

Operating manual | EN

ELX3202 and ELX3204

2- and 4-channel analog input terminals, RTD, 16 bit, Ex i

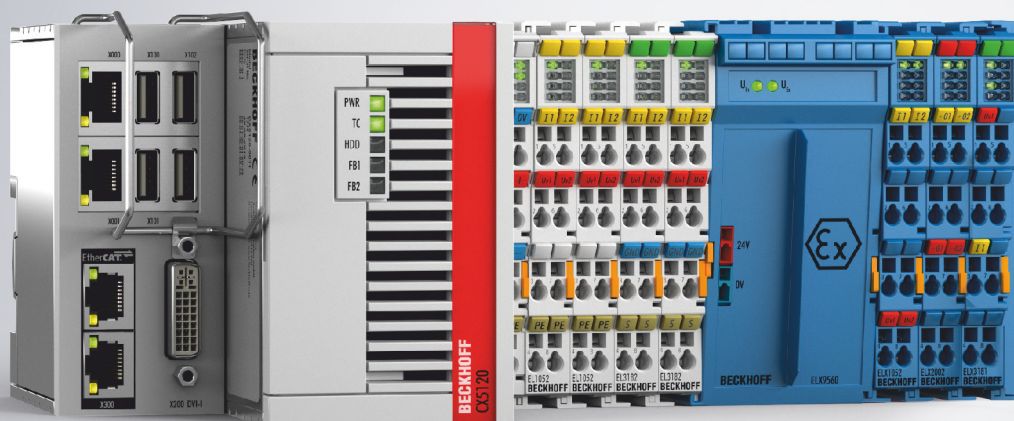


Table of contents

1 Foreword	5
1.1 Notes on the documentation	5
1.2 Safety instructions	6
1.3 Documentation Issue Status	7
1.4 Suggestions or proposals for documentation	7
1.5 Marking of ELX terminals	8
1.5.1 Ex marking for ATEX, IECEx and cFMus	9
1.5.2 Ex marking for ANZEx	12
2 Product overview	14
2.1 ELX3202 - Introduction	14
2.2 ELX3204 - Introduction	15
2.3 Technical data	16
2.4 Intended use	18
3 Mounting and wiring	19
3.1 Special conditions of use for ELX terminals	19
3.2 Installation notes for ELX terminals	19
3.3 Arrangement of ELX terminals within a bus terminal block	21
3.4 Installation position and minimum distances	24
3.5 Installation of ELX terminals on mounting rails	25
3.6 Disposal	26
3.7 Connection	27
3.7.1 Connection system	27
3.7.2 Wiring	28
3.7.3 Proper line connection	29
3.7.4 Shielding and potential separation	29
3.7.5 ELX3202 - Contact assignment	30
3.7.6 ELX3204 - Contact assignment	32
4 Basic function principles	34
4.1 EtherCAT basics	34
4.2 Notices on analog specifications	34
4.2.1 Full scale value (FSV)	34
4.2.2 Measuring error/ measurement deviation	35
4.2.3 Temperature coefficient tK [ppm/K]	35
4.2.4 Single-ended/differential typification	37
4.2.5 Common-mode voltage and reference ground (based on differential inputs)	40
4.2.6 Dielectric strength	40
4.2.7 Temporal aspects of analog/digital conversion	41
5 Parameterization and programming	44
5.1 Settings and application notes	44
5.1.1 Default settings	44
5.1.2 Changing the slave parameters in the CoE directory	44
5.1.3 Disabling of channels	45
5.1.4 Programmed characteristic sensor curves	46

5.2	Process data and operating modes	47
5.2.1	Data flow	47
5.2.2	Sync Manager (SM)	47
5.2.3	Operating modes and settings	47
5.2.4	Influence by interfering devices.....	51
5.3	TwinSAFE SC	51
5.3.1	TwinSAFE SC - operating principle.....	51
5.3.2	TwinSAFE SC - configuration	52
5.3.3	TwinSAFE SC process data of ELX320x-0090.....	56
5.4	ELX32x0 - Object description.....	57
5.4.1	Objects for commissioning	57
5.4.2	Standard objects (Index 0x1000 ... 0x1FFF)	59
5.4.3	Profile-specific objects (Index 0x6000 ... 0xFFFF)	65
5.5	Status word	67
6	Quick commissioning for experienced users	68
6.1	Setting the cycle time	68
6.2	Commissioning on the basis of CoE objects	69
6.3	Basic information for commissioning.....	69
6.4	Resistance measuring (R/RTD)	70
7	Appendix	72
7.1	EtherCAT AL Status Codes	72
7.2	UL notice	72
7.3	FM notice	73
7.4	Support and Service.....	74

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.

The qualified personnel is obliged to always use the currently valid documentation.

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

Disclaimer

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

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

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

Trademarks

Beckhoff®, ATRO®, EtherCAT®, EtherCAT G®, EtherCAT G10®, EtherCAT P®, MX-System®, Safety over EtherCAT®, TC/BSD®, TwinCAT®, TwinCAT/BSD®, TwinSAFE®, XFC®, XPlanar® and XTS® are registered trademarks of and licensed by Beckhoff Automation GmbH.

Other designations used in this publication may be trademarks whose use by third parties for their own purposes could violate the rights of the owners.



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

Copyright

© Beckhoff Automation GmbH & Co. KG, Germany.

The reproduction, distribution and utilization of this document as well as the communication of its contents to others without express authorization are prohibited.

Offenders will be held liable for the payment of damages. All rights reserved in the event of the grant of a patent, utility model or design.

Third-party brands

Trademarks of third parties may be used in this documentation. You can find the trademark notices here:

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

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.

Signal words

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

Personal injury warnings

DANGER

Hazard with high risk of death or serious injury.

WARNING

Hazard with medium risk of death or serious injury.

CAUTION

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

Warning of damage to property or environment

NOTICE

The environment, equipment, or data may be damaged.

Information on handling the product



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

1.3 Documentation Issue Status

Version	Comment
1.6.0	<ul style="list-style-type: none"> • ANZEx added: <ul style="list-style-type: none"> ◦ Chapter <i>Marking of ELX terminals</i> updated ◦ Chapter <i>Technical data</i> updated ◦ Chapter <i>Special conditions for ELX terminals</i> updated • Chapter <i>Arrangement of ELX terminals within a bus terminal block</i> extended
1.5.0	<ul style="list-style-type: none"> • Chapter <i>Disposal</i> added • Description of Ex marking extended • Design of the safety instructions adapted to IEC 82079-1 • New title page
1.4.0	<ul style="list-style-type: none"> • FM notice regarding ANSI/ISA EX added • Chapter <i>Marking of ELX terminals</i> updated
1.3.0	<ul style="list-style-type: none"> • Chapter <i>Basic function principles</i> added • Chapter <i>Parameterization and programming</i> added • Chapter <i>Quick commissioning for experienced users</i> added
1.2.0	<ul style="list-style-type: none"> • Contact assignment extended with sensor illustration • Chapter <i>Arrangement of ELX terminals within a bus terminal block</i> updated • Chapter <i>Marking of ELX terminals</i> updated • Technical data updated
1.1.0	<ul style="list-style-type: none"> • Chapter <i>Arrangement of ELX terminals at the bus terminal</i> updated
1.0.1	<ul style="list-style-type: none"> • Layout updated
1.0	<ul style="list-style-type: none"> • Chapter <i>Mounting and wiring</i> updated
0.3	<ul style="list-style-type: none"> • Technical data updated • Chapter <i>Mounting and wiring</i> updated
0.2	<ul style="list-style-type: none"> • Chapter <i>Intended use</i> added
0.1	<ul style="list-style-type: none"> • First preliminary version

1.4 Suggestions or proposals for documentation

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

1.5 Marking of ELX terminals

Designation

An ELX terminal has a 15-digit technical designation, composed of

- Family key
- Type
- Software variant
- Revision

Example	Family	Type	Software variant	Revision
ELX1052-0000-0001	ELX terminal	1052: Two-channel digital input terminal for NAMUR sensors, Ex i	0000: Basic type	0001
ELX9560-0000-0001	ELX terminal	9560: Power supply terminal	0000: Basic type	0001

Notes

- The elements mentioned above result in the **technical designation**. ELX1052-0000-0001 is used in the example below.
- Of these, ELX1052-0000 is the order identifier, commonly called just ELX1052 in the "-0000" revision. "-0001" is the EtherCAT revision.
- The **order identifier** is made up of
 - family key (ELX)
 - type (1052)
 - software version (-0000)
- The **Revision** -0001 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 website.
The revision has been applied to the terminals on the outside, see *Fig. ELX1052 with date code 3218FMFM, BTN 10000100 and Ex marking*.
- The hyphen is omitted in the labeling on the side of the terminal. Example:
Name: ELX1052-0000
Label: ELX1052₀₀₀₀
- The type, software version and revision are read as decimal numbers, even if they are technically saved in hexadecimal.

Identification numbers

ELX terminals have two different identification numbers:

- date code (batch number)
- **Beckhoff Traceability Number**, or BTN for short (as a serial number it clearly identifies each terminal)

Date code

The date code is an eight-digit number given by Beckhoff and printed on the ELX terminal. The date code indicates the build version in the delivery state and thus identifies an entire production batch but does not distinguish between the terminals in a batch.

Structure of the date code: **WW YY FF HH**
 WW - week of production (calendar week)
 YY - year of production
 FF - firmware version
 HH - hardware version

Example with date code 02180100:
 02 - week of production 02
 18 - year of production 2018
 01 - firmware version 01
 00 - hardware version 00

Beckhoff Traceability Number (BTN)

In addition, each ELX terminal has a unique **Beckhoff Traceability Number (BTN)**.

1.5.1 Ex marking for ATEX, IECEx and cFMus

Marking

The Ex marking can be found at the top left of the right side of the terminal:

II 3 (1) G Ex ec [ia Ga] IIC T4 Gc
 II (1) D [Ex ia Da] IIC
 I (M1) [Ex ia Ma] I
 IECEx BVS 18.0005X
 BVS 18 ATEX E 005 X

Examples

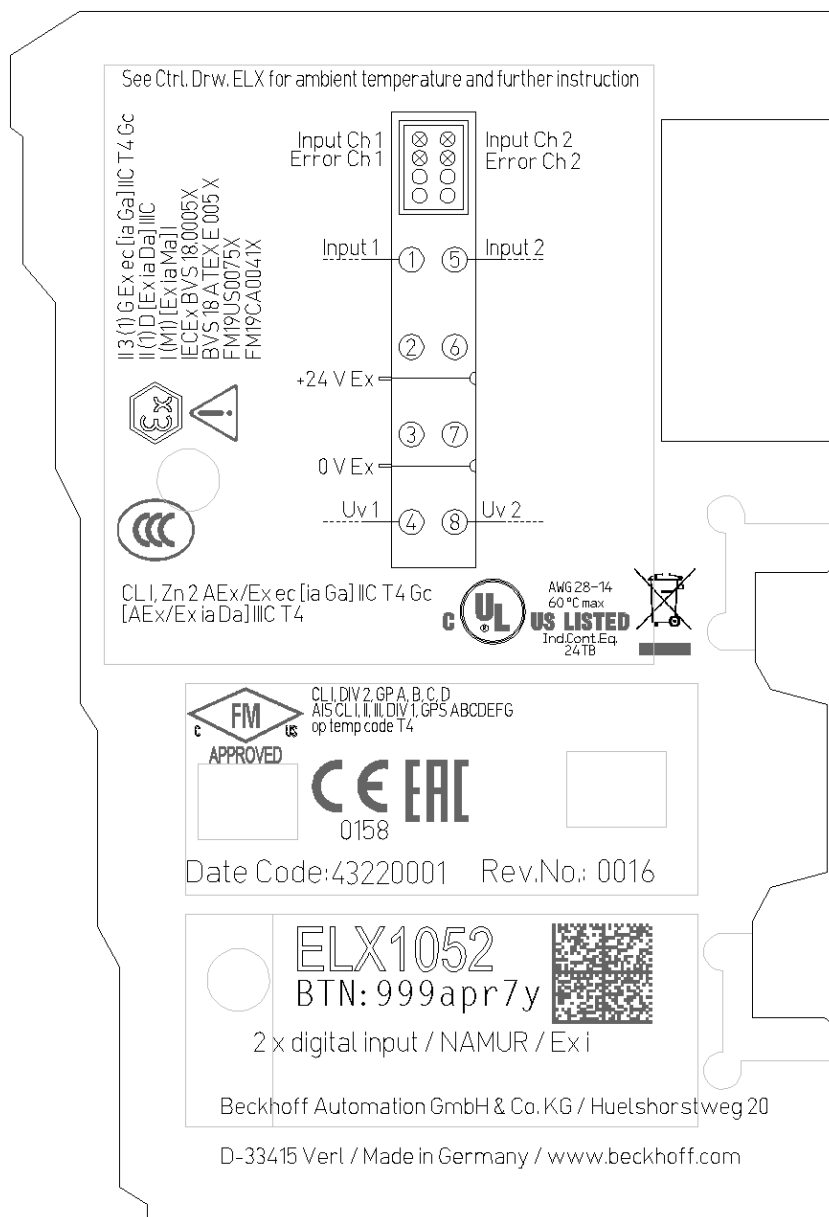


Fig. 1: ELX1052 with date code 43220001, BTN 999apr7y and marking für ATEX, IECEx and cFMus

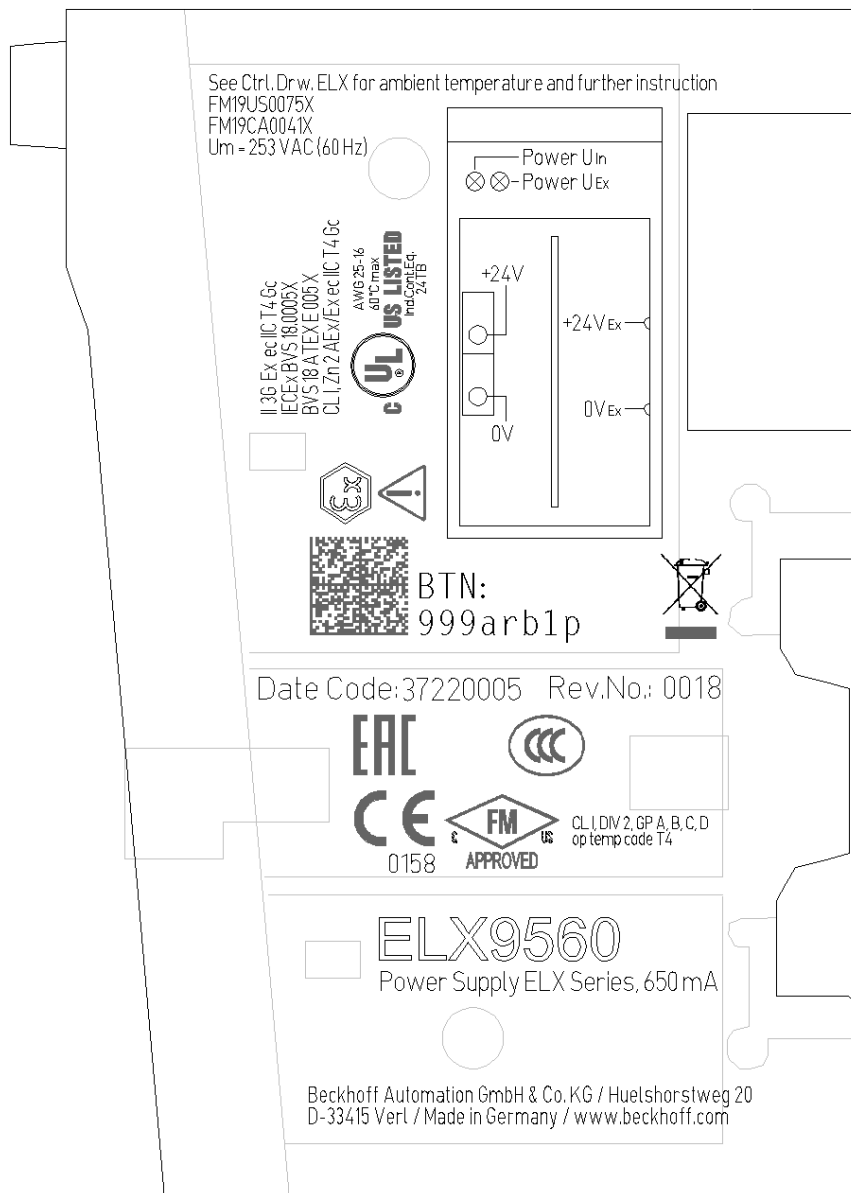


Fig. 2: ELX9560 with date code 37220005, BTN 999arb1p and marking für ATEX, IECEx and cFMus



Fig. 3: ELX9012 with date code 36230000, BTN 000bh4yr and marking für ATEX, IECEx and cFMus

1.5.2 Ex marking for ANZEx

The ANZEx marking is applied for the Australian and New Zealand markets.

Marking ELX signal terminals

The Ex marking can be found at the bottom left of the left side of the terminal:

Beckhoff Automation
ANZEx 20.3004X
Ex ec [ia Ga] IIC T4 Gc
[Ex ia Da] IIIC
[Ex ia Ma] I

Example

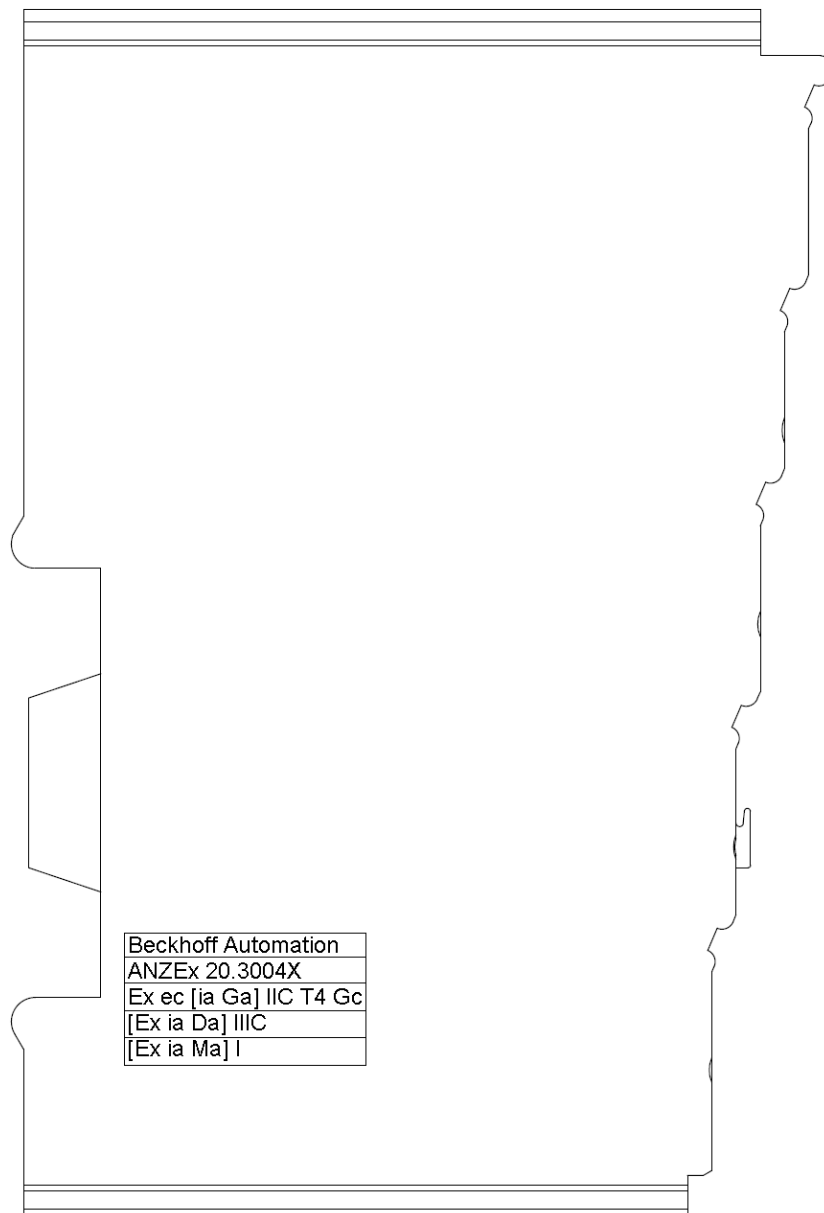


Fig. 4: ELX2002 with marking for ANZEx

Marking ELX9410 and ELX9560

The Ex marking can be found at the bottom left of the left side of the terminal:

