Operating instructions for

EK1914

TwinSAFE Bus Coupler with two fail-safe inputs and two fail-safe outputs

Version: 1.3.1
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BECKHOFF

Table of contents

1 Foreword

1.1 Notes on the manual

1.1.1 Intendent audience

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

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

1.1.2 Origin of the document

These operating instructions were originally written in German. All other languages are derived from the German original.

1.1.3 Actuality

Please check whether you have the latest and valid version of this document. On the Beckhoff homepage under the link http://www.beckhoff.de/english/download/twinsafe.htm you may find the latest version for download. If in doubt, please contact the technical support (see chapter 5.1 Beckhoff Support and Service).

1.1.4 Product properties

Valid are only the product properties that are specified in the respectively current user documentation. Other information, which is given on the product pages of the Beckhoff homepage, in emails or other publications is not relevant.

1.1.5 Disclaimer

The documentation has been prepared with care. The products described are, however, constantly under development. For that reason the documentation is not in every case checked for consistency with performance data, standards or other characteristics.
If it should contain technical or editorial errors, we reserve the right to make changes at any time and without notice.
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.

1.1.6 Trademarks

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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.

1.1.7 Patent Pending

The EtherCAT technology is patent protected, in particular by the following applications and patents: EP1590927, EP1789857, DE102004044764, DE102007017835 with the corresponding applications and registrations in various other countries.

The TwinCAT technology is patent protected, in particular by the following applications and patents: EP0851348, US6167425 with corresponding applications or registrations in various other countries.

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

1.1.8 Copyright

1.1.9 Delivery conditions

In addition, the general delivery conditions of the company Beckhoff Automation GmbH & Co. KG apply.

1.2 Safety instructions

1.2.1 Delivery state

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.

1.2.2 Operator's obligation to exercise diligence

The operator must ensure that

- the TwinSAFE products are only used as intended (see chapter Product description);
- the TwinSAFE products are only operated in sound condition and in working order (see chapter *Cleaning*).
- the TwinSAFE products are operated only by suitably qualified and authorized personnel.
- the personnel is instructed regularly about relevant occupational safety and environmental protection aspects, and is familiar with the operating instructions and in particular the safety instructions contained herein.
- the operating instructions are in good condition and complete, and always available for reference at the location where the TwinSAFE products are used.
- none of the safety and warning notes attached to the TwinSAFE products are removed, and all notes remain legible.

1.2.3 Description of safety symbols

The following safety symbols are used in these operating instructions. They are intended to alert the reader to the associated safety instructions.

 **DANGER**	**Serious risk of injury!** **Failure** to follow the safety instructions associated with this symbol directly endangers the life and health of persons.
 **WARNING**	**Caution - Risk of injury!** **Failure** to follow the safety instructions associated with this symbol endangers the life and health of persons.
 **CAUTION**	**Personal injuries!** **Failure** to follow the safety instructions associated with this symbol can lead to injuries to persons.
 **Attention**	**Damage to the environment or devices** **Failure** to follow the instructions associated with this symbol can lead to damage to the environment or equipment.
 **Note**	**Tip or pointer** This symbol indicates information that contributes to better understanding.

1.2.4 Documentation issue status

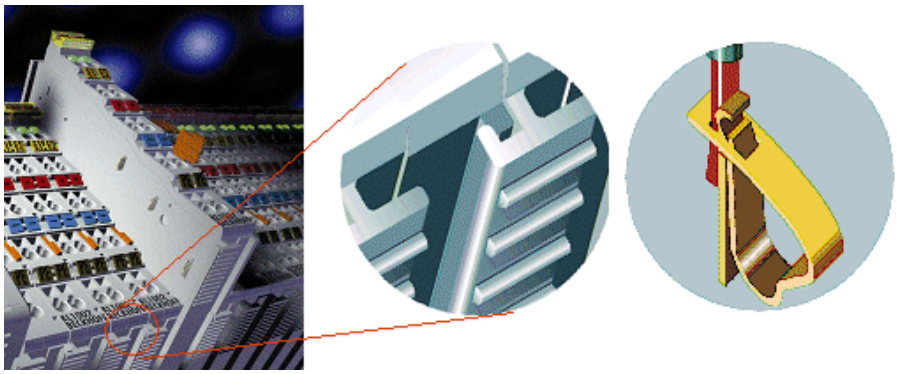
Version	Comment
1.3.1	• Technical data *permissible air pressure* expanded
1.3.0	• Note added to the technical data for the extended temperature range
1.2.0	• Reliability document updated • Safety parameters updated • Foreword overworked
1.1.2	• Reliability document added • Reaction times chapter added
1.1.1	• Certificate updated
1.1.0	• Revision levels added • Company address amended • DateCode description added • HFT and element classification added
1.0.1	• Certificate added
1.0.0	• First released version

2 System description

2.1 The Beckhoff Bus Terminal system

The Beckhoff Bus Terminal system is used for decentralized connection of sensors and actuators to a control system. The Beckhoff Bus Terminal system components are mainly used in industrial automation and building management applications. In its minimum configuration, a bus station consists of a Bus Coupler or a Bus Terminal Controller and Bus Terminals connected to it. The Bus Coupler forms the communication interface to the higher-level controller, and the terminals are the interface to sensors and actuators. The whole bus station is clipped onto a 35 mm DIN mounting rail (EN 60715). The mechanical cross connection of the bus station is established via a slot and key system at the Bus Coupler and the Bus Terminals.

The sensors and actuators are connected with terminals via the screwless Cage Clamp© connection system.

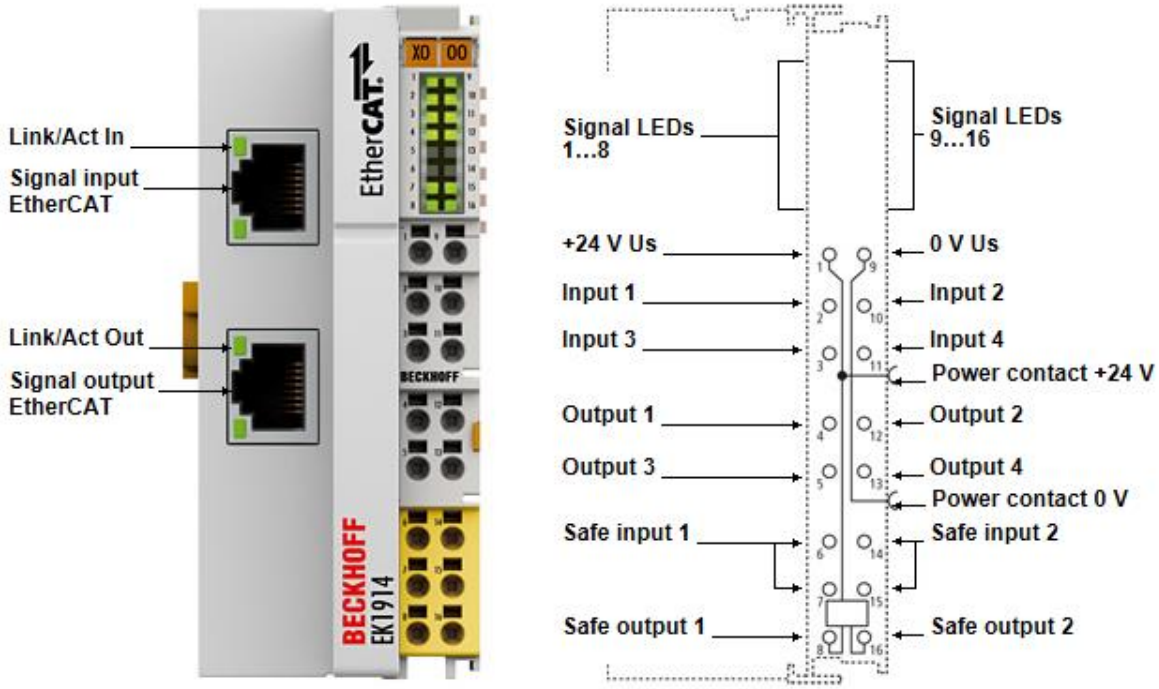


In order to accommodate the wide range of different communication standards encountered in industrial automation, Beckhoff offers Bus Couplers for a number of common bus systems
(e.g. EK1100 for EtherCAT).

2.1.1 Bus Coupler

Mechanical data

Mechanical data	Bus Coupler
Material	polycarbonate, polyamide (PA6.6).
Dimensions (W x H x D)	44 mm x 100 mm x 68 mm
Mounting	on 35 mm mounting rail (EN60715) with locking
Attachable by	double slot and key connection



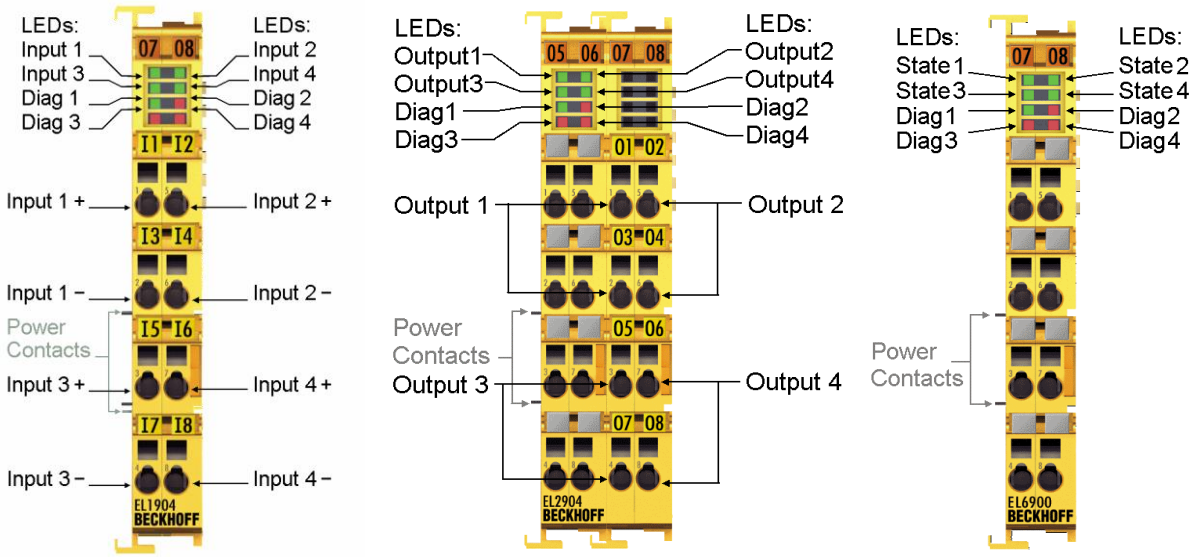
Connection technology

Connection technology	Bus Coupler
Wiring	solid wire conductors: direct plug-in technique stranded wire conductors and ferrules: spring actuation by screwdriver
Connection cross-section	solid wire: 0.08…1.5 mm² fine-wire: 0.25…1.5 mm² wire end sleeve: 0.14…0.75 mm²
Fieldbus connection	EtherCAT
Rated voltage	24 V_{DC}

2.1.2 Bus Terminals

Mechanical data

Mechanical data	Bus Terminal
Material	polycarbonate, polyamide (PA6.6).
Dimensions (W x H x D)	12 mm x 100 mm x 68 mm or 24 mm x 100 mm x 68 mm
Mounting	on 35 mm mounting rail (EN60715) with locking
Attachable by	double slot and key connection



Connection technology

Connection technology	Bus Terminal
Wiring	cage Clamp® spring-loaded system
Connection cross-section	0.08 mm² ... 2.5 mm², stranded wire, solid wire
Fieldbus connection	E-bus
Power contacts	up to 3 blade/spring contacts
Current load	10 A
Rated voltage	depends on Bus Terminal type

2.1.3 E-bus

The E-bus is the data path within a terminal strip. The E-bus is led through from the Bus Coupler through all the terminals via six contacts on the terminals' side walls.

