BECKHOFF New Automation Technology

Documentation | EN

# CU1521-xxxx, CU1561

EtherCAT Media Converter (RJ45, LWL, POF, SFP)


2026-06-16 | Version: 4.0.0

# Table of contents

# 1 Foreword

## 1.1 CU15x1 - Product overview

| Product designation | Description |
| --- | --- |
| CU1521 [▶ 17] | Infrastructure, media converter, Ethernet/EtherCAT, 100 Mbit/s, 24 V DC, fiber optic multi-mode |
| CU1521-0010 [▶ 17] | Infrastructure, media converter, Ethernet/EtherCAT, 100 Mbit/s, 24 V DC, fiber optic single-mode |
| CU1521-0020 [▶ 21] | Infrastructure, media converter, 3-port junction, Ethernet/EtherCAT, 1000/100 Mbit/s, 24 V DC, SFP |
| CU1561 [▶ 17] | Infrastructure, media converter, Ethernet/EtherCAT, 100 Mbit/s, 24 V DC, fiber optic POF |

## 1.2 Notes on the documentation

**Intended audience**

This description is only intended for the use of trained specialists in control and automation engineering who are familiar with the applicable national standards.
It is essential that the documentation and the following notes and explanations are followed when installing and commissioning these components.
The qualified personnel is obliged to always use the currently valid documentation.

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

**Disclaimer**

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

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

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

**Trademarks**

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## 1.3 Guide through documentation

**NOTICE**

**Further components of documentation**

This documentation describes device-specific content. It is part of the modular documentation concept for Beckhoff I/O components. For the use and safe operation of the device / devices described in this documentation, additional cross-product descriptions are required, which can be found in the following table.

| Title | Description |
|---|---|
| **EtherCAT System Documentation** (PDF) | • System overview<br>• EtherCAT basics<br>• Cable redundancy<br>• Hot Connect<br>• EtherCAT devices configuration |

The documentations can be viewed at and downloaded from the Beckhoff website (www.beckhoff.com) via:

- the “Documentation and Download” area of the respective product page,
- the Download finder,
- the Beckhoff Information System.

If you have any suggestions or proposals for our documentation, please send us an e-mail stating the documentation title and version number to: documentation@beckhoff.com

## 1.4 Safety instructions

**Safety regulations**

Please note the following safety instructions and explanations!
Product-specific safety instructions can be found on following pages or in the areas mounting, wiring, commissioning etc.

**Exclusion of liability**

All the components are supplied in particular hardware and software configurations appropriate for the application. Modifications to hardware or software configurations other than those described in the documentation are not permitted, and nullify the liability of Beckhoff Automation GmbH & Co. KG.

**Personnel qualification**

This description is only intended for trained specialists in control, automation and drive engineering who are familiar with the applicable national standards.

**Signal words**

The signal words used in the documentation are classified below. In order to prevent injury and damage to persons and property, read and follow the safety and warning notices.

**Personal injury warnings**

| ⚠ DANGER |
|---|
| Hazard with high risk of death or serious injury. |

| ⚠ WARNING |
|---|
| Hazard with medium risk of death or serious injury. |

| ⚠ CAUTION |
|---|
| There is a low-risk hazard that could result in medium or minor injury. |

**Warning of damage to property or environment**

| *NOTICE* |
|---|
| The environment, equipment, or data may be damaged. |

**Information on handling the product**

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

## 1.5 Safety instructions and behavioral rules for Class 1 laser

⚠ CAUTION

**Class 1 laser product in accordance with IEC 60825-1:2014 – danger of accident due to glare!**


The following laser-specific behavioral rules are to be followed for the Class 1 laser products described in this document:

- The laser beam may not be directed toward persons, since accidents may be caused by glare.
- Do not look into the direct or reflected beam.
- If laser radiation meets the eye, the eyes must be consciously closed and the head turned away from the beam immediately.
- When using the laser, no optical instruments may be used to view the radiation source, since this can lead to exposure limit values being exceeded.
- Manipulations (modifications) of the laser device are not permitted.

## 1.6 Documentation issue status

| Version | Changes |
|---|---|
| 4.0.0 | • Update chapter "Use of SFP in the CU1521-0020"<br>• Update chapter "Technical data"<br>• Update chapter "Application notes"<br>• Update chapter "Firmware compatibility" |
| 3.9.0 | • Chapter "Use of SFP in the CU1521-0020" added<br>• Chapter "Object description and parameterization CU1521-0020" added<br>• Update chapter "Application notes"<br>• Update chapter "Firmware compatibility"<br>• Update chapter "Diagnosis" |
| 3.8.0 | • Update chapter "Technical data"<br>• Update chapter "Application notes"<br>• Update chapter "Firmware compatibility"<br>• Structural update |
| 3.7.0 | • Update chapter "Technical data"<br>• Update chapter "Basics of fiber optic technology"<br>• Structural update |
| 3.6.0 | • Chapter "Technical data" updated<br>• Structural update |
| 3.5.0 | • Chapter "Technical data" updated<br>• Chapter "Application notes" updated<br>• Structural update |
| 3.4.0 | • Structural update |
| 3.3.0 | • Chapter “Introduction” updated<br>• Chapter "Firmware compatibility" updated<br>• Chapter "Operating and usage instructions"<br>• Structural update |
| 3.2.0 | • Chapter "Technical data" updated<br>• Chapter "Basics of fiber optic technology" updated<br>• Structural update |
| 3.1.0 | • Chapter "Technical data" updated<br>• Chapter “Power Supply Wiring” added<br>• Structural update |
| 3.0 | • Chapter "Technical data" and "Dimensions" updated<br>• Chapter "Disposal" added<br>• Structural update |
| 0.1 – 2.9 | *archived* |

# 1.7 Version identification of EtherCAT devices

## 1.7.1 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<br>12 mm, non-pluggable connection level | 3314<br>4-channel thermocouple terminal | 0000<br>basic type | 0016 |
| ES3602-0010-0017 | ES terminal<br>12 mm, pluggable connection level | 3602<br>2-channel voltage measurement | 0010<br>high-precision version | 0017 |
| CU2008-0000-0000 | CU device | 2008<br>8-port fast ethernet switch | 0000<br>basic type | 0000 |

### Notes

- The elements mentioned above result in the **technical designation**. EL3314-0000-0016 is used in the example below.
- EL3314-0000 is the order identifier, in the case of “-0000” usually abbreviated to EL3314. “-0016” is the EtherCAT revision.
- The **order identifier** is made up of
  - family key (EL, EP, CU, ES, KL, CX, etc.)
  - type (3314)
  - version (-0000)
- The **revision** -0016 shows the technical progress, such as the extension of features with regard to the EtherCAT communication, and is managed by Beckhoff.
  In principle, a device with a higher revision can replace a device with a lower revision, unless specified otherwise, e.g. in the documentation.
  Associated and synonymous with each revision there is usually a description (ESI, EtherCAT Slave Information) in the form of an XML file, which is available for download from the Beckhoff web site.
  From 2014/01 the revision is shown on the outside of the IP20 terminals, see Fig. *“EL2872 with revision 0022 and serial number 01200815”*.
- The type, version and revision are read as decimal numbers, even if they are technically saved in hexadecimal.

### 1.7.2 Version identification of CU Infrastructure Components

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

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


Fig. 1: CU1521 switch with serial number 4820/ and the unique Beckhoff Traceability Number (BTN) 00007su0

### 1.7.3 Beckhoff Identification Code (BIC)

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

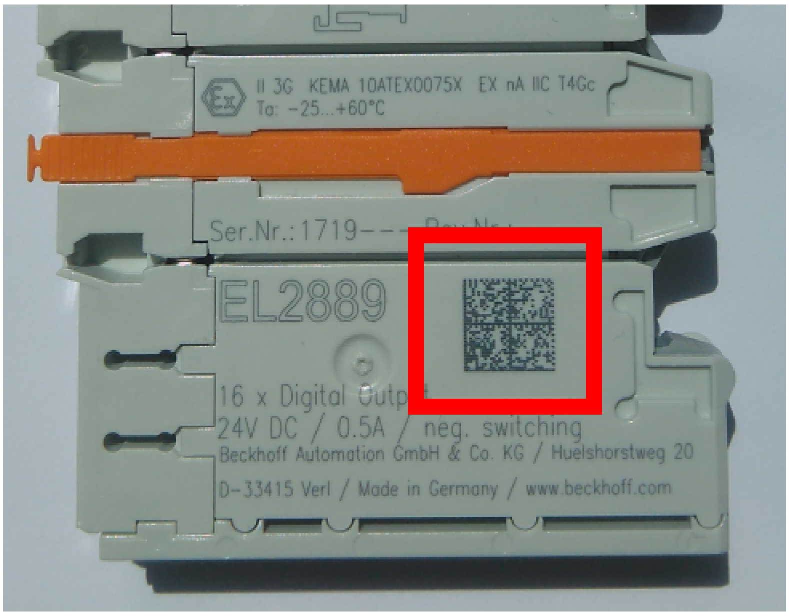



Fig. 2: BIC as data matrix code (DMC, code scheme ECC200)

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

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

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

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

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

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

| Posi-tion | Type of information | Explanation | Data identifier | Number of digits incl. data identifier | Example |
|---|---|---|---|---|---|
| 1 | Beckhoff order number | **Beckhoff order number** | 1P | 8 | **1P**072222 |
| 2 | Beckhoff Traceability Number (BTN) | **Unique serial number, see note below** | SBTN | 12 | **SBTN**k4p562d7 |
| 3 | Article description | **Beckhoff article description, e.g. EL1008** | 1K | 32 | **1K**EL1809 |
| 4 | Quantity | **Quantity in packaging unit, e.g. 1, 10, etc.** | Q | 6 | **Q**1 |
| 5 | Batch number | Optional: Year and week of production | 2P | 14 | **2P**401503180016 |
| 6 | ID/serial number | Optional: Present-day serial number system, e.g. with safety products | 51S | 12 | **51S**678294 |
| 7 | Variant number | Optional: Product variant number on the basis of standard products | 30P | 12 | **30P**F971, 2*K183 |
| ... | | | | | |

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

#### Structure of the BIC

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

**1P**072222**SBTN**k4p562d7**1K**EL1809 **Q**1 **51S**678294

Accordingly as DMC:

Fig. 3: Example DMC **1P**072222**SBTN**k4p562d7**1K**EL1809 **Q**1 **51S**678294

#### BTN

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

**NOTICE**

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

## 1.7.4 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.

The interface that the product can be electronically addressed by is crucial for the electronic readout.

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

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

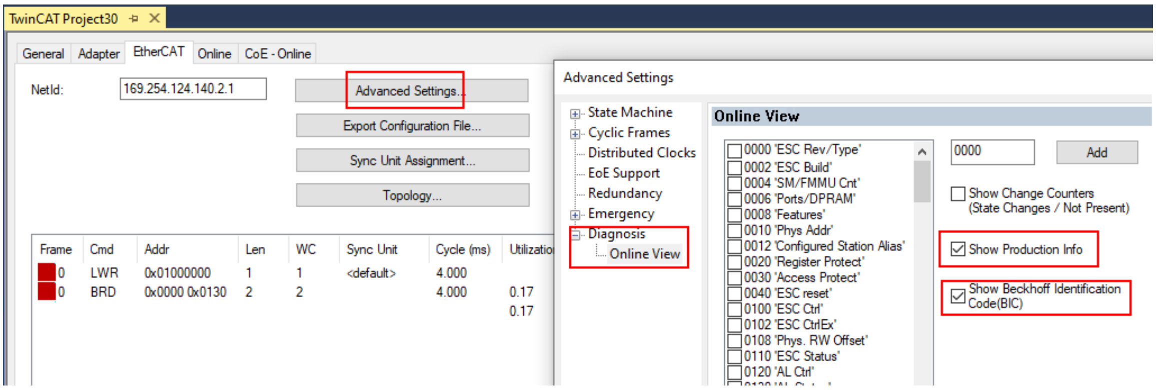
**EtherCAT devices (IP20, IP67)**

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

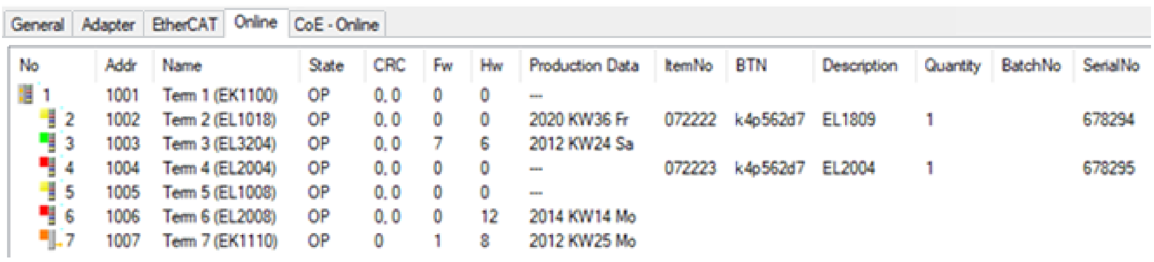
Beckhoff also stores the eBIC in the ESI-EEPROM. The eBIC was introduced into Beckhoff IO production (terminals, box modules) in 2020; as of 2023, implementation is largely complete.

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

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




    - The BTN and its contents are then displayed:




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

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

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

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

**PROFIBUS, PROFINET, and DeviceNet® devices**

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

# 2 Product description

## 2.1 CU1521 (Multimode) , CU1521-0010 (Singlemode) , CU1561 (POF)

### 2.1.1 Introduction

Fig. 4: CU1521, CU1521-0010, CU1561

The EtherCAT-capable CU1521, CU1521-0010 and CU1561 devices should be used as media converter for industrial fast Ethernet/100 Mbaud from optical fiber to copper and vice versa.

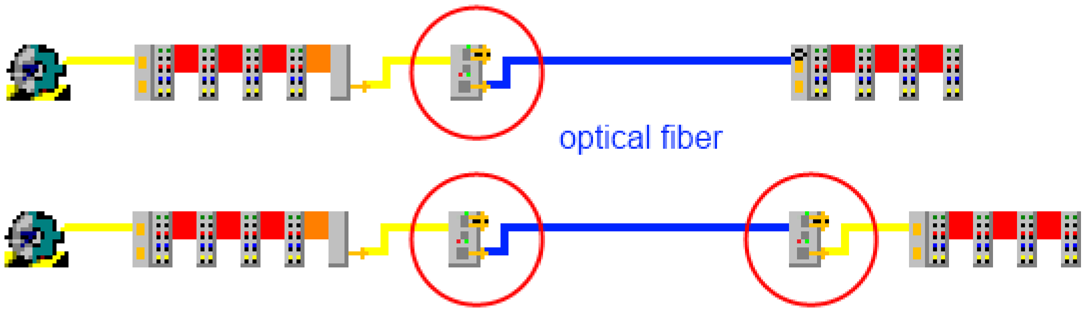



Fig. 5: Upper picture: one media converter, copper -> fiber optic,
Lower picture: two media converters, copper -> fiber optic -> copper

From the physical layer perspective the CU1521 is suitable for multimode, while the CU1521-0010 is suitable for single mode optical fiber and therefore for significantly longer transmission links up to 20 km.
The CU1561 is used for interfacing with POF (plastic optical fiber), which are suitable for small-scale machine installation thanks to relatively inexpensive cable material and field-configurability.

The media converter operates bidirectionally and collision-free. The CU15x1 devices are therefore also suitable as media converters for any Ethernet traffic. They support "Link Loss Forwarding", which means that, if the link fails at the outgoing strand, for example due to a broken wire, the link is also withdrawn from the incoming line, so that the sending device is notified of the link loss.

The CU15x1 devices are characterized by the fact that they support the requirements of an EtherCAT network for a converter particularly well. This includes fast link control (establishment and disconnection), diagnosis of communication errors, constant frame deceleration and readable identity (no transparent operation). If the CU15x1 is set to EtherCAT mode with the rotary switch, it can be diagnosed as a separate EtherCAT device. Hence, as opposed to standard media converters, he also ensures fast link control and thus the secure termination of an EtherCAT strand even in the event of a disruption. Since the transfer direction (copper Þ optical fiber or optical fibers Þ copper) is relevant for the EtherCAT bus, the operating direction can be configured via the rotary switch.

The CU15x1 are useful in applications where EtherCAT transfers over large distances are required or where higher EMC loads on the bus line are to be expected.

**Quick links**

- EtherCAT basics
- Application notes [▶ 32]
- Diagnostic LEDs [▶ 20]

## 2.1.2 Technical data

| Technical data | CU1521 | CU1521-0010 | CU1561 |
|---|---|---|---|
| Function Ethernet "IP" | Media converter Fast Ethernet/100Mbaud (all IEEE 802.3-based protocols)<br>IEEE 802.3u auto negotiation, half or full duplex, automatic settings<br>Link Loss-Forwarding (notification direction configurable)<br>Store and Forward Mode (FIFO)<br>unmanaged | | |
| Function EtherCAT "EC" | Media converter Fast Ethernet/100Mbaud<br>Cut-through mode<br>Port handling/link control | | |
| Number of Ethernet ports | 2 | | |
| Ethernet interface X1 | 100BASE-FX multimode glass fiber 50/125 µm (MM) typically 1310 nm<br>1 x SC Duplex | 100BASE-FX single mode glass fiber 9/125 µm (SM)<br>typically 1310 nm<br>1 x SC Duplex<br>Laser class 1, see note [▸ 9] | 100BASE-FX-POF glass fiber 980/1000 µm (POF);<br>typically 650 nm<br>1 x versatile link for POF duplex connector (connector set ZS1090-0008)<br>Laser class 1, see note [▸ 9] |
| Ethernet interface X2 | 10BASE-T/100BASE-TX Ethernet/EtherCAT cable (min. CAT 5), screened<br>RJ45 | | |
| Cable length X1 max. | max. 2 km (100BASE-FX) | max. 20 km (100BASE-FX) | max. 50 m (100BASE-FX-POF) |
| Minimum output power (opt.) | 62,5/125 µm,<br>NA = 0,275:<br>-20 dBm avg.<br>50/125 µm,<br>NA = 0,2:<br>-23,5 dBm avg. | -15 dBm (until year of manufacture 2022)<br>-5 dBm (from year of manufacture 2023) | NA = 0,5:<br>-13,5 dBm |
| Maximum output power (opt.) | -14 dBm | -8 dBm (until year of manufacture 2022)<br>0 dBm (from year of manufacture 2023) | -4 dBm |
| Min. necessary optical input power (sensivity) | -31 dBm | -25 dBm (until year of manufacture 2022)<br>-35 dBm (from year of manufacture 2023) | -26 dBm |
| Maximum permissible optical input power | -14 dBm | -8 dBm | -4 dBm |
| Cable length X2 max. | up to 100 m twisted pair CAT5 (e) | | |
| Diagnostics | LED: Supply voltage, link/activity X1/X2<br>EtherCAT: CRC | | |
| Power supply | via 3-pin supply connector with push-in wiring [▸ 29] (⏚, GND, +24V) | | |
| Supply voltage | 24 $V_{DC}$ (18 $V_{DC}$ to 30 $V_{DC}$), protected against polarity reversal. | | |
| Current consumption | typ. 95 mA | typ. 80 mA | typ. 60 mA |
| Weight | approx. 105 g | | |
| Dimensions without plugs (W x H x D) | approx. 35 mm x 98.5 mm x 76.5 mm | | |
| Mounting [▸ 28] | on 35 mm mounting rail (mounting rail according to EN 60715) | | |
| Permissible ambient temperature range during operation | -25°C ... +60°C | 0°C …+55°C | |
| Permissible ambient temperature range during storage | -40°C ... +85°C | -25°C ... +85°C | |
| Permissible relative humidity | 95%, no condensation | | |
| Vibration/shock resistance | conforms to EN 60068-2-6 / EN 60068-2-27, EN 60068-2-29 | | |
| EMC immunity/emission | conforms to EN 61000-6-2 / EN 61000-6-4 | | |
| Protection class | IP20 | | |
| Installation position | variable | | |
| Marking / Approval*) | CE, UKCA, EAC<br>cULus [▸ 30] | | |

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

## 2.1.3 Diagnostic LEDs


Fig. 6: Pin assignment CU1521, CU1521-0010, CU1561

### LEDs for fieldbus diagnostics/power supply

| LED | Color | Display | State | Description |
|---|---|---|---|---|
| L/A (X1) green (x2) | green | off | - | no connection on the EtherCAT strand |
| | | on | linked | EtherCAT device connected |
| | | flashing | active | Communication with EtherCAT device |
| Power | green | off | | No supply voltage |
| | | on | | 24 V supply voltage present |

### LED diagnostics EtherCAT State Machine

| LED | Color | Meaning | |
|---|---|---|---|
| RUN | green | This LED indicates the terminal's operating state: | |
| | | off | State of the EtherCAT State Machine: **INIT** = initialization of the terminal |
| | | Single flash | State of the EtherCAT State Machine: **PREOP** = function for mailbox communication and different default settings set |
| | | flashing | State of the EtherCAT State Machine: **SAFEOP** = verification of the Sync Manager channels and the distributed clocks.<br>Outputs remain in safe state |
| | | on | State of the EtherCAT State Machine: **OP** = normal operating state; mailbox and process data communication is possible |
| | | flickering | State of the EtherCAT State Machine: **BOOTSTRAP** = function for Firmware updates of the terminal |
| | orange | on | CU15x1 is in EtherCAT operation, rotary switch was changed during operation<br>*Remedy*: Reset or voltage reset |
| | red | on | CU15x1 is not **OP** in EtherCAT operation or in Ethernet operation, rotary switch was changed during operation<br>*Remedy*: Reset or voltage reset |
| | red/ green | flashing | invalid rotary switch position after PowerOn<br>*Remedy*: Move rotary switch to a approved position |

## 2.2 CU1521-0020 (SFP)

### 2.2.1 Introduction


Fig. 7: CU1521-0020

The CU1521-0020 is a 3-port Ethernet device with two SFP slots and serves as a universal media converter and junction for EtherCAT and Industrial Ethernet. It was specially developed for use in pairs in EtherCAT networks, especially when special transmission technologies such as BiDi fiber optics are used, for which standard couplers (e.g. EK1501/1501-0010) or media converters (e.g. CU1521/CU1521-0010) are not suitable.