Beckhoff Automation
ANZEx 20.3004X
Ex ec IIC T4 Gc

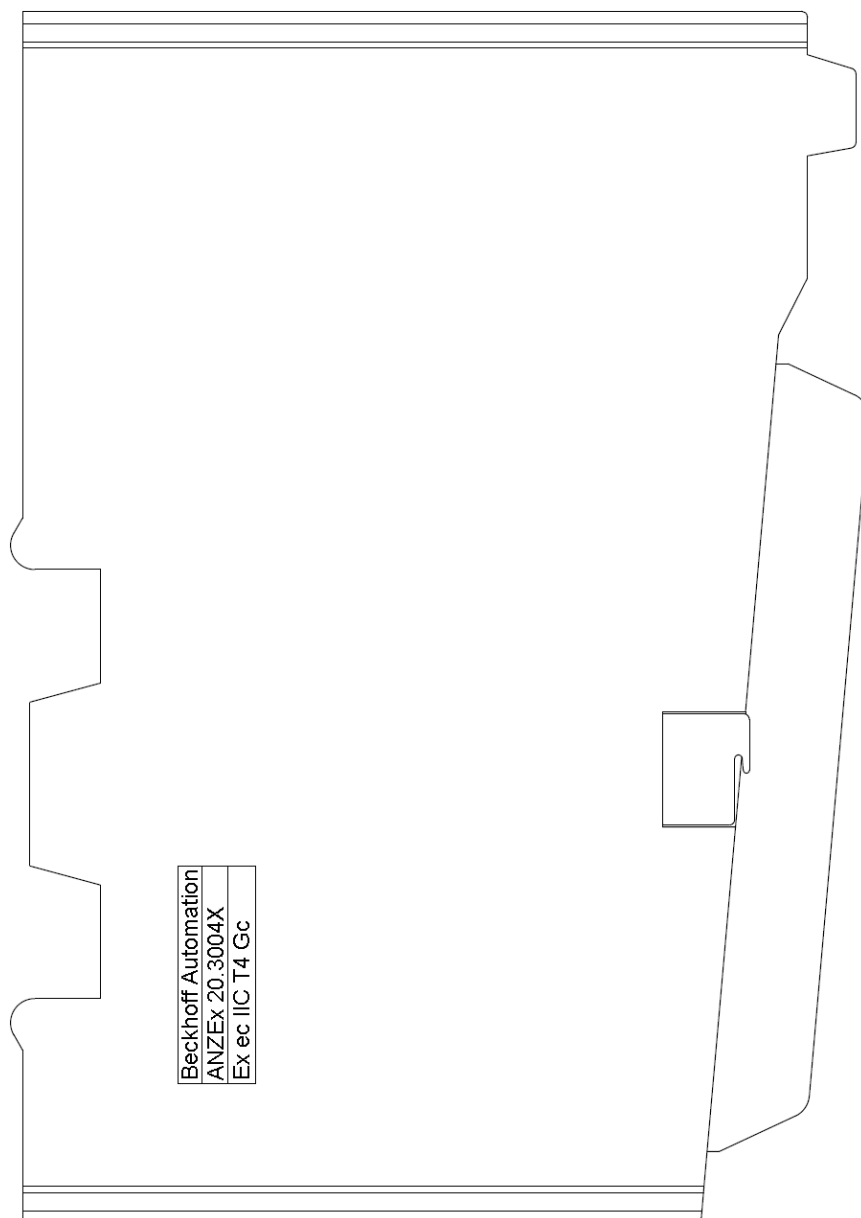
Example

Fig. 5: ELX9560 with marking for ANZEx

2 Product overview

2.1 ELX3202 - Introduction

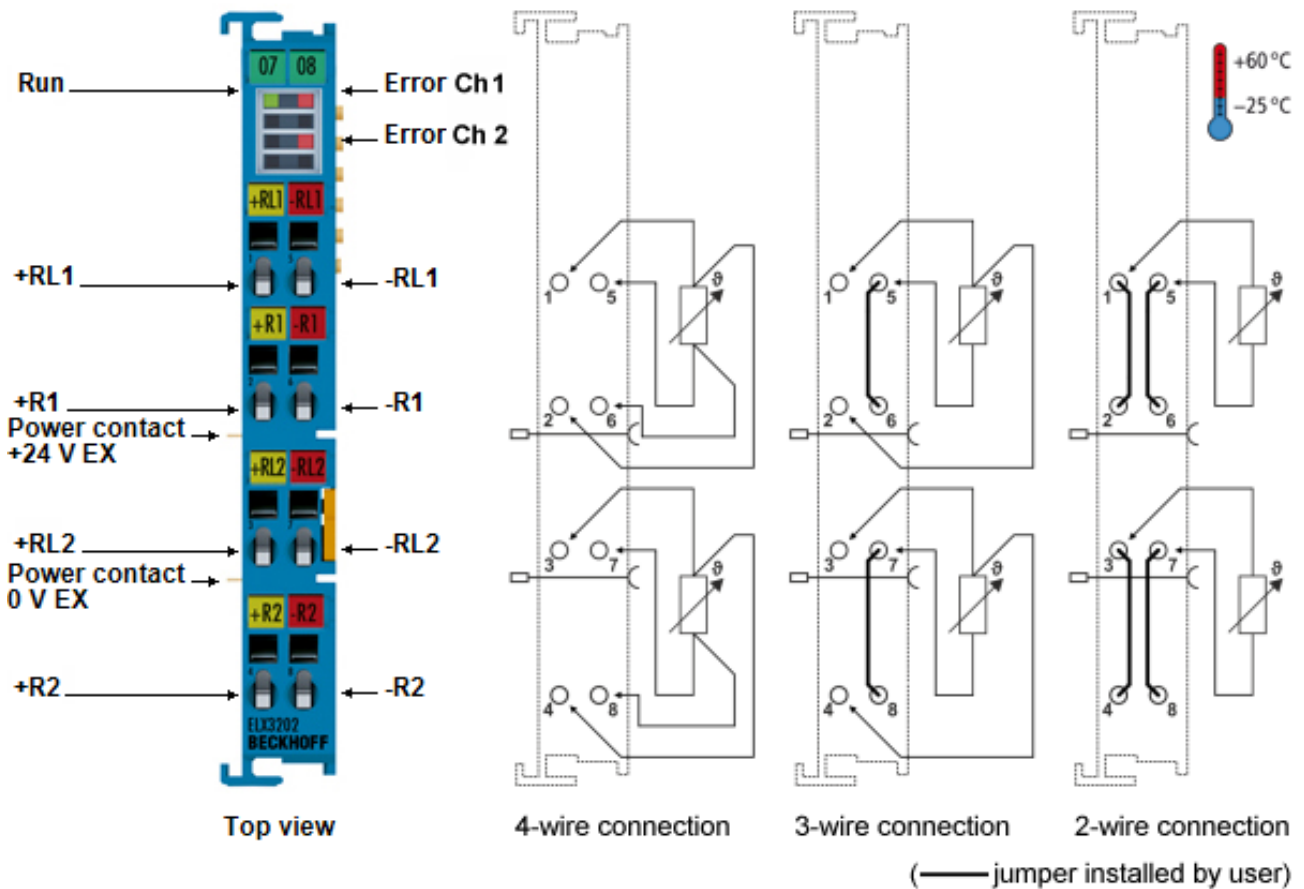


Fig. 6: ELX3202 - 2-channel analog input terminal RTD for 2, 3 and 4-wire connection, 16 bit, Ex i

The ELX3202 analog input terminal allows the direct connection of RTDs located in hazardous areas classified Zone 0/20 or 1/21. The circuitry of the ELX3202 can operate sensors with 2, 3 and 4-wire technology. Linearization is carried out over the entire freely selectable temperature range. By default the terminal is set to PT100 sensors with 2-wire technology. The ELX3202 terminal indicates signal state and sensor malfunctions (e.g. wire breakage) by means of LEDs.

2.2 ELX3204 - Introduction

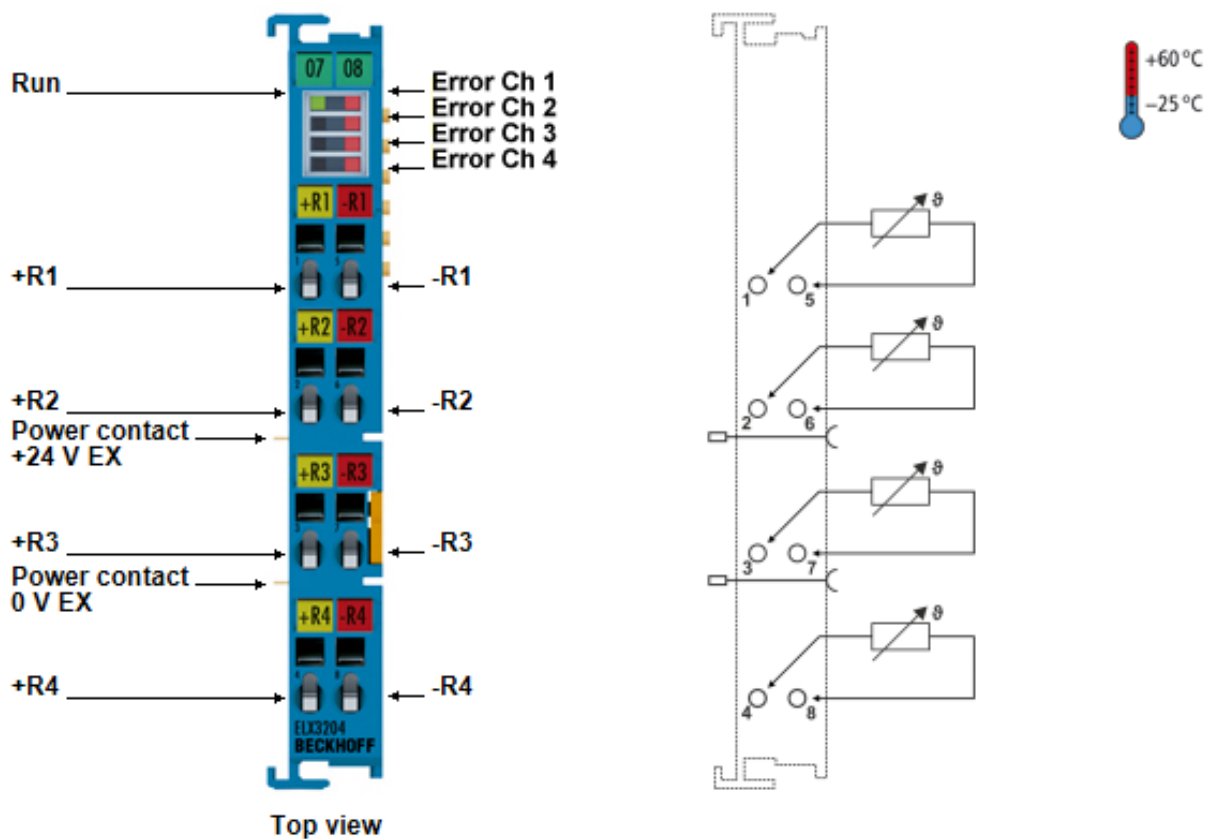


Fig. 7: ELX3204 - 4-channel analog input terminal RTD, 2-wire connection, 16 bit, Ex i

The ELX3204 analog input terminal allows the direct connection of RTDs located in hazardous areas classified Zone 0/20 or 1/21. The circuitry of the ELX3204 can operate sensors with 2-wire technology. Linearization is carried out over the entire freely selectable temperature range. By default the terminal is set to PT100 sensors with 2-wire technology. The ELX3204 terminal indicates signal state and sensor malfunctions (e.g. wire breakage) by means of LEDs.

2.3 Technical data

Technical data	ELX3202-0000	ELX3204-0000
Technology	temperature measurement	
Sensor types	Pt100, Pt200, Pt500, Pt1000, Ni100, Ni120, Ni1000 resistance measurement (10 Ω ...4 k Ω), KT(Y) sensors	
Number of inputs	2 (differential)	4 (differential)
Connection method	2-, 3-, 4-wire, default: 2-wire	2-wire
Measuring range	Pt sensors: -200...+850°C Ni sensors: -60...+250°C	
Resolution	0.1°C per digit	
Measuring current	< 1 mA (depending on sensor and measuring range)	
Measuring error	< $\pm 0,3$ % (relative to the respective full-scale value)	
Internal resistance	≥ 10 k Ω typ. (differential)	
Input filter limit frequency	typical 1 kHz	
Conversion time	adjustable: 10...3300 ms (default: 170 ms)	adjustable: 10...3300 ms (default: 270 ms)
Supply voltage electronics	via E-Bus (5 V _{DC}) and Power Contacts (24 V _{DC} Ex, feeding by ELX9560)	
Current consumption from the E-Bus	typically 70 mA	
Current consumption from the Power Contacts	typically 10 mA + load (ELX9560 power supply)	
Special features	limit value monitoring, digital filter and characteristic curve linearization integrated, connection method freely configurable	
Bit width in the process image	2 x 32 bit RTD input	4 x 32 bit RTD input
Electrical isolation	1500 V (E-Bus / field voltage)	
Weight	ca. 60 g	
Permissible ambient temperature range during operation	-25°C ... + 60°C	
Permissible ambient temperature range during storage	-40°C ... + 85°C	
Permissible relative humidity	95%, no condensation	
Permissible air pressure (operation, storage, transport)	800 hPa to 1100 hPa (this corresponds to a height of approx. -690 m to 2000 m over sea level assuming an international standard atmosphere)	
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	
Protect. class	IP20	
Permissible installation position	See chapter Installation position and minimum distances [► 24]	
Approvals / markings*	CE, cULus, CCC, ATEX, IECEx, ANZEx, cFMus	

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

Housing data

Technical data	ELX3202-0000, ELX3204-0000
Design	compact terminal housing with signal LEDs
Material	Polycarbonate, blue
Size (W x H x D)	approx. 15 mm x 100 mm x 70 mm (width aligned: 12 mm)
Mounting [► 25]	on 35 mm mounting rail according to EN 60715 with locking
Stackable by	double groove-tongue connection
Labelling	Labeling of the BZxxx series
Power contacts	2 blade/spring contacts

Technical data for explosion protection

Technical data for explosion protection		ELX3202-0000, ELX3204-0000	
Ex marking	ATEX	II 3 (1) G Ex ec [ia Ga] IIC T4 Gc II (1) D [Ex ia Da] IIIC I (M1) [Ex ia Ma] I	
	IECEEx, ANZEx	Ex ec [ia Ga] IIC T4 Gc [Ex ia Da] IIIC [Ex ia Ma] I	
	cFMus	AIS Class I, II, III, Division 1, Groups A thru G Class I, Division 2, Groups A, B, C, D Class I, Zone 2, AEx/Ex ec [ia Ga] IIC T4 Gc [AEx/Ex ia Da] IIIC T4	
Certificate numbers		BVS 18 ATEX E 005 X IECEEx BVS 18.0005X ANZEx 20.3004X FM19US0075X, FM19CA0041X	
Power supply		Invariable in connection with ELX9560	
Field interfaces		U ₀ = 4.94 V I ₀ = 12 mA P ₀ = 15 mW Characteristic curve: linear	
Reactance (without consideration of the simultaneousness)		L ₀	C ₀
	Ex ia I	100 mH	1000 µF
	Ex ia IIA	100 mH	1000 µF
	Ex ia IIB	100 mH	1000 µF
	Ex ia IIC	100 mH	100 µF
	Ex ia IIIC	100 mH	1000 µF

2.4 Intended use

WARNING

Endangering the safety of persons and equipment!

The ELX components may only be used for the purposes described below!

CAUTION

Observe ATEX and IECEx!

The ELX components may only be used in accordance with the ATEX directive and the IECEx scheme!

The ELX terminals extend the field of application of the Beckhoff bus terminal system with functions for integrating intrinsically safe field devices from hazardous areas. The intended field of application is data acquisition and control tasks in discrete and process engineering automation, taking into account explosion protection requirements.

The ELX terminals are protected by the type of protection "Increased safety" (Ex e) according to IEC 60079-7 and must only be operated in hazardous areas of Zone 2 or in non-hazardous areas.

The field interfaces of the ELX terminals achieve explosion protection through the type of protection "intrinsic safety" (Ex i) according to IEC 60079-11. For this reason, only appropriately certified, intrinsically safe devices may be connected to the ELX terminals. Observe the maximum permissible connection values for voltages, currents and reactances. Any infringement can damage the ELX terminals and thus eliminate the explosion protection.

The ELX terminals are open, electrical equipment for installation in lockable cabinets, enclosures or operating rooms. Make sure that access to the equipment is only possible for authorized personnel.

CAUTION

Ensure traceability!

The buyer has to ensure the traceability of the device via the Beckhoff Traceability Number (BTN).

3 Mounting and wiring

3.1 Special conditions of use for ELX terminals

WARNING

Observe the special conditions of use for the intended use of Beckhoff ELX terminals in potentially explosive areas!

- The certified components are to be installed in a suitable housing that guarantees an ingress protection of at least IP54 in accordance with IEC 60079-0! The prescribed environmental conditions during installation, operation and maintenance are thereby to be taken into account! Inside the housing, pollution degree 1 and 2 are permissible as defined in IEC 60664-1.
- 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 of Beckhoff ELX terminals!
- Measures must be taken to protect against the rated operating voltage being exceeded by more than 40% due to short-term interference voltages! The power supply of the ELX9560 power supply terminal must correspond to overvoltage category II according to IEC 60664-1
- The individual terminals may only be unplugged or removed from the bus terminal system if all supply voltages have been switched off or if a non-explosive atmosphere is ensured!
- The connections of the ELX9560 power supply terminal may only be connected or disconnected if all supply voltages have been switched off or if a non-explosive atmosphere is ensured!
- Address selectors and switches may only be adjusted if all supply voltages have been switched off or if a non-explosive atmosphere is ensured!

3.2 Installation notes for ELX terminals

NOTICE

Storage, transport and mounting

- Transport and storage are permitted only in the original packaging!
- Store in a dry place, free from vibrations.
- A brand new ELX terminal with a certified build version is delivered only in a sealed carton. Therefore, check that the carton and all seals are intact before unpacking.
- Do not use the ELX terminal if
 - its packaging is damaged
 - the terminal is visibly damaged or
 - you cannot be sure of the origin of the terminal.
- ELX terminals with a damaged packaging seal are regarded as used.

WARNING

Observe the accident prevention regulations

During mounting, commissioning, operation and maintenance, adhere to the safety regulations, accident prevention regulations and general technical rules applicable to your devices, machines and plants.

CAUTION

Observe the erection regulations

Observe the applicable erection regulations.

NOTICE**Protect the terminals against electrostatic discharge (ESD)**

Electronic components can be destroyed by electrostatic discharge. Therefore, take the safety measures to protect against electrostatic discharge as described in DIN EN 61340-5-1 among others. In conjunction with this, ensure that the personnel and surroundings are suitably earthed.

NOTICE**Do not place terminals on E-bus contacts**

Do not place the ELX terminals on the E-bus contacts located on the right-hand side. The function of the E-bus contacts can be negatively affected by damage caused by this, e.g. scratches.

NOTICE**Protect the terminals against dirt**

To ensure the functionality of the ELX terminals they must be protected against dirt, especially on the contact points. For this reason use only clean tools and materials.

NOTICE**Handling**

- It is forbidden to insert conductive or non-conductive objects of any kind into the interior of the housing (e.g. through the ventilation slots in the housing).
- Use only the openings provided in the housing front and appropriate tools to actuate the spring-loaded terminal contacts on the front side for attaching connection cables to the terminal; see chapter [Wiring](#) [► 28].
- The opening of the housing, the removal of parts and any mechanical deformation or machining of an ELX terminal are not permitted!

If an ELX terminal is defective or damaged it must be replaced by an equivalent terminal. Do not carry out any repairs to the devices. For safety reasons repairs may only be carried out by the manufacturer.

NOTICE**Contact marking and pin assignment**

The colored inscription labels above the front connection contacts shown in the illustrations in the introduction chapter are only examples and are not part of the scope of delivery!

A clear assignment of channel and terminal designation according to the chapter contact assignment to the actual terminal point can be made via the lasered channel numbers 1 to 8 on the left above the respective terminal point as well as via the laser image.

Observe any possible polarity dependency of connected intrinsically safe circuits!

3.3 Arrangement of ELX terminals within a bus terminal block

⚠ WARNING

Observe the following notes on the arrangement of ELX terminals!

- ELX signal terminals may only be mounted behind an ELX9560 power supply terminal without exception!
- Only signal terminals from the ELX series may be installed behind an ELX9560 power supply terminal!
- Several ELX9560 power supply terminals may be set in a terminal block as long as an ELX9410 is set before each additional ELX9560!
- An ELX9410 power supply terminal must not be mounted to the right of an ELX9560 or to the left of an ELX signal terminal!
- The last terminal of each ELX terminal segment must be covered with an ELX9012 bus cap or an EK1110 EtherCAT extension, unless two ELX9410 power supply terminals are installed directly behind each other in order to continue the terminal segment with standard Beckhoff EtherCAT Terminals (e.g. EL/ES/EK)!

Examples for the arrangement of ELX terminals

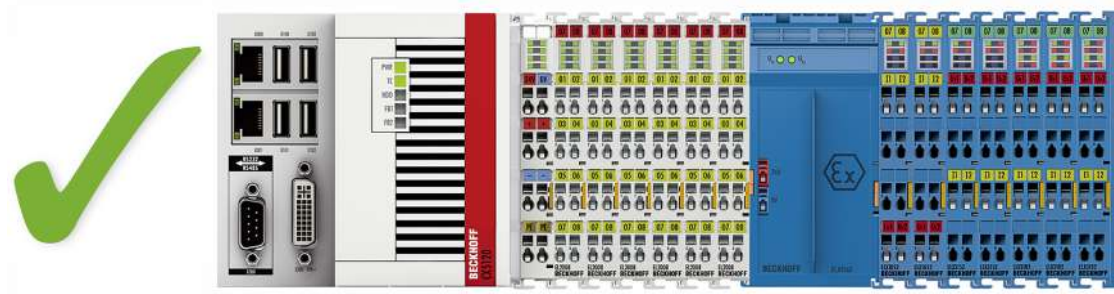


Fig. 8: Permissible arrangement of the ELX terminals (right terminal block).

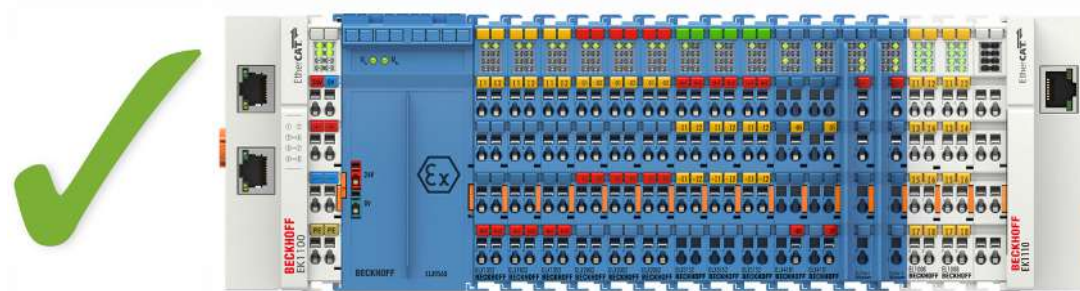


Fig. 9: Permitted arrangement - terminals that do not belong to the ELX series are placed before and after the ELX terminal segment. Isolation is provided by the ELX9560 at the beginning of the ELX terminal segment and two ELX9410 at the end of the ELX terminal segment.

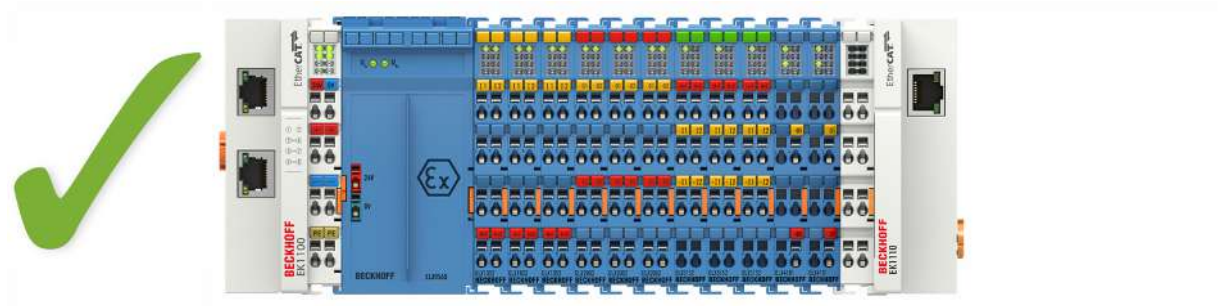


Fig. 10: Permitted arrangement - terminals that do not belong to the ELX series are placed before and after the ELX terminal segment. Isolation is provided by the ELX9560 at the beginning of the ELX terminal segment and the EK1110 at the end of the ELX terminal segment.

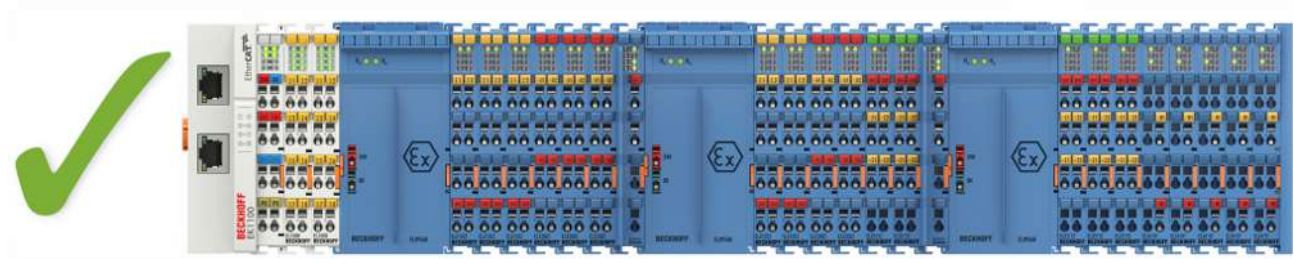


Fig. 11: Permitted arrangement - multiple resupplies by ELX9560 with an upstream ELX9410 in each case.

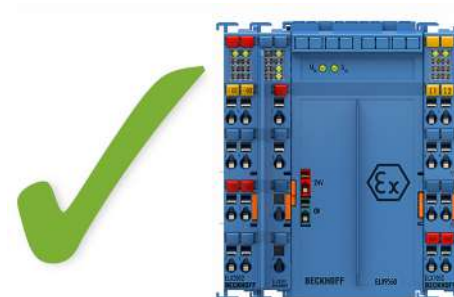


Fig. 12: Permitted arrangement - ELX9410 in front of an ELX9560 power supply terminal.

