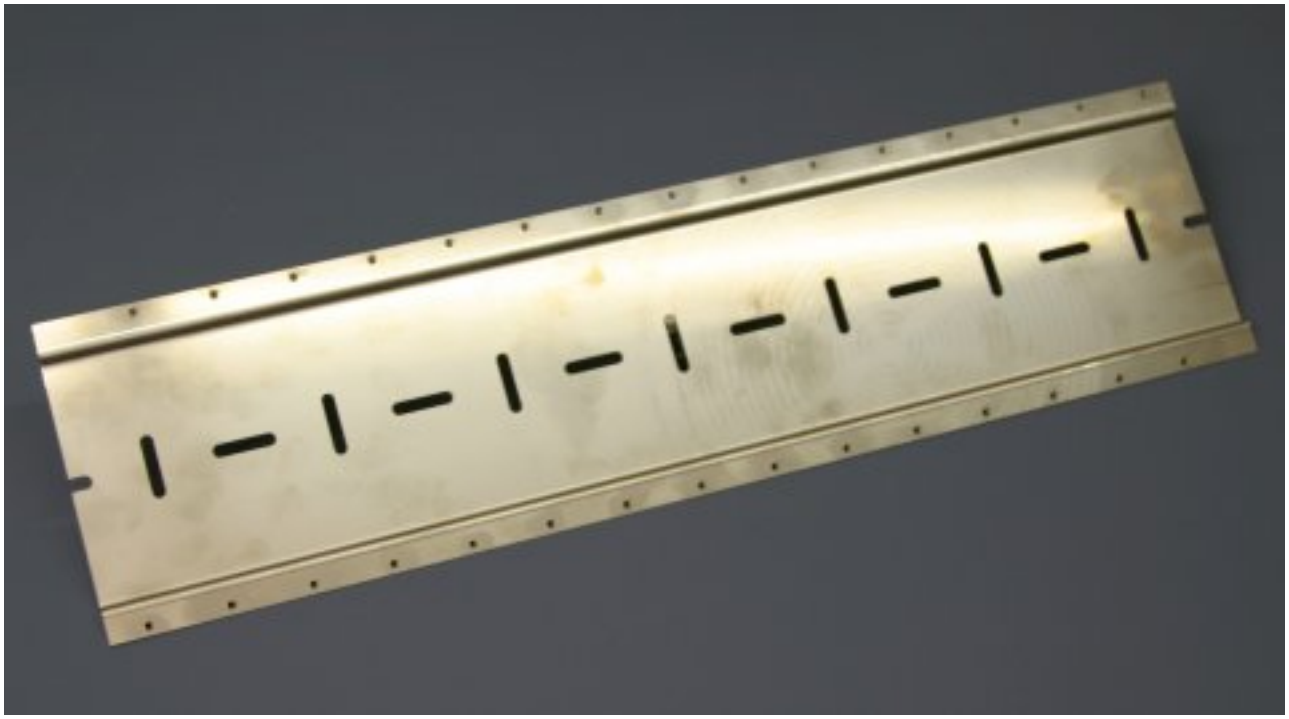

Fig. 21: Mounting Rail ZS5300-000

The mounting rail is 500 mm long, that way 15 narrow modules can be mounted with a distance of 2 mm between two modules. The rail can be cut to length for the application.

Mounting Rail ZS5300-0011

The mounting rail ZS5300-0011 (500 mm x 129 mm) has in addition to the M3 treads also pre-made M4 treads to fix 60 mm wide modules via their middle holes.

Up to 14 narrow or 7 wide modules may be mixed mounted.

4.1.3 Nut torque for connectors

M8 connectors

It is recommended to pull the M8 connectors tight with a nut torque of **0.4 Nm**.

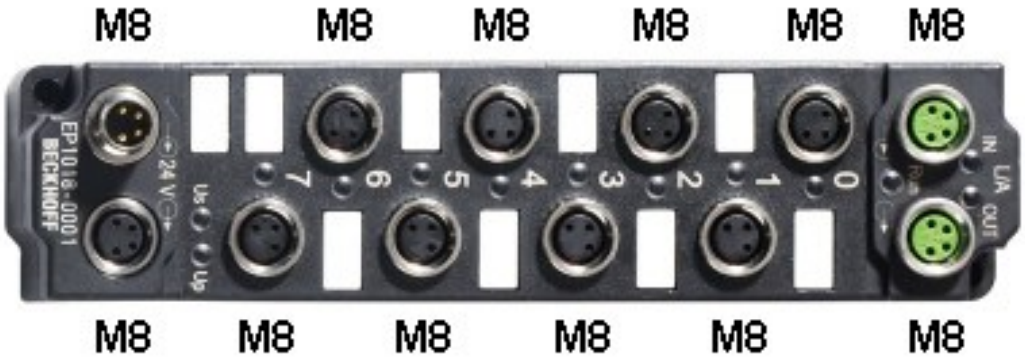

Fig. 22: EtherCAT Box with M8 connectors

M12 connectors

It is recommended to pull the M12 connectors tight with a nut torque of **0.6 Nm**.