2.1.4 Power contacts

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

2.2 TwinSAFE

2.2.1 The I/O construction kit is extended safely

With the TwinSAFE Terminals, Beckhoff offers the option of simply expanding the proven Bus Terminal system, and to transfer the complete cabling for the safety circuit into the already existing fieldbus cable. Safe signals can be mixed with standard signals without restriction. This saves design effort, installation and material. Maintenance is simplified significantly through faster diagnosis and simple replacement of only a few components.

The new ELx9xx series Bus Terminals only include three basic functionalities: digital inputs EL19xx, digital outputs EL29xx and a logic unit EL6900. For a large number of applications, all sensors and actuators can be wired on these Bus Terminals. The required logical link of the inputs and the outputs is handled by the EL6900. For small to medium-sized configurations, the tasks of a fail-safe PLC can thus be handled within the Bus Terminal system.

2.2.2 Safety concept

TwinSAFE: Safety and I/O technology in one system

- Extension of the familiar Beckhoff I/O system with TwinSAFE terminals
- Freely selectable mix of safe and standard signals
- Logical link of the I/Os in the EL6900 TwinSAFE logic terminal
- Safety-relevant networking of machines via bus systems

TwinSAFE protocol (Fail Safe over EtherCAT - FSoE)

- Transfer of safety-relevant data via any media (“genuine black channel”)
- TwinSAFE communication via fieldbus systems such as EtherCAT, Lightbus, PROFIBUS or Ethernet
- IEC 61508:2010 SIL 3 compliant

Configuring instead of wiring: the TwinSAFE configurator

- Configuration of the TwinSAFE system via the TwinCAT System Manager
- System Manager for editing and displaying all bus parameters
- Certified function blocks such as emergency stop, operation mode, etc.
- Simple handling
- Typical function blocks for machine safety
- Any bus connection with the EL6900 TwinSAFE logic terminal

TwinSAFE logic Bus Terminal EL6900

- Link unit between TwinSAFE input and output terminals
- Configuration of a simple, flexible, cost-effective, decentralized safety controller
- No safety requirements for higher-level control system
- TwinSAFE enables networks with up to 65535 TwinSAFE devices
- TwinSAFE logic terminal can establish up to 128 connections (TwinSAFE connections).
- Several TwinSAFE logic terminals are cascadable in a network
- Safety functions such as emergency stop, protective door, etc. are already included
- Suitable for applications up to SIL 3 according to IEC 61508:2010 and DIN EN ISO 13849-1:2006 (Cat 4, PL e).

TwinSAFE digital input (EL1904) and output terminal (EL2904)

- All current safety sensors can be connected
- Operation with a TwinSAFE logic terminal
- EL1904 with 4 fail-safe inputs for sensors (24 V_{DC}) with floating contacts
- EL2904 with four safe channels for actuators (24 V_{DC}, 0.5 A per channel)
- Conforming to IEC 61508:2010 SIL 3 and DIN EN ISO 13849-1:2006 (Cat 4, PL e) requirements.

2.2.3 EL1904, EL2904 - Bus Terminals with 4 fail-safe inputs or outputs

The EL1904 and EL2904 Bus Terminals enable connection of common safety sensors and actuators. They are operated with the EL6900 TwinSAFE logic terminal. The TwinSAFE logic terminal is the link unit between the TwinSAFE input and output terminals. It enables the configuration of a simple, flexible and cost-effective decentralized safety control system.

Therefore, there are no safety requirements for the higher-level controller! The typical safety functions required for the automation of machines, such as emergency stop, protective door, two-hand etc., are already permanently programmed in the EL6900. The user configures the EL6900 terminal according to the safety requirements of his application.

2.2.4 EL6900 - TwinSAFE logic terminal

The TwinSAFE logic terminal is the link unit between the TwinSAFE input and output terminals. The EL6900 meets the requirements of IEC 61508:2010 SIL 3 and DIN EN ISO 13849-1:2006 (Cat 4, PL e).

2.2.5 The fail-safe principle (Fail Stop)

The basic rule for a safety system such as TwinSAFE is that failure of a part, a system component or the overall system must never lead to a dangerous condition. The safe state is always the switched off and wattless state.

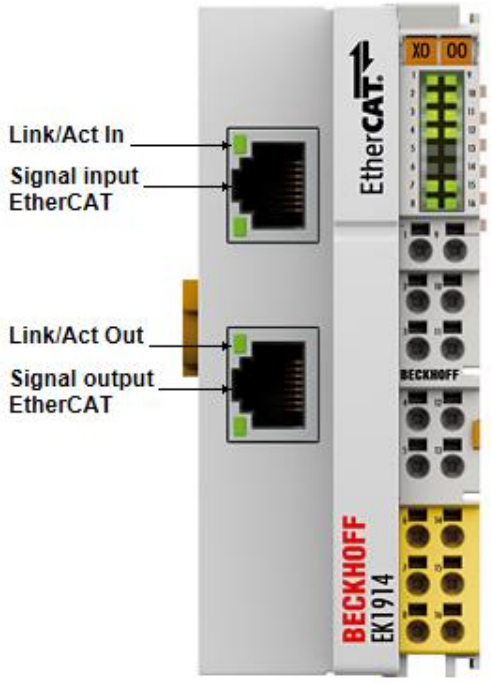
3 Product description

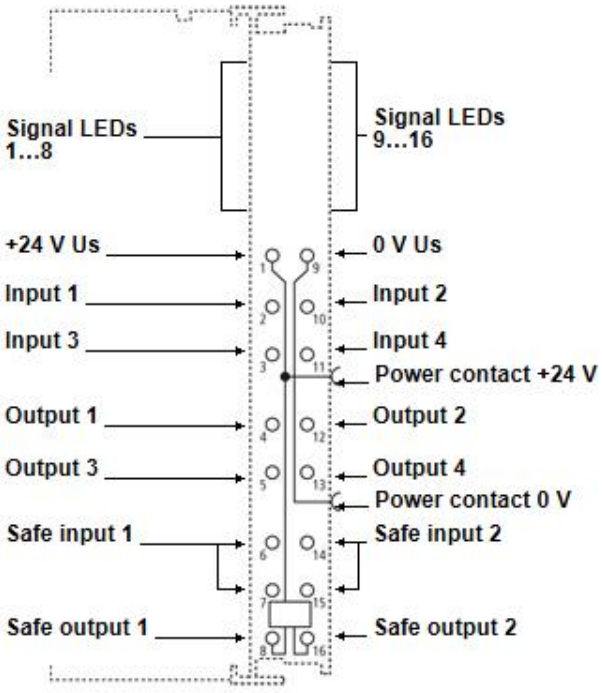
3.1 General description

EK1914 - TwinSAFE Bus Coupler with two fail-safe inputs and two fail-safe outputs
The EK1914 is an EtherCAT Bus Coupler with 4 standard inputs, 4 standard outputs, and 2 fail-safe inputs and 2 fail-safe outputs.

The EK1914 fulfils the requirements of DIN EN ISO 13849-1:2008 (Cat 4, PL e)

The TwinSAFE Bus Coupler has the usual design of an EtherCAT coupler.





3.2 Intended use

 WARNING	**Caution - Risk of injury!** The TwinSAFE Bus Coupler may only be used for the purposes described below!

The EK1914 TwinSAFE Bus Coupler expands the application area of the Beckhoff Bus Terminal system by functions that enable it to be used in the field of machine safety as well. The TwinSAFE Bus Coupler is designed for machine safety functions and directly associated industrial automation tasks. They are therefore only approved for applications with a defined fail-safe state. This safe state is the wattless state. Fail-safety according to the relevant standards is required.

The TwinSAFE Bus Coupler permits the connection of:

- 24 V_{DC} sensors such as
  emergency off push-button switches, rope pull switches, position switches, two-hand switches, safety switching mats, light curtains, light barriers, laser scanner, etc.
- 24 V_{DC} actuators such as
  contactors, protective door switches with tumbler, signal lamps, servo drives, etc.

 Note	**Test pulses** When selecting actuators, please ensure that the EK1914 test pulses do not lead to actuator switching or a diagnostic message from the EK1914.

This module is suitable for operation in an EtherCAT network and can be extended by EtherCAT Terminals of the type ELxxxx.

 CAUTION	**Follow the machinery directive** The TwinSAFE Bus Coupler may only be used in machines in accordance with the machinery directive.

 CAUTION	**Ensure traceability** The buyer has to ensure the traceability of the device via the serial number.

