

Documentation | EN

BK1120, BK1150, BK1250

EtherCAT Bus Coupler for K-Bus Terminals



Table of contents

1	Foreword	5
1.1	Notes on the documentation	5
1.2	Safety instructions	6
1.3	Documentation issue status	7
2	Product overview	8
2.1	Introduction	8
2.2	Technical data	10
3	Basic principles	11
3.1	System properties	11
3.2	The Beckhoff Bus Terminal system	14
3.3	CoE Interface	15
3.4	EtherCAT State Machine	20
4	Mounting and wiring	22
4.1	Instructions for ESD protection	22
4.2	Mounting	23
4.2.1	Installation on mounting rails.....	23
4.2.2	Installation instructions for enhanced mechanical load capacity.....	26
4.2.3	Disposal	26
4.2.4	Installation positions.....	27
4.3	Wiring	29
4.3.1	BK1120 and BK1150 - Contact assignment.....	29
4.3.2	BK1250 - Contact assignment	30
4.3.3	Power supply, potential groups	30
4.3.4	Ethernet cable	31
4.3.5	EtherCAT wiring	33
4.4	ATEX - Special conditions (extended temperature range).....	34
4.5	Continuative documentation for ATEX and IECEx	35
4.6	UL notice	35
5	Parameterization and commissioning	36
5.1	Start-up behavior of the Bus Coupler.....	36
5.2	EKxxxx - Optional Distributed Clocks support.....	36
5.3	KL register communication.....	38
5.3.1	Parameterization of K-bus terminals.....	38
5.3.2	Configuration of KL terminals via EtherCAT	40
5.3.3	Online parameterization of KL terminals via CoE	43
5.3.4	Online parameterization of KL terminals via AoE.....	45
5.3.5	Beckhoff coupler tables.....	46
5.4	TwinCAT System Manager	48
5.4.1	BK1120, BK1150 - configuration overview.....	48
5.4.2	BK1250 - configuration overview	49
5.4.3	Inputs - configuration overview	50
5.4.4	Outputs - configuration overview.....	50
5.4.5	Status of the working counter (Wc state) - configuration overview	51

5.4.6	Online status (info data) - configuration overview	52
5.4.7	ADS address (ADSAddr) - configuration overview.....	53
5.4.8	EtherCAT cycle time - configuration overview	54
5.4.9	Object description	54
5.4.10	Mapping the Bus Terminals	64
5.4.11	Process image example.....	65
5.5	KS2000 Configuration Software	66
5.5.1	Example: Parameterization with the KS2000 configuration software.....	66
5.5.2	Sample program for register communication via EtherCAT on KL3314 exemplary.....	69
6	Error handling and diagnosis	72
6.1	LEDs	72
6.2	Error messages to the EtherCAT master	75
7	Appendix	76
7.1	General operating conditions	76
7.2	Test standards for device testing	76
7.3	Firmware compatibility	77
7.4	Version identification of EtherCAT devices	78
7.4.1	Beckhoff Identification Code (BIC).....	82
7.5	Support and Service.....	84

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

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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".

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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
4.6	<ul style="list-style-type: none"> Chapter <i>Power supply, potential groups</i> corrected
4.5	<ul style="list-style-type: none"> Technical data updated Ex markings added to technical data Chapter <i>Disposal</i> added Document structure updated New title page
4.4	<ul style="list-style-type: none"> Chapter <i>Firmware compatibility</i> updated Document structure updated
4.3	<ul style="list-style-type: none"> Technical data updated Chapter <i>Instructions for ESD protection</i> updated Example program added to chapter <i>Parameterization and commissioning</i>, section <i>KS2000 Configuration Software</i>
4.2	<ul style="list-style-type: none"> Diagnostic LEDs corrected Document structure updated
4.1	<ul style="list-style-type: none"> Chapter <i>Notes on the documentation</i> updated Technical data updated Chapter <i>Instructions for ESD protection</i> added Chapter <i>ATEX - Special conditions</i> replaced with chapter <i>ATEX - Special conditions (extended temperature range)</i> Chapter <i>General operating conditions</i> updated Revision status updated
4.0	<ul style="list-style-type: none"> Migration Document structure updated Revision status updated
3.0	<ul style="list-style-type: none"> Document structure updated Notes regarding extended temperature range added
2.9	<ul style="list-style-type: none"> Note about status bits added
2.8	<ul style="list-style-type: none"> Technical data updated
2.7	<ul style="list-style-type: none"> Technical notes added
2.6	<ul style="list-style-type: none"> Technical data updated
2.5	<ul style="list-style-type: none"> BK1150 added
2.4	<ul style="list-style-type: none"> Extension of terminal diagnostics
2.3	<ul style="list-style-type: none"> Diagnostic LEDs corrected
2.2	<ul style="list-style-type: none"> CoE access, AoE
2.1	<ul style="list-style-type: none"> Object descriptions added
2.0	<ul style="list-style-type: none"> BK1250 added; object descriptions and technical data added
1.0	<ul style="list-style-type: none"> Object descriptions added
0.2	<ul style="list-style-type: none"> Technical data added
0.1	<ul style="list-style-type: none"> First preliminary version

2 Product overview

[BK1120, BK1150 \[► 8\]](#) - EtherCAT Bus Coupler for K-bus Terminals

[BK1250 \[► 9\]](#) - Coupler between E-bus and K-bus terminals

2.1 Introduction

BK1120, BK1150

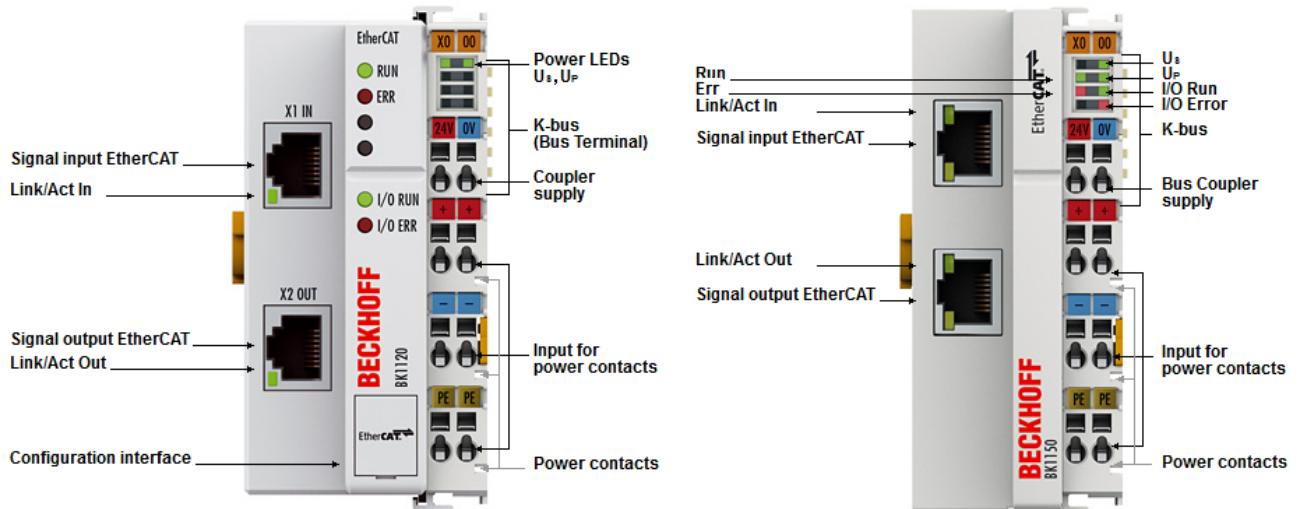


Fig. 1: BK1120 and BK1150 - EtherCAT Bus Coupler for K-bus terminals

The Bus Couplers BK1120 and BK1150 connect EtherCAT with the tried and tested Beckhoff K-bus terminals (KLxxx). A station consists of a BK1120 / BK1150 Bus Coupler, any number of K-bus terminals (up to 64, or up to 255 with K-bus extension) and a bus end terminal. The Bus Coupler recognizes the connected terminals and automatically allocates them into the EtherCAT process image. The Bus Coupler is connected to the network via the upper Ethernet interface. The lower RJ45 socket may be used to connect further EtherCAT devices in the same segment. In the EtherCAT network, the BK1120 / BK1150 Bus Coupler can be installed anywhere in the Ethernet signal transfer section (100BASE-TX) – except directly at the switch. The Bus Couplers BK9000 (for K-bus terminals) and EK1000 (for E-bus terminals) are suitable for application at the switch.

BK1250

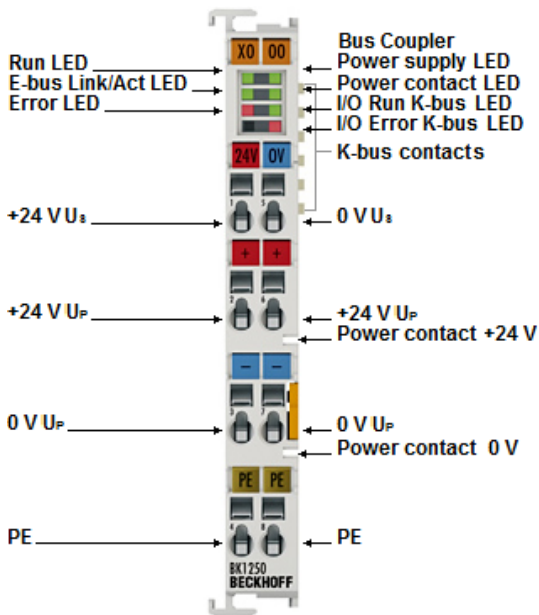


Fig. 2: BK1250 - Coupler between E-bus and K-bus terminals

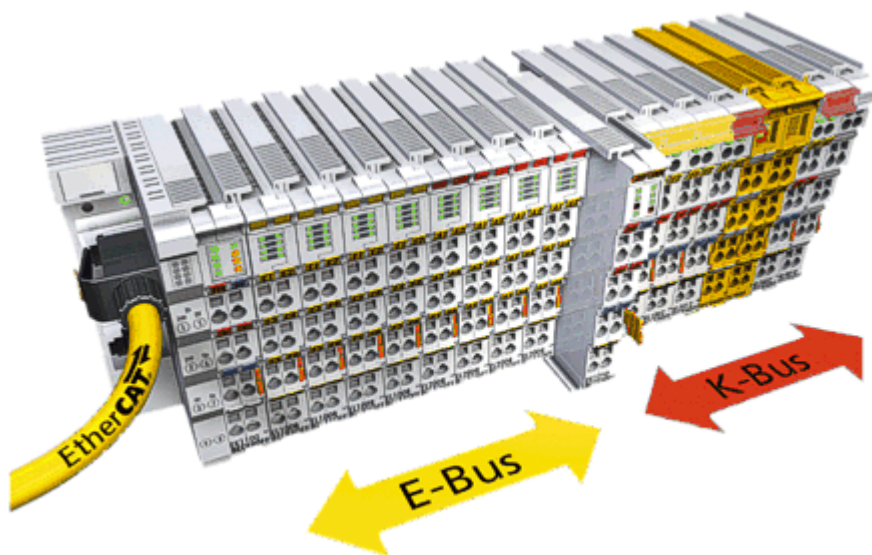


Fig. 3: Transition from E-bus to K-bus

The BK1250 is a "Bus Coupler in the terminal housing" for mixed application of EtherCAT terminals (ELxxxx) and standard Bus Terminals (KLxxxx) in a bus station. It allows implementation of compact and cost-effective control solutions. The wide range of more than 300 available Bus Terminals (incl. special terminals) can thus be optimally combined with the communication speed and large bandwidth of EtherCAT terminals. Up to 64 Bus Terminals (with K-bus extension up to 255) can be connected to a BK1250. The Bus Coupler recognizes the connected Bus Terminals and automatically allocates them into the EtherCAT process image.

2.2 Technical data

Technical data	BK1120	BK1150	BK1250
Task in the EtherCAT system	Coupling of standard Bus Terminals (KLxxxx) to 100BASE-TX EtherCAT networks		
Number of K-bus terminals	64 (255 with K-bus extension interface KL9020 and KL9050)		
Max. number of bytes, fieldbus	1024 bytes input and 1024 bytes output		
Digital peripheral signals	8192 inputs/outputs		
Analog peripheral signals	256 inputs/outputs		
Protocols	EtherCAT		
Baud rate	100 Mbaud		
Configuration	KS2000 configuration software, TwinCAT System Manager or via EtherCAT (ADS)		
Bus connection	2 x RJ45		via E-bus contacts
Power supply	24 V _{DC} (-15%/+20%)		
Current consumption	70 mA + (K-bus current)/4, max. 500 mA		70 mA + (K-bus current)/4, max. 200 mA
K-bus power supply (5 V)	max. 1750 mA	max. 1750 mA	max. 500 mA
Power contacts	max. 24 V _{DC} , max. 10 A		
Electrical isolation	500 V (power contact/supply voltage/Ethernet)		
Weight	approx. 170 g		approx. 55 g
Permissible ambient temperature during operation	-25°C ... +60°C (extended temperature range)		
Permissible ambient temperature during storage	-40°C ... + 85°C		
Permissible relative humidity	95%, no condensation		
Dimensions (W x H x D)	approx. 49 mm x 100 mm x 70 mm		approx. 15 mm x 100 mm x 70 mm (width aligned: 12 mm)
Mounting [▶ 23]	on 35 mm mounting rail conforms to EN 60715		
Enhanced mechanical load capacity	yes, see installation instructions [▶ 26] for enhanced mechanical load capacity		
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		
Approvals/markings*	CE, UKCA, cULus [▶ 35], EAC, ATEX [▶ 34]		

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

Ex marking

Standard	Marking
ATEX	II 3 G Ex nA IIC T4 Gc

3 Basic principles

3.1 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.

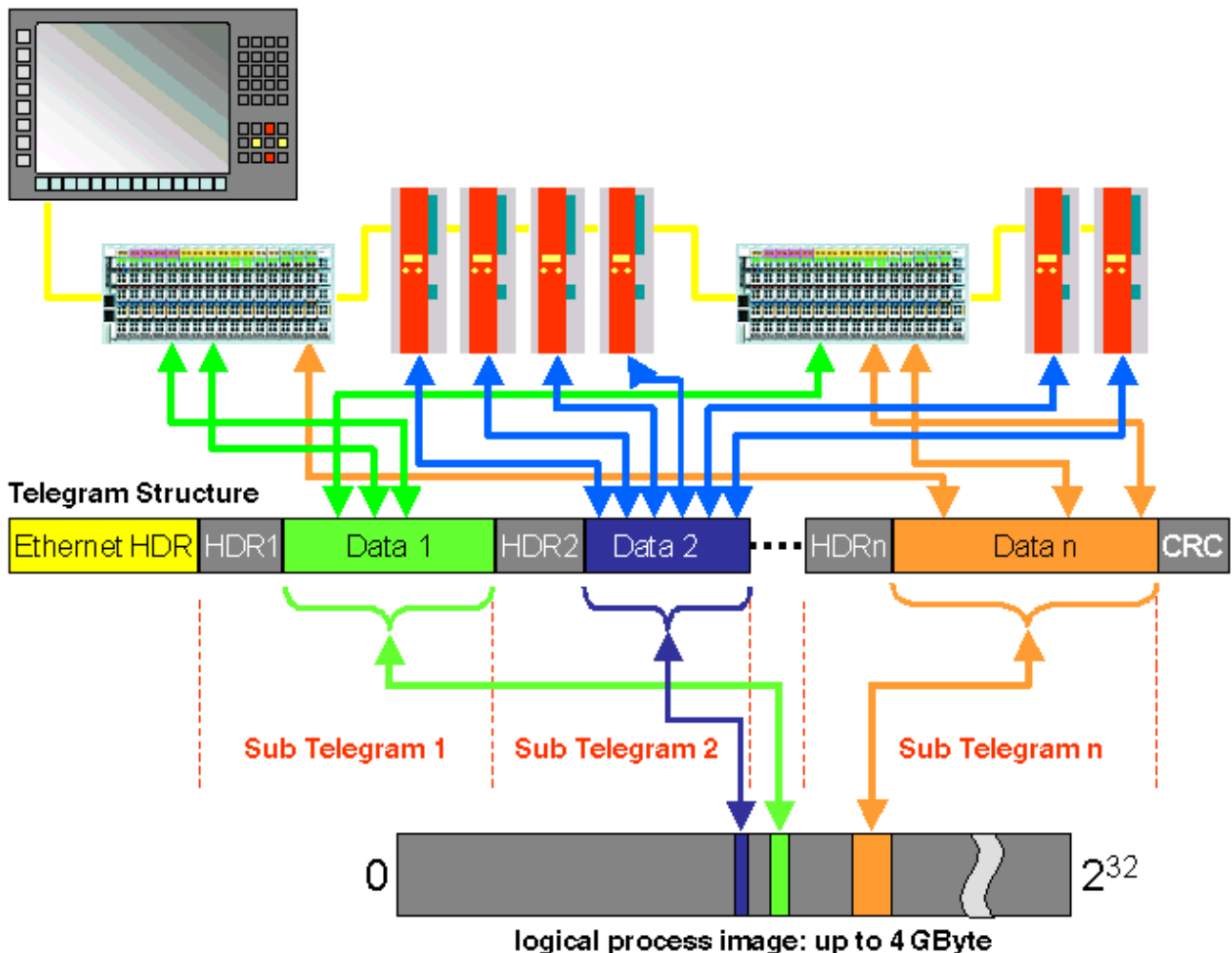


Fig. 4: EtherCAT Telegram Structure

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.

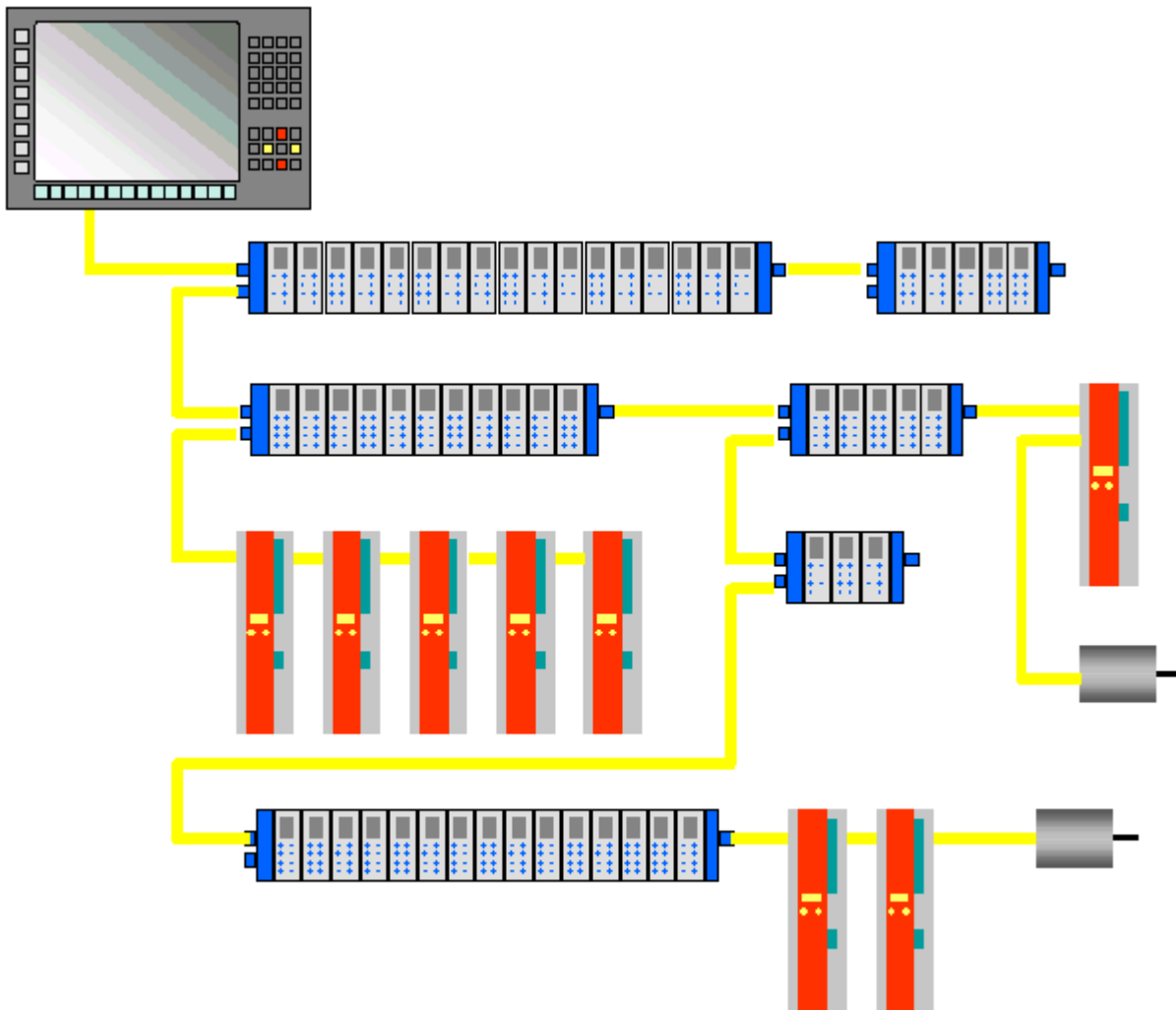


Fig. 5: EtherCAT Topology

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.

3.2 The Beckhoff Bus Terminal system

Up to 256 Bus Terminals, with 1 to 16 I/O channels per signal form

The Bus Terminal system is the universal interface between a fieldbus system and the sensor / actuator level. A unit consists of a Bus Coupler as the head station, and up to 64 electronic series terminals, the last one being an end terminal. Up to 255 Bus Terminals can be connected via the K-bus extension. For each technical signal form, terminals are available with one, two, four or eight I/O channels, which can be mixed as required. All the terminal types have the same mechanical construction, so that difficulties of planning and design are minimized. The height and depth match the dimensions of compact terminal boxes.

Decentralized wiring of each I/O level

Fieldbus technology allows more compact forms of controller to be used. The I/O level does not have to be brought to the controller. The sensors and actuators can be wired decentrally, using minimum cable lengths. The controller can be installed at any location within the plant.

Industrial PCs as controllers

The use of an Industrial PC as the controller means that the operating and observing element can be implemented in the controller's hardware. The controller can therefore be located at an operating panel, in a control room, or at some similar place. The Bus Terminals form the decentralized input/output level of the controller in the control cabinet and the subsidiary terminal boxes. The power sector of the plant is also controlled over the bus system in addition to the sensor/actuator level. The Bus Terminal replaces the conventional series terminal as the wiring level in the control cabinet. The control cabinet can have smaller dimensions.

Bus Couplers for all usual bus systems

The Beckhoff Bus Terminal system unites the advantages of a bus system with the possibilities of the compact series terminal. Bus Terminals can be driven within all the usual bus systems, thus reducing the controller parts count. The Bus Terminals then behave like conventional connections for that bus system. All the performance features of the particular bus system are supported.

Mounting on standardized mounting rails

The installation is standardized thanks to the simple and space-saving mounting on a standardized mounting rail (EN 50022, 35 mm) and the direct wiring of actuators and sensors, without cross connections between the terminals. The consistent labelling scheme also contributes.

The small physical size and the great flexibility of the Bus Terminal system allows it to be used wherever a series terminal is also used. Every type of connection, such as analog, digital, serial or the direct connection of sensors can be implemented.

Modularity

The modular assembly of the terminal strip with Bus Terminals of various functions limits the number of unused channels to a maximum of one per function. The presence of two channels in one terminal is the optimum compromise of unused channels and the cost of each channel. The possibility of electrical isolation through potential feed terminals also helps to keep the number of unused channels low.

Display of the channel state

The integrated LEDs show the state of the channel at a location close to the sensors and actuators.

K-bus

The K-bus is the data path within a terminal strip. The K-bus is led through from the Bus Coupler through all the terminals via six contacts on the terminals' side walls. The end terminal terminates the K-bus. The user does not have to learn anything about the function of the K-bus or about the internal workings of the terminals and the Bus Coupler. Many software tools that can be supplied make project planning, configuration and operation easy.

Potential feed terminals for isolated groups

The operating voltage is passed on to following terminals via three power contacts. You can divide the terminal strip into arbitrary isolated groups by means of potential feed terminals. The potential feed terminals play no part in the control of the terminals, and can be inserted at any locations within the terminal strip.

Up to 64 Bus Terminals can be used in a terminal block, with optional K-bus extension for up to 256 Bus Terminals. This count does include potential feed terminals, but not the end terminal.

Bus Couplers for various fieldbus systems

Various Bus Couplers can be used to couple the electronic terminal strip quickly and easily to different fieldbus systems. It is also possible to convert to another fieldbus system at a later time. The Bus Coupler performs all the monitoring and control tasks that are necessary for operation of the connected Bus Terminals. The operation and configuration of the Bus Terminals is carried out exclusively by the Bus Coupler. Nevertheless, the parameters that have been set are stored in each Bus Terminal, and are retained in the event of voltage drop-out. Fieldbus, K-bus and I/O level are electrically isolated.

If the exchange of data over the fieldbus is prone to errors or fails for a period of time, register contents (such as counter states) are retained, digital outputs are cleared, and analog outputs take a value that can be configured for each output when commissioning. The default setting for analog outputs is 0 V or 0 mA. Digital outputs return in the inactive state. The timeout periods for the Bus Couplers correspond to the usual settings for the fieldbus system. When converting to a different bus system it is necessary to bear in mind the need to change the timeout periods if the bus cycle time is longer.

The interfaces

A Bus Coupler has six different methods of connection. These interfaces are designed as plug connectors and as spring-loaded terminals.

3.3 CoE Interface

General description

The CoE interface (CAN application protocol over EtherCAT) is used for parameter management of EtherCAT devices. EtherCAT slaves or the EtherCAT master manage fixed (read only) or variable parameters which they require for operation, diagnostics or commissioning.

CoE parameters are arranged in a table hierarchy. In principle, the user has read access via the fieldbus. The EtherCAT master (TwinCAT System Manager) can access the local CoE lists of the slaves via EtherCAT in read or write mode, depending on the attributes.

