BECKHOFF New Automation Technology

Documentation | EN

# EP9128-0021

## EtherCAT junction with protection class IP67


2022-04-05 | Version: 2.5

# Inhaltsverzeichnis

# 1 Foreword

## 1.1 Notes on the documentation

### Intended audience

This description is only intended for the use of trained specialists in control and automation engineering who are familiar with the applicable national standards.
It is essential that the documentation and the following notes and explanations are followed when installing and commissioning these components.
It is the duty of the technical personnel to use the documentation published at the respective time of each installation and commissioning.

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

### Disclaimer

The documentation has been prepared with care. The products described are, however, constantly under development.

We reserve the right to revise and change the documentation at any time and without prior announcement.

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

### Trademarks

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

### Patent Pending

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


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

### Copyright

## 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 instructions

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

**⚠ DANGER**

**Serious risk of injury!**

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

**⚠ WARNING**

**Risk of injury!**

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

**⚠ CAUTION**

**Personal injuries!**

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

***NOTE***

**Damage to environment/equipment or data loss**

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

**Tip or pointer**

This symbol indicates information that contributes to better understanding.

## 1.3 Documentation issue status

| Version | Comment |
|---|---|
| 2.5 | • Technical data updated<br>• The port assignment in the chapter "Basic function principles" clarifies |
| 2.4 | • Dimensions updated<br>• UL requirements updated |
| 2.3 | • Front page updated<br>• Scope of delivery added<br>• Structure update |
| 2.2.1 | • Nut torque for connectors extended |
| 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<br>• English translation available |
| 1.0.0 | • First release |
| 0.1.0 | • preliminary version |
| 2.2 | • Dimensions updated<br>• UL requirements updated |

**Firmware and hardware versions**

This documentation refers to the firmware and hardware version that was applicable at the time the documentation was written.

The module features are continuously improved and developed further. Modules having earlier production statuses cannot have the same properties as modules with the latest status. However, existing properties are retained and are not changed, so that older modules can always be replaced with new ones.

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

**Syntax of the batch number (D-number)**

| | |
|---|---|
| D: WW YY FF HH | Example with D no. 29 10 02 01: |
| WW - week of production (calendar week)<br>YY - year of production<br>FF - firmware version<br>HH - hardware version | 29 - week of production 29<br>10 - year of production 2010<br>02 - firmware version 02<br>01 - hardware version 01 |

Further information on this topic: Version identification of EtherCAT devices [▶ 37].

# 2 EtherCAT Box - Introduction

The EtherCAT system has been extended with EtherCAT Box modules with protection class IP67. 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.

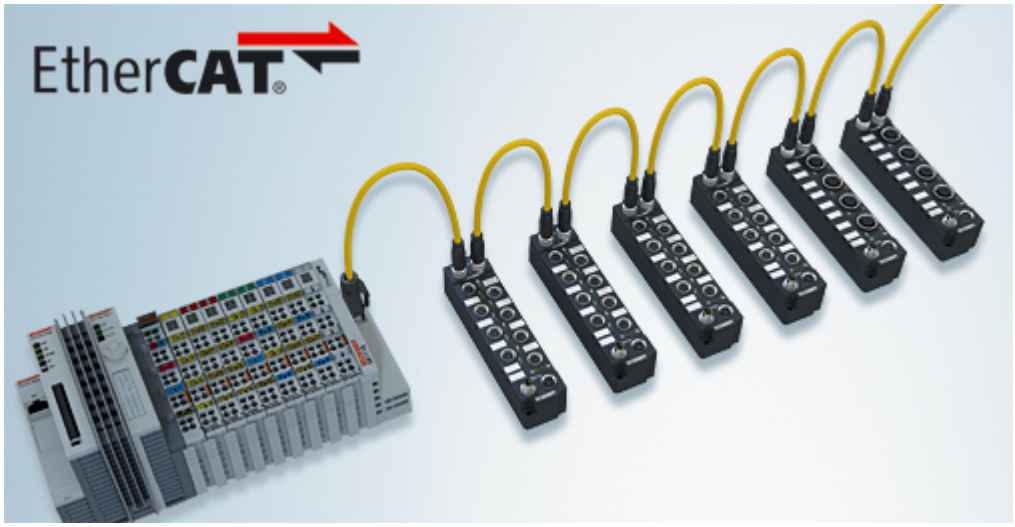



Fig. 1: EtherCAT Box Modules within an EtherCAT network

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

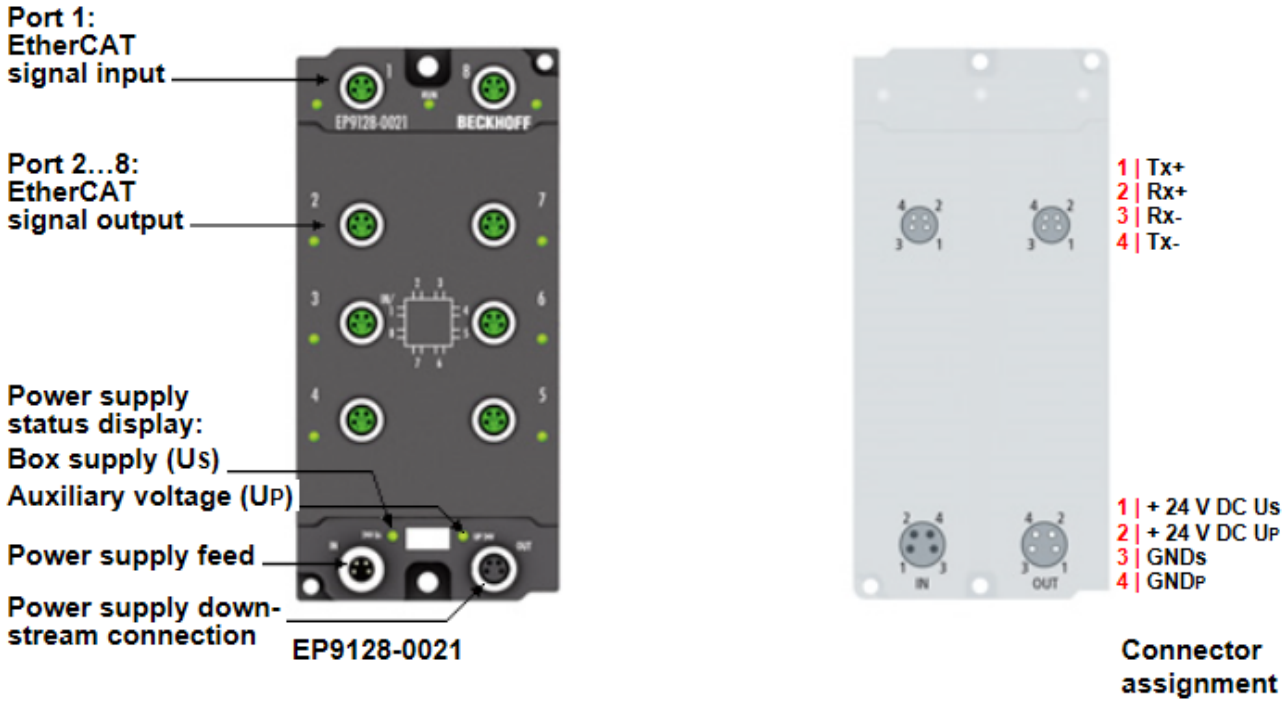
Fig. 3: EtherCAT Box with M12 connections for sensors/actuators

**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.

# 3 Product overview

## 3.1 Introduction




**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**

Technical data [▶ 11]
Basic function principles [▶ 21]
Dimensions [▶ 25]

## 3.2 Technical data

All values are typical values over the entire temperature range, unless stated otherwise.

| EtherCAT | |
|---|---|
| Connection | 8 x M8 socket, green |
| Data transfer medium | Ethernet cable / EtherCAT cable, min. CAT 5, shielded |
| Cable length | max. 100 m (100BASE-TX) |
| Data transfer rate | 100 Mbit/s |
| Configuration | not required |
| Distributed Clocks | Yes |
| Propagation delay | approx. 1 µs per port |

| Supply voltages | |
|---|---|
| Connection | Input: M8 connector, 4-pin<br>Downstream connection: M8 socket, 4-pin, black |
| $U_S$ nominal voltage | 24 $V_{DC}$ (-15 % / +20 %) |
| $U_S$ sum current: $I_{S,sum}$ | max. 4 A |
| Current consumption from $U_S$ | 150 mA |
| Rated voltage $U_P$ | 24 $V_{DC}$ (-15 % / +20 %) |
| $U_P$ sum current: $I_{P,sum}$ | max. 4 A |
| Current consumption from $U_P$ | None. $U_P$ is only forwarded. |

| Housing data | |
|---|---|
| Dimensions W x H x D | 60 mm x 126 mm x 26.5 mm (without plug connectors) |
| Weight | approx. 300 g |
| Installation position | variable |
| Material | PA6 (polyamide) |

| Environmental conditions | |
|---|---|
| Ambient temperature during operation | -25 … +60 °C<br>-25 … +55 °C according to cURus |
| Ambient temperature during storage | -40 … +85 °C |
| Vibration resistance, shock resistance | conforms to EN 60068-2-6 / EN 60068-2-27<br>Technical data [▶ 11] |
| EMC immunity / emission | conforms to EN 61000-6-2 / EN 61000-6-4 |
| Protection class | IP65, IP66, IP67 (conforms to EN 60529) |

| Approvals / markings | |
|---|---|
| Approvals / markings *) | CE, cURus [▶ 31] |

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

### Additional checks

The boxes have been subjected to the following checks:

| Verification | Explanation |
|---|---|
| Vibration | 10 frequency sweeps in 3 axes |
| | 5 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 |
| | 35 g, 11 ms |

## 3.3 Scope of supply

Make sure that the following components are included in the scope of delivery:

- 1x EtherCAT Box EP9128-0021
- 8x protective cap for EtherCAT socket, M8, green (pre-assembled)
- 1x protective cap for supply voltage input, M8, transparent (pre-assembled)
- 1x protective cap for supply voltage output, M8, black (pre-assembled)
- 10x labels, blank (1 strip of 10)

**Pre-assembled protective caps do not ensure IP67 protection**

Protective caps are pre-assembled at the factory to protect connectors during transport. They may not be tight enough to ensure IP67 protection.