3.3 Technical data

Product designation		EK1914
Task within the EtherCAT system		coupling of EtherCAT Terminals (ELxxxx) to 100BASE-TX EtherCAT networks
Protocol / Baud rate		EtherCAT Device Protocol / 100 MBaud
Cable length between two Bus Couplers		max. 100 m (100BASE-TX)
Transmission medium		at least Ethernet CAT-5 cable
Bus connection		2 x RJ45
Supply voltage for the EK1914 (PELV)		24 V_{DC} (–15% / +20%)
Number of standard inputs		4
Number of standard outputs		4
Number of safe inputs		2
Number of safe outputs		2
Status display		16 LEDs
Reaction time (Read input/write to E-bus)		typically: 4 ms, maximally: see error reaction time
Error reaction time		≤ watchdog time
Signal voltage “0”, standard inputs		-3 V ... 5 V (EN 61131-2, type 1/3)
Signal voltage “1”, standard inputs		11 V ... 30 V (EN 61131-2, type 3)
Input filter, standard inputs		500 µs
Input current, standard inputs		typically 3 mA (EN 61131-2, type 3)
Output current per standard output		max. 0.5A
Output current of the clock outputs		typically 10 mA, max. 15 mA
Output current per safe output		max. 500 mA, min. 20 mA
Actuators		when selecting actuators please ensure that the test pulses from the safe outputs do not lead to actuator switching.
Cable length between sensor/actuator and Bus Coupler	(unshielded)	100 m max.(at 0.75 or 1 mm²)
	(shielded)	100 m max.(at 0.75 or 1 mm²)
Input process image		8 byte
Output process image		8 byte
E-bus power supply (5 V)		max. 500 mA (in case of higher current consumption, please use additional EL9410 power feed terminals!)
Power contacts (PELV)		max. 24 V_{DC}, max. 4 A
Current consumption (excluding current consumption of the sensors/actuators and further terminals on the E-bus)		typically 72 mA
Power loss of the Bus Coupler		typically 1.8 W without connected sensors/actuators
Electrical isolation (between the channels)		no
Electrical isolation (between the channels and the E-bus)		no
Electrical isolation (between the EtherCAT connections and the channels/E-bus)		yes
Insulation voltage (between the EtherCAT connections and the channels/E-bus, under common operating conditions)		insulation tested with 500 V_{DC}
Dimensions (W x H x D)		approx. 44 mm x 100 mm x 68 mm
Weight		approx. 123 g

Product designation	EK1914
Permissible ambient temperature (operation) up to HW05	0°C to +55°C
Permissible ambient temperature (operation) from HW06	-25°C to +55°C
Permissible ambient temperature (transport/storage)	-25 C to +70°C
Permissible air humidity	5% to 95%, non-condensing
Permissible air pressure (operation/storage/transport)	750 hPa to 1100 hPa (this corresponds to a height of approx. -690 m to 2450 m over sea level assuming an international standard atmosphere)
Climate category according to EN 60721-3-3	3K3 (the deviation from 3K3 is possible only with optimal environmental conditions and also applies only to the technical data which are specified differently in this documentation)
Permissible level of contamination	level of contamination 2 (comply with the chapter Cleaning)
Impermissible operating conditions	TwinSAFE Bus Couplers must not be used under the following operating conditions: • under the influence of ionizing radiation • in corrosive environments • in an environment that leads to unacceptable soiling of the Bus Coupler
EMC immunity/emission	conforms to EN 61000-6-2 / EN 61000-6-4
Vibration/shock resistance	conforms to EN 60068-2-6 / EN 60068-2-27
Shocks	15 g with pulse duration 11 ms in all three axes
Protection class	IP20
Permitted operating environment	In the control cabinet or terminal box, with minimum protection class IP54 according to IEC 60529
Permissible installation position	see chapter *Installation position and minimum distances*
Approvals	CE, TÜV SÜD, UL

3.4 Safety parameters

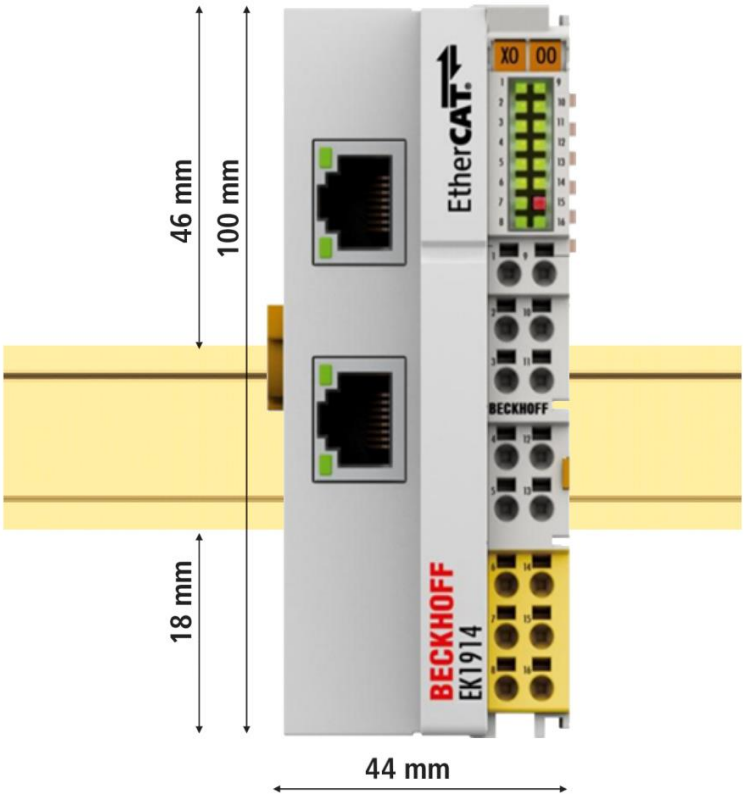
Key figures	EK1914
Lifetime [a]	20
Prooftest Interval [a]	not required [1)]
PFH_D	2.64E-09
%SIL3	2,64%
PFD_G	3.92E-05
%SIL3	3,92%
$MTTF_d$	High
B10d (cycles)	-
DC	High
Performance level	PL e
Category	4
HFT	1
Element classification*	Type B

*) Classification according to EN 61508-2:2010 (see chapter 7.4.4.1.2 and 7.4.4.1.3)

The TwinSAFE Bus Coupler can be used for safety-related applications within the meaning of EN ISO 13849-1 up to PL e (Cat4).
[1)] Special proof tests during the entire service life of the TwinSAFE Bus Coupler are not required.

To calculate or estimate the $MTTF_d$ value out of the PFH_D value please refer to the Application Guide TwinSAFE or to the ISO 13849-1:2015 table K.1.

3.5 Dimensions



Width: approx. 44 mm
Height: 100 mm
Depth 68 mm

4 Operation

Please ensure that the TwinSAFE Bus Coupler is only transported, stored and operated under the specified conditions (see technical data)!

 **WARNING**	**Caution - Risk of injury!** TwinSAFE Bus Coupler must not be used under the following operating conditions: • under the influence of ionizing radiation (that exceeds the level of the natural environmental radiation) • in corrosive environments • in an environment that leads to unacceptable soiling of the Bus Coupler

4.1 Installation

4.1.1 Safety instructions

Before installing and commissioning the TwinSAFE Bus Coupler please read the safety notes in the foreword of this documentation.

4.1.2 Transport / storage

Use the original packaging for transporting or storing the digital TwinSAFE Bus Coupler.

 **CAUTION**	**Note the specified environmental conditions** Please ensure that the TwinSAFE Bus Couplers are only stored and operated under the specified conditions (see technical data).

4.1.3 Mechanical installation

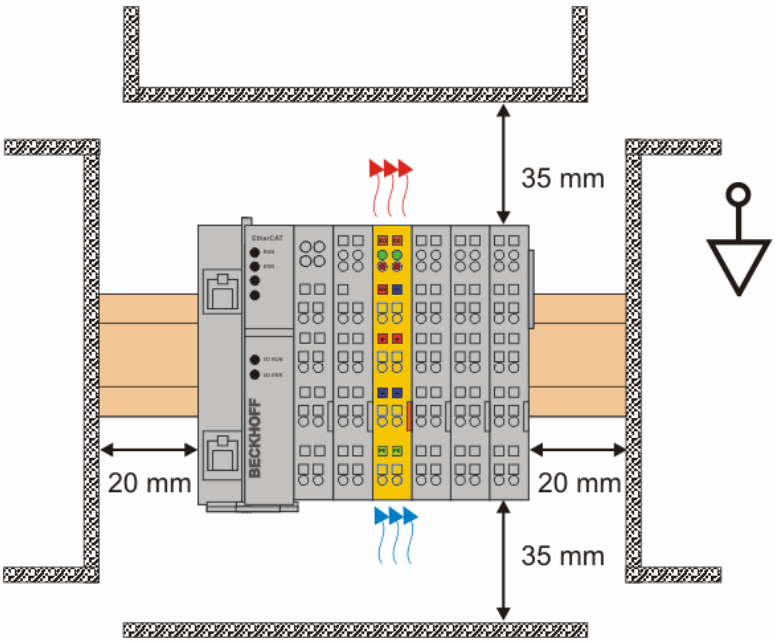
DANGER	**Serious risk of injury!** Bring the bus system into a safe, de-energized state before starting installation, disassembly or wiring of the Bus Terminals!

4.1.3.1 Control cabinet

The TwinSAFE terminals and Bus Couplers must be installed in a control cabinet or terminal box with IP54 protection class according to IEC 60529 as a minimum.

4.1.3.2 Installation position and minimum distances

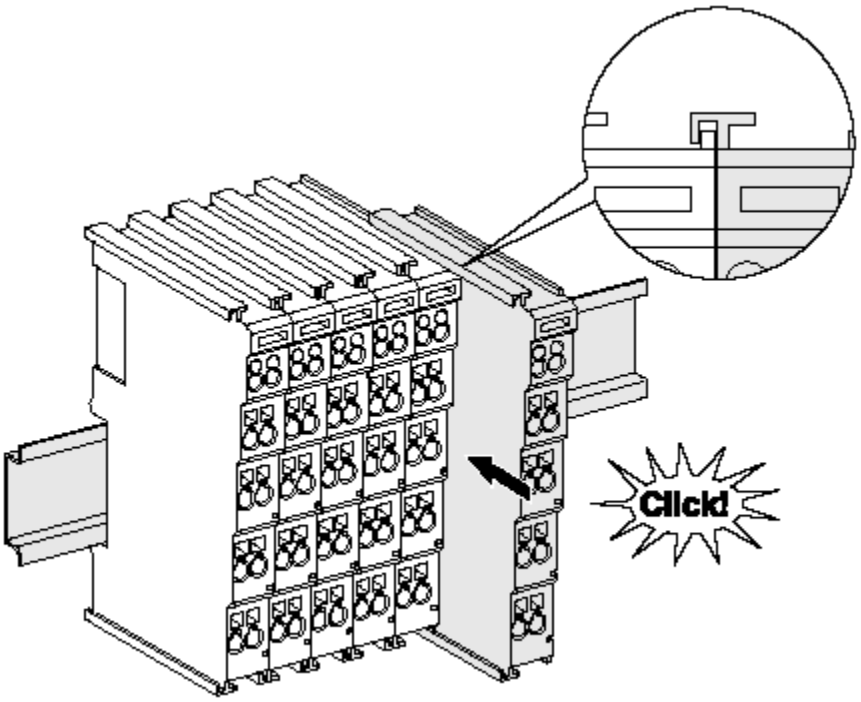
For the prescribed installation position the mounting rail is installed horizontally and the mating surfaces of the EL/KL terminals point toward the front (see illustration below). The terminals are ventilated from below, which enables optimum cooling of the electronics through convection. The direction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



In order to ensure optimum convection cooling, the distances to neighboring devices and to control cabinet walls must not be smaller than those shown in the diagram.