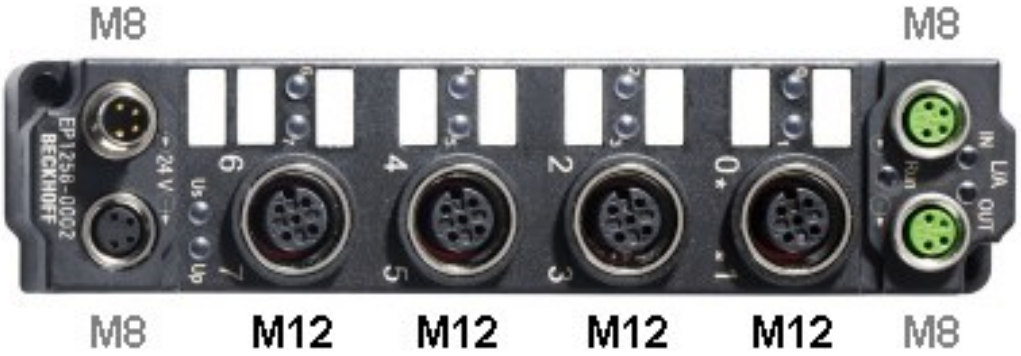

Fig. 23: EtherCAT Box with M8 and M12 connectors

7/8" connectors

It is recommended to pull the 7/8" connectors tight with a nut torque of **1.5 Nm**.

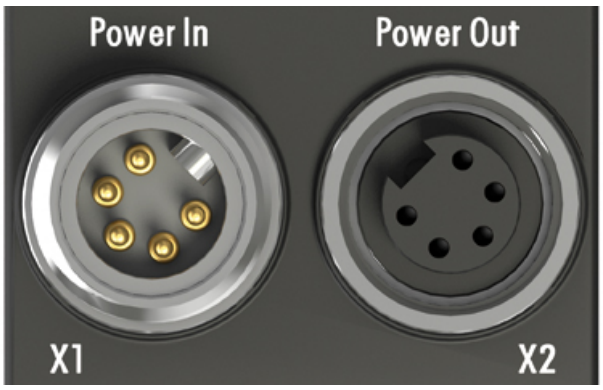

Fig. 24: 7/8" connectors

Torque socket wrenches

Fig. 25: ZB8801 torque socket wrench

Note	**Ensure the right torque** Use the torque socket wrenches available by Beckhoff to pull the connectors tight (see accessories)!

Also see about this

EtherCAT Box - Accessories [▶ 42]

4.2 EtherCAT

4.2.1 EtherCAT connection

For the incoming and ongoing EtherCAT connection,

- the EtherCAT Box (EPxxxx) has two M8 sockets, marked in **green**
- the Coupler Box (FBB-x110) has two M12 sockets

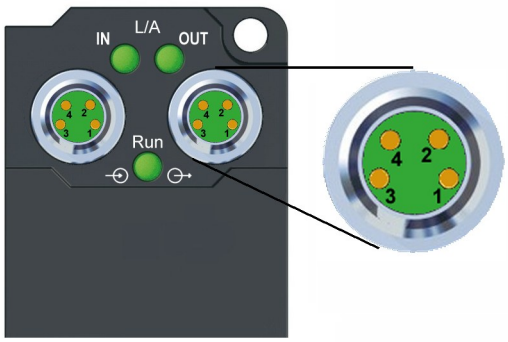

Fig. 26: EtherCAT Box: M8 (30 mm housing)

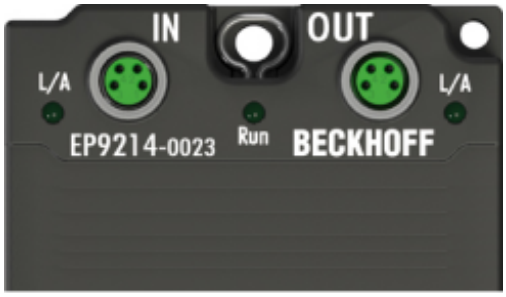

Fig. 27: EtherCAT Box: M8 60 mm housing (EP9214 for example)

Fig. 28: Coupler Box: M12

Assignment

There are various different standards for the assignment and colors of connectors and cables for Ethernet/ EtherCAT.

Ethernet/EtherCAT		Plug connector			Cable		Standard
Signal	**Description**	**M8**	**M12**	**RJ45[1]**	**ZB9010, ZB9020, ZB9030, ZB9032, ZK1090-6292, ZK1090-3xxx-xxxx**	**ZB9031 and old versions of ZB9030, ZB9032, ZK1090-3xxx-xxxx**	**TIA-568B**
Tx +	Transmit Data+	Pin 1	Pin 1	Pin 1	yellow[2]	orange/white[3]	white/ orange
Tx -	Transmit Data-	Pin 4	Pin 3	Pin 2	orange[2]	orange[3]	orange
Rx +	Receive Data+	Pin 2	Pin 2	Pin 3	white[2]	blue/white[3]	white/green
Rx -	Receive Data-	Pin 3	Pin 4	Pin 6	blue[2]	blue[3]	green
Shield	Shield	Housing		Shroud	Screen	Screen	Screen

[1]) colored markings according to EN 61918 in the four-pin RJ45 connector ZS1090-0003

[2]) wire colors according to EN 61918

[3]) wire colors

Note	**Assimilation of color coding for cable ZB9030, ZB9032 and ZK1090-3xxxx-xxxx (with M8 connectors)** For unification the prevalent cables ZB9030, ZB9032 and ZK1090-3xxx-xxxx this means the pre assembled cables with M8 connectors were changed to the colors of EN61918 (yellow, orange, white, blue).So different color coding exists. But the electrical properties are absolutely identical.