Ensure that the protective caps are correctly seated to ensure IP67 protection.

# 4 Basic function principles

## 4.1 Basic function principles of EtherCAT junctions

Some Beckhoff EtherCAT devices can be used for junctions in the EtherCAT segment. These include EK1122, EK1521, EP1122 or CU112x and EP9128-0021. 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 passes the data on to the *only* next slave; see following Fig. *EtherCAT line topology*.

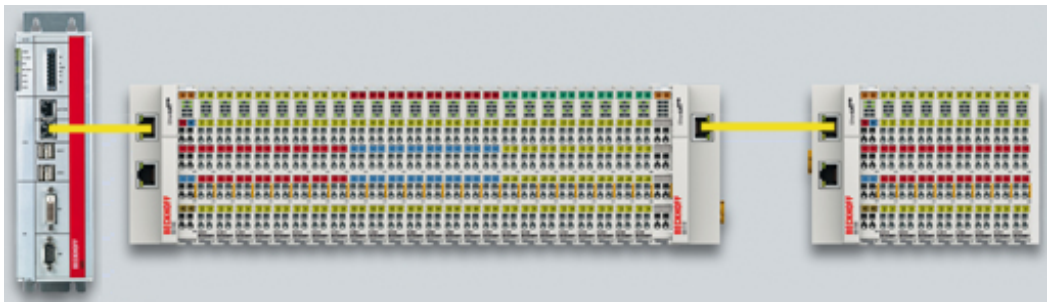


Fig. 4: EtherCAT line topology

When using, for example, EK1100 EtherCAT Couplers, a junction and thus a type of tree topology is possible; see following Fig. *Line topology with extensions*.

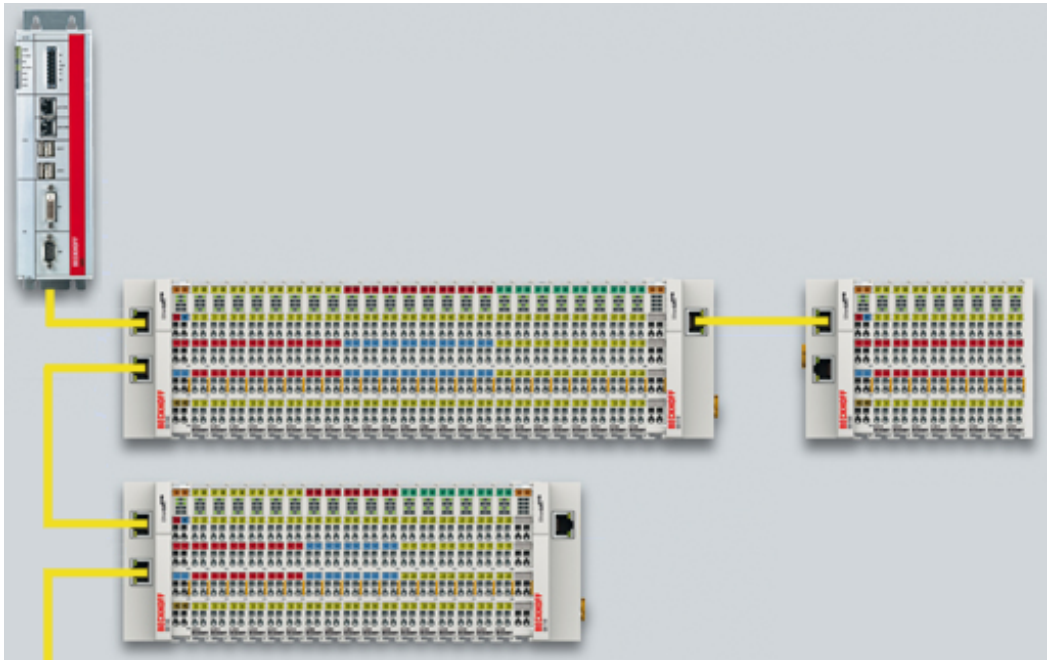


Fig. 5: Line topology with extensions

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 one to four ports. Via an open port it can handle outgoing and incoming Ethernet traffic. The direction of data flow in a fully configured ESC is shown in Fig. *Direction of data flow in the ESC* – the data in the EtherCAT datagrams are thereby processed only between Ports 0 (A) and 3 (D) in the EtherCAT processing unit.

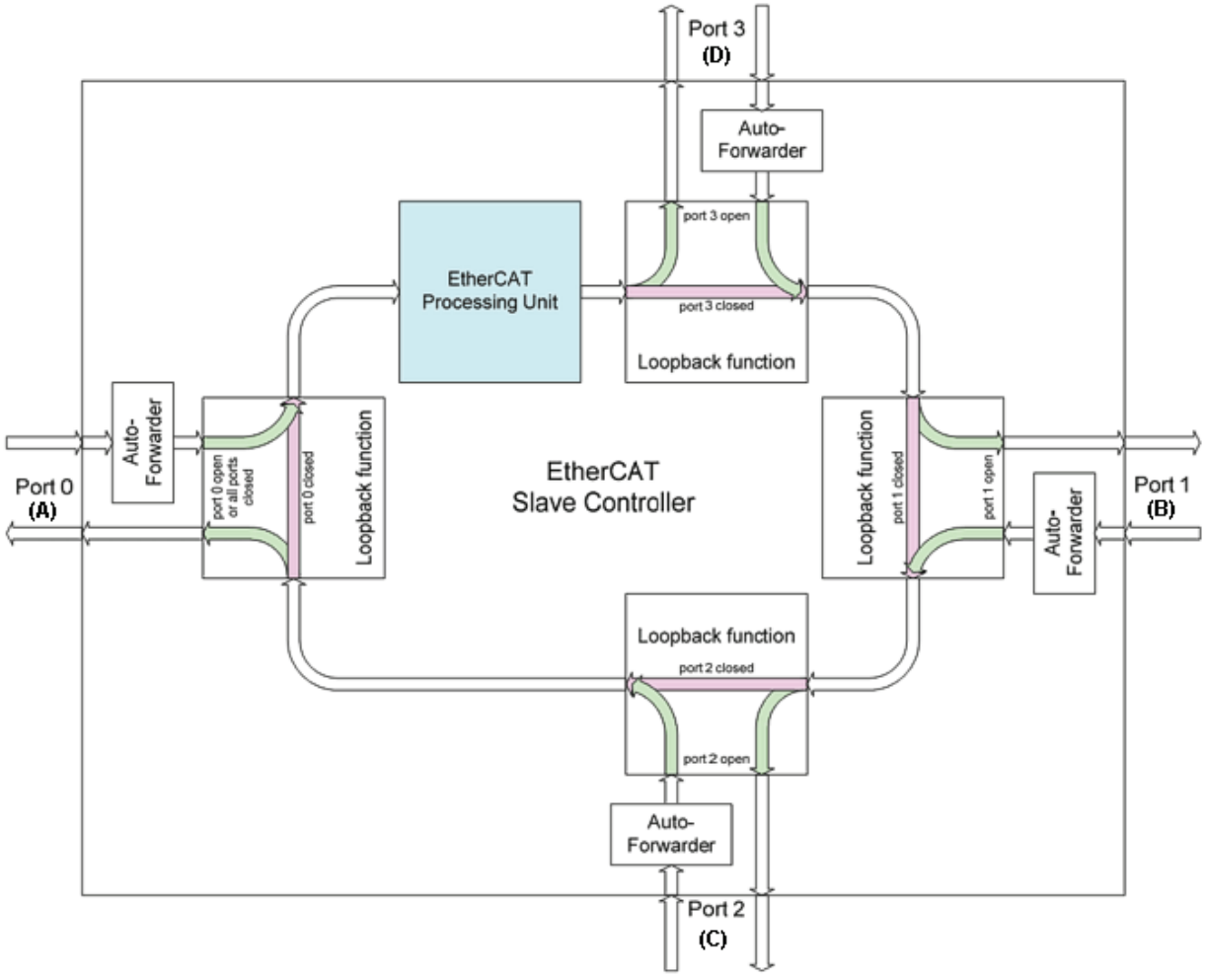



Fig. 6: Direction of data flow in the ESC

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: EP9128-0021 EtherCAT junction

The EP9128-0021 integrates three ESCs, which means eight ports in total are available to users. The three ESCs are interconnected via E-bus.

### Implementation: EL terminal

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

- one for incoming frames (port 0 [A])
- and 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

Three of the four available ports in the EK1100 EtherCAT Coupler are used, thus enabling a connection to the right to terminals and via an RJ45 socket to further couplers; cf. Fig. “Line topology with extensions [▶ 13]”. In the EK1100 the processing unit is not used for process data exchange.

### Implementation: EK1121-0010 EtherCAT junction, Extended Distance

As in the EK1100, three ESC ports can be connected in these junctions: Two via E-bus within the terminal and one via the RJ45 sockets with Ethernet configuration.

### Implementation: EK1122 EtherCAT junction

In the EK1122 all four 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 shown by the online display – they are designated there as ports A, B, C and D; see Fig. “Topology display for interrupted line [▶ 18]”.

### 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 fiber cable/POF line.

### Implementation: CU1123-00x0 EtherCAT junction

In the CU1123-00x0 EtherCAT junction three of the four available ports can be connected via the RJ45 sockets.

### Implementation: CU1124 EtherCAT junction

In the CU1124 EtherCAT junction all four available ports can be connected via the RJ45 sockets.

### Implementation: CU1128 EtherCAT junction

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.