The EtherCAT transmission direction (copper to SFP, SFP to copper, SFP to SFP) and the “Link Loss Forwarding” function for normal Ethernet operation can be conveniently configured via a rotary switch on the device.

To ensure compatibility with EtherCAT, the media converter operates collision-free with a constant delay and functions as an independent EtherCAT device. In contrast to standard media converters, this enables fast link control even in the event of a fault, ensuring safe termination of the EtherCAT segment and seamless continued operation.

The device is supplied without SFP modules, but with SFP dust caps inserted.

**Quick links**

• EtherCAT basics
• Application notes [▸ 32]
• Diagnostic LEDs [▸ 20]

## 2.2.2 Technical data

| Technical data | CU1521-0020 |
|---|---|
| Task in the EtherCAT system | Media change from RJ45 copper physics to others (depending on SFP modules) and back |
| Transmission medium | any (depending on the SFP module);<br>Ethernet / EtherCAT cable (min. Cat.5), shielded |
| Bus interface | 1 x RJ45<br>2x SFP: depending on SFP module |
| Distance between stations | RJ45: max. 100 m<br>SFP: depending on the SFP module |
| Protocol | 100 Mbit EtherCAT<br>10/100/1000 Mbit Ethernet |
| SFP-Interface X1/X2 | SFP interface according to Spec SFF INF-8074i for 100 Mbit and 1 Gbit SFP<br>Protocols: SGMII and 100BaseX<br>see note!<br>max. supply current: 1 A per SFP port, sum current both ports max. 1 A |
| SFP-Diagnostics | DDM information available |
| Ethernet interface X3 | 10/100/1000 BASE-T, see note! |
| Propagation delay | approx. 1 µs per port |
| Configuration | via rotary switch |
| Power supply | 24 (18...30) V DC, 3-pin connector (+, -, PE) |
| Current consumption 24 V DC | approx. 120 mA |
| Weight | approx. 150 g |
| Dimensions without connector (W x H x D) | approx. 35 x 98,5 x 76,5 (in mm) |
| Installation [▶ 28] | on 35 mm mounting rail (mounting rail according to EN 60715) |
| Approved ambient temperature range during operation | -25 °C ... +55 °C<br>Observe the instructions for use of the SFP in section “Approved ambient temperature range and thermal power budget [▶ 59]” |
| Approved ambient temperature range during storage | -40 °C ... +85 °C |
| approved relative air humidity | 95 %, no condensation |
| Vibration / shock resistance | conforms to EN 60068-2-6 / EN 60068-2-27, EN 60068-2-29 |
| EMC immunity / emission | conforms to EN 61000-6-2 / EN 61000-6-4 |
| Protection rating | IP20 |
| Installation position | variable |
| Marking / approval*) | CE, UKCA, EAC |

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

## 2.2.3 Diagnostic LEDs


Fig. 8: CU1521-0020 (front view)

### LEDs for fieldbus diagnostics/power supply

| LED | Color | Display | State | Description |
|---|---|---|---|---|
| L/A (X3) | green | off | - | no connection on the EtherCAT strand |
| | | on | linked | EtherCAT device connected |
| | | flashing | active | Communication with EtherCAT device |
| Power | green | off | | No supply voltage |
| | | on | | 24 V supply voltage present |

### LED diagnostics EtherCAT State Machine

| LED | Color | Meaning | |
|---|---|---|---|
| RUN | green | This LED indicates the terminal's operating state: | |
| | | off | State of the EtherCAT State Machine: **INIT** = initialization of the terminal |
| | | Single flash | State of the EtherCAT State Machine: **PREOP** = function for mailbox communication and different default settings set |
| | | flashing | State of the EtherCAT State Machine: **SAFEOP** = verification of the Sync Manager channels and the distributed clocks.<br>Outputs remain in safe state |
| | | on | State of the EtherCAT State Machine: **OP** = normal operating state; mailbox and process data communication is possible |
| | | flickering | State of the EtherCAT State Machine: **BOOTSTRAP** = function for Firmware updates of the terminal |
| | orange | on | CU15x1 is in EtherCAT operation, rotary switch was changed during operation<br>*Remedy*: Reset or voltage reset |
| | red | on | CU15x1 is not **OP** in EtherCAT operation or in Ethernet operation, rotary switch was changed during operation<br>*Remedy*: Reset or voltage reset |
| | red/ green | flashing | invalid rotary switch position after PowerOn<br>*Remedy*: Move rotary switch to a approved position |

# 3 Basic principles

## 3.1 EtherCAT basics

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

## 3.2 EtherCAT cabling – wire-bound

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

### Cables and connectors

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

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

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

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

**Recommended cables**

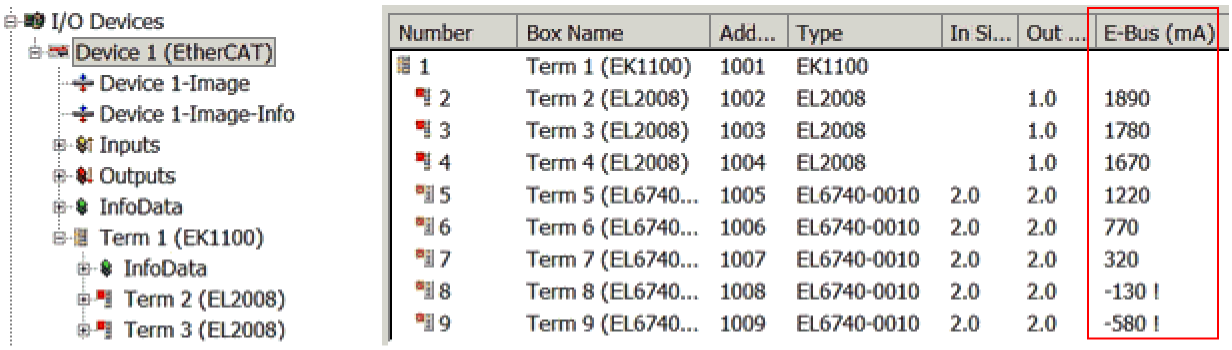
It is recommended to use the appropriate Beckhoff components e.g.
- cable sets ZK1090-9191-xxxx respectively
- RJ45 connector, field assembly ZS1090-0005
- EtherCAT cable, field assembly ZB9010, ZB9020

Suitable cables for the connection of EtherCAT devices can be found on the Beckhoff website!

### E-Bus supply

A bus coupler can supply the EL terminals added to it with the E-bus system voltage of 5 V; a coupler is thereby loadable up to 2 A as a rule (see details in respective device documentation).
Information on how much current each EL terminal requires from the E-bus supply is available online and in the catalogue. If the added terminals require more current than the coupler can supply, then power feed terminals (e.g. EL9410) must be inserted at appropriate places in the terminal strand.

The pre-calculated theoretical maximum E-Bus current is displayed in the TwinCAT System Manager. A shortfall is marked by a negative total amount and an exclamation mark; a power feed terminal is to be placed before such a position.




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

Fig. 9: System manager current calculation

**NOTICE**

**Malfunction possible!**

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

## 3.3 EtherCAT State Machine

The state of the EtherCAT slave is controlled via the EtherCAT State Machine (ESM). Depending upon the state, different functions are accessible or executable in the EtherCAT slave. Specific commands must be sent by the EtherCAT master to the device in each state, particularly during the bootup of the slave.

A distinction is made between the following states:

- Init
- Pre-Operational
- Safe-Operational
- Operational
- Bootstrap

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

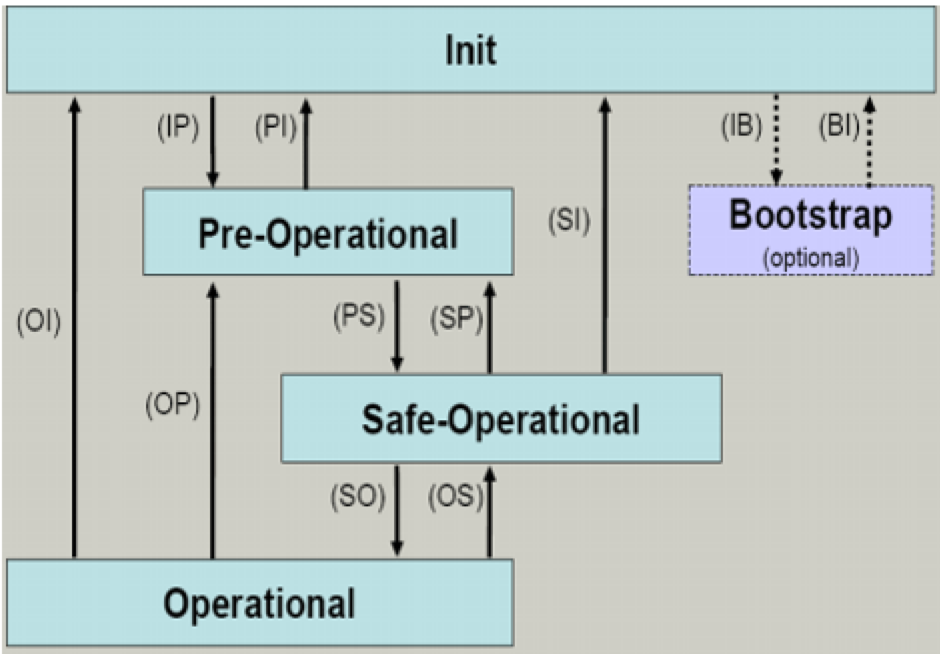



Fig. 10: States of the EtherCAT State Machine

### Init

After switch-on the EtherCAT slave in the *Init* state. No mailbox or process data communication is possible. The EtherCAT master initializes sync manager channels 0 and 1 for mailbox communication.

### Pre-Operational (Pre-Op)

During the transition between *Init* and *Pre-Op* the EtherCAT slave checks whether the mailbox was initialized correctly.

In *Pre-Op* state mailbox communication is possible, but not process data communication. The EtherCAT master initializes the sync manager channels for process data (from sync manager channel 2), the Fieldbus Memory Management Unit (FMMU) channels and, if the slave supports configurable mapping, PDO mapping or the sync manager PDO assignment. In this state the settings for the process data transfer and perhaps terminal-specific parameters that may differ from the default settings are also transferred.

### Safe-Operational (Safe-Op)

During transition between *Pre-Op* and *Safe-Op* the EtherCAT slave checks whether the sync manager channels for process data communication and, if required, the Distributed Clocks settings are correct. Before it acknowledges the change of state, the EtherCAT slave copies current input data into the associated Dual Port (DP)-RAM areas of the ESC.

In *Safe-Op* state mailbox and process data communication is possible, although the slave keeps its outputs in a safe state, while the input data are updated cyclically.

**Outputs in SAFEOP state**

The default set watchdog monitoring sets the outputs of the ESC module in a safe state - depending on the settings in SAFEOP and OP - e.g. in OFF state. If this is prevented by deactivation of the monitoring in the module, the outputs can be switched or set also in the SAFEOP state.

### Operational (Op)

Before the EtherCAT master switches the EtherCAT slave from *Safe-Op* to *Op* it must transfer valid output data.

In the *Op* state the slave copies the output data of the masters to its outputs. Process data and mailbox communication is possible.

### Boot

In the *Boot* state the slave firmware can be updated. The *Boot* state can only be reached via the *Init* state.

In the *Boot* state mailbox communication via the file access over EtherCAT (FoE) protocol is possible, but no other mailbox communication and no process data communication.

# 4 Mounting and wiring

## 4.1 Dimensions

**Space requirement in the control cabinet**

- The RJ45 connector increase the depth depending on their design and the Ethernet cable used.
- Above the mounting rail an additional height of approx. 10 mm is required to enable latching [▶ 28] of the switch onto the rail.

**CU1521-00x0**

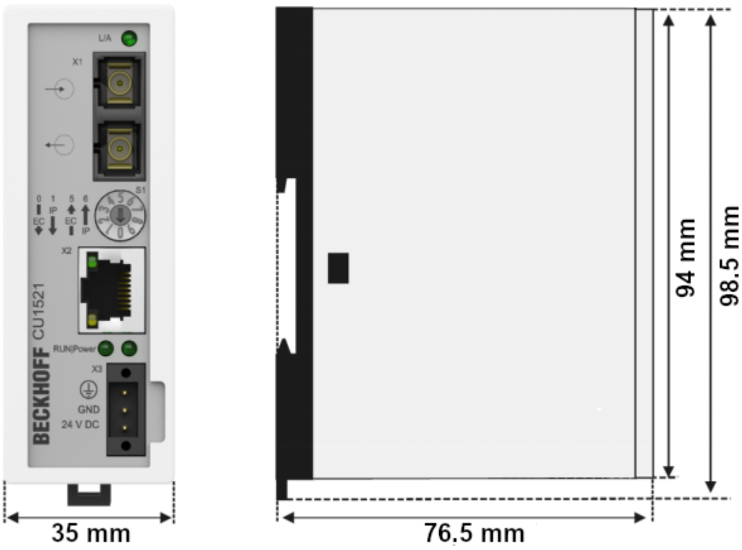



Fig. 11: CU1521-00x0

**CU1561**

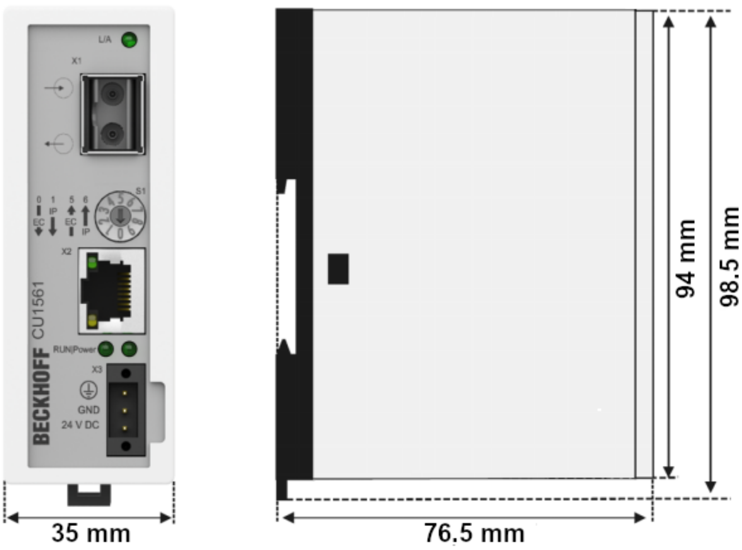



Fig. 12: CU1561

## 4.2 Mounting and demounting

The CU15xx converters are mounted on the mounting surface with the aid of a 35 mm DIN rail  (according to EN 60715).

**Mounting rail installation**

Please ensure that the CU15x1 engages properly on the mounting rail.

**Mounting**

- Fit the mounting rail to the planned assembly location.
- Position the device in the mounting rail with the spring at the top of its latching flange (1)
- Push the lower side of the device (2) against the mounting surface until it latches on the mounting rail.
- Attach the cable.

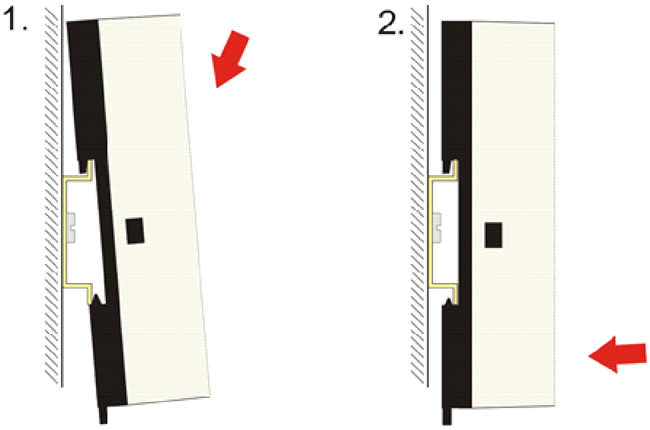



Fig. 13: Mounting

**Removal**

- Remove all the cables.
- Pull the strap on the underside of the device (1) downwards with a screwdriver
- Pull the device upwards away from the mounting surface (2)

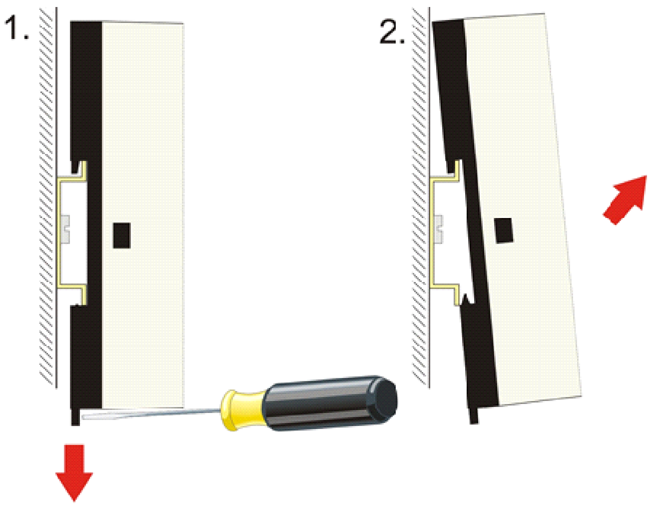



Fig. 14: Removal

# 4.3 Cabling of power supply

**Pin assignment power supply connection**


Fig. 15: Pin assignment of the connection terminal (X3)

**Permissible cable cross-sections of the supply connector**

The 3-pin supply connector is connected using push-in wiring.

The following cable cross-sections are permitted:

| Device | CU15xx |
|---|---|
| Solid conductor | 0.14 ... 1.5 mm$^2$ (AWG26-14) |
| Fine stranded conductor | 0.14 ... 1.5 mm$^2$ (AWG26-14) |
| Fine stranded conductor; with ferrule with plastic collar | 0.14 ... 1.5 mm$^2$ (AWG26-14) |
| Stripping length | 8 ... 9 mm |

## 4.4 UL notice

**⚠ CAUTION**

**Application**

Beckhoff EtherCAT modules are intended for use with Beckhoff’s UL Listed EtherCAT System only.

**⚠ CAUTION**

**Examination**

For cULus examination, the Beckhoff I/O System has only been investigated for risk of fire and electrical shock (in accordance with UL508 and CSA C22.2 No. 142).

**⚠ CAUTION**

**For devices with Ethernet connectors**

Not for connection to telecommunication circuits.

**Basic principles**

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

## 4.5 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.

# 5 Commissioning/application notes

## 5.1 Application notes

### 5.1.1 General notes

Special behavior is expected from the converter, depending on whether EtherCAT or standard Ethernet telegrams are to be transferred.

**Use in: Standard Ethernet 10/100/1000*) MBit**

An Ethernet connection is a managed point-to-point connection between two intelligent end devices.

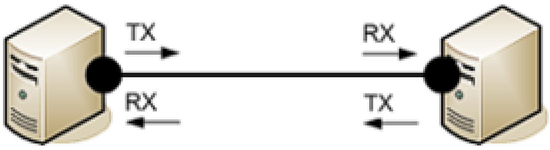



Fig. 16: Point-to-point connection between two Ethernet devices

Both devices transmit the so-called idle pattern in their Ethernet connection. When they also receive a corresponding pattern, the connection and thus the so-called *Link* has been established. Both devices then know that they can use this connection. If the connection is interrupted, the link is lost and both devices are notified.

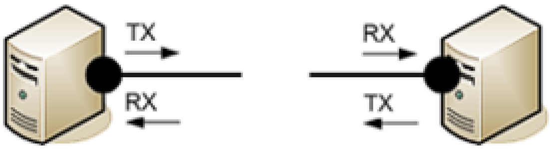



Fig. 17: Interrupted point-to-point connection

If a media converter is placed between the two stations, it too becomes an intelligent transmitter/receiver. If connection C is interrupted, device A would not necessarily be informed and would continue to send data to the converter via the existing link B, and the data would "trickle away". The CU15x1 therefore supports *Link Loss Forwarding* (LLF) in a selected direction. The notification is indicated by a label on the CU15x1. If the converter detects an interruption of connection C in switch setting *1* in Fig. *Interposed media converter in the Ethernet connection*, it also interrupts link B.

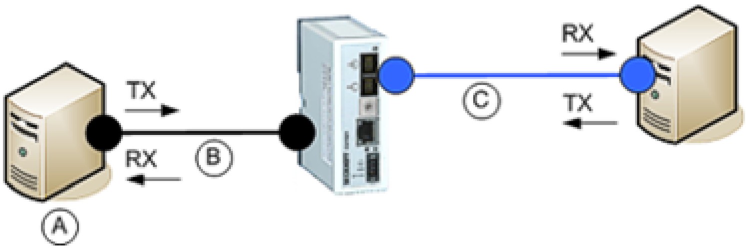



Fig. 18: Interposed media converter in the Ethernet connection

In both IP settings the CU15x1 operates as a store and forward network device with checksum function. Frames that are faulty (CRC error), too short (<64 bytes) or too long (>1522 bytes) are not passed on.

**Frame size in Ethernet mode**

In Ethernet MOD, only a frame size of 64 to 1522 bytes (CU1521-0020: 64 to 9018 bytes) is supported.

*) For possible data rates, see the respective device description

**Used for: EtherCAT 100 Mbit**

Other characteristics are required if it is used as a media converter in an EtherCAT network:

- Consistently low delay in the frame transit, irrespective of frame length
- Fast link detection when the connection is established and interrupted
- Identification as separate EtherCAT device with diagnostic function

EtherCAT slaves process the EtherCAT telegrams in forward direction from the perspective of the master. Accordingly, in the CU15x1 the forward direction may be X1 --> X2 or X2 --> X1, depending on the application. It has to be set at the rotary switch prior to commissioning. The direction of the arrow of S1 indicates the set forward direction.