EtherCAT connectors

The following connectors can be supplied for use in Beckhoff EtherCAT systems.

Designation	Plug connector	Comment
ZS1090-0003	RJ45	four-pin, IP20, for field assembly
ZS1090-0004	M12	four-pin, IP67, for field assembly
ZS1090-0005	RJ45	eight-pin, IP20, for field assembly, suitable for Gigabit Ethernet
ZS1090-0006	M8	four-pin, IP67, for field assembly
ZS1090-0007	M8 socket	four-pin, IP67, for field assembly, for ZB903x cable
ZS1090-1006	M8 plug	four-pin, IP67, for field assembly up to OD = 6.5 mm
ZS1090-1007	M8 socket	four-pin, IP67, for field assembly up to OD = 6.5 mm

4.2.2 EtherCAT cable

For connecting EtherCAT devices only shielded Ethernet cables that meet the requirements of at least **category 5 (CAt5) according to EN 50173 or ISO/IEC 11801** should be used.

Note	**Recommendations about cabling** You may get detailed recommendations about cabling EtherCAT from the documentation "Recommendations for the design of the infrastructure for EtherCAT/Ethernet", that is available for download at www.Beckhoff.com.

EtherCAT uses 4 wires for signal transfer.
Due to automatic cable detection (auto-crossing) symmetric (1:1) or cross-over cables can be used between EtherCAT devices from Beckhoff.

A selection of cables for EtherCAT follows.
Other cables with various lengths will be found in the Beckhoff price list, and under www.beckhoff.com.

Sold by meter

Designation	Description
ZB9010	CAT 5e, 4-core, for fixed laying, not for M8 connectors, AWG22
ZB9020	CAT 5e, 4-core, suitable for drag chain use, not for M8 connectors, AWG22
ZB9030	PVC, dmr. 4.9 mm, for M8 connectors, AWG26
ZB9031	PUR, dmr. 4.8 mm, for M8 connectors, AWG26
ZB9032	PUR, dmr. 5.4 mm, for M8 connectors, high flexibility, AWG26

Preassembled cables

ZK1090-3100-0xxx: M8 plug - open end, PUR, high flexibility, preassembled

Fig. 29: ZK1090-3100-0xxx

ZK1090-3100-	0020	0050
Length	2 m	5 m

ZK1090-3100-3xxx: M8 plug - open end, PVC, high flexibility, preassembled

Fig. 30: ZK1090-3100-3xxx

ZK1090-3100-	3020	3050
Length	2 m	5 m

ZK1090-3131-0xxx: 2 x M8 plug, PUR, high flexibility, ready-assembled

Fig. 31: ZK1090-3131-0xxx

ZK1090-3131-	0001	0003	0005	0010	0020	0030	0040	0050	0075	0100
Length	0.15 m	0.3 m	0.5 m	1.0 m	2.0 m	3.0 m	4.0 m	5.0 m	7.5 m	10 m

ZK1090-3131-	0150	0200	0250	0300	0350	0400	0450	0500
Length	15 m	20 m	25 m	30 m	35 m	40 m	45 m	50 m

ZK1090-3131-3xxx: 2 x M8 plug, PVC, ready-assembled

Fig. 32: ZK1090-3131-3xxx

ZK1090-3131-	3020	3030	3040	3050	3075	3100	3150	3200	3250	3300
Length	2.0 m	3.0 m	4.0 m	5.0 m	7.5 m	10 m	15 m	20 m	25 m	30 m

ZK1090-3131-	3350	3400	3450	3500
Length	35 m	40 m	45 m	50 m

ZK1090-3132-0xxx: M8 plug - M8 socket, PUR, high flexibility, ready-assembled

Fig. 33: ZK1090-3132-0xxx

ZK1090-3132-	0002	0004	0020	0050	0075	0100	0150	0200	0250	0300
Length	0.2 m	0.4 m	2.0 m	5.0 m	7.5 m	10 m	15 m	20 m	25 m	30 m

ZK1090-3132-	0400	0500	
Length	40 m	50 m	

ZK1090-3132-3xxx: M8 plug - M8 socket, PVC, ready-assembled

Fig. 34: ZK1090-3132-3xxx

ZK1090-3132-	0020	0050	0100	0150	0200	0250	0300	0400	0500
Length	2.0 m	5.0 m	10 m	15 m	20 m	25 m	30 m	40 m	50 m

ZK1090-3191-0xxx: M8 plug - RJ45 plug, PUR, high flexibility, ready-assembled

Fig. 35: ZK1090-3191-0xxx

ZK1090-3191-	0004	0005	0010	0020	0035	0050	0070	0100	0150	0200
Length	0.4 m	0.5 m	1 m	2 m	3,5 m	5 m	7 m	10 m	15 m	20 m

ZK1090-3191-	0250
Length	25 m

ZK1090-3191-3xxx: M8 plug - RJ45 plug, PVC, ready-assembled

Fig. 36: ZK1090-3191-3xxx

ZK1090-3191-	3005	3020	3050
Length	0.5 m	2 m	5 m

ZK1090-3291-3xxx: M8 socket - RJ45 plug, PVC, ready-assembled

Fig. 37: ZK1090-3291-3xxx

ZK1090-3291-	0004	0005	0010	0020	0050	100	200	250
Length	0.4 m	0.5 m	1 m	2 m	5 m	10 m	20 m	25 m

