

Documentation | EN

EKM1101

EtherCAT Coupler with ID switch and diagnostics

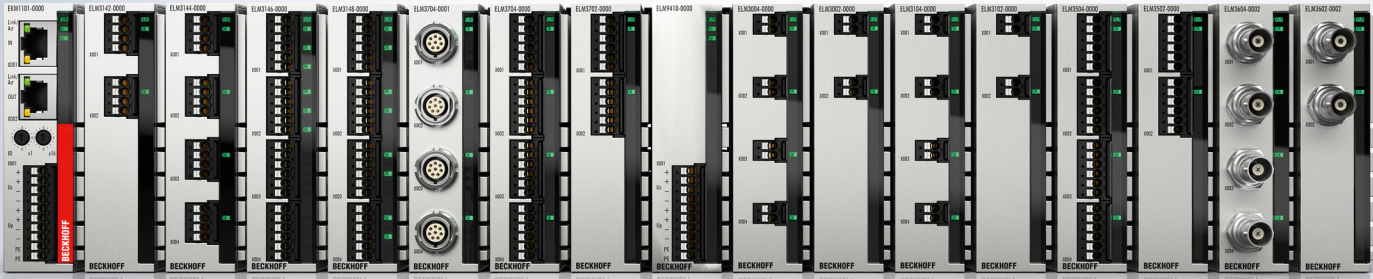


Table of contents

1	Foreword	5
1.1	Notes on the documentation	5
1.2	Safety instructions	6
1.3	Documentation issue status	7
1.4	Version identification of EtherCAT devices	7
1.4.1	General notes on marking	7
1.4.2	Version identification of EK Couplers	8
1.4.3	Version identification of EL terminals	8
1.4.4	Version identification of ELM terminals	8
1.4.5	Beckhoff Identification Code (BIC)	9
1.4.6	Electronic access to the BIC (eBIC)	11
2	Product overview	13
2.1	EKM1101 - Introduction	13
2.2	EKM1101 - Technical data	14
2.3	Notes on markings, approvals and calibration certificates	15
2.3.1	ATEX - Special conditions (standard temperature range)	15
2.3.2	IECEX - Special conditions	16
2.3.3	Continuative documentation for ATEX and IECEX	17
2.3.4	cFMus - Special conditions	17
2.3.5	Continuative documentation for cFMus	18
3	Mounting and wiring	19
3.1	LEDs and connection	19
3.2	Installation positions	20
3.3	Mounting of Passive Terminals	22
3.4	ELM/EKM terminal mounting on DIN rail	23
3.5	Protective earth (PE)	25
3.6	Wiring	27
3.7	Power supply, potential groups	27
3.8	Disposal	29
4	Commissioning/application notes	30
5	Basics communication	31
5.1	System properties	31
5.2	EtherCAT basics	34
5.3	EtherCAT State Machine	34
5.4	CoE - Interface: notes	35
5.5	Distributed Clock	35
6	Appendix	36
6.1	EtherCAT AL Status Codes	36
6.2	Firmware compatibility	36
6.3	Support and Service	36
6.4	Reshipment and return	37

1 Foreword

1.1 Notes on the documentation

Intended audience

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

It is essential that the documentation and the following notes and explanations are followed when installing and commissioning these components.

It is the duty of the technical personnel to use the documentation published at the respective time of each installation and commissioning.

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

Disclaimer

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

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

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

Trademarks

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

Patent Pending

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

The logo for EtherCAT, featuring the word "EtherCAT" in a bold, black, sans-serif font. A red arrow points from the top of the "A" towards the right, ending above the "T". A registered trademark symbol (®) is located to the right of the "T".

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

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1.2 Safety instructions

Safety regulations

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

Exclusion of liability

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

Personnel qualification

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

Description of instructions

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

DANGER

Serious risk of injury!

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

WARNING

Risk of injury!

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

CAUTION

Personal injuries!

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

NOTE

Damage to environment/equipment or data loss

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



Tip or pointer

This symbol indicates information that contributes to better understanding.

1.3 Documentation issue status

Version	Modifications
1.3	- Chapter "Product overview" updated - Subchapter "Version identification of EtherCAT devices" within foreword updated - Subchapter "Disposal" within chapter "Mounting and wiring" added
1.2	- Update Technical data - Update Commissioning/application notes
1.1	- Structure update - Update Technical data
1.0	- 1 st public issue
0.2	- Specifications of technical data updated - Insertion of section "Power supply, potential groups" within chapter "Mounting and wiring" - Connection descriptions updated - Chapter "LEDs and connection" updated
0.1	- First preliminary version

1.4 Version identification of EtherCAT devices

1.4.1 General notes on marking

Designation

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

- family key
- type
- version
- revision

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

Notes

- The elements mentioned above result in the **technical designation**. EL3314-0000-0016 is used in the example below.
- EL3314-0000 is the order identifier, in the case of "-0000" usually abbreviated to EL3314. "-0016" is the EtherCAT revision.
- The **order identifier** is made up of
 - family key (EL, EP, CU, ES, KL, CX, etc.)
 - type (3314)
 - version (-0000)
- The **revision** -0016 shows the technical progress, such as the extension of features with regard to the EtherCAT communication, and is managed by Beckhoff.
In principle, a device with a higher revision can replace a device with a lower revision, unless specified otherwise, e.g. in the documentation.
Associated and synonymous with each revision there is usually a description (ESI, EtherCAT Slave

Information) in the form of an XML file, which is available for download from the Beckhoff web site. From 2014/01 the revision is shown on the outside of the IP20 terminals, see Fig. “EL5021 EL terminal, standard IP20 IO device with batch number and revision ID (since 2014/01)”.

- The type, version and revision are read as decimal numbers, even if they are technically saved in hexadecimal.

1.4.2 Version identification of EK Couplers

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

Structure of the serial number: **KK YY FF HH**

KK - week of production (CW, calendar week)

YY - year of production

FF - firmware version

HH - hardware version

Example with serial number 12 06 3A 02:

12 - production week 12

06 - production year 2006

3A - firmware version 3A

02 - hardware version 02



Fig. 1: EK1101 EtherCAT coupler with revision 0815 and serial number 41130206

1.4.3 Version identification of EL terminals

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**

KK - week of production (CW, calendar week)

YY - year of production

FF - firmware version

HH - hardware version

Example with serial number 12 06 3A 02:

12 - production week 12

06 - production year 2006

3A - firmware version 3A

02 - hardware version 02



Fig. 2: EL2872 with revision 0022 and serial number 01200815

1.4.4 Version identification of ELM terminals

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)
 YY - year of production
 FF - firmware version
 HH - hardware version

12 - production week 12
 06 - production year 2006
 3A - firmware version 3A
 02 - hardware version 02



Fig. 3: ELM3002-0000 with BTN 0000www and unique serial number 09200506

1.4.5 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.

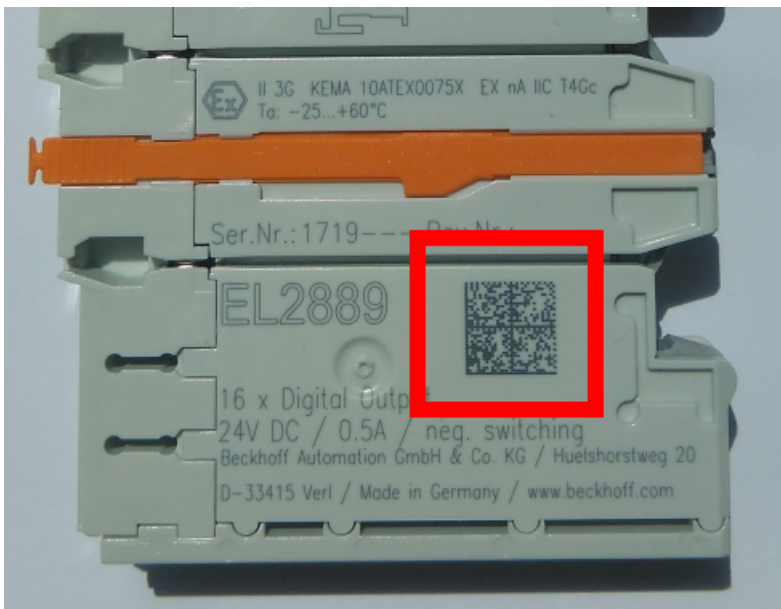


Fig. 4: BIC as data matrix code (DMC, code scheme ECC200)

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

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

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

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

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

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

Position	Type of information	Explanation	Data identifier	Number of digits incl. data identifier	Example
1	Beckhoff order number	Beckhoff order number	1P	8	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	32	30P F971, 2*K183
...					

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

Structure of the BIC

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

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

Accordingly as DMC:



Fig. 5: 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.