Different CoE parameter types are possible, including string (text), integer numbers, Boolean values or larger byte fields. They can be used to describe a wide range of features. Examples of such parameters include manufacturer ID, serial number, process data settings, device name, calibration values for analog measurement or passwords.

The order is specified in two levels via hexadecimal numbering: (main)index, followed by subindex. The value ranges are

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

A parameter localized in this way is normally written as 0x8010:07, with preceding “0x” to identify the hexadecimal numerical range and a colon between index and subindex.

The relevant ranges for EtherCAT fieldbus users are:

- 0x1000: This is where fixed identity information for the device is stored, including name, manufacturer, serial number etc., plus information about the current and available process data configurations.
- 0x8000: This is where the operational and functional parameters for all channels are stored, such as filter settings or output frequency.

Other important ranges are:

- 0x4000: here are the channel parameters for some EtherCAT devices. Historically, this was the first parameter area before the 0x8000 area was introduced. EtherCAT devices that were previously equipped with parameters in 0x4000 and changed to 0x8000 support both ranges for compatibility reasons and mirror internally.
- 0x6000: Input PDOs (“input” from the perspective of the EtherCAT master)
- 0x7000: Output PDOs (“output” from the perspective of the EtherCAT master)

● Availability



Not every EtherCAT device must have a CoE list. Simple I/O modules without dedicated processor usually have no variable parameters and therefore no CoE list.

If a device has a CoE list, it is shown in the TwinCAT System Manager as a separate tab with a listing of the elements:

Index	Name	Flags	Value
1000	Device type	RO	0x00FA1389 (16389001)
1008	Device name	RO	EL2502-0000
1009	Hardware version	RO	
100A	Software version	RO	
1011:0	Restore default parameters	RO	> 1 <
1018:0	Identity	RO	> 4 <
1018:01	Vendor ID	RO	0x00000002 (2)
1018:02	Product code	RO	0x09C63052 (163983442)
1018:03	Revision	RO	0x00130000 (1245184)
1018:04	Serial number	RO	0x00000000 (0)
10F0:0	Backup parameter handling	RO	> 1 <
1400:0	PWM RxPDO-Par Ch.1	RO	> 6 <
1401:0	PWM RxPDO-Par Ch.2	RO	> 6 <
1402:0	PWM RxPDO-Par h.1 Ch.1	RO	> 6 <
1403:0	PWM RxPDO-Par h.1 Ch.2	RO	> 6 <
1600:0	PWM RxPDO-Map Ch.1	RO	> 1 <

Fig. 6: “CoE Online” tab

The figure above shows the CoE objects available in device “EL2502”, ranging from 0x1000 to 0x1600. The subindices for 0x1018 are expanded.

NOTE**Changes in the CoE directory (CAN over EtherCAT), program access**

When using/manipulating the CoE parameters observe the general CoE notes in chapter "[CoE interface](#)" of the EtherCAT system documentation:

- Keep a startup list if components have to be replaced,
- Distinction between online/offline dictionary,
- Existence of current XML description (download from the [Beckhoff website](#)),
- "CoE-Reload" for resetting the changes
- Program access during operation via PLC (see [TwinCAT3 | PLC Library: Tc2 EtherCAT](#) and [Example program R/W CoE](#))

Data management and function "NoCoeStorage"

Some parameters, particularly the setting parameters of the slave, are configurable and writeable. This can be done in write or read mode

- via the System Manager (Fig. "CoE Online" tab) by clicking
This is useful for commissioning of the system/slaves. Click on the row of the index to be parameterized and enter a value in the "SetValue" dialog.
- from the control system/PLC via ADS, e.g. through blocks from the TcEtherCAT.lib library
This is recommended for modifications while the system is running or if no System Manager or operating staff are available.

● Data management

i If slave CoE parameters are modified online, Beckhoff devices store any changes in a fail-safe manner in the EEPROM, i.e. the modified CoE parameters are still available after a restart. The situation may be different with other manufacturers.

An EEPROM is subject to a limited lifetime with respect to write operations. From typically 100,000 write operations onwards it can no longer be guaranteed that new (changed) data are reliably saved or are still readable. This is irrelevant for normal commissioning. However, if CoE parameters are continuously changed via ADS at machine runtime, it is quite possible for the lifetime limit to be reached. Support for the NoCoeStorage function, which suppresses the saving of changed CoE values, depends on the firmware version.

Please refer to the technical data in this documentation as to whether this applies to the respective device.

- If the function is supported: the function is activated by entering the code word 0x12345678 once in CoE 0xF008 and remains active as long as the code word is not changed. After switching the device on it is then inactive. Changed CoE values are not saved in the EEPROM and can thus be changed any number of times.
- Function is not supported: continuous changing of CoE values is not permissible in view of the lifetime limit.

● Startup list

i Changes in the local CoE list of the terminal are lost if the terminal is replaced. If a terminal is replaced with a new Beckhoff terminal, it will have the default settings. It is therefore advisable to link all changes in the CoE list of an EtherCAT slave with the Startup list of the slave, which is processed whenever the EtherCAT fieldbus is started. In this way a replacement EtherCAT slave can automatically be parameterized with the specifications of the user.

If EtherCAT slaves are used which are unable to store local CoE values permanently, the Startup list must be used.

Recommended approach for manual modification of CoE parameters

- Make the required change in the System Manager
The values are stored locally in the EtherCAT slave

- If the value is to be stored permanently, enter it in the Startup list.
The order of the Startup entries is usually irrelevant.

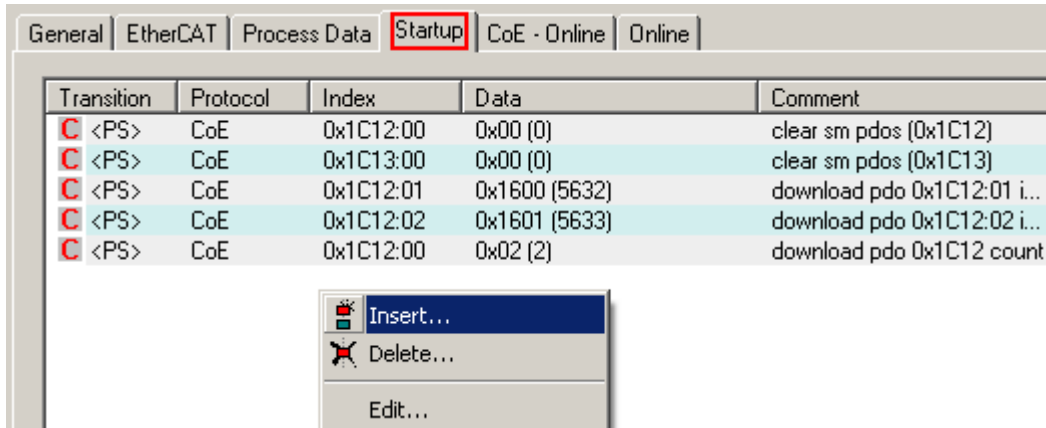


Fig. 7: Startup list in the TwinCAT System Manager

The Startup list may already contain values that were configured by the System Manager based on the ESI specifications. Additional application-specific entries can be created.

Online/offline list

While working with the TwinCAT System Manager, a distinction has to be made whether the EtherCAT device is “available”, i.e. switched on and linked via EtherCAT and therefore **online**, or whether a configuration is created **offline** without connected slaves.

In both cases a CoE list as shown in Fig. “CoE online tab” is displayed. The connectivity is shown as offline/online.

- If the slave is offline
 - The offline list from the ESI file is displayed. In this case modifications are not meaningful or possible.
 - The configured status is shown under Identity.
 - No firmware or hardware version is displayed, since these are features of the physical device.
 - **Offline** is shown in red.

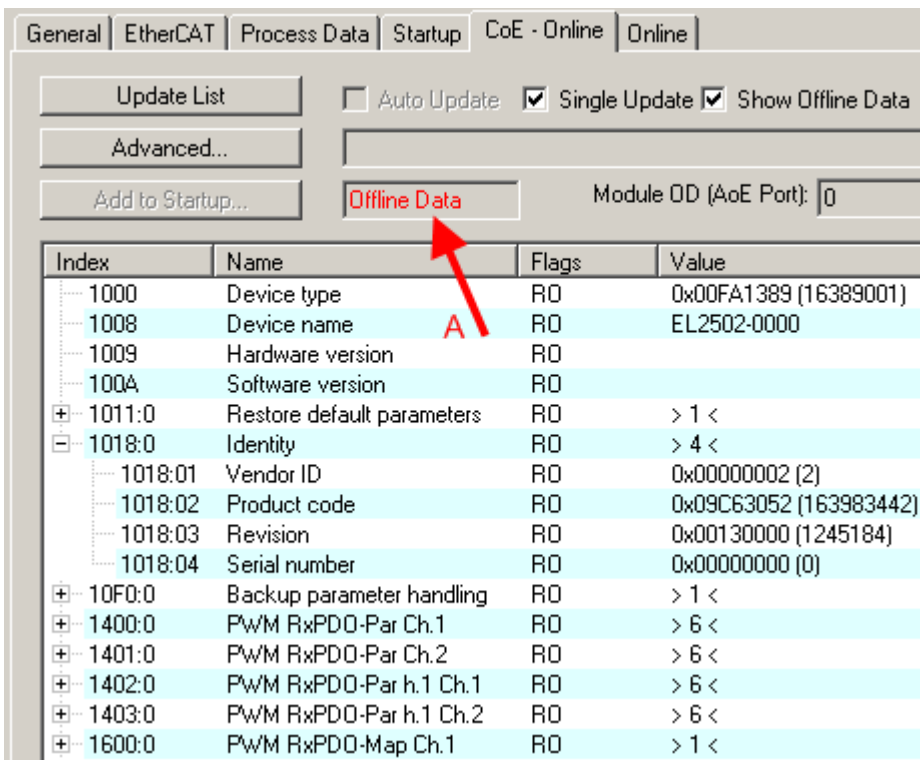


Fig. 8: Offline list

- If the slave is online
 - The actual current slave list is read. This may take several seconds, depending on the size and cycle time.
 - The actual identity is displayed
 - The firmware and hardware version of the equipment according to the electronic information is displayed
 - **Online** is shown in green.

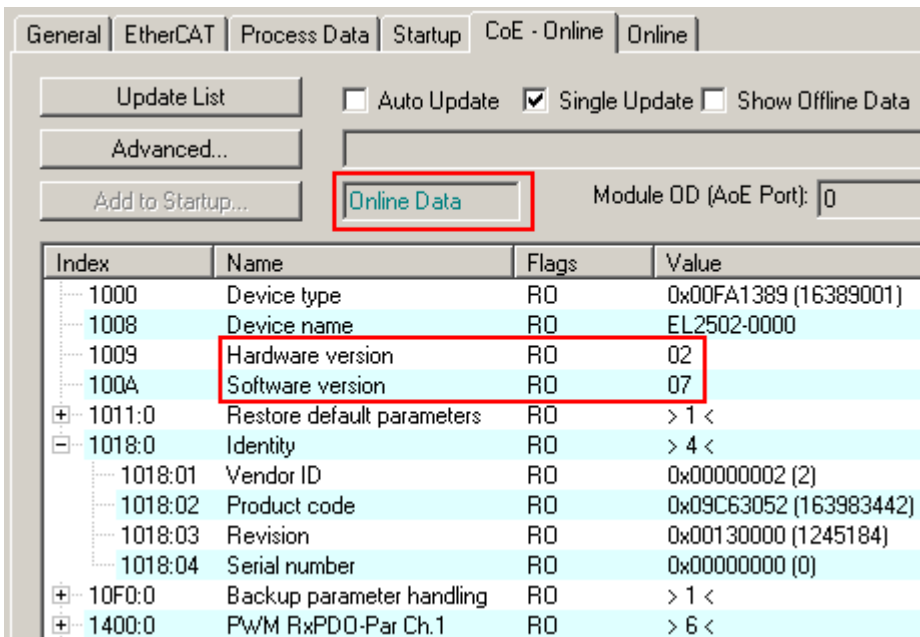


Fig. 9: Online list

Channel-based order

The CoE list is available in EtherCAT devices that usually feature several functionally equivalent channels. For example, a 4-channel analog 0...10 V input terminal also has four logical channels and therefore four identical sets of parameter data for the channels. In order to avoid having to list each channel in the documentation, the placeholder “n” tends to be used for the individual channel numbers.

In the CoE system 16 indices, each with 255 subindices, are generally sufficient for representing all channel parameters. The channel-based order is therefore arranged in $16_{\text{dec}}/10_{\text{hex}}$ steps. The parameter range 0x8000 exemplifies this:

- Channel 0: parameter range 0x8000:00 ... 0x800F:255
- Channel 1: parameter range 0x8010:00 ... 0x801F:255
- Channel 2: parameter range 0x8020:00 ... 0x802F:255
- ...

This is generally written as 0x80n0.

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

3.4 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.

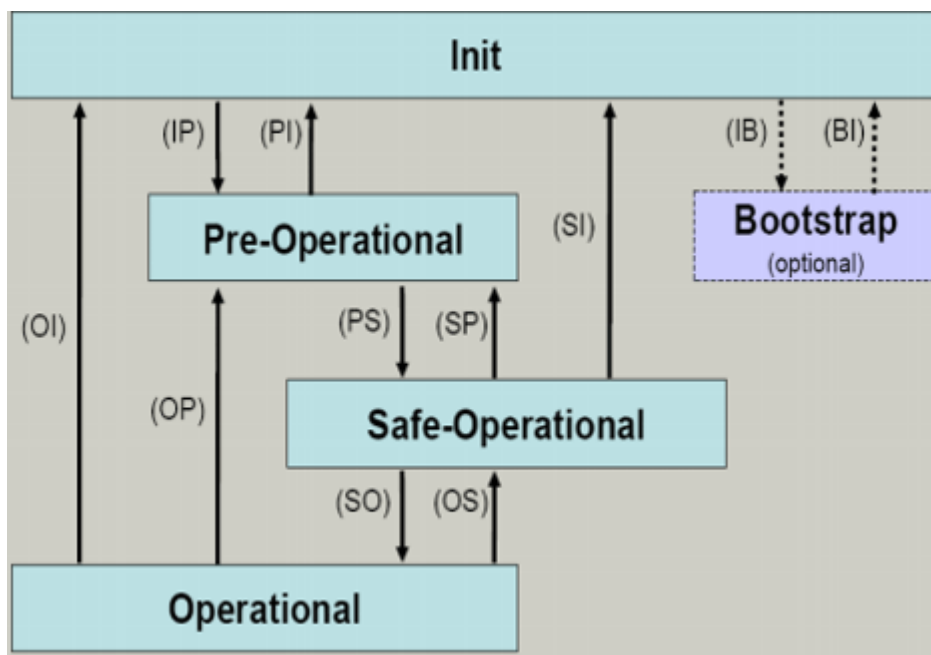


Fig. 10: States of the EtherCAT State Machine

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 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.

4 Mounting and wiring

4.1 Instructions for ESD protection

NOTE

Destruction of the devices by electrostatic discharge possible!

The devices contain components at risk from electrostatic discharge caused by improper handling.

- Please ensure you are electrostatically discharged and avoid touching the contacts of the device directly.
- Avoid contact with highly insulating materials (synthetic fibers, plastic film etc.).
- Surroundings (working place, packaging and personnel) should be grounded probably, when handling with the devices.
- Each assembly must be terminated at the right hand end with a KL9010 bus end terminal, to ensure the protection class and ESD protection.

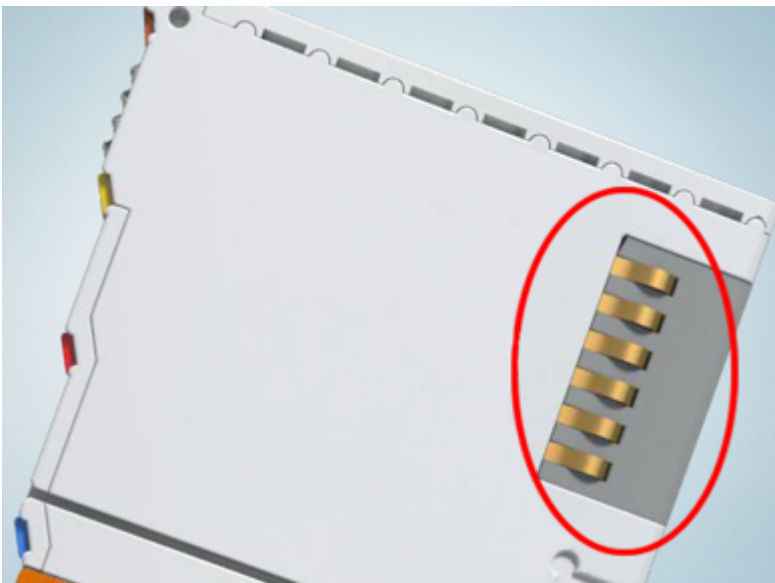


Fig. 11: Spring contacts of the Beckhoff I/O components

4.2 Mounting

4.2.1 Installation on mounting rails

⚠ 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!

The Bus Terminal system and is designed for mounting in a control cabinet or terminal box.

Assembly

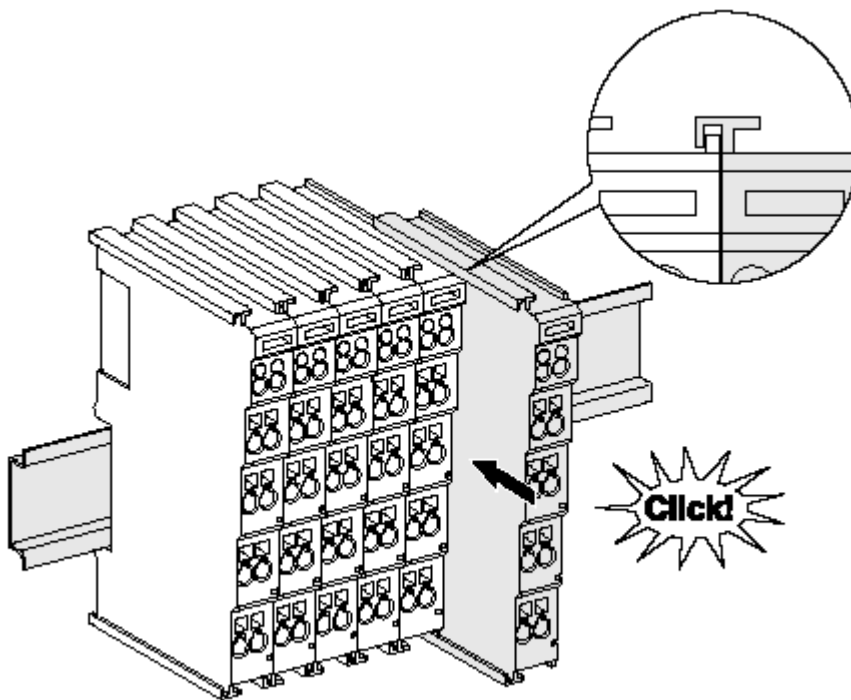


Fig. 12: Attaching on mounting rail

The bus coupler and bus terminals are attached to commercially available 35 mm mounting rails (DIN rails according to EN 60715) by applying slight pressure:

1. First attach the fieldbus coupler to the mounting rail.
2. The bus terminals are now attached on the right-hand side of the fieldbus coupler. Join the components with tongue and groove and push the terminals against the mounting rail, until the lock clicks onto the mounting rail.

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

● Fixing of mounting rails

i The locking mechanism of the terminals and couplers extends to the profile of the mounting rail. At the installation, the locking mechanism of the components must not come into conflict with the fixing bolts of the mounting rail. To mount the mounting rails with a height of 7.5 mm under the terminals and couplers, you should use flat mounting connections (e.g. countersunk screws or blind rivets).

Disassembly

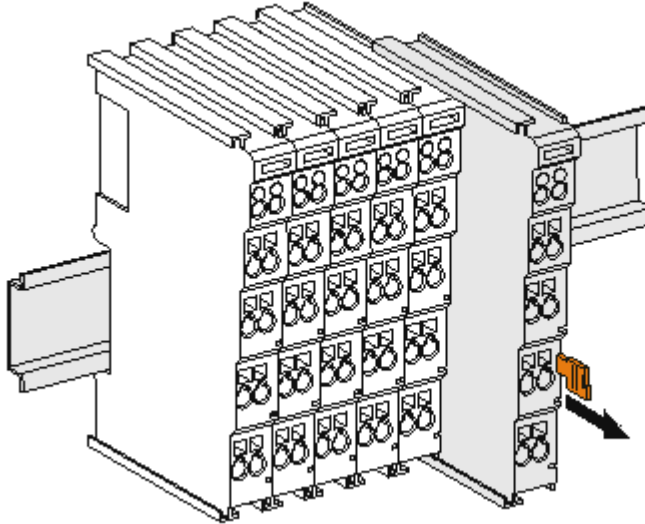


Fig. 13: Disassembling of terminal

Each terminal is secured by a lock on the mounting rail, which must be released for disassembly:

1. Pull the terminal by its orange-colored lugs approximately 1 cm away from the mounting rail. In doing so for this terminal the mounting rail lock is released automatically and you can pull the terminal out of the bus terminal block easily without excessive force.
2. Grasp the released terminal with thumb and index finger simultaneous at the upper and lower grooved housing surfaces and pull the terminal out of the bus terminal block.

Connections within a bus terminal block

The electric connections between the Bus Coupler and the Bus Terminals are automatically realized by joining the components:

- The six spring contacts of the K-Bus/E-Bus deal with the transfer of the data and the supply of the Bus Terminal electronics.
- The power contacts deal with the supply for the field electronics and thus represent a supply rail within the bus terminal block. The power contacts are supplied via terminals on the Bus Coupler (up to 24 V) or for higher voltages via power feed terminals.

● Power Contacts

i During the design of a bus terminal block, the pin assignment of the individual Bus Terminals must be taken account of, since some types (e.g. analog Bus Terminals or digital 4-channel Bus Terminals) do not or not fully loop through the power contacts. Power Feed Terminals (KL91xx, KL92xx or EL91xx, EL92xx) interrupt the power contacts and thus represent the start of a new supply rail.

PE power contact

The power contact labeled PE can be used as a protective earth. For safety reasons this contact mates first when plugging together, and can ground short-circuit currents of up to 125 A.

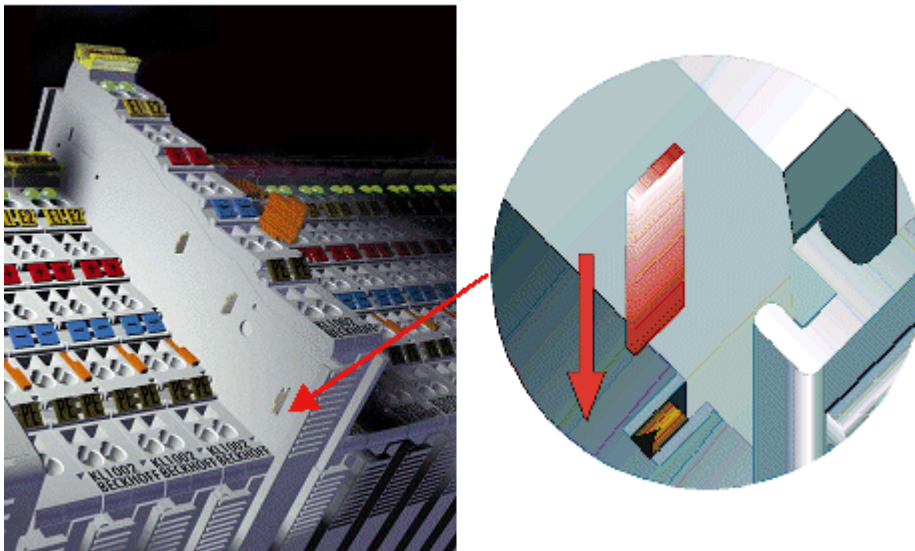


Fig. 14: Power contact on left side

NOTE

Possible damage of the device

Note that, for reasons of electromagnetic compatibility, the PE contacts are capacitatively coupled to the mounting rail. This may lead to incorrect results during insulation testing or to damage on the terminal (e.g. disruptive discharge to the PE line during insulation testing of a consumer with a nominal voltage of 230 V). For insulation testing, disconnect the PE supply line at the Bus Coupler or the Power Feed Terminal! In order to decouple further feed points for testing, these Power Feed Terminals can be released and pulled at least 10 mm from the group of terminals.

⚠ WARNING

Risk of electric shock!

The PE power contact must not be used for other potentials!

4.2.2 Installation instructions for enhanced mechanical load capacity

⚠ WARNING

Risk of injury through electric shock and damage to the device!

Bring the Bus Terminal system into a safe, de-energized state before starting mounting, disassembly or wiring of the Bus Terminals!

Additional checks

The terminals have undergone the following additional tests:

Verification	Explanation
Vibration	10 frequency runs in 3 axes
	6 Hz < f < 60 Hz displacement 0.35 mm, constant amplitude
	60.1 Hz < f < 500 Hz acceleration 5 g, constant amplitude
Shocks	1000 shocks in each direction, in 3 axes
	25 g, 6 ms

Additional installation instructions

For terminals with enhanced mechanical load capacity, the following additional installation instructions apply:

- The enhanced mechanical load capacity is valid for all permissible installation positions
- Use a mounting rail according to EN 60715 TH35-15
- Fix the terminal segment on both sides of the mounting rail with a mechanical fixture, e.g. an earth terminal or reinforced end clamp
- The maximum total extension of the terminal segment (without coupler) is:
64 terminals (12 mm mounting with) or 32 terminals (24 mm mounting with)
- Avoid deformation, twisting, crushing and bending of the mounting rail during edging and installation of the rail
- The mounting points of the mounting rail must be set at 5 cm intervals
- Use countersunk head screws to fasten the mounting rail
- The free length between the strain relief and the wire connection should be kept as short as possible. A distance of approx. 10 cm should be maintained to the cable duct.

4.2.3 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.

4.2.4 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.