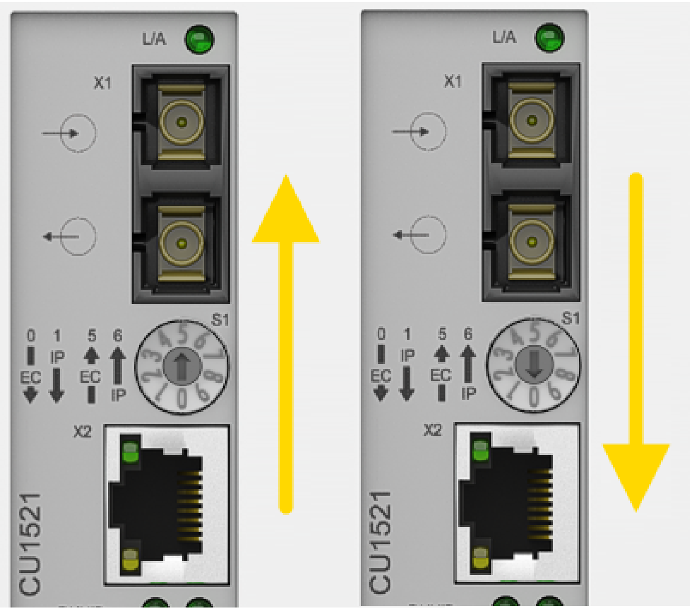



Fig. 19: Setting the forward direction at the media converter

Make sure the rotary switch is set to the right position, so that the CU15x1 operates in forward direction. For example, in Fig. *Copper -> optical fiber-> copper operation of two media converters,* the CU15x1 on the left operates as a copper --> optical fiber converter (rotary switch position 5), the CU15x1 on the right operates as an optical fiber --> copper converter (rotary switch position 0).

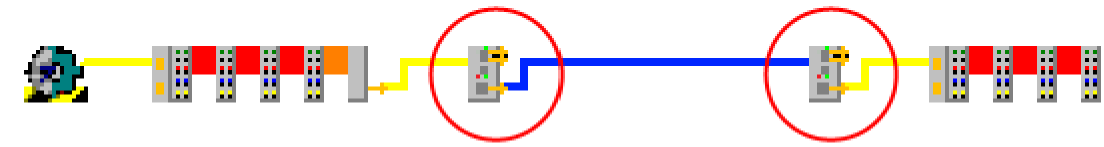


Fig. 20: Copper -> optical fiber-> copper operation of two media converters

If the opposite direction of rotation is set, the subsequent behavior depends on the EtherCAT master. The scanned CU15x1 may be inserted at a different position in the topology, or an INIT_VPRS error message of the EtherCAT master may occur.

## 5.1.2 Earthing/Shielding

The FE contact on the supply socket must be directly connected to the mounting rail contact. During installation, always take care of a conductive connection to the mounting rail.

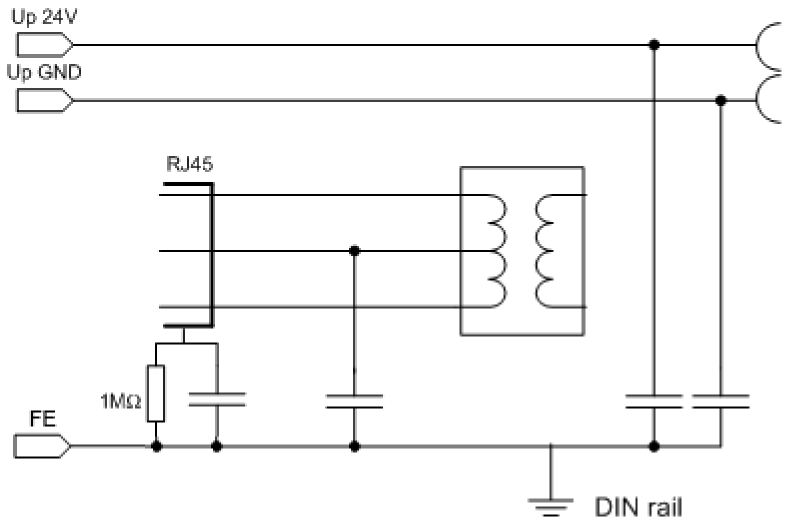



Fig. 21: Internal earthing concept CU15x1

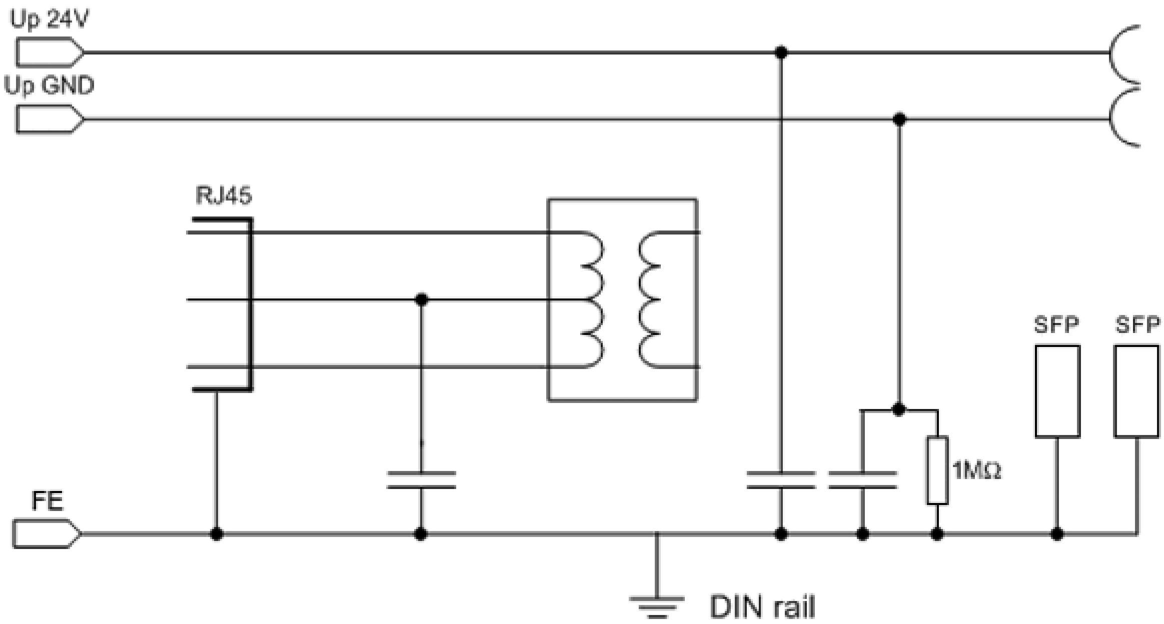



Fig. 22: Internal earthing concept CU1521-0020

## 5.1.3 Further notes

The CU15x1 deals with setting the rotary switch when the supply voltage is applied, unless the rotary switch is in an invalid position. In this case the CU15x1 deals with the setting when the rotary switch reaches a valid position for the first time.

If the rotary switch is moved during valid operation, the CU15x1 does not alter its function but indicates this state through its LED, see Diagnostics [▶ 20]. The switch setting must be rectified before the voltage is re-applied!

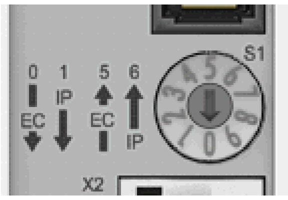



Fig. 23: Rotary switch

Slanting installation of the optical fiber socket in the CU15x1 reduces the bending radius of the optical fiber cable during connection in the control cabinet (Fig. *Slanting installation of the optical fiber socket*).

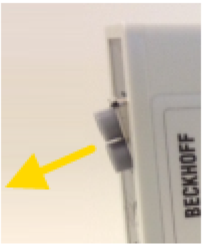



Fig. 24: Slanting installation of the optical fiber socket

## 5.2 Notes on converters with RJ45 fiber-optic connection


Fig. 25: CU1521

**Mounting rail installation**

**Mounting**

Please ensure that the CU15x1 engages properly on the mounting rail.
See chapter Mounting rail installation [▶ 28].

## 5.2.1 Principles of fiber-optic technology

When using fiber-optic cables for the transmission of data, there are various factors that influence the signal transmission and have to be observed in order to guarantee reliable transmission. Important principles of fiber-optic technology are described below.

**Attenuation**

Less light reaches the end of a connection with fiber-optic cables than is input at the start of the connection. This loss of light between the start and end of the transmission link is called attenuation. The attenuation between two points is often stated in decibels (dB). However, the decibel is not a unit, but a ratio – in the case of a fiber-optic cable it is the ratio of the light energy at the start of the connection to that at the end. It is one tenth of a Bel (B) (1 B = 10 dB). In general, decibel indicates a power level $L_P$ from the ratio of one power $P_1$ to another power $P_2$.

- $L_P$[dB] = $10*\log_{10}(P_1/P_2)$

A positive power factor is a signal amplification, a negative power factor conversely a weakening or attenuation of the signal.

The attenuation of a fiber-optic connection is essentially determined by three influencing factors. These influencing factors are the attenuation in the fiber-optic, the attenuation in the connector and the attenuations that result from the splices in the fiber-optic connection. The total attenuation is therefore given by

- Fiber-optic link attenuation [dB] = fiber loss attenuation [dB] + connector insertion attenuation [dB] + splice insertion attenuation [dB]

Where

- fiber loss attenuation [dB] = fiber attenuation coefficient [dB/km)] x length [km]
- connector insertion attenuation [dB] = number of connectors x connector insertion attenuation [dB]
- splice insertion attenuation [dB] = number of splices x splice insertion attenuation [dB]

**Dispersion**

A further influence that needs to be observed with the signal transmission is the dispersion. Dispersion describes the spreading or widening of a light pulse. Due to propagation differences resulting in the fiber-optic cable from different injection angles of the light waves, the optical pulse widens and is therefore wider at the output than at the input. The longer the transmission link, the greater the dispersion.

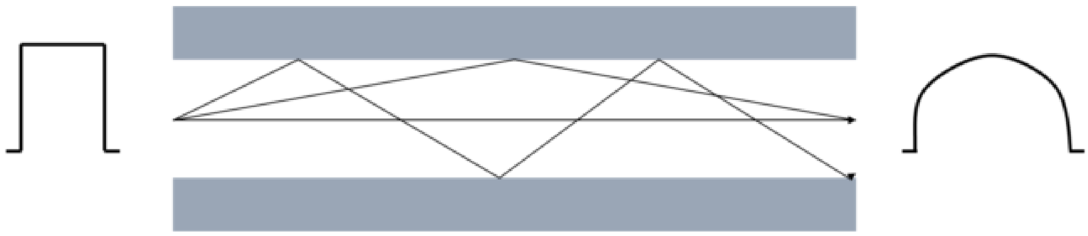


Fig. 26: Dispersion

If higher data rates are to be transmitted by the fiber-optic cable, the pulses must be sent faster at the input. What may happen then, however, is that pulses at the output run into one another and can no longer be distinguished from one another. The dispersion thus limits the maximum bandwidth of the fiber-optic connection.

The maximum bandwidth is specified in the data sheet for a fiber-optic cable as the bandwidth/length ratio in the unit MHz*km. Therefore, the longer a transmission link, the smaller the available bandwidth. The bandwidth/length ratio or product is always specified in the data sheet for a fiber-optic cable. The length of the transmission link can then be calculated with the necessary bandwidth.

s [km] = bandwidth [MHz] / bandwidth/length ratio [MHz/km]

### Further influences on the signal transmission

In addition to the main influences (attenuation and dispersion) that limit the transmission link, care must be taken when installing and maintaining fiber-optic transmission links.

Sharp kinks and micro-bends in the fiber-optic lead to additional reflections in the fiber, as a result of which the influences of the attenuation and dispersion are increased. The specified bending radii of fiber-optic cables must be adhered to.

Poorly installed connectors also have a great influence on the signal quality. In case of poor connections, the fiber-optic may be too far away from the connecting piece, so that the light waves do not enter the fiber at the right angle of entry.

The third influence on the signal transmission that needs to be observed is soiling of, or damage to the ends of optical fibers. Due to the size of the fibers, often just 125 µm, dirt or damage cannot be discerned with the naked eye. Only a microscope with a sufficient magnification (at least factor 100) enables the fiber ends to be checked. To prevent soiling, the cable cap supplied with the cable should always be fitted to the fiber end.

### Power and attenuation budget

The power budget specifies the minimum power available between transmitter and receiver. The attenuation budget describes the attenuation between transmitter and receiver due to the three attenuation factors – fiber, connectors and splices – described above.

Transceivers (derived from the words transmitter and receiver) are installed in fiber-optic transmitters and receivers. A transceiver is a combined transmitting and receiving device. The transceiver data sheet usually contains two key values that are required for calculating the power budget. These values are the **minimum output power** (worst level) of the transmitter and the **maximum sensitivity** (i.e. lowest received power/ level) of the receiver at which it still recognizes signals.

Both values are often specified in the unit decibel milliwatt (dBm). dBm describes the power level in relation to a reference value of 1 mW.

$$L_P[dB] = 10*\log_{10}(P_1/1\ mW)$$

0 dBm then corresponds to a power value of 1 mW, positive dBm values indicate power values >1 mW and negative dBm values indicate power values <1 mW.

For the technical application assessment, the difference between the minimum output power and the maximum sensitivity at the input is therefore regarded as the available power budget as a worst-case assumption:

```
Leistungsbudget = minimale Ausgangsleistung - maximale Empfindlichkeit
```

Note: In practice, the power budget is usually higher because the typical transmission power is higher than the minimum. However, this is not always the case.

Cable attenuation results from the attenuation influences described above.

```
Dämpfungspegel [dB] = Faserverlustdämpfung [dB] + Steckereinfügungsdämpfung [dB] +
Spleißeinfügungsdämpfung [dB].
```

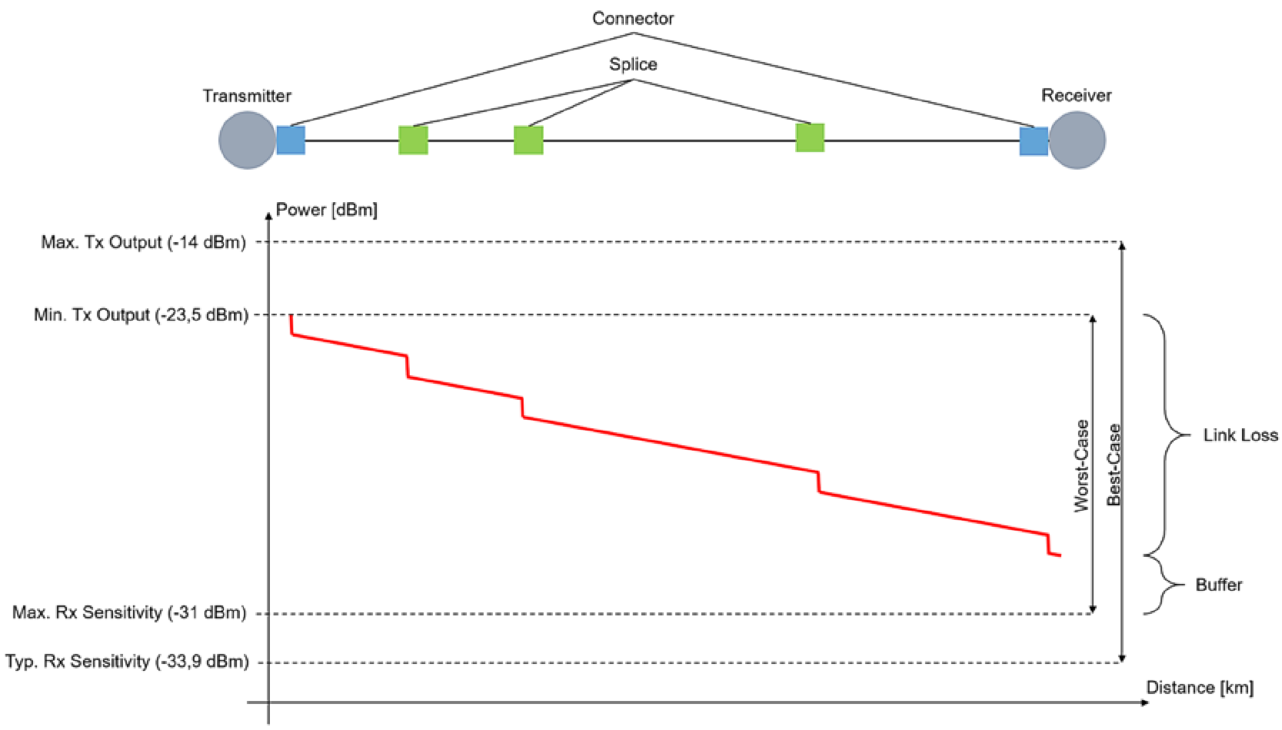



Fig. 27: Power and attenuation budget

The attenuation level must not exceed the power budget, otherwise reliable reception is no longer possible. A reserve as high as >3 dB is recommended (see diagram) to ensure long-term operation for years despite aging effects as sources in the transmitter age and lose power, connectors or splices deteriorate, or connectors become dirty when disconnected for rerouting or testing. If cables are accidentally cut later, a reserve is useful to accommodate splices for reconnection.

### Example calculation of power and attenuation budget

In an example calculation, the power and attenuation budget is to be calculated for a transmission link of 2.1 km in length between an EK1501 and an EK1521 with a multimode fiber in the strength 50/125 µm. The two fiber-optic couplers under consideration have the same transceiver. The optical data are given in the technical data for the EK1521.

First of all, the power budget existing between the two couplers must be calculated:

| **Power budget** | |
|---|---|
| **Parameter** | **Value** |
| Minimum output power [50/125 µm] | -23.5 dBm |
| Maximum sensitivity | -31 dBm |
| **Power budget** | **7.5 dBm** |

In the next step, the attenuation budget, i.e. the attenuation over the entire transmission link, must be calculated. A multimode fiber in the strength 50/125 µm from Beckhoff (ZK1091-1001-xxxx) is used for this example. A maximum attenuation of 0.8 dB/km at a wavelength of 1310 nm is specified in the data sheet for the fiber-optic cable. The cable is connected at both ends via an SC connector. The typical attenuation value of SC connectors is 0.25 dB, but it should nevertheless be checked for the specific application. Three splices were made over the entire link. A typical attenuation of 0.3 dB can be assumed per splice connection; however, the attenuation of a splice is dependent on its quality. The attenuation budget must be calculated from these values in the following.

| Attenuation budget | | |
|---|---|---|
| **Parameter** | **Number** | **Value** |
| Fiber loss attenuation (0.8 dB/km) | 2.1 km | 1.68 dB |
| Connector insertion attenuation (0.25 dB) | 2 | 0.5 dB |
| Splice insertion attenuation (0.3 dB) | 3 | 0.9 dB |
| **Attenuation budget** | | **3.08 dB** |

If the attenuation budget is now subtracted from the power budget, a power buffer of 4.42 dB results. This is greater than 3 dB and is therefore sufficient as a buffer for most applications, so that an additional splice or slight soiling of the fiber would not lead to failure of the data transmission.

If several values are given for a parameter in the data sheet for transceivers, cables or connectors, the worst value should always be taken and used for the calculation.

For the transmission link under consideration, the bandwidth/length ratio specified in the data sheet for the fiber should always be considered in addition to the attenuation and, as shown above, one should calculate whether the implementation of the length of the transmission link is possible with the desired bandwidth and the fiber.

### Overdrive

An optical receiver can not only receive too little light power (and thus cause data errors or bit errors), but also too much, resulting in overdriving with the same immediate consequences and possibly even long-term damage. In addition to the sensitivity of the receiver at low transmission power, compliance with the maximum permissible optical input power must therefore also be checked. Overloading can occur in particular, but not exclusively, with short connections and SFP modules.

The minimum and maximum transmit and receive power of an optical transceiver are usually specified in the technical data.

If the transmit power of the remote station exceeds the maximum permissible receive power of the receiver, an optical attenuator should be used to attenuate the transmit power and prevent the receiver from being overloaded. However, it should be borne in mind that optical components and links age over time, which is why the attenuator should not be set too high.

The connection between an EK1521 and a multimode SFP, operated in the CU1521-0020, is now considered as an example:

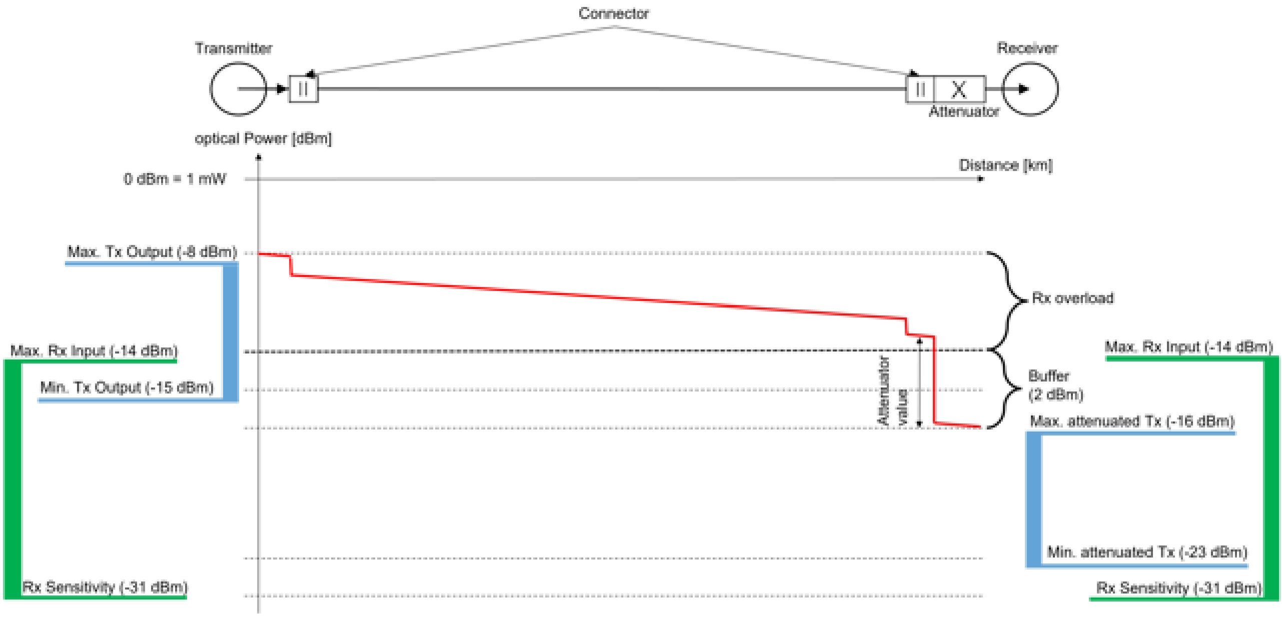



Fig. 28: Performance curve via the EK1521 vs. CU1521-0020 coupling

- Left scale: The maximum permanently permissible optical input power of the EK1521 (green: receiver, Rx) is -14 dBm*) and the maximum transmission power of the SFP (blue: transmitter, Tx) is -8 dBm; it is therefore significantly higher. Damage may occur with direct/short connections.
- The signal must therefore be attenuated by at least 6 dB on the path between the transmitter and receiver to prevent the receiver from overloading. It is also advisable to allow for a reserve of around 2 dB.
- Assume a fiber optic cable length of 2 km at 1.25 dB/km, which results in an attenuation of 2.5 dB*). With two connectors of 0.25 dB*) each, 0.5 dB attenuation is added. The attenuation budget of the transmission path is therefore 3 dB.
- With an attenuation budget of 3 dB and a reserve of 2 dB, an attenuator with 5 dB is therefore inserted in the transmitter-receiver path.