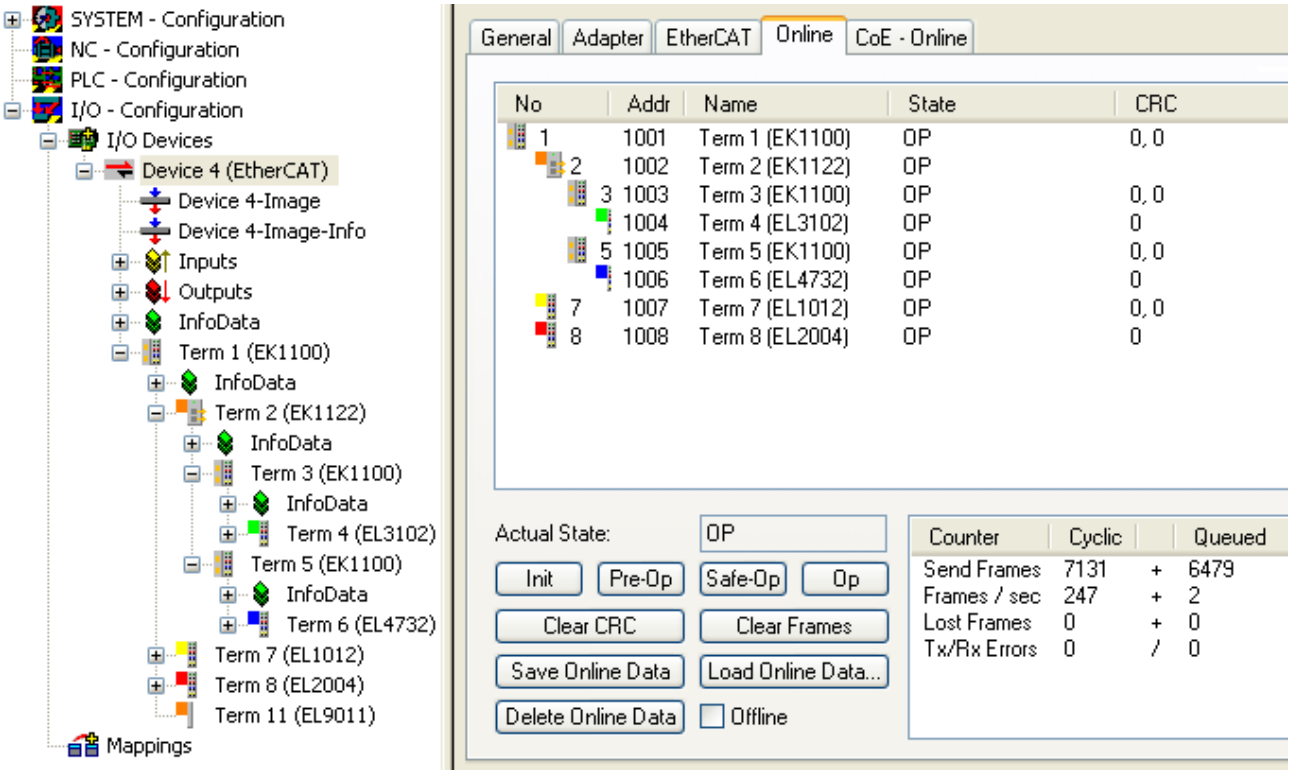



Fig. 7: Example configuration

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

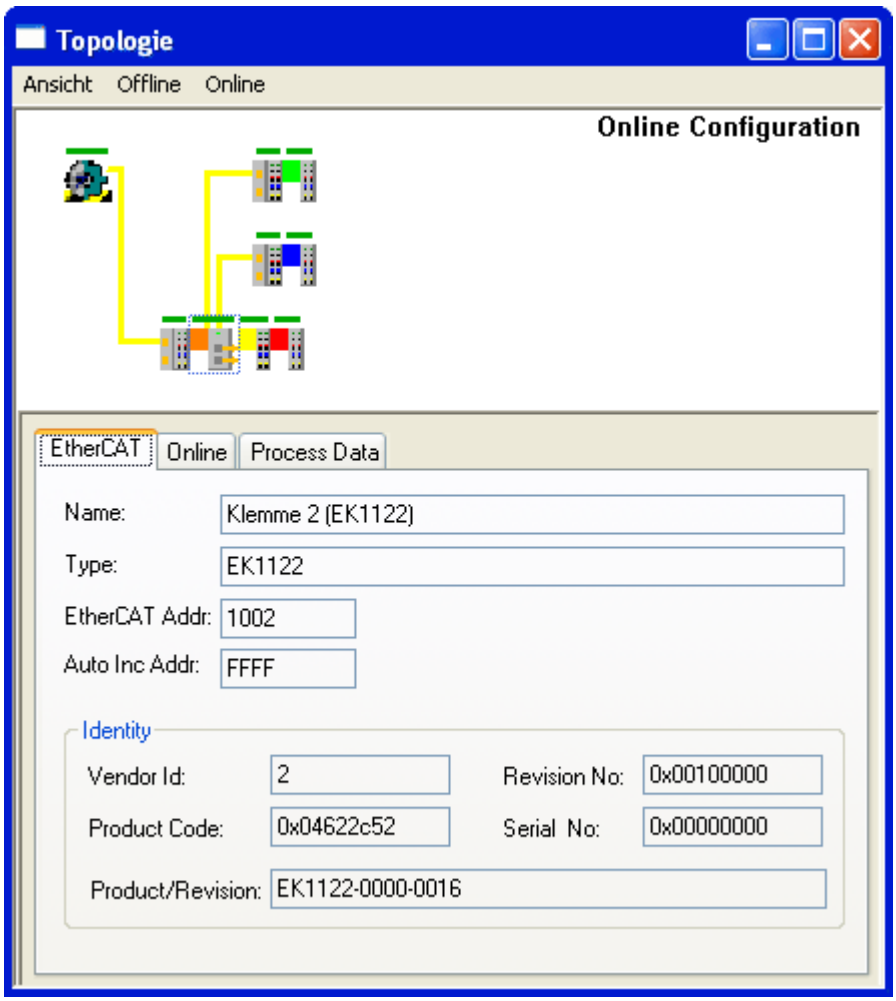



Fig. 8: Online topology

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 thus missing here and the System Manager marks this in the online display; see following Fig. *Example configuration with interrupted cable*.