ZK1090-3161-0xxx: M8 plug - M12 plug (d-coded), ready-assembled

Fig. 38: ZK1090-3161-0xxx

ZK1090-3161-	0010	0020	0050
Length	1.0 m	2.0 m	5.0 m

ZK1090-6161-0xxx: 2 x M12 plug (d-coded), PVC, ready-assembled

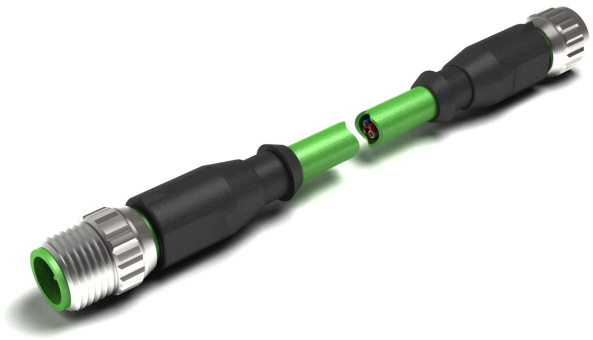

Fig. 39: ZK1090-6161-xxxx

ZK1090-6161-	0005	0010	0020	0025	0050	0100
Length	0.5 m	1.0 m	2.0 m	2.5 m	5.0 m	10 m

ZK1090-6191-0xxx: M12 plug - RJ45 plug, ready-assembled

Fig. 40: ZK1090-6191-0xxx

ZK1090-6191-	0005	0010	0020	0025	0050	0100
Length	0.5 m	1.0 m	2.0 m	2.5 m	5.0 m	10 m

ZK1090-6292-0xxx: M12 socket - RJ45 plug, ready-assembled

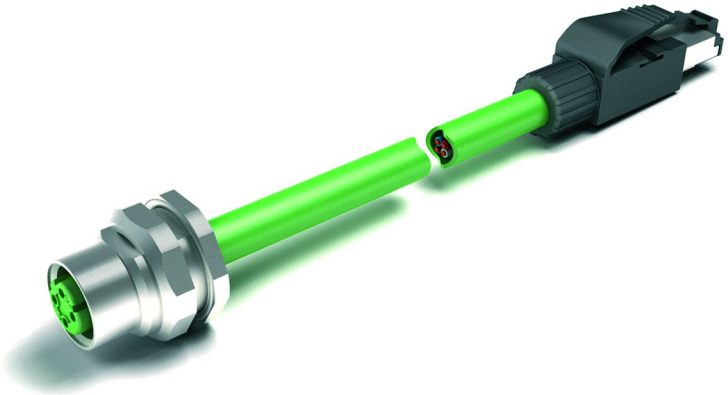

Fig. 41: ZK1090-6292-0xxx

ZK1090-6292-	0005	0020	0050	0100
Length	0.5 m	2 m	5 m	10 m

ZK1090-9191-0xxx: 2 x RJ45 plug, patch cable

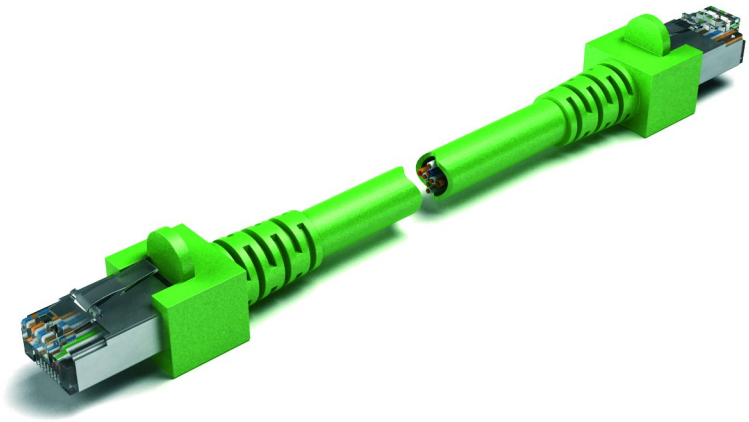

Fig. 42: ZK1090-9191-0xxx

ZK1090-9191-	0001	0002	0005	0010	0020	0030	0040	0050	0100	0150
Length	0.17 m	0.26 m	0.5 m	1.0 m	2.0 m	3.0 m	4.0 m	5.0 m	10 m	15 m

ZK1090-9191-	0200	0250	0300	0350	0400	0450	0500
Length	20 m	25 m	30 m	35 m	40 m	45 m	50 m

4.3 Power supply

4.3.1 Power Connection

The feeding and forwarding of supply voltages is done via two M8 connectors at the bottom end of the modules:

- IN: left M8 connector for feeding the supply voltages
- OUT: right M8 connector for forwarding the supply voltages

Fig. 43: EtherCAT Box, Connectors for power supply

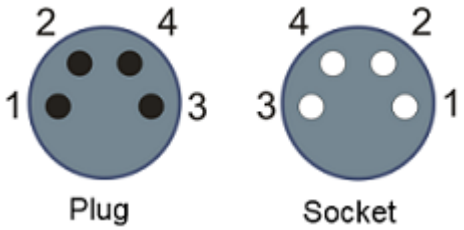

Fig. 44: Pin assignment M8, Power In and Power Out

Table 1: PIN assignment

Pin	Voltage	
1	Control voltage Us, +24 V_{DC}	
2	Auxiliary voltage Up, +24 V_{DC}	
3	GNDs*	*) may be connected internally to each other depending on the module: see specific module descriptions
4	GNDp*	

The pins M8 connectors carry a maximum current of 4 A.