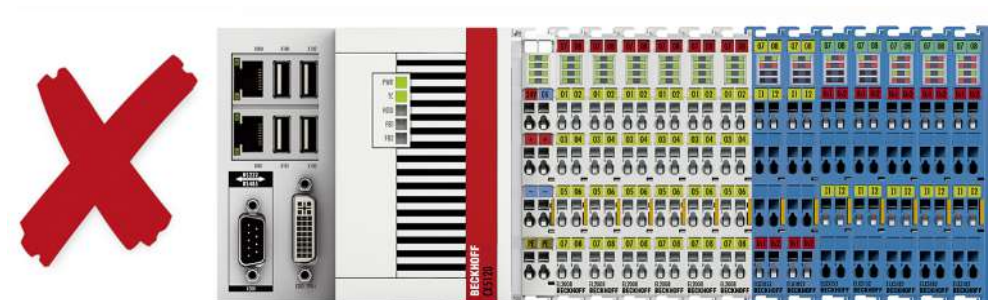


Fig. 13: Illegal arrangement - missing ELX9560 power supply terminal.

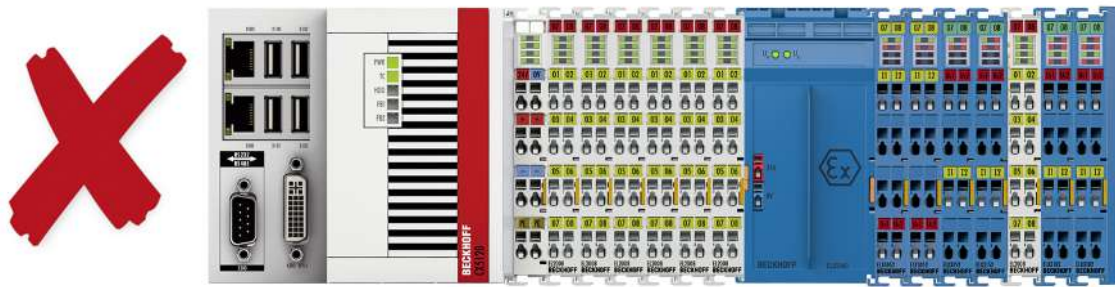


Fig. 14: Impermissible arrangement - terminal in the ELX terminal segment that does not belong to the ELX series

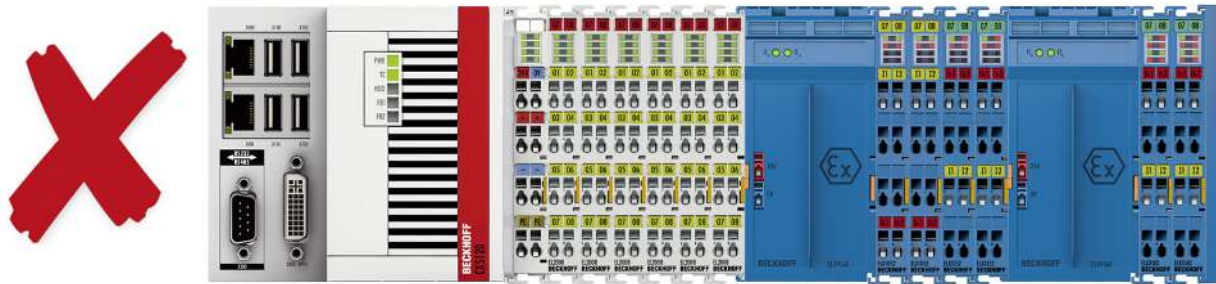


Fig. 15: Impermissible arrangement - second ELX9560 power supply terminal in the ELX terminal segment without upstream ELX9410.

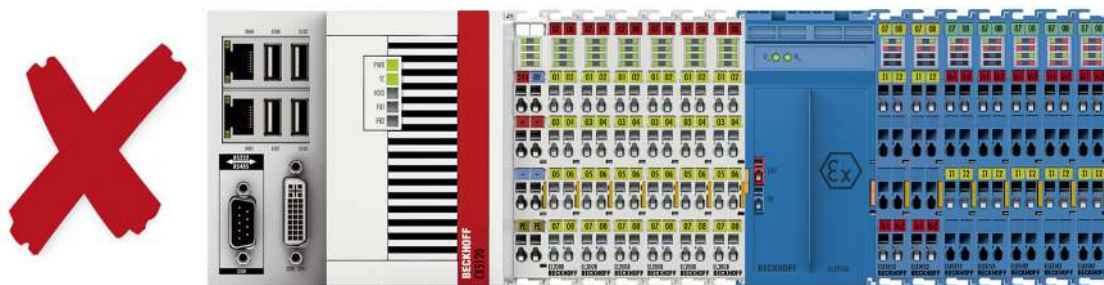


Fig. 16: Illegal arrangement - missing ELX9012 bus end cap.

NOTICE

Note the maximum output current of the ELX9560

When configuring the terminal segment, please observe the maximum available output current of the ELX9560 power supply terminal according to the specified technical data.

If necessary, an additional ELX9560 power supply terminal with upstream ELX9410 (see installation examples) must be installed or a completely new bus terminal block must be configured.

3.4 Installation position and minimum distances

Installation position

For the prescribed installation position the mounting rail is installed horizontally and the mating surfaces of the ELX terminals point toward the front (see illustration below). The terminals are ventilated from below, which enables optimum cooling of the electronics through convection. The direction indication “down” corresponds to the direction of positive acceleration due to gravity.

Minimum distances

Observe the following minimum distances to ensure optimum convection cooling:

- above and below the ELX terminals: 35 mm (required!)
- besides the bus terminal block: 20 mm (recommended)

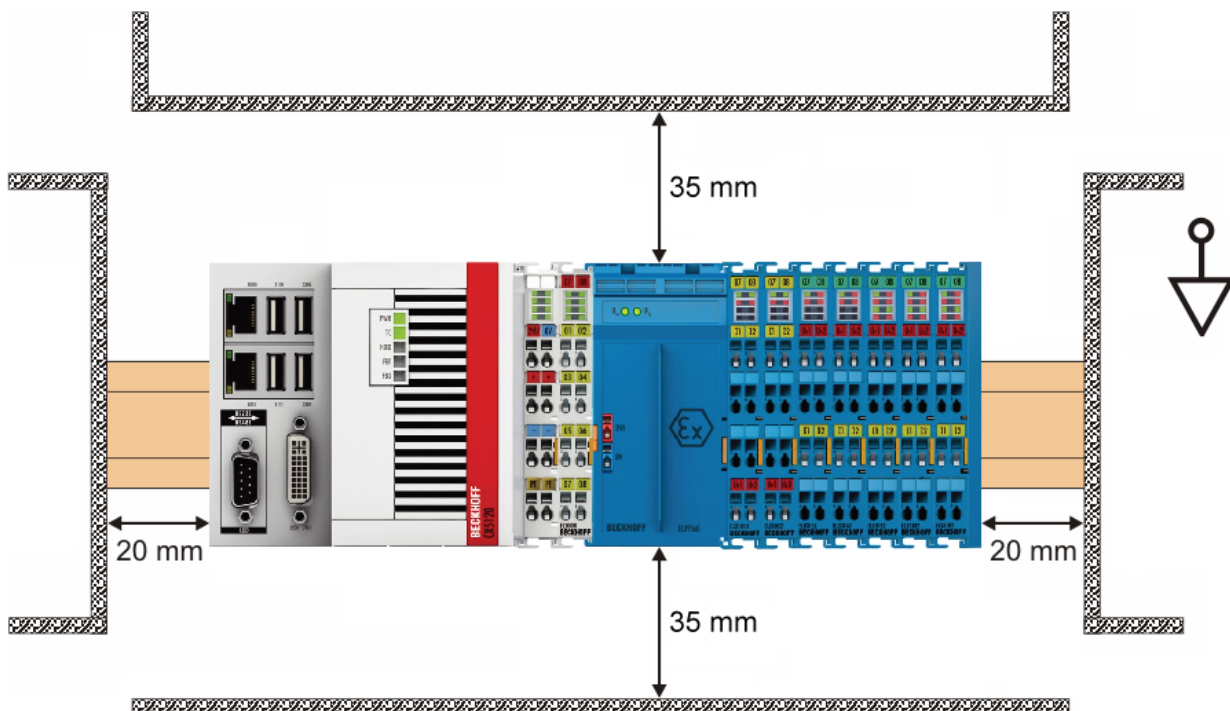


Fig. 17: Installation position and minimum distances

⚠ WARNING

Observe the minimum separation distances according to IEC 60079-14!

Observe the prescribed minimum separation distances between intrinsically safe and non-intrinsically safe circuits according to IEC 60079-14.

3.5 Installation of ELX terminals 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!

⚠ CAUTION

Danger of injury due to power contacts!

For your own protection, pay attention to careful and careful handling of the ELX terminals. In particular, the left side mounted, sharp-edged blade contacts pose a potential risk of injury.

Assembly

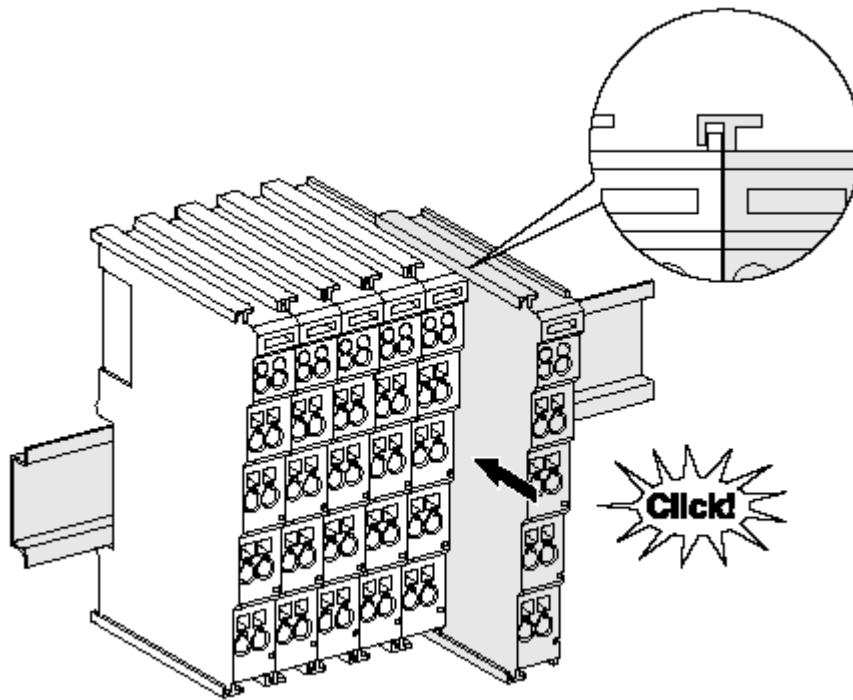


Fig. 18: Attaching on mounting rail

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).

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 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 of the ELX terminals are supplied by the ELX9560 power terminal. This interrupts the power contacts and thus represents the beginning of a new supply rail.

i Power Contacts

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.

Disassembly

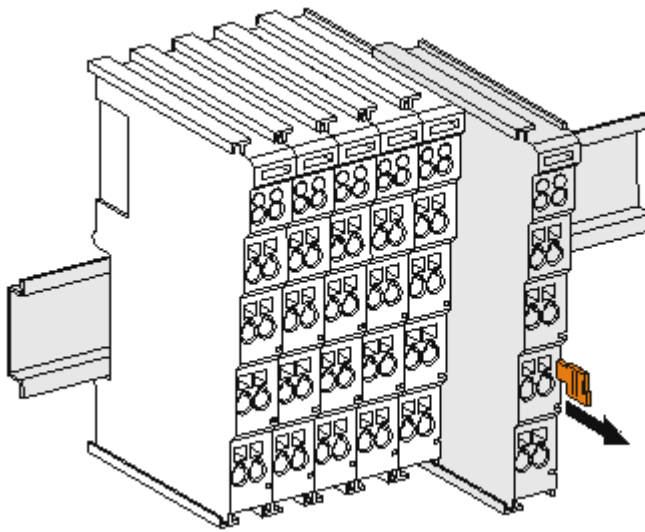


Fig. 19: Disassembling of terminal

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.

3.6 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.

3.7 Connection

3.7.1 Connection system

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 terminals of ELXxxxx series include electronics and connection level in a single enclosure.

Standard wiring

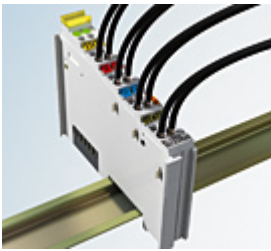


Fig. 20: Standard wiring

The terminals of ELXxxxx series feature integrated screwless spring force technology for fast and simple assembly.

High Density Terminals (HD Terminals)



Fig. 21: *High Density Terminals*

The Bus Terminals from these series with 16 connection points are distinguished by a particularly compact design, as the packaging density is twice as large as that of the standard 12 mm Bus Terminals. Massive conductors and conductors with a wire end sleeve can be inserted directly into the spring loaded terminal point without tools.

Ultrasonically "bonded" (ultrasonically welded) conductors



Ultrasonically "bonded" conductors

It is also possible to connect the Standard and High Density Terminals with ultrasonically "bonded" (ultrasonically welded) conductors. In this case, please note the tables concerning the wire-size width below!

3.7.2 Wiring

⚠ 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!

Terminals for standard wiring

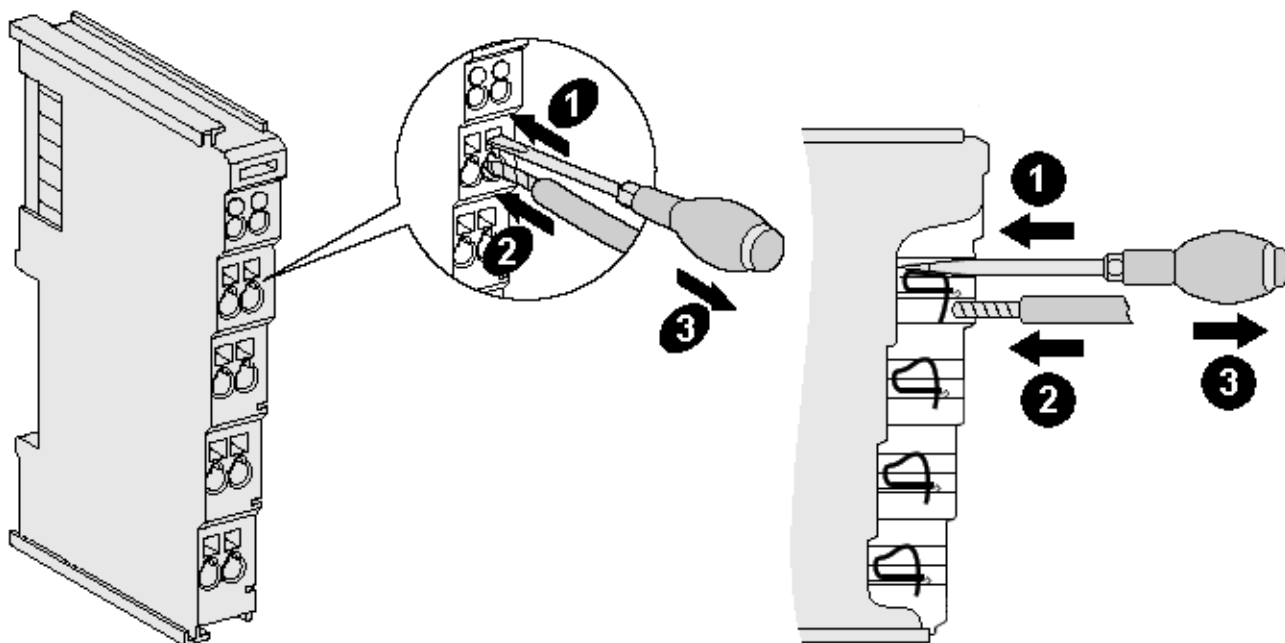


Fig. 22: Connecting a cable on a terminal point

Up to eight terminal points enable the connection of solid or finely stranded cables to the Bus Terminal. The terminal points are implemented in spring force technology. Connect the cables as follows:

1. Open a terminal point by pushing a screwdriver straight against the stop into the square opening above the terminal point. Do not turn the screwdriver or move it alternately (don't toggle).
2. The wire can now be inserted into the round terminal opening without any force.
3. The terminal point closes automatically when the pressure is released, holding the wire securely and permanently.

Observe the requirements for connecting cables and cross sections according to IEC 60079-7 and IEC 60079-11. See the following tables for the suitable wire size width.

Terminal housing	Standard wiring	ELX9560
Wire size width (single core wires)	0.08 ... 2.5 mm ²	0.14 ... 1.5 mm ²
Wire size width (fine-wire conductors)	0.08 ... 2.5 mm ²	0.14 ... 1.5 mm ²
Wire size width (conductors with a wire end sleeve)	0.14 ... 1.5 mm ²	0.14 ... 1.0 mm ²
Wire stripping length	8 ... 9 mm	8 ... 9 mm

NOTICE

Maximum screwdriver width for ELX9560

Use a screwdriver with a maximum width of 2 mm to wire the ELX9560 power supply terminal. Wider screwdrivers can damage the terminal points.

High Density Terminals (HD Terminals) with 16 terminal points

The conductors of the HD Terminals are connected without tools for single-wire conductors using the direct plug-in technique, i.e. after stripping the wire is simply plugged into the terminal point. The cables are released, as usual, using the contact release with the aid of a screwdriver. See the following table for the suitable wire size width.

Terminal housing	High Density Housing
Wire size width (single core wires)	0.08 ... 1.5 mm ²
Wire size width (fine-wire conductors)	0.25 ... 1.5 mm ²
Wire size width (conductors with a wire end sleeve)	0.14 ... 0.75 mm ²
Wire size width (ultrasonically "bonded" conductors)	only 1.5 mm ²
Wire stripping length	8 ... 9 mm

3.7.3 Proper line connection

Always connect only one wire per terminal point.

When using fine-wire conductors it is recommended to connect them with wire end sleeves in order to establish a safe, conductive connection.

In addition, make sure that the pin assignment is correct to prevent damage to the ELX terminals and the connected devices.

3.7.4 Shielding and potential separation



Shielding

Encoder, analog sensors and actors should always be connected with shielded, twisted paired wires!

CAUTION

Observe installation requirements in areas of potentially explosive atmospheres!

During installation, observe the requirements for cables, shielding and earth potential equalization in areas of potentially explosive atmospheres according to IEC 60079-11, IEC 60079-14 and IEC 60079-25!

WARNING

Ensure potential separation of the 24 V Ex busbar!

In any case, make sure that the galvanic isolation made by the ELX9560 between the 24 V Ex busbar (power contacts +24 V Ex and 0 V Ex) and other system potentials (if applicable also functional or protective earths) is not removed!

3.7.5 ELX3202 - Contact assignment

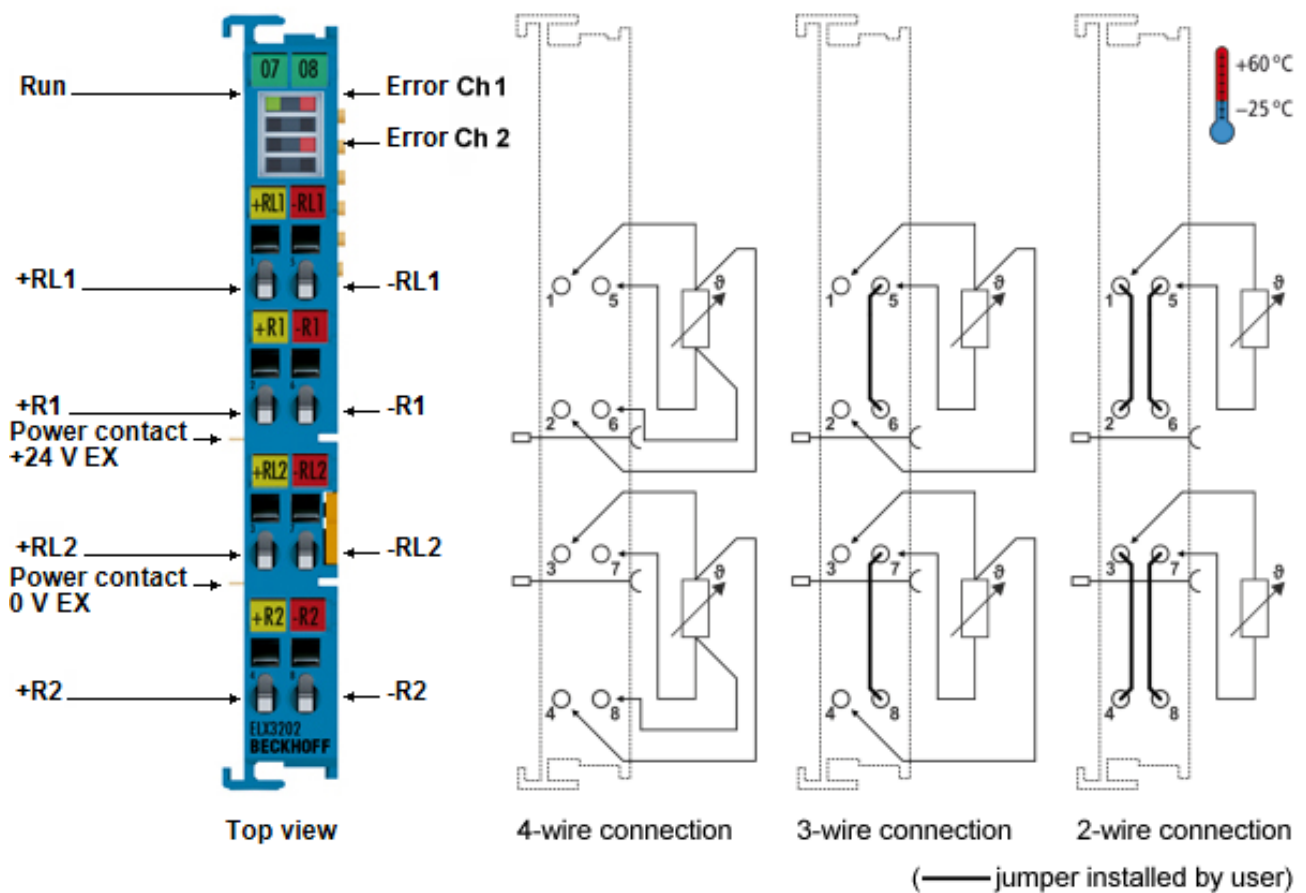


Fig. 23: ELX3202 - Contact assignment

Terminal point		Description
Name	No.	
+RL1	1	Channel 1: Input +RL1 (RTD current source)
+R1	2	Channel 1: Input +R1 (RTD voltage measurement)
+RL2	3	Channel 2: Input +RL2 (RTD current source)
+R2	4	Channel 2: Input +R2 (RTD voltage measurement)
-RL1	5	Channel 1: Input -RL1 (RTD current sink)
-R1	6	Channel 1: Input -R1 (RTD voltage measurement)
-RL2	7	Channel 2: Input: -RL2 (RTD current sink)
-R2	8	Channel 2: Input -R2 (RTD voltage measurement)

LED displays

LED	Color	Meaning	
Run	green	This LED indicates the terminal's operating state:	
		off	State of the EtherCAT State Machine: INIT = initialization of the terminal or BOOTSTRAP = function for firmware updates of the terminal
		flashing	State of the EtherCAT State Machine: PREOP = function for mailbox communication and different standard-settings set
		single flash	State of the EtherCAT State Machine: SAFEOP = verification of the Sync Manager channels and the distributed clocks. Outputs remain in safe state
		on	State of the EtherCAT State Machine: OP = normal operating state; mailbox and process data communication is possible
Error Ch 1	red	The resistance is in the invalid range of the characteristic curve. Possible short circuit or wire breakage at channel 1.	
Error Ch 2	red	The resistance is in the invalid range of the characteristic curve. Possible short circuit or wire breakage at channel 2.	