NOTE

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

1.4.6 Electronic access to the BIC (eBIC)

Electronic BIC (eBIC)

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

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

K-bus devices (IP20, IP67)

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

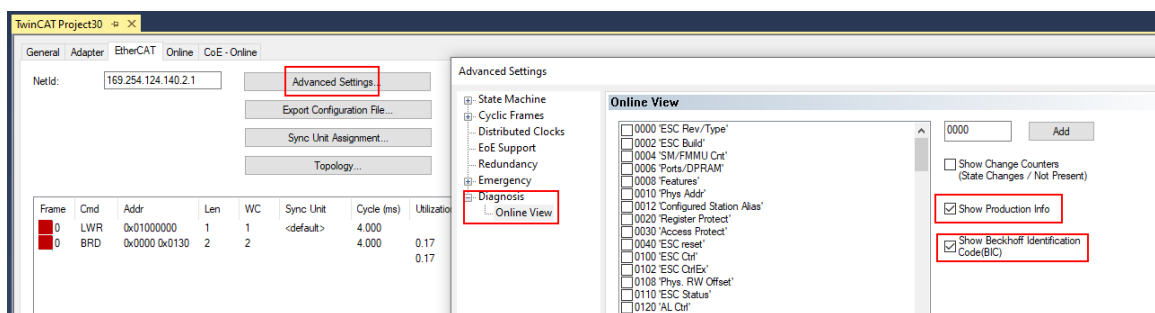
EtherCAT devices (IP20, IP67)

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

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

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

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



- The BTN and its contents are then displayed:

No	Addr	Name	State	CRC	Fw	Hw	Production Data	ItemNo	BTN	Description	Quantity	BatchNo	SerNo
1	1001	Term 1 (EK1100)	OP	0,0	0	0	—						
2	1002	Term 2 (EL1018)	OP	0,0	0	0	2020 KW36 Fr	072222	k4p562d7	EL1809	1		678294
3	1003	Term 3 (EL3204)	OP	0,0	7	6	2012 KW24 Sa						
4	1004	Term 4 (EL2004)	OP	0,0	0	0	—	072223	k4p562d7	EL2004	1		678295
5	1005	Term 5 (EL1008)	OP	0,0	0	0	—						
6	1006	Term 6 (EL2008)	OP	0,0	0	12	2014 KW14 Mo						
7	1007	Term 7 (EK1110)	OP	0	1	8	2012 KW25 Mo						

- Note: as can be seen in the illustration, the production data HW version, FW version and production date, which have been programmed since 2012, can also be displayed with "Show Production Info".

- From TwinCAT 3.1. build 4024.24 the functions *FB_EcReadBIC* and *FB_EcReadBTN* for reading into the PLC and further eBIC auxiliary functions are available in the Tc2_EtherCAT Library from v3.3.19.0.
- In the case of EtherCAT devices with CoE directory, the object 0x10E2:01 can additionally be used to display the device's own eBIC; the PLC can also simply access the information here:
 - The device must be in SAFEOP/OP for access:

Index	Name	Flags	Value
1000	Device type	RO	0x015E1389 (22942601)
1008	Device name	RO	ELM3704-0000
1009	Hardware version	RO	00
100A	Software version	RO	01
100B	Bootloader version	RO	J0.1.27.0
1011:0	Restore default parameters	RO	> 1 <
1018:0	Identity	RO	> 4 <
10E2:0	Manufacturer-specific Identification C...	RO	> 1 <
10E2:01	SubIndex 001	RO	1P158442SBTN0008jekp1KELM3704 Q1 2P482001000016
10F0:0	Backup parameter handling	RO	> 1 <
10F3:0	Diagnosis History	RO	> 21 <
10F8	Actual Time Stamp	RO	0x170fb277e

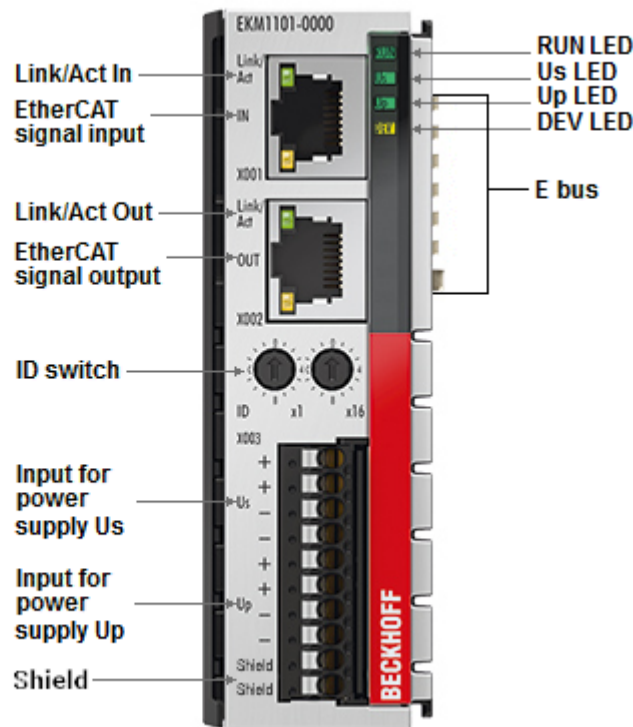
- the object 0x10E2 will be introduced into stock products in the course of a necessary firmware revision.
- From TwinCAT 3.1. build 4024.24 the functions *FB_EcCoEReadBIC* and *FB_EcCoEReadBTN* for reading into the PLC and further eBIC auxiliary functions are available in the Tc2_EtherCAT Library from v3.3.19.0.
- Note: in the case of electronic further processing, the BTN is to be handled as a string(8); the identifier "SBTN" is not part of the BTN.
- Technical background
The new BIC information is additionally written as a category in the ESI-EEPROM during the device production. The structure of the ESI content is largely dictated by the ETG specifications, therefore the additional vendor-specific content is stored with the help of a category according to ETG.2010. ID 03 indicates to all EtherCAT masters that they must not overwrite these data in case of an update or restore the data after an ESI update.
The structure follows the content of the BIC, see there. This results in a memory requirement of approx. 50..200 bytes in the EEPROM.
- Special cases
 - If multiple, hierarchically arranged ESCs are installed in a device, only the top-level ESC carries the eBIC Information.
 - If multiple, non-hierarchically arranged ESCs are installed in a device, all ESCs carry the eBIC Information.
 - If the device consists of several sub-devices with their own identity, but only the top-level device is accessible via EtherCAT, the eBIC of the top-level device is located in the CoE object directory 0x10E2:01 and the eBICs of the sub-devices follow in 0x10E2:nn.

Profibus/Profinet/DeviceNet... Devices

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

2 Product overview

2.1 EKM1101 - Introduction



EKM1101 | EtherCAT Coupler with ID switch and diagnostics

The EKM1101 EtherCAT Coupler connects the ELMxxxx EtherCAT measurement modules or other EL/ES/EMxxxx terminals with EtherCAT. Such a station consists

- of an EKM1101 coupler
- any number of EtherCAT Terminals (observe mounting rail length as well as E bus current!)
- and a bus end cap EL9011 or ELM9011 or an EtherCAT extension such as EK1110 or EK1122.

The coupler converts the passing telegrams from Ethernet 100BASE-TX to E bus signal representation.

On account of three significant properties, the EKM1101 and the functionally identical ELM9410 power supply terminal are designed to meet the needs of high-precision analog measurement technology, e.g. with ELM3xxx terminals:

- To reduce interference by the supply in the connected terminal, both the E-bus supply U_s and the 24 V power contact supply U_p are electrically isolated and filtered in the coupler. The power contact supply can carry a maximum load of 2 A permanently.
- The extensive voltage and temperature monitoring provides assistance with commissioning and operation; results are displayed by LED and in the process image.
- The built-in three-axis position and vibration sensor allows a constant view of the mechanical situation in the control cabinet.

As a result, the EKM1101 can be used in special measuring situations instead of the conventional EK1100 or EK1101 EtherCAT Coupler. Mixed operation with the following terminal EL9410 is possible, but this negates the concept of electrical isolation.

The EKM1101 has two hexadecimal ID switches for assigning an ID to a group of EtherCAT components. This group can then be located at any position within the EtherCAT network and also being removed and inserted again during run time (TwinCAT HotConnect). Variable topologies are therefore easily implementable.

2.2 EKM1101 - Technical data

Technical data		EKM1101
Task within the EtherCAT system/ technology		Coupling and supply of EtherCAT Terminals (ELxxxx, ELMxxxx) to 100BASE-TX EtherCAT networks
Data transfer medium		Ethernet/EtherCAT cable (min. Cat. 5), shielded
Distance between stations		max. 100 m (100BASE-TX)
Number of EtherCAT Terminals		up to 65,534
Type/number of peripheral signals		max. 4.2 GB addressable I/O points
Number of configurable IDs		256 (16 x 16)
Protocol		EtherCAT
Delay		typical 1 μ s
Data transfer rates		100 Mbit/s
Bus interface		2 x RJ45
U _S (E bus)	Permissible supply U _{S, IN}	24 V _{DC} (-15 %/ +20 %) 130 mA + (Σ E bus current/4)
	Measurement uncertainty	typ. ± 0.85 % of 24V (± 0.20 V)
	Technical measuring range	32.2 V
	Output E bus U _{S, OUT}	5V typ. I _{S, OUT} = max. 2000 mA
	Electrical isolation	functional isolation, 500V DC, permanently
U _P (power contacts)	Permissible supply U _{P, OUT}	24 V _{DC} (-15 %/ +20 %) 50 mA + load current
	Measurement uncertainty	typ. ± 0.85 % of 24V (± 0.20 V)
	Technical measuring range	32.2 V
	Output power contacts U _{P, OUT}	typ. 22.5 V as long as U _{P, IN} in permissible range I _{P, OUT} = max. 2000 mA permanent
	Electrical isolation	functional isolation, 500V DC, permanently
Power dissipation		max. 20 W, dependent of the converted electrical power
Special features		electrically isolated output voltages, reverse polarity protection, diagnostics of supply and output voltages, diagnostics of internal temperature, diagnostics of position and vibration
Electrical isolation U _S /U _P /EtherCAT		500 V DC
Weight		approx. 420 g
Permissible ambient temperature range during operation		In standard installation position, at I _{S, OUT} = 2A, without forced ventilation At I _{P, OUT} = 0 A: 0 °C ... +55 °C At I _{P, OUT} < 0.5 A: 0 °C ... +50 °C At I _{P, OUT} < 1.0 A: 0 °C ... +45 °C At I _{P, OUT} < 1.5 A: 0 °C ... +40 °C At I _{P, OUT} < 2.0 A: 0 °C ... +35 °C In all other installation positions the above mentioned max. permissible ambient temperature is reduced by 10 °C Note: the coupler gives a warning if the internal temperature is exceeded, this must be observed. Note: observe the surface temperature of the housing, the device heats up considerably
Permissible ambient temperature range during storage		-25 °C ... +85 °C
Permissible relative humidity		95 %, no condensation
Mounting		on 35 mm mounting rail conforms to EN 60715
Vibration/shock resistance		conforms to EN 60068-2-6/EN 60068-2-27
EMC immunity/emission		conforms to EN 61000-6-2 / EN 61000-6-4
Protection class		IP20
Installation position		variable
Approval ^{*)}		CE, UKCA, ATEX [▶ 15], IECEx [▶ 16], cFMus [▶ 17]