  Calculation: $\text{Attenuation}_{\text{Attenuator}} = \text{Attenuation}_{\text{necessary}} + \text{Attenuation}_{\text{reserve}} - \text{Attenuation}_{\text{budget}} = 6\text{ dB} + 2\text{ dB} - 3\text{ dB} = 5\text{ dB}$
- Right scale: The power ratio between receivable and actually received optical power, taking into account the transmission path and 5 dB attenuator, is as shown: the attenuated incoming transmission power (blue) is now within the permissible power range of the receiver and is therefore OK.

In some devices, the actual transmit and receive power can be viewed using the SFP diagnostic data (DDM)

| Name | [X] | Online | Type | Size | >Addr... | In/Out | Linked to |
|---|---|---|---|---|---|---|---|
| Actual | | 00 A4 1B 42 F2 41 4... | Actual_EB3... | 20.0 | 45.0 | Input | |
| Temperature | | 38.91015624 | REAL | 4.0 | 45.0 | Input | |
| Voltage | | 3.2383999 | REAL | 4.0 | 49.0 | Input | |
| Tx Bias | | 10.5500002 | REAL | 4.0 | 53.0 | Input | |
| Tx Power | | -9.4423952 | REAL | 4.0 | 57.0 | Input | |
| Rx Power | | -17.5945072 | REAL | 4.0 | 61.0 | Input | |

Fig. 29: Real-time display of Tx/Rx power in the CU1521-0020

Note: If the line from the Tx port to the Rx port of the SFP is bridged (loopback), the Tx power transmitted can be compared with the Rx power actually received.

*) Note: The values given are example values. The specific details in the device documentation are decisive.

**Evaluation of a fiber-optic transmission link by means of measurement**

A fiber-optic transmission link can be described and evaluated with parameters from data sheets. In order to obtain a real result for the attenuation over the entire link, however, the link must be measured using an optical power meter (OPM). The power at the end of the transmission link can be measured with an OPM.

When measuring with an OPM, it is essential to ensure that only the required adapter (FC, SC, …) is screwed to the OPM. If several adapters are screwed above one another to the OPM, the distance between the connector and the detector in the OPM is too large, with the result that lower power values are displayed (greater attenuation than actually exists).


OPM without adapter


OPM with FC adapter screwed on


OPM with SC adapter screwed on


OPM with FC and SC adapter screwed on - WRONG

## 5.2.2 Notes on suitable optical fiber cables

**General information on optical fiber types**

Optical fiber are available as multimode and single mode types with different step and graded indices.

**Step and graded index**

Optical fiber cables consist of 2 concentric materials, the core and cladding, plus a protective (colored) jacket. The core and the cladding have a different index of refraction, causing the light waves (modes; a mode is a natural wave in the optical fiber) to be reflected back into the core at the boundary. Due to the step change in the index of refraction this type of fiber is referred to as step index. A gradual/parabolic transition between the index of refraction in the core and the coating (referred to as graded index) can be achieved by mixing the materials. In a graded index fiber the modes are gradually diffracted back to the core, leading to propagation-time compensation and significantly higher quality of the light pulse at the outlet compared with a multimode step index fiber, where the different light modes have different signal run times (mode dispersion) with associated front distortion.

**Single mode**

Single-mode fibers have a very thin core (9 µm) and therefore conduct only a single mode of the light used, with high signal quality and virtually without mode dispersion. They are only available as step index fibers. Due to the high signal quality they are suitable for large transmission bandwidths > 10 GHz*km and distances > 50 km. The refractive index profile of single-mode fibers is dimensioned such that the multipath propagation (intermodal dispersion), which is a problem with multi-mode fibers, is omitted – the signal light propagates in a single-mode fiber only in a single guided fiber mode, hence the designation ‘single-mode’. This makes considerably larger transmission distances and/or bandwidths possible, and the limiting effect that arises next is the color distortion of the transmitted mode.

**Multimode**

Multimode fiber-optics are manufactured as step index or graded index. Step index multimode fiber cables are suitable for transmission bandwidths up to 100 MHz*km and distances up to 1 km. Graded index multimode fiber cables with core diameters between 50 and 62.5 µm reach transmission bandwidths > 1 GHz*km and ranges > 10 km. Multimode means that the core of the fiber-optic cable is thick enough to enable several light modes to propagate reflectively in the cable.

There are different types of multimode fiber-optics, which are optimized for different wavelengths or transmission sources. Through the optimization of the fibers for different wavelengths, the attenuation differs with different transmission rates and the bandwidth/length ratio differs for the different fiber types. The exact values must be taken from the data sheet for the selected fiber in order to check whether the use of the selected fiber is wise.

- OM1: 62.5/125 µm, optimized for 1310 nm LEDs
- OM2: 50/125 µm, optimized for 1310 nm LEDs
- OM3: 50/125 µm, optimized for 850 nm VCSEL (vertical-cavity surface-emitting laser)
- OM4: 50/125 µm, optimized for 850 nm VCSEL (vertical-cavity surface-emitting laser)

### 5.2.3 Application with CU1521 and CU1521-0010

The CU1521, CU1521-0010 are intended for application with optical fiber cables with the following characteristics:

- SC duplex connector.
- CU1521: Duplex multimode 50/125 µm or 62.5/125 µm (inner/outer core diameter). The use of both diameters is possible. However, the use of 50/125 µm is recommended due to the lower attenuation.
- CU1521-0010: Duplex single-mode 9/125 µm (inner/outer core diameter). A typically usable cable can be manufactured according to the specification ITU-T G.652.D (0.4.4dBm/km at 1310 nm).

**Recommended connectors**

The use of SC/PC connectors is recommended for connecting to the CU1521, CU1521-0010. The advantage of the "PC" (physical contact) version of this connector is the crowned end face, which allows the region of the fiber core that is relevant to transmission to be optimally joined when the connector is pushed together. Other versions include, for instance, the SC/**UPC** (ultra-polish PC), SC/**HRL** (high return loss) and the SC/**APC** plug (angled physical contact).
An additional feature of these connectors is that light that is reflected by the connector's end face, which is at an angle of about 8° to the fiber axis, is refracted from the core by the cladding glass into the air. This avoids interference with the data transmission, optimizing the core size of the back-scatter.

**50/125 µm or 62.5/125 µm**

The use of both diameters is possible. However, the use of 50/125 µm is recommended due to the lower attenuation.

In optical fibers the wavelengths 850 nm and 1310 nm are usually used for data transfer. Commercially available optical fiber cables are usually optimized for application in one of these ranges, since signal attenuation is frequency-dependent (like in copper cable), so that large ranges of several km can be achieved for the respective wavelength. In general, optical fiber cables exhibit a lower attenuation at a wavelength of 1310 nm than at 850 nm.

In the CU1521, CU1521-0010  a transceiver with the wavelength of 1310 nm is used.

**Range and bandwidth product**

Optical fiber cables are available in different qualities from reputable manufacturers. One of the relevant parameters for the user is the frequency-dependent bandwidth product of a cable, specified in [MHz*km]. The greater the bandwidth product, the lower the attenuation, and therefore the larger the range that can be achieved with this cable (see ITU-T G-651). To maximize the range with the CU1521, CU1521-0010 optical fiber cables with a maximum high bandwidth product at 1310 nm should therefore be used. We recommend optical fiber cables from the OM2 class (EN50173:2002).

Standard optical fiber cables have a minimum bandwidth product of 500 MHz*km at 1310 nm, higher-quality cables are suitable for distances > 500 m over > 1000 MHz*km.

For maximum distances the remote counterpart of the CU1521, CU1521-0010 should also support such ranges.

**Installation notes**

The following parameters must be taken into account in the installation of optical fiber cables

- permitted bending radius
- permitted tensile strength
- sensitivity of the exposed contact ends

Further information can be found in the following documents:

- ITU recommendation ITU-T G.651 - G.655
- EN 50173:2002
- EN 60793-2

### 5.2.4 Connecting and disconnecting the fiber cable

**NOTICE**

**Risk of damage to the cable!**

To disconnect the optical fiber cable always pull the connector to release the locking mechanism - never pull the optical fiber cable itself.

**Crossover cables**

Please note that when connecting the CU1521, CU1521-0010 to the remote station, it may be necessary to use "crossed" cables in order to establish a connection.

**Practical tip:**

The infrared light emission can be made visible with some digital/mobile phone cameras (see figure *Visualization of infrared light at the SC Duplex connector*), whether the camera used can receive the IR wavelengths; must be checked in each individual case. Avoid 'light meeting light' when connecting the optical fiber cable (Tx -> Tx). In this case no connection can be established, and you have to cross the cables (Tx -> Rx).


Fig. 30: Visualization of infrared light at the SC duplex connector

**Use of blind plugs**

To protect the transceiver from environmental influences, unused connection socket should be sealed with the blind plugs provided! See Fig.: *Blind plugs in unused sockets*

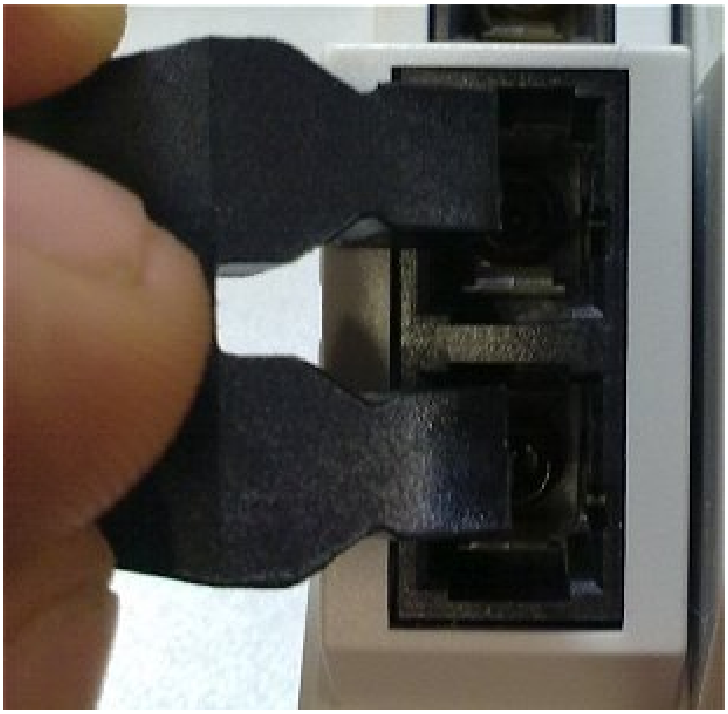


Fig. 31: Blind plugs in unused sockets

# 5.3 Notes on converters with RJ45 POF connection

## 5.3.1 Notes regarding suitable POF cables

**General information about POF cables**

The standard polymer fiber is 1 mm thick and consists of a 0.98 mm thick core made of polymethyl methacrylate (PMMA) as well as a thin sheath. In order to enable the guidance of light using the effect of total reflection in the core, the usually very thin sheath consists of fluorinated PMMA, which has a low refractive index. The core diameters lie between 0.06 mm and 1 mm, as a result of which simple plug connections are easy to implement. Furthermore, the splicing process often used for the connection of glass fibers and the unnecessarily high expenditure associated with it can usually be dispensed with. The maximum operating temperature of standard POF is approximately 60°C and has a refraction profile with step index (SI-POF). The refractive index of the core material is around 1.49 and that of the sheath around 1.41. The difference determines the numerical aperture (NA) and thus the maximum propagation angle. With a difference of 5% this angle is about 20 degrees in relation to the fiber axis, which leads to a reduction in the bandwidth.

Due to the simple and almost universally applicable connection techniques compared to glass fibers, POFs are used in particular for short transmission distances, such as inside rooms, technical equipment, mechanical systems or cars.

POFs have an attenuation of about 140 dB/km at a wavelength of 650 Nm, so that a maximum data transmission distance of 50 m can be achieved when used with the CU1561.

Insertion of additional connectors in the route increases the signal attenuation. For each additional connector, the maximum permitted distances typically reduces by 6.5 m.

**Application with CU1561**

**Recommended plug connectors and POF cables**

For the connection of the CU1561 it is recommended to use the connector set ZS1090-0008 [▶ 51] (Versatile Link Duplex plugs) in conjunction with a duplex polymer fiber with an outside diameter of 2 x 2.2 mm (Z1190), which are available from Beckhoff.

**Installation notes**

Among other things, the following items should be observed when laying POF cables:

- permissible bending radius (in general r ≥ 25 mm, refer to the manufacturer's data!)
- permitted tensile strength
- sensitivity of the exposed contact ends

## 5.3.2 Connecting and disconnecting the POF cable

To connect the cable, insert the plug (available as an accessory in the connector set ZS1090-0008) into the connection opening until it audibly latches.

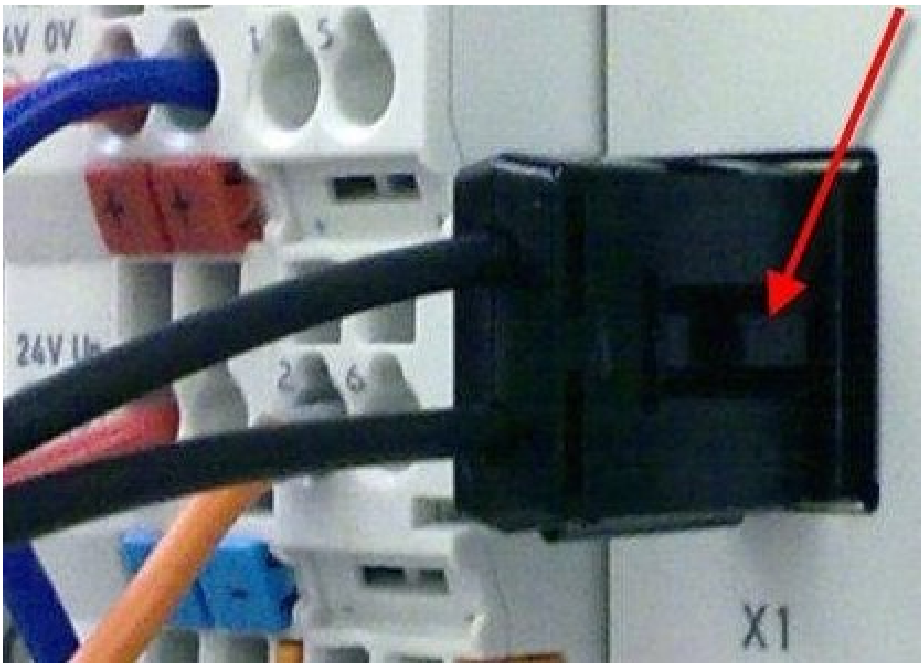



Fig. 32: Latching lug with release catch on the POF duplex plug

To release the connector activate the release device with the latching lug. This is located on the right-hand side of the connector (see Fig. *Latching lug with release catch on the POF duplex plug*)

**NOTICE**

**Risk of damage to the cable!**

To release the cable, press the release catch on the plug and pull the plug at the same time – never pull by the POF cable alone!

**NOTICE**

**TX / Rx channel assignment**

During cable assembly [▶ 51] note the assignment of the optical channels in the connection socket. In the case of the CU1561 the light-emitting transmitter channel (Tx) is the lower outlet in the connection socket (Fig. *Transmitter channel of the CU1561*).

Be sure to observe the safety instructions for class 1 lasers!

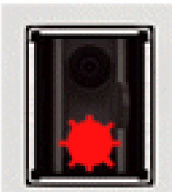


Fig. 33: Transmitter channel of the CU1561

**NOTICE**

**Use of blind plugs**

In order to avoid accidents due to glare (Class 1 laser, please observe the safety instructions) and to protect the transceiver against environmental influences, unused sockets should be sealed using the blind plugs provided (Fig. *Blind plugs in unused sockets*)


Fig. 34: Blind plugs in unused sockets

### 5.3.3 Notes regarding assembly of POF cables with the connector set ZS1090-0008

**Table of contents**




Fig. 35: Duplex connector set ZS1090-0008

The duplex connector set ZS1090-0008 from Beckhoff consists of 10 duplex Versatile Link connectors and several sheets of abrasive paper and polishing paper.

**Step-by-step instructions for assembling the POF cable**

The following step-by-step guide describes the correct assembly of a POF cable with a Versatile Link duplex connector. The connectors are attached to the cable ends with standard tools such as cutter knife or wire strippers. Polish the assembled cable with the polishing set provided with the connector set, consisting of a plastic sanding gauge, sheets of abrasive paper with grain size 600 and pink polishing sheets. Once assembled, the connector can be used right away.

Materials required:

1. POF cable (Polymeric Optical Fiber, e.g. Z1190 from Beckhoff)
2. Cutter knife or shears
3. Wire strippers
4. Polishing set (included with connector set ZS1090-0008 from Beckhoff)
5. Versatile Link duplex connector (included in connector set ZS1090-0008 from Beckhoff)

**1. Stripping the POF cable**

The cable should be split over a length between 100 and 150 mm from the cable end, so that the following steps can be carried out properly.

Once you have shortened the cable to the required length, use the wire strippers to remove approx. 7 mm of the external sheathing of the individual wires. The two cable ends should be stripped over approximately the same length. (Fig. *POF cable stripped over the same length*).

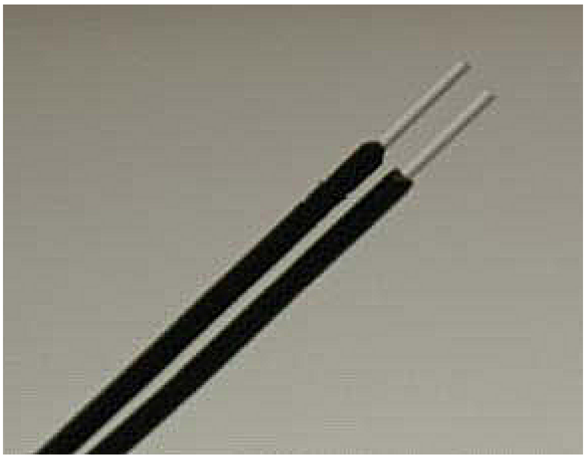


Fig. 36: POF cable stripped over the same length

**2. Attaching the connector**

Push the two cable ends into the connector and the connector back until it stops. The fibers should now protrude no more than 1.5 mm out of the front openings (Fig. *Cable inserted in the connector*).

Close the connector by folding the upper and lower halves together until they engage (Fig. *Closed connector*).

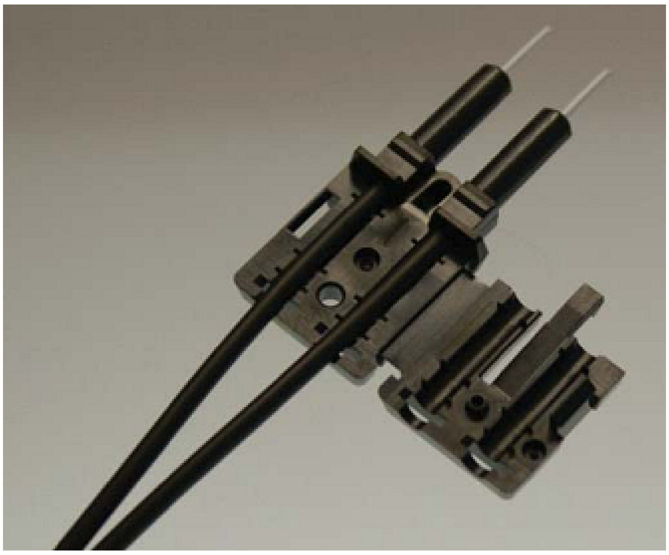


Fig. 37: Cable inserted in the connector

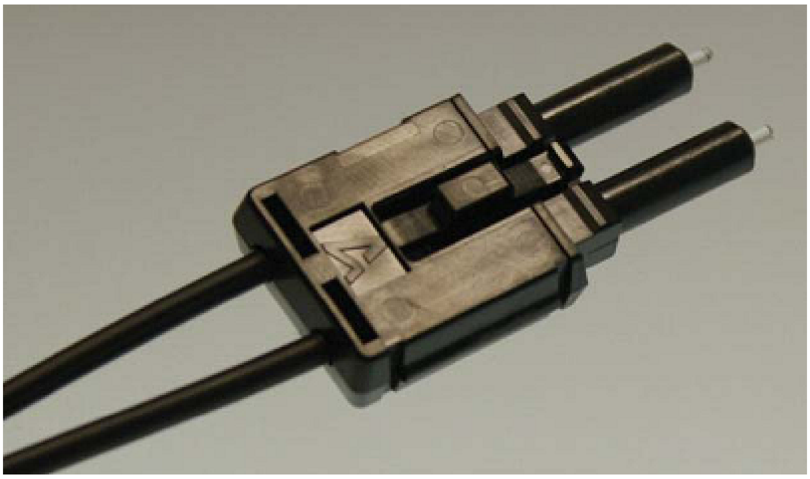


Fig. 38: Closed connector

When inserting the wires into the connector ensure the optical channels are crossed (Tx1 --> Rx2; Tx2 --> Rx1). The 'nose' at the connector hinge can be used as a guide (Fig. *Correctly connected optical channels*).