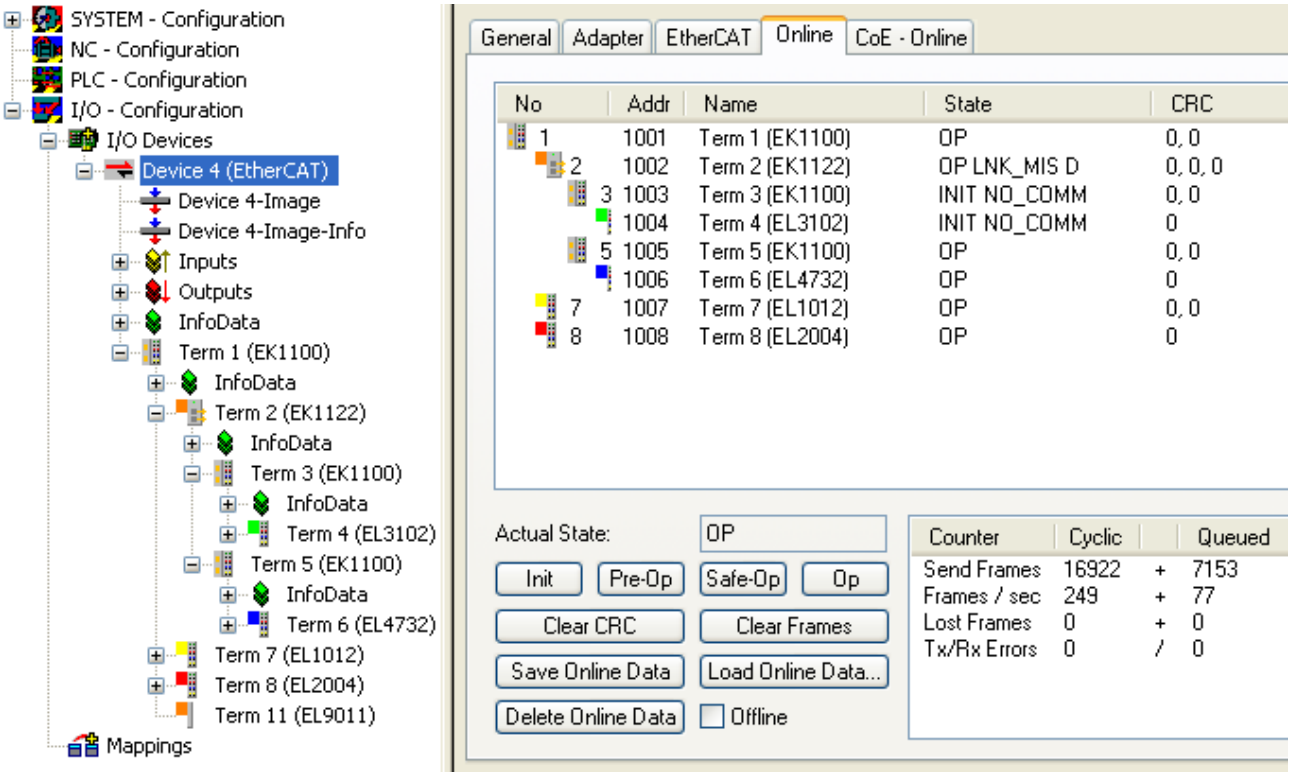



Fig. 9: Example configuration with interrupted cable

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

**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 the following Fig. *Topology display for interrupted line*.

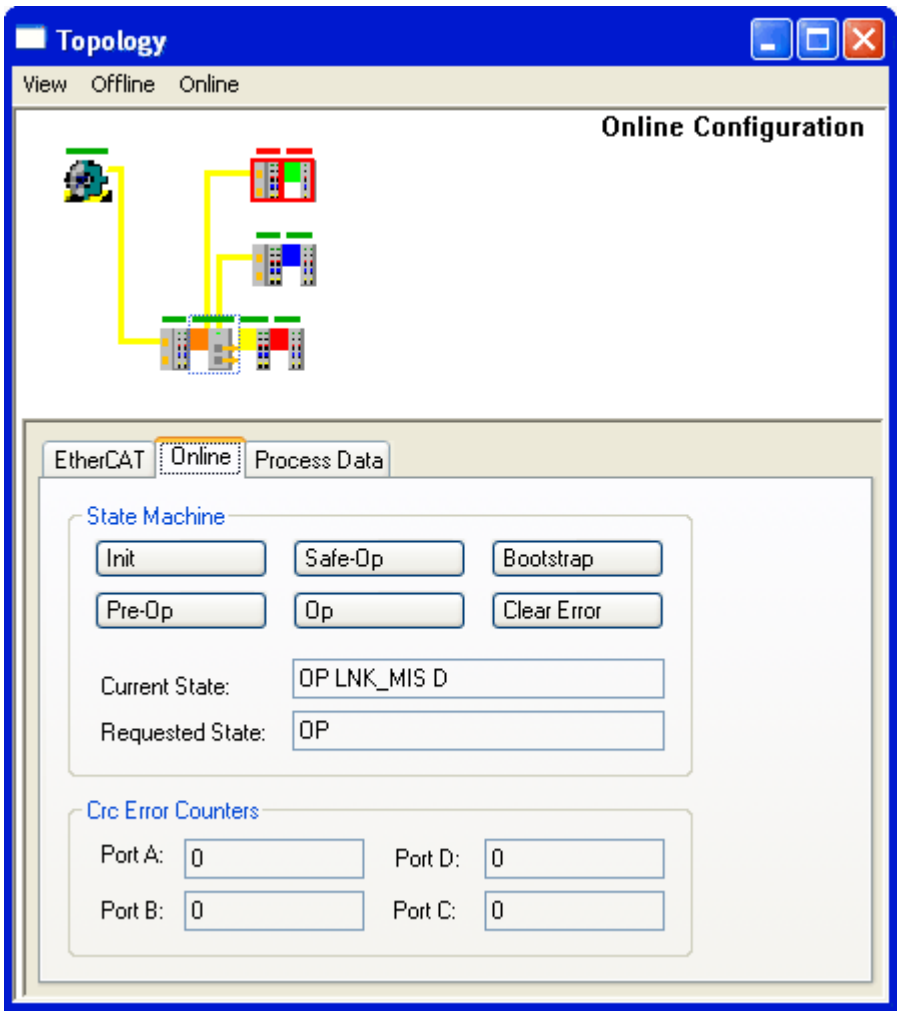



Fig. 10: Topology display for interrupted line

In Fig. "Example configuration [▶ 16]" and Fig. "Example configuration with interrupted cable" [▶ 18] note the display of acyclic frames, see the following Fig. *Comparison of the frame displays in the System Manager.*

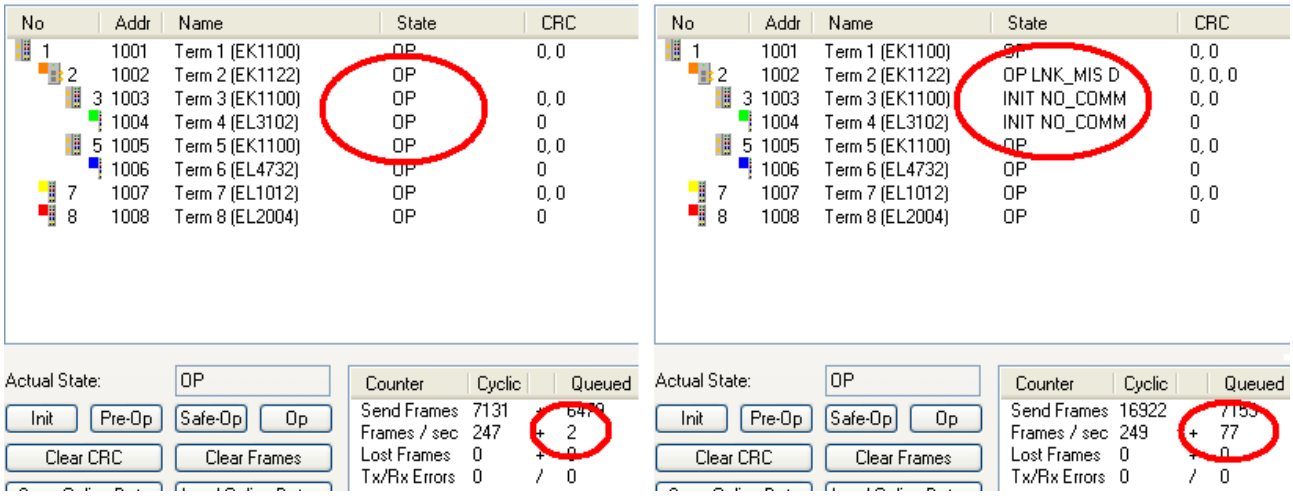



Fig. 11: Comparison of the frame displays in the System Manager

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.

**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.

## 4.2 Basic function principles

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

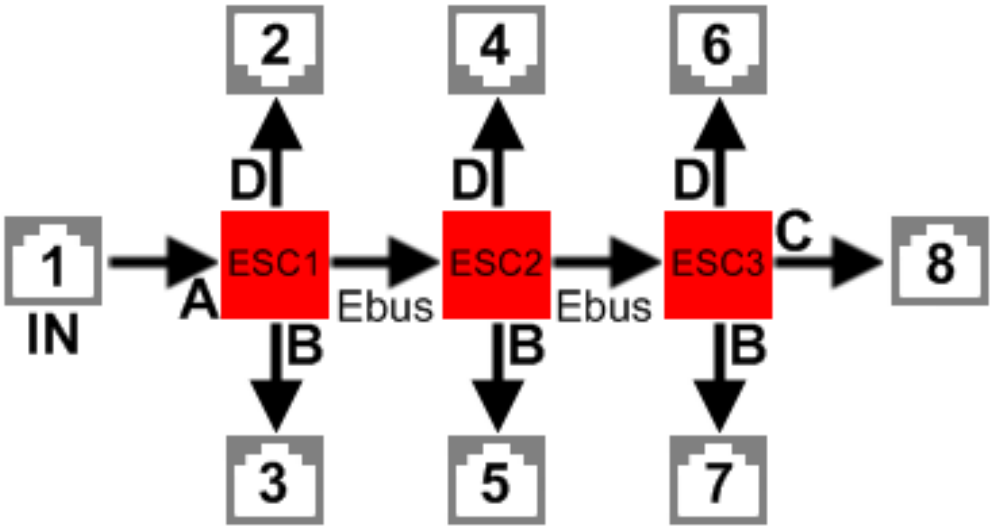
It can be used

- 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)

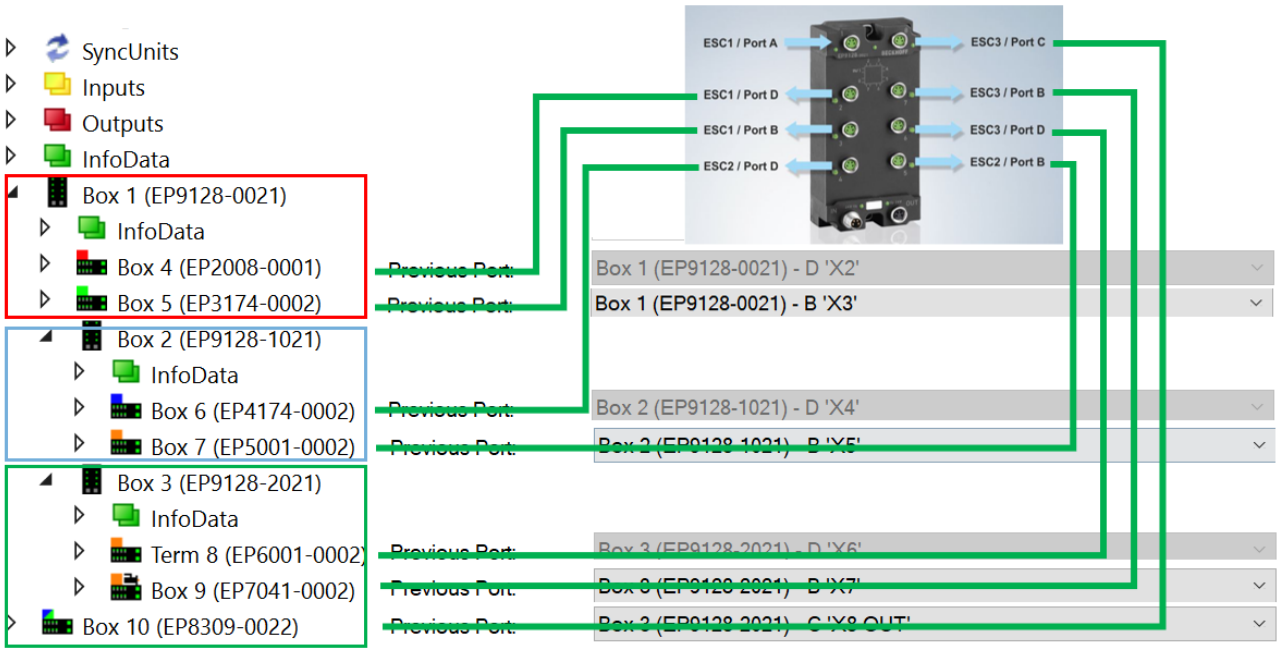
It has no I/O and no CoE directory and is not parameterizable. The core functions of the link control and distributed clocks synchronization are mapped by the ESCs.