Ex markings

Standard	Marking
ATEX	II 3 G Ex nA IIC T4 Gc
IECEX	Ex nA IIC T4 Gc
cFMus	Class I, Division 2, Groups A, B, C, D Class I, Zone 2, AEx/Ex ec IIC T4 Gc

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

2.3 Notes on markings, approvals and calibration certificates

2.3.1 ATEX - Special conditions (standard temperature range)

⚠ WARNING

Observe the special conditions for the intended use of Beckhoff fieldbus components with standard temperature range in potentially explosive areas (directive 2014/34/EU)!

- The certified components are to be installed in a suitable housing that guarantees a protection class of at least IP54 in accordance with EN 60079-15! The environmental conditions during use are thereby to be taken into account!
- For dust (only the fieldbus components of certificate no. KEMA 10ATEX0075 X Issue 9): The equipment shall be installed in a suitable enclosure providing a degree of protection of IP54 according to EN 60079-31 for group IIIA or IIIB and IP6X for group IIIC, taking into account the environmental conditions under which the equipment is used!
- If the temperatures during rated operation are higher than 70°C at the feed-in points of cables, lines or pipes, or higher than 80°C at the wire branching points, then cables must be selected whose temperature data correspond to the actual measured temperature values!
- Observe the permissible ambient temperature range of 0 to 55°C for the use of Beckhoff fieldbus components standard temperature range in potentially explosive areas!
- Measures must be taken to protect against the rated operating voltage being exceeded by more than 40% due to short-term interference voltages!
- The individual terminals may only be unplugged or removed from the Bus Terminal system if the supply voltage has been switched off or if a non-explosive atmosphere is ensured!
- The connections of the certified components may only be connected or disconnected if the supply voltage has been switched off or if a non-explosive atmosphere is ensured!
- The fuses of the KL92xx/EL92xx power feed terminals may only be exchanged if the supply voltage has been switched off or if a non-explosive atmosphere is ensured!
- Address selectors and ID switches may only be adjusted if the supply voltage has been switched off or if a non-explosive atmosphere is ensured!

Standards

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

- EN 60079-0:2012+A11:2013
- EN 60079-15:2010
- EN 60079-31:2013 (only for certificate no. KEMA 10ATEX0075 X Issue 9)

Marking

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



II 3G KEMA 10ATEX0075 X Ex nA IIC T4 Gc Ta: 0 ... +55°C

II 3D KEMA 10ATEX0075 X Ex tc IIIC T135°C Dc Ta: 0 ... +55°C
(only for fieldbus components of certificate no. KEMA 10ATEX0075 X Issue 9)

or



II 3G KEMA 10ATEX0075 X Ex nA nC IIC T4 Gc Ta: 0 ... +55°C

II 3D KEMA 10ATEX0075 X Ex tc IIIC T135°C Dc Ta: 0 ... +55°C
(only for fieldbus components of certificate no. KEMA 10ATEX0075 X Issue 9)

2.3.2 IECEx - Special conditions

⚠ WARNING

Observe the special conditions for the intended use of Beckhoff fieldbus components in potentially explosive areas!

- For gas: The equipment shall be installed in a suitable enclosure providing a degree of protection of IP54 according to IEC 60079-15, taking into account the environmental conditions under which the equipment is used!
- For dust (only the fieldbus components of certificate no. IECEx DEK 16.0078X Issue 3):
The equipment shall be installed in a suitable enclosure providing a degree of protection of IP54 according to EN 60079-31 for group IIIA or IIIB and IP6X for group IIIC, taking into account the environmental conditions under which the equipment is used!
- The equipment shall only be used in an area of at least pollution degree 2, as defined in IEC 60664-1!
- Provisions shall be made to prevent the rated voltage from being exceeded by transient disturbances of more than 119 V!
- If the temperatures during rated operation are higher than 70°C at the feed-in points of cables, lines or pipes, or higher than 80°C at the wire branching points, then cables must be selected whose temperature data correspond to the actual measured temperature values!
- Observe the permissible ambient temperature range for the use of Beckhoff fieldbus components in potentially explosive areas!
- The individual terminals may only be unplugged or removed from the Bus Terminal system if the supply voltage has been switched off or if a non-explosive atmosphere is ensured!
- The connections of the certified components may only be connected or disconnected if the supply voltage has been switched off or if a non-explosive atmosphere is ensured!
- Address selectors and ID switches may only be adjusted if the supply voltage has been switched off or if a non-explosive atmosphere is ensured!
- The front hatch of certified units may only be opened if the supply voltage has been switched off or a non-explosive atmosphere is ensured!

Standards

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

- EN 60079-0:2011
- EN 60079-15:2010
- EN 60079-31:2013 (only for certificate no. IECEx DEK 16.0078X Issue 3)

Marking

Beckhoff fieldbus components that are certified in accordance with IECEx for use in areas subject to an explosion hazard bear the following markings:

Marking for fieldbus components of certificate no. IECEx DEK 16.0078X Issue 3:	IECEx DEK 16.0078 X Ex nA IIC T4 Gc
--	--

Ex tc IIIC T135°C Dc

Marking for fieldbus components of certificates with later issues:

IECEX DEK 16.0078 X

Ex nA IIC T4 Gc

2.3.3 Continuative documentation for ATEX and IECEx

NOTE



Continuative documentation about explosion protection according to ATEX and IECEx

Pay also attention to the continuative documentation

Ex. Protection for Terminal Systems

Notes on the use of the Beckhoff terminal systems in hazardous areas according to ATEX and IECEx,

that is available for [download](#) within the download area of your product on the Beckhoff homepage www.beckhoff.com!

2.3.4 cFMus - Special conditions

⚠ WARNING

Observe the special conditions for the intended use of Beckhoff fieldbus components in potentially explosive areas!

- The equipment shall be installed within an enclosure that provides a minimum ingress protection of IP54 in accordance with ANSI/UL 60079-0 (US) or CSA C22.2 No. 60079-0 (Canada).
- The equipment shall only be used in an area of at least pollution degree 2, as defined in IEC 60664-1.
- Transient protection shall be provided that is set at a level not exceeding 140% of the peak rated voltage value at the supply terminals to the equipment.
- The circuits shall be limited to overvoltage Category II as defined in IEC 60664-1.
- The Fieldbus Components may only be removed or inserted when the system supply and the field supply are switched off, or when the location is known to be non-hazardous.
- The Fieldbus Components may only be disconnected or connected when the system supply is switched off, or when the location is known to be non-hazardous.

Standards

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

M20US0111X (US):

- FM Class 3600:2018
- FM Class 3611:2018
- FM Class 3810:2018
- ANSI/UL 121201:2019
- ANSI/ISA 61010-1:2012
- ANSI/UL 60079-0:2020
- ANSI/UL 60079-7:2017

FM20CA0053X (Canada):

- CAN/CSA C22.2 No. 213-17:2017
- CSA C22.2 No. 60079-0:2019
- CAN/CSA C22.2 No. 60079-7:2016

- CAN/CSA C22.2 No.61010-1:2012

Marking

Beckhoff fieldbus components that are certified in accordance with cFMus for use in areas subject to an explosion hazard bear the following markings:

FM20US0111X (US): **Class I, Division 2, Groups A, B, C, D**
 Class I, Zone 2, AEx ec IIC T4 Gc

FM20CA0053X (Canada): **Class I, Division 2, Groups A, B, C, D**
 Ex ec T4 Gc

2.3.5 Continuitive documentation for cFMus

NOTE



Continuitive documentation about explosion protection according to cFMus

Pay also attention to the continuative documentation

Control Drawing I/O, CX, CPX

Connection diagrams and Ex markings,

that is available for [download](#) within the download area of your product on the Beckhoff homepage www.beckhoff.com!