3.7.6 ELX3204 - Contact assignment

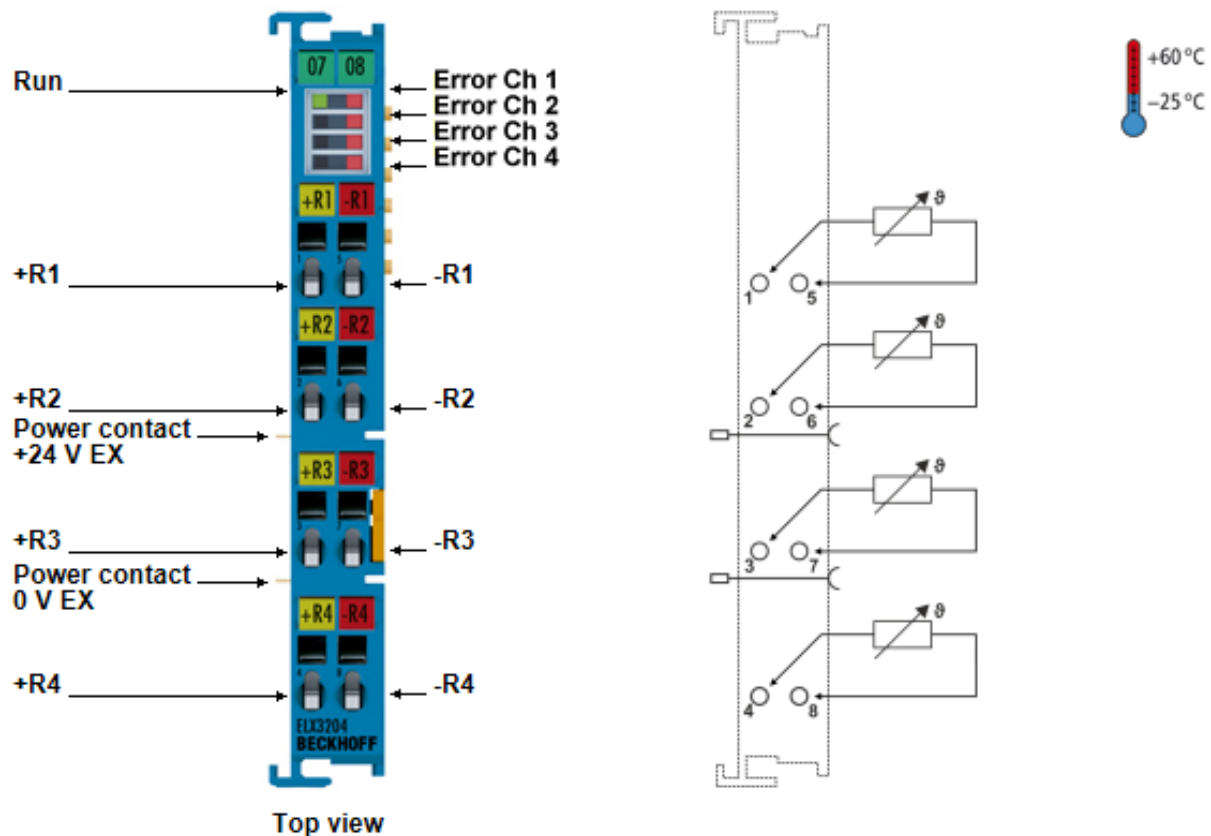


Fig. 24: ELX3204 - Contact assignment

Terminal point		Description
Name	No.	
+R1	1	Channel 1: Input +R1 (RTD voltage measurement, RTD current source)
+R2	2	Channel 2: Input +R2 (RTD voltage measurement, RTD current source)
+R3	3	Channel 3: Input +R3 (RTD voltage measurement, RTD current source)
+R4	4	Channel 4: Input +R4 (RTD voltage measurement, RTD current source)
-R1	5	Channel 1: Input -R1 (RTD voltage measurement, RTD current sink)
-R2	6	Channel 2: Input -R2 (RTD voltage measurement, RTD current sink)
-R3	7	Channel 3: Input -R3 (RTD voltage measurement, RTD current sink)
-R4	8	Channel 4: Input -R4 (RTD voltage measurement, RTD current sink)

LED displays

LED	Color	Meaning
Run	green	This LED indicates the terminal's operating state:
		off State of the EtherCAT State Machine: INIT = initialization of the terminal or BOOTSTRAP = function for firmware updates of the terminal
		flashing State of the EtherCAT State Machine: PREOP = function for mailbox communication and different standard-settings set
		single flash State of the EtherCAT State Machine: SAFEOP = verification of the Sync Manager channels and the distributed clocks. Outputs remain in safe state
		on State of the EtherCAT State Machine: OP = normal operating state; mailbox and process data communication is possible
Error Ch 1	red	The resistance is in the invalid range of the characteristic curve. Possible short circuit or wire breakage at channel 1.
Error Ch 2	red	The resistance is in the invalid range of the characteristic curve. Possible short circuit or wire breakage at channel 2.
Error Ch 3	red	The resistance is in the invalid range of the characteristic curve. Possible short circuit or wire breakage at channel 3.
Error Ch 4	red	The resistance is in the invalid range of the characteristic curve. Possible short circuit or wire breakage at channel 4.

4 Basic function principles

4.1 EtherCAT basics

For basic information about the EtherCAT fieldbus please refer to the [EtherCAT system documentation](#), which is also available as [PDF file](#) at www.beckhoff.com in the download area of your EtherCAT device.

4.2 Notices on analog specifications

Beckhoff I/O devices (terminals, boxes, modules) with analog inputs are characterized by a number of technical characteristic data; refer to the technical data in the respective documents.

Some explanations are given below for the correct interpretation of these characteristic data.

4.2.1 Full scale value (FSV)

An I/O device with analog input measures over a nominal measuring range, which is limited by an upper and a lower limit (start value and end value), which can usually already be taken from the device designation. The range between both limits is called measuring span and corresponds to the formula (end value - start value). Analogous to pointing devices this is the measuring scale (see IEC 61131) or also the dynamic range.

For analog I/O devices from Beckhoff, the full scale value (FSV) of the respective product (also: reference value) is selected as the largest limit of the nominal measuring range and is given a positive sign. This applies to both symmetrical and asymmetrical measuring spans.

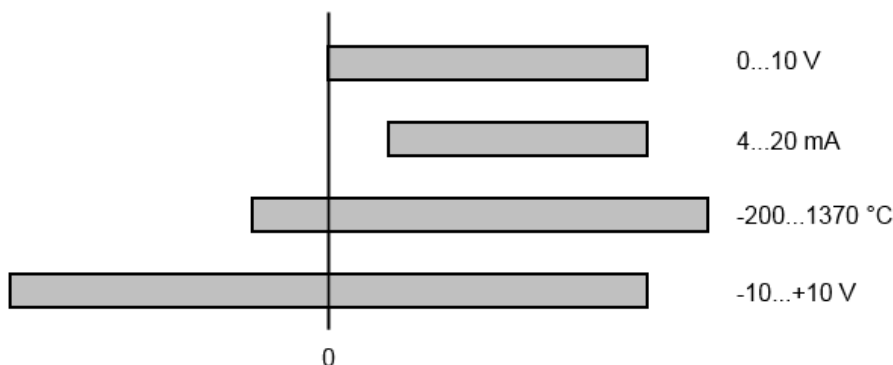


Fig. 25: Full scale value, measuring span

For the above **examples** this means:

- Measuring range 0...10 V: asymmetric unipolar, FSV = 10 V, measuring span = 10 V
- Measuring range 4...20 mA: asymmetric unipolar, FSV = 20 mA, measuring span = 16 mA
- Measuring range -200...1370 °C: asymmetric bipolar, FSV = 1370 °C, measuring span = 1570 °C
- Measuring range -10...+10 V: symmetric bipolar, FSV = 10 V, measuring span = 20 V

Depending on the functionality, an analog input channel may have a technical measuring range that exceeds the nominal measuring range, e.g. to gain more diagnostic information about the signal.

The case-by-case information in the device documentation on the behavior outside the nominal measuring range (measurement uncertainty, display value) must be observed.

The above thoughts are correspondingly applicable to analog output devices:

- The full scale value (FSV) becomes the output end value
- Here, too, there can be a (larger) technical output range in addition to the nominal output range

4.2.2 Measuring error/ measurement deviation



Analog output

The following information also applies analogously to the output end value of analog output devices.

The relative measuring error as a specification value of a Beckhoff analog device is specified in % of the nominal FSV (output end value) and calculated as the quotient of the numerically largest probable deviation from the true measured value (output value) with respect to the FSV (output end value):

$$\text{Measuring error} = \frac{\left| \text{max. deviation} \right|}{\text{full scale value}}$$

It should be noted here that the "true measured value" cannot be determined with infinite accuracy either, but can only be determined via reference devices with a higher expenditure of technology and measuring time and thus a significantly lower measurement uncertainty.

The value therefore describes the result window in which the measured value determined by the device under consideration (Beckhoff analog device) lies with a very high probability in relation to the "true value". Thus, colloquially, this is a "typical" value (typ.); this expresses that the vast statistical majority of values will be within the specification window, but in rare cases there may/will be deviations outside the window.

For this reason, the term "measurement uncertainty" has become established for this window, since "error" is now used to refer to known disturbance effects that can generally be systematically eliminated.

The uncertainty of measurement must always be considered in relation to potential environmental influences:

- invariable electrical channel properties such as temperature sensitivity,
- variable settings of the channel (noise via filters, sampling rate, ...).

Measurement uncertainty specifications without further operational limitation (also called "service error limit") can be assumed as a value "over everything": entire permissible operating temperature range, default setting, etc.

The window is always to be understood as a positive/negative span with "±", even if occasionally indicated as a "half" window without "±".

The maximum deviation can also be specified directly.

Example: measuring range 0...10 V (FSV = 10 V) and measurement uncertainty $< \pm 0.3\%_{\text{FSV}}$ → the expected maximum usual deviation is ± 30 mV in the permissible operating temperature range.



Lower measurement uncertainty possible

If this specification also includes the temperature drift, a significantly lower measuring error can usually be assumed in case of a constant ambient temperature of the device and thermal stabilization after a user calibration.

4.2.3 Temperature coefficient tK [ppm/K]

An electronic circuit is usually temperature dependent to a greater or lesser degree. In analog measurement technology this means that when a measured value is determined by means of an electronic circuit, its deviation from the "true" value is reproducibly dependent on the ambient/operating temperature.

A manufacturer can alleviate this by using components of a higher quality or by software means.

The temperature coefficient, when indicated, specified by Beckhoff allows the user to calculate the expected measuring error outside the basic accuracy. The basic accuracy is usually specified for 23 °C ambient temperature, in special cases also at other temperature.

Due to the extensive uncertainty considerations that are incorporated in the determination of the basic accuracy, Beckhoff recommends a quadratic summation.

Example: Let the basic accuracy be $\pm 0.01\%$ typ. (full scale value), $tK = 20 \text{ ppm/K}$ typ at 23°C .; the accuracy A35 at 35°C is wanted, hence $\Delta T = 12 \text{ K}$:

$$G35 = \sqrt{(0.01\%)^2 + (12\text{K} \cdot 20 \frac{\text{ppm}}{\text{K}})^2} = 0.026\% \text{ full scale value, typ.}$$

Remarks: $\text{ppm} \triangleq 10^{-6}$ $\% \triangleq 10^{-2}$

4.2.4 Single-ended/differential typification

For analog inputs Beckhoff makes a basic distinction between two types: *single-ended* (SE) and *differential* (DIFF), referring to the difference in electrical connection with regard to the potential difference.

The diagram shows two-channel versions of an SE module and a DIFF module as examples for all multi-channel versions.

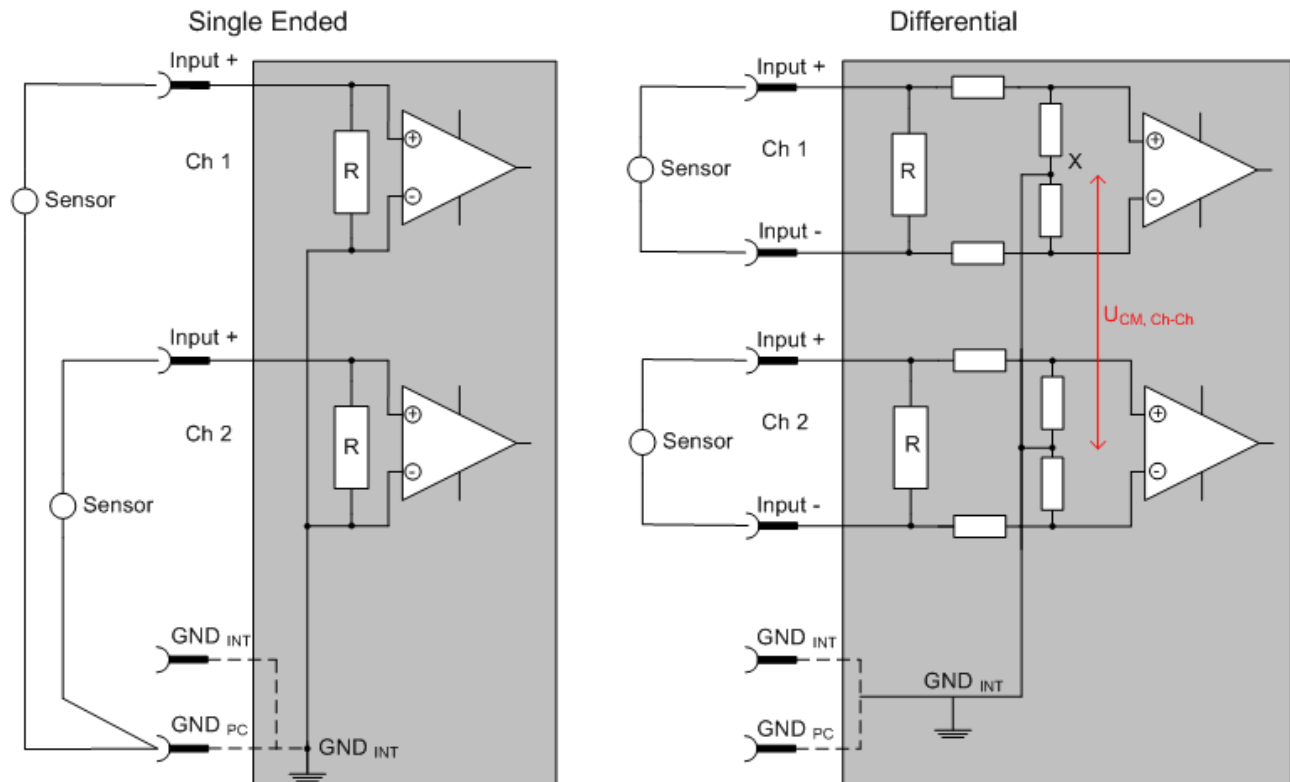


Fig. 26: SE and DIFF module as 2-channel version

Note: Dashed lines indicate that the respective connection may not necessarily be present in each SE or DIFF module. Electrical isolated channels are operating as differential type in general, hence there is no direct relation (voltaic) to ground within the module established at all. Indeed, specified information to recommended and maximum voltage levels have to be taken into account.

The basic rule

- Analog measurements always take the form of voltage measurements between two potential points. For voltage measurements a large R is used, in order to ensure a high impedance. For current measurements a small R is used as shunt. If the purpose is resistance measurement, corresponding considerations are applied.
 - Beckhoff generally refers to these two points as input+/signal potential and input-/reference potential.
 - For measurements between two potential points two potentials have to be supplied.
 - Regarding the terms “single-wire connection” or “three-wire connection”, please note the following for pure analog measurements: three- or four-wire connections can be used for sensor supply, but are not involved in the actual analog measurement, which always takes place between two potentials/wires.
In particular this also applies to SE, even though the term suggests that only one wire is required.
- The term “electrical isolation” should be clarified in advance.
Beckhoff I/O devices feature 1 to 8 or more analog channels; with regard to the channel connection a distinction is made in terms of:
 - how the channels WITHIN a module relate to each other, or
 - how the channels of SEVERAL modules relate to each other.

The property of electrical isolation indicates whether the channels are directly connected to each other.

- Beckhoff I/O devices always feature electrical isolation between the field/analog side and the bus/EtherCAT side. In other words, if two analog I/O devices are not connected via the power contacts (cable), they are effectively electrically isolated.
- If channels within a device are electrically isolated, or if a single-channel device has no power contacts, the channels are effectively always differential. See also explanatory notes below. Differential channels are not necessarily electrically isolated.
- Analog measuring channels are subject to technical limits, both in terms of the recommended operating range (continuous operation) and the destruction limit. Please refer to the respective device documentation for further details.

Explanation

• Differential (DIFF)

- Differential measurement is the most flexible concept. The user can freely choose both connection points, input+/signal potential and input-/reference potential, within the framework of the technical specification.
- A differential channel can also be operated as SE, if the reference potential of several sensors is linked. This interconnection may take place via the system GND.
- Since a differential channel is configured symmetrically internally (cf. Fig. SE and DIFF module as 2-channel variant), there will be a mid-potential (X) between the two supplied potentials that is the same as the internal ground/reference ground for this channel. If several DIFF channels are used in a module without electrical isolation, the technical property V_{CM} (common-mode voltage) indicates the degree to which the mean voltage of the channels may differ.
- The internal reference ground may be accessible as connection point at the device, in order to stabilize a defined GND potential in the device. In this case it is particularly important to pay attention to the quality of this potential (noiselessness, voltage stability). At this GND point a wire may be connected to make sure that $V_{CM,max}$ is not exceeded in the differential sensor cable. If differential channels are not electrically isolated, usually only one $V_{CM,max}$ is permitted. If the channels are electrically isolated this limit should not apply, and the channels voltages may differ up to the specified separation limit.
- Differential measurement in combination with correct sensor wiring has the special advantage that any interference affecting the sensor cable (ideally the feed and return line are arranged side by side, so that interference signals have the same effect on both wires) has very little effect on the measurement, since the potential of both lines varies jointly (hence the term common mode). In simple terms: Common-mode interference has the same effect on both wires in terms of amplitude and phasing.
- Nevertheless, the suppression of common-mode interference within a channel or between channels is subject to technical limits, which are specified in the technical data.
- Further helpfully information on this topic can be found on the documentation page *Configuration of 0/4..20 mA differential inputs* (see documentation for the EL30xx terminals, for example).

• Single-ended (SE)

- If the analog circuit is designed as SE, the input/reference wire is internally fixed to a certain potential that cannot be changed. This potential must be accessible from outside of the device on at least one point for connecting the reference potential, e.g. via the power contacts (cable).
- In other words, in situations with several channels SE offers users the option to avoid returning at least one of the two sensor cables to the device (in contrast to DIFF). Instead, the reference wire can be consolidated at the sensors, e.g. in the system GND.
- A disadvantage of this approach is that the separate feed and return line can result in voltage/current variations, which a SE channel may no longer be able to handle. See common-mode interference. A V_{CM} effect cannot occur, since the device channels are internally always 'hard-wired' through the input/reference potential.

Typification of the 2/3/4-wire connection of current sensors

Current transducers/sensors/field devices (referred to in the following simply as 'sensor') with the industrial 0/4-20 mA interface typically have internal transformation electronics for the physical measured variable (temperature, current, etc.) at the current control output. These internal electronics must be supplied with energy (voltage, current). The type of cable for this supply thus separates the sensors into *self-supplied* or *externally supplied* sensors:

Self-supplied sensors

- The sensor draws the energy for its own operation via the sensor/signal cable + and -.
So that enough energy is always available for the sensor's own operation and open-circuit detection is possible, a lower limit of 4 mA has been specified for the 4-20 mA interface, i.e., the sensor allows a minimum current of 4 mA and a maximum current of 20 mA to pass.
- 2-wire connection see Fig. 2-wire connection, cf. IEC60381-1
- Such current transducers generally represent a current sink and thus like to sit between + and - as a 'variable load'. See also the data of the sensor manufacturer.

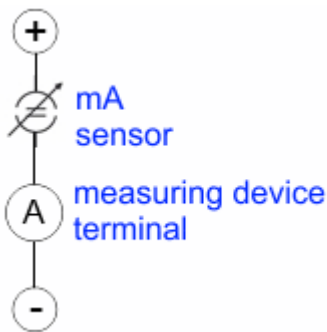


Fig. 27: 2-wire connection

Therefore, they are to be connected according to the Beckhoff terminology as follows:

preferably to '**single-ended**' inputs if the +Supply connections of the device are also to be used - connect to +Supply and Signal.

They can, however, also be connected to '**differential**' inputs, if the termination to GND is then manufactured on the application side – to be connected with the right polarity to +Signal and –Signal. It is important to refer to the information page *Configuration of 0/4...20 mA differential inputs* (see documentation for the EL30xx terminals, for example)!

Externally supplied sensors

No external supply for sensors / actuators

⚠ WARNING

An external supply of sensors / actuators connected to I/O devices of the ELX/EPX series is not permitted!

All I/O devices of the ELX/EPX series are energy-supplying, associated equipment in terms of intrinsic safety. Therefore, connected sensors or actuators are supplied exclusively via the respective channel of the I/O device and must not be externally supplied in any form (e.g. via an additional, external supply voltage).

This limitation is also independent of whether the additional, external supply is energy-limited in the sense of IEC 60079-11.

Connection of any externally powered, intrinsically safe circuits to an I/O device of the ELX/EPX series is contrary to the intended use and the specified technical data on explosion protection. The explosion protection provided by the specified ignition protection type is thus automatically extinguished.

4.2.5 Common-mode voltage and reference ground (based on differential inputs)

Common-mode voltage (V_{cm}) is defined as the average value of the voltages of the individual connections/inputs and is measured/specified against reference ground.

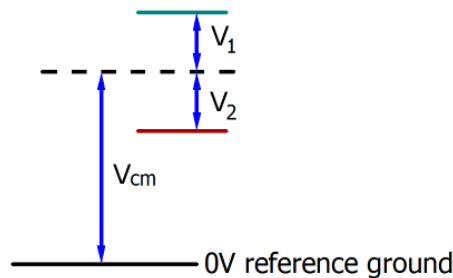


Fig. 28: Common-mode voltage (V_{cm})

The definition of the reference ground is important for the definition of the permitted common-mode voltage range and for measurement of the common-mode rejection ratio (CMRR) for differential inputs.

The reference ground is also the potential against which the input resistance and the input impedance for single-ended inputs or the common-mode resistance and the common-mode impedance for differential inputs is measured.

The reference ground is usually accessible at or near the I/O device. Locations for this can be terminal contacts, power contacts/power line or just a mounting rail.

Please refer to the documentation regarding positioning. The reference ground should be specified for the device under consideration.

For multi-channel I/O devices with resistive (= direct, ohmic, galvanic) or capacitive connection between the channels, the reference ground should preferably be the symmetry point of all channels, taking into account the connection resistances.

Reference ground samples for Beckhoff IO devices:

1. Internal AGND fed out: EL3102/EL3112, resistive connection between the channels
2. 0 V power contact: EL3104/EL3114, resistive connection between the channels and AGND; AGND connected to 0 V power contact with low-resistance
3. Earth or SGND (shield GND):
 - EL3174-0002: Channels have no resistive connection between each other, although they are capacitively coupled to SGND via leakage capacitors
 - EL3314: No internal ground fed out to the terminal points, although capacitive coupling to SGND

4.2.6 Dielectric strength

A distinction should be made between:

- Dielectric strength (destruction limit): Exceedance can result in irreversible changes to the electronics
 - Against a specified reference ground
 - Differential
- Recommended operating voltage range: If the range is exceeded, it can no longer be assumed that the system operates as specified
 - Against a specified reference ground
 - Differential

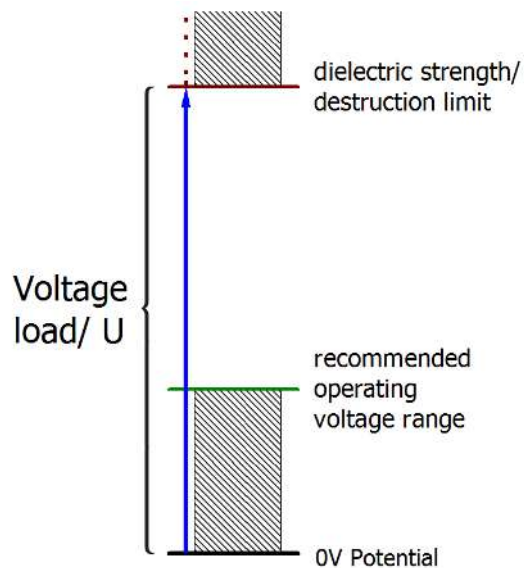


Fig. 29: Recommended operating voltage range

The device documentation may contain particular specifications and timings, taking into account:

- Self-heating
- Rated voltage
- Insulating strength
- Edge steepness of the applied voltage or holding periods
- Normative environment (e.g. PELV)

4.2.7 Temporal aspects of analog/digital conversion



Analog output

The following information applies analogously to analog signal output via DAC (digital-to-analog converter).