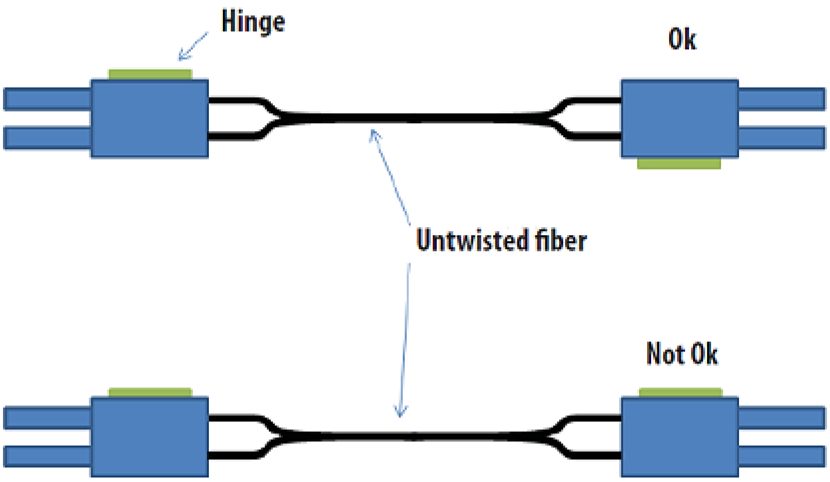



Fig. 39: Correctly connected optical channels

**3. Grinding and polishing**

Any fibers protruding more than 1.5 mm from the connector should be shortened with a cutter knife or a pair of scissors.

Now push the connector fully into the sanding gauge, so that the ends to be polished protrude from the lower side (Fig. Sanding gauge with protruding fiber ends). The sanding gauge is suitable for polishing one or two simplex connectors or a duplex connector.

Fig. 40: Sanding gauge with protruding fiber ends

**Wear indicator**

The wear indicator of the sanding gauge consists of four points on the underside. The sanding gauge should be replaced when one of these points is no longer visible.

Now press the sanding gauge onto the abrasive paper with uniform pressure and as perpendicular as possible. In order to achieve a uniform result, use the abrasive paper in the form of a figure of 8 (Fig. *Polishing in the form of a figure "8"*), until the fibers are flush with the sanding gauge. Then clean the sanding gauge and the connector from below with a soft, dry cloth.

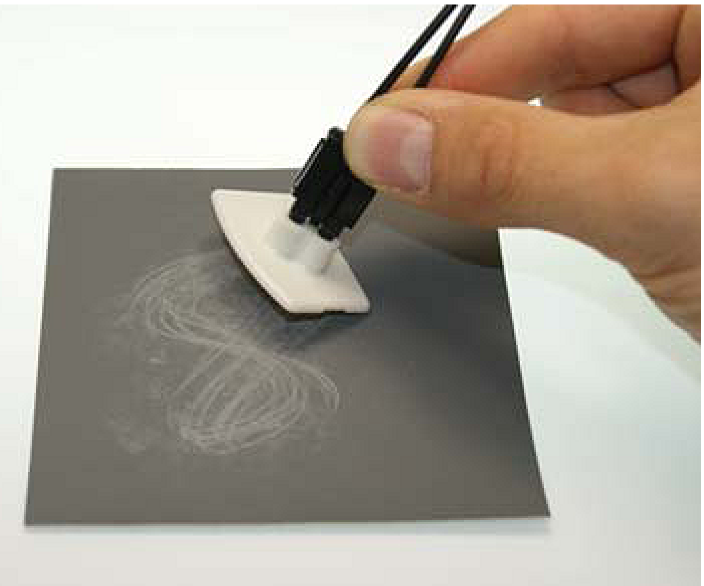


Fig. 41: Polishing in the form of a figure of "8"

**4. Fine polishing**

Now use the pink polishing sheet for fine polishing in the same manner. Apply the connector with the sanding gauge to the matt side of the polishing sheet with slight pressure and polish in the form of a figure of 8 up to 25 times. After the procedure the fiber end should be flat, smooth and clean.

**Improving the transfer performance by fine polishing**

Fine polishing with a polishing sheet can improve the transfer performance between the transmitter and the receiver or in the cable joint by up to 0.5 dB compared with to treatment with abrasive paper alone. For short transfer distances the polishing step can be omitted.

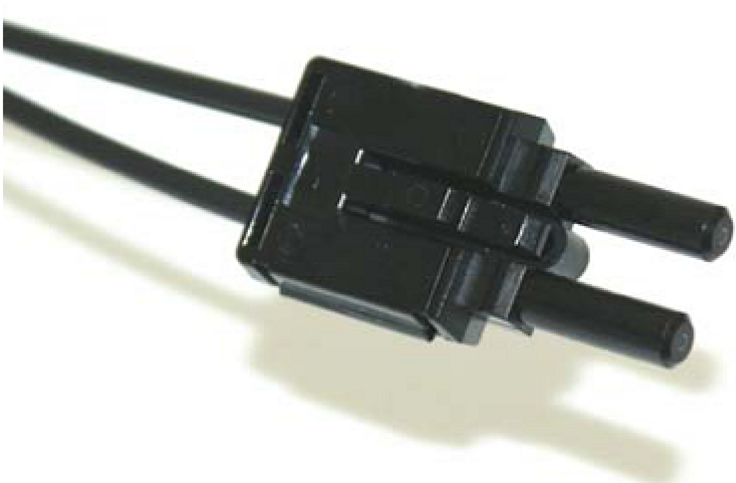


Fig. 42: Fine-polished fibers in the connector

# 5.4 Use of SFP in the CU1521-0020

## 5.4.1 Purpose and user guidance

This chapter describes the commissioning of the CU1521-0020 with SFP modules. The structure deliberately follows the practical process: first define the operating mode and topology, then select the SFP, check the thermal and optical boundary conditions, set up the device, put the connection into operation and only then look at the diagnostics for ongoing operation.

**Note**

Each step of the brief commissioning refers to a subsequent chapter in which the respective point is explained in technical terms. This allows you to work through the checklist and jump directly to the appropriate explanatory chapter if required.

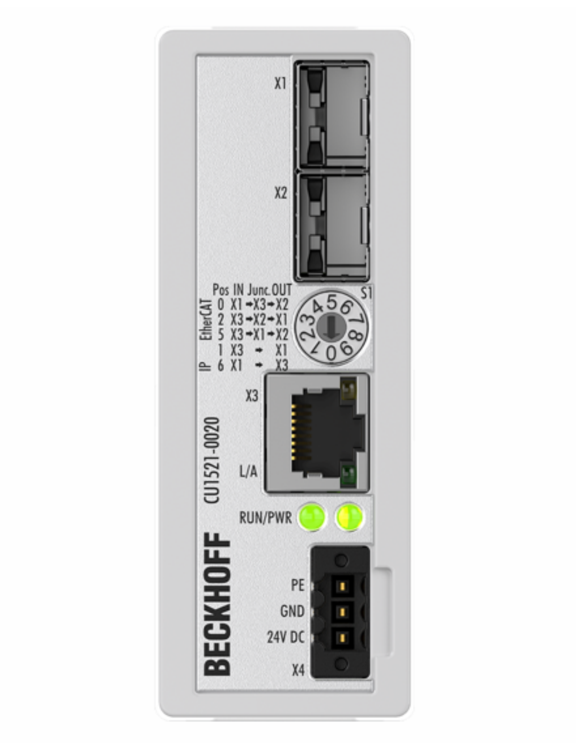



Fig. 43: *Fig. 1: CU1521-0020, rotary switch positions and ports (original illustration).*

### 5.4.2 Commissioning in the recommended order

The following checklist is the common thread for commissioning.

| No. | Step | Explanatory chapter |
|---|---|---|
| 1 | Set operating mode: EtherCAT mode or Ethernet mode. | Define operating mode and topology [▶ 57] |
| 2 | Define topology and port usage: Which ports are used and in which direction does the connection work? | Define operating mode and topology [▶ 57] |
| 3 | Choose a suitable SFP for the remote station: Check data rate, encoding, wavelength, fiber type, range, connector type and BiDi pairing if necessary. | Select SFP [▶ 57] |
| 4 | Check the thermal power budget: Evaluate current consumption or power loss of the SFP and ambient temperature. | Approved ambient temperature range and thermal power budget [▶ 59] |
| 5 | Check optical power budget and wiring: Evaluate transmission power, receive sensitivity, attenuation, saturation and fiber distance. | Check optical power budget and fiber path [▶ 60] |
| 6 | Set the rotary switch to the desired mode. Setting is applied when the device is restarted. | Set rotary switch and define encoding [▶ 60] |
| 7 | Establish connection and check link. | Putting EtherCAT mode into operation [▶ 60] or Putting Ethernet mode into operation [▶ 61] |
| 8 | For EtherCAT: Integrate device into TwinCAT, check process data and provide a separate SyncManager for robust SFP diagnostics. | Putting EtherCAT mode into operation [▶ 60] and SFP diagnostics during operation (DDM) [▶ 63] |
| 9 | Check SFP identity information and encoding in the CoE (from HW02). | Check CoE information on the SFP [▶ 63] |
| 10 | Evaluate DDM/SFP diagnostics for ongoing operation and check limit values (from HW02). | SFP diagnostics during operation (DDM) [▶ 63] |
| 11 | In the event of faults, check systematically using typical fault patterns. | Operating instructions and typical troubleshooting [▶ 65] |

### 5.4.3 Define operating mode and topology

Before making the choice of SFP, it must be clear whether the CU1521-0020 converts/branches an EtherCAT line or is used as an Ethernet media converter.

| Use case | Operation mode | Active ports | Important consequence |
|---|---|---|---|
| Convert or branch EtherCAT line via fiber optic cable | EtherCAT mode | X1, X2 and X3 according to rotary switch position | X3 only supports 100 Mbit remote stations; select SFPs on X1/X2 to match the remote station. |
| Implement Ethernet connection via SFP | Ethernet mode | X1 and X3 | Device works as a 2-port media converter with store-and-forward and link loss forwarding. |

**Decision support**

If an EtherCAT topology is implemented, read Putting EtherCAT mode into operation [▶ 60]. If only one Ethernet line is implemented between RJ45 and SFP, read Putting Ethernet mode into operation [▶ 61].

### 5.4.4 Select SFP

SFP stands for Small Form-factor Pluggable. It is a pluggable transceiver module for optical or electrical network connections.

**Basics: Data rate, 100BaseX and SGMII**

100BaseX is a fast Ethernet standard with a fixed transmission rate of 100 Mbit/s.

SGMII stands for Serial Gigabit Media Independent Interface. The interface is designed for Gbit Ethernet and can also map lower net data rates such as 100 Mbit/s or 10 Mbit/s via symbol repetitions.

SFP+ modules must not be used because SFP+ is intended for data rates above 1 Gbit/s.

**Functionality of the CU1521-0020 with SFP**

| HW | FW | Functionality |
|---|---|---|
| 00-01 | 01 | Only use in pairs CU1521-0020 <-> CU1521-0020, with identical 1 Gbit SFP on both sides |
| 00-01 | 02-04 | Can also be used against EK1501, CU1521 etc., with 100 Mbit SFP |
| 02 | From 06 | Identification of the plugged SFP; diagnosis of the SFP EtherCAT line; setting the Ethernet encoding |

The CU1521-0020 communicates via SFP with 100BaseX if an SFP type "100 Mbit" is plugged in and the Ethernet encoding has not been changed.

The CU1521-0020 communicates via SFP with SGMII 1 Gbit if an SFP type "1 Gbit" is plugged in and the Ethernet encoding has not been changed.

### Checklist for the choice of SFP

| Test point | Why is it important? | Measure |
|---|---|---|
| Data rate / Encoding | SFP and remote station must support the same procedure. | 100 Mbit SFP for 100BaseX; 1 Gbit SFP for SGMII. From HW02 Encoding check and set in CoE if necessary. |
| Wavelength | The transmitter on one side must match the receive wavelength of the remote station. | Compare SFP data sheets from both sides. |
| Fiber type | Single-mode and multi-mode routes are not interchangeable. | Match the fiber type of the system with the SFP type. |
| BiDi pairing | Two identical BiDi-SFPs do not form a correct route. | Use complementary pair. |
| Current consumption / power loss | The SFP heats the appliance and must not exceed the power budget. | Evaluate the data sheet value at Approved ambient temperature range and thermal power budget [▶ 59]. |
| Temperature class | Commercial SFPs can warn earlier or fail. | Industrial-SFP with at least 85°C recommended. |
| EtherCAT suitability | Link control and timing must not be affected. | Preferably use qualified SFPs. |

**Note on third-party SFP**

The SFP is not sold by Beckhoff as accessories and is not part of the scope of supply. Beckhoff cannot provide a functional guarantee and compatibility with all SFPs available worldwide.

| SFP qualified by Beckhoff (status 2025-05) | Name |
|---|---|
| Single-mode 100 Mbit | Optomedia PT1-S1-4203L |
| Multi-mode 100 Mbit | Optomedia PT1-M4-4023L |
| Bidirectional 1 Gbit | FS 36888 1000BASE-BX-D BiDi SFP 1550 nm-TX/ 1310 nm-RX 40 km LC (2024) |
| Bidirectional 1 Gbit | FS 36889 1000BASE-BX-U BiDi SFP 1310 nm-TX/ 1550 nm-RX 40 km LC (2024) |

### 5.4.5 Approved ambient temperature range and thermal power budget

The thermal power budget must be checked before final installation. There are two relevant heat sources in the CU1521-0020: the basic device and the SFP modules used. Depending on the SFP used, additional internal heat is generated. As a result, the maximum approved operating temperatures of the SFP and/or the basic device may be exceeded.

An SFP generates an approximate internal temperature increase of +7 K/W.

The basic appliance from HW02 has larger cooling openings.

Standard industrial SFPs report a warning from 85 °C intrinsic temperature and an error from 95 °C.

If commercial SFPs with a warning temperature of 70 °C are used, the SFP lines must be lowered by 15 °C accordingly.

Example: In the CU1521-0020 HW01, two SFPs with 1 W each (3.3 V × 300 mA) can be used at $T_{ambient}$ = 55 °C, so that the warning threshold for industrial SFPs is just reached.

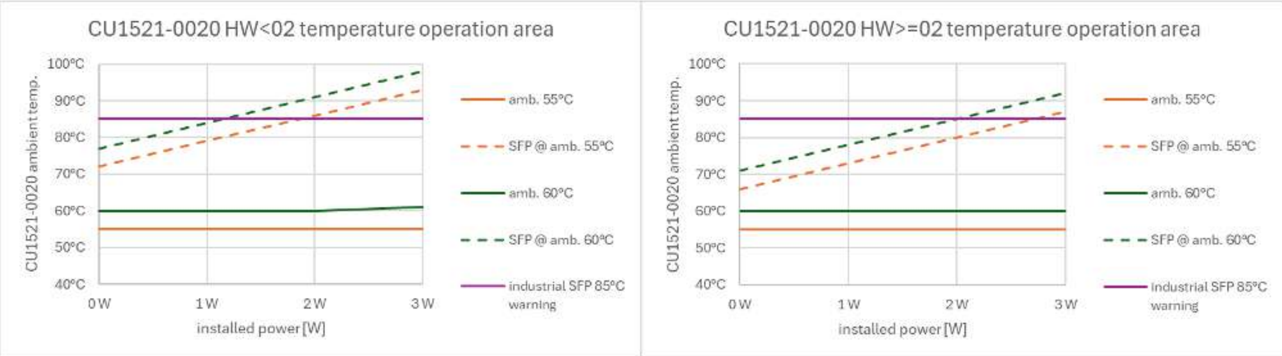



Fig. 44: Approved ambient temperature range as a function of SFP power loss and hardware status (original illustration).

**Practical recommendation**

Check the power loss from the SFP data sheet in advance. If the ambient temperature is high or two SFPs are plugged in, use SFPs with low power consumption and an industrial temperature range if possible.

## 5.4.6 Check optical power budget and fiber path

After the SFP choice, the optical path must be checked. The aim is a stable connection with sufficient reception power, but without overloading or saturating the receiver.

| Test | Explanation | Typical measure |
|---|---|---|
| Transmission power of the SFP | The output power determines how much optical power is fed into the line. | Check the data sheet value of the transmitter. |
| Reception area of the remote station | The receiver requires a minimum power and must not be overridden. | Check sensitivity and maximum input power. |
| Line attenuation | Fiber length, connectors, splices and patch panels attenuate the signal. | Compare the attenuation budget of the system with SFP data. |
| Wavelength and fiber type | The wrong combination can cause link loss or poor reserve. | Cross-check single-mode/multi-mode and wavelength. |
| BiDi Direction | With BiDi, Tx/Rx wavelengths must fit crosswise. | Check complementary mating. |

**Note on the optical power budget**

An optical connection can fail due to either too little reception power or too much reception power. Therefore, check not only "enough power", but also possible saturation.

## 5.4.7 Set rotary switch and define encoding

The rotary switch fixes the operating mode, port sequence or direction and thus the behavior of the CU1521-0020.

In EtherCAT mode, X1, X2 and X3 are active in the order indicated by the rotary switch.

In Ethernet mode, only X1 and X3 are active.

In Ethernet mode, the direction of the arrow influences which port speed is traded down to the other port.

**Note on setting the operating mode via the rotary switch**

The set operating mode is only adopted when the CU1521-0020 is switched on. The CU1521-0020 must therefore be switched off and on again.

From HW02/FW06, the Ethernet encoding of the SFP can be selected under 0x80n0:11, provided the SFP used supports this.

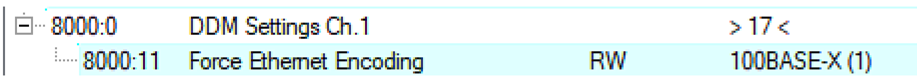



Fig. 45: 0x80n0:11: Force Ethernet encoding

| Encoding setting from HW02 | Effect/application |
|---|---|
| Auto | Automatic detection based on the SFP used: SFP type "100 Mbit" -> 100BaseX; SFP type "1 Gbit" -> SGMII. |
| SGMII | SGMII encoding is enforced. Not supported for SFP type "100 Mbit". |
| 100BaseX | 100BaseX is forced; generally supported for SFP types "100 Mbit" and "1 Gbit". |

## 5.4.8 Putting EtherCAT mode into operation

In EtherCAT mode, the CU1521-0020 is used as an EtherCAT junction or as a 3-port junction with media converter function.

All three ports X1, X2, and X3 are in operation in the order indicated by the rotary switch.

The CU1521-0020 can be used as a 2-port media converter or as a 3-port junction.

100 Mbit EtherCAT is supported (as of 2025), EtherCAT G is in preparation.

The ports X1/X2 can be equipped with different SFPs, at least one SFP is required.

Use a 100 Mbit SFP with 100BaseX remote station.

1 Gbit SFP with SGMII remote station.

Only 100 Mbit remote stations can be connected to port X3 (RJ45).

As of HW02, diagnostic data from the plugged SFP modules is available in EtherCAT mode.

**TwinCAT/SyncManager note**

For robust SFP diagnostics, place the CU1521-0020 or the SFP diagnostics in a separate SyncManager. In addition, monitor wcState to determine the validity of the process data. The details of the diagnosis can be found at SFP diagnostics during operation (DDM) [▶ 63].

## 5.4.9 Putting Ethernet mode into operation

In Ethernet mode, the CU1521-0020 works as a 2-port media converter between X1 (SFP) and X3 (RJ45).

Only ports X1 and X3 are active.

Different Ethernet transmission rates can be applied to X1 and X3: 10 Mbit/s, 100 Mbit/s or 1 Gbit/s.

The device operates according to the store-and-forward principle.

Port X1 must be equipped with a suitable SFP.

Link loss forwarding is supported; the link loss is reported in the direction indicated by the arrow.

The transmission rates of X1 and X3 result from the switch position, the SFP used and the connected remote stations.

The transmission rate of the port to which the arrow is pointing is reduced to the speed of the other port in the CU1521-0020.

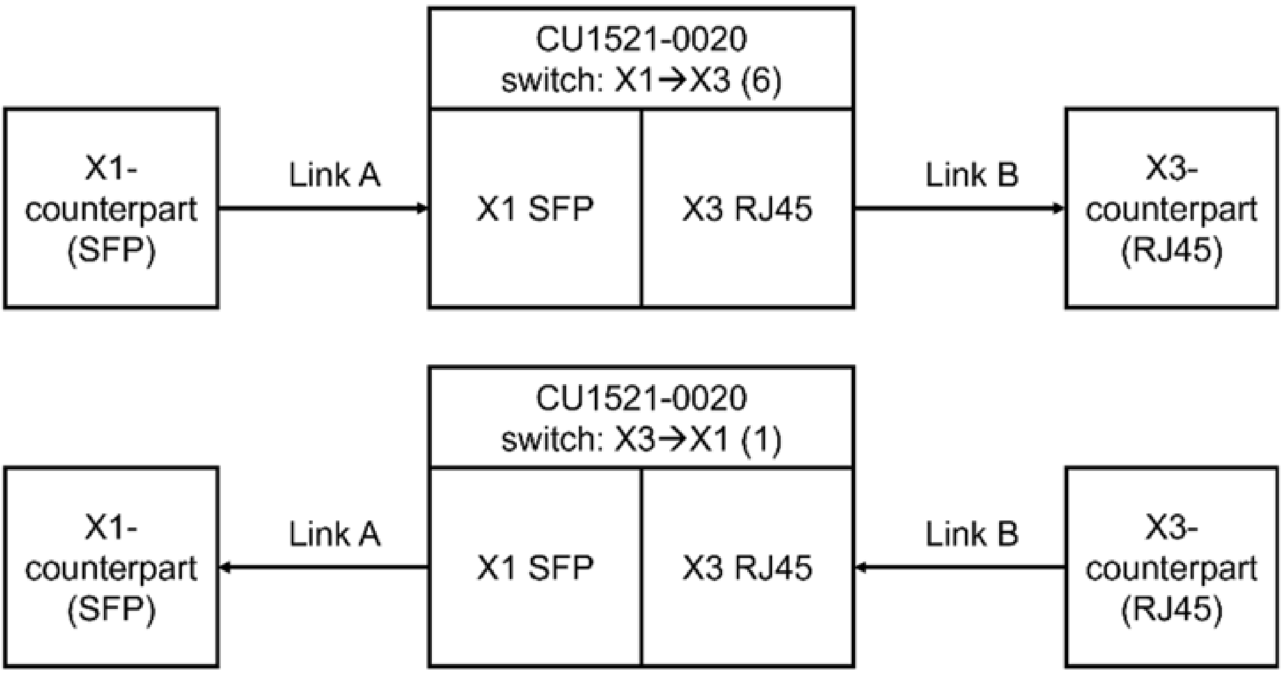



Fig. 46: Transmission modes according to switch position in CU1521-0020 according to switch position

### Transmission rates in switch position 6 (X1 -> X3)

In switch position 6, the transmission rate of the X1 remote station determines the data transfer rate of port X3.

| Transmission rate of the X3 remote station (RJ45) | X1 remote station 1 Gbit * | X1 remote station 100 Mbit | X1 remote station 10 Mbit * |
|---|---|---|---|
| 1 Gbit | Link-A: 1 Gbit<br>Link-B: 1 Gbit | Link-A: 100 Mbit<br>Link-B: 100 Mbit | Link-A: 10 Mbit<br>Link-B: 10 Mbit |
| 100 Mbit | Link-A: 1 Gbit<br>Link-B: 100 Mbit | Link-A: 100 Mbit<br>Link-B: 100 Mbit | Link-A: 10 Mbit<br>Link-B: 10 Mbit |
| 10 Mbit | Link-A: 1 Gbit<br>Link-B: 10 Mbit | Link-A: 100 Mbit<br>Link-B: 10 Mbit | Link-A: 10 Mbit<br>Link-B: 10 Mbit |

* For remote stations on X1 with 1 Gbit or 10 Mbit Ethernet, a 1 Gbit SFP must be used (SGMII).