3 Mounting and wiring

3.1 LEDs and connection

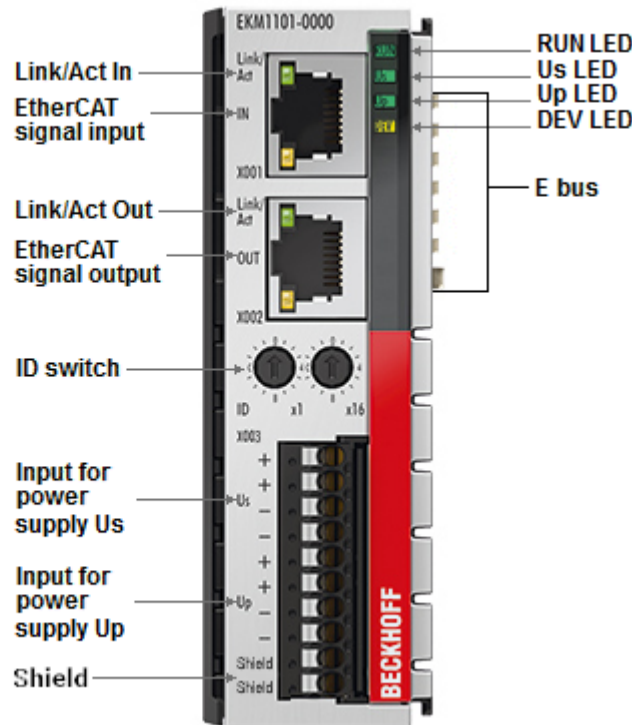


Fig. 6: Diagnostic LEDs EKM1101

EtherCAT Status RUN

LED	Display	State	Description
RUN	green	off	Init The bus coupler is in initialization state
		flashing	Pre-Operational The bus coupler is in <i>pre operational</i> state
		single flash	Safe-Operational The bus coupler is in <i>safe operational</i> state
		on	Operational The bus coupler is in <i>operational</i> state
		flickers	Bootstrap A new firmware will be loaded
Us		off	No 24 V _{DC} operating voltage for U _s available on bus coupler
		green	Incoming 24 V _{DC} operating voltage for U _s available on the bus coupler within the permissible range
		red	Under voltage approx. < 20.3 V Under voltage approx. > 28.8 V (simultaneously PDO Error = TRUE)
Up		off	No 24 V _{DC} operating voltage for U _p available on bus coupler
		green	Incoming 24 V _{DC} operating voltage for U _p available on the bus coupler within the permissible range and outgoing U _p on power contacts OK
		red	Incoming 24 V _{DC} operating voltage for U _p or outgoing U _p on power contacts: Under voltage approx. < 20.3 V Under voltage approx. > 28.8 V (simultaneously PDO Error = TRUE)
DEV		off	Normal operation
		yellow	Over temperature within device > 85°C Position sensor error

EtherCAT Link LEDs (EKM1101 only)

LED	Display	State	Description
LINK/ACT (X001 IN)	green	off	No connection on the incoming EtherCAT strand
		on	Preceding EtherCAT device connected
		flashing	Communication with preceding EtherCAT device
LINK/ACT (X002 OUT)	green	off	No connection on the outgoing EtherCAT strand
		on	Following EtherCAT device connected
		flashing	Communication with following EtherCAT device

Connection EKM1101, ELM9410

EKM1101: Terminal point X003 ELM9410: Terminal point X001		Description
Indication	No.	
+U _s	1, 2	Supply input + 24 V for U _s (E Bus; terminal no. 1 and 2 internal connected)
-U _s	3, 4	Supply input 0 V for U _s (E Bus; terminal no. 3 and 4 internal connected)
+U _p	5, 6	Supply input + 24 V for U _p (Power contacts; terminal no. 5 and 6 internal connected)
-U _p	7, 8	Supply input 0 V for U _p (Power contacts; terminal no. 7 and 8 internal connected)
Shield	9, 10	Grounding connector to DIN rail or rather housing (terminal no. 9 and 10 internal connected) Note: PE accessible under cover as screw connection

3.2 Installation positions

NOTE**Constraints regarding installation position and operating temperature range**

Please refer to the technical data for a terminal to ascertain whether any restrictions regarding the installation position and/or the operating temperature range have been specified. When installing high power dissipation terminals ensure that an adequate spacing is maintained between other components above and below the terminal in order to guarantee adequate ventilation!

Optimum installation position (standard)

The optimum installation position requires the mounting rail to be installed horizontally and the connection surfaces of the EL/KL terminals to face forward (see Fig. "Recommended distances for standard installation position"). The terminals are ventilated from below, which enables optimum cooling of the electronics through convection. "From below" is relative to the acceleration of gravity.

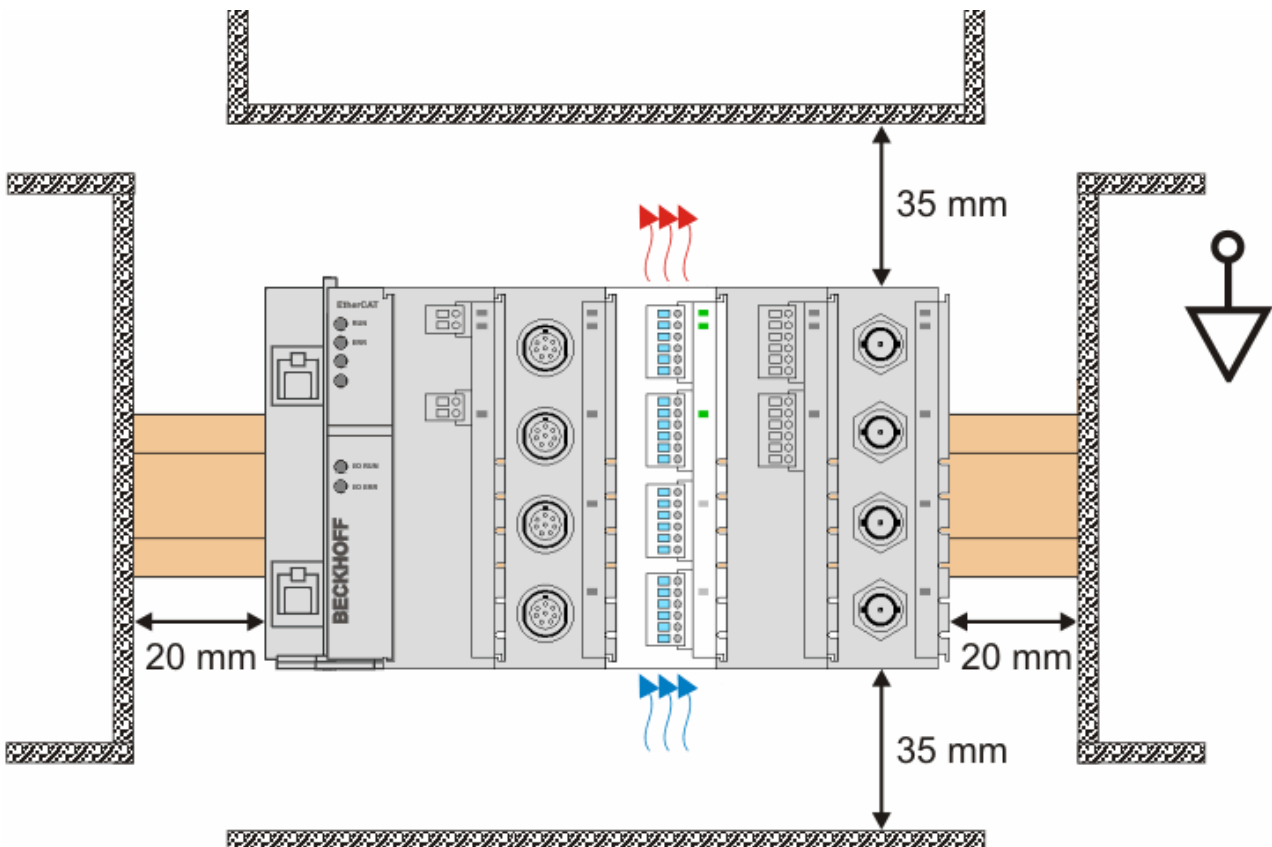


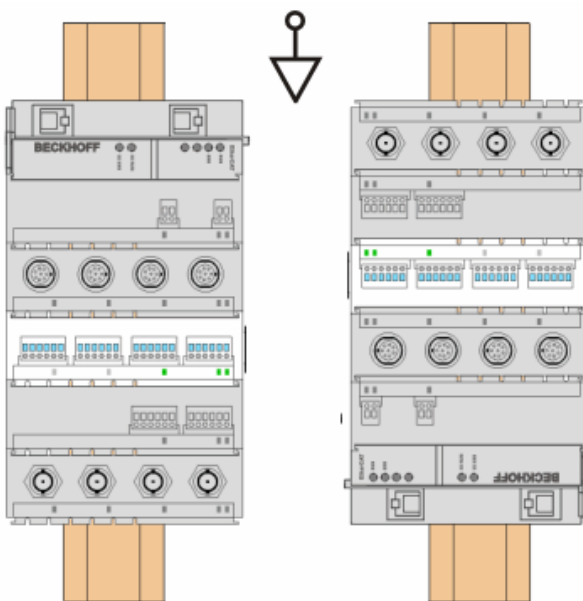
Fig. 7: Recommended distances for standard installation position

Compliance with the distances shown in Fig. “Recommended distances for standard installation position” is recommended.

Other installation positions

All other installation positions are characterized by different spatial arrangement of the mounting rail - see Fig “Other installation positions”.

The minimum distances to ambient specified above also apply to these installation positions.