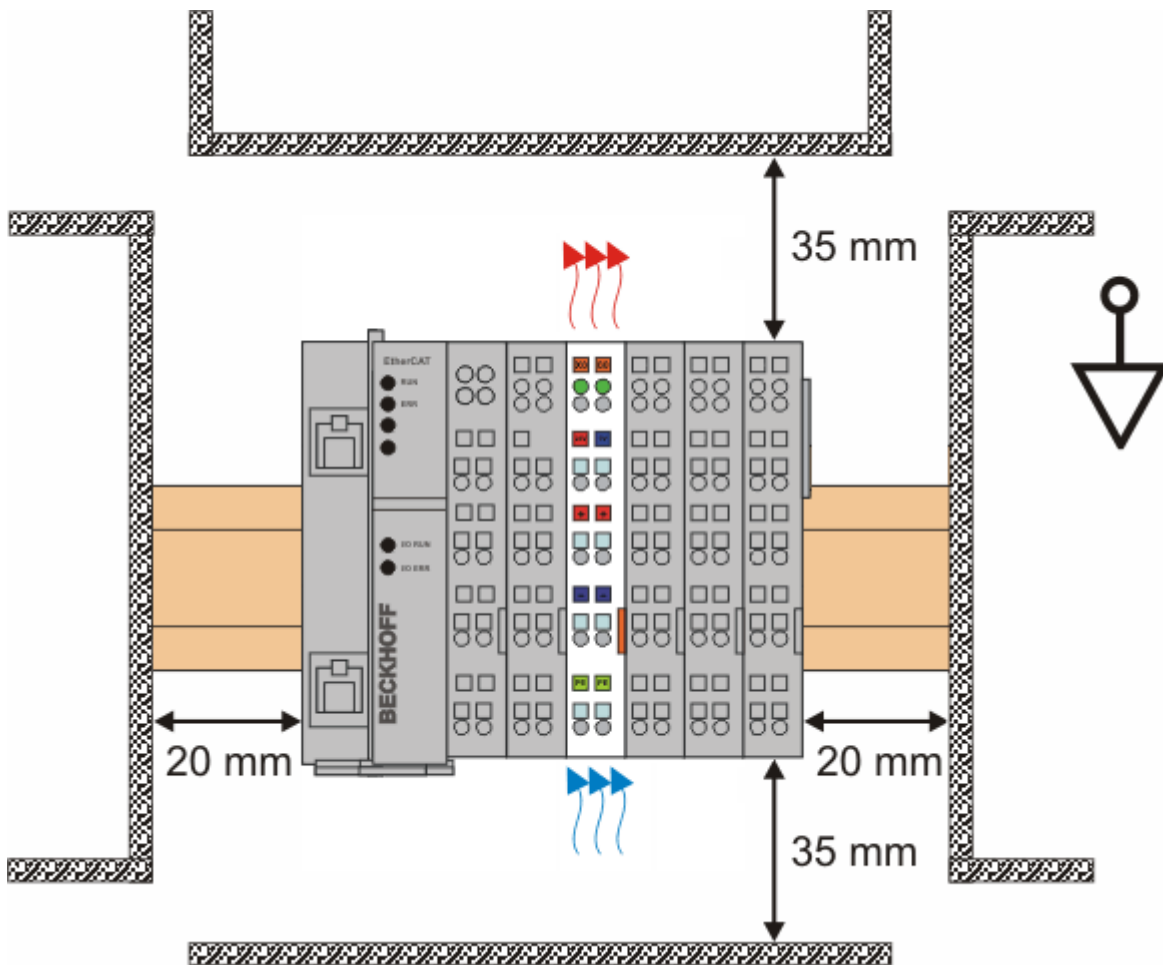


Fig. 15: Recommended distances for standard installation position

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.

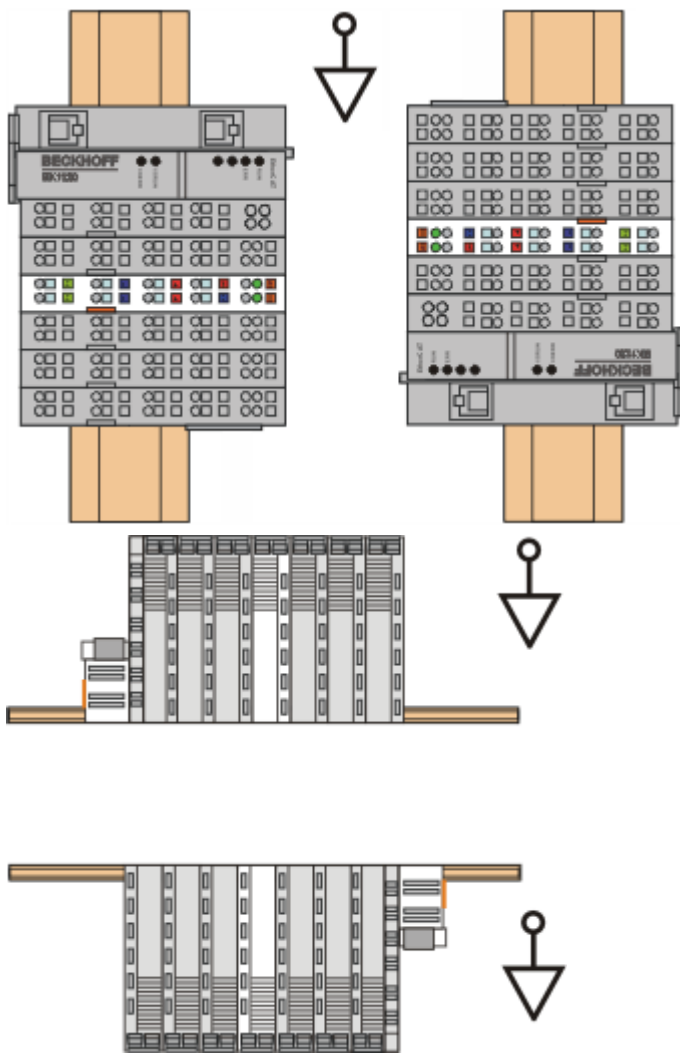


Fig. 16: Other installation positions

4.3 Wiring

4.3.1 BK1120 and BK1150 - Contact assignment

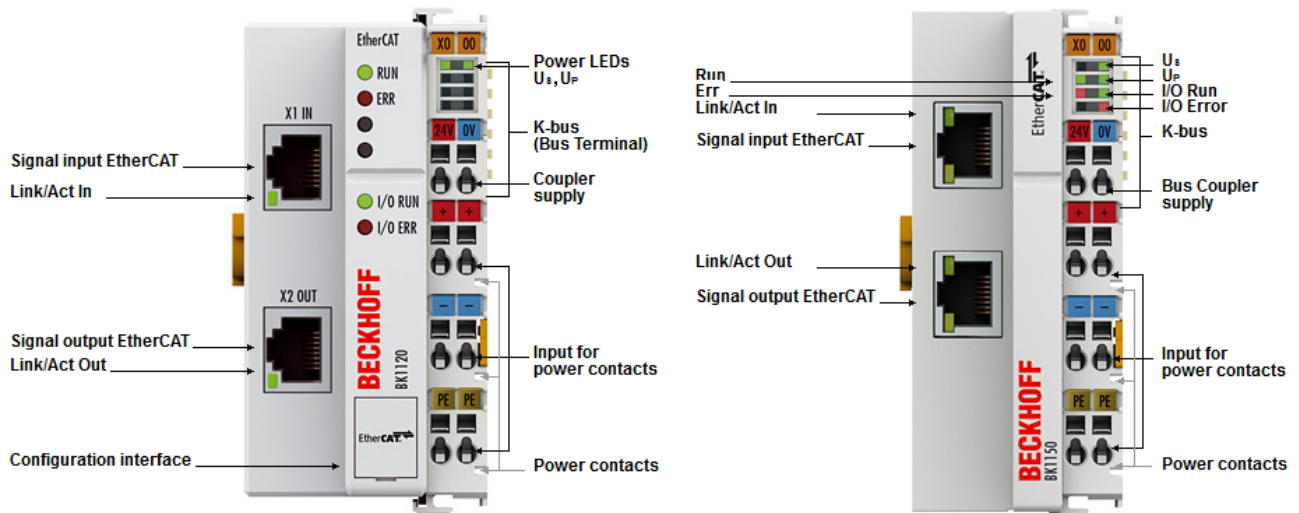


Fig. 17: BK1120, BK1150 - Contact assignment

Terminal point		Description
Name	No.	
+24 V Us	1	Power supply for Bus Coupler and K-bus electronics
+24 V Up	2	Power supply for power contacts (internally connected to terminal point 6)
0 V Up	3	Power supply for power contacts (internally connected to terminal point 7)
PE	4	PE connection (internally connected to terminal point 8)
0 V Us	5	Power supply for Bus Coupler and k-bus electronics
+24 V Up	6	Power supply for power contacts (internally connected to terminal point 2)
0 V Up	7	Power supply for power contacts (internally connected to terminal point 3)
PE	8	PE connection (internally connected to terminal point 4)

4.3.2 BK1250 - Contact assignment

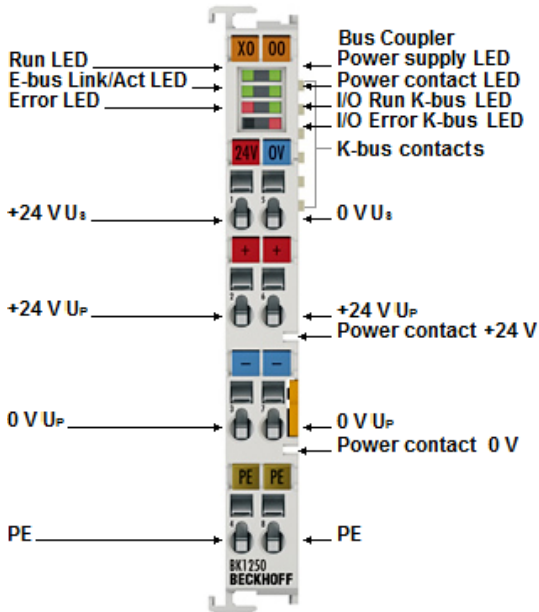


Fig. 18: BK1250 - Contact assignment

Terminal point		Description
Name	No.	
+24 V Us	1	Power supply for Bus Coupler and K-bus electronics
+24 V Up	2	Power supply for power contacts (internally connected to terminal point 6)
0 V Up	3	Power supply for power contacts (internally connected to terminal point 7)
PE	4	PE connection (internally connected to terminal point 8)
0 V Us	5	Power supply for Bus Coupler and K-bus electronics
+24 V Up	6	Power supply for power contacts (internally connected to terminal point 2)
0 V Up	7	Power supply for power contacts (internally connected to terminal point 3)
PE	8	PE connection (internally connected to terminal point 4)

4.3.3 Power supply, potential groups

Bus Coupler power supply

The Bus Couplers require a 24 V_{DC} supply for their operation. The connection is made by means of the upper spring-loaded terminals labelled 24 V and 0 V. The supply voltage is used by the Bus Coupler electronics and for direct voltage generation for the K-bus. The voltage generation for the K-bus takes place in a DC/DC converter without electrical isolation.

The BK1xxx units supply the K-bus with max. 1750 mA K-bus current. Power feed terminals are to be inserted if the added terminals require more current.

Input for power contacts

The bottom six connections with spring-loaded terminals can be used to feed the supply for the peripherals. The spring-loaded terminals are joined in pairs to a power contact. The feed for the power contacts has no connection to the voltage supply for the Bus Coupler. The design of the feed permits voltages of up to 24 V. The assignment in pairs and the electrical connection between feed terminal contacts allows the connection wires to be looped through to various terminal points. The current load via the power contacts may not permanently exceed 10 A; the supply line must therefore be protected by a 10 A fuse (slow-blow).

Power contacts

On the right hand face of the Bus Coupler there are three spring contacts for the power contact connections. 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 of the power contacts may not permanently exceed 10 A.

Electrical isolation

The bus couplers operate by means of three independent potential groups. The supply voltage feeds the K-bus electronics in the bus coupler and the K-bus itself, which are electrically isolated. The supply voltage is also used to generate the operating voltage for the fieldbus.

Note: All the Bus Terminals are electrically isolated from the K-bus. The K-bus is thus electrically isolated from everything else.

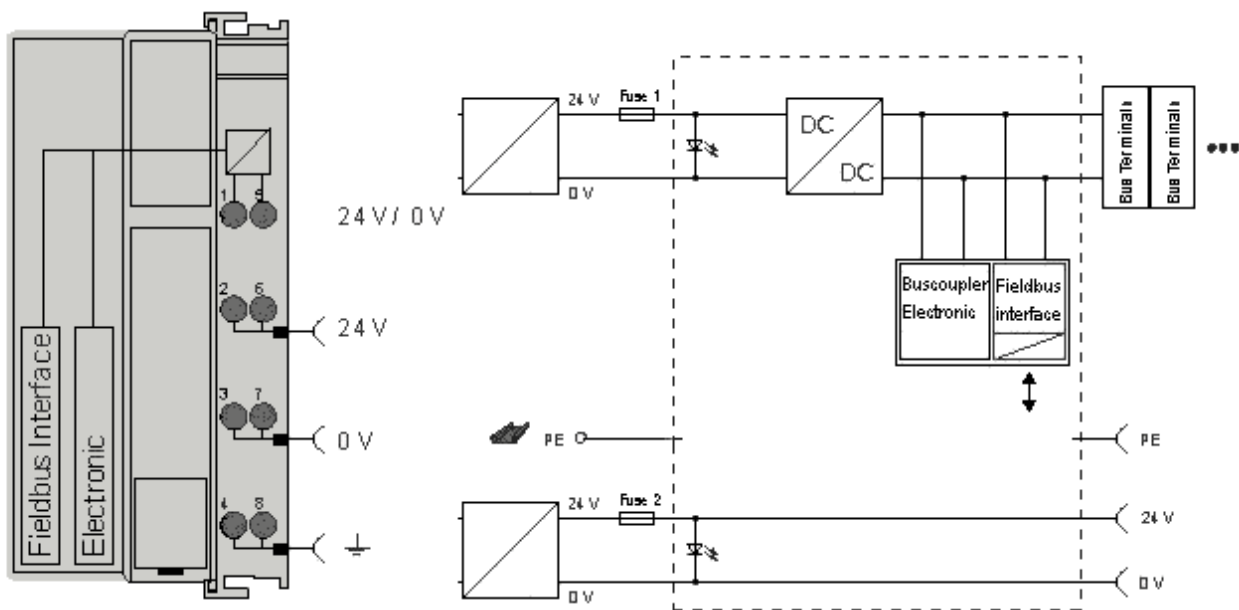


Fig. 19: BK1xxx - Potential diagram

4.3.4 Ethernet cable

Transmission standards

10Base5

The transmission medium for 10Base5 consists of a thick coaxial cable ("yellow cable") with a max. transmission speed of 10 Mbaud arranged in a line topology with branches (drops) each of which is connected to one network device. Because all the devices are in this case connected to a common transmission medium, it is inevitable that collisions occur often in 10Base5.

10Base2

10Base2 (Cheaper net) is a further development of 10Base5, and has the advantage that the coaxial cable is cheaper and, being more flexible, is easier to lay. It is possible for several devices to be connected to one 10Base2 cable. It is frequent for branches from a 10Base5 backbone to be implemented in 10Base2.

10BaseT

Describes a twisted pair cable for 10 Mbaud. The network here is constructed as a star. It is no longer the case that every device is attached to the same medium. This means that a broken cable no longer results in failure of the entire network. The use of switches as star couplers enables collisions to be reduced. Using full-duplex connections they can even be entirely avoided.

100BaseT

Twisted pair cable for 100 MBaud. It is necessary to use a higher cable quality and to employ appropriate hubs or switches in order to achieve the higher data rate.

10BaseF

The 10BaseF standard describes several optical fiber versions.

Short description of the 10BaseT and 100BaseT cable types

Twisted-pair copper cable for star topologies, where the distance between two devices may not exceed 100 meters.

UTP

Unshielded twisted-pair

This type of cable belongs to category 3, and is not recommended for use in an industrial environment.

S/UTP

Screened/unshielded twisted-pair (shielded with copper braid)

Has an overall shield of copper braid to reduce influence of external interference. This cable is recommended for use with Bus Couplers.

FTP

Foiled shielded twisted-pair (shielded with aluminium foil)

This cable has an outer screen of laminated aluminium and plastic foil.

S/FTP

Screened/foiled-shielded twisted-pair (shielded with copper braid and aluminium foil)

Has a laminated aluminium screen with a copper braid on top. Such cables can provide up to 70 dB reduction in interference power.

STP

Shielded twisted-pair

Describes a cable with an outer screen, without defining the nature of the screen any more closely.

S/STP

Screened/shielded twisted pair (wires are individually shielded)

This identification refers to a cable with a shield for each of the two wires as well as an overall shield.

ITP

Industrial Twisted-Pair.

The structure is similar to that of S/STP, but, in contrast to S/STP, it has only one pair of conductors.

4.3.5 EtherCAT wiring

The cable length between two EtherCAT devices must not exceed 100 m.

Cables and connectors

For connecting EtherCAT devices only Ethernet cables that meet the requirements of at least category 5 (CAT5) according to EN 50173 or ISO/IEC 11801 should be used. EtherCAT uses 4 wires for signal transfer.

EtherCAT uses RJ45 connectors. 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.

The following Beckhoff cables and connectors are suitable for application in EtherCAT systems:

- ZB9010 (Industrial Ethernet/EtherCAT cable, fixed installation, CAT 5e, 4-core)
- ZB9020 (Industrial Ethernet/EtherCAT cable, suitable for drag chain applications CAT 5e, 4-core)
- ZS1090-0003 (RJ45 connector, 4-pin, IP 20, field-configurable)
- ZS1090-0005 (RJ45 connector, 8-pin (suitable for GigaBit), IP20, field-configurable)
- ZK1090-9191-0001 (0.17 m EtherCAT patch cable)
- ZK1090-9191-0005 (0.5m EtherCAT patch cable)
- ZK1090-9191-0010 (1.0m EtherCAT patch cable)
- ZK1090-9191-0020 (2.0m EtherCAT patch cable)
- ZK1090-9191-0030 (3.0m EtherCAT patch cable)
- ZK1090-9191-0050 (5.0m EtherCAT patch cable)

E-bus supply

NOTE

Attention! Malfunction possible!

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

4.4 ATEX - Special conditions (extended temperature range)

⚠ WARNING

Observe the special conditions for the intended use of Beckhoff fieldbus components with extended temperature range (ET) 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 -25 to 60°C for the use of Beckhoff fieldbus components with extended temperature range (ET) 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 extended temperature range (ET) certified according to the ATEX directive for potentially explosive areas bear the following marking:



II 3G KEMA 10ATEX0075 X Ex nA IIC T4 Gc Ta: -25 ... +60°C

II 3D KEMA 10ATEX0075 X Ex tc IIIC T135°C Dc Ta: -25 ... +60°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: -25 ... +60°C

II 3D KEMA 10ATEX0075 X Ex tc IIIC T135°C Dc Ta: -25 ... +60°C
(only for fieldbus components of certificate no. KEMA 10ATEX0075 X Issue 9)

4.5 Continuative documentation for ATEX and IECEx

NOTE	
	<p>Continuative documentation about explosion protection according to ATEX and IECEx</p> <p>Pay also attention to the continuative documentation</p> <p>Ex. Protection for Terminal Systems</p> <p>Notes on the use of the Beckhoff terminal systems in hazardous areas according to ATEX and IECEx,</p> <p>that is available for download within the download area of your product on the Beckhoff homepage www.beckhoff.com!</p>

4.6 UL notice

⚠ CAUTION	
	<p>Application</p> <p>Beckhoff EtherCAT modules are intended for use with Beckhoff's UL Listed EtherCAT System only.</p>
⚠ CAUTION	
	<p>Examination</p> <p>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).</p>
⚠ CAUTION	
	<p>For devices with Ethernet connectors</p> <p>Not for connection to telecommunication circuits.</p>

Basic principles

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



5 Parameterization and commissioning

5.1 Start-up behavior of the Bus Coupler

Immediately after being switched on, the Bus Coupler checks, in the course of a self test, all the functions of its components and the communication on the K-bus/E-bus. The red I/O LED blinks while this is happening. After completion of the self-test, the Bus Coupler starts to test the attached Bus Terminals (the "Bus Terminal Test"), and reads in the configuration. The Bus Terminal configuration is used to generate an internal structure list, which is not accessible from outside. In case of an error, the Bus Coupler enters the *Stop* state. Once the start-up has completed without error, the Bus Coupler enters the *fieldbus start* state.

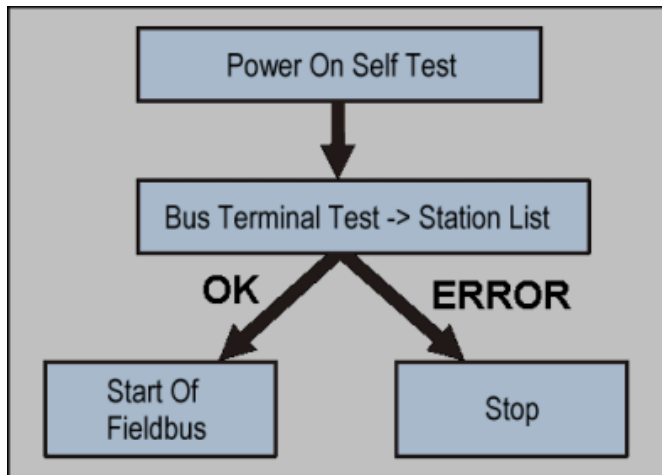


Fig. 20: Flow chart showing start-up behavior of the Bus Coupler

The Bus Coupler can be made to enter the normal operating state by switching it on again once the fault has been rectified.

5.2 EKxxxx - Optional Distributed Clocks support

Basic principles Distributed Clocks (DC)

The EtherCAT Distributed Clocks system comprises local clocks that are integrated in the EtherCAT slaves and are synchronized by the EtherCAT master via special datagrams. Not all EtherCAT slaves support the Distributed Clocks procedure. It is only supported by slaves whose function requires it. In the TwinCAT System Manager a slave indicates its DC capability by showing "DC" in the settings dialog.

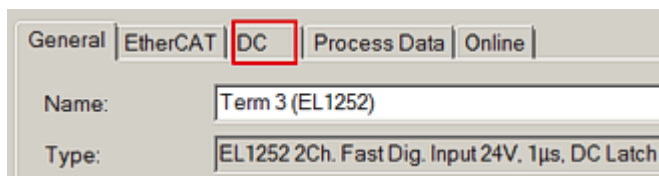


Fig. 21: DC tab for indicating the Distributed Clocks function

Once of these local clocks is the reference clock, based on which all other clocks are synchronized. See also explanatory notes in the [Basic EtherCAT documentation](#). The reference clock must be the first DC-capable EtherCAT slave. By default TwinCAT therefore selects the first DC-capable device as reference clock. This is shown (and can be modified by the user) under advanced properties of the EtherCAT master. The standard setting should not be changed, except in cases where external synchronization is recommended in the relevant documentation, for example.

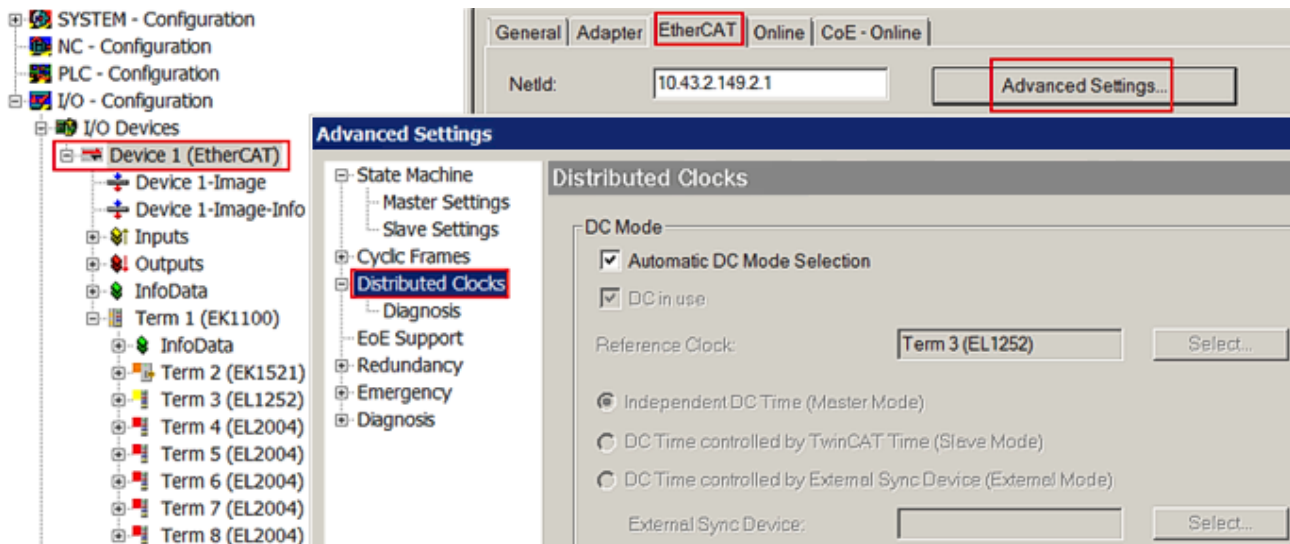


Fig. 22: Advanced Distributed Clocks settings in the EtherCAT master

The figure shows how TwinCAT selects the EL1252 as reference clock by default, since the preceding components do not support DC.

Settings EtherCAT device

System and infrastructure devices such as EK1100 or EK1122 couplers and junction etc. do not require Distributed Clocks to function properly. Nevertheless, it may be topologically expedient to designate the first coupler in an EtherCAT system as reference clock, for example. For this reason, from a certain level the infrastructure components are able to operate as reference clocks, based on special configuration settings.