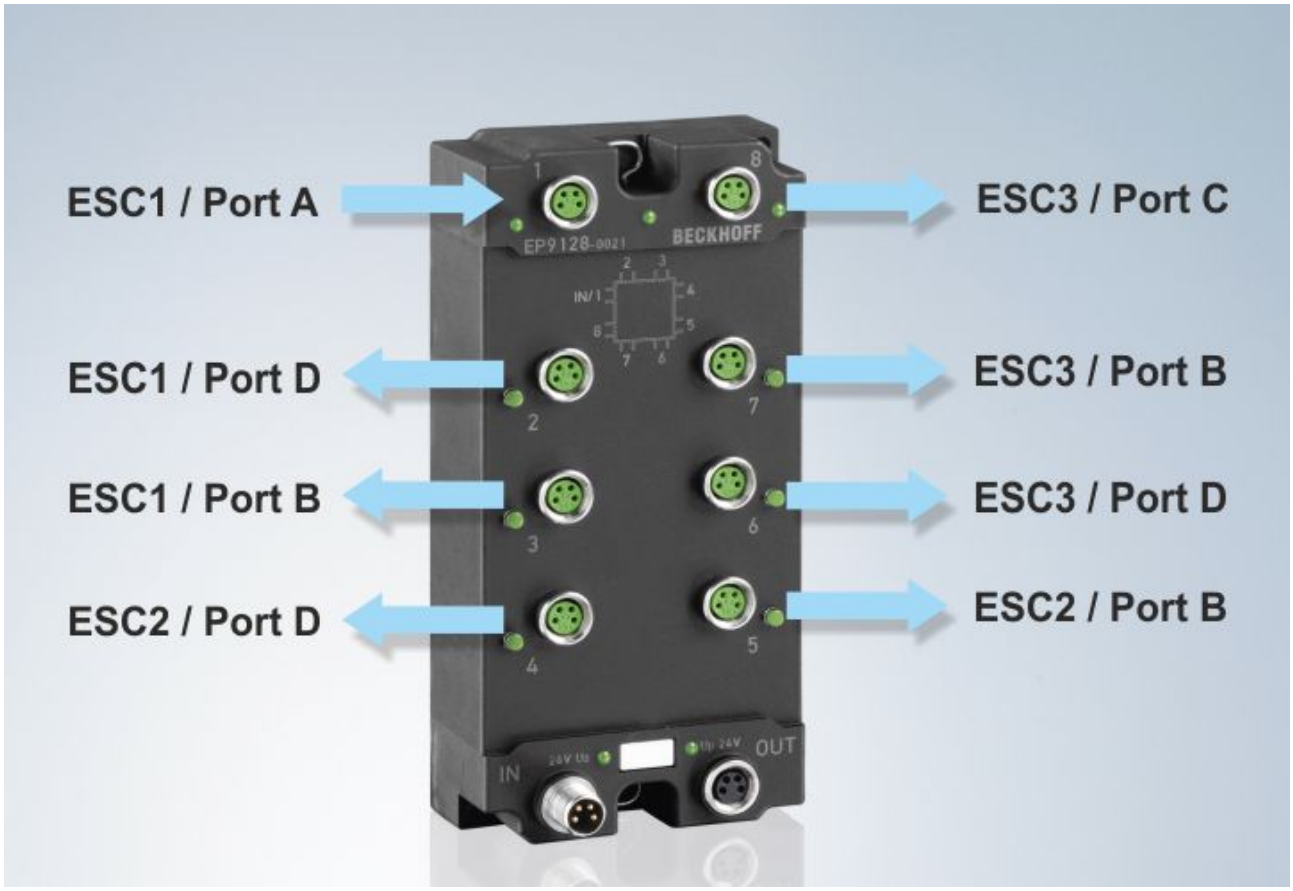
### Structure

In order to provide eight EtherCAT ports, the EP9128 has 3 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:




In TwinCAT each ESC is represented as an individual device. Therefore, the EP9128 is displayed as three devices in the Solution Explorer:






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 subdevices once the EP9128-0021 has been configured

For differentiation see also EEPROM Update [▶ 34].

### 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:

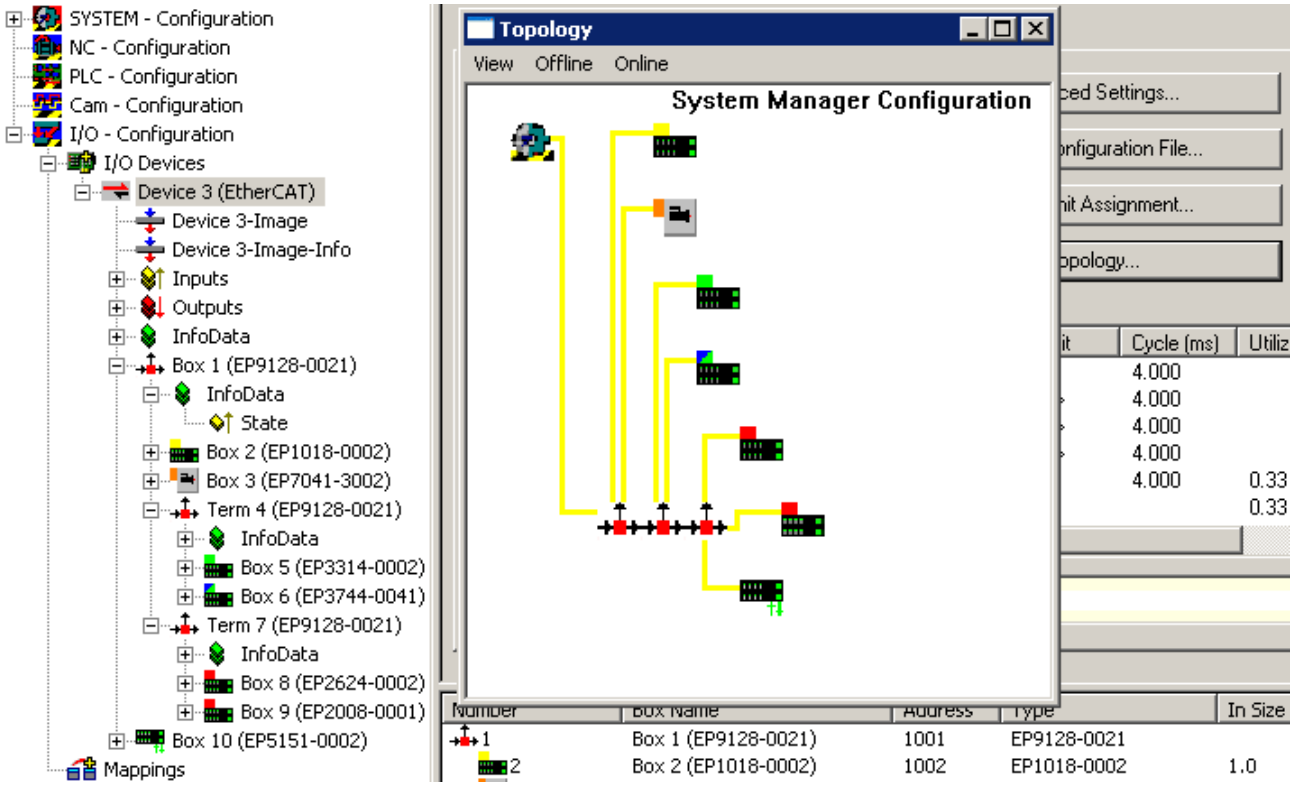



Fig. 12: Previous port of the second ESC in the EP9128

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 und
- EP5151-0002 at port 8

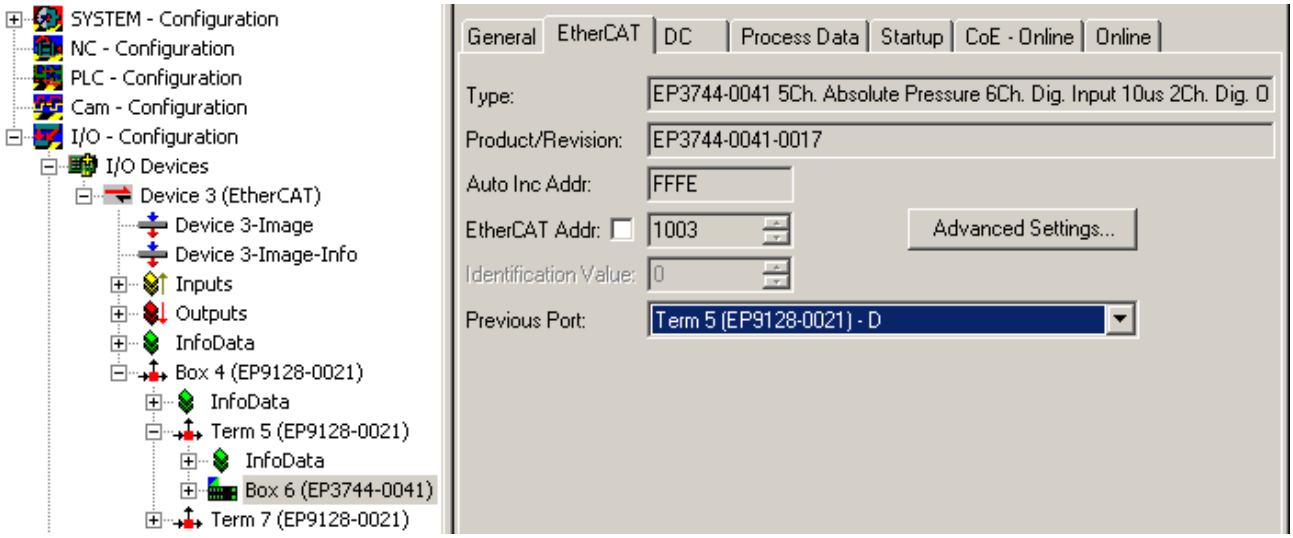



Fig. 13: Setting the PreviousPort for an EP box

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*.

## 4.3 LED displays

### EtherCAT

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


Fig. 14: LED display per channel

| LED | Display | |
|---|---|---|
| Link<br>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.