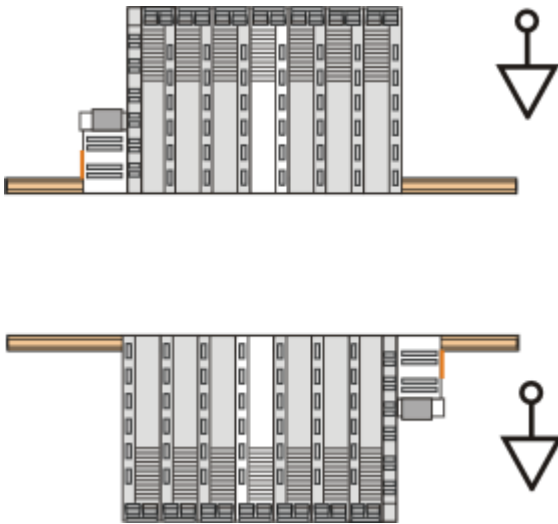


Fig. 8: Other installation positions

3.3 Mounting of Passive Terminals

Hint for mounting passive terminals

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

Examples for mounting passive terminals (highlighted)

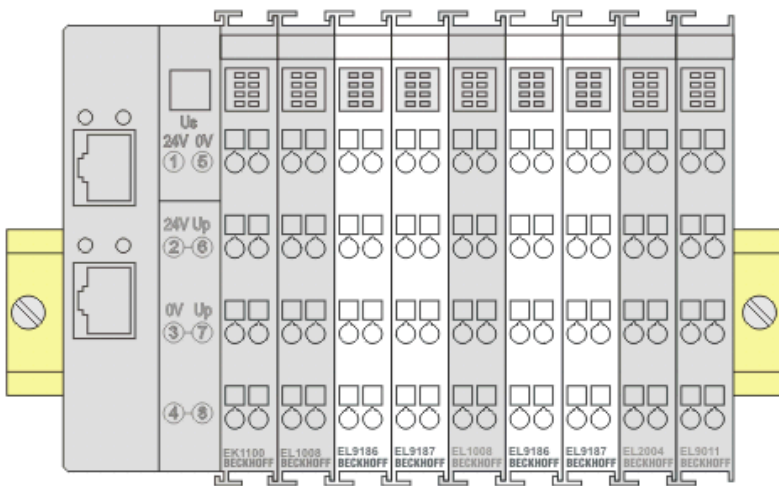


Fig. 9: Correct configuration

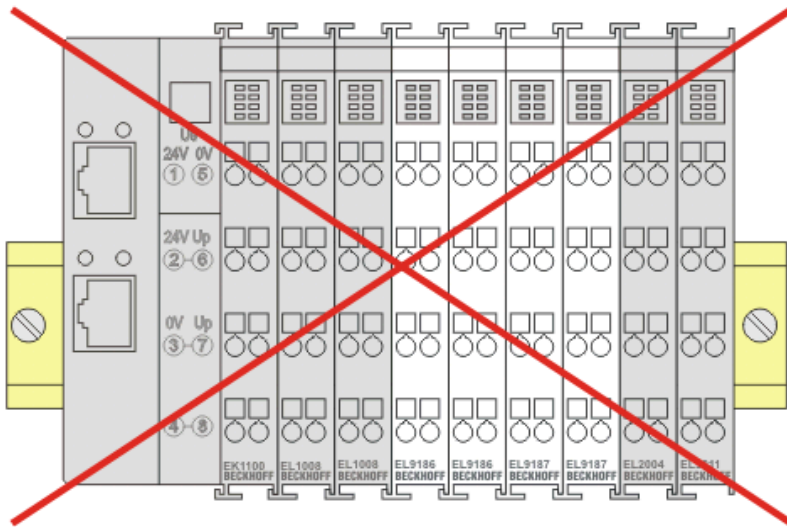


Fig. 10: *Incorrect configuration*

3.4 ELM/EKM terminal mounting on DIN rail

⚠ WARNING

Risk of electric shock and damage of device!

Bring the bus terminal system into a safe, powered down state before starting installation, disassembly or wiring of the bus terminals!

Assembly

The ELM terminals are locked to commercially available 35 mm mounting rails (DIN rails according to EN 60715) as following described:

- The ELM terminal can easily be latched onto the DIN rail. Therefore the clips of the terminal on top and down side have to be opened first:

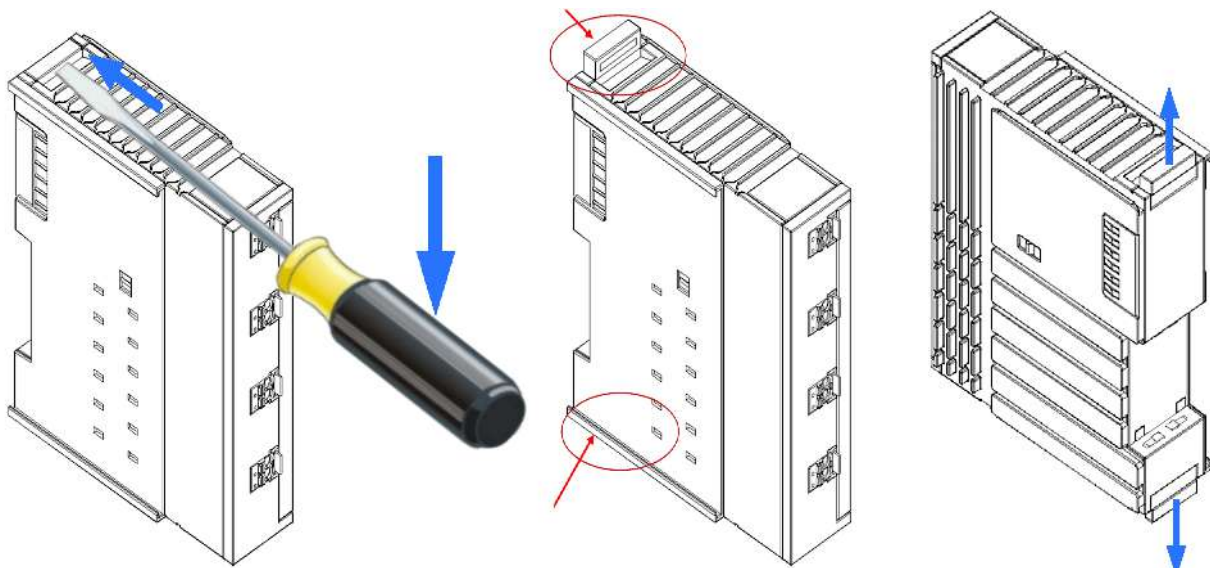


Fig. 11: Opening the clips on top and down side by lifting them e.g. with a screw driver

- Insert the ELM terminal to other already on the DIN rail arranged moduls together with tongue and groove and push the terminals against the mounting rail, until it clicks onto the touchdown point of the mounting rail. Then close the both clips on top and down side of the terminal respectively:

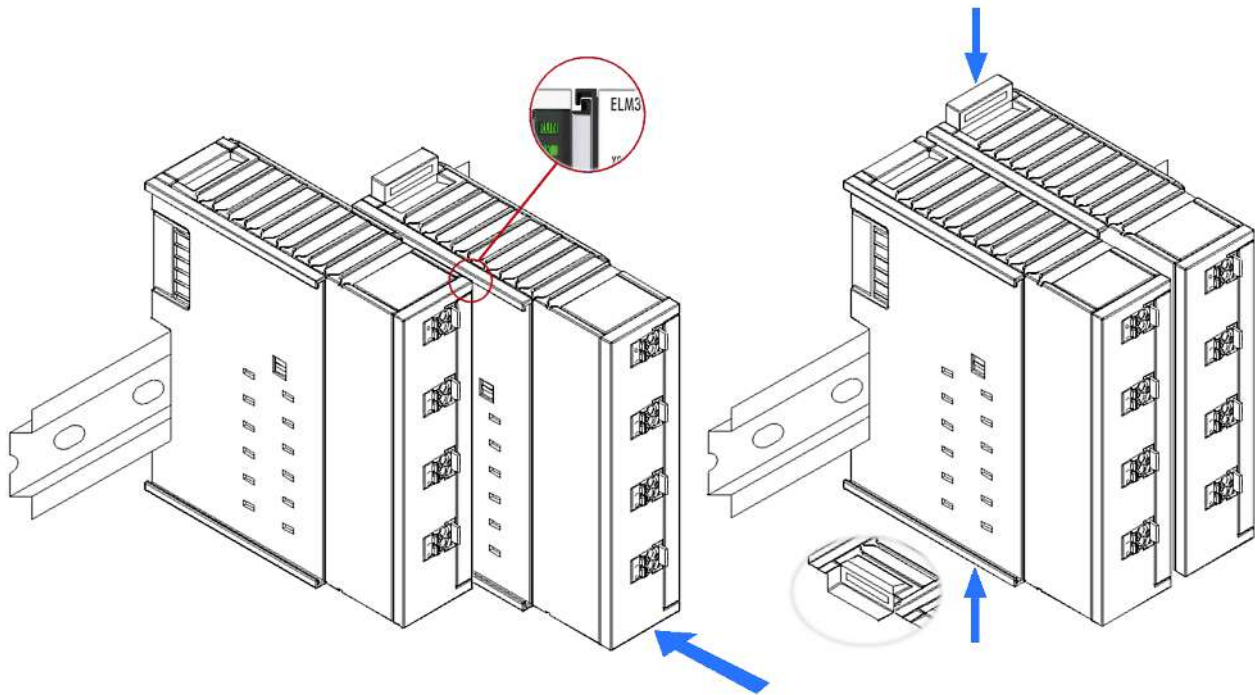
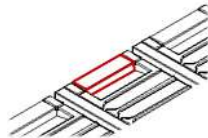


Fig. 12: Push-in of the ELM terminal and closing the mounting rail clips top and down

- During closing of the both clips there mustn't be a disruptive mechanical resistance being noticeable. The clips have to be snapped so that they're ending flat with the housing:



Attention: If the ELM terminal is clipped onto the mounting rail first and then pushed together without tongue and groove, the connection will not be operational! When correctly assembled, no significant gap should be visible between the housings.