According to the following table (*DC support from rev/firmware version*), the components support activation of distributed clocks:

Device	XML revision in the configuration	Serial number of the component
BK1150	from BK1150-0000-0016	from firmware 01: xxxx01yy
CU1128	from CU1128-0000-0000	from firmware 00: xxxx00yy
EK1100	from EK1100-0000-0017	from firmware 06: xxxx06yy
EK1101	from EK1101-0000-0017	from firmware 01: xxxx01yy
EK1501	from EK1501-0000-0017	from firmware 01: xxxx01yy
EK1501-0010	from EK1501-0010-0017	from firmware 02: xxxx02yy
EK1122	from EK1122-0000-0017	from firmware 01: xxxx02yy
EK1521	from EK1521-0000-0018	from firmware 03: xxxx03yy
EK1541	from EK1541-0000-0016	from firmware 01: xxxx01yy
EK1561	from EK1561-0000-0016	from firmware 01: xxxx01yy
EK1521-0010	from EK1521-0010-0018	from firmware 03: xxxx03yy
EK1814	from EK1814-0000-0016	from firmware 00: xxxx00yy

To ensure that TwinCAT uses such a component as DC reference clock, a manual intervention during the configuration setup is required, as shown here using the EK1100 as an example.

The checkboxes “Cyclic Mode Enable” and “Use as potential Reference Clock” must be set.

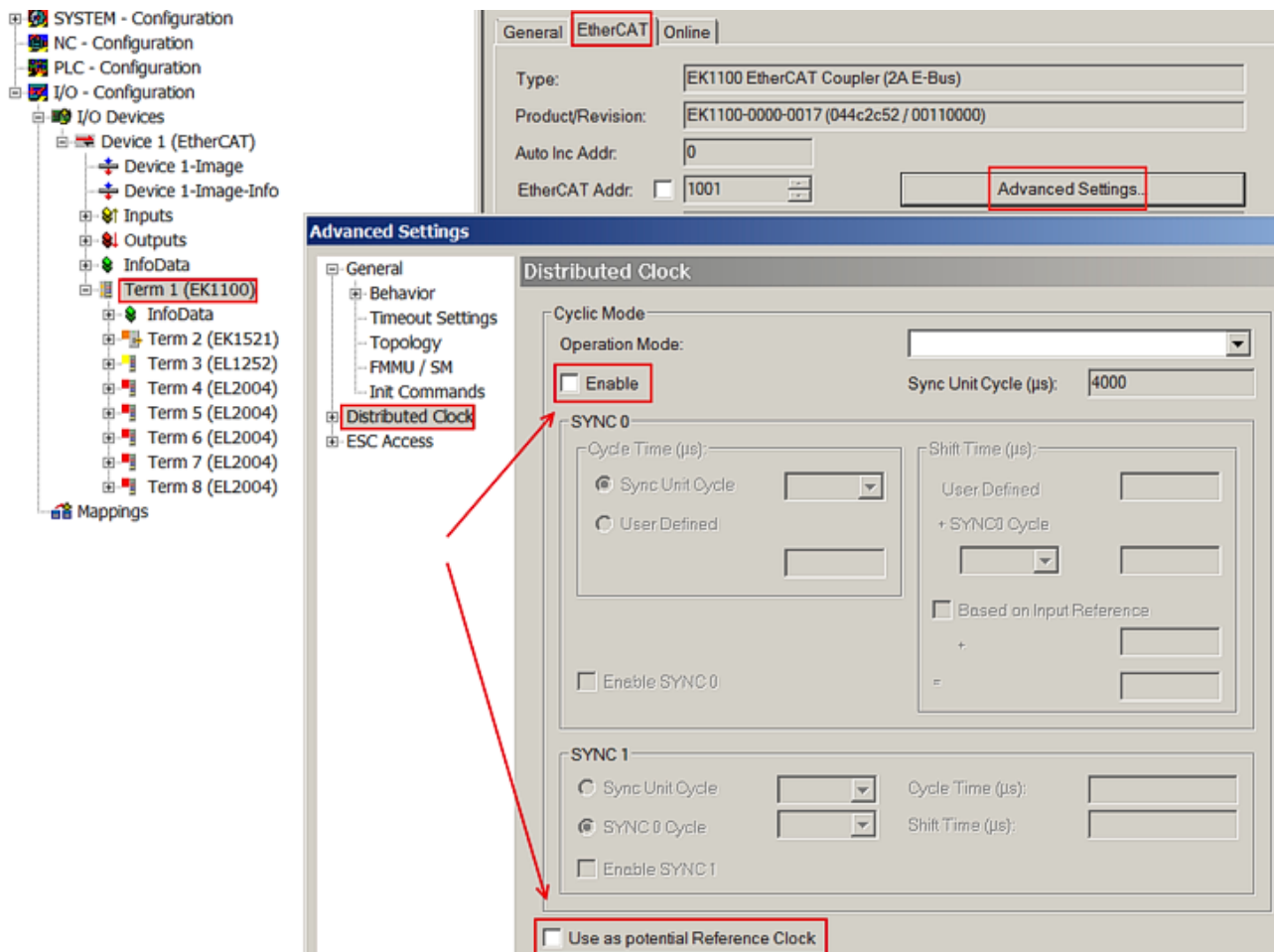


Fig. 23: TwinCAT setting for using this component as reference clock

● **Activation of Distributed Clocks support**

i The (synchronization) procedure described here is only successful for the components described above. The checkboxes can be set for other components, too, although the hardware does not support this function, unless specified in the respective documentation. In particular, please note that after commissioning the component may not be replaced with a previous version without DC support.

5.3 KL register communication

5.3.1 Parameterization of K-bus terminals

If a K-bus terminal supports this kind of parameterization, the parameters can be changed via the register communication. The parameters are managed in so-called registers in the terminal. They can be changed during the startup phase or online during operation.

The available parameters/registers are described in the corresponding terminal documentation. In these chapters, only the route to the registers via EtherCAT is described.

The following 3 routes are available; all require the coupler as a gateway:

- Change during the EtherCAT startup phase via the coupler's [CoE startup list](#) [▶ 40]
 - This ensures that the terminal is parameterized correctly and immediately, even after the terminal is exchanged.
- Change during operation
 - via EtherCAT CoE access to the coupler

- via [AoE access \[▶ 45\]](#) (ADS over EtherCAT) from a TwinCAT system by means of ADS commands on the K-bus terminal

As a rule, it is not necessary to reboot the K-bus terminal after a parameter change; see terminal documentation.

- KS2000 configuration software

The [KS2000 configuration software](#) for parameterizing K-bus terminals runs on Windows IPCs and can communicate with the terminals and the upstream coupler via two communication channels:

- Internal ADS.
- External via a serial RS232 COM cable or a USB cable. Both are available from Beckhoff. A KS2000 interface at the coupler (e.g. BK1120) is a prerequisite for external access.

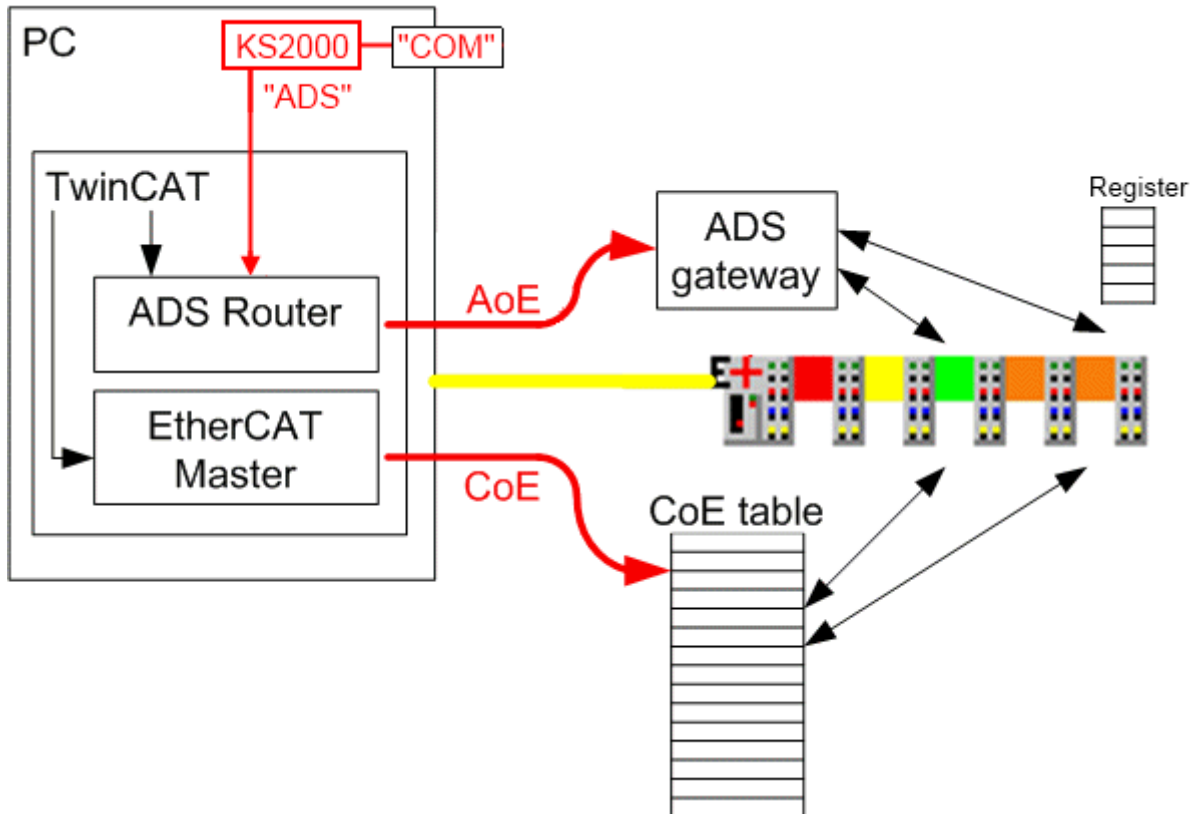


Fig. 24: Register access on K-bus terminals

i ADS access

In contrast to COM access via a cable, ADS access is not limited to the local IPC platform. The routing capabilities of each TwinCAT IPC enable the KL registers to be accessed from other TwinCAT stations.

5.3.2 Configuration of KL terminals via EtherCAT

The following is an explanation of how register communication with the KL terminals is parameterized during the EtherCAT start-up.

This ensures that the KL terminal used always contains the desired register set, even if the terminal (hardware) is exchanged, because the register data is written to the KL terminal again at the next start-up of the system or EtherCAT.

The principle:

- a set of calls is stored in the CoE startup list of the BK11x0/BK1250 for each terminal to be parameterized.
- the entering and cancelling of the code word must thereby be included if required.
- the startup entries are processed in succession by the TwinCAT EtherCAT master during the start-up.
- in doing so, confirmed mailbox communication takes place, so that the next entry will be initiated only when the previous one has been successfully completed.
- no check is made of whether certain values already exist in the KL terminal; the defined startup entries will be written to the terminal position in all cases.
- the startup entries are to be sent in the PREOP -> SAFEOP transition.

This is the process to be adhered to for each terminal:

- entry of the terminal number to CoE 0x427F: 00 as a 2-byte value
the first KL terminal after the BK11x0/BK1250 also has the number 1; accordingly consecutive.
- if necessary: set the code word in register 31
0x4280:20 = 0x1235.
- List the register values sequentially; **subindex_{hex} = register number + 1**
e.g. 0x4280: 21 = 0x0800
See table, among others, for the required CoE index.
- if the code word was needed: delete the code word in order to accept data
0x4280:20 = 0.
- deselect terminal selection by CoE 0x427F: 00 = 0

Information for the register values

- a KL terminal can have a maximum of 4 parameterisable channels/register pages; see the corresponding terminal documentation.
- each channel/register page has n registers, 0 – 63 is usual.
- each register is accessible via the CoE sub-index: **Subindex_{hex} = Register number + 1**.
- the following assignments apply to the channels/register pages:

Channel	Register	CoE Index
Channel /Register page 0	Register 0 - 63	0x4280
	Register > 63 (if available)	0x4281
Channel /Register page 1	Register 0 - 63	0x4282
	Register > 63 (if available)	0x4283
Channel /Register page 2	Register 0 - 63	0x4284
	Register > 63 (if available)	0x4285
Channel /Register page 3	Register 0 - 63	0x4286
	Register > 63 (if available)	0x4287

i Code word

The user parameters in registers 32 - 47 can only be changed if the code word 0x1235 is written in register 31. Register 31 must be set back to 0 for non-volatile storage of the modified user parameters in the terminal.

Please refer to the corresponding terminal documentation for access to the register.

Example

TwinCAT 2:11 b1539 and a BK1120 with firmware B8 were used in the following example. In an existing configuration (scanned or manually created), the user scaling (offset) of the KL3314 is to be changed in the startup list of the BK1120 coupler in order to ensure that the desired scaling is also saved in the terminal in the event of the terminal being exchanged.

2 entries have already been created: selection of terminal 3 and setting of the code word.

Now the user scaling (offset) will be set in register 33 (see terminal documentation). A right click opens the "Insert" dialog.

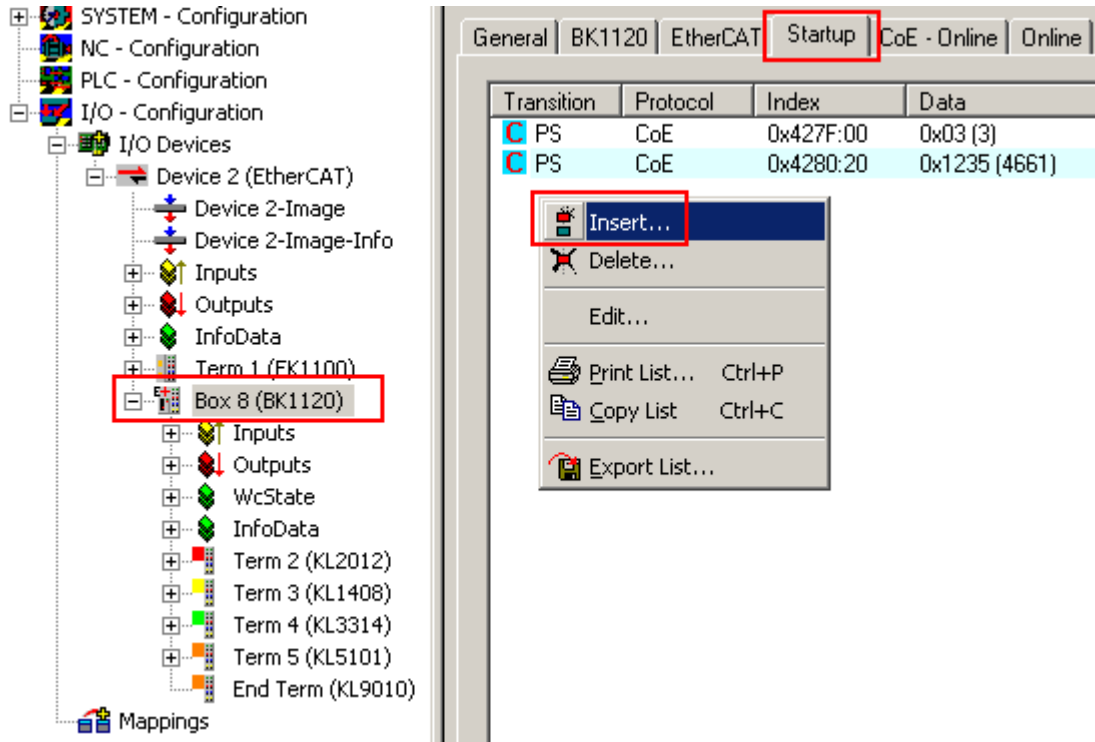


Fig. 25: Insert dialog

The following is to be entered in the dialogue

- The state transition P -> S
- the sub-index as register number + 1
in this case: Register 33_{dec} = Subindex 22_{hex}
- the hexadecimal register value as a byte pair, the high-order byte first
in this case: Set value 1234_{dec} = 04D2_{hex}

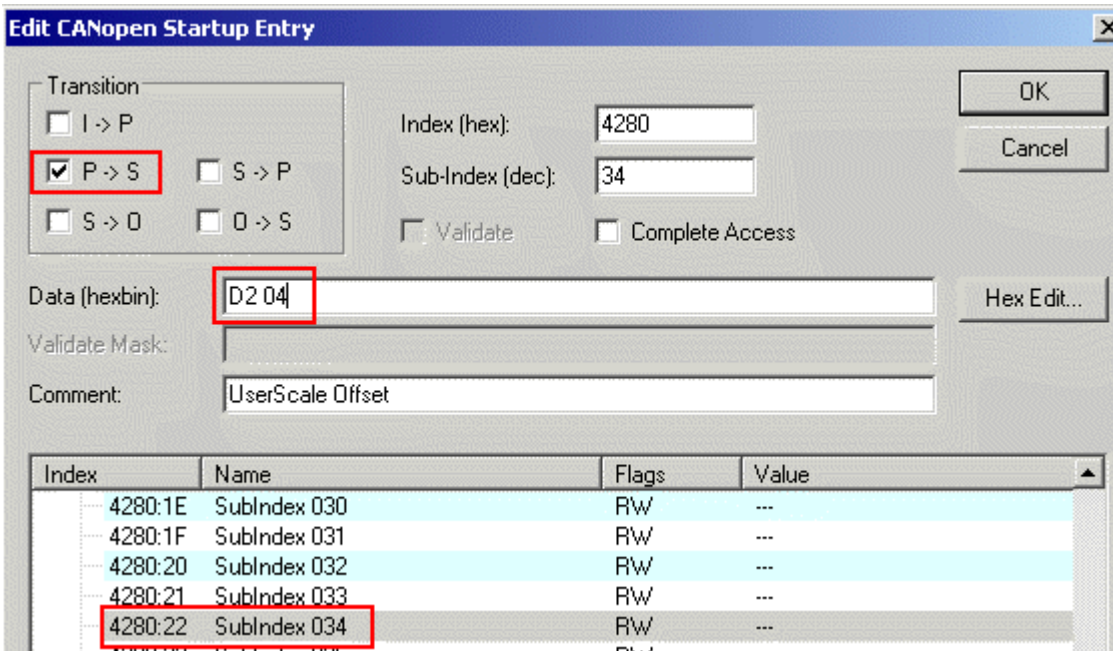


Fig. 26: Data entry

The complete entry is shown in Fig. *Entry*.

Transition	Protocol	Index	Data	Comment
PS	CoE	0x427F:00	0x03 (3)	Terminal No
PS	CoE	0x4280:20	0x1235 (4661)	Codeword
PS	CoE	0x4280:22	0x04D2 (1234)	UserScale Offset

Fig. 27: Entry

Since the code word was used, it must also be reset in order to complete the terminal access.

Transition	Protocol	Index	Data	Comment
PS	CoE	0x427F:00	0x03 (3)	Terminal No
PS	CoE	0x4280:20	0x1235 (4661)	Codeword open
PS	CoE	0x4280:22	0x04D2 (1234)	UserScale Offset
PS	CoE	0x4280:20	0x0000 (0)	Codeword close

Fig. 28: Complete terminal access

More extensive register access is possible, if required, see Fig. *Access to two KL terminals*. In this case, two KL2541s with the numbers 3 and 4 will be parameterized in the startup phase.

Transition	Protocol	Index	Data	Comment
PS	CoE	0x427F:00	0x0003 (3)	Terminal No
PS	CoE	0x4280:20	0x1235 (4661)	Codewort open
PS	CoE	0x4280:21	0x0A04 (2564)	Register 32
PS	CoE	0x4280:22	0x00C8 (200)	Register 33
PS	CoE	0x4280:23	0x0320 (800)	Register 34
PS	CoE	0x4280:24	0x0064 (100)	Register 35
PS	CoE	0x4280:25	0x0064 (100)	Register 36
PS	CoE	0x4280:26	0x0001 (1)	Register 37
PS	CoE	0x4280:2B	0x0064 (100)	Register 42
PS	CoE	0x4280:2C	0x0064 (100)	Register 43
PS	CoE	0x4280:2D	0x0064 (100)	Register 44
PS	CoE	0x4280:2E	0x0064 (100)	Register 45
PS	CoE	0x4280:2F	0x0005 (5)	Register 46
PS	CoE	0x4280:30	0x0007 (7)	Register 47
PS	CoE	0x4280:33	0x07FF (2047)	Register 50
PS	CoE	0x4280:20	0x0000 (0)	Codewort close
PS	CoE	0x427F:00	0x0004 (4)	Terminal No
PS	CoE	0x4280:20	0x1235 (4661)	Codewort open
PS	CoE	0x4280:21	0x0A04 (2564)	Register 32
PS	CoE	0x4280:22	0x00C8 (200)	Register 33
PS	CoE	0x4280:23	0x0320 (800)	Register 34
PS	CoE	0x4280:24	0x0064 (100)	Register 35
PS	CoE	0x4280:25	0x0064 (100)	Register 36
PS	CoE	0x4280:26	0x0001 (1)	Register 37
PS	CoE	0x4280:2B	0x0064 (100)	Register 42
PS	CoE	0x4280:2C	0x0064 (100)	Register 43
PS	CoE	0x4280:2D	0x0064 (100)	Register 44
PS	CoE	0x4280:2E	0x0064 (100)	Register 45
PS	CoE	0x4280:2F	0x0005 (5)	Register 46
PS	CoE	0x4280:30	0x0007 (7)	Register 47
PS	CoE	0x4280:33	0x07FF (2047)	Register 50
PS	CoE	0x4280:20	0x0000 (0)	Codewort close
PS	CoE	0x427F:00	0x0000 (0)	Terminal No

Fig. 29: Access to two KL terminals

5.3.3 Online parameterization of KL terminals via CoE

In the same way as with the CoE startup entry (CANopen over EtherCAT), online access to a KL terminal is also possible via the CoE directory of the BK11x0/BK1250 EtherCAT coupler used. Using this route, access to the coupler-internal tables or to the registers in the terminals is possible.

The coupler-internal tables are displayed in the CoE directory; the terminal registers can be dynamically displayed and edited via the 0x4280ff indices.

Index	Name	Flags	Value
+ 1A01:0	TxPDO Mapping Terminal 002	RW	> 8 <
+ 1A02:0	TxPDO Mapping Terminal 003	RW	> 12 <
+ 1A03:0	TxPDO Mapping Terminal 004	RW	> 3 <
+ 1AFF:0	Status PDO	RW	> 1 <
+ 1B01:0	TxPDO Digital Align	RW	> 1 <
+ 1C00:0	Sync Manager Type	RO	> 4 <
+ 1C12:0	RxPDO Assign	RW	> 5 <
+ 1C13:0	TxPDO Assign	RW	> 5 <
+ 4000:0	Coupler Table 0 [LO]	RW	> 128 <
+ 4001:0	Coupler Table 0 [HI]	RW	> 128 <
+ 4012:0	Coupler Table 9 [LO]	RO	> 5 <
+ 4013:0	Coupler Table 9 [HI]	RO	> 0 <
+ 40B4:0	Coupler Table 90 [LO]	RO	> 128 <
+ 40B5:0	Coupler Table 90 [HI]	RO	> 128 <
+ 40C4:0	Coupler Table 98 [LO]	RW	> 3 <
+ 40C5:0	Coupler Table 98 [HI]	RW	> 0 <
+ 40C6:0	Coupler Table 99 [LO]	RW	> 128 <
+ 40C7:0	Coupler Table 99 [HI]	RW	> 128 <
+ 40C8:0	Coupler Table 100 [LO]	RW	> 128 <
+ 40C9:0	Coupler Table 100 [HI]	RW	> 128 <
+ 40FE:0	Coupler Table 127 [LO]	RO	> 128 <
+ 40FF:0	Coupler Table 127 [HI]	RO	> 128 <
427F	Terminal No	RW	0x03 (3)
- 4280:0	Terminal Channel 0 [LO]	RW	> 64 <
- 4280:01	SubIndex 001	RW	0x7FFF (32767)
- 4280:02	SubIndex 002	RW	0x17A3 (6051)
- 4280:03	SubIndex 003	RW	0x020C (524)

Fig. 30: Online CoE directory of the BK11x0

The CoE directory (B) of the BK11x0 (A) includes the coupler tables (C) and the terminal-specific registers (D).

Coupler tables

- from CoE 0x4000

Terminal register

- Set terminal number CoE 0x427F: 0 as a 2-byte value
- Address register in CoE 0x4280 - 0x4287
 - a KL terminal has a maximum of 4 channels [0 - 3], which have n registers
the registers 0 - 63 are each in channel n (LO)
the registers > 63 (if available) are each in channel n (HI)
 - the sub-index corresponds to the register number: **Subindex_{hex} = Register number + 1**
 - specify values /data as a 2-byte value

i Online display based on Fig. Online CoE directory of the BK11x0

The online display of register values, as shown in Fig. 1 in the CoE directory from CoE objects 0x4280ff, only works for KL terminals with register communication. If a terminal number is specified in CoE object 0x427F:

- which does not exist
- whose terminals do not feature register communication
the System Manager logger window shows "SDO Abort".

Example

Download (https://infosys.beckhoff.com/content/1033/bk11x0_bk1250/Resources/2180724363/.zip)

In this example program (TwinCAT 2.11, BK1120 with firmware 08), AoE and CoE register communication with a KL3314 (thermocouple terminal) is executed in the PLC. Here, register R34 (user scaling, offset) in Channel 1 is repeatedly incremented - success can be verified with the KS2000 software or via the visualization page; to do this, connect a type K thermocouple to channel 1.

Note: In the startup list of the BK1120, entries are available that set the user offset to a start value at each switch-on or INIT-OP transition.

5.3.4 Online parameterization of KL terminals via AoE

Access via AoE (ADS over EtherCAT) is useful from TwinCAT 2:11. An additional AoE NetId is required for the coupler used, so that the TwinCAT-internal ADS router can access it. It is useful to link this AoE NetId with the PLC program.

The same procedure is described [here](#) |▶ 66| to access the KL terminals with the KS2000 software via ADS.