4.1.3.3 Mounting rail installation

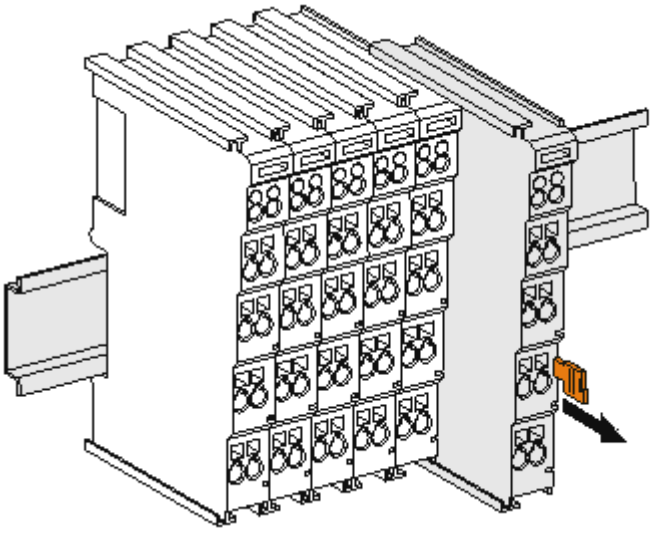
Mounting
The Bus Couplers and Bus Terminals are attached to commercially available 35 mm mounting rails (according to EN 60715) by applying slight pressure:



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 slot and key 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 slot and key, the connection will not be operational! When correctly assembled, no significant gap should be visible between the housings.

During the installation of the Bus Terminals, the locking mechanism of the terminals must not come into conflict with the fixing bolts of the mounting rail.

Removal



1. Carefully pull the orange-colored lug approximately 1 cm out of the terminal to be disassembled, until it protrudes loosely. The lock with the mounting rail is now released for this terminal, and the terminal can be pulled from the mounting rail 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 away from the mounting rail.

4.1.4 Electrical installation

4.1.4.1 Connections within a Bus Terminal block

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

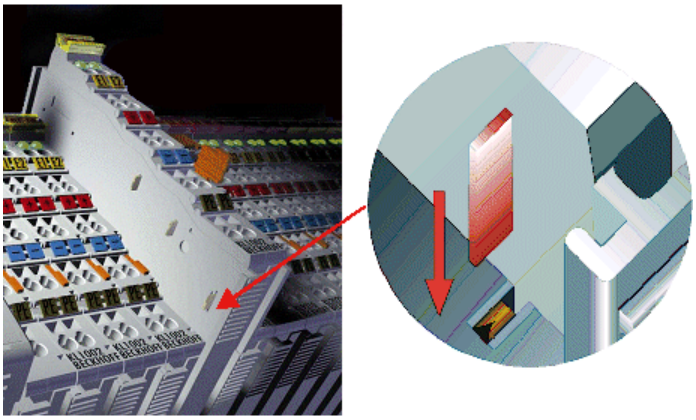
- The six spring contacts of the E-bus deal with the transfer of the data and the supply of the Bus Terminal electronics.

Note	**Note the maximum E-bus current!** Observe the maximum current that your Bus Coupler can supply to the E-bus! Use the EL9410 Power Supply Terminal if the current consumption of your terminals exceeds the maximum current that your Bus Coupler can feed to the E-bus supply.

- The power contacts deal with the supply for the field electronics and thus represent a supply rail within the Bus Terminal block. The power contacts are supplied via terminals on the Bus Coupler.

Note	**Note the pin assignment of the 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. Power Feed Terminals (EL91xx, EL92xx) interrupt the power contacts and thus represent the start of a new supply rail.

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



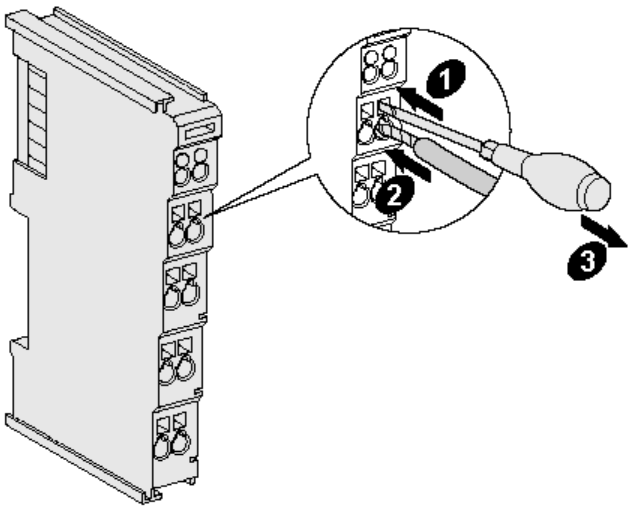
CAUTION	**Insulation tests** Note that, for reasons of electromagnetic compatibility, the PE contacts are capacitatively coupled to the mounting rail. This may lead to incorrect results during insulation testing or to damage on the terminal (e.g. disruptive discharge to the PE line during insulation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

DANGER	**Serious risk of injury!** The PE power contact must not be used for other potentials!

4.1.4.2 Overvoltage protection

If protection against overvoltage is necessary in your plant, provide a surge filter for the voltage supply to the Bus Terminal blocks and the TwinSAFE terminals.

4.1.4.3 Wiring



Up to eight or sixteen connections enable the connection of solid or finely stranded cables to the Bus Terminals. The terminals are implemented in spring force technology. Connect the cables as follows:

1. Open a spring-loaded terminal by slightly pushing with a screwdriver or a rod into the square opening above the terminal.
2. The wire can now be inserted into the round terminal opening without any force.
3. The terminal closes automatically when the pressure is released, holding the wire safely and permanently.

High-density terminals (HD terminals)

The Bus Terminals from the ELx8xx/KLx8xx series, as well as the EK1914 with 16 connection points, are distinguished by a particularly compact design, since the packing density is twice as large as that of the standard Bus Terminals. Solid conductors and conductors with a wire end sleeve can be inserted directly into the spring loaded terminal point without tools.

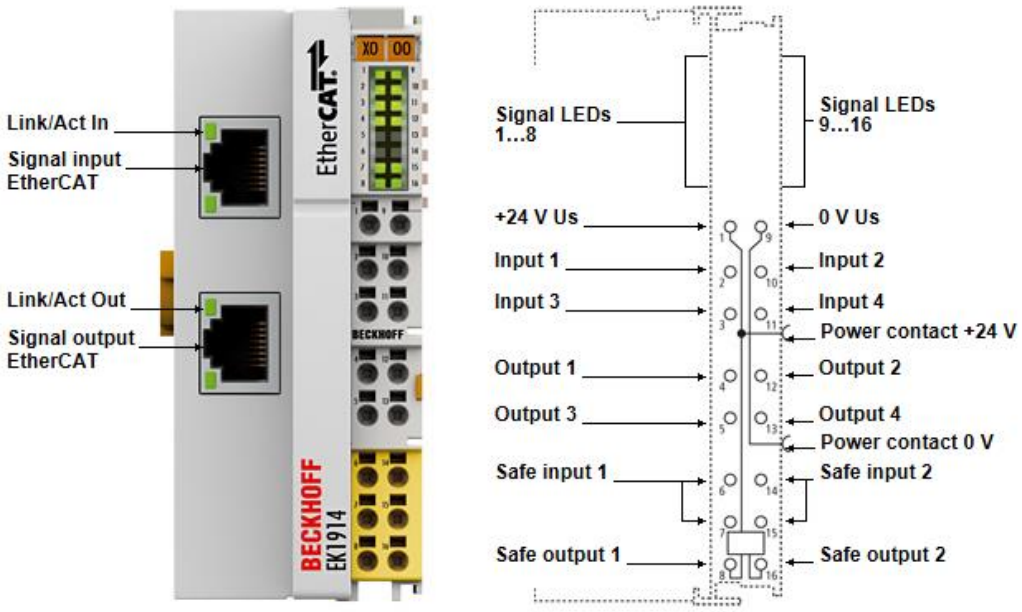
Note	**Ultrasonically "bonded" (ultrasonically welded) conductors** It is also possible to connect the Standard and High Density Terminals with ultrasonically "bonded" (ultrasonically welded) conductors. Please observe the tables concerning the wire cross section below!

4.1.5 Wire cross sections (HD)

With the HD Terminals or Bus Couplers the wires are connected without tools in the case of solid wires using the direct plug-in technique, i.e. the wire is simply inserted into the contact point after stripping the insulation. The cables are released, as in the case of the standard terminals, using the contact release with the aid of a screwdriver. The permissible conductor cross-sections can be taken from the following table.

Terminal housing	EK1914
Wire cross-section (core wire with wire end sleeve)	0.14... 0.75 mm²
Wire cross-section (solid)	0.08 ... 1.5 mm²
Wire cross-section (fine-wire)	0.25 ... 1.5 mm²
Wire cross-section (Ultrasonically "bonded")	1.5 mm² only
Strip length	8 ... 9 mm

4.1.6 Pin assignment of the EK1914

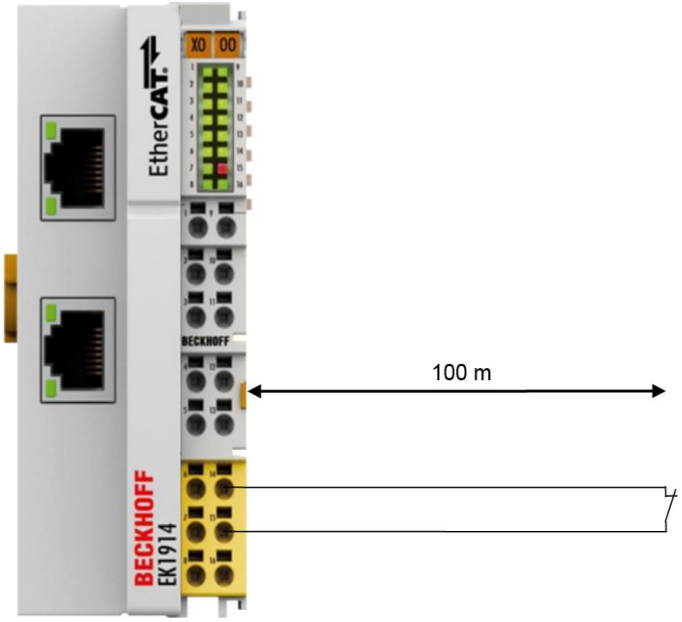


Terminal point	Signal	Description
1	+24V	Supply voltage Us
2	In1	Standard input 1
3	In3	Standard input 3
4	Out 1	Standard output 1
5	Out 3	Standard output 3
6	Safe In1	Clock output safe input 1
7		Safe input 1
8	Safe Out 1	Safe output 1
9	0V	Supply voltage Us
10	In2	Standard input 2
11	In4	Standard input 4
12	Out 2	Standard output 2
13	Out 4	Standard output 4
14	Safe In2	Clock output safe input 2
15		Safe input 2
16	Safe Out 2	Safe output 2