Disassembly

Each ELM terminal is secured by a lock on the mounting rail, which must be released for disassembly. The procedure for demounting have to be done in *reverse* order as described in [Assembly \[► 23\]](#):

1. Release the mounting rail lock of the ELM terminal on the top and down side and you can pull the terminal out of the bus terminal block easily without excessive force.
2. Grasp the released terminal with thumb and index finger simultaneous at the upper and lower grooved housing surfaces and pull the terminal out of the bus terminal block.

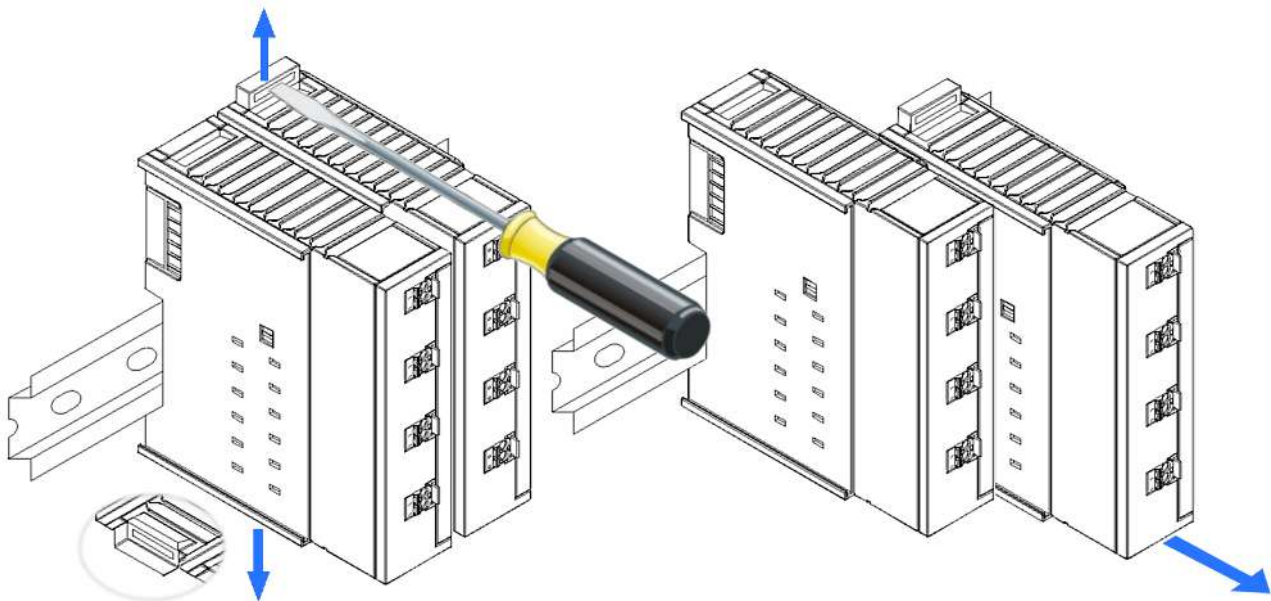


Fig. 13: Opening of the upper and lower mounting rail lock and pull out the ELM terminal module

Connections within a bus terminal block

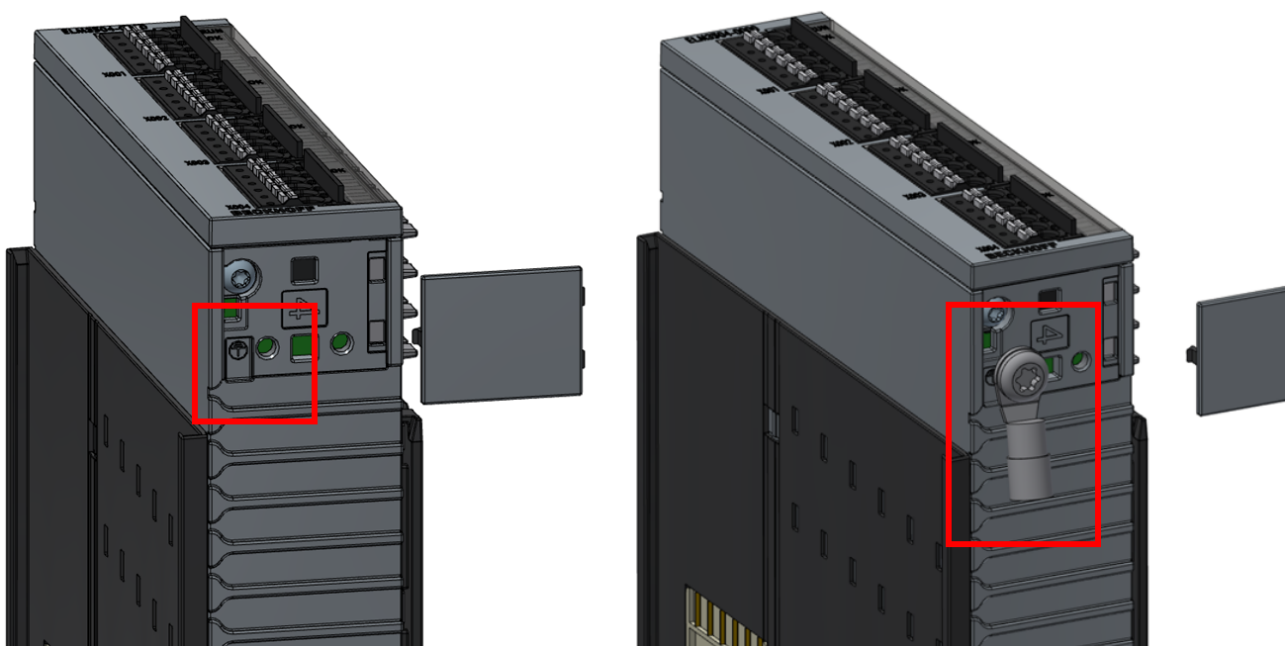
The electric connections between the Bus Coupler and the Bus Terminals are automatically realized by joining the components: The six spring contacts of the K-Bus/E-Bus deal with the transfer of the data and the supply of the Bus Terminal electronics.

3.5 Protective earth (PE)

The housings of the ELM/EKM series are made of die-cast zinc and are thus metallic. This results in a need for clarification regarding the use of protective earthing against the risk of electric shock.

Attention: The relevant application standards refer to the surrounding control cabinet/control box as "housing", whereas this documentation refers to the Beckhoff terminal as "housing".

See also chapter "Notes regarding analog equipment - shielding and earth" in this documentation.



The housing offers the option of an M3 bolted connection for connecting a ring terminal to PE.

The procedure for this is as follows:

- Lever off the plastic cover from the ELM housing and retain it for later reuse, if required
- Secure the previously prepared ring terminal, which was crimped to the protective conductor, using an M3x4 screw; max. torque 0.5 Nm. Use a suitable tool.
ATTENTION: The screw must not be longer than specified, in order to avoid it protruding into the interior, where it could cause damage. This would be evident if the unit is sent in for repair.
- Connect the PE cable to the protective conductor system.

Notes on whether a PE connection is necessary in the specific application

- A PE connection is required if the terminal could pose a risk of electric shock due to an inadmissible contact voltage. A distinction is made between two causes:
 - if the terminal is subjected to high internal voltages (not SELV/PELV), this high voltage may reach the housing in the event of a fault. For such terminals, a PE connection is essential. See the corresponding mechanical options at the module. For background information please refer to product and device standards such as EN 61010.
Note: The terminals of type ELM3004, ELM3002, ELM3104, ELM3102, ELM3504, ELM3502, ELM3604, ELM3602, ELM3704, ELM3702 operate with low voltage SELV/PELV, so that there is usually no potential risk.
 - A connection to the protective earth conductor system must nevertheless be provided if the terminal operates with protective extra-low voltage (SELV/PELV), but there is a risk that a live conductor may come into contact with the housing in the event of a fault, resulting in unacceptable touch voltage. This is stipulated by application standards such as EN60204-1 or EN61439-1 relating to control cabinet design.
- It is therefore always necessary to check in which environment the application is used to ascertain whether a PE connection is required.

Note on protective earth (PE) with regard to analog measurements

The protective earth conductor system is specifically designed for discharging high currents. This may result in significant high-frequency interference, which could adversely affect an analog measuring device if it is/has to be connected to the protective conductor system. In such cases, a strictly star-shaped configuration of the FE and PE systems may be advisable, in order to have as few interference sources as possible on the PE system that are close to the analog measuring system. Ideally, no PE connection should be used at all. However, in this case the installation must comply with the two conditions referred to above, which may necessitate splitting the system into a high-voltage and a low-voltage control cabinet, so that no PE would be required for the latter.

3.6 Wiring

The two 4- and 6-pole connectors support the push-in wiring of individual wires and fine-wire conductors with wire-end sleeves.

In the case of multi-wire and fine-wire conductors, the latch must be depressed to connect the conductor with the contact point.