The conversion of the constant electrical input signal to a value-discrete digital and machine-readable form takes place in the analog Beckhoff EL/KL/EP input modules with ADC (analog digital converter). Although different ADC technologies are common, from the user's point of view they all have one common feature: after the end of the conversion, a certain digital value is available for further processing in the controller. This digital value, the so-called analog process data, has a fixed temporal relationship with the "original parameter", i.e. the electrical input value. Therefore, corresponding temporal characteristic data can be determined and specified for Beckhoff analogue input devices.

This process involves several functional components, which act more or less strongly in every AI (analog input) module:

- the electrical input circuit
- the analog/digital conversion
- the digital further processing
- the final provision of the process and diagnostic data for collection at the fieldbus (EtherCAT, K-bus, etc.)

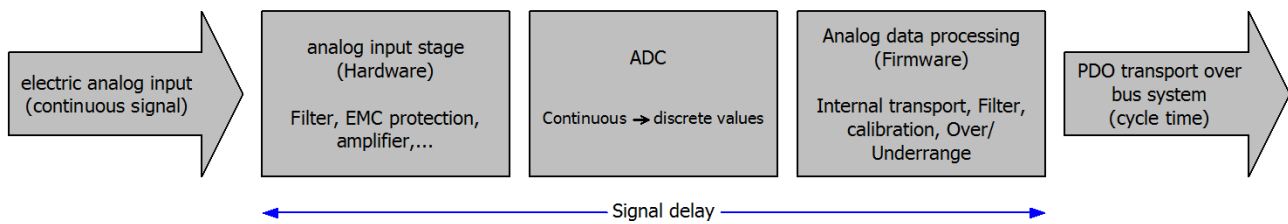


Fig. 30: Signal processing analog input

Two aspects are crucial from a user perspective:

- “How often do I receive new values?”, i.e. a sampling rate in terms of speed with regard to the device/channel
- What delay does the (whole) AD conversion of the device/channel cause?
So hardware and firmware parts in toto. For technological reasons, the signal characteristics must be considered to determine this specification: depending on the signal frequency, there may be different propagation times through the system.

This is the “external” view of the “Beckhoff AI channel” system – internally the signal delay in particular is composed of different components: hardware, amplifier, conversion itself, data transport and processing. Internally a higher sampling rate may be used (e.g. in the deltaSigma converters) than is offered “externally” from the user perspective. From a user perspective of the “Beckhoff AI channel” component this is usually irrelevant or is specified accordingly, if it is relevant for the function.

For Beckhoff AI devices the following specification parameters for the AI channel are available for the user from a temporal perspective:

1. Minimum conversion time [ms, μ s]

This is the reciprocal value of the maximum **sampling rate** [Sps, samples per second]:

Specifies how often the analog channel provides a newly detected process data value for collection by the fieldbus. Whether the fieldbus (EtherCAT, K-bus) fetches the value with the same speed (i.e. synchronous), or more quickly (if the AI channel operates in slow FreeRun mode) or more slowly (e.g. with oversampling), is then a question of the fieldbus setting and which modes the AI device supports.

For EtherCAT devices the so-called toggle bit indicates (by toggling) for the diagnostic PDOs when a newly determined analog value is available.

Accordingly, a maximum conversion time, i.e. a smallest sampling rate supported by the AI device, can be specified.

Corresponds to IEC 61131-2 Chap. 7.10.2 2, “Sampling repeat time”

2. Typical signal delay

Corresponds to IEC 61131-2, Chapter 7.10.2 1, “Sampling duration”. From this perspective it includes all internal hardware and firmware components, but not “external” delay components from the fieldbus or the controller (TwinCAT).

This delay is particularly relevant for absolute time considerations, if AI channels also provide a timestamp that corresponds to the amplitude value – which can be assumed to match the physically prevailing amplitude value at the time.

Due to the frequency-dependent runtime of a signal, a dedicated value can only be specified for a given signal. The value also depends on possibly changing filter settings of the channel.

A typical characterization in the device documentation can be:

2.1 Signal delay (step response)

Keyword settling time:

The square wave signal can be generated externally with a frequency generator (note impedancel!).

The 90% limit is used as detection threshold.

The signal delay [ms, μ s] is then the time interval between the (ideal) electrical square wave signal and the time when the analog process value has reached the 90% amplitude.

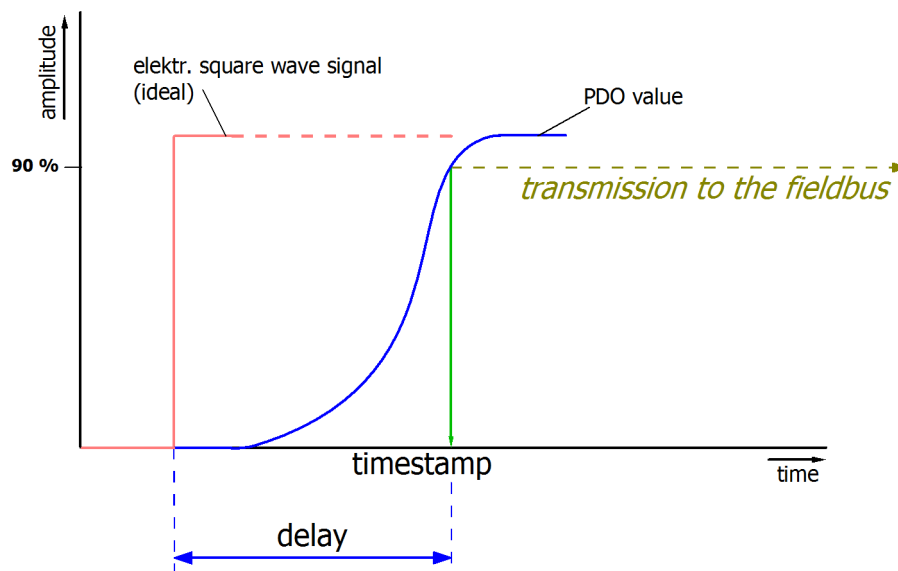


Fig. 31: Diagram Signal delay (step response)

2.2 Signal delay (linear)

Keyword group delay:

Describes the delay of a frequency-constant signal

Test signal can be generated externally with a frequency generator, e.g. as sawtooth or sine. Reference would then be a simultaneous square wave signal.

The signal delay [ms, μ s] is then the time interval between the applied electrical signal of a certain amplitude and the moment when the analog process value reaches the same value.

For this purpose, the test frequency must be selected in a reasonable range; this can be, for example, 1/20 of the maximum sampling rate.

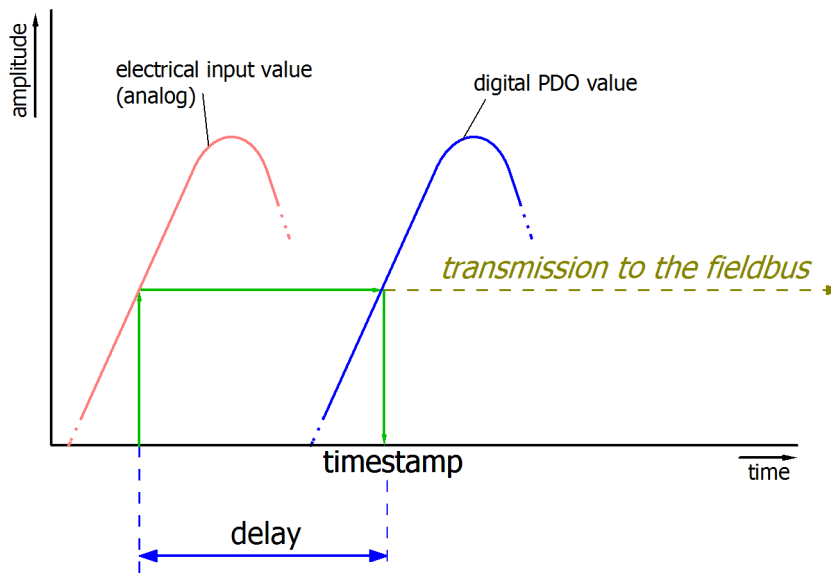


Fig. 32: Diagram Signal delay (linear)

3. Additional information

Additional information may be provided in the specification, e.g.

- actual sampling rate of the ADC (if different from the channel sampling rate)
- time correction values for runtimes with different filter settings
- etc.

5 Parameterization and programming

5.1 Settings and application notes

5.1.1 Default settings

The EL320x can be used for direct temperature or resistance measurements. The corresponding CoE settings are shown in the following table.

The relationship between temperature and resistance of a Pt100/Pt1000 sensor is shown below:

Temperature	typical resistance, approx.
850°C	Pt1000: 3.9 kΩ Pt100: 390 Ω
320°C	Pt1000: 2.2 kΩ Pt100: 220 Ω
-200°C	Pt1000: 180 Ω Pt100: 18 Ω

Characteristic sensor curves are available from the sensor manufacturers.

You can obtain further information in the chapters [Object description and parameterization \[► 57\]](#) and [Process data and operating modes](#).

	ELX3202	ELX3204
Default/ factory setting	<ul style="list-style-type: none"> • 4-wire connection • Pt100 (CoE 0x80n0:19) • Presentation signed (CoE 0x80n0:02) • Limits disabled • All channels enabled 	<ul style="list-style-type: none"> • 2-wire connection • Pt100 (CoE 0x80n0:19) • Presentation signed (CoE 0x80n0:02) • Limits disabled • All channels enabled

Notice regarding Resistance Measurement mode

In Resistance Measurement mode the measured value is always displayed unsigned, irrespective of the Presentation setting (object [0x80n0:02 \[► 57\]](#)), as 0...xFFFF with the respective value.

1/16 Ω -> ~62 mΩ/Digit

1/64 Ω -> ~15 mΩ/Digit

5.1.2 Changing the slave parameters in the CoE directory

During commissioning it may be necessary to change the CoE parameters.

- If the terminal is accessed online, the CoE directory is read from the slave and can be changed, see *fig. Accessing the CoE parameters in the TwinCAT System Manager*.
- If the terminal is accessed offline (the terminal is then not addressable) the data from the XML description is used. The parameters cannot be changed.

The CoE parameters (CAN over EtherCAT) can be changed in the *CoE-Online* tab of the EtherCAT slave.

The screenshot shows the TwinCAT software interface. On the left, the 'Solution Explorer' displays a project named 'ELX320x' with a tree structure including SYSTEM, MOTION, PLC, SAFETY, C++, and I/O. Under I/O, 'Devices' is expanded, showing 'Device 1 (EtherCAT)' with various sub-items like Image, Image-Info, SyncUnits, Inputs, Outputs, InfoData, and several Terms (Term 1 to Term 6). 'Term 3 (ELX3202)' is selected. On the right, the 'CoE - Online' tab is active, showing a table of parameters with columns for Index, Name, Flags, Value, and Unit. The table lists various parameters such as Device type, Device name, Hardware version, Software version, Bootloader version, and several RTD and Sync manager parameters. The 'Value' column shows the current values for these parameters.

Index	Name	Flags	Value	Unit
1000	Device type	RO	0x01401389 (20976521)	
1008	Device name	RO	ELX3202	
1009	Hardware version	RO	00	
100A	Software version	RO	01	
100B	Bootloader version	RO	H0.1.3.0	
1011:0	Restore default parameters	RO	> 1 <	
1018:0	Identity	RO	> 4 <	
10F0:0	Backup parameter handling	RO	> 1 <	
1A00:0	RTD TxPDO-Map Inputs Ch.1	RO	> 9 <	
1A01:0	RTD TxPDO-Map Inputs Ch.2	RO	> 9 <	
1C00:0	Sync manager type	RO	> 4 <	
1C12:0	RxPDO assign	RO	> 0 <	
1C13:0	TxPDO assign	RO	> 2 <	
1C33:0	SM input parameter	RO	> 32 <	
6000:0	RTD Inputs Ch.1	RO	> 17 <	
6010:0	RTD Inputs Ch.2	RO	> 17 <	
8000:0	RTD Settings Ch.1	RW	> 27 <	
8000:01	Enable user scale	RW	FALSE	
8000:02	Presentation	RW	Signed (0)	
8000:05	Siemens bits	RW	FALSE	
8000:06	Enable filter	RW	FALSE	
8000:07	Enable limit 1	RW	FALSE	
8000:08	Enable limit 2	RW	FALSE	
8000:...	Enable user calibration	RW	FALSE	

Fig. 33: ELX3202 - Accessing the CoE parameters in TwinCAT

NOTICE**Changes in the CoE directory, in the case of exchange**

So that, in the case of exchanging an EtherCAT slave, the CoE parameters are set correctly in the new slave, changes on the customer side must be entered in the start-up list.

Changes in the CoE directory, program access

The CoE parameters can also be read and written during operation (insofar as it makes sense) by the PLC using corresponding control commands. For details, see the corresponding articles in the Beckhoff Information System, for example.

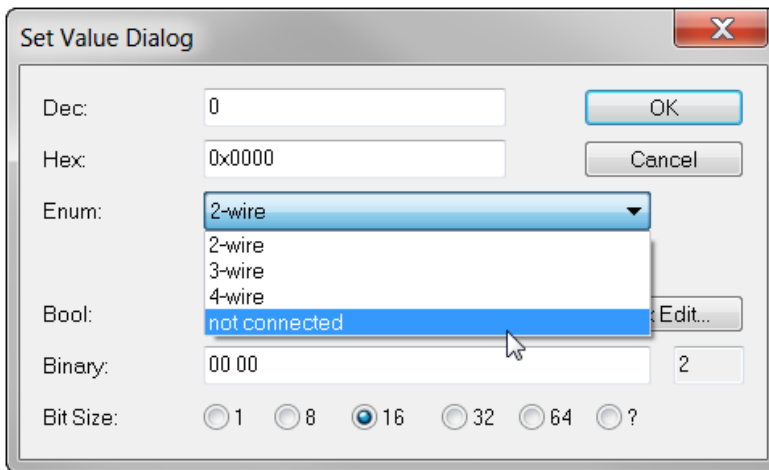
The CoE parameters should be written in the status *PreOperational* or *SafeOperational* and then the slave should be switched to the status *Operational*!

For detailed information on settings and operating modes, please read the chapter Process data and operating modes.

5.1.3 Disabling of channels**Connection technology setting**

Besides 2, 3 and 4-wire connection*, *not connected* can also be selected for each channel. The channel concerned is completely disabled and the conversion time of the ELX320x is correspondingly shortened.

*) 3- and 4-wire not valid for ELX3204

Fig. 34: ELX3202 - *not connected* setting

By means of a double click on the corresponding object [0x80n0:1A \[► 57\]](#), the respective channels can be switched off in the Set Value Dialog by selecting the Enum value *not connected*; see [fig. not connected setting](#).

5.1.4 Programmed characteristic sensor curves

Direct resistance measurement

The ELX320x can be used for direct resistance measurement in three measuring ranges ($n = \text{channel } 0 \dots 3$)

CoE setting 0x80n0:19 [► 57]	Measuring range	Resolution/digit
0x101	0 ... 6,553.5 Ω	0.1 Ω
0x102	0 ... 0.650.535 Ω	1 Ω
0x103	0 ... 240,000 Ω	10 Ω

Notice: The way in which the ELX320x measures is electrically the same with these three settings. Only the displayed resolution is changed in the firmware. The full-scale value is therefore 240 k Ω for all three measurements.

Fixed characteristic sensor curves

Further programmed characteristic sensor curves in the defined measuring range can be selected individually in the CoE entry [0x80n0:19 \[► 57\]](#) for each channel ($n = \text{channel } 0 \dots 3$).

Type	Resistance range	Implemented temperature range	Resolution/ digit
Pt1000 (0.00385 $\Omega/\Omega^\circ\text{C}$, IEC60751 characteristic curve Pt385) (PTC)	~180 ... ~ 3,900 Ω	-200 $^\circ\text{C}$...850 $^\circ\text{C}$	0.1 $^\circ\text{C}$
Ni1000 (PTC)	~700 ... ~ 2,300 Ω	-60 $^\circ\text{C}$...250 $^\circ\text{C}$	0.1 $^\circ\text{C}$
Ni1000, TK1500 (at 100 $^\circ\text{C}$: 1500 Ω) (PTC)		-30...160 $^\circ\text{C}$	0.1 $^\circ\text{C}$
NTC 5k (0 $^\circ\text{C}$: 16325 Ω)	~167,000 ... ~340 Ω	-40...100 $^\circ\text{C}$	0.1 $^\circ\text{C}$
NTC 10k (0 $^\circ\text{C}$: 32650 Ω)	~176,000 ... ~180 Ω	-30...150 $^\circ\text{C}$	0.1 $^\circ\text{C}$
NTC 10k (0 $^\circ\text{C}$: 29490 Ω)	~135,000 ... ~240 Ω	-30...150 $^\circ\text{C}$	0.1 $^\circ\text{C}$
NTC 10k (0 $^\circ\text{C}$: 27280 Ω , same as KL3204-0030)	~190,000 ... ~760 Ω	-40...110 $^\circ\text{C}$	0.1 $^\circ\text{C}$
NTC 20k (0 $^\circ\text{C}$: 70200 Ω)	~221,000 ... ~270 Ω	-20...150 $^\circ\text{C}$	0.1 $^\circ\text{C}$
FeT (0 $^\circ\text{C}$: 2226 Ω)	~1,900 ... ~ 3,900 Ω	-30...150 $^\circ\text{C}$	0.1 $^\circ\text{C}$

5.2 Process data and operating modes

5.2.1 Data flow

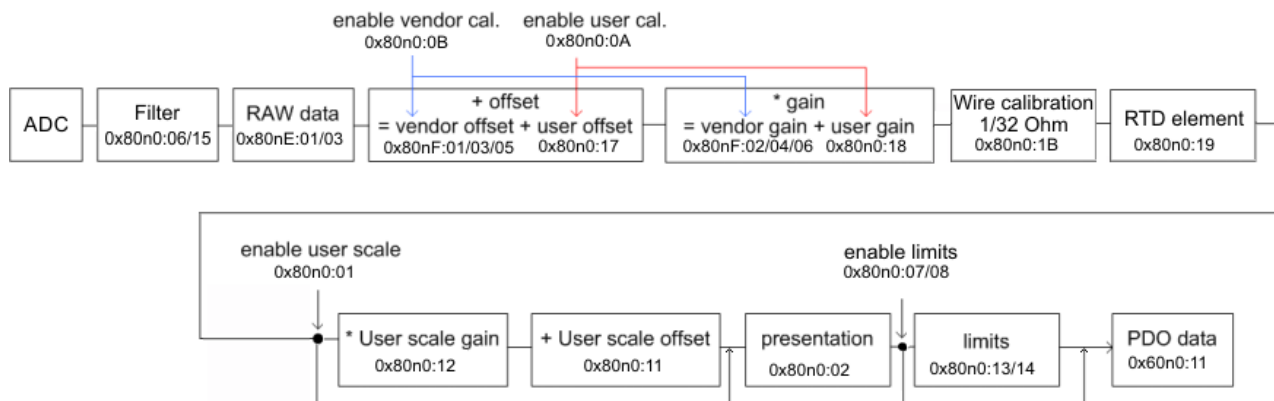


Fig. 35: Data diagram

5.2.2 Sync Manager (SM)

PDO Assignment

SM3, PDO assignment 0x1C13, for $0 \leq n \leq 3$ (Ch. 1...4) (depending on number of channels)				
Index	Index of excluded PDOs	Size (byte.bit)	Name	PDO content
0x1A0n (default)	-	4.0	RTD Inputs Channel 1...4	Index 0x60n0:01 [► 65] - Underrange Index 0x60n0:02 [► 65] - Overrange Index 0x60n0:03 [► 65] - Limit 1* Index 0x60n0:05 [► 65] - Limit 2* Index 0x6000:07 [► 65] - Error Index 0x60n0:0F - TxPDO Status Index 0x60n0:10 - TxPDO Toggle Index 0x60n0:11 [► 65] - Value

5.2.3 Operating modes and settings

5.2.3.1 Presentation, Index 80n0:02

In the delivery state, the measured value is output in increments of $1/10^{\circ}\text{C}$ in two's complement format (signed integer).

The complete measuring range is output for each resistance sensor. Index 0x80n0:02 [► 57] offers the possibility to change the method of representation of the measured value.

Measured value	Output (hexadecimal)	Output (signed integer, decimal)
-250.0 °C	0xF63C	-2500
-200.0 °C	0xF830	-2000
-100.0 °C	0xFC18	-1000
-0.1 °C	0xFFFF	-1
-0.0 °C	0x0000	0
-0.1 °C	0x0001	1
100.0 °C	0x03E8	1000
200.0 °C	0x07D0	2000
500.0 °C	0x1388	5000
850.0 °C	0x2134	8500

Signed Integer

The measured value is presented in two's complement format.
Maximum presentation range for 16 bit = -32768 ... +32767

Example

```
1000 0000 0000 0000bin = 8000hex = - 32768dec
1111 1111 1111 1110bin = FFFEhex = - 2dec
1111 1111 1111 1111bin = FFFFhex = - 1dec
0000 0000 0000 0001bin = 0001hex = +1dec
0000 0000 0000 0010bin = 0002hex = +2dec
0111 1111 1111 1111bin = 7FFFhex = +32767dec
```

Absolute value with MSB as sign

The measured value is output in magnitude-sign format.
Maximum presentation range for 16 bit = -32767 ... +32767

Example

```
1111 1111 1111 1111bin = FFFFhex = - 32767dec
1000 0000 0000 0010bin = 8002hex = - 2dec
1000 0000 0000 0001bin = 8001hex = - 1dec
0000 0000 0000 0001bin = 0001hex = +1dec
0000 0000 0000 0010bin = 0002hex = +2dec
0111 1111 1111 1111bin = 7FFFhex = +32767dec
```

High resolution (1/100°C)

The measured value is output in 1/100°C steps.
As a result, the maximum measuring range is limited to $32767_{dec} * (1/100)^{\circ}\text{C} = 327.67^{\circ}\text{C}$, but can be extended by the user scaling [► 50]!

5.2.3.2 Siemens bits, Index 80n0:05

If this bit (index 0x80n0:05 [► 57]) is set, status displays are superimposed on the lowest three bits. In the error case *overrange* or *underrange*, bit 0 is set.

5.2.3.3 Undershoot and overshoot of the measuring range

Pt100: $T > 850^{\circ}\text{C}$ ($R > 400\ \Omega$): Index [0x60n0:02 \[► 65\]](#) and index [0x60n0:07](#) (over range and error bit) are set. The linearization of the characteristic curve is continued with the coefficients of the upper range limit up to the limit stop of the A/D converter (approx. $500\ \Omega$ for Pt100).

Pt100: $T < -200^{\circ}\text{C}$ ($R < 18\ \Omega$): Index [0x60n0:01 \[► 65\]](#) and index [0x60n0:07](#) (under range and error bit) are set. The smallest negative number is displayed ($0x8001$ corresponds to -32767_{dec}).

For over range or under range the red error LED is switched on.