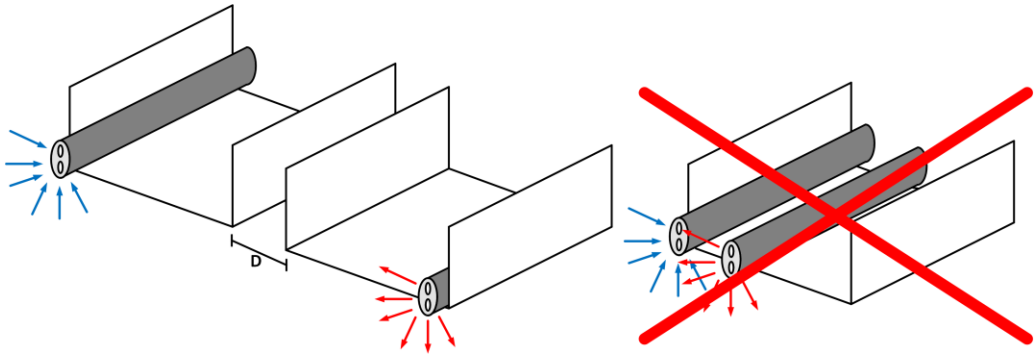
Note	**Configurable safe inputs** The safe inputs 1 and 2 can be connected alternatively to normally closed contacts or normally open contacts. The corresponding analysis is carried out in the safety PLC.

Note	**Test pulses of the safe outputs** When selecting actuators, please ensure that the EK1914 test pulses do not lead to actuator switching or a diagnostic message from the EK1914.

Permitted cable length - inputs



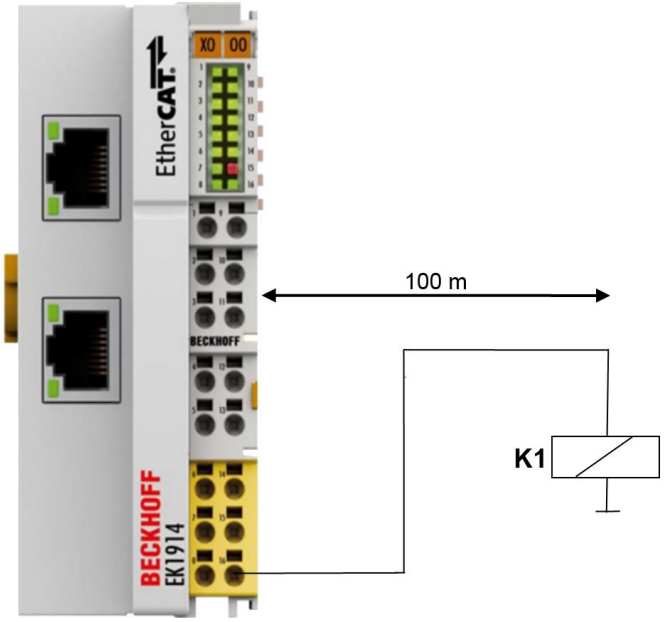
When connecting a single switching contact via its own continuous cabling (or via a non-metallic sheathed cable), the maximum permitted cable length is 100 m.

Attention	**Route the signal cable separately** The signal cable must be routed separately from potential sources of interference, such as motor supply cables, 230 V_{AC} power cables etc.! Interference caused by cables routed in parallel can influence the signal form of the test pulses and thus cause diagnostic messages (e.g. sensor errors).  D - Distance between the cable ducts should be as large as possible Blue arrows - signal line Red arrows - potential source of interference

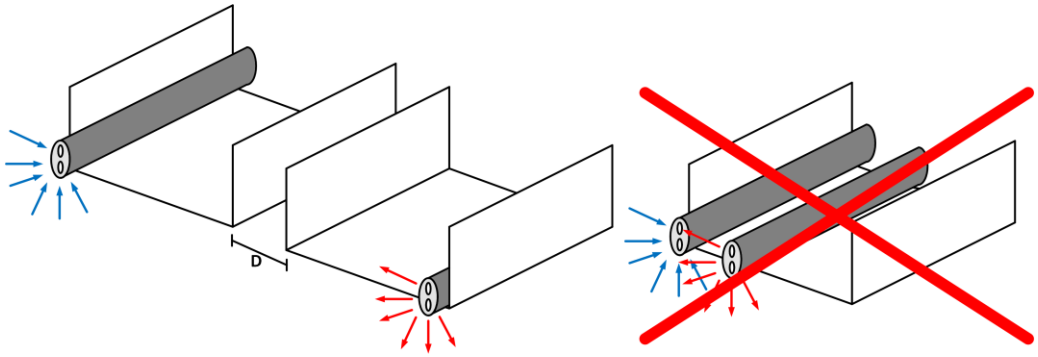
The common routing of signals together with other clocked signals in a common cable also reduces the maximum propagation, since crosstalk of the signals can occur over long cable lengths and cause diagnostic messages. The test pulses can be switched off (sensor test parameter) if the connection of a common cable is unavoidable. However, this then leads to a reduction in the degree of diagnostic cover when calculating the performance level.
The use of contact points, plug connectors or additional switching contacts in the cabling also reduces the maximum propagation.

The typical length of a test pulse (switching from 24 V to 0 V and back to 24 V) is about 380 µs and takes place approx. 400 times per second.
In safety mat mode (parameter: “Short cut is no module fault”), test pulses with a typical length of 750 µs are generated in addition to the typical test pulse lengths of 380 µs.

Permitted cable length - outputs



When connecting a single actuator via its own continuous cabling (or via a sheathed cable), the maximum permitted cable length is 100 m.

Attention	**Route the signal cable separately** The signal cable must be routed separately from potential sources of interference, such as motor supply cables, 230 V_{AC} power cables etc.! Interference caused by cables routed in parallel can influence the signal form of the test pulses and thus cause diagnostic messages (e.g. sensor errors).  D - Distance between the cable ducts should be as large as possible Blue arrows - signal line Red arrows - potential source of interference

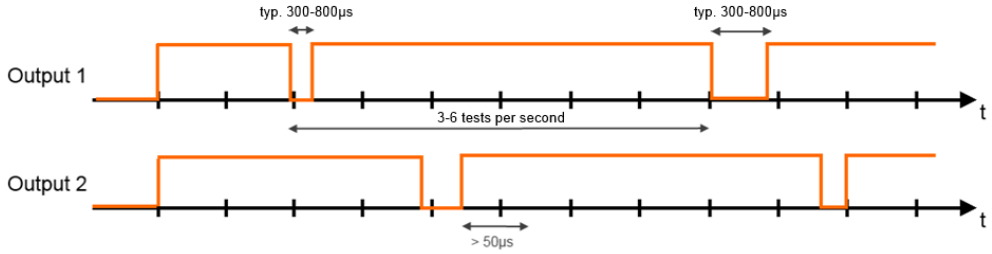
The common routing of signals together with other clocked signals in a common cable also reduces the maximum propagation, since crosstalk of the signals can occur over long cable lengths and cause diagnostic messages. If connection via a common cable cannot be avoided, the test pulses can be switched off (parameter: “Testing of outputs active”). However, this then leads to a reduction in the degree of diagnostic cover when calculating the performance level.
The use of contact points or plug connectors in the cabling similarly reduces the maximum expansion.

The typical length of a test pulse (switching from 24 V to 0 V and back to 24 V) is 300 µs to 800 µs, but can also be longer in individual cases. Testing usually takes place 3 to 6 times per second.

Note

Test pulses for the outputs

The following diagram shows a typical test pulse curve for the two outputs of an EK1914. The parameter *Testing of outputs active* is enabled.

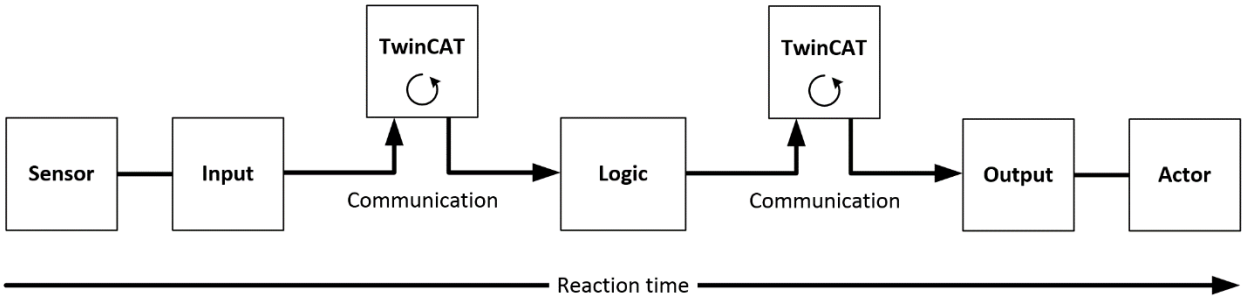


4.1.7 TwinSAFE reaction times

The TwinSAFE terminals form a modular safety system that exchanges safety-oriented data via the Safety-over-EtherCAT protocol. This chapter is intended to help you determine the system's reaction time from the change of signal at the sensor to the reaction at the actuator.

4.1.7.1 Typical reaction time

The typical reaction time is the time that is required to transmit information from the sensor to the actuator, if the overall system is working without error in normal operation.