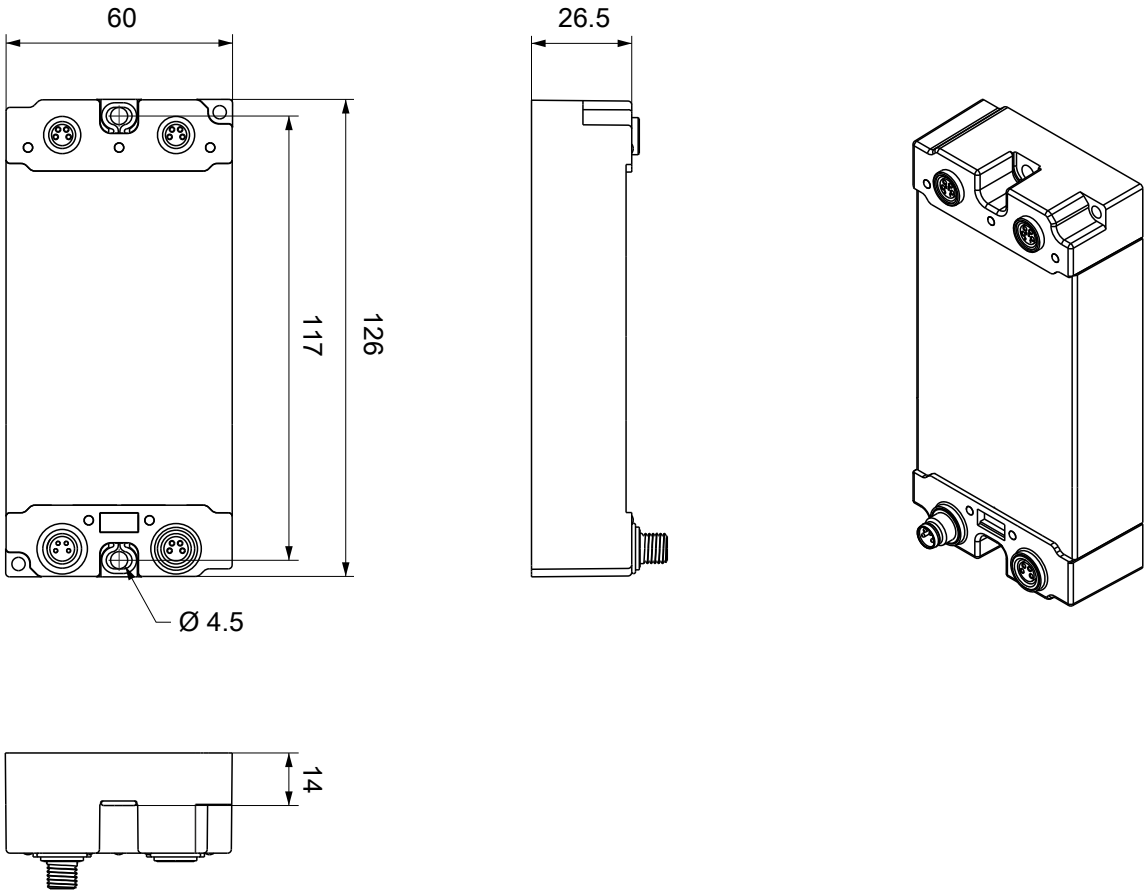
Us is used for the module electronics, Up is passed through.


Fig. 15: LED display for the supply voltages

# 5 Mounting and cabling

## 5.1 Mounting

### 5.1.1 Dimensions




All dimensions are given in millimeters.
The drawing is not true to scale.

**Housing features**

| | |
|---|---|
| Housing material | PA6 (polyamide) |
| Sealing compound | polyurethane |
| Mounting | two fastening holes Ø 4.5 mm for M4 |
| Metal parts | brass, nickel-plated |
| Contacts | CuZn, gold-plated |
| Installation position | variable |
| Protection class | IP65, IP66, IP67 (conforms to EN 60529) when screwed together |
| Dimensions (H x W x D) | approx. 126 x 60 x 26.5 mm (without connectors) |

### 5.1.2 Fixing

**NOTE**

**Dirt during assembly**

Dirty connectors can lead to malfunctions. Protection class IP67 can only be guaranteed if all cables and connectors are connected.

- Protect the plug connectors against dirt during the assembly.

Mount the module with two M4 screws in the centrally located fastening holes.

### 5.1.3 Nut torque for connectors

Screw M8 connectors tight with a torque wrench. (e.g. ZB8801 from Beckhoff)
Torque: 0.4 Nm.

# 5.2 EtherCAT

## 5.2.1 Connectors

**NOTE**

**Risk of confusion: supply voltages and EtherCAT**

Defect possible through incorrect insertion.

- Observe the color coding of the connectors:
  black: Supply voltages
  green: EtherCAT

The EtherCAT connections are implemented as green M8 sockets.


Fig. 16: EtherCAT connector

| EtherCAT | M8 connector | Core colors | | |
|---|---|---|---|---|
| **Signal** | **Contact** | **ZB9010, ZB9020, ZB9030, ZB9032, ZK1090-6292, ZK1090-3xxx-xxxx** | **ZB9031 and old versions of ZB9030, ZB9032, ZK1090-3xxx-xxxx** | **TIA-568B** |
| Tx + | 1 | yellow[1)] | orange/white | white/orange |
| Tx - | 4 | orange[1)] | orange | orange |
| Rx + | 2 | white[1)] | blue/white | white/green |
| Rx - | 3 | blue[1)] | blue | green |
| Shield | Housing | Shield | Shield | Shield |

[1)] Core colors according to EN 61918

**Adaptation of core colors for cables ZB9030, ZB9032 and ZK1090-3xxxx-xxxx**

For standardization, the core colors of the ZB9030, ZB9032 and ZK1090-3xxx-xxxx cables have been changed to the EN61918 core colors: yellow, orange, white, blue. So there are different color codes in circulation. The electrical properties of the cables have been retained when the core colors were changed.

## 5.2.2 Status LEDs

**L/A (Link/Act)**

A green LED labelled "L/A" is located next to each EtherCAT socket. The LED indicates the communication state of the respective socket:

| LED | Meaning |
|---|---|
| off | no connection to the connected EtherCAT device |
| lit | LINK: connection to the connected EtherCAT device |
| flashes | ACT: communication with the connected EtherCAT device |

**Run**

Each EtherCAT slave has a green LED labelled "Run". The LED signals the status of the slave in the EtherCAT network:

| LED | Meaning |
|---|---|
| off | Slave is in "Init" state |
| flashes uniformly | Slave is in "Pre-Operational“ state |
| flashes sporadically | Slave is in "Safe-Operational" state |
| lit | Slave is in "Operational" state |

Description of the EtherCAT slave states

## 5.2.3 Cables

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.

EtherCAT uses four wires for signal transmission.
Thanks to automatic line detection ("Auto MDI-X"), both symmetrical (1:1) or cross-over cables can be used between Beckhoff EtherCAT.

Detailed recommendations for the cabling of EtherCAT devices

## 5.3 Supply voltages

The EtherCAT Box is supplied with two supply voltages. The supply voltages are electrically isolated in the EtherCAT Box.

- Control voltage $U_S$
- Peripheral voltage $U_P$

### Redirection of the supply voltages

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

**NOTE**

**Pay attention to the maximum permissible current!**

Pay attention also for the redirection of the supply voltages $U_S$ and $U_P$, the maximum permissible current for M8 connectors of 4 A must not be exceeded!

### 5.3.1 Connectors

**NOTE**

**Risk of confusion: supply voltages and EtherCAT**

Defect possible through incorrect insertion.

- Observe the color coding of the connectors:
  black: Supply voltages
  green: EtherCAT


Fig. 17: Connectors for supply voltages

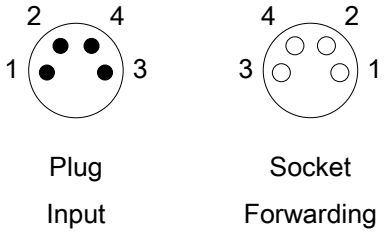



Fig. 18: M8 connector

| Contact | Function | Description | Core color [1)] |
|---|---|---|---|
| 1 | $U_S$ | Control voltage | Brown |
| 2 | $U_P$ | Peripheral voltage | White |
| 3 | $GND_S$ | GND to $U_S$ | Blue |
| 4 | $GND_P$ | GND to $U_P$ | Black |

[1)] The core colors apply to cables of the type: Beckhoff ZK2020-3xxx-xxxx

## 5.3.2 Status LEDs

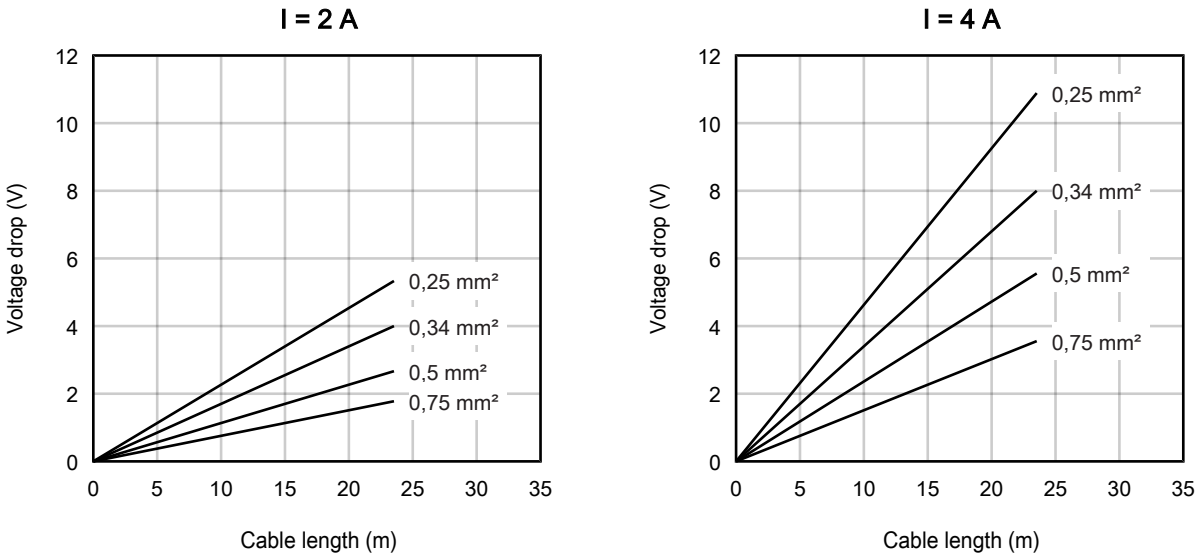

Fig. 19: Status LEDs for the supply voltages

| LED | Display | Meaning |
|---|---|---|
| $U_S$ (control voltage) | off | Supply voltage $U_S$ is not present |
| | green illuminated | Supply voltage $U_S$ is present |
| $U_P$ (peripheral voltage) | off | Supply voltage $U_P$ is not present |
| | green illuminated | Supply voltage $U_P$ is present |

## 5.3.3 Conductor losses

Take into account the voltage drop on the supply line when planning a system. Avoid the voltage drop being so high that the supply voltage at the box lies below the minimum nominal voltage.
Variations in the voltage of the power supply unit must also be taken into account.