### Transmission rates in switch position 1 (X3 -> X1)

In switch position 1, the transmission rate of the X3 remote station determines the data transfer rate of port X1.

| Transmission rate of the X3 remote station (RJ45) | SFP in X1: 1 Gbit | SFP in X1: 100 Mbit |
|---|---|---|
| 1 Gbit | Link-A: max. 1 Gbit **<br>Link-B: 1 Gbit | Link-A: 100 Mbit<br>Link-B: 1 Gbit |
| 100 Mbit | Link-A: max. 100 Mbit **<br>Link-B: 100 Mbit | Link-A: 100 Mbit<br>Link-B: 100 Mbit |
| 10 Mbit | Link-A: 10 Mbit<br>Link-B: 10 Mbit | Link-A: 100 Mbit<br>Link-B: 10 Mbit |

** If the remote station on SFP port X1 is slower, its speed is taken over by the SFP in X1.

## 5.4.10 Check CoE information on the SFP

The following information about the SFP can be read out under 0x90n0: Manufacturer, article number, serial number, date of manufacture and Ethernet encoding.

| | | | |
|---|---|---|---|
| 9000:0 | DDM Info Data Ch.1 | | > 21 < |
| 9000:11 | Vendor Name | RO | OptoMedia |
| 9000:12 | Part Number | RO | PT1-S1-4203L |
| 9000:13 | Serial Number | RO | 2411S00024 |
| 9000:14 | Date Code | RO | 2024-11-02 |
| 9000:15 | Ethernet Encoding | RO | 100BASE-X (1) |

Fig. 47: 0x90n0: SFP identification in the CoE

The prerequisite is that the SFP used provides this information.

The limit values for alarm and warning bits are listed under 0xA0n0. The limit values are specified by the SFP manufacturer and cannot be changed.

| CoE area | Contents | Benefit during commissioning |
|---|---|---|
| 0x90n0 | SFP identification, manufacturer data, article number, serial number, date of manufacture, encoding information | Check whether the expected SFP is actually plugged in. |
| 0xA0n0 | Warning and alarm limit values from the SFP | Basis for the subsequent evaluation of the DDM values. |
| 0x80n0:11 | Ethernet encoding choice | Auto, SGMII or 100BaseX: set to match the remote station. |

## 5.4.11 SFP diagnostics during operation (DDM)

SFP diagnostics is used to continuously monitor the operating parameters of the SFP transceiver used and the associated optical transmission link. The standardized data from the Digital Diagnostics Monitoring (DDM) can be retrieved in a Beckhoff EtherCAT device, provided that the SFP used supplies this data. In Beckhoff EtherCAT devices with SFP diagnostics, parameters specified in accordance with SFF 8472 can be evaluated:

- Temperature (Temperature, °C)
- Supply voltage (Voltage, V)
- Transmission power (Tx Power, dBm)
- Reception power (Rx Power, dBm)
- Bias current (Tx Bias, mA)

**Note**

Not all SFP transceivers deliver all the values mentioned. Availability, scope and resolution of the DDM data are manufacturer-specific and can be found in the respective SFP data sheet.

### SFP Process image

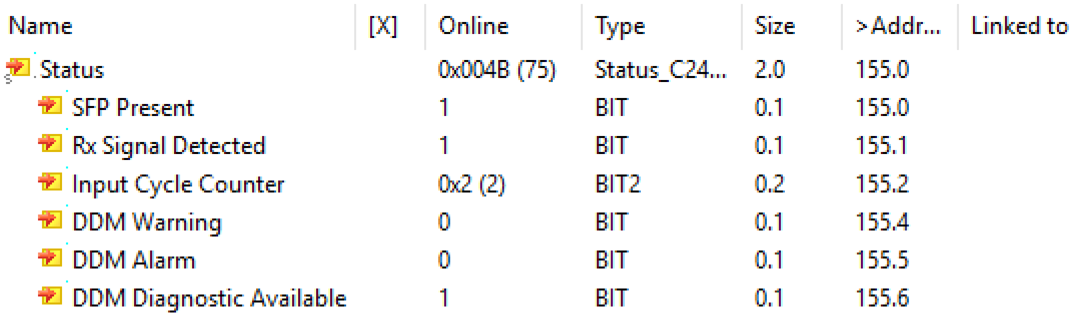
The following PDOs can be selected in the process image of the SFP diagnostic data. It is also possible to work without DDM PDOs. By default, the DDM status is selected for all SFP ports.

| PDO | Meaning |
|---|---|
| 0x1An0 | DDM Status Channel x |
| 0x1An1 | DDM Ext. status channel x |
| 0x1An2 | DDM Values Channel x |

### 0x1An0: DDM Status Channel n

The following basic information on the functionality of the SFP ports is displayed in the status.

| Name | Type | Description |
|---|---|---|
| SFP Present | BIT | An SFP is plugged into the port. |
| Rx Signal Detected | BIT | The SFP receives an optical signal. |
| Input Cycle Counter | BIT2 | The 2-bit counter is incremented as soon as new DDM data is available from the SFP. |
| DDM Warning | BIT | At least one DDM size is in the warning area. |
| DDM Alarm | BIT | At least one DDM size is in the alarm area. |
| DDM Diagnostics Available | BIT | The plugged SFP supports DDM. |



| Name | [X] | Online | Type | Size | >Addr... | Linked to |
|---|---|---|---|---|---|---|
| Status | | 0x004B (75) | Status_C24... | 2.0 | 155.0 | |
| SFP Present | | 1 | BIT | 0.1 | 155.0 | |
| Rx Signal Detected | | 1 | BIT | 0.1 | 155.1 | |
| Input Cycle Counter | | 0x2 (2) | BIT2 | 0.2 | 155.2 | |
| DDM Warning | | 0 | BIT | 0.1 | 155.4 | |
| DDM Alarm | | 0 | BIT | 0.1 | 155.5 | |
| DDM Diagnostic Available | | 1 | BIT | 0.1 | 155.6 | |

Fig. 48: 0x1An0: DDM status

**Note on the Working Counter**

If the EtherCAT connection behind the EtherCAT SFP device is disconnected, SFP diagnostic data in the process data may lose its validity even though the EtherCAT device is in OP. Therefore, wcState should be monitored and a separate SyncManager created for the SFP device.

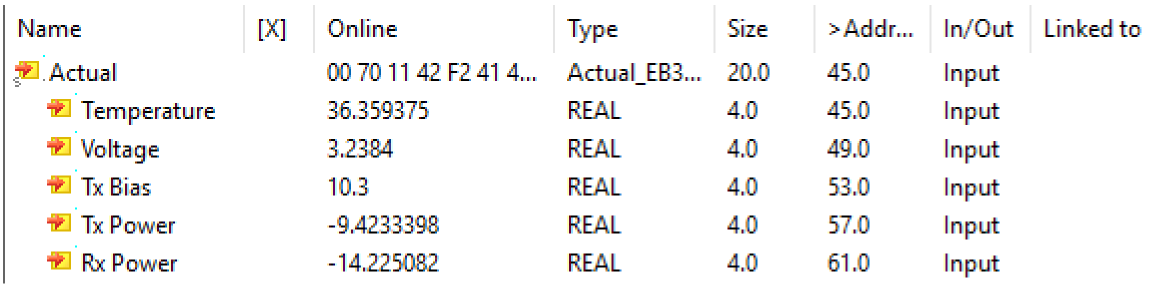
### 0x1An1: DDM Ext. status channel n

The extended status can be used to examine in more detail which DDM size is too high or too low. For each DDM size there are the bits Alarm High, Alarm Low, Warning High and Warning Low. The bits and associated limit values originate from the SFP transceiver and can be read out via the CoE interface in object 0xA0n0 (see Check CoE information on the SFP [▸ 63]).

### 0x1An2: DDM Values Channel n

The live measured values of the SFP diagnostics can be viewed in this PDO.

| Name | Type | Unit |
|---|---|---|
| Temperature | REAL | °C |
| Voltage | REAL | V |
| Tx Bias | REAL | mA |
| Tx Power | REAL | dBm |
| Rx Power | REAL | dBm |



| Name | [X] | Online | Type | Size | >Addr... | In/Out | Linked to |
|---|---|---|---|---|---|---|---|
| Actual | | 00 70 11 42 F2 41 4... | Actual_EB3... | 20.0 | 45.0 | Input | |
| Temperature | | 36.359375 | REAL | 4.0 | 45.0 | Input | |
| Voltage | | 3.2384 | REAL | 4.0 | 49.0 | Input | |
| Tx Bias | | 10.3 | REAL | 4.0 | 53.0 | Input | |
| Tx Power | | -9.4233398 | REAL | 4.0 | 57.0 | Input | |
| Rx Power | | -14.225082 | REAL | 4.0 | 61.0 | Input | |

Fig. 49: 0x1An2: DDM Values

## 5.4.12 Operating instructions and typical troubleshooting

**Notes on CU1521-0020**

The CU1521-0020 operates in FreeRun mode.

As the CU1521-0020 has no outputs, no watchdog is required.

| Symptom | Probable cause | Test/measure |
|---|---|---|
| No link on the SFP port | Wrong SFP type, wrong wavelength, wrong remote station or fiber problem | Check SFP data sheet, wavelength, fiber type, connector, attenuation and Rx Signal Detected. |
| Link available, but no data | Encoding or operating mode does not match | Check rotary switch position, EtherCAT/Ethernet mode and from HW02 CoE 0x80n0:11. |
| DDM warning/alarm | Temperature, supply, Tx/Rx power or bias outside limit value | Check DDM Ext. status and DDM values; evaluate optical and thermal budget. |
| EtherCAT diagnostic data implausible | Process data invalid if continuing EtherCAT connection is disconnected | wcState and configure a separate SyncManager for the SFP device. |
| BiDi route does not work | Two identical instead of complementary BiDi-SFPs used | Compare Tx/Rx wavelengths of both sides and insert complementary pair. |
| SFP gets too warm | SFP power loss or ambient temperature too high | Use industrial SFP, check temperature diagram and select SFP with lower power consumption if necessary. |

## 5.5 Object description and parameterization CU1521-0020

### Index 1000 Device type

| Index | Name | Meaning | Data Type | Flags | Default |
|---|---|---|---|---|---|
| 1000:0 | Device type | Device type of the EtherCAT slave: the Lo-Word contains the used CoE profile (5001). The Hi-Word contains the module profile according to the modular device profile. | UINT32 | RO | 0x03FC1389 ($66851721_{dec}$) |

### Index 1008 Device name

| Index | Name | Meaning | Data Type | Flags | Default |
|---|---|---|---|---|---|
| 1008:0 | Device name | Device name of the EtherCAT slave | STRING | RO | CU1521-0020 |

### Index 1009 Hardware version

| Index | Name | Meaning | Data Type | Flags | Default |
|---|---|---|---|---|---|
| 1009:0 | Hardware version | Hardware version of the EtherCAT slave | STRING | RO | |

### Index 100A Software version

| Index | Name | Meaning | Data Type | Flags | Default |
|---|---|---|---|---|---|
| 100A:0 | Software version | Firmware version of the EtherCAT slave | STRING | RO | 00 |

### Index 100B Bootloader version

| Index | Name | Meaning | Data Type | Flags | Default |
|---|---|---|---|---|---|
| 100B:0 | Bootloader version | | STRING | RO | N/A |

### Index 1011 Restore default parameters

| Index | Name | Meaning | Data Type | Flags | Default |
|---|---|---|---|---|---|
| 1011:0 | Restore default parameters | Restoring the default parameters | UINT8 | RO | 0x01 ($1_{dec}$) |
| 1011:01 | SubIndex 001 | If this object is set to "0x64616F6C" in the set value dialog, all backup objects are reset to their delivery state. | UINT32 | RW | 0x00000000 ($0_{dec}$) |

### Index 1018 Identity

| Index | Name | Meaning | Data Type | Flags | Default |
|---|---|---|---|---|---|
| 1018:0 | Identity | Information for identifying the slave | UINT8 | RO | 0x04 ($4_{dec}$) |
| 1018:01 | Vendor ID | Vendor ID of the EtherCAT slave | UINT32 | RO | 0x00000002 ($2_{dec}$) |
| 1018:02 | Product code | Product code of the EtherCAT slave | UINT32 | RO | 0x05F15432 ($99701810_{dec}$) |
| 1018:03 | Revision | Revision number of the EtherCAT slave; the Low Word (bit 0-15) indicates the special terminal number, the High Word (bit 16-31) refers to the device description | UINT32 | RO | 0x00000000 ($0_{dec}$) |
| 1018:04 | Serial number | Serial number of the EtherCAT slave; the low byte (bit 0-7) of the low word contains the year of production, the high byte (bit 8-15) of the low word contains the week of production, the high word (bit 16-31) is 0 | UINT32 | RO | 0x00000000 ($0_{dec}$) |

### Index 1020 Device Statistics

| Index | Name | Meaning | Data Type | Flags | Default |
|---|---|---|---|---|---|
| 1020:0 | Device Statistics | | UINT8 | RO | 0x03 ($3_{dec}$) |
| 1020:01 | Time since power on | Unit: 1 s | UINT32 | RO | 0x00000000 ($0_{dec}$) |
| 1020:02 | Total time powered | Unit: 1 s | UINT32 | RO | 0x00000000 ($0_{dec}$) |
| 1020:03 | Number of power cycles | | UINT32 | RO | 0x00000000 ($0_{dec}$) |

### Index 10E2 Manufacturer-specific Identification Code

| Index | Name | Meaning | Data Type | Flags | Default |
|---|---|---|---|---|---|
| 10E2:0 | Manufacturer-specific Identification Code | | UINT8 | RO | 0x01 ($1_{dec}$) |
| 10E2:01 | SubIndex 001 | | STRING | RO | |

### Index 10F0 Backup parameter handling

| Index | Name | Meaning | Data Type | Flags | Default |
|---|---|---|---|---|---|
| 10F0:0 | Backup parameter handling | Information for standardized loading and saving of backup entries | UINT8 | RO | 0x01 ($1_{dec}$) |
| 10F0:01 | Checksum | Checksum across all backup entries of the EtherCAT slave | UINT32 | RO | 0x00000000 ($0_{dec}$) |

### Index 1A00 DDM TxPDO-Map Status Ch.1

| Index | Name | Meaning | Data Type | Flags | Default |
|---|---|---|---|---|---|
| 1A00:0 | DDM TxPDO-Map Status Ch.1 | PDO Mapping TxPDO 1 | UINT8 | RO | 0x07 ($7_{dec}$) |
| 1A00:01 | SubIndex 001 | 1. PDO Mapping entry (object 0x6000 (DDM Inputs Ch.1), entry 0x01 (Status__SFP Present)) | UINT32 | RO | 0x6000:01, 1 |
| 1A00:02 | SubIndex 002 | 2nd PDO Mapping entry (object 0x6000 (DDM Inputs Ch.1), entry 0x02 (Status__Rx Signal Detected)) | UINT32 | RO | 0x6000:02, 1 |
| 1A00:03 | SubIndex 003 | 3. PDO Mapping entry (object 0x6000 (DDM Inputs Ch.1), entry 0x03 (Status__Input Cycle Counter)) | UINT32 | RO | 0x6000:03, 2 |
| 1A00:04 | SubIndex 004 | 4. PDO Mapping entry (object 0x6000 (DDM Inputs Ch.1), entry 0x05 (Status__DDM Warning)) | UINT32 | RO | 0x6000:05, 1 |
| 1A00:05 | SubIndex 005 | 5. PDO Mapping entry (object 0x6000 (DDM Inputs Ch.1), entry 0x06 (Status__DDM Alarm)) | UINT32 | RO | 0x6000:06, 1 |
| 1A00:06 | SubIndex 006 | 6. PDO Mapping entry (object 0x6000 (DDM Inputs Ch.1), entry 0x07 (Status__DDM Diagnostic Available)) | UINT32 | RO | 0x6000:07, 1 |
| 1A00:07 | SubIndex 007 | 7. PDO Mapping entry (9 bits align) | UINT32 | RO | 0x0000:00, 9 |

### Index 1A01 DDM TxPDO-Map Ext. Status Ch.1

| Index | Name | Meaning | Data Type | Flags | Default |
|---|---|---|---|---|---|
| 1A01:0 | DDM TxPDO-Map Ext. Status Ch.1 | PDO Mapping TxPDO 2 | UINT8 | RO | 0x16 ($22_{dec}$) |
| 1A01:01 | SubIndex 001 | 1st PDO Mapping entry (object 0x6000 (DDM Inputs Ch.1), entry 0x11 (Alarm__Temperature High)) | UINT32 | RO | 0x6000:11, 1 |
| 1A01:02 | SubIndex 002 | 2nd PDO mapping entry (object 0x6000 (DDM Inputs Ch.1), entry 0x12 (Alarm__Temperature Low)) | UINT32 | RO | 0x6000:12, 1 |
| 1A01:03 | SubIndex 003 | 3. PDO Mapping entry (object 0x6000 (DDM Inputs Ch.1), entry 0x13 (Alarm__Voltage High)) | UINT32 | RO | 0x6000:13, 1 |
| 1A01:04 | SubIndex 004 | 4. PDO Mapping entry (object 0x6000 (DDM Inputs Ch.1), entry 0x14 (Alarm__Voltage Low)) | UINT32 | RO | 0x6000:14, 1 |
| 1A01:05 | SubIndex 005 | 5th PDO Mapping entry (object 0x6000 (DDM Inputs Ch.1), entry 0x15 (Alarm__Tx Bias High)) | UINT32 | RO | 0x6000:15, 1 |
| 1A01:06 | SubIndex 006 | 6th PDO Mapping entry (object 0x6000 (DDM Inputs Ch.1), entry 0x16 (Alarm__Tx Bias Low)) | UINT32 | RO | 0x6000:16, 1 |
| 1A01:07 | SubIndex 007 | 7th PDO Mapping entry (object 0x6000 (DDM Inputs Ch.1), entry 0x17 (Alarm__Tx Power High)) | UINT32 | RO | 0x6000:17, 1 |

| Index | Name | Meaning | Data Type | Flags | Default |
|---|---|---|---|---|---|
| 1A01:08 | SubIndex 008 | 8. PDO Mapping entry (object 0x6000 (DDM Inputs Ch.1), entry 0x18 (Alarm__Tx Power Low)) | UINT32 | RO | 0x6000:18, 1 |
| 1A01:09 | SubIndex 009 | 9. PDO Mapping entry (object 0x6000 (DDM Inputs Ch.1), entry 0x19 (Alarm__Rx Power High)) | UINT32 | RO | 0x6000:19, 1 |
| 1A01:0A | SubIndex 010 | 10. PDO Mapping entry (object 0x6000 (DDM Inputs Ch.1), entry 0x1A (Alarm__Rx Power Low)) | UINT32 | RO | 0x6000:1A, 1 |
| 1A01:0B | SubIndex 011 | 11. PDO Mapping entry (6 bits align) | UINT32 | RO | 0x0000:00, 6 |
| 1A01:0C | SubIndex 012 | 12. PDO Mapping entry (object 0x6000 (DDM Inputs Ch.1), entry 0x21 (Warning__Temperature High)) | UINT32 | RO | 0x6000:21, 1 |
| 1A01:0D | SubIndex 013 | 13. PDO Mapping entry (object 0x6000 (DDM Inputs Ch.1), entry 0x22 (Warning__Temperature Low)) | UINT32 | RO | 0x6000:22, 1 |
| 1A01:0E | SubIndex 014 | 14. PDO Mapping entry (object 0x6000 (DDM Inputs Ch.1), entry 0x23 (Warning__Voltage High)) | UINT32 | RO | 0x6000:23, 1 |
| 1A01:0F | SubIndex 015 | 15. PDO Mapping entry (object 0x6000 (DDM Inputs Ch.1), entry 0x24 (Warning__Voltage Low)) | UINT32 | RO | 0x6000:24, 1 |
| 1A01:10 | SubIndex 016 | 16. PDO Mapping entry (object 0x6000 (DDM Inputs Ch.1), entry 0x25 (Warning__Tx Bias High)) | UINT32 | RO | 0x6000:25, 1 |
| 1A01:11 | SubIndex 017 | 17. PDO Mapping entry (object 0x6000 (DDM Inputs Ch.1), entry 0x26 (Warning__Tx Bias Low)) | UINT32 | RO | 0x6000:26, 1 |
| 1A01:12 | SubIndex 018 | 18. PDO Mapping entry (object 0x6000 (DDM Inputs Ch.1), entry 0x27 (Warning__Tx Power High)) | UINT32 | RO | 0x6000:27, 1 |
| 1A01:13 | SubIndex 019 | 19. PDO Mapping entry (object 0x6000 (DDM Inputs Ch.1), entry 0x28 (Warning__Tx Power Low)) | UINT32 | RO | 0x6000:28, 1 |
| 1A01:14 | SubIndex 020 | 20. PDO Mapping entry (object 0x6000 (DDM Inputs Ch.1), entry 0x29 (Warning__Rx Power High)) | UINT32 | RO | 0x6000:29, 1 |
| 1A01:15 | SubIndex 021 | 21. PDO Mapping entry (object 0x6000 (DDM Inputs Ch.1), entry 0x2A (Warning__Rx Power Low)) | UINT32 | RO | 0x6000:2A, 1 |
| 1A01:16 | SubIndex 022 | 22. PDO Mapping entry (6 bits align) | UINT32 | RO | 0x0000:00, 6 |