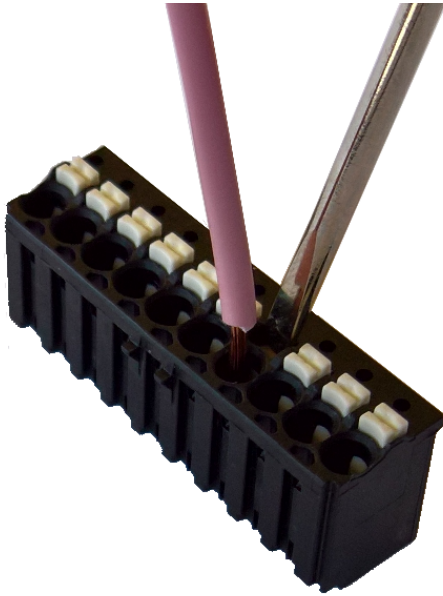


Fig. 14: Depressing the latch for push-in wiring

Depress the latch with a screwdriver, insert the conductor and release the latch.

3.7 Power supply, potential groups

Bus Coupler power supply U_s

The EKM1101 Bus Coupler and the ELM9410 Power Feed Terminal require a voltage of 24 V DC for operation. They are connected via the upper 4-pin connector with the designation + and -. The supply voltage is used by the electronics of the Bus Coupler as well as for the voltage generation for the E-bus.

The voltage generation for the E-bus takes place in a DC/DC converter without electrical isolation. The E-bus is supplied with a maximum of 2,000 mA E-bus current. Power feed terminals, e.g. ELM9410, are to be inserted if the appended terminals require more current.

The fuse should have a rating of max. 1 A, depending on the required current consumption of the configured terminals.

Power contact power supply U_p

The 4 connectors below that in the lower 6-pin connector with the designations + and - are to be used for the power supply to the periphery if this is needed. These feed the outgoing power contacts +/-.

The voltage for the power contacts is generated in a DC/DC converter with electrical isolation. The power contacts are supplied with a maximum of 2,000 mA. Power feed terminals, e.g. ELM9410, are to be inserted if the appended terminals require more current.

The EKM1101/ELM9410 devices re-condition the power contact supply with electrical isolation so that the downstream terminals are supplied with a stable, smoothed and monitored voltage.

The fuse should have a rating of max. 4 A, depending on the required current consumption and thus on the configured terminals.

Power contacts

The two spring contacts of the power contact connections +/- are located on the right-hand lateral surface of the Bus Coupler. The spring contacts are hidden in slots so that they can not be accidentally touched. By attaching a Bus Terminal the blade contacts on the left hand side of the Bus Terminal are connected to the spring contacts. The tongue and groove guides on the top and bottom of the Bus Coupler and of the Bus Terminals guarantees that the power contacts mate securely. The current load on the power contacts must not permanently exceed 10 A; since the output current is limited to 2 A on the part of EKM1101/ELM9410, this value is not usually exceeded.

Electrical isolation

The EKM1101/ELM9410 devices operate with three independent potential groups.

Note: All Bus Terminals feature electrical isolation from the field side to the E-bus. The E-bus is thus electrically isolated from everything else.

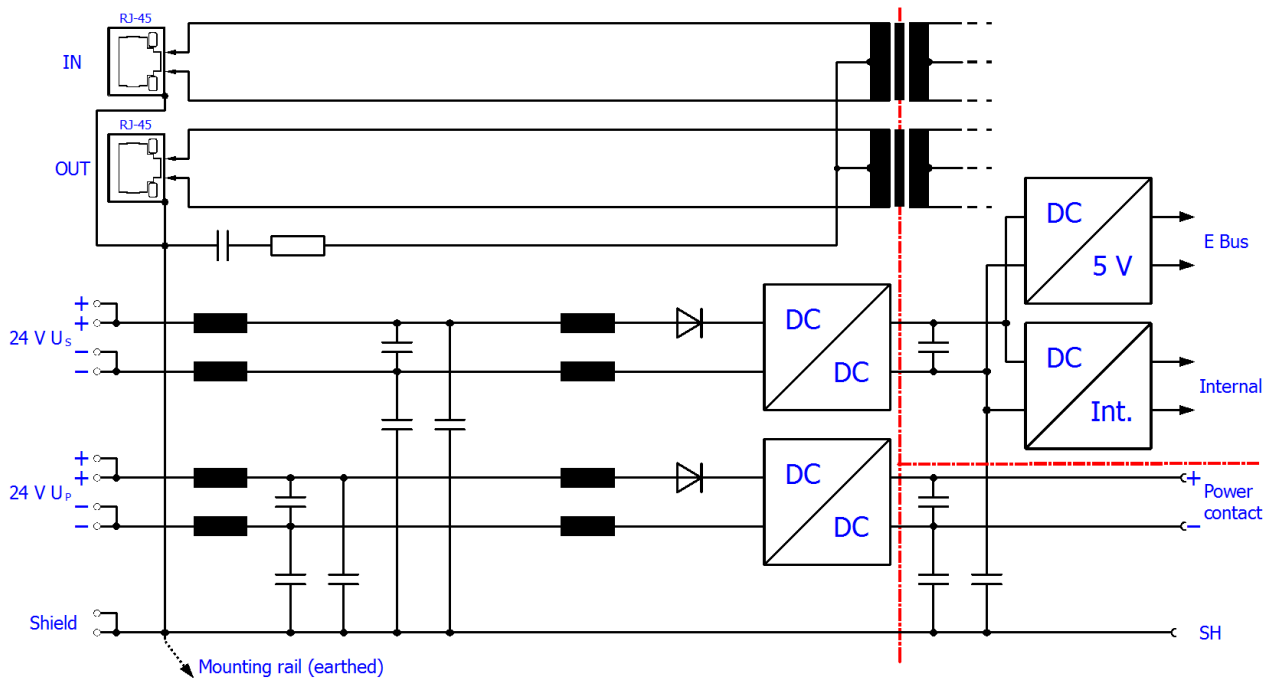


Fig. 15: Internal wiring EKM1101 (principle/simplified)

3.8 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.

4 Commissioning/application notes

More detailed information on the configuration settings can be found in the [EtherCAT System Documentation](#) on the Beckhoff website.

Further product specific information follows.