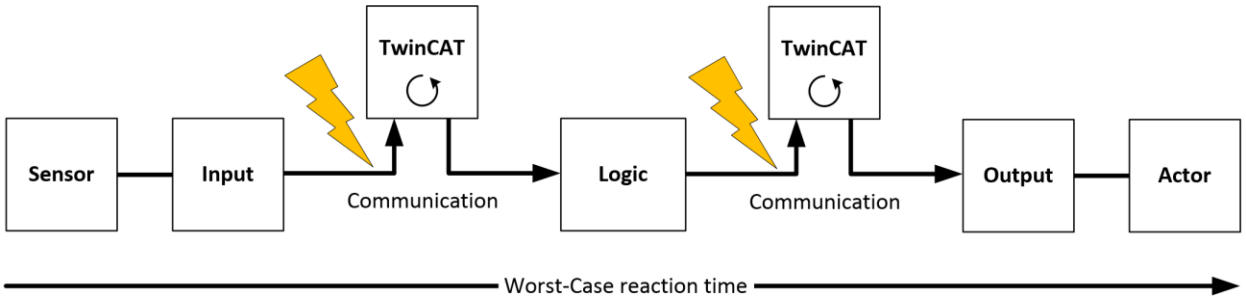
Definition	Description
RT_{Sensor}	Reaction time of the sensor until the signal is provided at the interface. Typically supplied by the sensor manufacturer.
RT_{Input}	Reaction time of the safe input, such as EL1904 or EP1908. This time can be found in the technical data. In the case of the EL1904 it is 4 ms.
RT_{Comm}	Reaction time of the communication This is typically 3x the EtherCAT cycle time, because new data can only be sent in a new Safety-over-EtherCAT telegram. These times depend directly on the higher-level standard controller (cycle time of the PLC/NC).
RT_{Logic}	Reaction time of the logic terminal. This is the cycle time of the logic terminal and typically ranges from 500 µs to 10 ms for the EL6900, depending on the size of the safety project. The actual cycle time can be read from the terminal.
RT_{Output}	Reaction time of the output terminal. This typically lies within the range of 2 to 3 ms.
RT_{Actor}	Reaction time of the actuator. This information is typically supplied by the actuator manufacturer
WD_{Comm}	Watchdog time of the communication

$$ReactionTime_{typ} = RT_{Sensor} + RT_{Input} + 3 * RT_{Comm} + RT_{Logic} + 3 * RT_{Comm} + RT_{output} + RT_{Actor}$$

with, for example

$$ReactionTime_{typ} = 5ms + 4ms + 3 * 1ms + 10ms + 3 * 1ms + 3ms + 20ms = 48ms$$

4.1.7.2 Worst case reaction time



The worst case reaction time is the maximum time required to switch off the actuator in the case of an error.

This assumes that a signal change occurs at the sensor and is transmitted to the input. A communication error occurs at precisely the moment when the signal is to be transferred to the communication interface. This is detected by the logic following the watchdog time of the communication link. This information should then be transferred to the output, but a further communication error occurs here. This error is detected at the output following a safety watchdog time out and leads to a switch-off.

This results in the following equation for the worst-case reaction:

$$ReactionTime_{max} = WD_{Comm} + WD_{Comm} + RT_{Actor}$$

with, for example

$$ReactionTime_{max} = 2 * 15ms + 20ms = 50ms$$

4.1.8 Tested devices

The following list contains devices that were tested together with the EK1914 TwinSAFE Bus Coupler. The results only apply for the current device hardware version at the time of testing. The tests were carried out in a laboratory environment. Modifications of these products cannot be considered here. If you are unsure please test the hardware together with the TwinSAFE Bus Coupler.

The tests were carried out as function tests only. The information provided in the respective manufacturer documentation remains valid.

Sensors

Manufacturer	Type	Comment
SICK	C4000	Safety light curtain
SICK	S3000	Safety laser scanner
Wenglor	SG2-14ISO45C1	Safety light grids
Leuze	lumiflex ROBUST 42/43/44	Safety light barriers
Schmersal	BNS250-11ZG	Safety switch
ifm	GM701S	Inductive safety sensor
Keyence	SL-V (with PNP cable set)	Safety light curtain

Actuators

Manufacturer	Type	Comment
Beckhoff	AX5801	TwinSAFE Drive option card: safe restart lock
Siemens	SIRIUS series S00 3RT1016-1BB42	Schütz

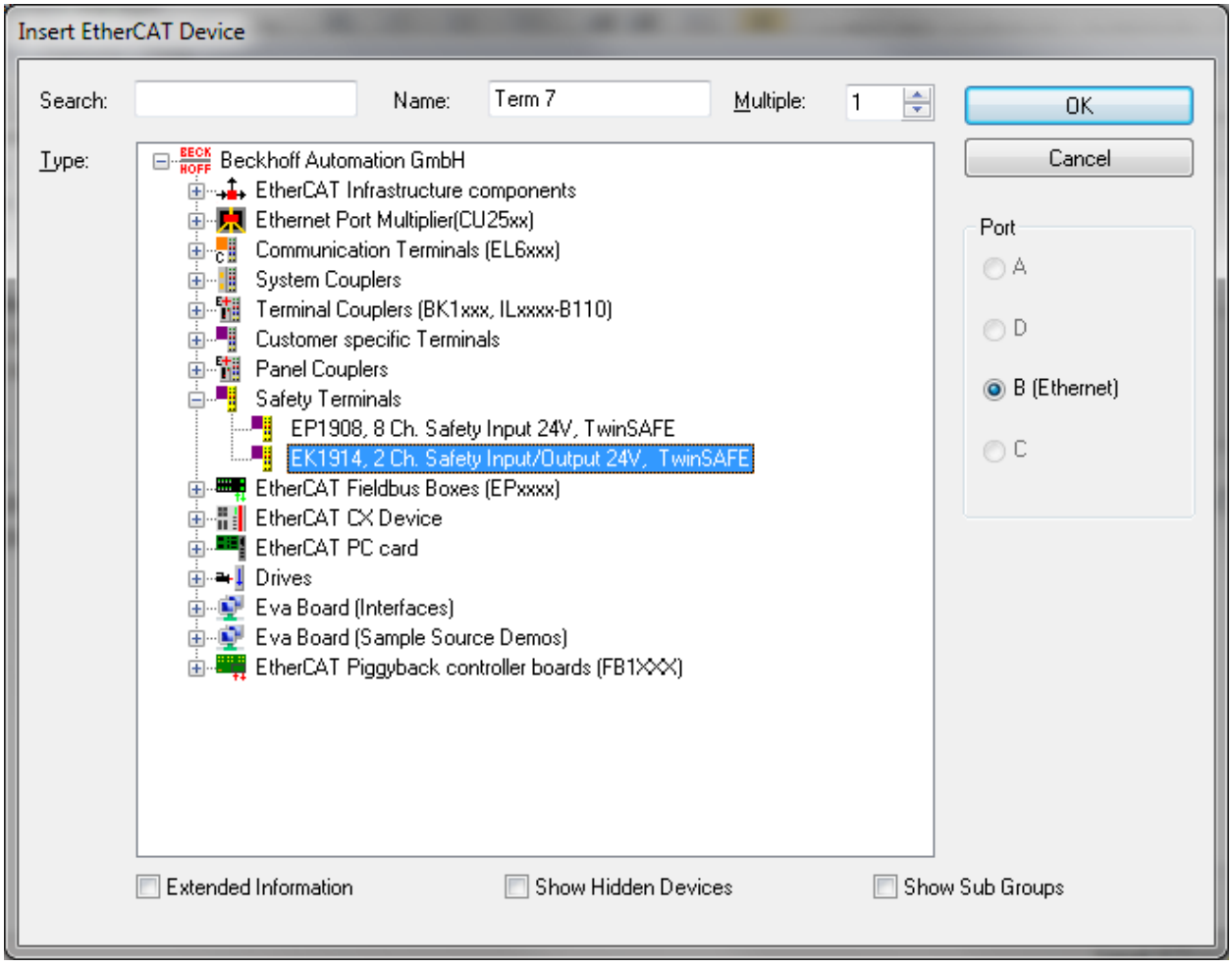
Note	**Recommended protective circuits** We recommend R/C or diode-based protective circuits for actuators. Varistor-based protective circuits should not be used.

4.3 Configuration of the EK1914 in the TwinCAT System Manager

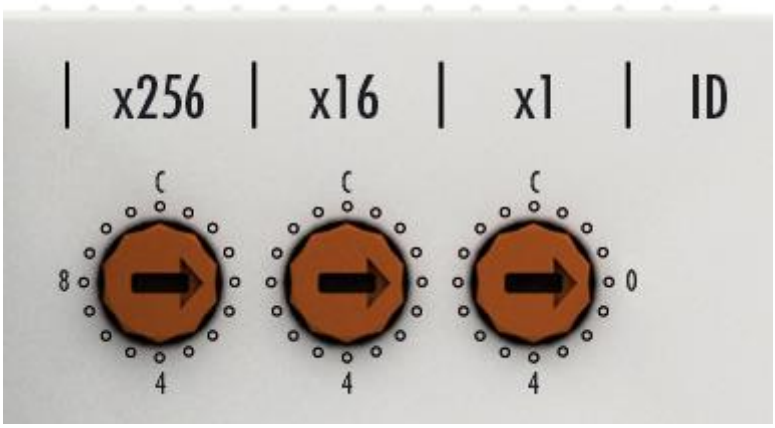
CAUTION	**Do not change the register values!** Do not make any modifications to the CoE objects of the TwinSAFE Bus Coupler. Any modifications (e.g. via the System Manager) of the CoE objects would permanently set the couplers to the Fail-Stop state!

4.3.1 Inserting a Beckhoff TwinSAFE Bus Coupler

An EK1914 is inserted in exactly the same way as any other Beckhoff Bus Coupler. In the list, open *Safety Terminals* and select the EK1914.