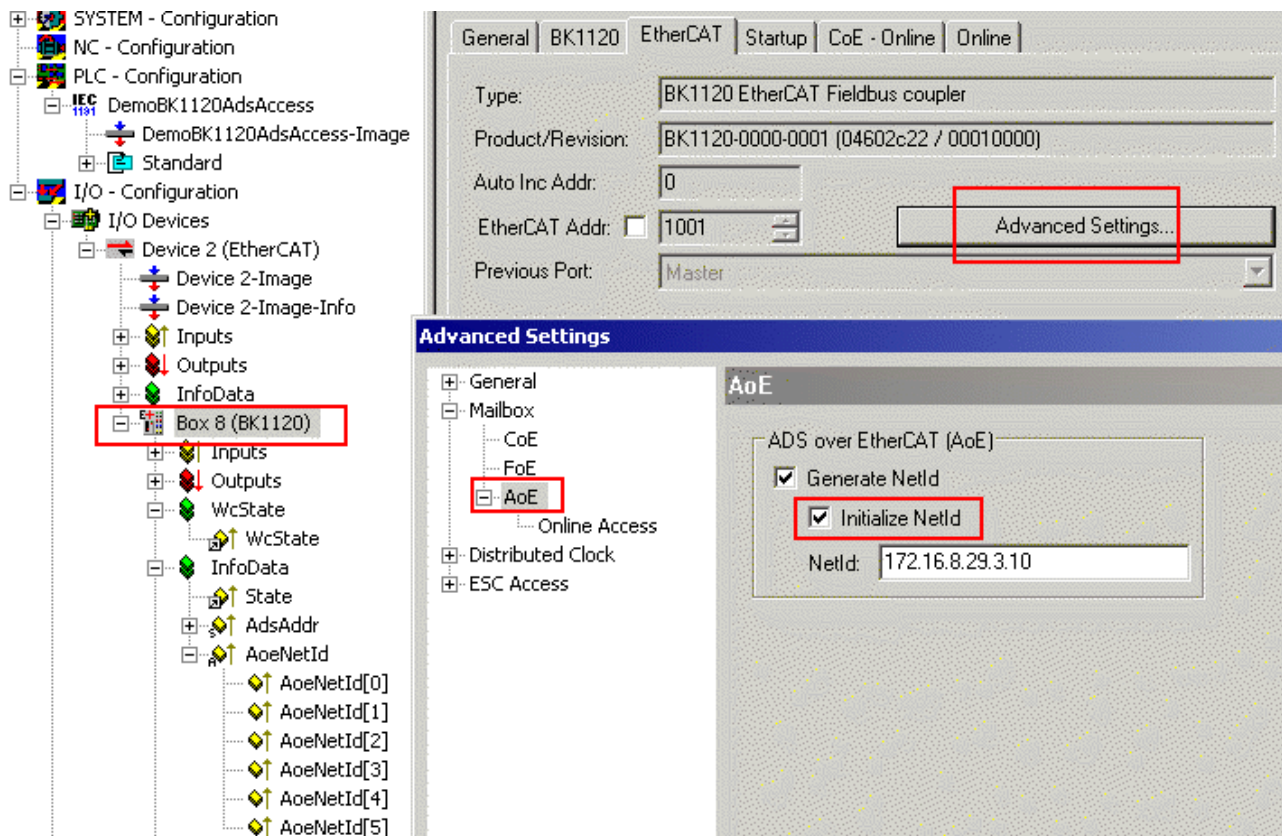


Fig. 31: Activation of the AoE NetID

The AoE NetId can be generated in the advanced settings of the BK11x0/BK1250. Optionally, it can be initialized with a pre-specified (unique!) start value.

After a TwinCAT restart it is available in the ADS router and can be used, for example, from the PLC.

The following applies to ADS accesses:

- AmsNetId: AoE NetID
- Port: 100
- IdxGrp: 0= coupler, 1.. = terminal number
- IdxOffset:

Channel	IdxGrp = 0, coupler	IdxGrp> 0, terminal number
High Word	Coupler table, e.g. 99	Terminal channel [0 - 3] for the channels 1 - 4
Low Word	Register	Register

A possible call would be:

- AmsNetId: 172.16.8.29.3.10
- Port: 100
- IdxGrp: 3 (3rd terminal after the coupler)
- IdxOffset: 0x0001001F (channel 2 of the terminal and register 31 [code word])

Example



Download (https://infosys.beckhoff.com/content/1033/bk11x0_bk1250/Resources/2180724363/.zip)

In this example program (TwinCAT 2.11, BK1120 with firmware 08), AoE and CoE register communication with a KL3314 (thermocouple terminal) is executed in the PLC. Here, register R34 (user scaling, offset) in Channel 1 is repeatedly incremented - success can be verified with the KS2000 software or via the visualization page; to do this, connect a type K thermocouple to channel 1.

Note: In the startup list of the BK1120, entries are available that set the user offset to a start value at each switch-on or INIT-OP transition.

5.3.5 Beckhoff coupler tables

The Beckhoff BK/BCxxxx Fieldbus Couplers feature internal information lists referred to as tables that are identified by unique numbers. The BK11x0/BK1250 maps these tables in its CoE directory, see [Object overview](#) [► 54].

Tables 0, 9, 90, 98, 99, 100 and 127 are available.

Table 9

Table 9, which maps the scanned state of the added terminals after the coupler is switched on, i.e. the status with which the terminals have identified themselves at the coupler, is helpful for terminal bus analysis. The first 63 K-bus devices are listed in CoE index 0x4012 and/or its subindices, the remaining devices in CoE index 0x4013, see Fig. *Table 9 with terminal type*.

Index	Name	Flags	Value
1B01:0	TxPDO Digital Align	RW	> 1 <
1C00:0	Sync Manager Type	RO	> 4 <
1C12:0	RxPDO Assign	RW	> 7 <
1C13:0	TxPDO Assign	RW	> 7 <
4000:0	Coupler Table 0 [LO]	RW	> 128 <
4001:0	Coupler Table 0 [HI]	RW	> 128 <
4012:0	Coupler Table 9 [LO] C	RO	> 7 <
4012:01	SubIndex 001	RO	0x04E2 (1250)
4012:02	SubIndex 002	RO	0x0CF2 (3314) D
4012:03	SubIndex 003	RO	0x8801 (34817)
4012:04	SubIndex 004	RO	0x8202 (33282)
4012:05	SubIndex 005	RO	0x0FA2 (4002)
4012:06	SubIndex 006	RO	0x0BF8 (3064)
4012:07	SubIndex 007	RO	0x0CF0 (3312)
4013:0	Coupler Table 9 [HI]	RO	> 0 <
4004:0	Coupler Table 90 [LO]	RO	> 128 <

Number	Terminal Name	Type	In Size	Out Size
1	Term 2 (KL3314) B	KL3314	16.0	16.0
2	Term 3 (KL1408)	KL1408	1.0	0.0
3	Term 4 (KL2012)	KL2012	0.0	0.2
4	Term 5 (KL4002)	KL4002	8.0	8.0
5	Term 6 (KL3064)	KL3064	16.0	16.0
6	Term 7 (KL3312)	KL3312	8.0	8.0
7	End Term (KL9010)	KL9010	0.0	0.0

Fig. 32: Table 9 with terminal type

SubIndex 1 is the "name" of the coupler itself, the terminals follow from subindex 2. Subindex 0 contains the number of terminals that were found. Since the subindex 1 contains the coupler name itself, the value in subindex 0 corresponds to the number of terminals, including the KL9010.

For each KL/KM terminal the type is specified as a 16-bit value based on the following key (see index [0x4012](#) [▶ 57](#))

Terminal type	High byte								Low byte								
	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0	
complex terminal (e.g. analog terminals)	0	terminal type (decimal) from terminal reg. 8															
simple digital input/output terminals	1	process data configuration [bit]							shift register Extension						1: KL1212	1: output terminal	1: input terminal

5.4 TwinCAT System Manager

5.4.1 BK1120, BK1150 - configuration overview

In the TwinCAT System Manager, in Config mode under Devices enter the BK1120 / BK1150 as EtherCAT device (Fig. *TwinCAT tree showing BK1120 as example*). Any Bus Couplers already connected to the network can also be read. This will cause all the Bus Couplers with Bus Terminals and their configurations to be loaded. You can then adapt these to meet your requirements.

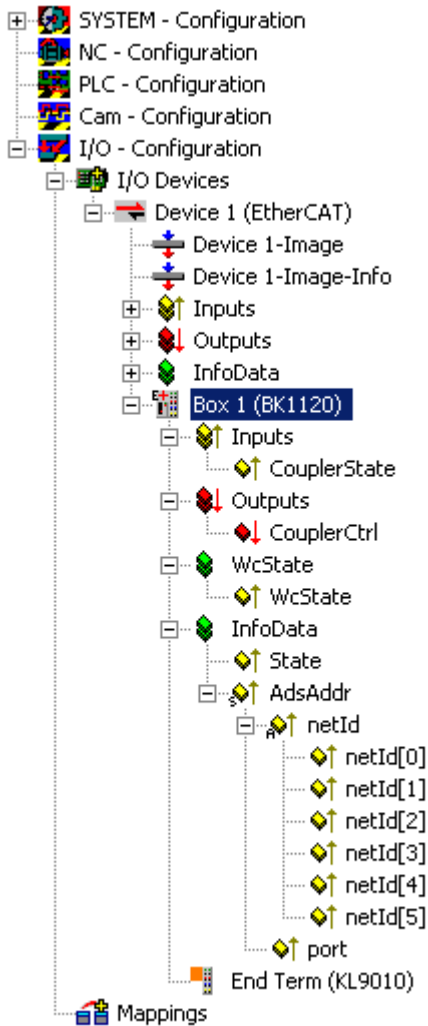


Fig. 33: TwinCAT tree showing BK1120 as example

5.4.2 BK1250 - configuration overview

The BK1250 can be added in the TwinCAT System Manager (Config mode) as a further box under a corresponding coupler (e.g. EK1100) by right-clicking in the terminal network (Fig. *TwinCAT tree BK1250*). If the Bus Coupler is already integrated in the network, it is automatically added as a box during scanning. Subsidiary Bus Terminals and their configuration are also uploaded.

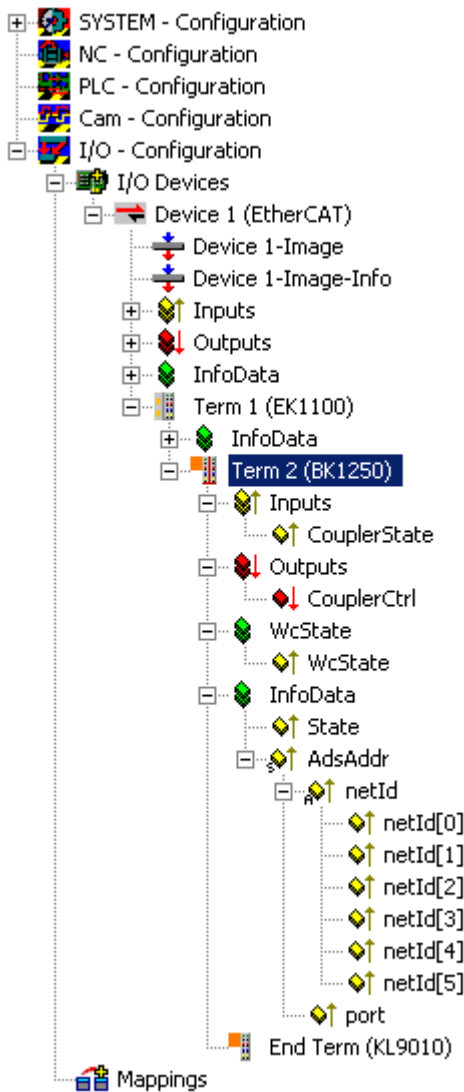


Fig. 34: TwinCAT tree BK1250

5.4.3 Inputs - configuration overview

CouplerState, "Online" tab

Display of general coupler errors.

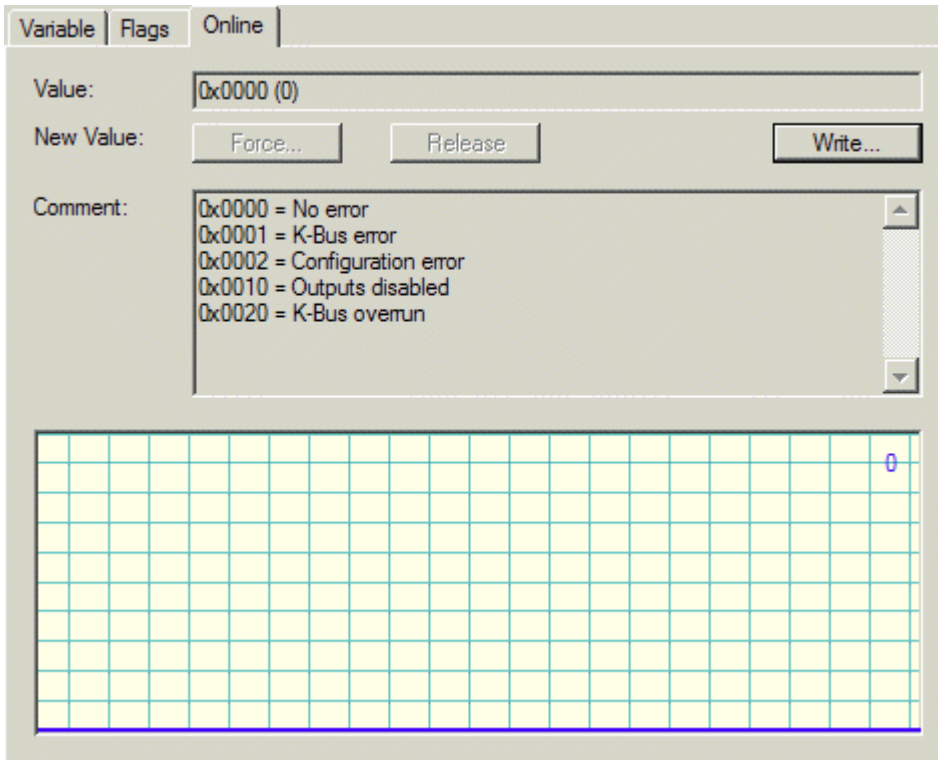


Fig. 35: CouplerState, "Online" tab

5.4.4 Outputs - configuration overview

CouplerCtrl, "Online" tab

Display of K-bus errors or deactivation of outputs.

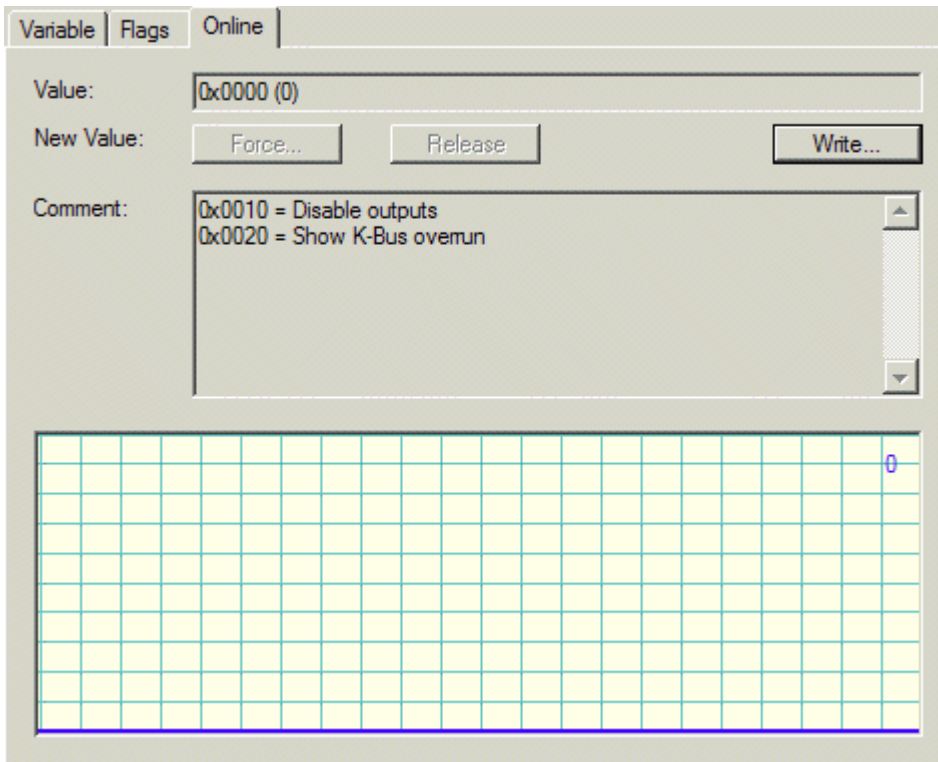


Fig. 36: CouplerCtrl, "Online" tab

5.4.5 Status of the working counter (Wc state) - configuration overview

WCstate, "Online" tab

Boolean variable indicating the working counter status of coupler. An invalid working counter (value: 1) is displayed if invalid data were transferred by the EtherCAT slave controller.

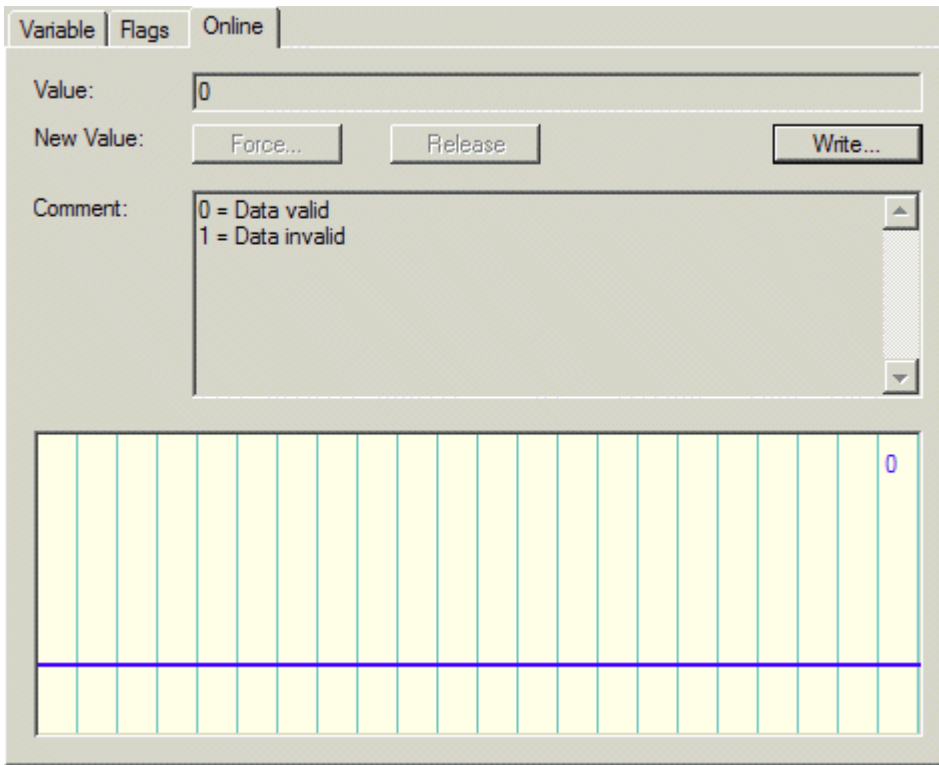


Fig. 37: WCstate, "Online" tab

5.4.6 Online status (info data) - configuration overview

State, "Online" tab

Indicates the online status of the coupler.

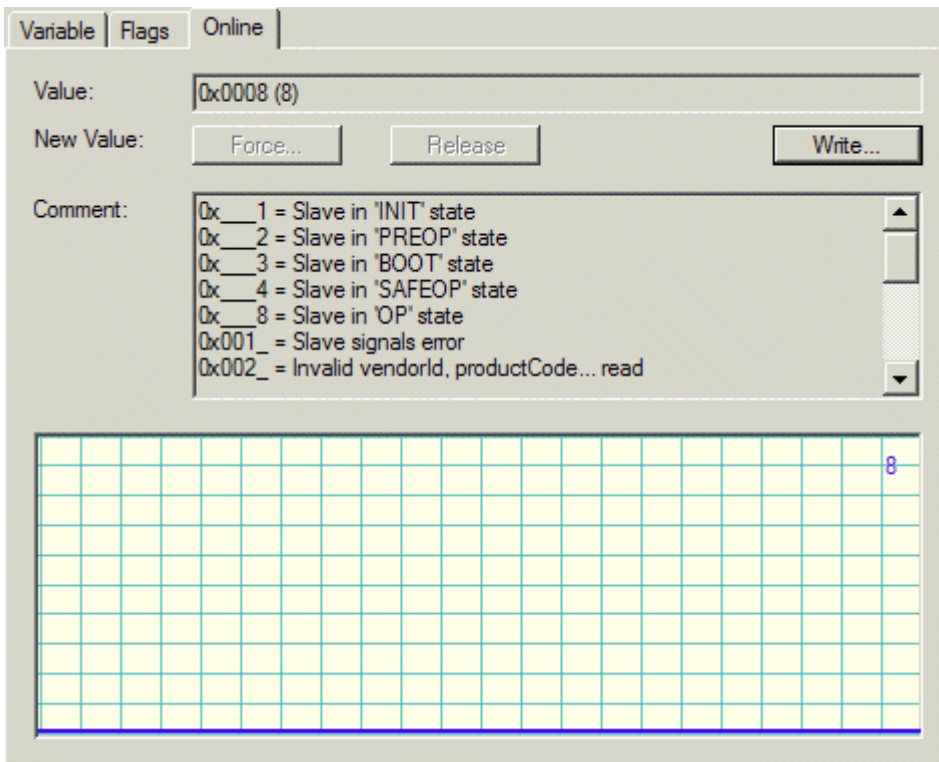


Fig. 38: State, "Online" tab

Value	Description
0x__1	Slave in 'INIT' state
0x__2	Slave in 'PREOP' state
0x__3	Slave in 'BOOT' state
0x__4	Slave in 'SAFEOP' state
0x__8	Slave in 'OP' state
0x001_	Slave signals error
0x002_	Invalid vendorId, productCode... read
0x004_	Initialization error occurred
0x010_	Slave not present
0x020_	Slave signals link error
0x040_	Slave signals missing link
0x080_	Slave signals unexpected link
0x100_	Communication port A
0x200_	Communication port B
0x400_	Communication port C
0x800_	Communication port D

5.4.7 ADS address (ADSAddr) - configuration overview

ADSAddr, Online tab

Single line indicating the AMS NetID and the AMS port of the coupler using the hexadecimal system. This information is required for mailbox communication via ADS.

Sample:

AC 10 06 31 02 01 (AMS netID) = 172.16.06.49.2.1
 03 E9 (port) = 1001_{dec}

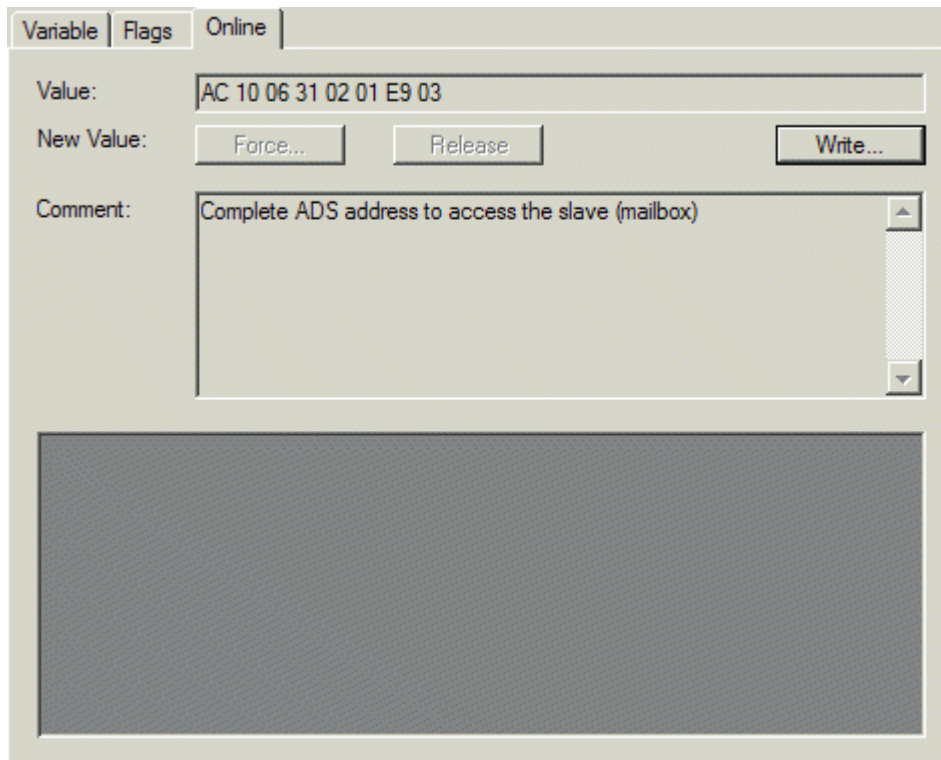


Fig. 39: ADSAddr, "Online" tab

5.4.8 EtherCAT cycle time - configuration overview

The EtherCAT cycle time with which the couplers can be operated should be considered in conjunction with the achieved K-bus cycle time. The cycle time achieved with the K-bus terminals is shown in the BK1250 tab (or BK1120 / BK1150).