### Index 1A02 DDM TxPDO-Map Values Ch.1

| Index | Name | Meaning | Data Type | Flags | Default |
|---|---|---|---|---|---|
| 1A02:0 | DDM TxPDO-Map Values Ch.1 | PDO Mapping TxPDO 3 | UINT8 | RO | 0x05 ($5_{dec}$) |
| 1A02:01 | SubIndex 001 | 1. PDO Mapping entry (object 0x6000 (DDM Inputs Ch.1), entry 0x31 (Actual__Temperature)) | UINT32 | RO | 0x6000:31, 32 |
| 1A02:02 | SubIndex 002 | 2. PDO Mapping entry (object 0x6000 (DDM Inputs Ch.1), entry 0x32 (Actual__Voltage)) | UINT32 | RO | 0x6000:32, 32 |
| 1A02:03 | SubIndex 003 | 3. PDO Mapping entry (object 0x6000 (DDM Inputs Ch.1), entry 0x33 (Actual__Tx Bias)) | UINT32 | RO | 0x6000:33, 32 |
| 1A02:04 | SubIndex 004 | 4. PDO Mapping entry (object 0x6000 (DDM Inputs Ch.1), entry 0x34 (Actual__Tx Power)) | UINT32 | RO | 0x6000:34, 32 |
| 1A02:05 | SubIndex 005 | 5. PDO Mapping entry (object 0x6000 (DDM Inputs Ch.1), entry 0x35 (Actual__Rx Power)) | UINT32 | RO | 0x6000:35, 32 |

### Index 1A10 DDM TxPDO-Map Status Ch.2

| Index | Name | Meaning | Data Type | Flags | Default |
|---|---|---|---|---|---|
| 1A10:0 | DDM TxPDO-Map Status Ch.2 | PDO Mapping TxPDO 17 | UINT8 | RO | 0x07 ($7_{dec}$) |
| 1A10:01 | SubIndex 001 | 1. PDO Mapping entry (object 0x6010 (DDM Inputs Ch.2), entry 0x01 (Status__SFP Present)) | UINT32 | RO | 0x6010:01, 1 |
| 1A10:02 | SubIndex 002 | 2nd PDO Mapping entry (object 0x6010 (DDM Inputs Ch.2), entry 0x02 (Status__Rx Signal Detected)) | UINT32 | RO | 0x6010:02, 1 |
| 1A10:03 | SubIndex 003 | 3. PDO Mapping entry (object 0x6010 (DDM Inputs Ch.2), entry 0x03 (Status__Input Cycle Counter)) | UINT32 | RO | 0x6010:03, 2 |
| 1A10:04 | SubIndex 004 | 4. PDO Mapping entry (object 0x6010 (DDM Inputs Ch.2), entry 0x05 (Status__DDM Warning)) | UINT32 | RO | 0x6010:05, 1 |
| 1A10:05 | SubIndex 005 | 5. PDO Mapping entry (object 0x6010 (DDM Inputs Ch.2), entry 0x06 (Status__DDM Alarm)) | UINT32 | RO | 0x6010:06, 1 |
| 1A10:06 | SubIndex 006 | 6. PDO Mapping entry (object 0x6010 (DDM Inputs Ch.2), entry 0x07 (Status__DDM Diagnostic Available)) | UINT32 | RO | 0x6010:07, 1 |
| 1A10:07 | SubIndex 007 | 7. PDO Mapping entry (9 bits align) | UINT32 | RO | 0x0000:00, 9 |

## Index 1A11 DDM TxPDO-Map Ext. Status Ch.2

| Index | Name | Meaning | Data Type | Flags | Default |
|---|---|---|---|---|---|
| 1A11:0 | DDM TxPDO-Map Ext. Status Ch.2 | PDO Mapping TxPDO 18 | UINT8 | RO | 0x16 ($22_{dec}$) |
| 1A11:01 | SubIndex 001 | 1st PDO Mapping entry (object 0x6010 (DDM Inputs Ch.2), entry 0x11 (Alarm__Temperature High)) | UINT32 | RO | 0x6010:11, 1 |
| 1A11:02 | SubIndex 002 | 2nd PDO mapping entry (object 0x6010 (DDM Inputs Ch.2), entry 0x12 (Alarm__Temperature Low)) | UINT32 | RO | 0x6010:12, 1 |
| 1A11:03 | SubIndex 003 | 3. PDO Mapping entry (object 0x6010 (DDM Inputs Ch.2), entry 0x13 (Alarm__Voltage High)) | UINT32 | RO | 0x6010:13, 1 |
| 1A11:04 | SubIndex 004 | 4. PDO Mapping entry (object 0x6010 (DDM Inputs Ch.2), entry 0x14 (Alarm__Voltage Low)) | UINT32 | RO | 0x6010:14, 1 |
| 1A11:05 | SubIndex 005 | 5th PDO Mapping entry (object 0x6010 (DDM Inputs Ch.2), entry 0x15 (Alarm__Tx Bias High)) | UINT32 | RO | 0x6010:15, 1 |
| 1A11:06 | SubIndex 006 | 6th PDO Mapping entry (object 0x6010 (DDM Inputs Ch.2), entry 0x16 (Alarm__Tx Bias Low)) | UINT32 | RO | 0x6010:16, 1 |
| 1A11:07 | SubIndex 007 | 7th PDO Mapping entry (object 0x6010 (DDM Inputs Ch.2), entry 0x17 (Alarm__Tx Power High)) | UINT32 | RO | 0x6010:17, 1 |
| 1A11:08 | SubIndex 008 | 8. PDO Mapping entry (object 0x6010 (DDM Inputs Ch.2), entry 0x18 (Alarm__Tx Power Low)) | UINT32 | RO | 0x6010:18, 1 |
| 1A11:09 | SubIndex 009 | 9. PDO Mapping entry (object 0x6010 (DDM Inputs Ch.2), entry 0x19 (Alarm__Rx Power High)) | UINT32 | RO | 0x6010:19, 1 |
| 1A11:0A | SubIndex 010 | 10. PDO Mapping entry (object 0x6010 (DDM Inputs Ch.2), entry 0x1A (Alarm__Rx Power Low)) | UINT32 | RO | 0x6010:1A, 1 |
| 1A11:0B | SubIndex 011 | 11. PDO Mapping entry (6 bits align) | UINT32 | RO | 0x0000:00, 6 |
| 1A11:0C | SubIndex 012 | 12. PDO Mapping entry (object 0x6010 (DDM Inputs Ch.2), entry 0x21 (Warning__Temperature High)) | UINT32 | RO | 0x6010:21, 1 |
| 1A11:0D | SubIndex 013 | 13. PDO Mapping entry (object 0x6010 (DDM Inputs Ch.2), entry 0x22 (Warning__Temperature Low)) | UINT32 | RO | 0x6010:22, 1 |
| 1A11:0E | SubIndex 014 | 14. PDO Mapping entry (object 0x6010 (DDM Inputs Ch.2), entry 0x23 (Warning__Voltage High)) | UINT32 | RO | 0x6010:23, 1 |
| 1A11:0F | SubIndex 015 | 15. PDO Mapping entry (object 0x6010 (DDM Inputs Ch.2), entry 0x24 (Warning__Voltage Low)) | UINT32 | RO | 0x6010:24, 1 |
| 1A11:10 | SubIndex 016 | 16. PDO Mapping entry (object 0x6010 (DDM Inputs Ch.2), entry 0x25 (Warning__Tx Bias High)) | UINT32 | RO | 0x6010:25, 1 |
| 1A11:11 | SubIndex 017 | 17. PDO Mapping entry (object 0x6010 (DDM Inputs Ch.2), entry 0x26 (Warning__Tx Bias Low)) | UINT32 | RO | 0x6010:26, 1 |
| 1A11:12 | SubIndex 018 | 18. PDO Mapping entry (object 0x6010 (DDM Inputs Ch.2), entry 0x27 (Warning__Tx Power High)) | UINT32 | RO | 0x6010:27, 1 |
| 1A11:13 | SubIndex 019 | 19. PDO Mapping entry (object 0x6010 (DDM Inputs Ch.2), entry 0x28 (Warning__Tx Power Low)) | UINT32 | RO | 0x6010:28, 1 |
| 1A11:14 | SubIndex 020 | 20. PDO Mapping entry (object 0x6010 (DDM Inputs Ch.2), entry 0x29 (Warning__Rx Power High)) | UINT32 | RO | 0x6010:29, 1 |
| 1A11:15 | SubIndex 021 | 21. PDO Mapping entry (object 0x6010 (DDM Inputs Ch.2), entry 0x2A (Warning__Rx Power Low)) | UINT32 | RO | 0x6010:2A, 1 |
| 1A11:16 | SubIndex 022 | 22. PDO Mapping entry (6 bits align) | UINT32 | RO | 0x0000:00, 6 |

## Index 1A12 DDM TxPDO-Map Values Ch.2

| Index | Name | Meaning | Data Type | Flags | Default |
|---|---|---|---|---|---|
| 1A12:0 | DDM TxPDO-Map Values Ch.2 | PDO Mapping TxPDO 19 | UINT8 | RO | 0x05 ($5_{dec}$) |
| 1A12:01 | SubIndex 001 | 1. PDO Mapping entry (object 0x6010 (DDM Inputs Ch.2), entry 0x31 (Actual__Temperature)) | UINT32 | RO | 0x6010:31, 32 |
| 1A12:02 | SubIndex 002 | 2. PDO Mapping entry (object 0x6010 (DDM Inputs Ch.2), entry 0x32 (Actual__Voltage)) | UINT32 | RO | 0x6010:32, 32 |
| 1A12:03 | SubIndex 003 | 3. PDO Mapping entry (object 0x6010 (DDM Inputs Ch.2), entry 0x33 (Actual__Tx Bias)) | UINT32 | RO | 0x6010:33, 32 |
| 1A12:04 | SubIndex 004 | 4. PDO Mapping entry (object 0x6010 (DDM Inputs Ch.2), entry 0x34 (Actual__Tx Power)) | UINT32 | RO | 0x6010:34, 32 |
| 1A12:05 | SubIndex 005 | 5. PDO Mapping entry (object 0x6010 (DDM Inputs Ch.2), entry 0x35 (Actual__Rx Power)) | UINT32 | RO | 0x6010:35, 32 |

### Index 1C00 Sync manager type

| Index | Name | Meaning | Data Type | Flags | Default |
|---|---|---|---|---|---|
| 1C00:0 | Sync manager type | Using the Sync Managers | UINT8 | RO | 0x04 ($4_{dec}$) |
| 1C00:01 | SubIndex 001 | Sync Manager Type Channel 1: Mailbox Write | UINT8 | RO | 0x01 ($1_{dec}$) |
| 1C00:02 | SubIndex 002 | Sync Manager Type Channel 2: Mailbox Read | UINT8 | RO | 0x02 ($2_{dec}$) |
| 1C00:03 | SubIndex 003 | Sync Manager Type Channel 3: Process Data Write (Outputs) | UINT8 | RO | 0x03 ($3_{dec}$) |
| 1C00:04 | SubIndex 004 | Sync Manager Type Channel 4: Process Data Read (Inputs) | UINT8 | RO | 0x04 ($4_{dec}$) |

### Index 1C12 RxPDO assign

| Index | Name | Meaning | Data Type | Flags | Default |
|---|---|---|---|---|---|
| 1C12:0 | RxPDO assign | PDO Assign Outputs | UINT8 | RW | 0x00 ($0_{dec}$) |

### Index 1C13 TxPDO assign

| Index | Name | Meaning | Data Type | Flags | Default |
|---|---|---|---|---|---|
| 1C13:0 | TxPDO assign | PDO Assign Inputs | UINT8 | RW | 0x02 ($2_{dec}$) |
| 1C13:01 | SubIndex 001 | 1. allocated TxPDO (contains the index of the associated TxPDO mapping object) | UINT16 | RW | 0x1A00 ($6656_{dec}$) |
| 1C13:02 | SubIndex 002 | 2. allocated TxPDO (contains the index of the associated TxPDO mapping object) | UINT16 | RW | 0x1A10 ($6672_{dec}$) |
| 1C13:03 | SubIndex 003 | 3. allocated TxPDO (contains the index of the associated TxPDO mapping object) | UINT16 | RW | 0x0000 ($0_{dec}$) |
| 1C13:04 | SubIndex 004 | 4. allocated TxPDO (contains the index of the associated TxPDO mapping object) | UINT16 | RW | 0x0000 ($0_{dec}$) |
| 1C13:05 | SubIndex 005 | 5. allocated TxPDO (contains the index of the associated TxPDO mapping object) | UINT16 | RW | 0x0000 ($0_{dec}$) |
| 1C13:06 | SubIndex 006 | 6. allocated TxPDO (contains the index of the associated TxPDO mapping object) | UINT16 | RW | 0x0000 ($0_{dec}$) |

### Index 1C33 SM input parameter

| Index | Name | Meaning | Data Type | Flags | Default |
|---|---|---|---|---|---|
| 1C33:0 | SM input parameter | Synchronization parameters for the inputs | UINT8 | RO | 0x20 ($32_{dec}$) |
| 1C33:01 | Sync mode | Current synchronization mode: 0: Free Run 1: Synchron with SM 3 Event (no outputs available) 2: DC - Synchron with SYNC0 Event 3: DC - Synchron with SYNC1 Event 34: Synchron with SM 2 Event (outputs available) | UINT16 | RW | 0x0000 ($0_{dec}$) |
| 1C33:02 | Cycle time | as 1C32:02 | UINT32 | RW | 0x000F4240 ($1000000_{dec}$) |
| 1C33:03 | Shift time | Time between SYNC0 event and reading of the inputs (in ns, DC Mode only) | UINT32 | RO | 0x00000000 ($0_{dec}$) |
| 1C33:04 | Sync modes supported | Supported synchronization modes: Bit 0: Free Run is supported Bit 1: Synchron with SM 2 Event is supported (outputs available) Bit 1: Synchron with SM 3 Event is supported (no outputs available) Bit 2-3 = 01: DC Mode is supported Bit 4-5 = 01: Input Shift by local event (outputs available) Bit 4-5 = 10: Input Shift with SYNC1 Event (no outputs available) Bit 14 = 1: Dynamic times (measurement by writing to 1C32:08 or 1C33:08 ) | UINT16 | RO | 0x0001 ($1_{dec}$) |
| 1C33:05 | Minimum cycle time | as 1C32:05 | UINT32 | RO | 0x000186A0 ($100000_{dec}$) |
| 1C33:06 | Calc and copy time | Time between reading of the inputs and the inputs being available for the master (in ns, DC Mode only) | UINT32 | RO | 0x00000000 ($0_{dec}$) |
| 1C33:07 | Minimum delay time | | UINT32 | RO | 0x00000000 ($0_{dec}$) |
| 1C33:08 | Get Cycle Time | as 1C32:08 | UINT16 | RW | 0x0000 ($0_{dec}$) |
| 1C33:09 | Maximum delay time | Time between SYNC1 event and reading of the inputs (in ns, DC Mode only) | UINT32 | RO | 0x00000000 ($0_{dec}$) |
| 1C33:0B | SM event missed counter | as 1C32:11 | UINT16 | RO | 0x0000 ($0_{dec}$) |
| 1C33:0C | Cycle exceeded counter | as 1C32:12 | UINT16 | RO | 0x0000 ($0_{dec}$) |
| 1C33:0D | Shift too short counter | as 1C32:13 | UINT16 | RO | 0x0000 ($0_{dec}$) |
| 1C33:20 | Sync error | as 1C32:32 | BOOLEAN | RO | 0x00 ($0_{dec}$) |

### Index 6000 DDM Inputs Ch.1

| Index | Name | Meaning | Data Type | Flags | Default |
|---|---|---|---|---|---|
| 6000:0 | DDM Inputs Ch.1 | | UINT8 | RO | 0x35 ($53_{dec}$) |
| 6000:01 | Status__SFP Present | | BOOLEAN | RO | 0x00 ($0_{dec}$) |
| 6000:02 | Status__Rx Signal Detected | | BOOLEAN | RO | 0x00 ($0_{dec}$) |
| 6000:03 | Status__Input Cycle Counter | | BIT2 | RO | 0x00 ($0_{dec}$) |
| 6000:05 | Status__DDM Warning | | BOOLEAN | RO | 0x00 ($0_{dec}$) |
| 6000:06 | Status__DDM Alarm | | BOOLEAN | RO | 0x00 ($0_{dec}$) |
| 6000:07 | Status__DDM Diagnostic Available | | BOOLEAN | RO | 0x00 ($0_{dec}$) |
| 6000:11 | Alarm__Temperature High | | BOOLEAN | RO | 0x00 ($0_{dec}$) |
| 6000:12 | Alarm__Temperature Low | | BOOLEAN | RO | 0x00 ($0_{dec}$) |
| 6000:13 | Alarm__Voltage High | | BOOLEAN | RO | 0x00 ($0_{dec}$) |
| 6000:14 | Alarm__Voltage Low | | BOOLEAN | RO | 0x00 ($0_{dec}$) |
| 6000:15 | Alarm__Tx Bias High | | BOOLEAN | RO | 0x00 ($0_{dec}$) |
| 6000:16 | Alarm__Tx Bias Low | | BOOLEAN | RO | 0x00 ($0_{dec}$) |
| 6000:17 | Alarm__Tx Power High | | BOOLEAN | RO | 0x00 ($0_{dec}$) |
| 6000:18 | Alarm__Tx Power Low | | BOOLEAN | RO | 0x00 ($0_{dec}$) |
| 6000:19 | Alarm__Rx Power High | | BOOLEAN | RO | 0x00 ($0_{dec}$) |
| 6000:1A | Alarm__Rx Power Low | | BOOLEAN | RO | 0x00 ($0_{dec}$) |
| 6000:21 | Warning__Temperature High | | BOOLEAN | RO | 0x00 ($0_{dec}$) |
| 6000:22 | Warning__Temperature Low | | BOOLEAN | RO | 0x00 ($0_{dec}$) |
| 6000:23 | Warning__Voltage High | | BOOLEAN | RO | 0x00 ($0_{dec}$) |
| 6000:24 | Warning__Voltage Low | | BOOLEAN | RO | 0x00 ($0_{dec}$) |
| 6000:25 | Warning__Tx Bias High | | BOOLEAN | RO | 0x00 ($0_{dec}$) |
| 6000:26 | Warning__Tx Bias Low | | BOOLEAN | RO | 0x00 ($0_{dec}$) |
| 6000:27 | Warning__Tx Power High | | BOOLEAN | RO | 0x00 ($0_{dec}$) |
| 6000:28 | Warning__Tx Power Low | | BOOLEAN | RO | 0x00 ($0_{dec}$) |
| 6000:29 | Warning__Rx Power High | | BOOLEAN | RO | 0x00 ($0_{dec}$) |
| 6000:2A | Warning__Rx Power Low | | BOOLEAN | RO | 0x00 ($0_{dec}$) |
| 6000:31 | Actual__Temperature | Unit: 1 °C | REAL32 | RO | 0x00000000 ($0_{dec}$) |
| 6000:32 | Actual__Voltage | Unit: 1 V | REAL32 | RO | 0x00000000 ($0_{dec}$) |
| 6000:33 | Actual__Tx Bias | Unit: 1 mA | REAL32 | RO | 0x00000000 ($0_{dec}$) |
| 6000:34 | Actual__Tx Power | Unit: 1 dBm | REAL32 | RO | 0x00000000 ($0_{dec}$) |
| 6000:35 | Actual__Rx Power | Unit: 1 dBm | REAL32 | RO | 0x00000000 ($0_{dec}$) |

### Index 6010 DDM Inputs Ch.2

| Index | Name | Meaning | Data Type | Flags | Default |
|---|---|---|---|---|---|
| 6010:0 | DDM Inputs Ch.2 | | UINT8 | RO | 0x35 ($53_{dec}$) |
| 6010:01 | Status__SFP Present | | BOOLEAN | RO | 0x00 ($0_{dec}$) |
| 6010:02 | Status__Rx Signal Detected | | BOOLEAN | RO | 0x00 ($0_{dec}$) |
| 6010:03 | Status__Input Cycle Counter | | BIT2 | RO | 0x00 ($0_{dec}$) |
| 6010:05 | Status__DDM Warning | | BOOLEAN | RO | 0x00 ($0_{dec}$) |
| 6010:06 | Status__DDM Alarm | | BOOLEAN | RO | 0x00 ($0_{dec}$) |
| 6010:07 | Status__DDM Diagnostic Available | | BOOLEAN | RO | 0x00 ($0_{dec}$) |
| 6010:11 | Alarm__Temperature High | | BOOLEAN | RO | 0x00 ($0_{dec}$) |
| 6010:12 | Alarm__Temperature Low | | BOOLEAN | RO | 0x00 ($0_{dec}$) |
| 6010:13 | Alarm__Voltage High | | BOOLEAN | RO | 0x00 ($0_{dec}$) |
| 6010:14 | Alarm__Voltage Low | | BOOLEAN | RO | 0x00 ($0_{dec}$) |
| 6010:15 | Alarm__Tx Bias High | | BOOLEAN | RO | 0x00 ($0_{dec}$) |
| 6010:16 | Alarm__Tx Bias Low | | BOOLEAN | RO | 0x00 ($0_{dec}$) |
| 6010:17 | Alarm__Tx Power High | | BOOLEAN | RO | 0x00 ($0_{dec}$) |
| 6010:18 | Alarm__Tx Power Low | | BOOLEAN | RO | 0x00 ($0_{dec}$) |
| 6010:19 | Alarm__Rx Power High | | BOOLEAN | RO | 0x00 ($0_{dec}$) |
| 6010:1A | Alarm__Rx Power Low | | BOOLEAN | RO | 0x00 ($0_{dec}$) |
| 6010:21 | Warning__Temperature High | | BOOLEAN | RO | 0x00 ($0_{dec}$) |
| 6010:22 | Warning__Temperature Low | | BOOLEAN | RO | 0x00 ($0_{dec}$) |
| 6010:23 | Warning__Voltage High | | BOOLEAN | RO | 0x00 ($0_{dec}$) |
| 6010:24 | Warning__Voltage Low | | BOOLEAN | RO | 0x00 ($0_{dec}$) |
| 6010:25 | Warning__Tx Bias High | | BOOLEAN | RO | 0x00 ($0_{dec}$) |
| 6010:26 | Warning__Tx Bias Low | | BOOLEAN | RO | 0x00 ($0_{dec}$) |
| 6010:27 | Warning__Tx Power High | | BOOLEAN | RO | 0x00 ($0_{dec}$) |
| 6010:28 | Warning__Tx Power Low | | BOOLEAN | RO | 0x00 ($0_{dec}$) |
| 6010:29 | Warning__Rx Power High | | BOOLEAN | RO | 0x00 ($0_{dec}$) |
| 6010:2A | Warning__Rx Power Low | | BOOLEAN | RO | 0x00 ($0_{dec}$) |
| 6010:31 | Actual__Temperature | Unit: 1 °C | REAL32 | RO | 0x00000000 ($0_{dec}$) |
| 6010:32 | Actual__Voltage | Unit: 1 V | REAL32 | RO | 0x00000000 ($0_{dec}$) |
| 6010:33 | Actual__Tx Bias | Unit: 1 mA | REAL32 | RO | 0x00000000 ($0_{dec}$) |
| 6010:34 | Actual__Tx Power | Unit: 1 dBm | REAL32 | RO | 0x00000000 ($0_{dec}$) |
| 6010:35 | Actual__Rx Power | Unit: 1 dBm | REAL32 | RO | 0x00000000 ($0_{dec}$) |