Two LEDs display the status of the supply voltages.

Attention	**Don't confuse the power connectors with the EtherCAT connectors!** Never connect the power cables (M8, 24 V_{DC}) with the green marked EtherCAT sockets of the EtherCAT Box Modules! This can damage the modules!

Control voltage Us: 24 V_{DC}

Power is supplied to the fieldbus, the processor logic, the inputs and the sensors from the 24 V_{DC} control voltage Us. The control voltage is electrically isolated from the fieldbus circuitry.

Auxiliary voltage Up 24 V_{DC}

The Auxiliary voltage Up 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.

Redirection of the supply voltages

The IN and OUT power connections are bridged in the module (not IP204x-Bxxx and IE204x). The supply voltages Us and Up can thus easily be transferred from EtherCAT Box to EtherCAT Box.

Attention	**Pay attention to the maximum permissible current!** Pay attention also for the redirection of the supply voltages Us and Up, the maximum permissible current for M8 connectors of 4 A must not be exceeded!

Supply via EP92x4-0023 PowerBox modules

If the machine requires higher current or if the EtherCAT Box Modules are installed far away from the control cabinet with included power supply, the usage of four cannel power distribution modules EP9214 or EP9224 (with integrated data logging, see www.beckhoff.com/EP9224) is recommended.

With these modules intelligent power distribution concepts with up to 2 x 16 A and a maximum of 2.5 mm² cable cross-section can be realized.

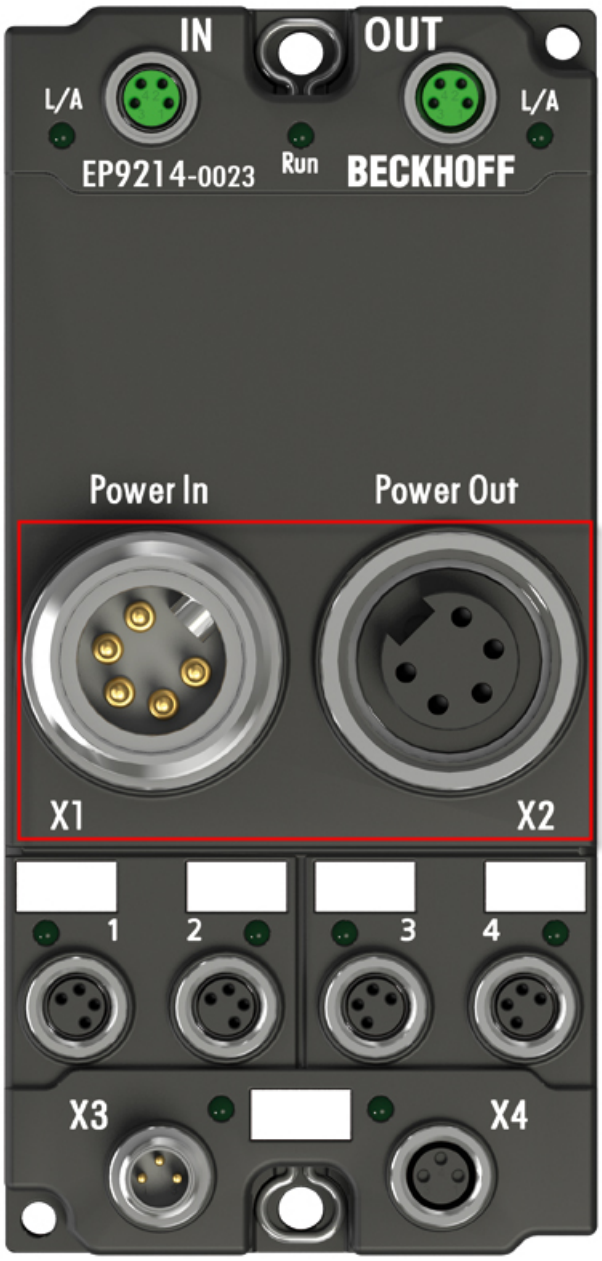

Fig. 45: EP92x4-0023, Connectors for Power In and Power Out

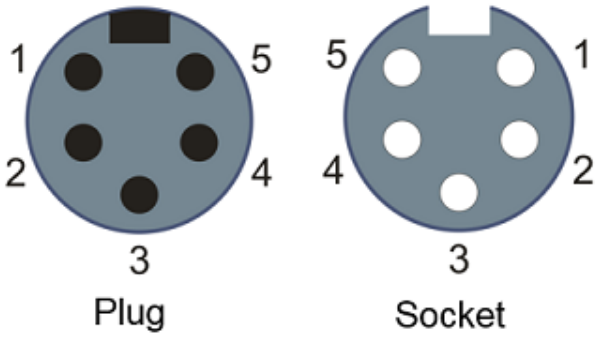

Fig. 46: Pin assignment 7/8", Power In and Power Out

Electrical isolation

Digital modules

In the digital input/output modules, the grounds of the control voltage (GNDs) and the auxiliary voltage (GNDp) are connected to each other!

Check this at the documentation of each used EtherCAT Box.

Analog modules

In the analog input/output modules the grounds of the control voltage (GNDs) and the auxiliary voltage (GNDp) are separated from each other in order to ensure electrical isolation of the analog signals from the control voltage.

In some of the analog modules the sensors or actuators are supplied by Up - this means, for instance, that in the case of 0...10 V inputs, any reference voltage (0...30 V) may be connected to Up; this is then available to the sensors (e.g. smoothed 10 V for measuring potentiometers).