4.3.2 Address settings on the EK1914 TwinSAFE Bus Coupler



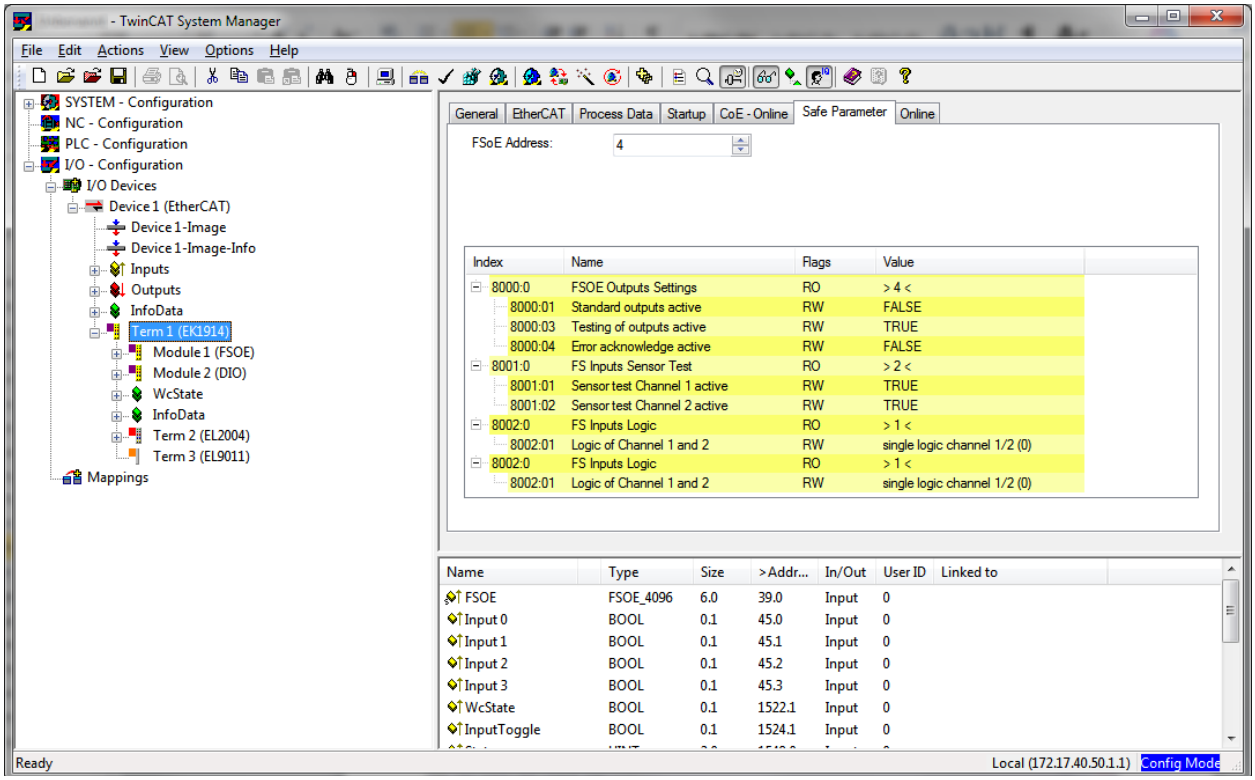
The TwinSAFE address of the coupler must be set using the three rotary switches on the side of the EK1914 TwinSAFE Bus Coupler. TwinSAFE addresses between 1 and 4095 are available.

Rotary switch			Address
1 (left)	2 (center)	3 (right)	
0	0	1	**1**
0	0	2	**2**
0	0	3	**3**
…	…	…	**…**
0	0	F	**15**
0	1	0	**16**
0	1	1	**17**
…	…	…	**…**
0	F	F	**255**
1	0	0	**256**
1	0	1	**257**
…	…	…	**…**
F	F	F	**4095**

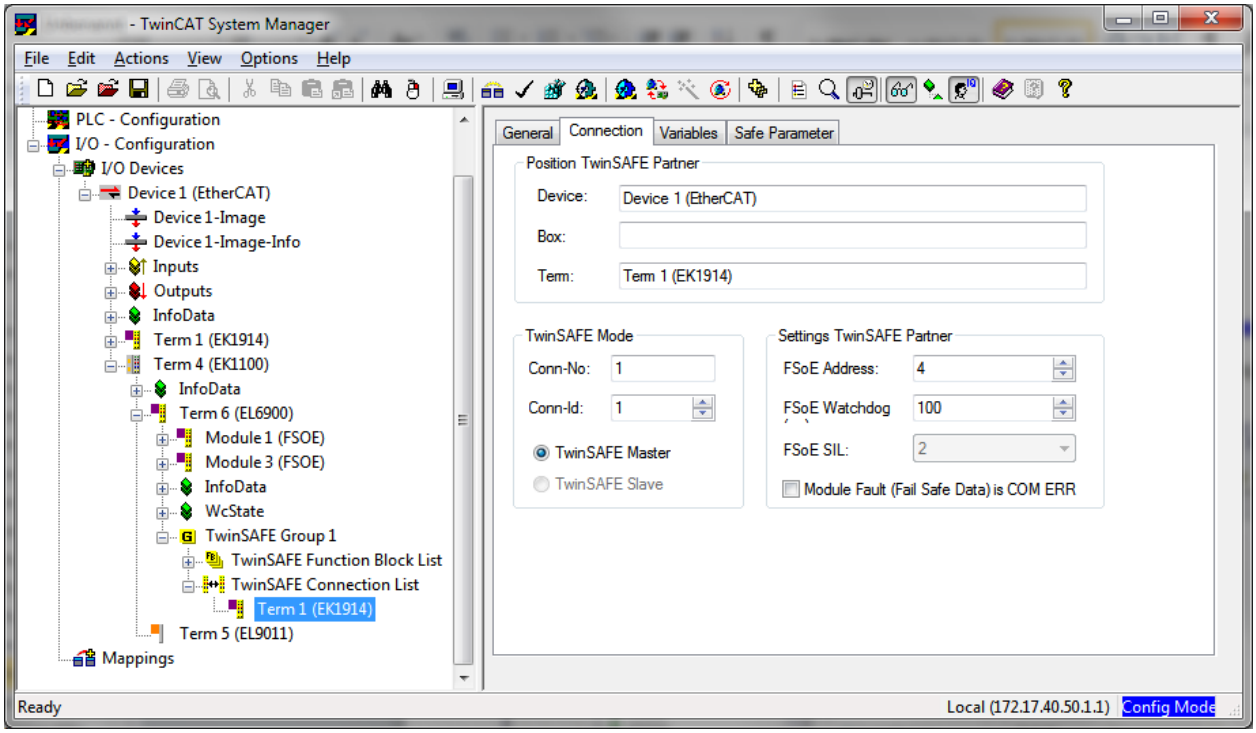
WARNING	**Unique TwinSAFE address** Each TwinSAFE address may only be used once within a network! The address 0 is not a valid address.

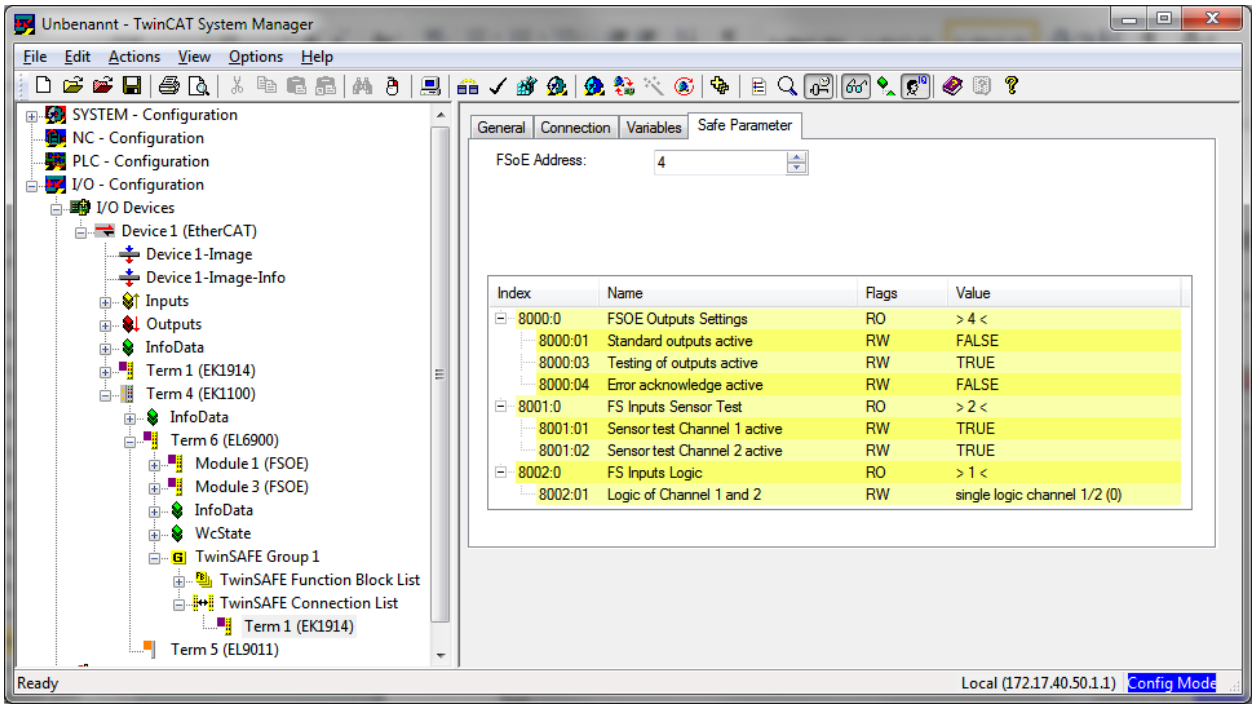
4.3.3 Entering a TwinSAFE address and parameters in the System Manager

The TwinSAFE address set using the DIP switch must also be set on the *Safe Parameter* tab (*FSoE Address* entry) underneath the EK1914. The parameters for the safe inputs and outputs can also be set here.



The parameter settings of the EK1914 can also be set under the respective TwinSAFE connection on the Connection and Safe Parameter tabs.



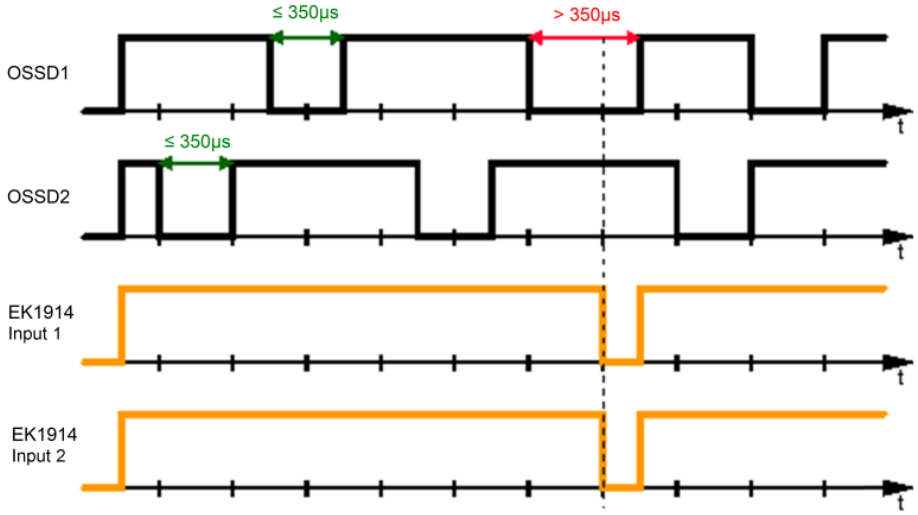

Unbenannt - TwinCAT System Manager
File Edit Actions View Options Help
SYSTEM - Configuration
NC - Configuration
PLC - Configuration
I/O - Configuration
I/O Devices
Device 1 (EtherCAT)
Device 1-Image
Device 1-Image-Info
Inputs
Outputs
InfoData
Term 1 (EK1914)
Term 4 (EK1100)
InfoData
Term 6 (EL6900)
Module 1 (FSOE)
Module 3 (FSOE)
InfoData
WcState
TwinSAFE Group 1
TwinSAFE Function Block List
TwinSAFE Connection List
Term 1 (EK1914)
Term 5 (EL9011)
General Connection Variables Safe Parameter
FSoE Address: 4
Index Name Flags Value
8000:0 FSOE Outputs Settings RO > 4 <
8000:01 Standard outputs active RW FALSE
8000:03 Testing of outputs active RW TRUE
8000:04 Error acknowledge active RW FALSE
8001:0 FS Inputs Sensor Test RO > 2 <
8001:01 Sensor test Channel 1 active RW TRUE
8001:02 Sensor test Channel 2 active RW TRUE
8002:0 FS Inputs Logic RO > 1 <
8002:01 Logic of Channel 1 and 2 RW single logic channel 1/2 (0)
Ready
Local (172.17.40.50.1.1)
Config Mode