**Voltage drop on the supply line**



## 5.4 UL Requirements

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

### Supply voltage

**⚠ CAUTION**

**CAUTION!**

This UL requirements are valid for all supply voltages of all marked EtherCAT Box Modules!
For the compliance of the UL requirements the EtherCAT Box Modules should only be supplied

- 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 -25 °C to +55 °C!

### Marking for UL

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


Fig. 20: UL label

## 5.5 Disposal

Products marked with a crossed-out wheeled bin shall not be discarded with the normal waste stream. The device is considered as waste electrical and electronic equipment. The national regulations for the disposal of waste electrical and electronic equipment must be observed.

# 6 Appendix

## 6.1 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 IP67 modules and the used metal parts. In the table below you will find some typical resistance.

| Character | Resistance |
|---|---|
| Steam | at temperatures >100°C: not resistant |
| Sodium base liquor (ph-Value > 12) | at room temperature: resistant<br>> 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

## 6.2 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.

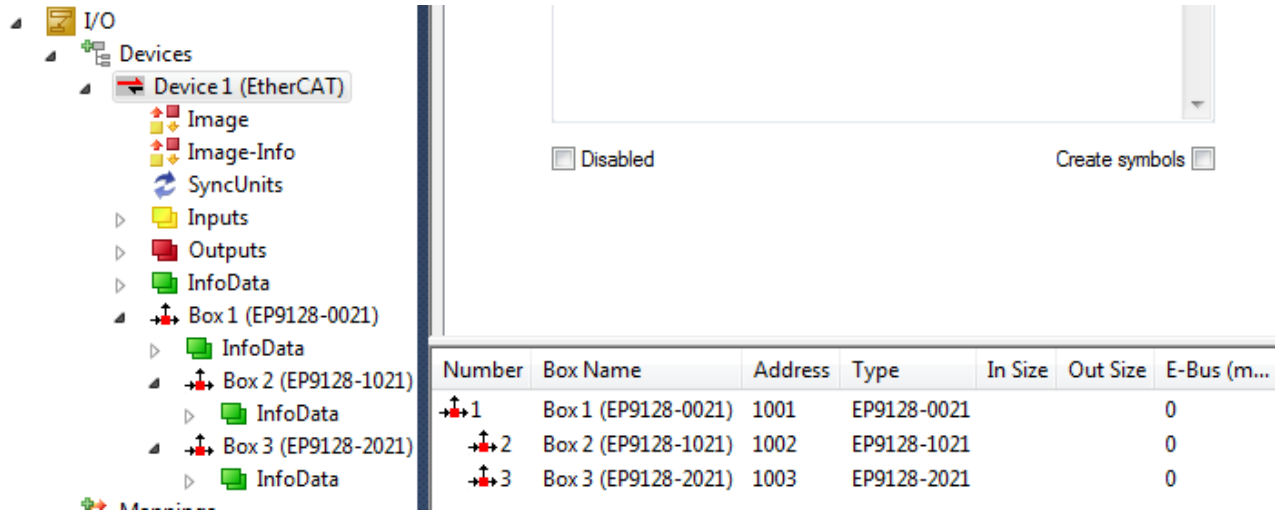



*Fig. 1: The 3 internal ESC names of the EP9128*

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.

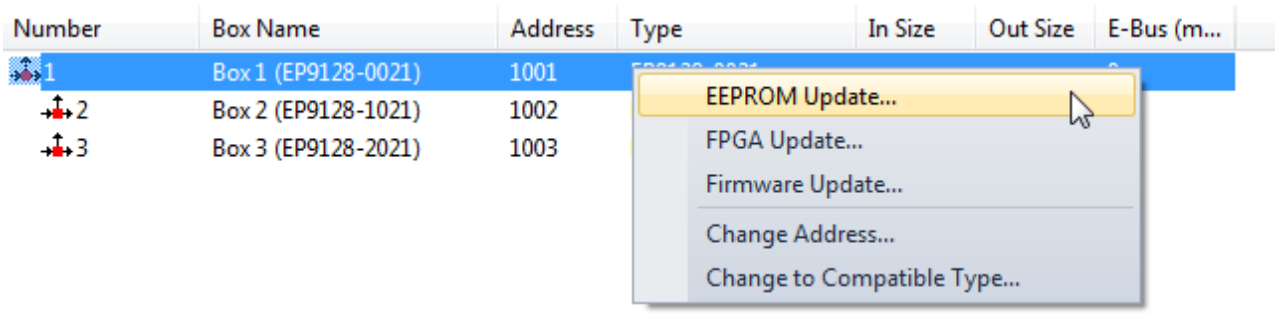



*Fig. 2: EEPROM Update TwinCAT*

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.

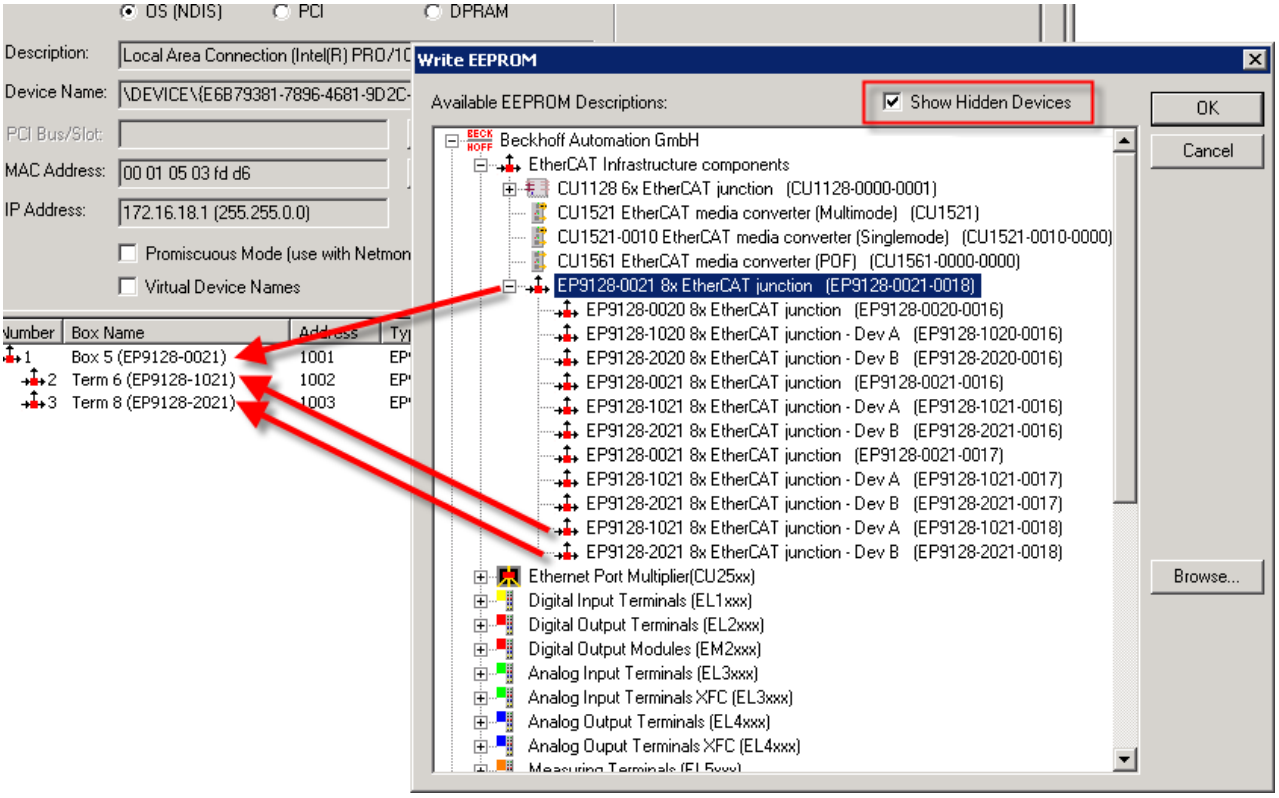



*Fig. 3: Currently available EEPROM descriptions for EP9128 and assignment*

# 6.3 Accessories

### Mounting

| Ordering information | Description | Link |
|---|---|---|
| ZS5300-0011 | Mounting rail | Website |

### Labeling material, protective caps

| Ordering information | Description |
|---|---|
| ZS5000-0010 | Protective cap for M8 sockets, IP67 (50 pieces) |
| ZS5100-0000 | Inscription labels, unprinted, 4 strips of 10 |
| ZS5000-xxxx | Printed inscription labels on enquiry |

### Cables

A complete overview of pre-assembled cables for fieldbus components can be found here.

| Ordering information | Description | Link |
|---|---|---|
| ZK1090-3xxx-xxxx | EtherCAT cable M8, green | Website |
| ZK1093-3xxx-xxxx | EtherCAT cable M8, yellow | Website |
| ZK2020-3xxx-xxxx | Power cable M8, 4-pin | Website |

### Tools

| Ordering information | Description |
|---|---|
| ZB8801-0000 | Torque wrench for plugs, 0.4…1.0 Nm |
| ZB8801-0001 | Torque cable key for M8 / wrench size 9 for ZB8801-0000 |

**Further accessories**

Further accessories can be found in the price list for fieldbus components from Beckhoff and online at https://www.beckhoff.com.