5.2.3.4 Notch filter

The ELX320x terminals are equipped with a digital filter. The filter performs a notch filter function and determines the conversion time of the terminal. It is enabled via the index [0x80n0:06 \[► 57\]](#) and parameterized via the index [0x8000:15 \[► 57\]](#). The higher the filter frequency, the faster the conversion time.

Notch filter means that the filter has zeros (notches) in the frequency response at the specified filter frequency and multiples thereof, i.e. it masks out these frequencies. In order to filter out 50 Hz, therefore, the 50 or the 10 Hz filter can be used. Since all frequencies lower than the notch frequency usually have to be measured, however, the 50 Hz setting is to be used in this case.

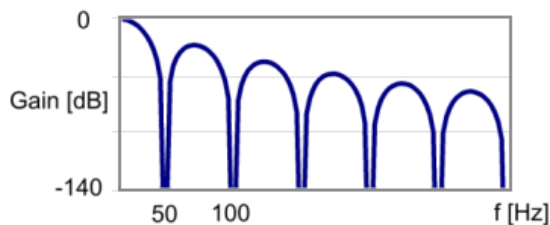


Fig. 36: Typical frequency response of a notch filter set to 50 Hz

● Index 80n0:06



The filter function is always active even if the bit is not set, since this is obligatory for the measurement process!

Details of the conversion time

- the conversion time depends on *number of active channels, number of measurements (2/4-wire), filter time, const. computing time*
- the conversion time for the 2-wire measurement is about twice as long as for the 4-wire measurement
- the resistance measurement corresponds to a 4-wire measurement
- the process data *TxPDO Toggle* changes its state if a new measured value is present

● The filter characteristics are set via index [0x8000:15 \[► 57\]](#)



The filter frequencies are set for all channels of the ELX320x terminals centrally via index [0x8000:15](#) (channel 1). The corresponding indices [0x8010:15](#) of the ELX3202 or [0x8010:15](#), [0x8020:15](#), [0x8030:15](#) of the ELX3204 have no parameterization function.

● Switching off the unused channels of multi-channel terminals



Unused channels should be switched off if filter frequencies are $\geq 1\ \text{kHz}$ (optimization of conversion times)!

The channel concerned is completely disabled and the conversion time of the ELX320x is correspondingly shortened.

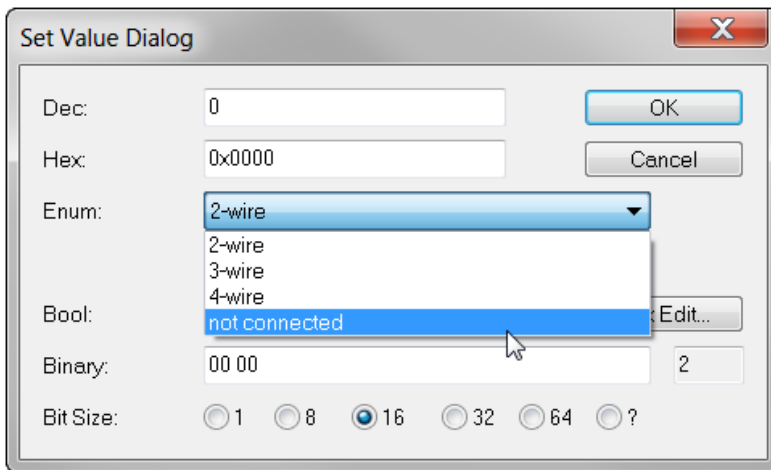


Fig. 37: Set Value Dialog

By means of a double click on the corresponding object [0x80n0:1A \[► 57\]](#), the respective channels can be switched off in the Set Value Dialog by selecting the Enum value *not connected*; see fig. *Set Value Dialog*.

5.2.3.5 Limit 1 and Limit 2, Index [0x80n0:13 \[► 57\]](#), Index [0x80n0:14 \[► 57\]](#)

A temperature range can be set that is compared with the values in the indices [0x80n0:13 \[► 57\]](#) and [0x80n0:14 \[► 57\]](#). The bits are set in the process data if the limit values are undershot or exceeded.

The limit evaluation takes place after taking into account the set characteristic curve and negative values.

Limit [2-bit] interpretation (default), index [0x60n0:03 \[► 65\]](#), [0x60n0:05 \[► 65\]](#):

0x00, 0: not active
 0x01, 1: Value is larger than the limit value
 0x10, 2: Value is smaller than the limit value
 0x11, 3: Value is equal to the limit value

5.2.3.6 Calibration

User scaling, index [0x80n0:01 \[► 57\]](#)

The user scaling is enabled via index [0x80n0:01 \[► 57\]](#). Parameterization takes place via the indices

- [0x80n0:11 \[► 57\]](#) User scaling, offset
- [0x80n0:12 \[► 57\]](#) User scaling, gain

Manufacturer calibration, [0x80nF \[► 66\]](#)

The manufacturer compensation is enabled via index [0x80n0:0B \[► 57\]](#). Parameterization takes place via the indices

- [0x80nF:01 \[► 66\]](#) Calibration offset
- [0x80nF:02 \[► 66\]](#) Calibration gain
- [0x80nF:03 \[► 66\]](#) Calibration offset, PT1000
- [0x80nF:04 \[► 66\]](#) Calibration gain, PT1000
- [0x80nF:05 \[► 66\]](#) Calibration offset, input RL
- [0x80nF:06 \[► 66\]](#) Calibration gain, input RL

User calibration, index [0x80n0:18 \[► 57\]](#), [0x80n0:17 \[► 57\]](#)

The user calibration is enabled via index [0x80n0:0A \[► 57\]](#). Parameterization takes place via the indices

- [0x80n0:17 \[► 57\]](#) User calibration offset
- [0x80n0:18 \[► 57\]](#) User calibration gain

Basic calibration**Producer Codeword**

The vendor reserves the authority for the basic calibration of the terminals. The Producer codeword is therefore at present reserved.

5.2.3.7 Process data calculation

The terminal records measured values continuously and places the raw values of its A/D converter into the ADC raw value object [0x80nE:01 \[► 65\]](#) or [0x80nE:0 \[► 65\]](#)3. The calculation of the correction with the vendor calibration values takes place after each acquisition of the analog signal. User scaling then follows (optionally):

$$Y_H = (X_{ADC} - B_K) \times A_K \quad \text{Measured value following manufacturer calibration (corresponds to } Y_A \text{ if index } 0x80n0:0A [► 57] \text{ is inactive)}$$

$$Y_A = Y_H \times A_W \times 2^{-16} + B_W \quad \text{Measured value following user scaling}$$

Key

Name	Name	Index
X_{ADC}	Output value of the A/D converter	0x80nE:01 [► 65] , 0x80nE:03 [► 65]
B_K	Manufacturer calibration offset (only changeable if the object Producer codeword [► 51] 0xF008 [► 66] is set)	0x80nF:01 [► 66] , 0x80nF:05 [► 66]
A_K	Manufacturer calibration gain (only changeable if the object Producer codeword [► 51] 0xF008 [► 66] is set)	0x80nF:02 [► 66] , 0x80nF:06 [► 66]
B_W	User scaling offset (can be activated via index 0x80n0:0A [► 57])	0x80n0:17 [► 57]
A_W	User scaling gain (can be activated via index 0x80n0:0A [► 57])	0x80n0:18 [► 57]
Y_A	Process data for controller	-

5.2.4 Influence by interfering devices

When operating the ELX320x analog EtherCAT terminals, high frequency superimposed signals from interfering devices (e.g. proportional valves, stepper motors or DC motor output stages) can be picked up by the terminal. For interference-free operation the integrated filter of the terminal (see index [0x80n0:06 \[► 57\]](#)) should be switched on.

5.3 TwinSAFE SC**5.3.1 TwinSAFE SC - operating principle**

The TwinSAFE SC (Single Channel) technology enables the use of standard signals for safety tasks in any networks of fieldbuses. To do this, EtherCAT Terminals from the areas of analog input, angle/displacement measurement or communication (4...20 mA, incremental encoder, IO-Link, etc.) are extended by the TwinSAFE SC function. The typical signal characteristics and standard functionalities of the I/O components are retained. TwinSAFE SC I/Os have a yellow strip at the front of the housing to distinguish them from standard I/Os.

The TwinSAFE SC technology enables communication via a TwinSAFE protocol. These connections can be distinguished from the usual safe communication via Safety over EtherCAT.

The data of the TwinSAFE SC components are transferred via a TwinSAFE protocol to the TwinSAFE logic, where they can be used in the context of safety-relevant applications. Detailed examples for the correct application of the TwinSAFE SC components and the respective normative classification, which were confirmed/calculated by TÜV SÜD, can be found in the [TwinSAFE application manual](#).

5.3.2 TwinSAFE SC - configuration

The TwinSAFE SC technology enables communication with standard EtherCAT terminals via the Safety over EtherCAT protocol. These connections use another checksum, in order to be able to distinguish between TwinSAFE SC and TwinSAFE. Eight fixed CRCs can be selected, or a free CRC can be entered by the user.

By default the TwinSAFE SC communication channel of the respective TwinSAFE SC component is not enabled. In order to be able to use the data transfer, the corresponding TwinSAFE SC module must first be added under the Slots tab. Only then is it possible to link to a corresponding alias device.

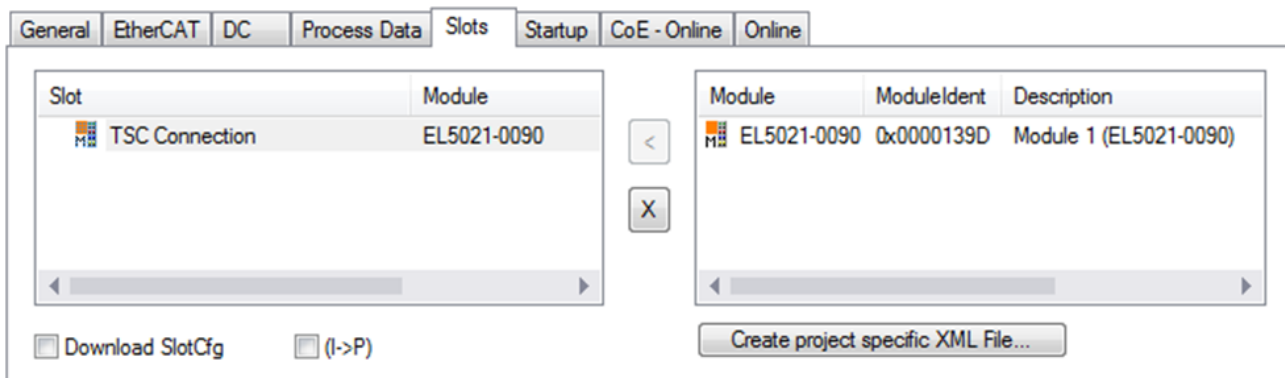


Fig. 38: Adding the TwinSAFE SC process data under the component, e.g. EL5021-0090

Additional process data with the ID TSC Inputs, TSC Outputs are generated (TSC - TwinSAFE Single Channel).

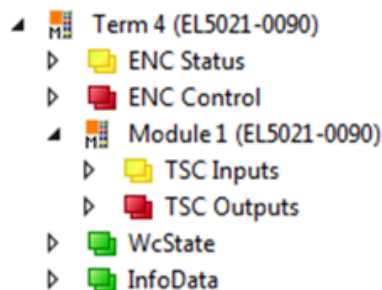


Fig. 39: TwinSAFE SC component process data, example EL5021-0090

A TwinSAFE SC connection is added by adding an alias devices in the safety project and selecting TSC (*TwinSAFE Single Channel*)

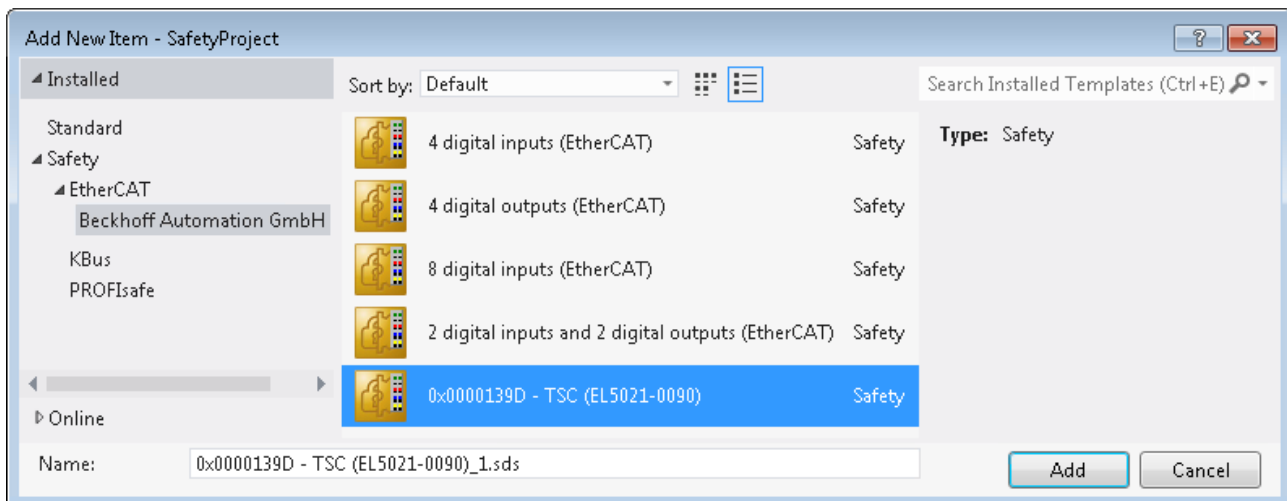



Fig. 40: Adding a TwinSAFE SC connection

After opening the alias device by double-clicking, select the Link button  next to *Physical Device*, in order to create the link to a TwinSAFE SC terminal. Only suitable TwinSAFE SC terminals are offered in the selection dialog.

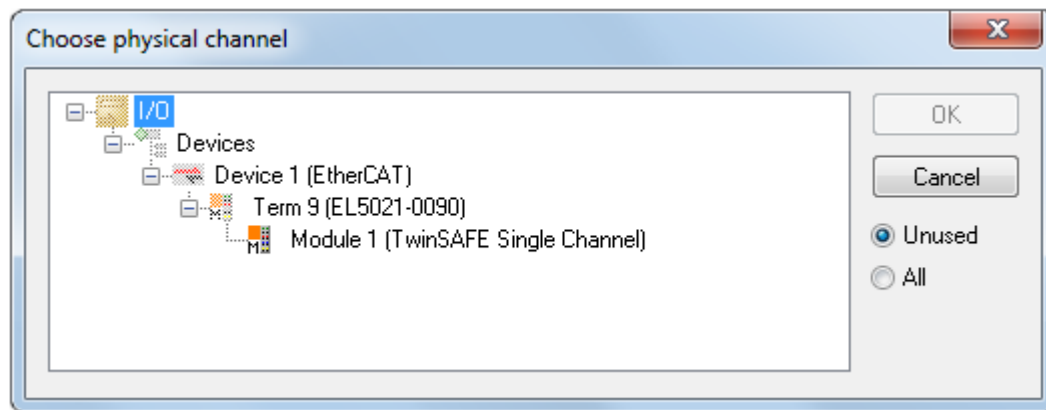


Fig. 41: Creating a link to TwinSAFE SC terminal

The CRC to be used can be selected or a free CRC can be entered under the Connection tab of the alias device.

Entry Mode	Used CRCs
TwinSAFE SC CRC 1 master	0x17B0F
TwinSAFE SC CRC 2 master	0x1571F
TwinSAFE SC CRC 3 master	0x11F95
TwinSAFE SC CRC 4 master	0x153F1
TwinSAFE SC CRC 5 master	0x1F1D5
TwinSAFE SC CRC 6 master	0x1663B
TwinSAFE SC CRC 7 master	0x1B8CD
TwinSAFE SC CRC 8 master	0x1E1BD

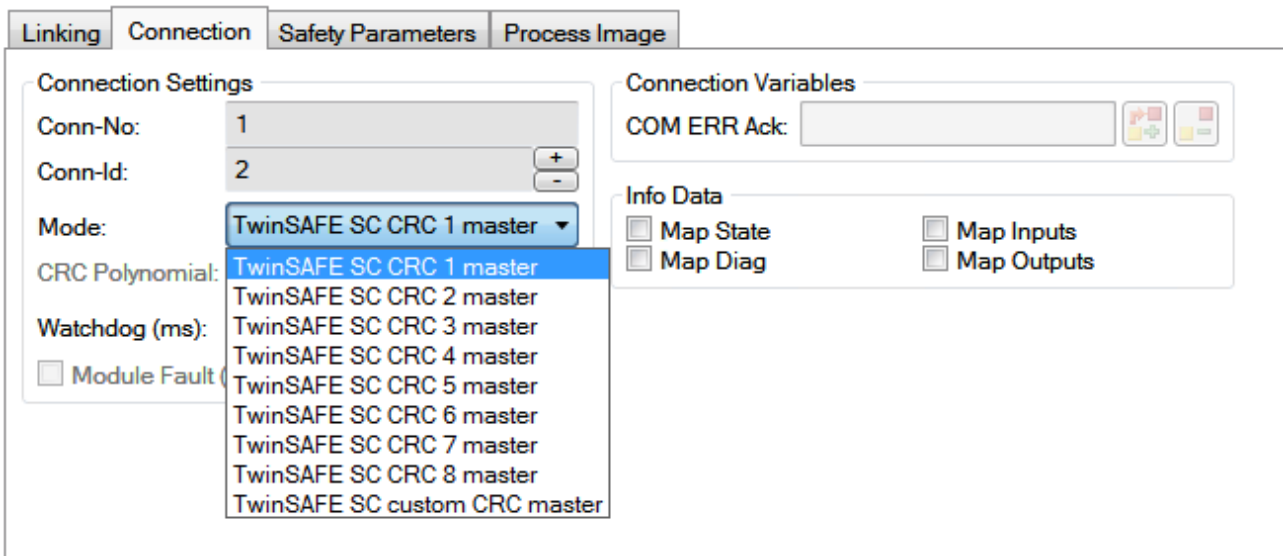


Fig. 42: Selecting a free CRC

These settings must match the settings in the CoE objects of the TwinSAFE SC component. The TwinSAFE SC component initially makes all available process data available. The *Safety Parameters* tab typically contains no parameters. The process data size and the process data themselves can be selected under the *Process Image* tab.

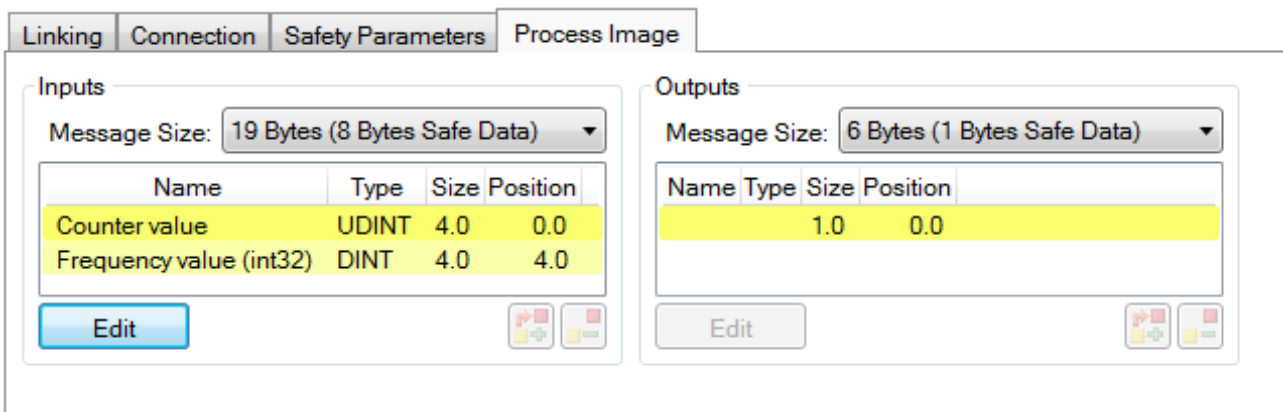


Fig. 43: Selecting the process data size and the process data

The process data (defined in the ESI file) can be adjusted to user requirements by selecting the *Edit* button in the dialog *Configure I/O element(s)*.

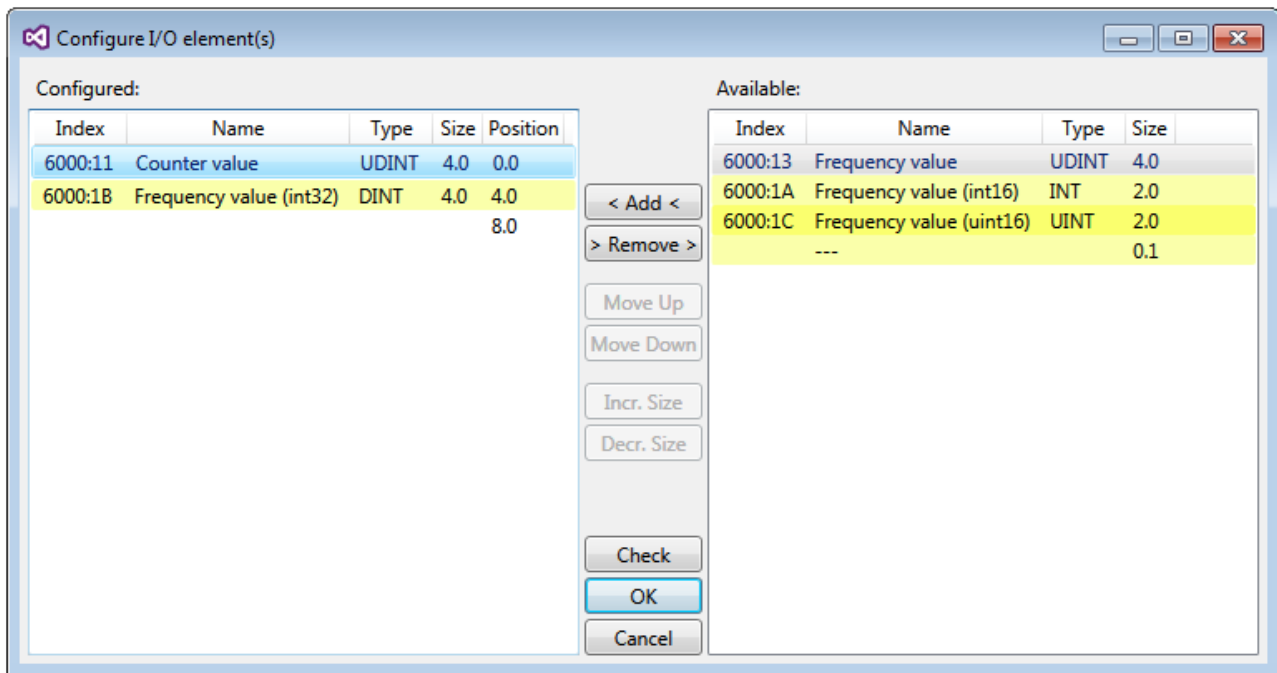


Fig. 44: Selection of the process data

The safety address together with the CRC must be entered on the TwinSAFE SC slave side. This is done via the CoE objects under *TSC settings* of the corresponding TwinSAFE SC component (here, for example, EL5021-0090, 0x8010: 01 and 0x8010: 02). The address set here must also be set in the *alias device* as *FSoE* address under the *Linking* tab.

Under the object 0x80n0:02 Connection Mode the CRC to be used is selected or a free CRC is entered. A total of 8 CRCs are available. A free CRC must start with 0x00ff in the high word.