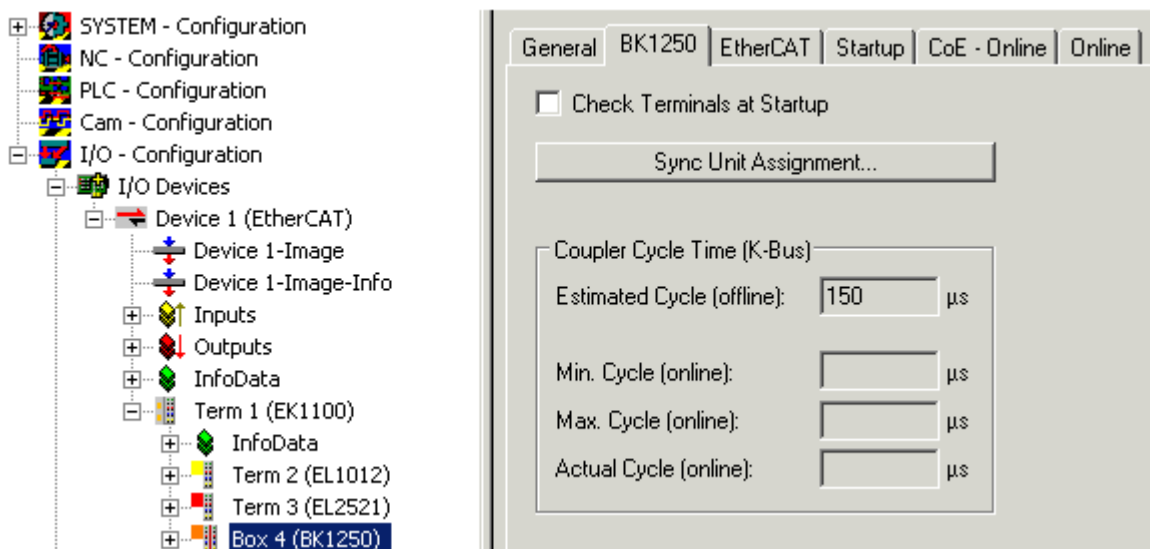


Fig. 40: BK1250, "BK1250" tab

If the EtherCAT cycle time exceeds the K-bus cycle time both systems operate in synchronous mode. The K-bus is started after an EtherCAT telegram and copies its inputs into the memory. They are retrieved with the next EtherCAT telegram, i.e. the inputs are always one cycle old.

If the EtherCAT cycle is shorter than the K-bus cycle, the K-bus operates asynchronous relative to EtherCAT. Faster polling than "Estimated Cycle (offline)" is therefore possible but may lead to outdated input data or outputs not being set in time via the K-bus.

The EtherCAT cycle applied to the BK1120 / BK1150 (BK1250) should therefore be significantly greater than the "Estimated Cycle (offline)" (min. 250 μs, depending on the Bus Terminal configuration). Online control in the system through "Max. Cycle (online)" or "CouplerState" is recommended.

5.4.9 Object description

5.4.9.1 Standard objects

Index 1000: Device type

Device type (read only) of the EtherCAT slave.

Index 1008 Device name

Device name (read only, value: e.g. BK1120-0000-0000) of the EtherCAT slave.

Index 1009 Hardware version

Hardware version (read only) of the EtherCAT slave.

Index 100A Software version

Version (read only, value: e.g. 07 (B7)) of the firmware (chip for processing the I/O signals) of the EtherCAT slave.

Index 1018 Identity object

Index (hex)	Name	Meaning	Flags	Default
1018:0	Identity object	Length of this object	RO	-
1018:01	Vendor id	Vendor ID of the EtherCAT slave	RO	0x00000002 (2 _{dec})
1018:02	Product code	Product code of the EtherCAT slave	RO	0x04602C22 (73411618 _{dec})
1018:03	Revision number	Revision number of the EtherCAT slave	RO	0x00000000 (0 _{dec})
1018:04	Serial number	Serial number of the EtherCAT slave	RO	0x00000000 (0 _{dec})

Index 16kk RxDPO Mapping Terminal

Value ranges:

(kk = 00..FE)_{hex} ,
 [(hh = 01..FF)_{hex} , (ddd = 001..255)]_{dec}

Index (hex)	Name	Meaning	Flags	Default
16kk:0	RxDPO Mapping Terminal	Length of this object	RW	-
16kk:01	Output Mapping Area 001	First output variable of this terminal (subindex 001)	RW	e.g. 0x7kk0:01, 1
16kk:hh	Output Mapping Area ddd	Last output variable (subindex ddd)	RW	e. g. 0x7kk0:hh, 1

Index 16FF Control PDO

Index (hex)	Name	Meaning	Flags	Default
16FF:0	Control PDO	Length of this object	RW	-
16FF:01	Output Mapping Area	Control word	RW	0xF200:01, 16

Index 1701 RxDPO Digital Align

Index (hex)	Name	Meaning	Flags	Default
1701:0	RxDPO Digital Align	Length of this object	RW	-
1701:01	PDO Align	Word Alignment Dummy for Digital RxDPOs	RW	0x0000:00, 00

Index 1Akk TxPDO Mapping Terminal

Value ranges:

(kk = 00..FE)_{hex} ,
 [(hh = 01..FF)_{hex} , (ddd = 001..255)]_{dec}]

Index (hex)	Name	Meaning	Flags	Default
1Akk:0	TxDPO Mapping Terminal	Length of this object	RW	-
1Akk:01	Input Mapping Area 001	First input variable of this terminal (subindex 001)	RW	e.g. 0x6kk0:01, 1
1Akk:hh	Input Mapping Area ddd	Last input variable for this terminal (subindex ddd)	RW	e.g. 0x6kk0:hh, 1

Index 1AFF Status PDO

Index (hex)	Name	Meaning	Flags	Default
16FF:0	Status PDO	Length of this object	RW	-
16FF:01	Input Mapping Area	Status word	RW	0xF100:01, 16

Index 1B01 TxPDO Digital Align

Index (hex)	Name	Meaning	Flags	Default
1B01:0	TxDPO Digital Align	Length of this object	RW	-
1B01:01	PDO Align	Word Alignment Dummy for Digital TxPDOs	RW	0x0000:00, 00

Index 1C00 SM type

Index (hex)	Name	Meaning	Flags	Default
1C00:0	Sync Manager Type	Length of this object	RO	4
1C00:01	Subindex 001	Sync manager, parameter 1	RO	0x01 (1 _{dec})
1C00:02	Subindex 002	Sync manager, parameter 2	RO	0x02 (2 _{dec})
1C00:03	Subindex 003	Sync manager, parameter 3	RO	0x03 (3 _{dec})
1C00:04	Subindex 004	Sync manager, parameter 4	RO	0x04 (4 _{dec})

Index 1C12 RxPDO Assign

Value ranges:

[(hh = 01..FF)_{hex}, (ddd = 001..255)_{dec}]

Index (hex)	Name	Meaning	Flags	Default
1C12:0	RxPDO Assign	Length of this object	RW	-
1C32:01	Subindex 001	Assignment of the control PDO	RW	0x16FF(5887 _{dec})
1C12:02	Subindex 002	Assignment of first RxPDO analog terminals	RW	e.g. 0x1603 (5635 _{dec})
1C12:nn	Subindex nnn	Assignment of n th RxPDO analog terminals	RW	e.g. 0x1605 (5637 _{dec})
1C12:(nn+1)	Subindex (nnn+1)	Assignment of (n+1) th RxPDO digital terminals	RW	e.g. 0x1600 (5632 _{dec})
1C12:hh	Subindex ddd	Assignment Word Alignment Dummy for Digital RxPDOs	RW	0x1701(5889 _{dec})

Index 1C13 TxPDO Assign

Value ranges:

[(hh = 01..FF)_{hex}, (ddd = 001..255)_{dec}]

Index (hex)	Name	Meaning	Flags	Default
1C13:0	TxPDO Assign	Length of this object	RW	-
1C13:01	Subindex 001	Assignment of the control PDO	RW	0x1AFF(6911 _{dec})
1C13:02	Subindex 002	Assignment of first TxPDO analog terminals	RW	e.g. 0x1A03 (6659 _{dec})
1C13:nn	Subindex nnn	Assignment of n th TxPDO analog terminals	RW	e.g. 0x1A05 (6661 _{dec})
1C13:(nn+1)	Subindex (nnn+1)	Assignment of (n+1) th TxPDO digital terminals	RW	e.g. 0x1A01 (6657 _{dec})
1C13:hh	Subindex ddd	Assignment Word Alignment Dummy for Digital TxPDOs	RW	0x1B01(6913 _{dec})

5.4.9.2 Device-specific objects**Index 4000 Coupler Table 0 [LO]: general configuration of the Bus Coupler**

Index (hex)	Name	Meaning	Flags	Default
4000:0	Coupler Table 0 [LO]	Length of this object	RW	128
4000:01	Subindex 001	Register 0	RW	
4000:02	Subindex 002	Register 1	RW	
4000:80	Subindex 128	Register 127	RW	

Index 4001 Coupler Table 0 [HI]: general configuration of the Bus Coupler (cont.)

Index (hex)	Name	Meaning	Flags	Default
4001:0	Coupler Table 0 [HI]	Length of this object	RW	128
4001:01	Subindex 001	Register 128	RW	
4001:02	Subindex 002	Register 129	RW	
4001:80	Subindex 128	Register 255	RW	

Index 4012 Coupler Table 9 [LO]: Configuration of the Bus Terminal block

Index (hex)	Name	Meaning	Flags	Default
4012:0	Coupler Table 9 [LO]	Length of this object	RO	max. 128
4012:01	Subindex 001	Register 0: Name of the Bus Coupler	RO	0x0460 (1120 _{dec} ¹)
4012:02	Subindex 002	Register 1: Name of the first terminal	RO	e.g.: 0x8201 (33281 _{dec} ²)
4012:03	Subindex 003	Register 2: Name of the 2 nd terminal	RO	e.g.: 0x0BBA (3002 _{dec} ¹)
4012:04	Subindex 004	Register 3: Name of the 3 rd terminal	RO	e.g.: 0x0C84 (3204 _{dec} ¹)
4012:80	Subindex 128	Register 127: Name of the 127 th terminal	RO	

¹⁾ For Bus Coupler and intelligent (e.g. analog) terminals, the terminal designation is specified decimally in plain text; e.g. 0x0C84 (3204_{dec}) means KL3204.

²⁾ For simple (digital) terminals, the following coding applies:

Bit	Value	Meaning	
15	0 _{bin}	intelligent (e.g. analog) terminal	
	1 _{bin}	simple (digital) terminal	
14...8	xxxxxx _{bin}	terminal size in bit (range of values: 0 to 63 bit)	
7	1 _{bin}	Shift register extension for Control Panels	
6...3	0 _{bin}	reserved	
2	1 _{bin}	KL1212	
1	1 _{bin}	Output terminal	Special case: 00 _{bin} means KL1202 or KL2212 (digital terminals with input and output data)
0	1 _{bin}	Input terminal	

Index 4013 Coupler Table 9 [HI]: Configuration of the Bus Terminal block (continuation if more than 127 terminals)

Index (hex)	Name	Meaning	Flags	Default
4013:0	Coupler Table 9 [HI]	Length of this object	RO	max. 128 _{dec}
4013:01	Subindex 001	Register 128: Name of the 128 th terminal	RO	
4013:02	Subindex 002	Register 129: Name of the 129 th terminal	RO	
4013:04	Subindex 128	Register 255: Name of the 255 th terminal	RO	

Index 40B4 Coupler Table 90 [LO]: Internal diagnostic information for the Bus Coupler

Index (hex)	Name	Meaning	Flags	Default
40B4:0	Coupler Table 90 [LO]	Length of this object	RO	128 _{dec}
40B4:01	Subindex 001	Register 0: reserved	RO	
40B4:02	Subindex 002	Register 1: reserved	RO	
40B4:04	Subindex 128	Register 127: reserved	RO	

Index 40B5 Coupler Table 90 [HI]: Internal diagnostic information for the Bus Coupler (cont.)

Index (hex)	Name	Meaning	Flags	Default
40B5:0	Coupler Table 90 [HI]	Length of this object	RO	128 _{dec}
40B5:01	Subindex 001	Register 128: reserved	RO	
40B5:02	Subindex 002	Register 129: reserved	RO	
40B5:04	Subindex 128	Register 255: reserved	RO	

Index 40C4 Coupler Table 98 [LO]: Pd Update time (µs)

Index (hex)	Name	Meaning	Flags	Default
40C4:0	Coupler Table 98 Pd Update time (µs)	Length of this object	RW	5
40C4:01	Min time	minimum update time on the K-bus	RW	0x0355 (853 _{dec})
40C4:02	Max time	maximum update time on the K-bus	RW	0x059A (1434 _{dec})
40C4:03	Curr time	current update time on the K-bus	RW	0x036A (874 _{dec})
40C4:04	-	reserved	RW	0x0000 (0 _{dec})
40C4:50	-	reserved	RW	0x09F8 (2552 _{dec})

Index 40C5 Coupler Table 98 [HI]: Pd update time (μ s) (cont.)

Index (hex)	Name	Meaning	Flags	Default
40C5:0	Coupler Table 98 Pd Update time (μ s)	Length of this object	RW	0

Index 40C8 Coupler Table 100 [LO]: Reserved for internal fieldbus-specific settings

Index (hex)	Name	Meaning	Flags	Default
40C8:0	Coupler Table 100 [LO]	Length of this object	RO	128 _{dec}
40C8:01	Subindex 001	Register 0: reserved	RO	
40C8:02	Subindex 002	Register 1: reserved	RO	
40C8:04	Subindex 128	Register 127: reserved	RO	

Index 40C9 Coupler Table 100 [HI]: Reserved for internal fieldbus-specific settings (cont.)

Index (hex)	Name	Meaning	Flags	Default
40C9:0	Coupler Table 100 [HI]	Length of this object	RO	128 _{dec}
40C9:01	Subindex 001	Register 128: reserved	RO	
40C9:02	Subindex 002	Register 129: reserved	RO	
40C9:04	Subindex 128	Register 255: reserved	RO	

Index 40FE Coupler Table 127 [LO]: Reserved for internal settings

Index (hex)	Name	Meaning	Flags	Default
40FE:0	Coupler Table 100 [LO]	Length of this object	RO	128 _{dec}
40FE:01	Subindex 001	Register 0: reserved	RO	
40FE:02	Subindex 002	Register 1: reserved	RO	
40FE:04	Subindex 128	Register 127: reserved	RO	

Index 40FF Coupler Table 127 [HI]: Reserved for internal settings (cont.)

Index (hex)	Name	Meaning	Flags	Default
40FF:0	Coupler Table 100 [HI]	Length of this object	RO	128 _{dec}
40FF:01	Subindex 001	Register 128: reserved	RO	
40FF:02	Subindex 002	Register 129: reserved	RO	
40FF:04	Subindex 128	Register 255: reserved	RO	

Index 427F Terminal No

Index (hex)	Name	Meaning	Flags	Default
427F:0	Terminal No	Number of the terminal in the Bus Terminal block, which can be parameterized with the following four tables (object 4280 - 4287). Counting method: the Bus Coupler is no. 0 in the Bus Terminal block. The first terminal connected to the Bus Coupler is no. 1 etc. Only intelligent terminals (with register set) can be parameterized!	RO	3

Index 4280 Terminal Table 0 [LO]: for parameterization of the terminal specified with object 427F

Index (hex)	Name	Meaning	Flags	Default
4280:0	Terminal Table 0	Length of this object	RW	64
4280:01	Subindex 001	Register 0	RW	0x0000 (0 _{dec})
4280:02	Subindex 002	Register 1	RW	0x0000 (0 _{dec})
4280:40	Subindex 064	Register 63	RW	0x0000 (0 _{dec})

Index 4281 Terminal Table 0 [HI]: for parameterization of the terminal specified with object 427F (cont.)

Index (hex)	Name	Meaning	Flags	Default
4081:0	Terminal Table 0	Length of this object	RW	0

Index 4282 Terminal Table 1 [LO]: for parameterization of the terminal specified with object 427F

Index (hex)	Name	Meaning	Flags	Default
4282:0	Terminal Table 1	Length of this object	RW	64
4282:01	Subindex 001	Register 0	RW	0x0000 (0 _{dec})
4282:02	Subindex 002	Register 1	RW	0x0000 (0 _{dec})
4282:40	Subindex 064	Register 63	RW	0x0000 (0 _{dec})

Index 4283 Terminal Table 1 [HI]: for parameterization of the terminal specified with object 427F (cont.)

Index (hex)	Name	Meaning	Flags	Default
4083:0	Terminal Table 1	Length of this object	RW	0

Index 4284 Terminal Table 2 [LO]: for parameterization of the terminal specified with object 427F

Index (hex)	Name	Meaning	Flags	Default
4284:0	Terminal Table 2	Length of this object	RW	64
4284:01	Subindex 001	Register 0	RW	0x0000 (0 _{dec})
4284:02	Subindex 002	Register 1	RW	0x0000 (0 _{dec})
4284:40	Subindex 064	Register 63	RW	0x0000 (0 _{dec})

Index 4285 Terminal Table 2 [HI]: for parameterization of the terminal specified with object 427F (cont.)

Index (hex)	Name	Meaning	Flags	Default
4085:0	Terminal Table 2	Length of this object	RW	0

Index 4286 Terminal Table 3 [LO]: for parameterization of the terminal specified with object 427F

Index (hex)	Name	Meaning	Flags	Default
4286:0	Terminal Table 3	Length of this object	RW	64
4286:01	Subindex 001	Register 0	RW	0x0000 (0 _{dec})
4286:02	Subindex 002	Register 1	RW	0x0000 (0 _{dec})
4286:40	Subindex 064	Register 63	RW	0x0000 (0 _{dec})

Index 4287 Terminal Table 3 [HI]: for parameterization of the terminal specified with object 427F (cont.)

Index (hex)	Name	Meaning	Flags	Default
4087:0	Terminal Table 3	Length of this object	RW	0

Index 6kk0 Terminal Input Data

i Mapping

The value ranges of the "kk", "hh", and "ddd" variables of the input and output indices are shown below [► 61]. The dynamic generation of the input and output objects depends on the order of the terminals in the Bus Terminal block.

Example configuration of the Bus Terminal block

BK1120 - KL1408 - KL2032 - K3403 - KL4032

Mapping of the assigned PDOs (from index 0x6000)

Index (hex)	Name	Meaning		
6000:0	KL1408	KL1408, max. Subindex (8)	Position 1 after the coupler: KL1408	Input data
6000:01	Channel 1	Channel 1, KL1408		
6000:02	Channel 2	Channel 2, KL1408		
6000:03	Channel 3	Channel 3, KL1408		
6000:04	Channel 4	Channel 4, KL1408		
6000:05	Channel 5	Channel 5, KL1408		
6000:06	Channel 6	Channel 6, KL1408		
6000:07	Channel 7	Channel 7, KL1408		
6000:08	Channel 8	Channel 8, KL1408		
6010:0		not mapped, since no inputs available	Position 2 after the coupler: KL2032	
6020:0	KL3403	KL3403, max. Subindex (9)	Position 3 after the coupler: KL3403	
6020:01	Channel 1 Status	Channel 1, status, KL3403		
6020:02	Channel 1 Word Aligment	Channel 1, word alignment KL3403		
6020:03	Channel 1 Data	Channel 1, data KL3403		
6020:04	Channel 2 Status	Channel 2, status, KL3403		
6020:05	Channel 2 Word Aligment	Channel 2, word alignment, KL3403		
6020:06	Channel 2 Data	Channel 2, data, KL3403		
6020:07	Channel 3 Status	Channel 3, status, KL3403		
6020:08	Channel 3 Word Aligment	Channel 3, word alignment, KL3403		
6020:09	Channel 3 Data	Channel 3, data, KL3403		
6030:0	KL4032	KL4032, max. Subindex (6)	Position 4 after the coupler: KL4032	
6030:01	Channel 1 Status	Channel 1, status, KL4032		
6030:02	Channel 1 Word Aligment	Channel 1, word alignment KL4032		
6030:03	Channel 1 Data	Channel 1, data KL4032		
6030:04	Channel 2 Status	Channel 2, status, KL4032		
6030:05	Channel 2 Word Aligment	Channel 2, word alignment KL4032		
6030:06	Channel 2 Data	Channel 2, data, KL4032		

Index (hex)	Name	Meaning		
7000:0		not mapped, since no outputs available	Position 1 after the coupler: KL1408	Output data
7010:0	KL2032	KL2032, max. Subindex (2)	Position 2 after the coupler: KL2032	
7010:01	Channel 1	Channel 1, KL2032		
7010:02	Channel 2	Channel 2, KL2032		
7020:0	KL3403	KL3403, max. Subindex (9)	Position 3 after the coupler: KL3403	
7020:01	Channel 1 Status	Channel 1, status, KL3403		
7020:02	Channel 1 Word Alignment	Channel 1, word alignment KL3403		
7020:03	Channel 1 Data	Channel 1, data KL3403		
7020:04	Channel 2 Status	Channel 2, status, KL3403		
7020:05	Channel 2 Word Alignment	Channel 2, word alignment, KL3403		
7020:06	Channel 2 Data	Channel 2, data, KL3403		
7020:07	Channel 3 Status	Channel 3, status, KL3403		
7020:08	Channel 3 Word Alignment	Channel 3, word alignment, KL3403		
7020:09	Channel 3 Data	Channel 3, data, KL3403		
7030:0	KL4032	KL4032, max. Subindex (6)	Position 4 after the coupler: KL4032	
7030:01	Channel 1 Status	Channel 1, status, KL4032		
7030:02	Channel 1 Word Alignment	Channel 1, word alignment KL4032		
7030:03	Channel 1 Data	Channel 1, data KL4032		
7030:04	Channel 2 Status	Channel 2, status, KL4032		
7030:05	Channel 2 Word Alignment	Channel 2, word alignment KL4032		
7030:06	Channel 2 Data	Channel 2, data, KL4032		

Value ranges:

$(kk = 00..FF)_{hex}$, $[(hh = 01..FF)_{hex}, (ddd = 001..255)_{dec}]$

Index (hex)	Name	Meaning	Flags	Default
6kk0:0	Terminal Input Data	[Terminal designation]	RO P	-
6kk0:01	Channel 001	Channel 001	RO P	-
6kk0:hh	Channel ddd	Channel ddd	RO P	-

Non-digital terminals (for hh ≥ 03; ddd ≥ 003):

Value ranges:

$(kk = 00..FF)_{hex}$, dec. increment $(_{hex})$
 $[(hh = 03..FF)_{hex}, (ddd = 003..255)_{dec}]$ for integer values that are divisible by 3 hh or ddd

Index (hex)	Name	Meaning	Flags	Default
6kk0:0	Terminal Input Data	[Terminal designation]	RO P	-
6kk0:01	Channel 001 Status	Channel 001: Status	RO P	-
6kk0:02	Channel 001 Word-Alignment	Channel 001: Word Alignment	RO P	-
6kk0:03	Channel 001 Data	Channel 001: Data	RO P	-
6kk0:hh-2	Channel ddd/3	Channel ddd/3: Status	RO P	-
6kk0:hh-1	Channel ddd/3	Channel ddd/3: Word Alignment	RO P	-
6kk0:hh	Channel ddd/3	Channel ddd/3: Data	RO P	-

Index 7kk0 Terminal Output Data

Digital terminals:

Value ranges:

$(kk = 00..FF)_{hex}$, $[(hh = 01..FF)_{hex}, (ddd = 001..255)_{dec}]$

Index (hex)	Name	Meaning	Flags	Default
7kk0:0	Terminal Output Data	[Terminal designation]	RO P	-
7kk0:01	Channel 001	Channel 001	RO P	-
7kk0:hh	Channel ddd	Channel ddd	RO P	-

Non-digital terminals (for hh ≥ 03; ddd ≥ 003):

Value ranges: (kk = 00..FF)_{hex},
 [(hh = 03..FF)_{hex}, (ddd = 003..255)_{dec}] for integer values that are divisible by 3 hh or ddd

Index (hex)	Name	Meaning	Flags	Default
7kk0:0	Terminal Input Data	[Terminal designation]	RO P	-
7kk0:01	Channel 001 Ctrl	Channel 001: Control	RO P	-
7kk0:02	Channel 001 Word-Alignment	Channel 001: Word Alignment	RO P	-
7kk0:03	Channel 001 Data	Channel 001: Data	RO P	-
7kk0:hh-2	Channel ddd/3 Ctrl	Channel ddd/3: Control	RO P	-
7kk0:hh-1	Channel ddd/3 Word Alignment	Channel ddd/3: Word Alignment	RO P	-
7kk0:hh	Channel ddd/3 Data	Channel ddd/3: Data	RO P	-

Index 9kk0 Slave Info Data

Value ranges:
 (kk = 00..FF)_{hex}

Index (hex)	Name	Meaning	Flags	Default
9kk0:0	Slave Info Data	[Terminal designation]	RO	-
9kk0:01	Position	Module position in the terminal network	RO	-
9kk0:09	Module PDO Group	Module PDO Group <ul style="list-style-type: none"> • Non-digital terminals: Group 1 • Digital terminals: Group 2 	RO	-
9kk0:0A	Module Ident	Module name (terminal designation) [► 57]	RO	-

Index F000 Modular Device Profile

Index (hex)	Name	Meaning	Flags	Default
F000:0	Modular Device Profile	Length of this object	RO	5
F000:01	Module Index Distance	Module Index Distance	RO	0x0010 (16 _{dec})
F000:02	Maximum Number of Modules	Max. number of K-bus modules	RO	0x00FF (255 _{dec})
F000:03	Standard Entries in Object 0x8yy0	Possible entries in object 0x8kk0	RO	0x0000000 (0 _{dec})
F000:04	Standard Entries in Object 0x9yy0	Possible entries in object 0x9kk0	RO	0x0000300 (0 _{dec})
F000:04	Module PDO Group	Module PDO group of device = 0, (control and status word data are assigned before all terminals in the process data)	RO	0x00 (0 _{dec})

Index F00E Group Alignment PDO

Index (hex)	Name	Meaning	Flags	Default
F00E:0	Group Alignment PDO	Length of this object (3 PDO terminal groups)	RO	3
F00E:01	Subindex 001	Group 0: no alignment required	RO	0x0000 (0 _{dec})
F00E:02	Subindex 002	Group 1: PDO alignment (PDO 257) for PDO group 1 (non-digital terminals)	RO	0x0100 (256 _{dec})
F00E:03	Subindex 003	Group 2: PDO alignment (PDO 258) for PDO group 2 (digital terminals)	RO	0x0101 (257 _{dec})

Index F00F Module Group Mapping Alignment

Index (hex)	Name	Meaning	Flags	Default
F00F:0	Module Group Mapping Alignment	Length of this object (3 PDO terminal groups)	RO	3
F00F:01	Subindex 001	Group 0: no alignment for PDO group 0 required, control and status word data are fixed	RO	0x0000 (0 _{dec})
F00F:02	Subindex 002	Group 1: word alignment for PDO group 1 (non-digital terminals). In this way, the following process data for the digital terminals are always assigned to an even byte address	RO	0x0002 (2 _{dec})
F00F:03	Subindex 003	Group 2: word alignment for PDO group 2 (digital terminals). The process data size of the digital terminals is always even-numbered.	RO	0x0002 (2 _{dec})

Index F010 Module List

Value ranges:
(hh = 01..FF)_{hex}, (ddd = 001..255)_{dec}

Index (hex)	Name	Meaning	Flags	Default
F010:0	Module list	Length of this object	RO	-
F010:01	Subindex 001	Terminal designation module [► 57] 001	RO	-
F010:hh	Subindex ddd	Terminal designation module [► 57] ddd	RO	-

Index F030 Configured Module List

Value ranges:
(hh = 01..FF)_{hex}, (ddd = 001..255)_{dec}

Index (hex)	Name	Meaning	Flags	Default
F030:0	Module list	Length of this object	RW	-
F030:01	Subindex 001	Terminal designation of the configured terminal at position 1 (value as 0x8kk0:0A)	RW	-
F030:hh	Subindex ddd	Terminal designation of the configured terminal at the last position (value as 0x8kk0:0A)	RW	-

Index F040 Detected Address List

Value ranges:
(hh = 01..FF)_{hex}, (ddd = 001..255)_{dec}

Index (hex)	Name	Meaning	Flags	Default
F040:0	Module list	Length of this object	RO	-
F040:01	Subindex 001	Position of the first terminal (value as 0x9kk0:01 [► 62])	RO	0x0001 (1 _{dec})
F040:hh	Subindex ddd	Position of the last terminal (value as 0x9kk0:01 [► 62])	RO	0x00hh (ddd _{dec})

Index F050 Detected Module List

Value ranges:
(hh = 01..FF)_{hex}, (ddd = 001..255)_{dec}

Index (hex)	Name	Meaning	Flags	Default
F050:0	Module list	Length of this object	RO	-
F050:01	Subindex 001	Terminal designation of the terminal at position 1 (value as 0x9kk0:0A [► 62])	RO	-
F050:hh	Subindex ddd	Terminal designation of the terminal at last position (value as 0x9kk0:0A [► 62])	RO	-

Index F100 Status PDO

Index (hex)	Name	Meaning	Flags	Default
F100:0	Status PDO	Length of this object	RO	1
F100:01	CouplerState	Coupler status word	RO P	0x0000 (0 _{dec})

Index F200 Control PDO

Index (hex)	Name	Meaning	Flags	Default
F100:0	ControlPDO	Length of this object	RO	1
F100:01	CouplerCtrl	Coupler control word	RO P	0x0000 (0 _{dec})

5.4.10 Mapping the Bus Terminals

The precise assignment of the byte-oriented Bus Terminals may be found in the configuration guide for the particular bus terminal. This documentation is available on the Beckhoff *Products & Solutions* CD or on the Internet under <http://www.beckhoff.de>.