### Index 8000 DDM Settings Ch.1

| Index | Name | Meaning | Data Type | Flags | Default |
|---|---|---|---|---|---|
| 8000:0 | DDM Settings Ch.1 | | UINT8 | RO | 0x11 ($17_{dec}$) |
| 8000:11 | Force Ethernet Encoding | permitted values:<br>• 0: SGMII<br>• 1: 100BASE-X<br>• 255: Auto | UINT8 | RW | 0xFF ($255_{dec}$) |

### Index 8010 DDM Settings Ch.2

| Index | Name | Meaning | Data Type | Flags | Default |
|---|---|---|---|---|---|
| 8010:0 | DDM Settings Ch.2 | | UINT8 | RO | 0x11 ($17_{dec}$) |
| 8010:11 | Force Ethernet Encoding | permitted values:<br>• 0: SGMII<br>• 1: 100BASE-X<br>• 255: Auto | UINT8 | RW | 0xFF ($255_{dec}$) |

### Index 9000 DDM Info Data Ch.1

| Index | Name | Meaning | Data Type | Flags | Default |
|---|---|---|---|---|---|
| 9000:0 | DDM Info Data Ch.1 | | UINT8 | RO | 0x15 ($21_{dec}$) |
| 9000:11 | Vendor Name | | STRING | RO | |
| 9000:12 | Part Number | | STRING | RO | |
| 9000:13 | Serial Number | | STRING | RO | |
| 9000:14 | Date Code | | STRING | RO | |
| 9000:15 | Ethernet Encoding | permitted values:<br>• 0: SGMII<br>• 1: 100BASE-X<br>• 16: SGMII (Forced)<br>• 17: 100BASE-X (Forced)<br>• 254: - | UINT8 | RO | 0x00 ($0_{dec}$) |

### Index 9010 DDM Info Data Ch.2

| Index | Name | Meaning | Data Type | Flags | Default |
|---|---|---|---|---|---|
| 9010:0 | DDM Info Data Ch.2 | | UINT8 | RO | 0x15 ($21_{dec}$) |
| 9010:11 | Vendor Name | | STRING | RO | |
| 9010:12 | Part Number | | STRING | RO | |
| 9010:13 | Serial Number | | STRING | RO | |
| 9010:14 | Date Code | | STRING | RO | |
| 9010:15 | Ethernet Encoding | permitted values:<br>• 0: SGMII<br>• 1: 100BASE-X<br>• 16: SGMII (Forced)<br>• 17: 100BASE-X (Forced)<br>• 254: - | UINT8 | RO | 0x00 ($0_{dec}$) |

### Index A000 DDM Thresholds Ch.1

| Index | Name | Meaning | Data Type | Flags | Default |
|---|---|---|---|---|---|
| A000:0 | DDM Thresholds Ch.1 | | UINT8 | RO | 0x34 ($52_{dec}$) |
| A000:21 | Temp High Alarm | Unit: 1 °C | REAL32 | RO | 0x00000000 ($0_{dec}$) |
| A000:22 | Temp High Warning | Unit: 1 °C | REAL32 | RO | 0x00000000 ($0_{dec}$) |
| A000:23 | Temp Low Warning | Unit: 1 °C | REAL32 | RO | 0x00000000 ($0_{dec}$) |
| A000:24 | Temp Low Alarm | Unit: 1 °C | REAL32 | RO | 0x00000000 ($0_{dec}$) |
| A000:25 | Voltage High Alarm | Unit: 1 V | REAL32 | RO | 0x00000000 ($0_{dec}$) |
| A000:26 | Voltage High Warning | Unit: 1 V | REAL32 | RO | 0x00000000 ($0_{dec}$) |
| A000:27 | Voltage Low Warning | Unit: 1 V | REAL32 | RO | 0x00000000 ($0_{dec}$) |
| A000:28 | Voltage Low Alarm | Unit: 1 V | REAL32 | RO | 0x00000000 ($0_{dec}$) |
| A000:29 | Bias High Alarm | Unit: 1 mA | REAL32 | RO | 0x00000000 ($0_{dec}$) |
| A000:2A | Bias High Warning | Unit: 1 mA | REAL32 | RO | 0x00000000 ($0_{dec}$) |
| A000:2B | Bias Low Warning | Unit: 1 mA | REAL32 | RO | 0x00000000 ($0_{dec}$) |
| A000:2C | Bias Low Alarm | Unit: 1 mA | REAL32 | RO | 0x00000000 ($0_{dec}$) |
| A000:2D | Tx Power High Alarm | Unit: 1 dBm | REAL32 | RO | 0x00000000 ($0_{dec}$) |
| A000:2E | Tx Power High Warning | Unit: 1 dBm | REAL32 | RO | 0x00000000 ($0_{dec}$) |
| A000:2F | Tx Power Low Warning | Unit: 1 dBm | REAL32 | RO | 0x00000000 ($0_{dec}$) |
| A000:30 | Tx Power Low Alarm | Unit: 1 dBm | REAL32 | RO | 0x00000000 ($0_{dec}$) |
| A000:31 | Rx Power High Alarm | Unit: 1 dBm | REAL32 | RO | 0x00000000 ($0_{dec}$) |
| A000:32 | Rx Power High Warning | Unit: 1 dBm | REAL32 | RO | 0x00000000 ($0_{dec}$) |
| A000:33 | Rx Power Low Warning | Unit: 1 dBm | REAL32 | RO | 0x00000000 ($0_{dec}$) |
| A000:34 | Rx Power Low Alarm | Unit: 1 dBm | REAL32 | RO | 0x00000000 ($0_{dec}$) |

### Index A010 DDM Thresholds Ch.2

| Index | Name | Meaning | Data Type | Flags | Default |
|---|---|---|---|---|---|
| A010:0 | DDM Thresholds Ch.2 | | UINT8 | RO | 0x34 ($52_{dec}$) |
| A010:21 | Temp High Alarm | Unit: 1 °C | REAL32 | RO | 0x00000000 ($0_{dec}$) |
| A010:22 | Temp High Warning | Unit: 1 °C | REAL32 | RO | 0x00000000 ($0_{dec}$) |
| A010:23 | Temp Low Warning | Unit: 1 °C | REAL32 | RO | 0x00000000 ($0_{dec}$) |
| A010:24 | Temp Low Alarm | Unit: 1 °C | REAL32 | RO | 0x00000000 ($0_{dec}$) |
| A010:25 | Voltage High Alarm | Unit: 1 V | REAL32 | RO | 0x00000000 ($0_{dec}$) |
| A010:26 | Voltage High Warning | Unit: 1 V | REAL32 | RO | 0x00000000 ($0_{dec}$) |
| A010:27 | Voltage Low Warning | Unit: 1 V | REAL32 | RO | 0x00000000 ($0_{dec}$) |
| A010:28 | Voltage Low Alarm | Unit: 1 V | REAL32 | RO | 0x00000000 ($0_{dec}$) |
| A010:29 | Bias High Alarm | Unit: 1 mA | REAL32 | RO | 0x00000000 ($0_{dec}$) |
| A010:2A | Bias High Warning | Unit: 1 mA | REAL32 | RO | 0x00000000 ($0_{dec}$) |
| A010:2B | Bias Low Warning | Unit: 1 mA | REAL32 | RO | 0x00000000 ($0_{dec}$) |
| A010:2C | Bias Low Alarm | Unit: 1 mA | REAL32 | RO | 0x00000000 ($0_{dec}$) |
| A010:2D | Tx Power High Alarm | Unit: 1 dBm | REAL32 | RO | 0x00000000 ($0_{dec}$) |
| A010:2E | Tx Power High Warning | Unit: 1 dBm | REAL32 | RO | 0x00000000 ($0_{dec}$) |
| A010:2F | Tx Power Low Warning | Unit: 1 dBm | REAL32 | RO | 0x00000000 ($0_{dec}$) |
| A010:30 | Tx Power Low Alarm | Unit: 1 dBm | REAL32 | RO | 0x00000000 ($0_{dec}$) |
| A010:31 | Rx Power High Alarm | Unit: 1 dBm | REAL32 | RO | 0x00000000 ($0_{dec}$) |
| A010:32 | Rx Power High Warning | Unit: 1 dBm | REAL32 | RO | 0x00000000 ($0_{dec}$) |
| A010:33 | Rx Power Low Warning | Unit: 1 dBm | REAL32 | RO | 0x00000000 ($0_{dec}$) |
| A010:34 | Rx Power Low Alarm | Unit: 1 dBm | REAL32 | RO | 0x00000000 ($0_{dec}$) |

### Index B000 DDM Command Ch.1

| Index | Name | Meaning | Data Type | Flags | Default |
|---|---|---|---|---|---|
| B000:0 | DDM Command Ch.1 | | UINT8 | RO | 0x03 ($3_{dec}$) |
| B000:01 | Request | | OCTET-STRING[6] | RW | {0} |
| B000:02 | Status | | UINT8 | RO | 0x00 ($0_{dec}$) |
| B000:03 | Response | | OCTET-STRING[6] | RO | {0} |

### Index B010 DDM Command Ch.2

| Index | Name | Meaning | Data Type | Flags | Default |
|---|---|---|---|---|---|
| B010:0 | DDM Command Ch.2 | | UINT8 | RO | 0x03 ($3_{dec}$) |
| B010:01 | Request | | OCTET-STRING[6] | RW | {0} |
| B010:02 | Status | | UINT8 | RO | 0x00 ($0_{dec}$) |
| B010:03 | Response | | OCTET-STRING[6] | RO | {0} |

### Index F000 Modular Device Profile

| Index | Name | Meaning | Data Type | Flags | Default |
|---|---|---|---|---|---|
| F000:0 | Modular Device Profile | General information for the Modular Device Profile | UINT8 | RO | 0x02 ($2_{dec}$) |
| F000:01 | Index distance | Index distance of the objects of the individual channels | UINT16 | RO | 0x0010 ($16_{dec}$) |
| F000:02 | Maximum number of modules | Number of channels | UINT16 | RO | 0x0002 ($2_{dec}$) |

### Index F008 Code word

| Index | Name | Meaning | Data Type | Flags | Default |
|---|---|---|---|---|---|
| F008:0 | Code word | | UINT32 | RW | 0x00000000 ($0_{dec}$) |

### Index F081 Download revision

| Index | Name | Meaning | Data Type | Flags | Default |
|---|---|---|---|---|---|
| F081:0 | Download revision | | UINT8 | RO | 0x01 ($1_{dec}$) |
| F081:01 | Revision number | | UINT32 | RW | 0x00000000 ($0_{dec}$) |

### Index FB00 DDM Command

| Index | Name | Meaning | Data Type | Flags | Default |
|---|---|---|---|---|---|
| FB00:0 | DDM Command | | UINT8 | RO | 0x03 ($3_{dec}$) |
| FB00:01 | Request | | OCTET-STRING[6] | RW | {0} |
| FB00:02 | Status | | UINT8 | RO | 0x00 ($0_{dec}$) |
| FB00:03 | Response | | OCTET-STRING[6] | RO | {0} |

# 6 Appendix

## 6.1 Volatility

If there are requirements concerning the volatility of products in your application, for example of the U.S. Department of Defense or similar authorities or security organizations, the following process applies:

The product has both volatile and non-volatile components. Volatile components lose their data immediately after removing power. Non-volatile components keep the data even after loss of power.

If there is customer specific data saved on the product, it cannot be ensured that this data might not be restored through for example forensic measures, even after the data is deleted through the provided tool chain. If this data is confidential, the scrapping of the product after usage is recommended to protect this data.

## 6.2 Firmware compatibility

Beckhoff EtherCAT devices are delivered with the latest available firmware version. Compatibility of firmware and hardware is mandatory; not every combination ensures compatibility. The overview below shows the hardware versions on which a firmware can be operated.

**Note**

- It is recommended to use the newest possible firmware for the respective hardware
- Beckhoff is not under any obligation to provide customers with free firmware updates for delivered products.

**NOTICE**

**Risk of damage to the device!**

Pay attention to the instructions for firmware updates on the separate page.
If a device is placed in BOOTSTRAP mode for a firmware update, it does not check when downloading whether the new firmware is suitable.
This can result in damage to the device! Therefore, always make sure that the firmware is suitable for the hardware version!

**CU1521, CU1521-0010, CU1561**

The converter firmware cannot be updated.

**CU1521-0020**

| Hardware (HW) | Firmware (FW) | Revision no. | Release date |
|---|---|---|---|
| 00 | 01 | CU1521-0020-0000 | 2023/07 |
| | 02 | CU1521-0020-0000 | 2025/03 |
| | 03 | CU1521-0020-0000 | 2025/05 |
| | 04 | CU1521-0020-0001 | 2025/08 |
| 02 | 06 | CU1521-0020-0002 | 2026/05 |

**Firmware-Update of CU1521-0020**

HW00-01: The converter can be updated via *.rpd firmware file.

HW02: The converter can be updated via *.efw firmware file

**NOTICE**

**The voltage must not be switched off when updating the firmware**

The CU1521-0020 is damaged and can only be repaired by the service department.

## Update via *.rpd firmware file (HW00-HW01)

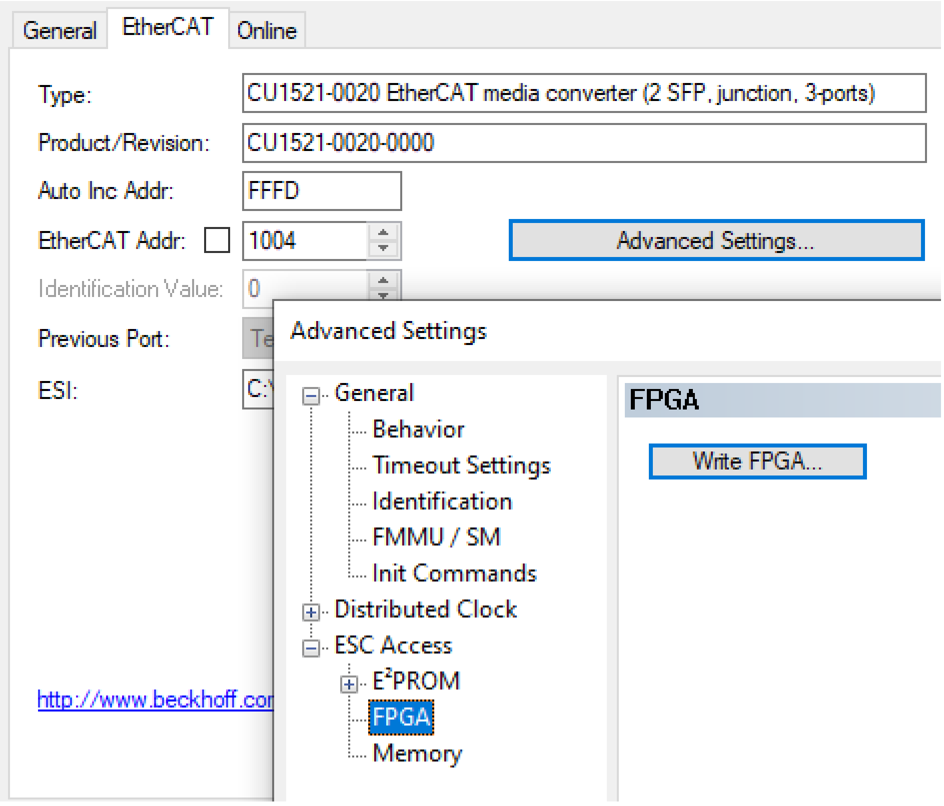



Fig. 50: Firmware update by writing to the FPGA with *.rpd file

The firmware version is displayed online in register x0E06, here: FW02

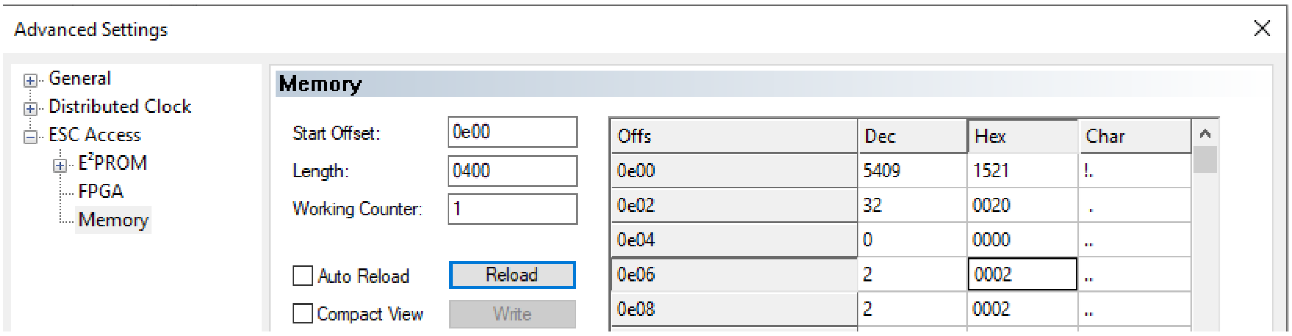



Fig. 51: Display firmware version in register x0E06

### Update via *.efw firmware file (HW02)

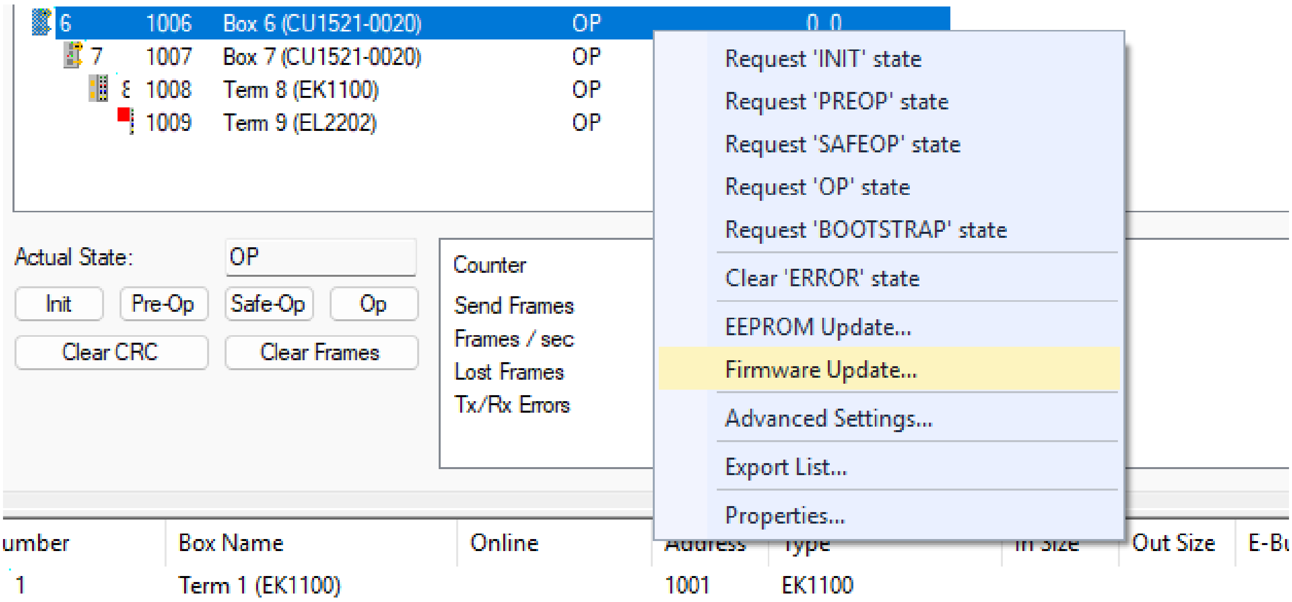



Fig. 52: FW update via *.efw file

The firmware version is displayed online in CoE register 0x100A, here: FW06

| | | | |
|---|---|---|---|
| 1000 | Device type | RO | 0x03FC1389 (66851721) |
| 1008 | Device name | RO | CU1521-0020 |
| 1009 | Hardware version | RO | 02 |
| 100A | Software version | RO | 06 |

Fig. 53: Display firmware version in CoE register: 0x100A

*) This is the current compatible firmware/hardware version at the time of the preparing this documentation. Check on the Beckhoff web page whether more up-to-date documentation is available.

## 6.3 Support and Service

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

### Beckhoff's branch offices and representatives

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

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

You will also find further documentation for Beckhoff components there.

### Support

The Beckhoff 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 |
| e-mail: | support@beckhoff.com |
| web: | www.beckhoff.com/support |

### Service

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

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- repair service
- spare parts service
- hotline service

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|---|---|
| Hotline: | +49 5246 963 460 |
| e-mail: | service@beckhoff.com |
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