# 6.4 Version identification of EtherCAT devices

## 6.4.1 General notes on marking

### Designation

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

- family key
- type
- version
- revision

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

### Notes

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

## 6.4.2 Version identification of EP/EPI/EPP/ER/ERI boxes

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

| Structure of the serial number: **KK YY FF HH** | Example with serial number 12 06 3A 02: |
|---|---|
| KK - week of production (CW, calendar week) | 12 - production week 12 |
| YY - year of production | 06 - production year 2006 |
| FF - firmware version | 3A - firmware version 3A |
| HH - hardware version | 02 - hardware version 02 |

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

Syntax: D ww yy x y z u

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

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

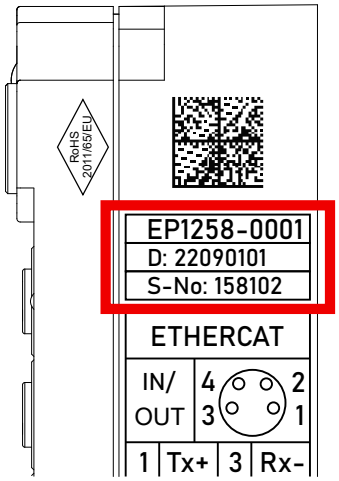



Fig. 21: EP1258-00001 IP67 EtherCAT Box with batch number/DateCode 22090101 and unique serial number 158102

### 6.4.3 Beckhoff Identification Code (BIC)

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

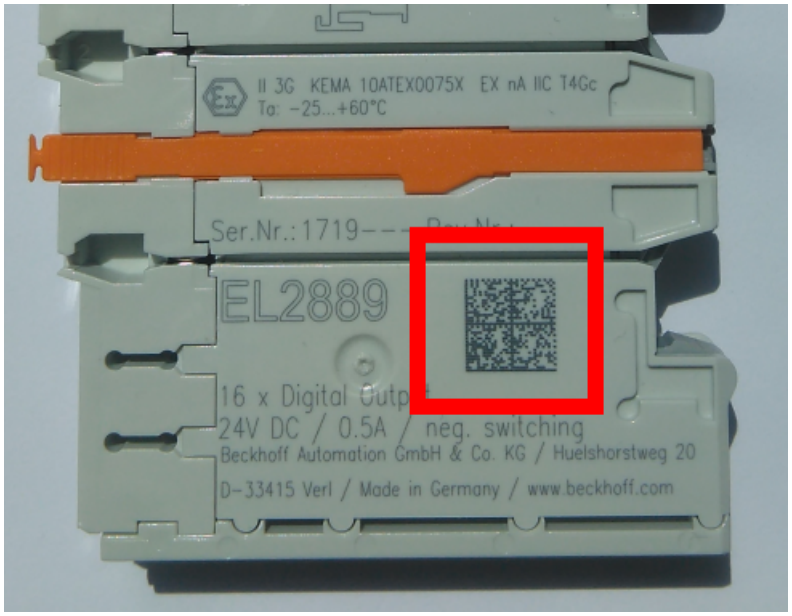



Fig. 22: BIC as data matrix code (DMC, code scheme ECC200)

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

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

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

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

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

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

| Position | Type of information | Explanation | Data identifier | Number of digits incl. data identifier | Example |
|---|---|---|---|---|---|
| 1 | Beckhoff order number | **Beckhoff order number** | 1P | 8 | 1P072222 |
| 2 | Beckhoff Traceability Number (BTN) | **Unique serial number, see note below** | SBTN | 12 | SBTNk4p562d7 |
| 3 | Article description | **Beckhoff article description, e.g. EL1008** | 1K | 32 | 1KEL1809 |
| 4 | Quantity | **Quantity in packaging unit, e.g. 1, 10, etc.** | Q | 6 | Q1 |
| 5 | Batch number | Optional: Year and week of production | 2P | 14 | 2P401503180016 |
| 6 | ID/serial number | Optional: Present-day serial number system, e.g. with safety products | 51S | 12 | 51S678294 |
| 7 | Variant number | Optional: Product variant number on the basis of standard products | 30P | 32 | 30PF971, 2*K183 |
| ... | | | | | |

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

### Structure of the BIC

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

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

Accordingly as DMC:

Fig. 23: Example DMC **1P**072222**S**BTNk4p562d7**1K**EL1809 **Q**1 **51S**678294

### BTN

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

**NOTE**

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

## 6.4.4 Electronic access to the BIC (eBIC)

### Electronic BIC (eBIC)

The Beckhoff Identification Code (BIC) is applied to the outside of Beckhoff products in a visible place. If possible, it should also be electronically readable.

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

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

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

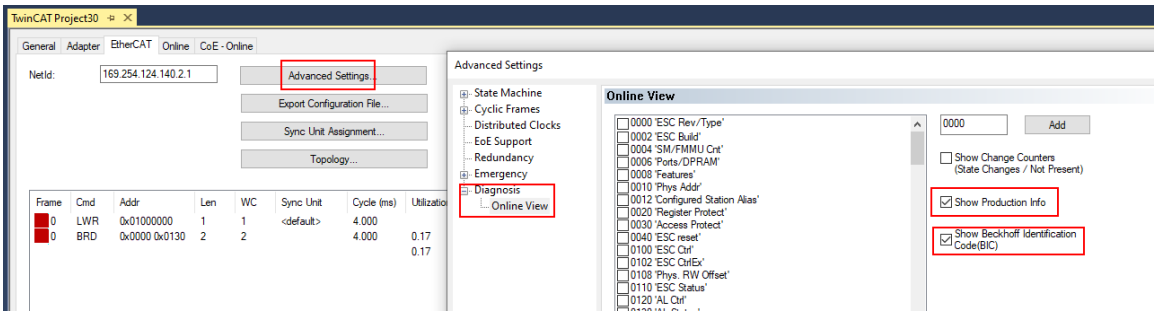
### EtherCAT devices (IP20, IP67)

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

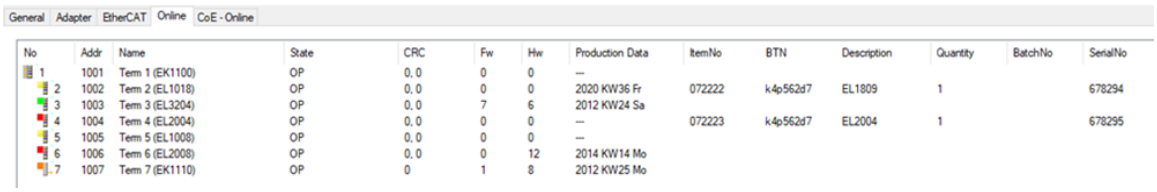
The eBIC is also stored in the ESI-EEPROM. The eBIC was introduced into the Beckhoff I/O production (terminals, boxes) from 2020; widespread implementation is expected in 2021.

The user can electronically access the eBIC (if existent) as follows:

- With all EtherCAT devices, the EtherCAT master (TwinCAT) can read the eBIC from the ESI-EEPROM
  - From TwinCAT 3.1 build 4024.11, the eBIC can be displayed in the online view.
  - To do this,
    check the checkbox "Show Beckhoff Identification Code (BIC)" under
    EtherCAT → Advanced Settings → Diagnostics:




  - The BTN and its contents are then displayed:




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

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

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

- the object 0x10E2 will be introduced into stock products in the course of a necessary firmware revision.
- From TwinCAT 3.1. build 4024.24 the functions *FB_EcCoEReadBIC* and *FB_EcCoEReadBTN* for reading into the PLC and further eBIC auxiliary functions are available in the Tc2_EtherCAT Library from v3.3.19.0.

- Note: in the case of electronic further processing, the BTN is to be handled as a string(8); the identifier "SBTN" is not part of the BTN.
- Technical background
  The new BIC information is additionally written as a category in the ESI-EEPROM during the device production. The structure of the ESI content is largely dictated by the ETG specifications, therefore the additional vendor-specific content is stored with the help of a category according to ETG.2010. ID 03 indicates to all EtherCAT masters that they must not overwrite these data in case of an update or restore the data after an ESI update.
  The structure follows the content of the BIC, see there. This results in a memory requirement of approx. 50..200 bytes in the EEPROM.
- Special cases
  - If multiple, hierarchically arranged ESCs are installed in a device, only the top-level ESC carries the eBIC Information.
  - If multiple, non-hierarchically arranged ESCs are installed in a device, all ESCs carry the eBIC Information.
  - If the device consists of several sub-devices with their own identity, but only the top-level device is accessible via EtherCAT, the eBIC of the top-level device is located in the CoE object directory 0x10E2:01 and the eBICs of the sub-devices follow in 0x10E2:nn.

### Profibus/Profinet/DeviceNet... Devices

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

## 6.5 Support and Service

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

### Beckhoff's branch offices and representatives

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

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

You will also find further documentation for Beckhoff components there.

### Beckhoff Support

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

- support
- design, programming and commissioning of complex automation systems
- and extensive training program for Beckhoff system components

| | |
|---|---|
| Hotline: | +49 5246 963 157 |
| Fax: | +49 5246 963 9157 |
| e-mail: | support@beckhoff.com |

### Beckhoff Service

The Beckhoff Service Center supports you in all matters of after-sales service:

- on-site service
- repair service
- spare parts service
- hotline service

| | |
|---|---|
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| Fax: | +49 5246 963 479 |
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