Byte oriented Bus Terminals	Bit oriented Bus Terminals
KL15x1	KL10xx, KL11xx, KL12xx, KL17xx, KM1xxx
KL25xx	KL20xx, KL21xx, KL22xx, KL26xx, KL27xx, KM2xxx
KL3xxx	
KL4xxx	
KL5xxx	
KL6xxx	
KL7xxx	
KL8xxx	
	KL9110, KL9160, KL9210, KL9260

5.4.11 Process image example

The following examples with the BK1120 illustrates the process image of a Bus Terminal block.

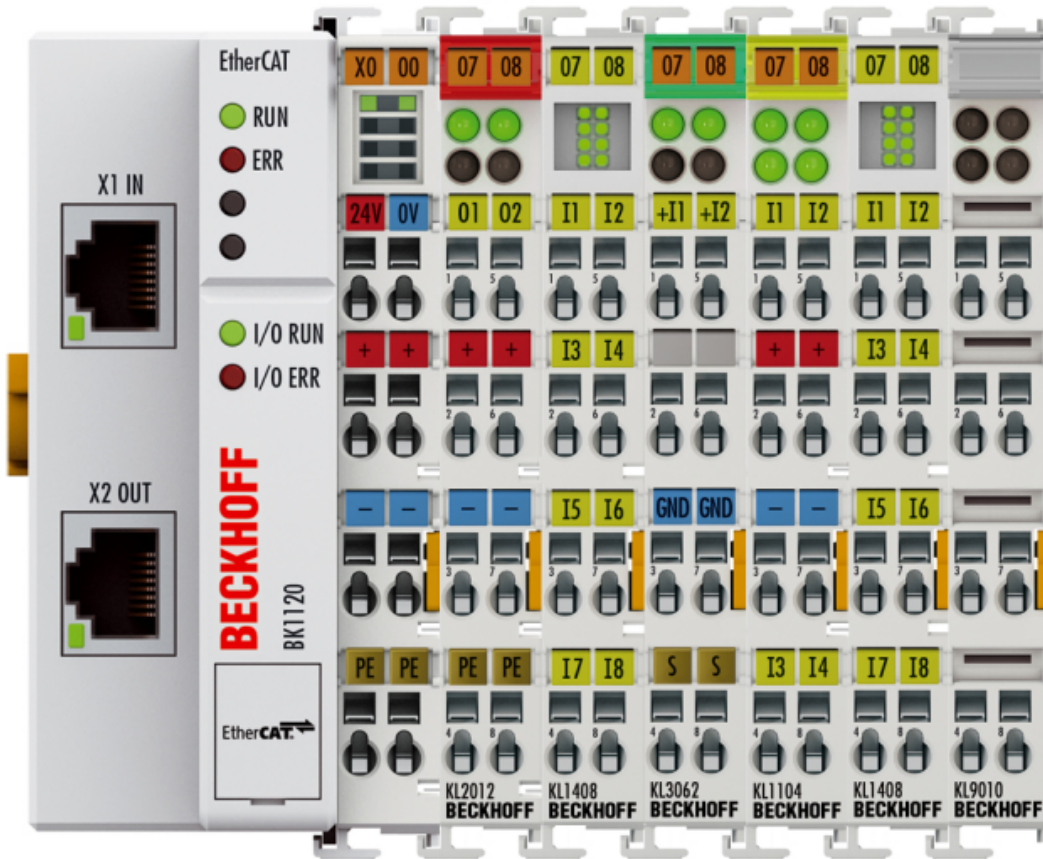


Fig. 41: Configuration example for explaining the process image

The Bus Terminal block shown in the example consists of a Bus Coupler with attached KL2012, KL1408, KL3062, KL1104, KL1408 and KL9010 (see image). For complex mapping with Word alignment (factory settings) all non-digital terminals are shown in the process input and output image. Please refer to the relevant terminal documentation regarding the mapping details. The non-digital terminals are mapped first, followed by the digital terminals. The first 16 bits of the process image are reserved for the status word (process input image) and the control word (process output image).

Process input image

The status word (SW) is located in the output process image, and is transmitted from terminal to the controller.

Word-Offset		High byte							Low byte								
		15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	Status								K-bus overr.	Outputs disabled	no valid output data	no valid input data				Config Error	K- bus Error
1	KL3062 (non- digital)	Dummy for Word alignment							Status byte channel 1								
2		Process data channel 1															
3		Dummy for Word alignment							Status byte channel 2								
4		Process data channel 2															
5	Digital terminals	KL1408 (2)				KL1104			KL1408 (1)								
6									KL1408 (2)								

Process output image

The control word (CW) is located in the output process image, and is transmitted from the controller to the terminal.

Word-Offset		High byte								Low byte								
		15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0	
0	Control								Show K-bus overrun	Disable Outputs								
1	KL3062 (non- digital)	Dummy for Word alignment								Control byte channel 1								
2		Register communication data channel 1																
3		Dummy for Word alignment								Control byte channel 2								
4		Register communication data channel 2																
5	Digital terminals																	KL2012

5.5 KS2000 Configuration Software

5.5.1 Example: Parameterization with the KS2000 configuration software

The KS2000 configuration software is used for planning, parameterization, and commissioning Bus Couplers and Bus Terminals.



Fig. 42: KS2000 configuration software

i Support for KS2000

Access via ADS is supported for the KS2000 Configuration Software from the following firmware versions:

- BK1120: from FW08
- BK1150: from FW01
- BK1250: from FW01

The following example describes how to set up communication via ADS with a BK11x0/BK1250. The AmsServerNetId of the target system is required for this purpose.

Step 1: In the TwinCAT System Manager select the corresponding coupler BK11x0/BK1250, navigate to the "EtherCAT" tab and click on "Advanced Settings" (Fig. *TwinCAT System Manager: EtherCAT tab for box BK11x0/BK1250*).

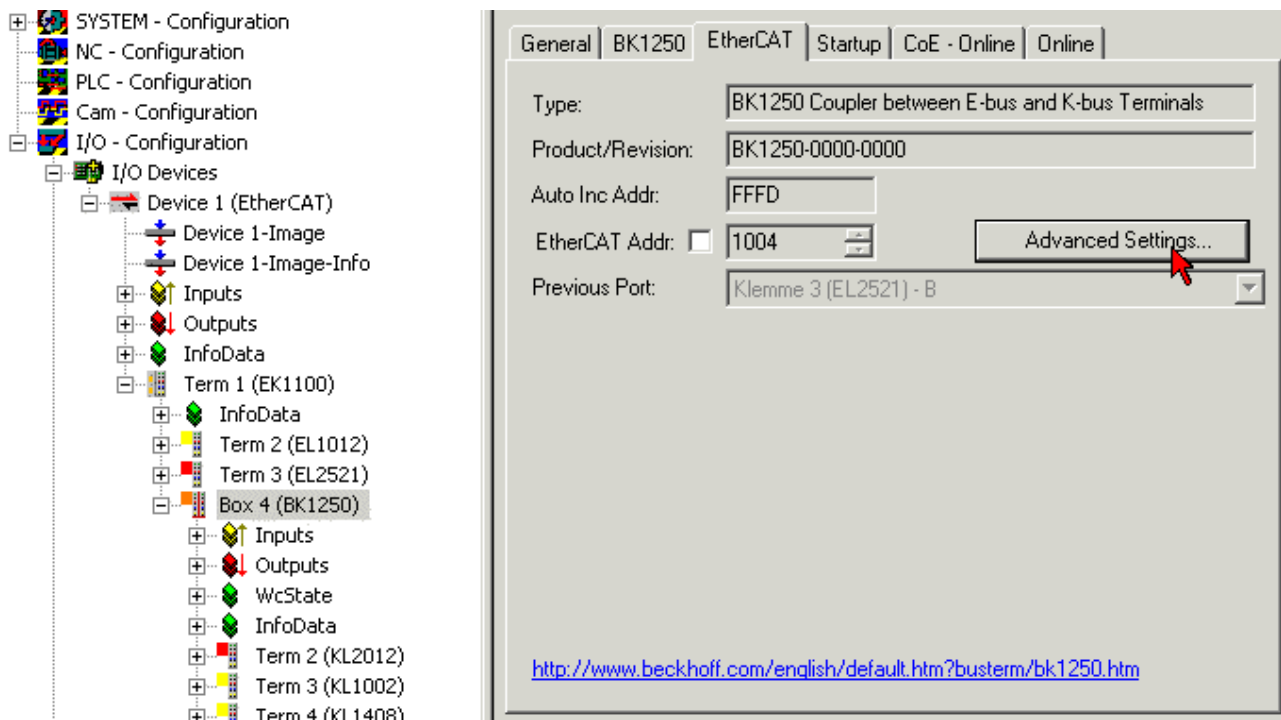


Fig. 43: TwinCAT System Manager: EtherCAT tab for Box BK11x0/BK1250

Step 2: Under "Mailbox", "AoE" (ADS over EtherCAT) select "Generate NetId" and "Initialize NetId". Confirm with OK.

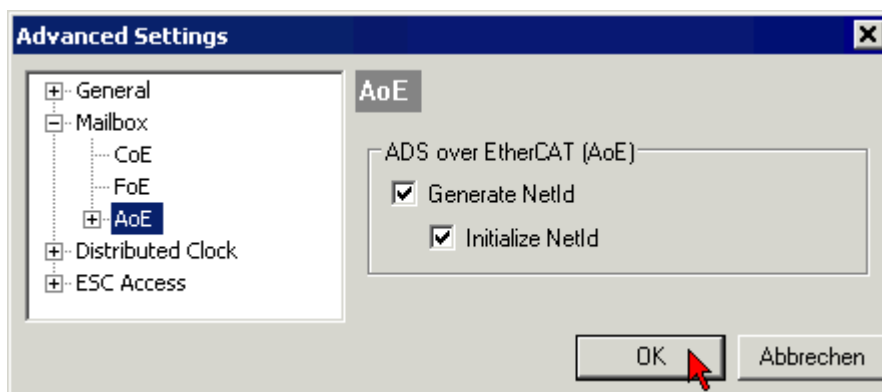


Fig. 44: Dialog "EtherCAT", "Advanced Settings", "AoE"

Step 3: After the KS2000 software has been started and the ADS communication channel has been activated ("Options", "Communication channel", "ADS"), enter the AmsServerNetId specified in the TwinCAT System Manager under "Mailbox", "ADS Info" (Fig. *TwinCAT System Manager: dialog "Mailbox", transferring the AmsServerNetId*) in the pull-down menu of the "ADS" tab (Fig.4):

- **Existing device:** If you select an existing device under Name (1), the AmsServerNetId (2) is entered automatically. The AdsPort setting ("100") (3) should not be changed. Click on Test(4) to check the connection settings.
- **User Defined:** For User Defined the AmsServerNetId has to be entered manually (2). Click on Test(4) to check the connection settings.

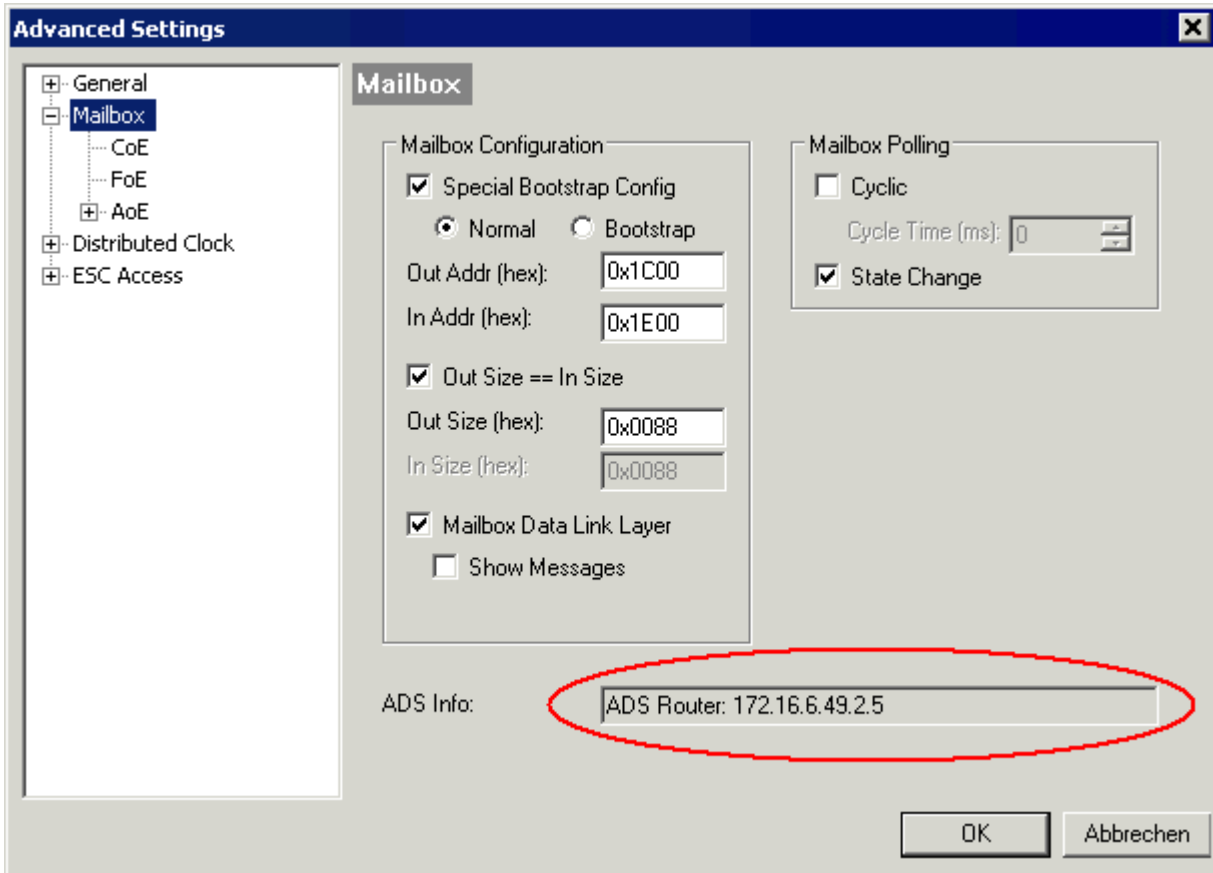


Fig. 45: TwinCAT System Manager: "Mailbox" dialog, transfer of AmsServerNetID

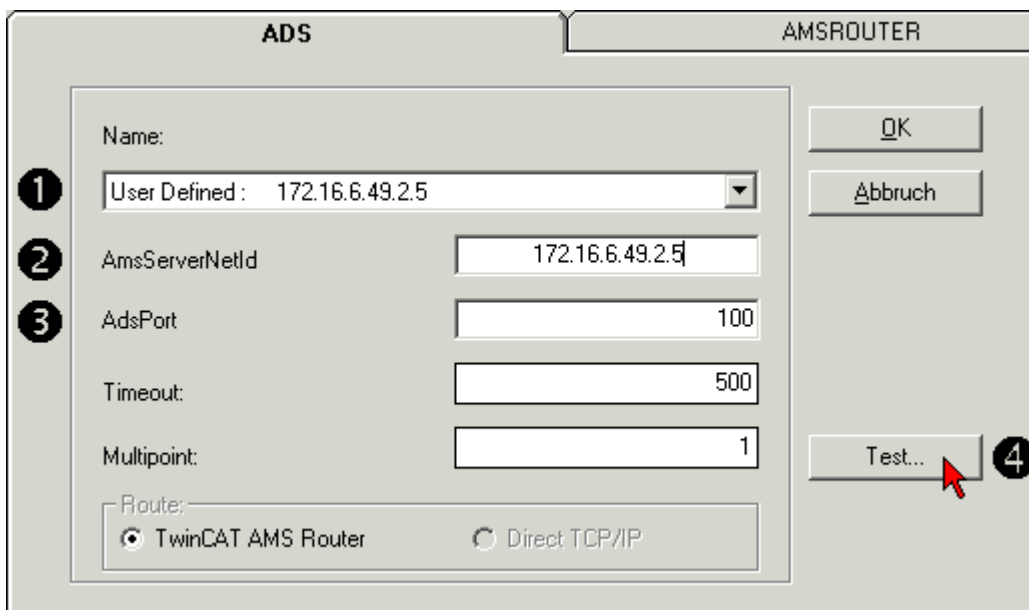


Fig. 46: KS2000: "ADS" tab, enter the AmsServerNetID

Step 4: The test was successful, if the following dialog box appears (Fig. *KS2000: Confirmation of successful communication test*). Click OK to close the dialog box.



Fig. 47: Confirmation of successful communication test

Step 5: Click *OK* to accept the set value (Fig. *KS2000: "ADS" tab, entering the AmsServerNetID*).

Step 6: Log into the KS2000 system. Parameterization can now be carried out according to the Bus Terminal configuration. Further information can be found in the associated terminal documentation.

5.5.2 Sample program for register communication via EtherCAT on KL3314 exemplary

i Using the sample programs

This document contains sample applications of our products for certain areas of application. The application notes provided here are based on typical features of our products and only serve as examples. The notes contained in this document explicitly do not refer to specific applications. The customer is therefore responsible for assessing and deciding whether the product is suitable for a particular application. We accept no responsibility for the completeness and correctness of the source code contained in this document. We reserve the right to modify the content of this document at any time and accept no responsibility for errors and missing information.

Program description / function

This example program (TwinCAT 3) provides change of single register values of the KL3314 as selection of the element type, characteristic settings of the feature register R32 and user scaling offset and gain (R33 / R34) similar as per KS2000 Configuration Software.

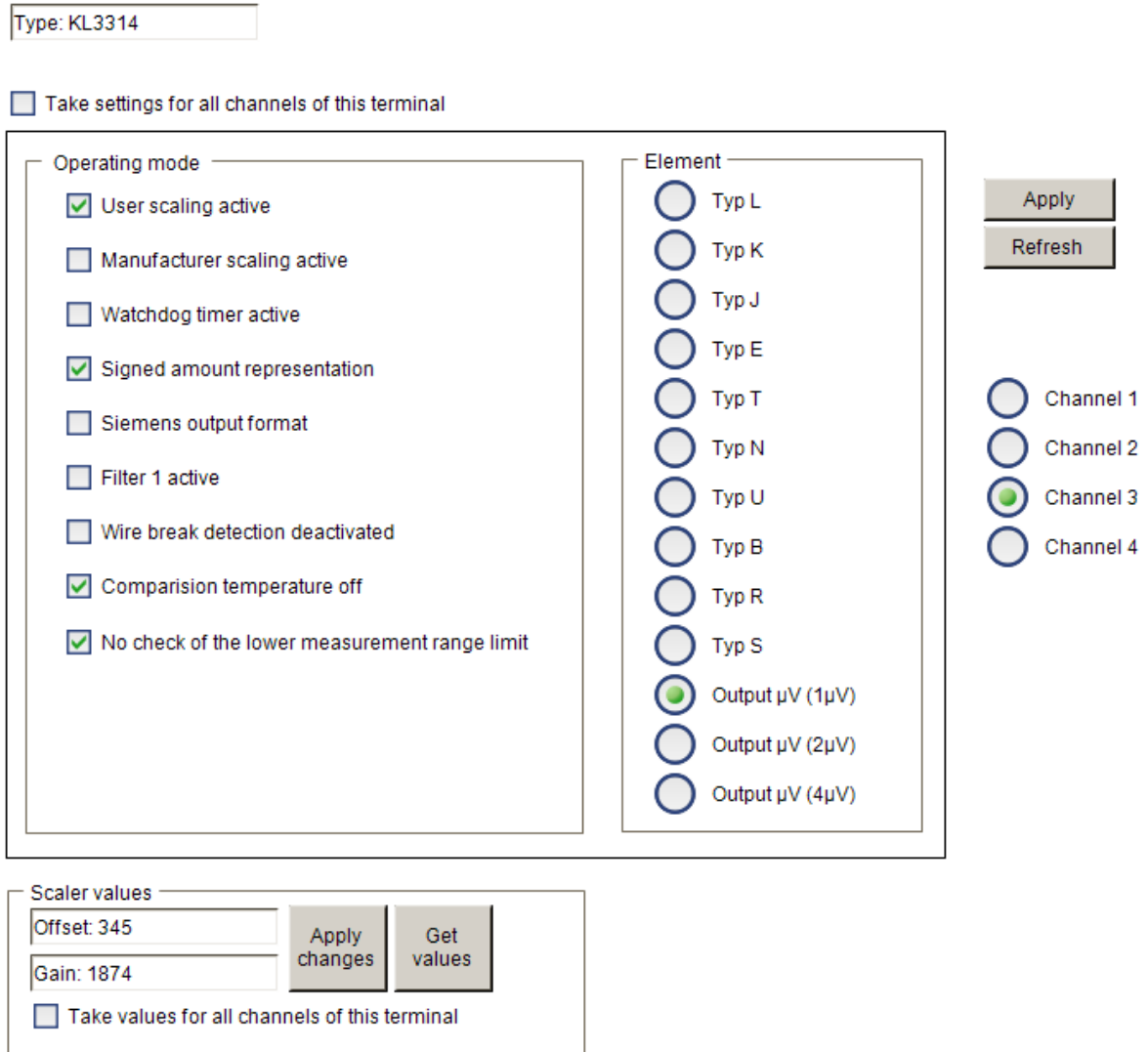



Fig. 48: Settings of KL3314 via visualization of TwinCAT 3

At least following configuration setup shall be present:

[coupler (e.g. BK1120) or embedded PC] + KL3314 + KL9010.

 Download:
https://infosys.beckhoff.com/content/1033/bk11x0_bk1250/Resources/5996114571/.zip

Preparations for starting the sample programs (tzip file / TwinCAT 3)

- Click on the download button to save the Zip archive locally on your hard disk, then unzip the *.tzip archive file in a temporary folder.