Details of the power supply may be taken from the specific module descriptions.

Attention	**Electrical isolation may be cancelled!** If digital and analog fieldbus boxes are connected directly via four-core power leads, the analog signals in the fieldbus boxes may be no longer electrically isolated from the control voltage!

4.3.2 Status LEDs for power supply

Fig. 47: Status LEDs for power supply

LED display

LED	Display	Meaning
Us (Control voltage)	off	The power supply voltage Us is not present
	green illuminated	The power supply voltage Us is present
	reed illuminated	Because of overload (current > 0.5 A) the sensor supply generated from power supply voltage Us was switched off for all sensors fed from this.
Up (Auxiliary voltage)	off	The power supply voltage Up is not present
	green illuminated	The power supply voltage Up is present

4.3.3 Power cable conductor losses

The ZK2020-xxxx-yyyy power cables should not exceed the total length of 15 m at 4 A (with continuation). When planning the cabling, note that at 24 V nominal voltage, the functionality of the module can no longer be assured if the voltage drop reaches 6 V. Variations in the output voltage from the power supply unit must also be taken into account.

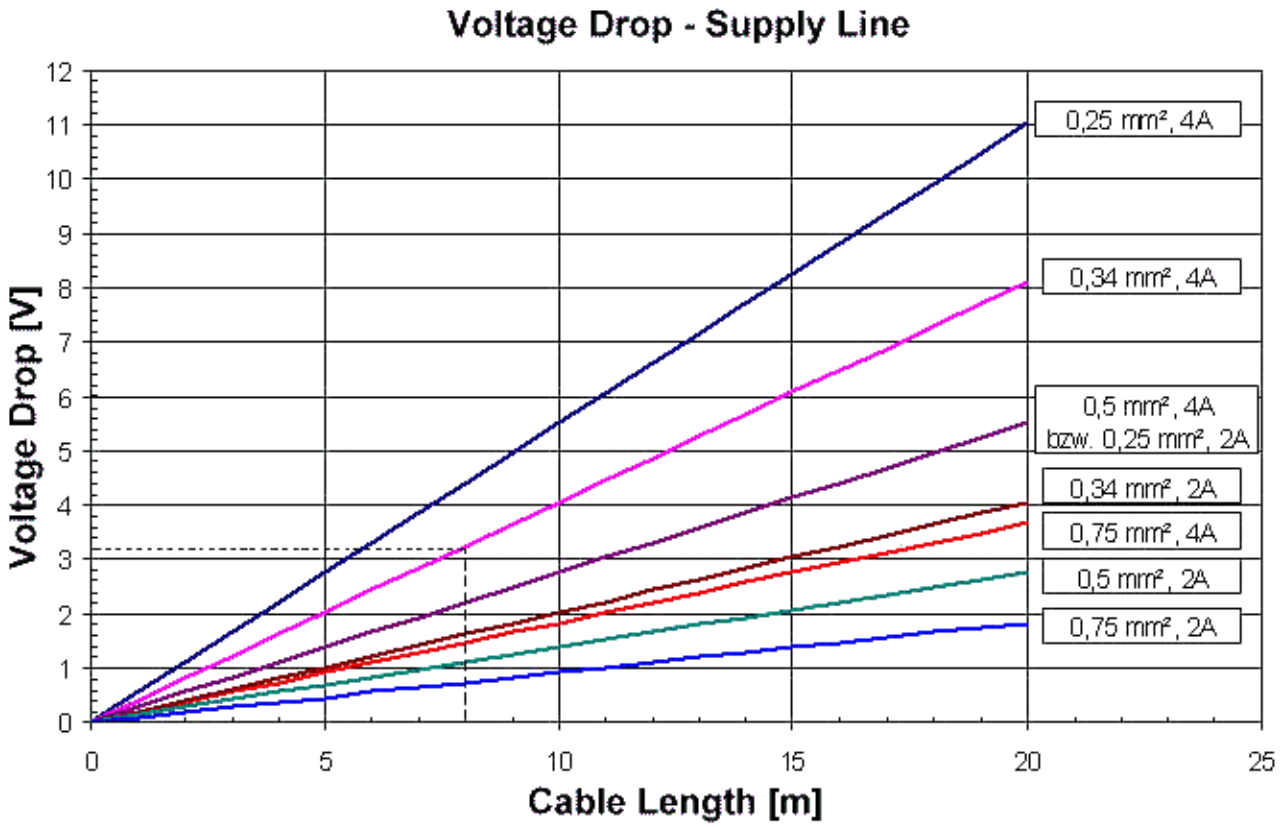

Fig. 48: Power cable conductor losses

Example

8 m power cable with 0.34 mm² cross-section has a voltage drop of 3.2 V at 4 A.

Note	**EP92x4 Power Distribution Modules** With EP9214 and EP9224 Power Distribution Modules intelligent concepts for voltage supply are available. Further information may be found under www.beckhoff.com/EP9224.

4.4 UL Requirements

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

Supply voltage

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

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

Networks

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

Ambient temperature range

CAUTION	**CAUTION!** To meet the UL requirements, EtherCAT Box Modules has to be operated only at an ambient temperature range of 0 to 55°C!

Marking for UL

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

Fig. 49: UL label

5 Appendix

5.1 General operating conditions

Protection degrees (IP-Code)

The standard IEC 60529 (DIN EN 60529) defines the degrees of protection in different classes.