8010:0	TSC Settings	RW	> 2 <
8010:01	Address	RW	0x0000 (0)
8010:02	Connection Mode	RW	TwinSAFE SC CRC1 master (97039)

Fig. 45: CoE objects 0x8010:01 and 0x8010:02

Object TSC Settings

Depending on the terminal, the index designation of the configuration object *TSC Settings* can vary. Example:

- EL3214-0090 and EL3314-0090, TSC Settings, Index 8040
- EL5021-0090, TSC Settings, Index 8010
- EL6224-0090, TSC Settings, Index 800F

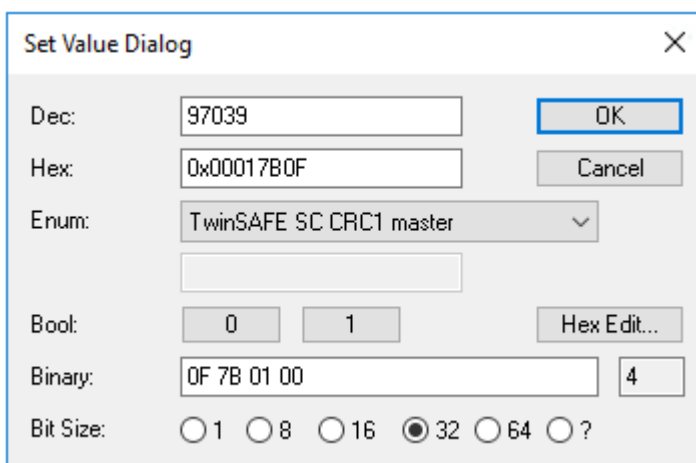


Fig. 46: Entering the safety address and the CRC



TwinSAFE SC connections

If several TwinSAFE SC connections are used within a configuration, a different CRC must be selected for each TwinSAFE SC connection.

5.3.3 TwinSAFE SC process data of ELX320x-0090

The ELX320x-0090 transmit the following process data to the TwinSAFE logic:

Index	Name	Type	Size
6000:11	RTD Module 1.Value	INT	2.0
6010:11	RTD Module 2.Value	INT	2.0
6020:11*	RTD Module 3.Value	INT	2.0
6030:11*	RTD Module 4.Value	INT	2.0

*) Only valid for ELX3204-0090

The process data of all channels are transmitted by default. Via the *Process Image* tab, the other data types of the frequency value can be selected or completely deselected in the Safety Editor.

Depending on the version of TwinCAT 3.1, process data can be renamed automatically when linking to the Safety Editor.

5.4 ELX32x0 - Object description

● EtherCAT XML Device Description



The display matches that of the CoE objects from the EtherCAT XML Device Description. We recommend downloading the latest XML file from the download area of the [Beckhoff website](#) and installing it according to installation instructions.

● Parameterization via the CoE list (CAN over EtherCAT)



The terminal is parameterized via the CoE-Online tab (double-click on the respective object) or via the Process Data tab (allocation of PDOs). Please note the following general CoE information when using/manipulating the CoE parameters:

- Keep a startup list if components have to be replaced
- Differentiation between online/offline dictionary, existence of current XML description
- Use *CoE reload* for resetting changes

● Relevant objects



The object description refers to the analog input terminals for Pt100 (RTD) in 1 to 4 channel versions. Observe the indices with regard to the objects relevant for the respective terminal (channel dependent).

Introduction

The CoE overview contains objects for different intended applications:

- Objects required for parameterization and profile-specific objects required during commissioning
- Objects for indicating internal settings (may be fixed)

The following section first describes the objects required for normal operation, followed by a complete overview of missing objects.

5.4.1 Objects for commissioning

Index 1011: Restore default parameters

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

Index 80n0: RTD settings for $0 \leq n \leq 4$ (Ch. 1...4)

● The filter properties are set only via index 0x8000:15



The filter frequencies are set for all channels of the ELX320x terminals centrally via channel 1 (index 0x8000:15).

Index (hex)	Name	Meaning	Data type	Flags	Default
80n0:0	RTD Settings	Maximum subindex	UINT8	RW	0x1B (27 _{dec})
80n0:01	Enable user scale	User scale is active.	BOOLEAN	RW	0x00 (0 _{dec})
80n0:02	Presentation	0: Signed presentation 1: Absolute value with MSB as sign Signed amount representation 2: High resolution (1/100°C)	BIT3	RW	0x00 (0 _{dec})
80n0:05	Siemens bits	The S5 bits are superimposed on the three low-order bits (value 60n0:11 [► 65]) Bit 0 = 1 (overrange or underrange) Bit 1 (not used) Bit 2 (not used)	BOOLEAN	RW	0x00 (0 _{dec})
80n0:06	Enable filter	Enable software filter, which makes PLC-cycle-synchronous data exchange unnecessary	BOOLEAN	RW	0x00 (0 _{dec})
80n0:07	Enable limit 1	The status bits are set in relation to Limit 1	BOOLEAN	RW	0x00 (0 _{dec})
80n0:08	Enable limit 2	The status bits are set in relation to Limit 2	BOOLEAN	RW	0x00 (0 _{dec})
80n0:0A	Enable user calibration	Enabling of the user calibration	BOOLEAN	RW	0x00 (0 _{dec})
80n0:0B	Enable vendor calibration	Enabling of the vendor calibration	BOOLEAN	RW	0x01 (1 _{dec})
80n0:11	User scale offset	User scaling offset	INT16	RW	0x0000 (0 _{dec})
80n0:12	User scale gain	This is the user scaling gain. The gain is represented in fixed-point format, with the factor 2 ⁻¹⁶ . The value 1 corresponds to 65535 (0x00010000).	INT32	RW	0x00010000 (65536 _{dec})
80n0:13	Limit 1	First limit value for setting the status bits (resolution 0.1°C)	INT16	RW	0x0000 (0 _{dec})
80n0:14	Limit 2	Second limit value for setting the status bits (resolution 0.1°C)	INT16	RW	0x0000 (0 _{dec})
80n0:15	Filter settings	This object determines the digital filter settings, if it is active via Enable filter (index 0x80n0:06 [► 57]). 0 _{dec} : 2,5 Hz SYNC3 1 _{dec} : 5 Hz SYNC3 2 _{dec} : 10 Hz SYNC3 3 _{dec} : 16,6 Hz SYNC3 4 _{dec} : 20 Hz SYNC3 5 _{dec} : 50 Hz SYNC3 6 _{dec} : 60 Hz SYNC3 7 _{dec} : 100 Hz SYNC3 8 _{dec} : 200 Hz SYNC3 9 _{dec} : 400 Hz SYNC3 10 _{dec} : 800 Hz SYNC3 11 _{dec} : 2 kHz SYNC3 16 _{dec} : 2,5 Hz 17 _{dec} : 5 Hz 18 _{dec} : 10 Hz 19 _{dec} : 16,6 Hz 20 _{dec} : 50/ 60 Hz (default) 21 _{dec} : 50 Hz 22 _{dec} : 60 Hz 23 _{dec} : 100 Hz 24 _{dec} : 200 Hz 25 _{dec} : 400 Hz 26 _{dec} : 800 Hz 27 _{dec} : 2 kHz	UINT16	RW	0x0014 (20 _{dec})
80n0:17	User calibration offset	User offset calibration	INT16	RW	0x0000 (0 _{dec})
80n0:18	User calibration gain	User gain compensation	UINT16	RW	0xFFFF (65535 _{dec})

Index (hex)	Name	Meaning	Data type	Flags	Default
80n0:19	RTD element	RTD element: 0_{dec}: Pt100 (default) 1 _{dec} : Ni100, -60°C to 250°C 2 _{dec} : Pt1000, -200°C to 850°C 3 _{dec} : Pt500, -200°C to 850°C 4 _{dec} : Pt200, -200°C to 850°C 5 _{dec} : Ni1000, -60°C to 250°C 6 _{dec} : Ni1000, 100°C: 1500 Ω (-30 to 160°C) 7 _{dec} : Ni120, -60°C to 320°C 8 _{dec} : Output in Ohm, Resolution 1/16 Ω (0 to 4095 Ω) 9 _{dec} : Output in Ohm, Resolution 1/64 Ω (0 to 1047 Ω) 10 _{dec} : KT100/110/130/210/230 KTY10/11/13/16/19 11 _{dec} : KTY81/82-110,120,150 (-50...150°C) 12 _{dec} : KTY81-121 13 _{dec} : KTY81-122 14 _{dec} : KTY81-151 15 _{dec} : KTY81-152 16 _{dec} : KTY81/82-210,220,250 17 _{dec} : KTY81-221 18 _{dec} : KTY81-222 19 _{dec} : KTY81-251 20 _{dec} : KTY81-252 21 _{dec} : KTY83-110,120,150 (-50...175°C) 22 _{dec} : KTY83-121 23 _{dec} : KTY83-122 24 _{dec} : KTY83-151 25 _{dec} : KTY83-152 26 _{dec} : KTY84-130,150 (-40...300°C) 27 _{dec} : KTY84-151 28 _{dec} : KTY21/23-6 (-50...150°C) 29 _{dec} : KTY1x-5 30 _{dec} : KTY1x-7 31 _{dec} : KTY21/23-5 32 _{dec} : KTY21/23-7	UINT16	RW	0x0000 (0 _{dec})
80n0:1A	Connection technology	Connection technology: 0: Two-wire connection 1*: Three-wire connection 2*: Four-wire connection 3: not connected	UINT16	RW	0x0000 (0 _{dec})
80n0:1B	Wire calibration 1/32 Ohm	Calibration of the supply lines	INT16	RW	0x0000 (0 _{dec})

*) not for ELX3204

Index 8040: TSC Settings (only ELX320x-0090)

Index (hex)	Name	Meaning	Data type	Flags	Default
8040:0	TSC Settings [► 52]	Max. ubindex	UINT8	RO	0x02 (2 _{dec})
8040:01	Address	TwinSAFE SC Address	UINT16	RW	0x0000 (0 _{dec})
8040:02	Connection Mode	Selection of TwinSAFE SC CRC	UINT32	RO	0x00000000 (0 _{dec})

5.4.2 Standard objects (Index 0x1000 ... 0x1FFF)

The standard objects have the same meaning for all EtherCAT slaves.

Index 1000: Device type

Index (hex)	Name	Meaning	Data type	Flags	Default
1000	Device type	Device type of the EtherCAT slave: the Lo-Word contains the CoE profile used (5001). The Hi-Word contains the module profile according to the modular device profile.	UINT32	RO	()

Index 1008: Device name

Index (hex)	Name	Meaning	Data type	Flags	Default
1008	Device name	Device name of the EtherCAT slave	STRING	RO	()

Index 1009: Hardware version

Index (hex)	Name	Meaning	Data type	Flags	Default
1009	Hardware version	Hardware version of the EtherCAT slave	STRING	RO	00

Index 100A: Software version

Index (hex)	Name	Meaning	Data type	Flags	Default
100A	Software version	Version of the firmware of the EtherCAT slave	STRING	RO	()

Index 100B: Bootloader version

Index (hex)	Name	Meaning	Data type	Flags	Default
100B	Bootloader version	Version of the Bootloader of the EtherCAT slave	STRING	RO	()

Index 1018: Identity

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

Index 10F0: Backup parameter handling

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

Index 1600: TSC RxPDO-Map Master Message (only ELX320x-0090)

Index (hex)	Name	Meaning	Data type	Flags	Default
1600:0	TSC RxPDO-Map Master Message	PDO Mapping RxPDO	UINT8	RO	0x04 (4 _{dec})
1600:01	SubIndex 001	1. PDO Mapping entry (object 0x7040 (TSC Master Frame Elements), entry 0x01 (TSC__Master Cmd))	UINT32	RO	0x7040:01, 8
1600:02	SubIndex 002	2. PDO Mapping entry (8 bits align)	UINT32	RO	0x0000:00, 8
1600:03	SubIndex 003	3. PDO Mapping entry (object 0x7040 (TSC Master Frame Elements), entry 0x03 (TSC__Master CRC_0))	UINT32	RO	0x7040:03, 16
1600:04	SubIndex 004	4. PDO Mapping entry (object 0x7040 (TSC Master Frame Elements), entry 0x02 (TSC__Master ConnID))	UINT32	RO	0x7040:02, 16

Index 1A0n: TxPDO Map for $0 \leq n \leq 3$ (Ch. 1...4)

Index (hex)	Name	Meaning	Data type	Flags	Default
1A0n:0	TxPDO Map Ch.1	PDO Mapping TxPDO 1	UINT8	RW	0x09 (9 _{dec})
1A0n:01	SubIndex 01	1. PDO Mapping entry (object 0x60n0 (RTD Inputs Ch.1), entry 0x01 (Underrange))	UINT32	RW	0x60n0:01, 1
1A0n:02	SubIndex 02	2. PDO Mapping entry (object 0x60n0 (RTD Inputs Ch.1), entry 0x02 (Overrange))	UINT32	RW	0x60n0:02, 1
1A0n:03	SubIndex 03	3. PDO Mapping entry (object 0x60n0 (RTD Inputs Ch.1), entry 0x03 (Limit 1))	UINT32	RW	0x60n0:03, 2
1A0n:04	SubIndex 04	4. PDO Mapping entry (object 0x60n0 (RTD Inputs Ch.1), entry 0x05 (Limit 2))	UINT32	RW	0x60n0:05, 2
1A0n:05	SubIndex 05	5. PDO Mapping entry (object 0x60n0 (RTD Inputs Ch.1), entry 0x07 (Error))	UINT32	RW	0x60n0:07, 1
1A0n:06	SubIndex 06	6. PDO Mapping entry (7 bits align)	UINT32	RW	0x0000:00, 7
1A0n:07	SubIndex 07	7. PDO Mapping entry (object 0x180n (TxPDO-Par Ch.1), entry 0x07 (TxPDO-State))	UINT32	RW	0x180n:07, 1
1A0n:08	SubIndex 08	8. PDO Mapping entry (object 0x180n (TxPDO-Par Ch.1), entry 0x09 (TxPDO-Toggle))	UINT32	RW	0x180n:09, 1
1A0n:09	SubIndex 09	9. PDO Mapping entry (object 0x60n0 (RTD Inputs Ch.1), entry 0x11 (Value))	UINT32	RW	0x60n0:11, 16

Index 1A02: TSC TxPDO-Map Slave Message (ELX3202-0090 only)

Index (hex)	Name	Meaning	Data type	Flags	Default
1A02:0	TSC TxPDO-Map Slave Message	PDO Mapping TxPDO	UINT8	RW	0x0A (10 _{dec})
1A02:01	SubIndex 01	1. PDO Mapping entry (object 0x6040 (TSC Slave Frame Elements), entry 0x01 (TSC__Slave Cmd))	USINT8	RW	0x6040:01, 8
1A02:02	SubIndex 02	2. PDO Mapping entry (object 0x6000 (ENC Inputs), entry 0x11 (Counter value))	INT16	RW	0x6000:11, 16
1A02:03	SubIndex 03	3. PDO Mapping entry (object 0x6040 (TSC Slave Frame Elements), entry 0x03 (TSC__Slave CRC_0))	UINT16	RW	0x6040:03, 16
1A02:04	SubIndex 04	4. PDO Mapping entry (object 0x6010 (ENC Inputs), entry 0x11 (Counter value))	INT16	RW	0x6010:11, 16
1A02:05	SubIndex 05	5. PDO Mapping entry (object 0x6040 (TSC Slave Frame Elements), entry 0x04 (TSC__Slave CRC_1))	UINT16	RW	0x6040:04, 16

Index 1A04: TSC TxPDO-Map Slave Message (ELX3204-0090 only)

Index (hex)	Name	Meaning	Data type	Flags	Default
1A04:0	TSC TxPDO-Map Slave Message	PDO Mapping TxPDO	UINT8	RW	0x0A (10 _{dec})
1A04:01	SubIndex 01	1. PDO Mapping entry (object 0x6040 (TSC Slave Frame Elements), entry 0x01 (TSC__Slave Cmd))	USINT8	RW	0x6040:01, 8
1A04:02	SubIndex 02	2. PDO Mapping entry (object 0x6000 (ENC Inputs), entry 0x11 (Counter value))	INT16	RW	0x6000:11, 16
1A04:03	SubIndex 03	3. PDO Mapping entry (object 0x6040 (TSC Slave Frame Elements), entry 0x03 (TSC__Slave CRC_0))	UINT16	RW	0x6040:03, 16
1A04:04	SubIndex 04	4. PDO Mapping entry (object 0x6010 (ENC Inputs), entry 0x11 (Counter value))	INT16	RW	0x6010:11, 16
1A04:05	SubIndex 05	5. PDO Mapping entry (object 0x6040 (TSC Slave Frame Elements), entry 0x04 (TSC__Slave CRC_1))	UINT16	RW	0x6040:04, 16
1A04:06	SubIndex 06	6. PDO Mapping entry (object 0x6020 (ENC Inputs), entry 0x11 (Counter value))	INT16	RW	0x6020:11, 16
1A04:07	SubIndex 07	7. PDO Mapping entry (object 0x6040 (TSC Slave Frame Elements), entry 0x05 (TSC__Slave CRC_2))	UINT16	RW	0x6040:05, 16
1A04:08	SubIndex 08	8. PDO Mapping entry (object 0x6030 (ENC Inputs), entry 0x11 (Counter value))	INT16	RW	0x6030:11, 16
1A04:09	SubIndex 09	9. PDO Mapping entry (object 0x6040 (TSC Slave Frame Elements), entry 0x06 (TSC__Slave CRC_3))	UINT16	RW	0x6040:06, 16
1A04:0A	SubIndex 00	10. PDO Mapping entry (object 0x6040 (TSC Slave Frame Elements), entry 0x02 (TSC__Slave ConnID))	UINT16	RW	0x6040:02, 16

Index 1C00: Sync manager type

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

Index 1C12: RxPDO assign

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

Index 1C13: TxPDO assign

Index (hex)	Name	Meaning	Data type	Flags	Default
1C13:0	TxPDO assign	PDO Assign Inputs	UINT8	RW	0x08 (8 _{dec})
1C13:01	Subindex 01	1. allocated TxPDO (contains the index of the associated TxPDO mapping object)	UINT16	RW	0x1A00 (6656 _{dec})
1C13:02*	Subindex 02	2. allocated TxPDO (contains the index of the associated TxPDO mapping object)	UINT16	RW	0x1A01 (6657 _{dec})
1C13:03*	Subindex 03	3. allocated TxPDO (contains the index of the associated TxPDO mapping object)	UINT16	RW	0x1A02 (6658 _{dec})
1C13:04	Subindex 04	4. allocated TxPDO (contains the index of the associated TxPDO mapping object)	UINT16	RW	0x1A03 (6659 _{dec})

*) ELX3204 only

Index 1C32: SM output parameter (ELX320x-0090 only)

Index (hex)	Name	Meaning	Data type	Flags	Default
1C32:0	SM output parameter	Synchronization parameters for the outputs	UINT8	RO	0x20 (32 _{dec})
1C32:01	Sync mode	Current synchronization mode: <ul style="list-style-type: none"> 0: Free Run 1: Synchron with SM 2 Event 2: DC-Mode - Synchron with SYNC0 Event 3: DC-Mode - Synchron with SYNC1 Event 	UINT16	RW	0x0001 (1 _{dec})
1C32:02	Cycle time	Cycle time (in ns): <ul style="list-style-type: none"> Free Run: Cycle time of the local timer Synchronous with SM 2 event: Master cycle time DC mode: SYNC0/SYNC1 Cycle Time 	UINT32	RW	0x000F4240 (1000000 _{dec})
1C32:03	Shift time	Time between SYNC0 event and output of the outputs (in ns, DC mode only)	UINT32	RO	0x00000000 (0 _{dec})
1C32:04	Sync modes supported	Supported synchronization modes: <ul style="list-style-type: none"> Bit 0 = 1: free run is supported Bit 1 = 1: Synchronous with SM 2 event is supported Bit 2-3 = 01: DC mode is supported Bit 4-5 = 10: Output shift with SYNC1 event (only DC mode) Bit 14 = 1: dynamic times (measurement through writing of 0x1C32:08) 	UINT16	RO	0xC007 (49159 _{dec})
1C32:05	Minimum cycle time	Minimum cycle time (in ns)	UINT32	RO	0x0003D090 (250000 _{dec})
1C32:06	Calc and copy time	Minimum time between SYNC0 and SYNC1 event (in ns, DC mode only)	UINT32	RO	0x00000000 (0 _{dec})
1C32:07	Minimum delay time		UINT32	RO	0x00000000 (0 _{dec})
1C32:08	Command	<ul style="list-style-type: none"> 0: Measurement of the local cycle time is stopped 1: Measurement of the local cycle time is started <p>The entries 0x1C32:03, 0x1C32:05, 0x1C32:06, 0x1C32:09, 0x1C33:03, 0x1C33:06, 0x1C33:09 [► 63] are updated with the maximum measured values. For a subsequent measurement the measured values are reset</p>	UINT16	RW	0x0000 (0 _{dec})
1C32:09	Maximum Delay time	Time between SYNC1 event and output of the outputs (in ns, DC mode only)	UINT32	RO	0x00000000 (0 _{dec})
1C32:0B	SM event missed counter	Number of missed SM events in OPERATIONAL (DC mode only)	UINT16	RO	0x0000 (0 _{dec})
1C32:0C	Cycle exceeded counter	Number of occasions the cycle time was exceeded in OPERATIONAL (cycle was not completed in time or the next cycle began too early)	UINT16	RO	0x0000 (0 _{dec})
1C32:0D	Shift too short counter	Number of occasions that the interval between SYNC0 and SYNC1 event was too short (DC mode only)	UINT16	RO	0x0000 (0 _{dec})
1C32:20	Sync error	The synchronization was not correct in the last cycle (outputs were output too late; DC mode only)	BOOLEAN	RO	0x00 (0 _{dec})

Index 1C33: SM input parameter

Index (hex)	Name	Meaning	Data type	Flags	Default
1C33:0	SM input parameter	Synchronization parameters for the inputs	UINT8	RO	0x20 (32 _{dec})
1C33:01	Sync mode	Current synchronization mode: <ul style="list-style-type: none"> 0: Free Run 1: Synchronous with SM 3 event (no outputs available) 2: DC - Synchronous with SYNC0 Event 3: DC - Synchronous with SYNC1 Event 34: Synchronous with SM 2 event (outputs available) 	UINT16	RW	0x0022 (34 _{dec})
1C33:02	Cycle time	Cycle time (in ns): <ul style="list-style-type: none"> Free Run: Cycle time of the local timer Synchronous with SM 2 event: Master cycle time DC-Mode: SYNC0/SYNC1 Cycle Time 	UINT32	RW	0x000F4240 (1000000 _{dec})
1C33:03	Shift time	Time between SYNC0 event and reading of the inputs (in ns, only DC mode)	UINT32	RW	0x00000000 (0 _{dec})
1C33:04	Sync modes supported	Supported synchronization modes: <ul style="list-style-type: none"> Bit 0: free run is supported Bit 1: synchronous with SM 2 event is supported (outputs available) Bit 1: synchronous with SM 3 event is supported (no outputs available) Bit 2-3 = 01: DC mode is supported Bit 4-5 = 01: input shift through local event (outputs available) Bit 4-5 = 10: input shift with SYNC1 event (no outputs available) Bit 14 = 1: dynamic times (measurement through writing of 0x1C33:08) 	UINT16	RO	0xC007 (49159 _{dec})
1C33:05	Minimum cycle time	Minimum cycle time (in ns)	UINT32	RO	0x0003D090 (250000 _{dec})
1C33:06	Calc and copy time	Time between reading of the inputs and availability of the inputs for the master (in ns, only DC mode)	UINT32	RO	0x00000000 (0 _{dec})
1C33:07	Minimum delay time	Minimum time between SYNC1 event and output of the outputs (in ns, DC mode only)	UINT32	RO	0x00000000 (0 _{dec})
1C33:08	Command	<ul style="list-style-type: none"> 0: Measurement of the local cycle time is stopped 1: Measurement of the local cycle time is started <p>The entries 0x1C32:03, 0x1C32:05, 0x1C32:06, 0x1C32:07, 0x1C32:09, 0x1C33:03, 0x1C33:06, 0x1C33:07 and 0x1C33:09 are updated with the maximum measured values. For a subsequent measurement the measured values are reset.</p>	UINT16	RW	0x0000 (0 _{dec})
1C33:09	Maximum delay time	Time between SYNC1 event and reading of the inputs (in ns, only DC mode)	UINT32	RO	0x00000000 (0 _{dec})
1C33:0B	SM event missed counter	Number of missed SM events in OPERATIONAL (DC mode only)	UINT16	RO	0x0000 (0 _{dec})
1C33:0C	Cycle exceeded counter	Number of occasions the cycle time was exceeded in OPERATIONAL (cycle was not completed in time or the next cycle began too early)	UINT16	RO	0x0000 (0 _{dec})
1C33:0D	Shift too short counter	Number of occasions that the interval between SYNC0 and SYNC1 event was too short (DC mode only)	UINT16	RO	0x0000 (0 _{dec})
1C33:20	Sync error	The synchronization was not correct in the last cycle (outputs were output too late; DC mode only)	BOOLEAN	RO	0x00 (0 _{dec})

5.4.3 Profile-specific objects (Index 0x6000 ... 0xFFFF)

The profile-specific objects have the same meaning for all EtherCAT slaves that support the profile 5001.