5 Basics communication

5.1 System properties

Protocol

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

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

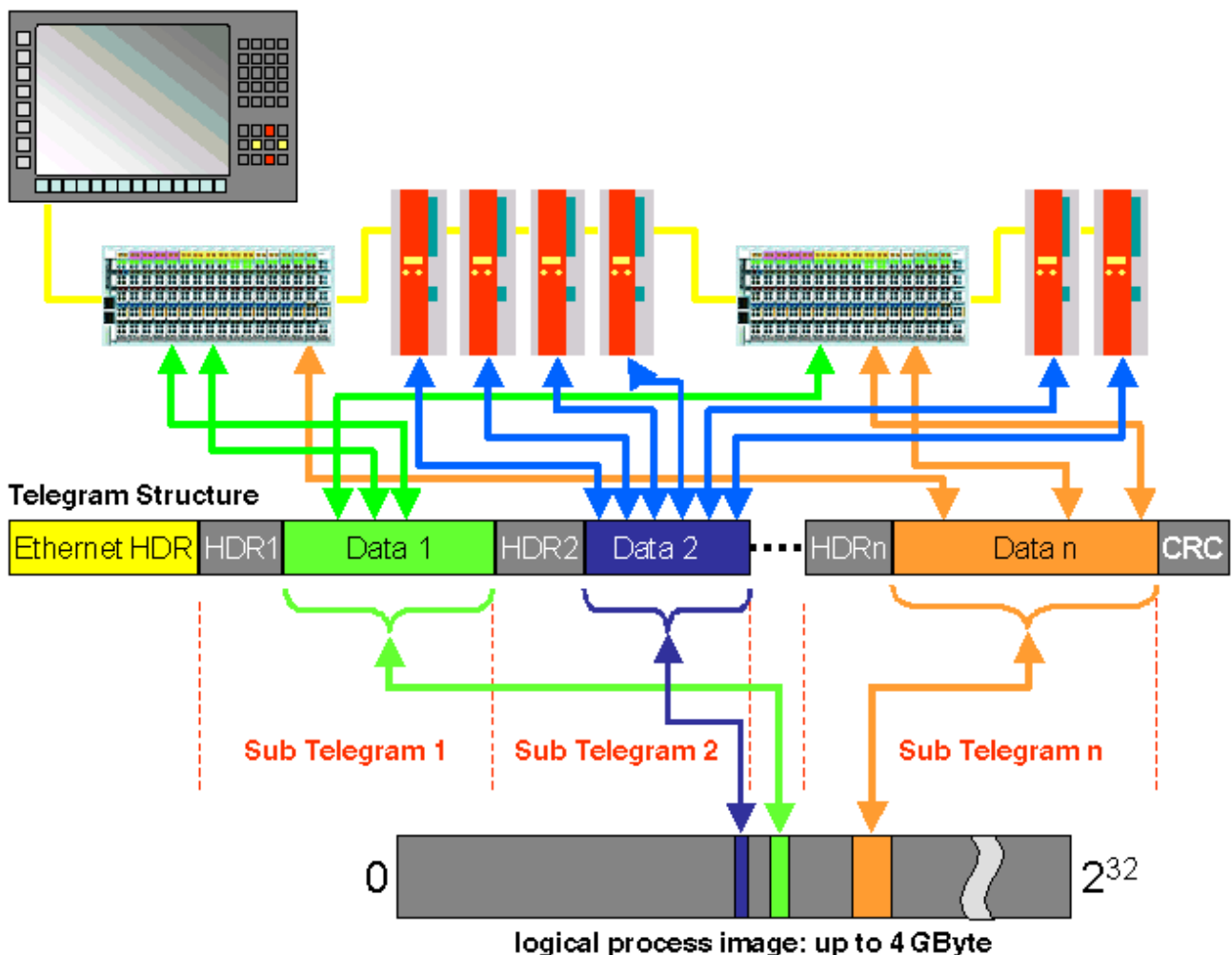


Fig. 16: EtherCAT Telegram Structure

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

Topology

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

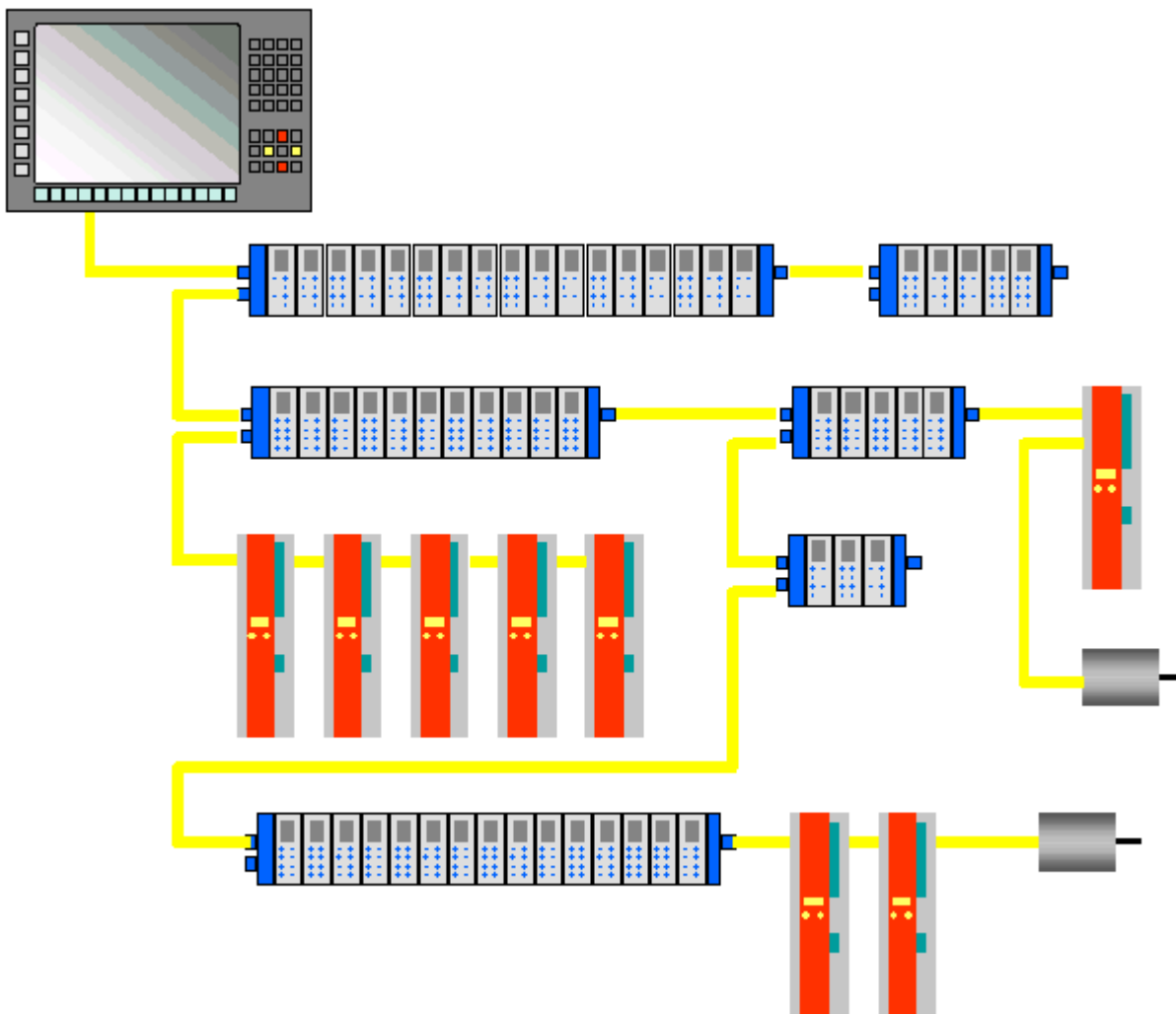


Fig. 17: EtherCAT Topology

Maximum wiring flexibility:

with or without switch, line or tree topologies, can be freely selected and combined.

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

Distributed Clocks

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

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

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

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

Performance

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

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

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

Diagnostics

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

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

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

Integration of standard Bus Terminals from Beckhoff

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

5.2 EtherCAT basics

Please refer to the [EtherCAT System Documentation](#) for the EtherCAT fieldbus basics.

5.3 EtherCAT State Machine

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

A distinction is made between the following states:

- Init
- Pre-Operational
- Safe-Operational and
- Operational
- Boot

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

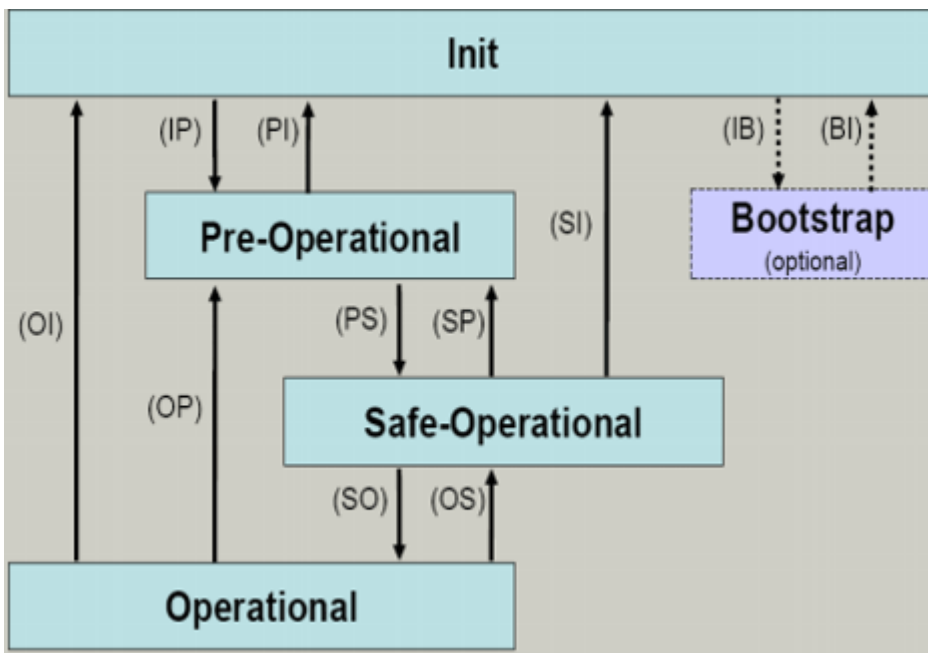


Fig. 18: States of the EtherCAT State Machine

Init

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

Pre-Operational (Pre-Op)

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

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

Safe-Operational (Safe-Op)

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

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

● Outputs in SAFEOP state

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

Operational (Op)

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

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

Boot

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

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

5.4 CoE - Interface: notes

This device has no CoE.

Detailed information on the CoE interface can be found in the [EtherCAT system documentation](#) on the Beckhoff website.

5.5 Distributed Clock

The distributed clock represents a local clock in the EtherCAT slave controller (ESC) with the following characteristics:

- Unit *1 ns*
- Zero point *1.1.2000 00:00*
- Size *64 bit* (sufficient for the next 584 years; however, some EtherCAT slaves only offer 32-bit support, i.e. the variable overflows after approx. 4.2 seconds)
- The EtherCAT master automatically synchronizes the local clock with the master clock in the EtherCAT bus with a precision of < 100 ns.

For detailed information please refer to the [EtherCAT system description](#).

6 Appendix

6.1 EtherCAT AL Status Codes

For detailed information please refer to the [EtherCAT system description](#).

6.2 Firmware compatibility

The EKM1101 has no firmware.

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: <https://www.beckhoff.com>

You will also find further documentation for Beckhoff components there.

Beckhoff Support

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

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

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e-mail: support@beckhoff.com

Beckhoff Service

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

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

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web: <https://www.beckhoff.com>

6.4 Reshipment and return

This product is individually packed and sealed. Unless otherwise agreed, Beckhoff can only accept returns in unopened original packaging with the seal intact.

List of illustrations

Fig. 1	EK1101 EtherCAT coupler with revision 0815 and serial number 41130206	8
Fig. 2	EL2872 with revision 0022 and serial number 01200815	8
Fig. 3	ELM3002-0000 with BTN 0000www and unique serial number 09200506	9
Fig. 4	BIC as data matrix code (DMC, code scheme ECC200)	9
Fig. 5	Example DMC 1P072222SBTNk4p562d71KEL1809 Q1 51S678294	10
Fig. 6	Diagnostic LEDs EKM1101	19
Fig. 7	Recommended distances for standard installation position	21
Fig. 8	Other installation positions	22
Fig. 9	Correct configuration	22
Fig. 10	Incorrect configuration	23
Fig. 11	Opening the clips on top and down side by lifting them e.g. with a screw driver	23
Fig. 12	Push-in of the ELM terminal and closing the mounting rail clips top and down	24
Fig. 13	Opening of the upper and lower mounting rail lock and pull out the ELM terminal module	25
Fig. 14	Depressing the latch for push-in wiring	27
Fig. 15	Internal wiring EKM1101 (principle/simplified)	28
Fig. 16	EtherCAT Telegram Structure	31
Fig. 17	EtherCAT Topology	32
Fig. 18	States of the EtherCAT State Machine	34

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