1. Number: dust protection and touch guard	Definition
0	Non-protected
1	Protected against access to hazardous parts with the back of a hand. Protected against solid foreign objects of Ø 50 mm
2	Protected against access to hazardous parts with a finger. Protected against solid foreign objects of Ø 12,5 mm.
3	Protected against access to hazardous parts with a tool. Protected against solid foreign objects Ø 2,5 mm.
4	Protected against access to hazardous parts with a wire. Protected against solid foreign objects Ø 1 mm.
5	Protected against access to hazardous parts with a wire. Dust-protected. Intrusion of dust is not totally prevented, but dust shall not penetrate in a quantity to interfere with satisfactory operation of the device or to impair safety.
6	Protected against access to hazardous parts with a wire. Dust-tight. No intrusion of dust.

2. Number: water* protection	Definition
0	Non-protected
1	Protected against water drops
2	Protected against water drops when enclosure tilted up to 15°.
3	Protected against spraying water. Water sprayed at an angle up to 60° on either side of the vertical shall have no harmful effects.
4	Protected against splashing water. Water splashed against the disclosure from any direction shall have no harmful effects
5	Protected against water jets
6	Protected against powerful water jets
7	Protected against the effects of temporary immersion in water. Intrusion of water in quantities causing harmful effects shall not be possible when the enclosure is temporarily immersed in water for 30 min. in 1 m depth.

*) These protection classes define only protection against water!

Chemical Resistance

The Resistance relates to the Housing of the Fieldbus Box and the used metal parts.

Character	Resistance
Steam	at temperatures >100°C: not resistant
Sodium base liquor (ph-Value > 12)	at room temperature: resistant > 40°C: not resistant
Acetic acid	not resistant
Argon (technical clean)	resistant

Key

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

5.2 EEPROM update

The EP9128 features 3 internal EtherCAT slave controllers (ESC). This means that 3 EEPROMs are available for write access. In the EP9128 they are different, since all 3 ESCs have different port technology (Ethernet or E-bus), see Fig. 1.

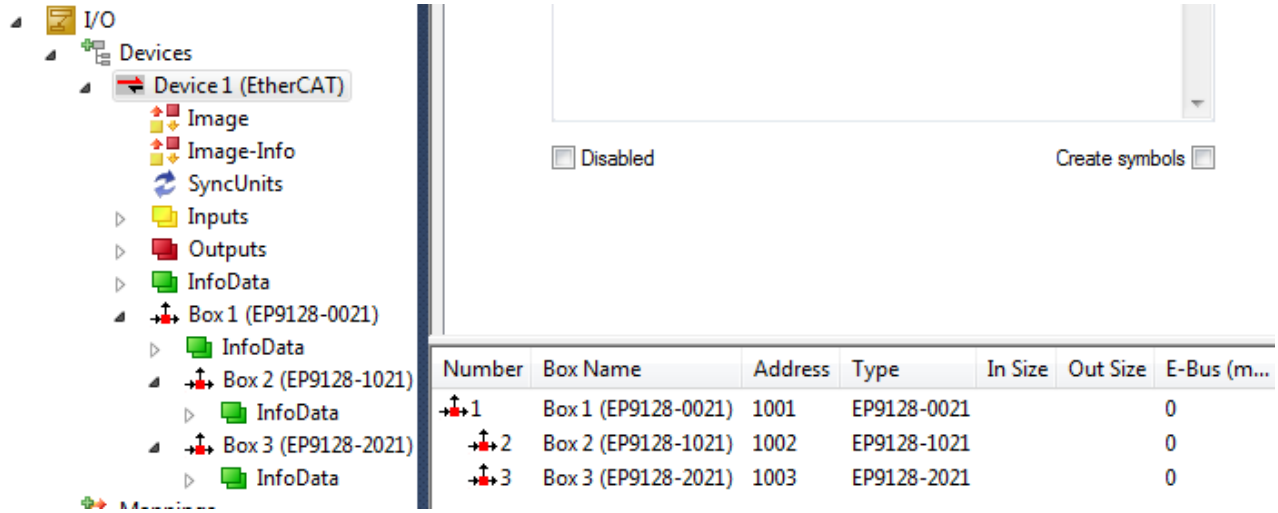

Fig. 1: The 3 internal ESC names of the EP9128

The main slave is the EP9128-0000, in this case revision -0000. The two following internal slaves are EP9128-0001 and EP9128-0002.

The EEPROM can be updated via the EEPROM Update dialog in the System Manager. This is only necessary in special cases and should only be done if instructed by Beckhoff support/service.