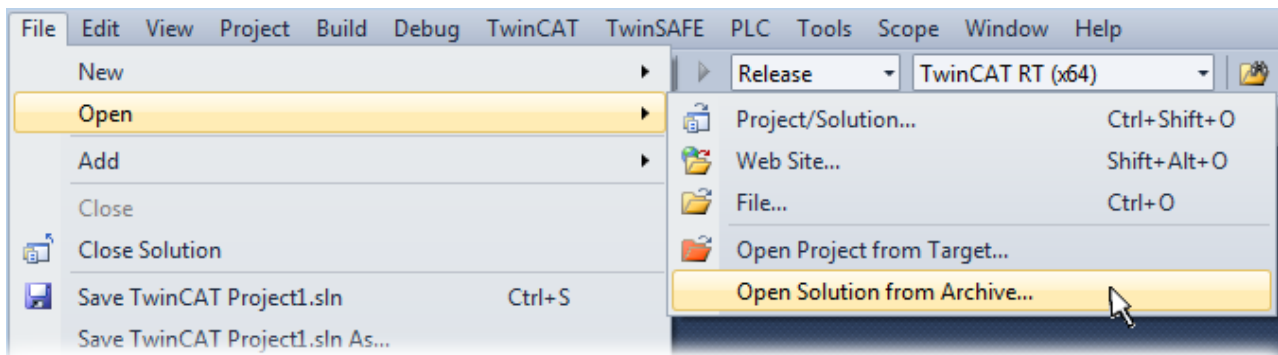


Fig. 49: Opening the *. tzip archive

- Select the .tnzip file (sample program).
- A further selection window opens. Select the destination directory for storing the project.
- For a description of the general PLC commissioning procedure and starting the program please refer to the terminal documentation or the EtherCAT system documentation.
- The EtherCAT device of the example should usually be declared your present system. After selection of the EtherCAT device in the “Solutionexplorer” select the “Adapter” tab and click on “Search...”:

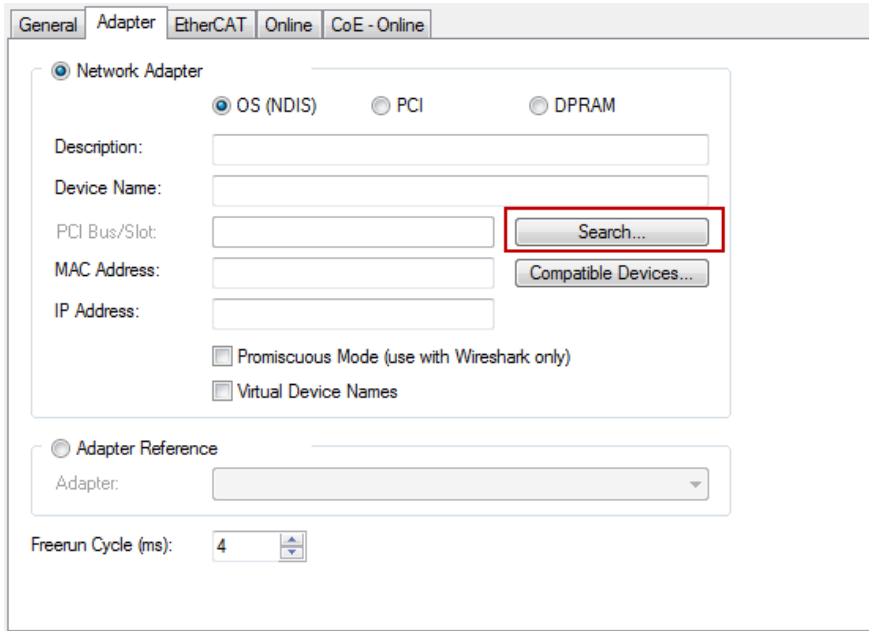
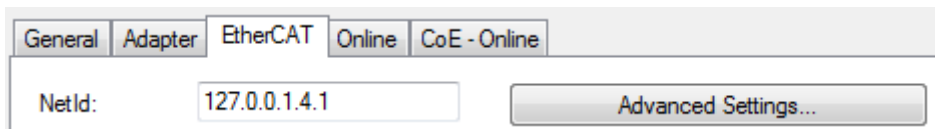


Fig. 50: Search of the existing HW configuration for the EtherCAT configuration of the example

- Checking NetId: the “EtherCAT” tab of the EtherCAT device shows the configured NetId:



The first four numbers must be identical with the project NetId of the target system. The project NetId can be viewed within the TwinCAT environment above, where a pull down menu can be opened to choose a target system (by clicking right in the text field). The number blocks are placed in brackets there next to each computer name of a target system.

- Modify the NetId: By right clicking on “EtherCAT device” within the solution explorer a context menu opens where “Change NetId...” have to be selected. The first four numbers of the NetId of the target computer must be entered; both last values are 4.1 usually.
Example:

- NetId of project: myComputer (123.45.67.89.1.1)
- Entry via „Change NetId...“: 123.45.67.89.4.1

6 Error handling and diagnosis

6.1 LEDs

After switching on, the Bus Coupler immediately checks the connected configuration. Error-free start-up is signaled by the red LED *I/O ERR* being extinguished. If the *I/O ERR* LED blinks, an error in the area of the terminals is indicated. The frequency and number of flashes indicate the error code (see below).

The BK1120 / BK1150 Bus Coupler has a green LED *Link/Act In / Link/Act Out* at the RJ45 sockets, which indicates the fieldbus status.

The *RUN* and *ERROR* LEDs (for BK1120: center top, for BK1150: left row of the LED prism) indicate the state of the EtherCAT state machine.

On the upper right hand side of the BK1120 are two more green LEDs that indicate the supply voltage. The left hand LED indicates the presence of the 24 V supply for the Bus Coupler. The right hand LED indicates the presence of the supply to the power contacts. At the BK1150, the diagnostic LEDs are on the right side of the LED prism, as shown in Fig. *BK1120, BK1150 - Diagnostic LEDs at Bus Coupler*.

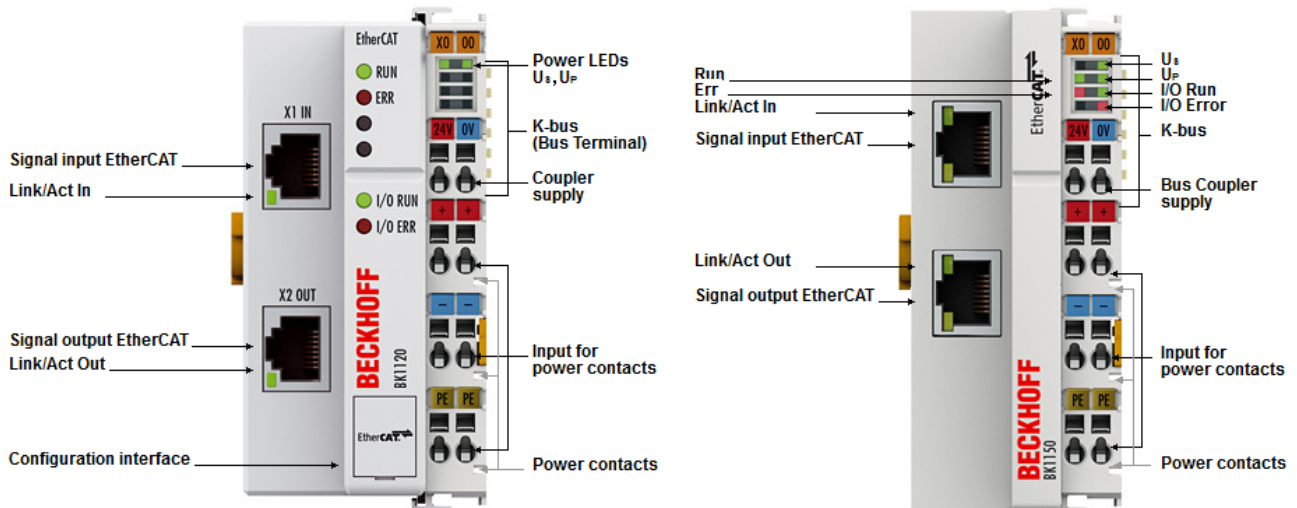


Fig. 51: BK1120, BK1150 - Diagnostic LEDs at Bus Coupler

The diagnostic LEDs for the BK1250 are arranged as shown in Fig. *BK1250 - Diagnostic LEDs at Bus Coupler*.

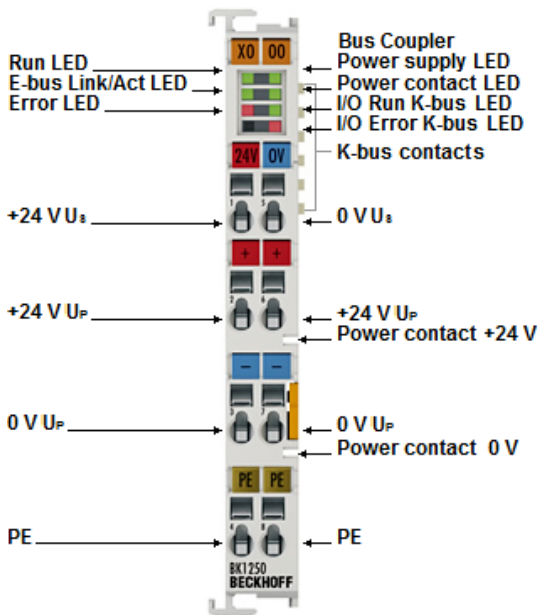


Fig. 52: Diagnostic LEDs at Bus Coupler BK1250

LEDs for power supply diagnostics

LED	Display	State	Description
Us (POWER SUPPLY)	green	off	No operating voltage present at the Bus Coupler
		on	24 V _{DC} operating voltage present at the Bus Coupler
Up (POWER CONTACTS)	green	off	No power supply present at the power contacts
		on	24 V _{DC} power supply present at the power contacts

Diagnostic LEDs for the EtherCAT State Machine/PLC

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	Firmware is being loaded.
ERROR	red	off	-	No error
		flashing	Err-Operational No Communication	PLC error / lost frames

LEDs for fieldbus diagnostics

BK1120, BK1150				
LED	Display	State	Description	
LINK / ACT (X1 IN)	green	off	-	No connection on the incoming EtherCAT segment
		on	linked	Preceding EtherCAT device connected
		flashing	active	Communication with preceding EtherCAT device
LINK / ACT (X2 OUT)	green	off	-	No connection on the outgoing EtherCAT segment
		on	linked	Following EtherCAT device connected
		flashing	active	Communication with downstream EtherCAT device

BK1250				
LED	Display	State	Description	
LINK/ACT	green	off	-	No connection/communication with the E-bus
		flashing	linked	Connection/communication with the E-bus established

LEDs for K-bus diagnostics

LED	Display	State	Description	
I/O-RUN	green	off	-	K-bus inactive
		on	-	K-bus active
LED red; I/O-Error	Error code argument	Description	Remedy	
Persistent, continuous flashing		EMC problems	<ul style="list-style-type: none"> Check power supply for undervoltage or overvoltage peaks Implement EMC measures If a K-bus error is present, it can be localized by a restart of the coupler (by switching it off and then on again) 	
1 pulse	0	EEPROM checksum error	<ul style="list-style-type: none"> Enter factory settings with the KS2000 configuration software (Menu "Online -> Coupler -> Services -> Factory Setting") 	
	1	Code buffer overflow	<ul style="list-style-type: none"> Insert fewer Bus Terminals. Too many entries in the table for the programmed configuration 	
	2	Unknown data type	<ul style="list-style-type: none"> Software update required for the Bus Coupler 	
2 pulses	0	Programmed configuration has an incorrect table entry	<ul style="list-style-type: none"> Check programmed configuration for correctness 	
	n (n > 0)	Table comparison (Bus Terminal n)	<ul style="list-style-type: none"> Incorrect table entry 	
3 pulses	0	K-bus command error	<ul style="list-style-type: none"> No Bus Terminal inserted 	
			<ul style="list-style-type: none"> One of the Bus Terminals is defective; halve the number of Bus Terminals attached and check whether the error is still present with the remaining Bus Terminals. Repeat until the defective Bus Terminal is located. 	
4 pulses	0	K-bus data error, break behind the Bus Coupler	<ul style="list-style-type: none"> Check whether the n+1 Bus Terminal is correctly connected; replace if necessary. 	
	n	Break behind Bus Terminal n	<ul style="list-style-type: none"> Check whether the bus end terminal 9010 is connected. 	
5 pulses	n	K-bus error in register communication with Bus Terminal n	<ul style="list-style-type: none"> Exchange the nth bus terminal 	
14 pulses	n	n th Bus Terminal has the wrong format	<ul style="list-style-type: none"> Start the Bus Coupler again, and if the error occurs again then exchange the Bus Terminal 	
15 pulses	n	Number of Bus Terminals is no longer correct	<ul style="list-style-type: none"> Start the Bus Coupler again. If the error occurs again, restore the manufacturers setting using the KS2000 configuration software 	
16 pulses	n	Length of the K-bus data is no longer correct	<ul style="list-style-type: none"> Start the Bus Coupler again. If the error occurs again, restore the manufacturers setting using the KS2000 configuration software 	

6.2 Error messages to the EtherCAT master

The Beckhoff TwinCAT EtherCAT master issues the slave error message after the ETG specification in plain text in the logger window.



Fig. 53: Switching the logger window on/off

Error message

Server (Port)	Timestamp	Message
65535	21.12.2011 14:27:39 266 ms	'Box 1 (BK1120)' (1001): 'PREOP to SAFEOP' failed! Error: 'check device state for SAFEOP'. AL Status '0x0002' read and '0x0004' expected. AL Status Code '0x0003'

Fig. 54: Display of the error message AL Status Code '0x0003' in the logger window

Error code

AL Status Code '0x0003'

Explanation

The error message is displayed in the logger window, if a K-bus error is present and the coupler should enter the status SAFEOP. Rectify the K-bus error.

Error Message:

Server (Port)	Timestamp	Message
65535	21.12.2011 14:20:09 418 ms	'Box 3 (BK1250)' (1003): 'PREOP to SAFEOP' failed! Error: 'check device state for SAFEOP'. AL Status '0x0012' read and '0x0004' expected. AL Status Code '0x001e - Invalid SM IN cfg'

Fig. 55: Display of the error message AL Status Code '0x001e - invalid SM IN cfg' in the logger window

Error code

AL Status Code '0x001e - Invalid SM IN cfg'

Explanation:

The process data scope is incorrect. The BK11x0/BK1250 is set by the EtherCAT master based on the EtherCAT extent of process data according to the configured KL terminals. Before that the coupler scans its KL terminals and establishes its internal process data image based on their message. If the two process data do not match, the system reports a SyncManager error.

Use the KS2000 software or correct CoE startup entries to ensure that a KL terminal does not report with an alternative process data format that may differ from the TwinCAT configuration, for example.

7 Appendix

7.1 General operating conditions

The following conditions must be met in order to ensure flawless operation of the fieldbus components. Also note the details in chapter "[Technical data \[► 10\]](#)".

Environmental conditions

Operation

The components may not be used without additional protection in the following locations:

- in difficult environments, such as where there are corrosive vapours or gases, or high dust levels
- in the presence of high levels of ionizing radiation

Condition	Permissible range
Permissible ambient temperature during operation	-25°C ... +60°C
Relative humidity during operation	95 %, no condensation
Installation position	variable
Vibration resistance	conforms to EN 60068-2-6
Shock resistance	conforms to EN 60068-2-27, EN 60068-2-29, see also installation instructions for enhanced mechanical load capacity [► 26]
EMC resistance	conforms to EN 61000-6-2
Emission	conforms to EN 61000-6-4

Transport and storage

Condition	Permissible range
Permissible ambient temperature during storage	-40°C... +85°C
Relative humidity	95 %, no condensation
Free fall	up to 1 m in the original packaging

Protection classes and types

Condition	Permissible range
Protection class in accordance with IEC 536 (VDE 0106, Part 1)	A protective conductor connection to the mounting rail is necessary!
Protection class conforms to IEC 529	IP20 (protection against contact with a standard test finger)
Protection against foreign objects	Less than 12 mm in diameter
Protection against water	no protection

7.2 Test standards for device testing

EMC

EN 61000-6-2
EN 61000-6-4

Vibration resistance

EN 60068-2-6 vibration test
EN 60068-2-27/29 shock test

7.3 Firmware compatibility

Firmware and hardware versions

Documentation Version	BK1120		BK1150	
	Firmware	Hardware	Firmware	Hardware
4.2	19	20	06	06
4.1	18	19	05	05
3.0	18	19	04	05
3.0	17	17	03	05
2.9	15	15	01	04
2.8	15	15	01	04
2.7	13 (C2)	12	01	00
2.6	13 (C2)	12	00	00
2.5	12 (C1)	12	00	00
2.4	12 (C1)	11	-	-
2.3	11 (C0)	11	-	-
2.2	09 (B9)	09	-	-
2.1	08 (B8)	05	-	-
2.0	08 (B8)	03	-	-
1.0	06	02	-	-
0.2	06	02	-	-
0.1	06	02	-	-

Documentation Version	BK1250	
	Firmware	Hardware
4.2	12	13
4.1	12	13
3.0	11	13
2.9	05	10
2.8	05	09
2.7	04	05
2.6	04	05
2.5	04	05
2.4	04	05
2.3	04	05
2.2	03	03
2.1	02	01
2.0	01	01

The firmware and hardware versions (delivery state) can be taken from the serial number printed on the side of the terminal.

Syntax of the serial number

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 34 06 08 02:
 34 - week of production 34
 06 - year of production 2006
 08 - firmware version 08
 02 - Hardware-Stand 02

7.4 Version identification of EtherCAT devices

Designation

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

- family key
- type
- version
- revision

Example	Family	Type	Version	Revision
EL3314-0000-0016	EL terminal (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.

Identification number

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

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

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

Structure of the serial number: **KK YY FF HH**
 KK - week of production (CW, calendar week)
 YY - year of production
 FF - firmware version
 HH - hardware version

Example with serial number 12 06 3A 02:
 12 - production week 12
 06 - production year 2006
 3A - firmware version 3A
 02 - hardware version 02

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

Syntax: D ww yy x y z u

D - prefix designation

ww - calendar week

yy - year

x - firmware version of the bus PCB

y - hardware version of the bus PCB

z - firmware version of the I/O PCB

u - hardware version of the I/O PCB

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

Unique serial number/ID, ID number

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

See also the further documentation in the area

- IP67: [EtherCAT Box](#)
- Safety: [TwinSAFE](#)
- Terminals with factory calibration certificate and other measuring terminals

Examples of markings



Fig. 56: EL5021 EL terminal, standard IP20 IO device with serial/ batch number and revision ID (since 2014/01)



Fig. 57: EK1100 EtherCAT coupler, standard IP20 IO device with serial/ batch number



Fig. 58: CU2016 switch with serial/ batch number

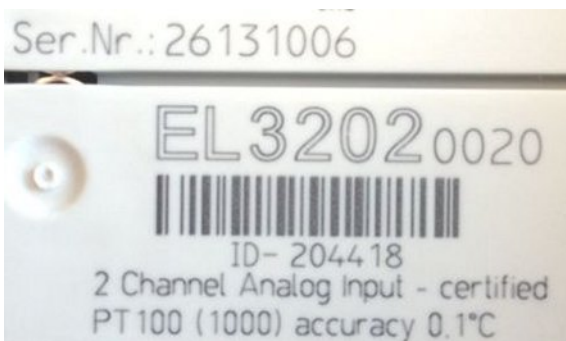


Fig. 59: EL3202-0020 with serial/ batch number 26131006 and unique ID-number 204418

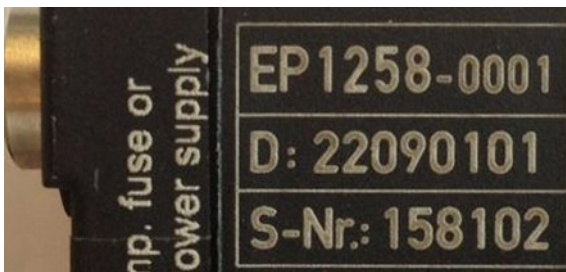


Fig. 60: EP1258-00001 IP67 EtherCAT Box with batch number/ date code 22090101 and unique serial number 158102

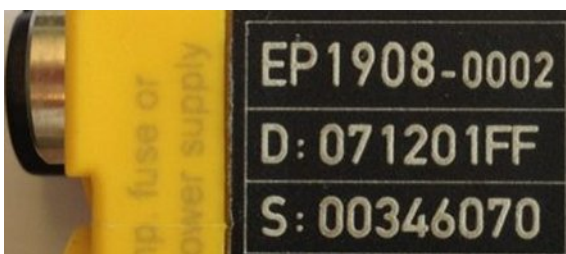


Fig. 61: EP1908-0002 IP67 EtherCAT Safety Box with batch number/ date code 071201FF and unique serial number 00346070



Fig. 62: EL2904 IP20 safety terminal with batch number/ date code 50110302 and unique serial number 00331701



Fig. 63: ELM3604-0002 terminal with unique ID number (QR code) 100001051 and serial/ batch number 44160201

7.4.1 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.

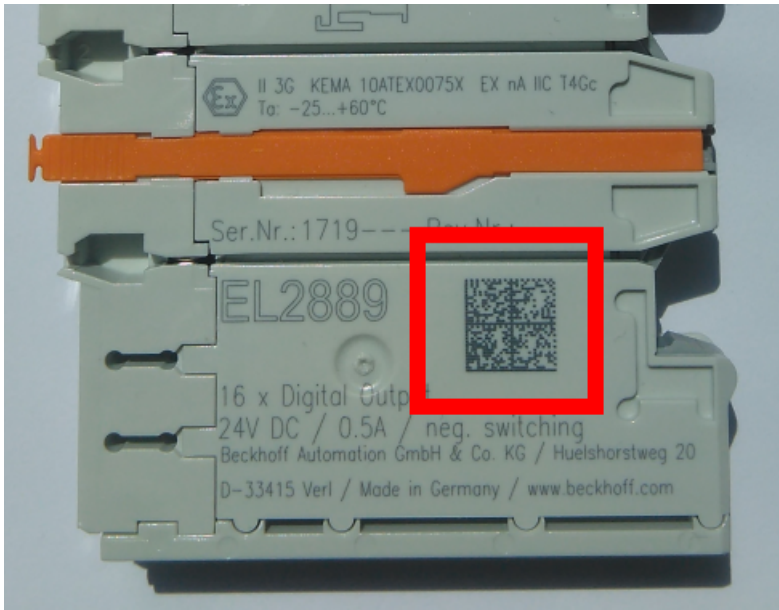


Fig. 64: BIC as data matrix code (DMC, code scheme ECC200)

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. The data under positions 1 to 4 are always available.

The following information is contained:

Item no.	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	S	12	S BTNk4p562d7
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 or calibrated terminals	51S	12	51S 678294104
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 item 1 to 4 and 6. The data identifiers are marked in red for better display:

BTN

An important component of the BIC is the Beckhoff Traceability Number (BTN, item no. 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.

7.5 Support and Service

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

Beckhoff's branch offices and representatives

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

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

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Table of figures

Fig. 1	BK1120 and BK1150 - EtherCAT Bus Coupler for K-bus terminals.....	8
Fig. 2	BK1250 - Coupler between E-bus and K-bus terminals.....	9
Fig. 3	Transition from E-bus to K-bus	9
Fig. 4	EtherCAT Telegram Structure.....	11
Fig. 5	EtherCAT Topology.....	12
Fig. 6	“CoE Online” tab	16
Fig. 7	Startup list in the TwinCAT System Manager	18
Fig. 8	Offline list	19
Fig. 9	Online list	19
Fig. 10	States of the EtherCAT State Machine	20
Fig. 11	Spring contacts of the Beckhoff I/O components	22
Fig. 12	Attaching on mounting rail.....	23
Fig. 13	Disassembling of terminal	24
Fig. 14	Power contact on left side	25
Fig. 15	Recommended distances for standard installation position	27
Fig. 16	Other installation positions	28
Fig. 17	BK1120, BK1150 - Contact assignment.....	29
Fig. 18	BK1250 - Contact assignment	30
Fig. 19	BK1xxx - Potential diagram.....	31
Fig. 20	Flow chart showing start-up behavior of the Bus Coupler.....	36
Fig. 21	DC tab for indicating the Distributed Clocks function	36
Fig. 22	Advanced Distributed Clocks settings in the EtherCAT master	37
Fig. 23	TwinCAT setting for using this component as reference clock	38
Fig. 24	Register access on K-bus terminals.....	39
Fig. 25	Insert dialog.....	41
Fig. 26	Data entry.....	42
Fig. 27	Entry.....	42
Fig. 28	Complete terminal access.....	42
Fig. 29	Access to two KL terminals	43
Fig. 30	Online CoE directory of the BK11x0	44
Fig. 31	Activation of the AoE NetID.....	45
Fig. 32	Table 9 with terminal type	47
Fig. 33	TwinCAT tree showing BK1120 as example.....	48
Fig. 34	TwinCAT tree BK1250	49
Fig. 35	CouplerState, "Online" tab	50
Fig. 36	CouplerCtrl, "Online" tab	51
Fig. 37	WCstate, "Online" tab	52
Fig. 38	State, "Online" tab	52
Fig. 39	ADSAddr, "Online" tab	53
Fig. 40	BK1250, "BK1250" tab	54
Fig. 41	Configuration example for explaining the process image	65
Fig. 42	KS2000 configuration software	66
Fig. 43	TwinCAT System Manager: EtherCAT tab for Box BK11x0/BK1250.....	67
Fig. 44	Dialog "EtherCAT", "Advanced Settings", "AoE".....	67

Fig. 45	TwinCAT System Manager: "Mailbox" dialog, transfer of AmsServerNetID	68
Fig. 46	KS2000: "ADS" tab, enter the AmsServerNetID	68
Fig. 47	Confirmation of successful communication test	69
Fig. 48	Settings of KL3314 via visualization of TwinCAT 3	70
Fig. 49	Opening the *. tzip archive	70
Fig. 50	Search of the existing HW configuration for the EtherCAT configuration of the example	71
Fig. 51	BK1120, BK1150 - Diagnostic LEDs at Bus Coupler	72
Fig. 52	Diagnostic LEDs at Bus Coupler BK1250	73
Fig. 53	Switching the logger window on/off	75
Fig. 54	Display of the error message AL Status Code '0x0003' in the logger window	75
Fig. 55	Display of the error message AL Status Code '0x001e - invalid SM IN cfg' in the logger window	75
Fig. 56	EL5021 EL terminal, standard IP20 IO device with serial/ batch number and revision ID (since 2014/01)	79
Fig. 57	EK1100 EtherCAT coupler, standard IP20 IO device with serial/ batch number	79
Fig. 58	CU2016 switch with serial/ batch number	80
Fig. 59	EL3202-0020 with serial/ batch number 26131006 and unique ID-number 204418	80
Fig. 60	EP1258-00001 IP67 EtherCAT Box with batch number/ date code 22090101 and unique serial number 158102	80
Fig. 61	EP1908-0002 IP67 EtherCAT Safety Box with batch number/ date code 071201FF and unique serial number 00346070	80
Fig. 62	EL2904 IP20 safety terminal with batch number/ date code 50110302 and unique serial number 00331701	81
Fig. 63	ELM3604-0002 terminal with unique ID number (QR code) 100001051 and serial/ batch number 44160201	81
Fig. 64	BIC as data matrix code (DMC, code scheme ECC200)	82

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