Index 60n0: RTD Inputs for $0 \leq n \leq 3$ (Ch. 1...4)

Index (hex)	Name	Meaning	Data type	Flags	Default
60n0:0	RTD Inputs	Maximum subindex	UINT8	RO	0x11 (17 _{dec})
60n0:01	Underrange	The measuring range is undershot.	BOOLEAN	RO P	0x00 (0 _{dec})
60n0:02	Overrange	The measuring range is overshot. ("open circuit" detection if "error" [index 0x60n0:07 [► 65]]) is set	BOOLEAN	RO P	0x00 (0 _{dec})
60n0:03	Limit 1	Limit value monitoring 0: not active 1: Value is larger than the limit value 2: Value is smaller than the limit value 3: Value is equal to the limit value	BIT2	RO P	0x00 (0 _{dec})
60n0:05	Limit 2	Limit value monitoring 0: not active 1: Value is larger than the limit value 2: Value is smaller than the limit value 3: Value is equal to the limit value	BIT2	RO P	0x00 (0 _{dec})
60n0:07	Error	The error bit is set if the data is invalid.	BOOLEAN	RO P	0x00 (0 _{dec})
60n0:0F	TxPDO State	Validity of the data of the associated TxPDO (0 = valid, 1 = invalid).	BOOLEAN	RO P	0x00 (0 _{dec})
60n0:10	TxPDO Toggle	The TxPDO toggle is toggled by the slave when the data of the associated TxPDO is updated.	BOOLEAN	RO P	0x00 (0 _{dec})
60n0:11	Value	The analog input data	INT16	RO P	0x0000 (0 _{dec})

Index 6040: TSC Slave Frame Elements (only ELX320x-0090)

Index (hex)	Name	Meaning	Data type	Flags	Default
6040:0	TSC Slave Frame Elements [► 52]	Max. subindex	UINT8	RO	0x06 (7 _{dec})
6040:01	TSC__Slave Cmd	reserved	UINT8	RO P	0x00 (0 _{dec})
6040:02	TSC__Slave ConnID	reserved	UINT16	RO P	0x0000 (0 _{dec})
6040:03	TSC__Slave CRC_0	reserved	UINT16	RO P	0x0000 (0 _{dec})
6040:04	TSC__Slave CRC_1	reserved	UINT16	RO P	0x0000 (0 _{dec})
6040:05	TSC__Slave CRC_2	reserved	UINT16	RO P	0x0000 (0 _{dec})
6040:06	TSC__Slave CRC_3	reserved	UINT16	RO P	0x0000 (0 _{dec})

Index 7040: TSC Master Frame Elements (only ELX320x-0090)

Index (hex)	Name	Meaning	Data type	Flags	Default
7040:0	TSC Master Frame Elements	Max. subindex	UINT8	RO	0x03 (3 _{dec})
7040:01	TSC__Master Cmd	reserved	UINT8	RO P	0x00 (0 _{dec})
7040:02	TSC__Master ConnID	reserved	UINT16	RO P	0x0000 (0 _{dec})
7040:03	TSC__Master CRC_0	reserved	UINT16	RO P	0x0000 (0 _{dec})

Index 80nE: RTD Internal data for $0 \leq n \leq 3$ (Ch. 1...4)

Index (hex)	Name	Meaning	Data type	Flags	Default
80nE:0	RTD Internal data	Maximum subindex	UINT8	RO	0x04 (4 _{dec})
80nE:01	ADC raw value 1	ADC raw value 1	INT32	RO	0x00000000 (0 _{dec})
80nE:02	Resistor 1	Resistance 1 (measured value of resistance sensor, resolution 1/32 Ohm)	UINT16	RO	0x0000 (0 _{dec})
80nE:03	ADC raw value 2 (RL)	ADC raw value 2 (RL)	INT32	RO	0x00000000 (0 _{dec})
80nE:04	Resistor 2 (RL)	Resistance 2 (RL) (measured value of the supply line, resolution 1/32 Ohm)	UINT16	RO	0x0000 (0 _{dec})

Index 80nF: RTD Vendor data for $0 \leq n \leq 3$ (Ch. 1...4)

Index (hex)	Name	Meaning	Data type	Flags	Default
80nF:0	RTD Vendor data	Maximum subindex	UINT8	RO	0x06 (6 _{dec})
80nF:01	Calibration offset	Manufacturer calibration offset	INT16	RW	0x0000 (0 _{dec})
80nF:02	Calibration gain	Manufacturer calibration gain	UINT16	RW	0x9E50 (40528 _{dec})
80nF:03	Calibration offset Pt1000	Manufacturer calibration offset Pt1000	UINT32	RW	()
80nF:04	Calibration gain Pt1000	Manufacturer calibration gain Pt1000	UINT32	RW	()
80nF:05	Calibration offset RL	Manufacturer calibration offset (input RL)	INT16	RW	0x0000 (0 _{dec})
80nF:06	Calibration gain RL	Manufacturer calibration gain (input RL)	UINT16	RW	0x9E50 (40528 _{dec})

Index F000: Modular device profile

Index (hex)	Name	Meaning	Data type	Flags	Default
F000:0	Modular device profile	General information for the modular device profile	UINT8	RO	0x02 (2 _{dec})
F000:01	Module index distance	Index spacing of the objects of the individual channels	UINT16	RO	0x0010 (16 _{dec})
F000:02	Maximum number of modules	Number of channels	UINT16	RO	()

Index F008: Code word

Index (hex)	Name	Meaning	Data type	Flags	Default
F008:0	Code word	Vendor function	UINT32	RW	0x00000000 (0 _{dec})

Index F010: Module list

Index (hex)	Name	Meaning	Data type	Flags	Default
F010:0	Module list	Number of channels	UINT8	RO	()
F010:0n	Subindex 0n	Profile 320	INT32	RO	0x00000140 (320 _{dec})

5.5 Status word

The status information for each channel of the ELX320x is transmitted cyclically from the terminal to the EtherCAT Master as process data (PDO).

Status word

Bit	SW.15	SW.14	SW.13 ... SW.7	SW.6	SW.5	SW.4	SW.3	SW.2	SW.1	SW.0
Name	TxPDO Toggle	TxPDO State	-	Error	Limit 2		Limit 1		Overrange	Underrange

Key

- **TxPDO Toggle:** The TxPDO toggle is toggled by the slave when the data of the associated TxPDO is updated. This allows the currently required conversion time to be derived.
- **TxPDO State:** Validity of the data of the associated TxPDO (0 = valid, 1 = invalid).
- **Error:** The error bit is set if the process data is invalid (cable break, overrange, underrange)
- **Limit 2:** Limit value monitoring
0: ok
1: Limit value overshoot
2: Limit value undershoot
- **Limit 1:** Limit value monitoring
0: ok,
1: Limit value overshoot
2: Limit value undershoot
- **Overrange:** Range of measurement exceeded (Cable break together with Error)
- **Underrange:** Measurement is below range

The limit evaluation is set in the CoE directory in object [0x80n0](#) [► 57].

6 Quick commissioning for experienced users

⚠ WARNING

Observe the notes on explosion protection

Especially in the chapters

- [Product overview \[► 14\]](#)
- [Mounting and wiring \[► 19\]](#)

Commissioning

- Install the ELX320x as described in chapter [Mounting and wiring \[► 19\]](#).
- To document the intrinsic safety of the electrical circuits connected to ELX terminals, a template for the intrinsic safety certificate is available at www.beckhoff.com.
- Configure the ELX320x in TwinCAT as described in this chapter.

6.1 Setting the cycle time

Set the task cycle time for the terminal under TwinCAT 3 Project → System → Real Time.

The screenshot shows the TwinCAT 3 Project Manager on the left and the Settings dialog for the 'PlcTask' on the right. Red arrows point from the 'Real-Time' and 'PlcTask' entries in the project tree to their respective sections in the settings dialog.

Settings Dialog - Real-Time Tab:

- Router Memory (MByte): 32
- Available CPUs (Windows/Isolated): 1 / 0
- Buttons: Read from Target, Set on target

CPU	RT-CPU	Base Time	CPU Limit	Latency Warning
0	<input checked="" type="checkbox"/> Default	1 ms	80 %	(none)

Settings Dialog - Task Tab:

Name: PlcTask

Port: 350

Object Id: 0x02010030

Options:

- ☐ Disable
- ☐ Create symbols
 - ☐ Include external symbols
- ☒ Floating point exceptions
- ☐ Watchdog stack

Task Configuration:

- ☒ Auto start
- ☐ Auto Priority Management
- Priority: 20
- Cycle ticks: 1 / 1.000 ms
- Start tick (modulo): 0
- ☐ Separate input update
- Pre ticks: 0
- ☐ Warning by exceeding
- ☐ Message box
- Watchdog Cycles: 0

Comment: [Empty text box]

Fig. 47: StartUp: cycle time of the PLC task

● Validity of the measured values

i Before the process data is evaluated, the diagnostic data for the terminal and the channel should be checked for invalid data:

- Channel status: Error, TxPDOstate
- Terminal status: WC (working counter), State in OP

● Restoring the delivery state (CoE Reset)



The terminal can be reset to the delivery state. This also resets the interface selection in object 0x80n0. The procedure for restoring the delivery state is described in the respective chapter.

6.2 Commissioning on the basis of CoE objects

The following instructions can be implemented via the commissioning interface or directly via CoE access and PDO setting.

The digital measured value will be available in PDO (process data object) *Value* of the PLC. Note in particular the RTD settings at CoE object 0x80n0 [► 57].

Analog input settings

- Is the correct measuring configuration selected?
In the objects 0x80n0:19 and 0x80n0:1A the sensor and the connection technology used must be set using the CoE objects.
- Are the correct/required filters enabled?
With object 0x80n0:15 an optional filter can be set, which influences the output value accordingly.
- Have scaling values been entered?
In objects 0x80n0:11 and 0x80n0:12, offset and gain values can be set for user scaling. These only influence the measured value if object 0x80n0:10 (Enable User Scale) is set to TRUE.



● User calibration via RTD settings Data object 0x80n0 [► 57]

The objects 0x80n0:17 to 0x80n0:18 may contain coefficients for user-specific calibration.

6.3 Basic information for commissioning

Parasitic thermoelectric effects

Check the correct galvanic connection from the measuring point to the terminal inputs.

Note the sampling speed



● Terminal is clocked by program task

The terminal is "clocked" by the cycle time of the program task, in which a variable linked with its *Value* PDO is used based on an assignment (read access).

If this variable is initially only available as a global variable, it can be assigned to a program task with a pragma instruction. See also: infosys.beckhoff.com, under:

TwinCAT 3 → TE1000 XAE → PLC → Reference Programming → Pragmas → Attribut Pragmas → Attribute TcContextName).

Start-up behavior

The distributed clocks synchronization function requires a synchronization phase, including ADC synchronization, when the terminal is due to switch to SAFEOP/OP status. This phases lasts a few milliseconds. During this time the channel shows *TxPDO=TRUE*; this means the channel does not provide valid values.

6.4 Resistance measuring (R/RTD)

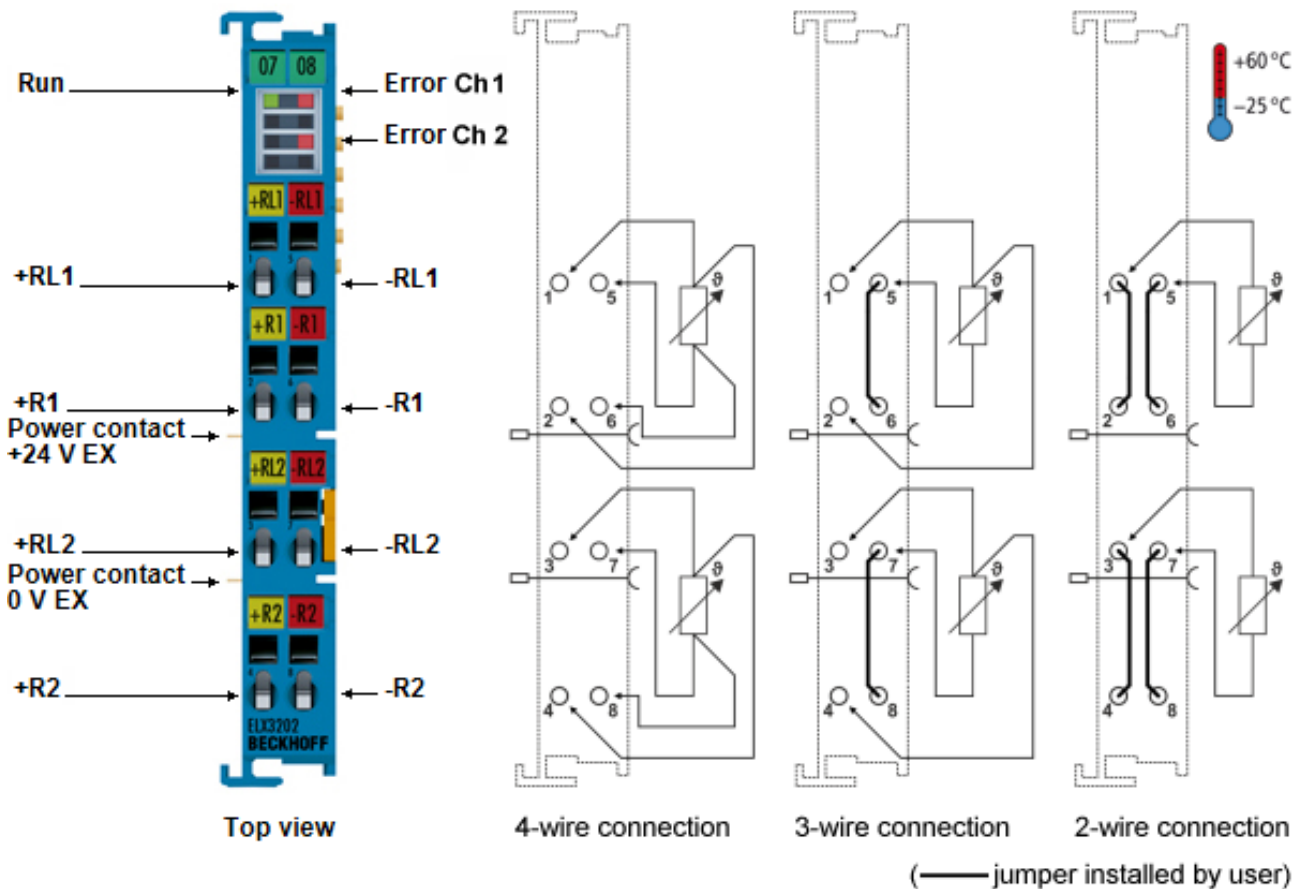


Fig. 48: ELX3202 - Contact assignment

RTD stands for resistance temperature device, what means temperature-dependent resistance.

For resistance measurement/RTD measurement:

- select the measuring range and the 2/3/4-wire connection via CoE object [0x80n0 \[► 57\]](#): (RTD settings channel n)

● Connection method

i If an incorrect connection method is selected, the measurement is generally nevertheless successful, although the specified accuracy is not reached.

- if necessary, select the required resistance transformation (i.e. the RTD element) in CoE object [0x80n0:19 \[► 57\]](#).
- data processing features of the ELX320x (filter and user scaling) can be used.

Result: The resistance or the temperature at the sensor can be read via the *Value* variable or the CoE object [0x600n.11 \[► 65\]](#) and is then available in a PLC program, for example.

See also [Basic function principles \[► 34\]](#) chapter

Diagnosis: safety of operation

For increased operational reliability and simple diagnosis (keyword: wire break diagnosis), the [status word \[► 67\]](#) can be used to read out when the underrange/overrange limits are reached.

Diagnosis: safety of operation

If an increased safety of operation is desired (keyword: wire break detection), the feature of variable underrange/overrange limits of the firmware may be used where applicable. E.g. if the full scale values of 0 and 5 k Ω (or appropriate temperatures) are not possible to occur by the real sensor, the user may enter reduced values accordingly. If exceeding of the measurement range occurs by a contrary wiring for example, the Error-Bit/ Error-LED would indicate that.

7 Appendix

7.1 EtherCAT AL Status Codes

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

7.2 UL notice



Application

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



Examination

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



For devices with Ethernet connectors

Not for connection to telecommunication circuits.

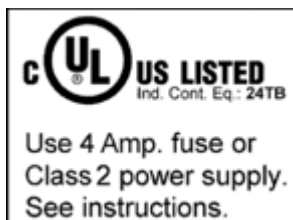
Basic principles

Two UL certificates are met in the Beckhoff EtherCAT product range, depending upon the components:

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



2. UL certification according to UL508 with limited power consumption. The current consumed by the device is limited to a max. possible current consumption of 4 A. Devices with this kind of certification are marked by this sign:



Almost all current EtherCAT products (as at 2010/05) are UL certified without restrictions.

Application

If *restricted* certified devices are used, the current consumption at 24 V_{DC} must be limited accordingly by supplying

- from an isolated source protected by a fuse of max. 4 A (according to UL248) or
- from a voltage supply complying with *NEC class 2*.
An *NEC class 2* voltage source must not be connected in series or parallel with another *NEC class 2* voltage source!

These requirements apply to the supply of all EtherCAT bus couplers, power supply terminals, bus terminals and their power contacts.

7.3 FM notice

Special notice regarding ANSI/ISA Ex

WARNING

Observe the permissible range of application!

The I/O modules of the ELX series may only be used in potentially explosive areas of Class I, Division 2, Group A, B, C, D or in non-explosive areas!

WARNING



Consider the *Control Drawing ELX* documentation!

When installing the I/O modules of the ELX series, be sure to read the *Control Drawing ELX* documentation, which is available in the download area of your ELX terminal on <https://www.beckhoff.com/ELXxxxx>!

7.4 Support and Service

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

Beckhoff's branch offices and representatives

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

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

You will also find further documentation for Beckhoff components there.

Support

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

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

Hotline: +49 5246 963 157
e-mail: support@beckhoff.com
web: www.beckhoff.com/support

Service

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

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

Hotline: +49 5246 963 460
e-mail: service@beckhoff.com
web: www.beckhoff.com/service

Headquarters Germany

Beckhoff Automation GmbH & Co. KG

Hülshorstweg 20
33415 Verl
Germany

Phone: +49 5246 963 0
e-mail: info@beckhoff.com
web: www.beckhoff.com

Table of figures

Fig. 1	ELX1052 with date code 43220001, BTN 999apr7y and marking für ATEX, IECEx and cFMus.	9
Fig. 2	ELX9560 with date code 37220005, BTN 999arb1p and marking für ATEX, IECEx and cFMus	10
Fig. 3	ELX9012 with date code 36230000, BTN 000bh4yr and marking für ATEX, IECEx and cFMus.	11
Fig. 4	ELX2002 with marking for ANZEx.....	12
Fig. 5	ELX9560 with marking for ANZEx.....	13
Fig. 6	ELX3202 - 2-channel analog input terminal RTD for 2, 3 and 4-wire connection, 16 bit, Ex i	14
Fig. 7	ELX3204 - 4-channel analog input terminal RTD, 2-wire connection, 16 bit, Ex i.....	15
Fig. 8	Permissible arrangement of the ELX terminals (right terminal block).	21
Fig. 9	Permitted arrangement - terminals that do not belong to the ELX series are placed before and after the ELX terminal segment. Isolation is provided by the ELX9560 at the beginning of the ELX terminal segment and two ELX9410 at the end of the ELX terminal segment.	21
Fig. 10	Permitted arrangement - terminals that do not belong to the ELX series are placed before and after the ELX terminal segment. Isolation is provided by the ELX9560 at the beginning of the ELX terminal segment and the EK1110 at the end of the ELX terminal segment.....	22
Fig. 11	Permitted arrangement - multiple resupplies by ELX9560 with an upstream ELX9410 in each case.....	22
Fig. 12	Permitted arrangement - ELX9410 in front of an ELX9560 power supply terminal.....	22
Fig. 13	Illegal arrangement - missing ELX9560 power supply terminal.	22
Fig. 14	Impermissible arrangement - terminal in the ELX terminal segment that does not belong to the ELX series	23
Fig. 15	Impermissible arrangement - second ELX9560 power supply terminal in the ELX terminal segment without upstream ELX9410.	23
Fig. 16	Illegal arrangement - missing ELX9012 bus end cap.....	23
Fig. 17	Installation position and minimum distances	24
Fig. 18	Attaching on mounting rail.....	25
Fig. 19	Disassembling of terminal	26
Fig. 20	Standard wiring	27
Fig. 21	High Density Terminals	27
Fig. 22	Connecting a cable on a terminal point.....	28
Fig. 23	ELX3202 - Contact assignment	30
Fig. 24	ELX3204 - Contact assignment	32
Fig. 25	Full scale value, measuring span.....	34
Fig. 26	SE and DIFF module as 2-channel version	37
Fig. 27	2-wire connection	39
Fig. 28	Common-mode voltage (V _{cm})	40
Fig. 29	Recommended operating voltage range	41
Fig. 30	Signal processing analog input	42
Fig. 31	Diagram Signal delay (step response)	43
Fig. 32	Diagram Signal delay (linear).....	43
Fig. 33	ELX3202 - Accessing the CoE parameters in TwinCAT	45
Fig. 34	ELX3202 - not connected setting	46
Fig. 35	Data diagram.....	47
Fig. 36	Typical frequency response of a notch filter set to 50 Hz	49
Fig. 37	Set Value Dialog	50
Fig. 38	Adding the TwinSAFE SC process data under the component, e.g. EL5021-0090.....	52
Fig. 39	TwinSAFE SC component process data, example EL5021-0090.....	52

Fig. 40	Adding a TwinSAFE SC connection.....	53
Fig. 41	Creating a link to TwinSAFE SC terminal	53
Fig. 42	Selecting a free CRC	54
Fig. 43	Selecting the process data size and the process data.....	54
Fig. 44	Selection of the process data.....	55
Fig. 45	CoE objects 0x8010:01 and 0x8010:02	55
Fig. 46	Entering the safety address and the CRC.....	55
Fig. 47	StartUp: cycle time of the PLC task	68
Fig. 48	ELX3202 - Contact assignment	70

Trademark statements

Beckhoff®, TwinCAT®, TwinCAT/BSD®, TC/BSD®, EtherCAT®, EtherCAT G®, EtherCAT G10®, EtherCAT P®, Safety over EtherCAT®, TwinSAFE®, XFC®, XTS® and XPlanar® are registered trademarks of and licensed by Beckhoff Automation GmbH.

More Information:
www.beckhoff.com/ELXxxx

Beckhoff Automation GmbH & Co. KG
Hülshorstweg 20
33415 Verl
Germany
Phone: +49 5246 9630
info@beckhoff.com
www.beckhoff.com