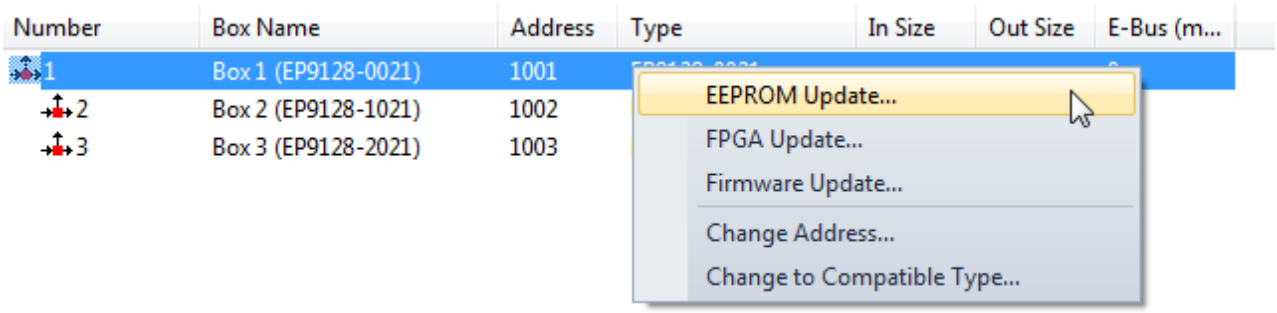

Fig. 2: EEPROM Update TwinCAT

All 3 internal ESCs can be write-accessed sequentially, followed by an off/on restart, in order to load the EEPROM. See Fig. 3 for assignment in the TwinCAT selection dialog.

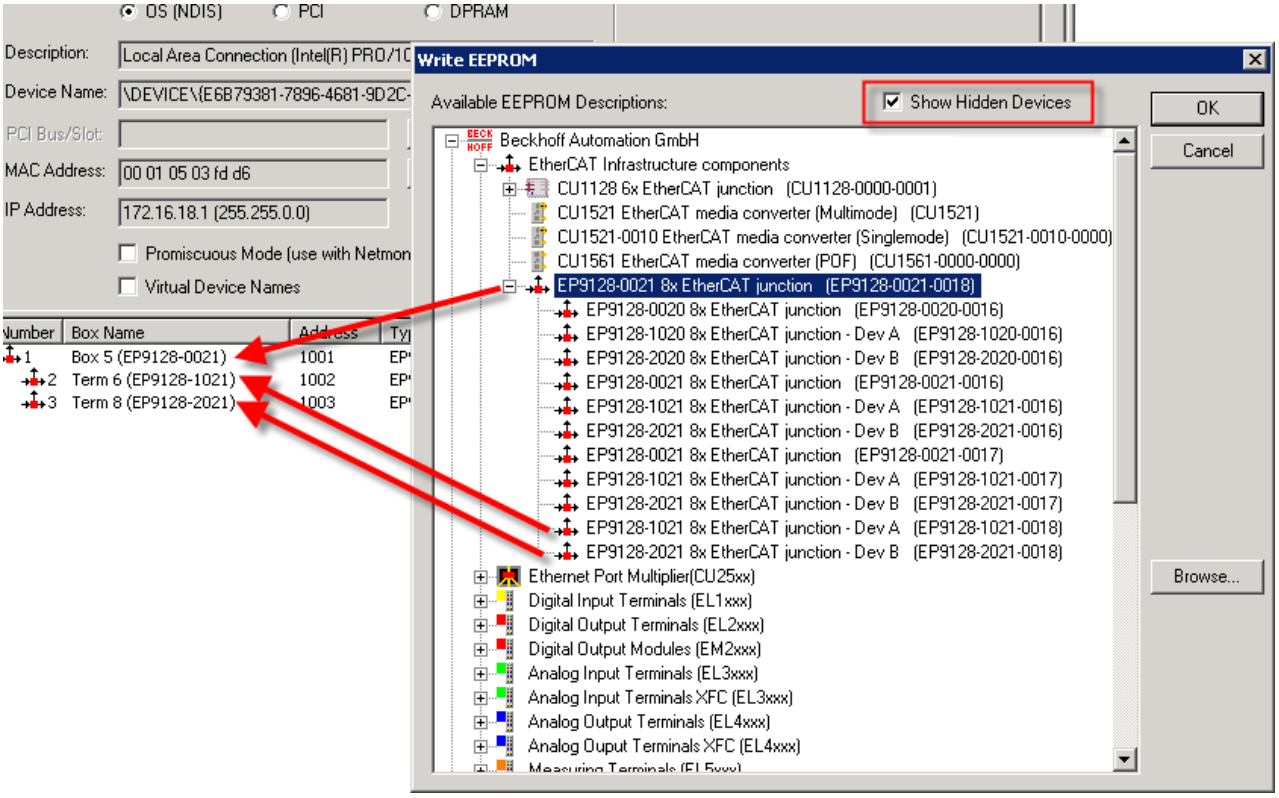

Fig. 3: Currently available EEPROM descriptions for EP9128 and assignment

5.3 EtherCAT Box - Accessories

Fixing

Ordering information	Description
ZS5300-0001	Mounting rail (500 mm x 129 mm)

Marking material, plugs

Ordering information	Description
ZS5000-0000	Fieldbus Box set M8 (contact labels, plugs)
ZS5000-0002	Fieldbus Box set M12 (contact labels, plugs)
ZS5000-0010	plugs M8, IP67 (50 pieces)
ZS5000-0020	plugs M12, IP67 (50 pieces)
ZS5100-0000	marking labels, not printed, 4 stripes at 10 pieces
ZS5100-xxxx	printed marking labels, on request

Tools

Ordering information	Description
ZB8800	Torque socket wrench with ratchet wrench for M8 connectors (over molded)
ZB8800-0001	ratchet wrench for M8 connectors (field assembly)
ZB8800-0002	ratchet wrench for M12 connectors (over molded)

Note	**Further accessories** Further accessories may be found at the price list for Beckhoff fieldbus components and at the internet under www.beckhoff.com.

5.4 Support and Service

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

Beckhoff's branch offices and representatives

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

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

You will also find further documentation for Beckhoff components there.

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