Parameter overview

PrmName	Meaning	Values
FSoE_Address	DIP switch address	1 to 4095
Standard outputs active	In addition the safe output can be switched off from the standard PLC. The safe output is linked with the standard logic signal AND.	true / false
Testing of outputs active	Test pulses for the outputs are activated	true / false
Error acknowledge active	True: Bus Coupler errors lead to a reset of the TwinSAFE connection (error code 14 (0x0E)). This error code is shown in the diagnostic data for the connection until the user acknowledges it via ErrAck in the TwinSAFE group. False (Default): Bus Coupler errors can only be reset by switching the power supply off and back on again.	true / false
Sensor test channel 1 active	The clock signal of the “Clock output safe input 1” connection is tested at the “Safe input 1” connection.	true / false
Sensor test channel 2 active	The clock signal of the “Clock output safe input 2” connection is tested at the “Safe input 2” connection.	true / false
Logic channel 1 and 2	Logic of channels 1 and 2	- single logic - asynchronous repetition OSSD (sensor test must be switched off) - any pulse repetition OSSD (sensor test must be switched off) - Short cut is no module fault
Store Code	This parameter is required for the TwinSAFE Restore Mode	-
Project CRC	This parameter is required for the TwinSAFE Restore Mode	-
Identity	These parameters are used internally only.	-
Detected Modules	These parameters are used internally only.	-

4.3.3.1 Configuration of the EK1914 for light barriers, light grids, light curtains, etc.

The EK1914 also supports direct connection of contact-free protective devices with two self-testing outputs such as light barriers, light grids, light curtains, laser scanners, etc.

CAUTION	**Sensors with self-testing outputs** Only sensors with self-testing outputs and a maximum sensor self-test duration of 350 µs may be connected to the EK1914. 

Parameter
To connect these sensors please set the following parameters for the EK1914 in the TwinCAT System Manager:

- Connect the two sensor signals to channels 1 and 2 and activate the entry *asynchronous repetition OSSD* or *any pulse repetition* for both the inputs used under the parameter *Logic for channel 1 and 2*. The difference between these settings is that with *any pulse repetition* simultaneous tests of the OSSD signals up to 350 µs are allowed.
- Switch the sensor test of the EK1914 to *false* for both the inputs used.

4.3.3.2 Configuration of the EK1914 for safety switching mats

The EK1914 also supports the direct connection of safety switching mats.

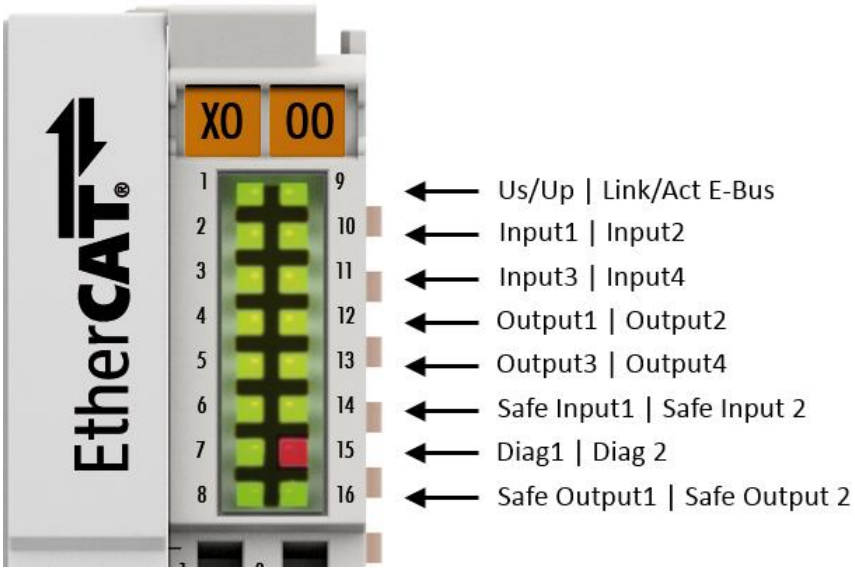
Parameter
To connect these safety mats please set the following parameters for the EK1914 in the TwinCAT System Manager:

- Connect the two sensor signals to channels 1 and 2 and activate the entry *short cut channel x/y is no module fault* for both the inputs used under the parameter *Logic for channel 1 and 2*.
- Switch the sensor test of the EK1914 to *true* for both the inputs used.

4.4 Diagnostics

4.4.1 Diagnostic LEDs

The LEDs Diag 1 (LED 7) and Diag 2 (LED 15) display diagnostic information for the EL1914.



4.4.1.1 Diag 1 (green)

The *Diag 1* LED indicates the state of the TwinSAFE interface. The LED is set as soon as the FSoE State Reset is quit and TwinSAFE communication is thus started.

4.4.1.2 Diag 2 (red) steady

The *Diag 2* LED illuminates red if the Bus Coupler detects an external supply or cross-circuit. The LED extinguishes once the error is rectified.
A more precise error cause is set in the diagnostic CoE object 0x800E (see chapter 4.4.2).

4.4.1.3 Diag 2 (red) flashing code

In the case of an error, the *Diag 2* LED displays a flashing code that describes the error in more detail. The flashing codes are structured as follows:

Flashing sequence	Meaning
Rapid flickering	Start of flashing code
First slow sequence	Error code 1
Second slow sequence	Error code 2
Third slow sequence	Error code 3
fourth slow sequence	Error code 4

Start Error code 1 Error code 2 ...

The errors indicated by the following flashing codes are reversible. After rectification of the error cause, the Bus Coupler can be put back into operation with a restart.

Diag 2 LED		
Flashing Code	**Meaning**	**Remedy**
2-1-1-1	The temperature has exceeded the maximum permissible temperature (µC1)	Ensure observance of the permissible ambient temperature.
3-1-1-1	The temperature has exceeded the maximum permissible temperature (µC2)	
4-1-1-1	The temperature has fallen below the minimum permissible temperature (µC1)	
5-1-1-1	The temperature has fallen below the minimum permissible temperature (µC2)	

If another flashing code is displayed, there is an internal coupler error that has stopped the Bus Coupler. In this case the Bus Coupler must be checked by Automation GmbH & Co. KG.

Note	**Note flashing codes; return the Bus Coupler** Note the flashing code displayed and include this information with the Bus Coupler when you return it.

4.4.2 Diagnostic objects

The CoE objects $800E_{hex}$ display further diagnostic information.

CAUTION	**Do not change CoE objects!** Do not make any modifications to the CoE objects of the TwinSAFE Bus Coupler! Any modifications (e.g. using the TwinCAT system manager) of the CoE objects would permanently set the Bus Coupler to the Fail-Stop state.

Index $800E_{hex}$: diagnostic objects - safe inputs

Index	Name	Meaning			Flags	Default
800E:0	Diag	The following sub-indices contain detailed diagnostic information.			RO	
800E:0A	Sensor test error	Bit	Error during the sensor test		RO	
		0	1_{bin}	Error at input 1		0_{bin}
		1	1_{bin}	Error at input 2		0_{bin}
800E:0B	Error during two-channel evaluation	Bit	Error during the contiguous evaluation of two channels, i.e. the two channels contradict each other.		RO	
		0	1_{bin}	Error in the first input pair		0_{bin}
800E:0C	Error in the safety mat operating mode: input pair not identical	Bits	Error in the input pair		RO	
		1, 0	11_{bin}	Error in the first input pair		00_{bin}
800E:0D	Error in the safety mat operating mode: external supply	Bit	Error in the test pulses in the safety mat operating mode; i.e. the Bus Coupler has detected an external supply.		RO	
		0	1_{bin}	Error at input 1		0_{bin}
		1	1_{bin}	Error at input 2		0_{bin}

Index 800E$_{hex}$: diagnostic objects - safe outputs

Index	Name	Meaning		Flags	Default
800E:0E	Diagnosis µC1	Value	Description	RO	
		5	Cross-circuit output 1 and output 2		0
		6	Cross-circuit output 1 and output 2		0
		10	Overvoltage		0
		11	Undervoltage		0
		21... 27	Error when testing the field voltage switches		0
		30... 33	Start-up of the output circuit failed		0
		101	External supply 0 V output 1, detected with set output		0
		102	External supply 24 V output 1		0
		103	External supply 0 V output 2, detected with set output		0
		104	External supply 24 V output 2		0
800E:0F	Diagnosis µC2	Value	Description	RO	
		201	External supply 0 V output 1, detected with set output		0
		202	External supply 24 V output 1		0
		203	External supply 0 V output 2, detected with set output		0
		204	External supply 24 V output 2		0

Note	**Differing diagnostic messages possible** Due to the variable order or execution of the test series, diagnostic messages differing from those given in the table above are possible.

4.4.3 Possible causes of diagnostic messages

Diagnostics	Possible cause	Remedial actions
Diag 2 LED 800E:0E / 800E:0F set to: 5.6 or greater than 100	If parameter *Testing of outputs active* is switched on:	
	Faulty test pulses. Cause: external supply or cross-circuit.	Eliminate cross-circuit or external supply.
	Faulty test pulses. Cause: parallel routed cables with high capacitive coupling and dynamized signals, possibly also in common cables	Isolate lines and lay in separate non-metallic sheathed cable. Create a distance between the non-metallic sheathed cables.
	Cause: current exceeds the limit of 500 mA.	Select actuator accordingly. Current < 500 mA
	Irrespective of whether the parameter *Testing of outputs active* is switched on:	
	The output voltage lies below the permissible voltage range (24 V -15%/+20%). A possible cause is a short-circuit at the output or e.g. a voltage drop at the instant of switching.	Eliminate short-circuit. Design power supply accordingly. Check supply lines for voltage drop.
	EMC faults	Take suitable EMC measures
	Internal defect	Exchange Bus Coupler
Diag 2 LED 800E:0E / 800E:0F set to: 11	Voltage on the power contacts too low.	Increase Bus Coupler supply voltage and reset error display by power-on reset of the Bus Coupler
	EMC faults	Take suitable EMC measures
	Internal defect	Exchange Bus Coupler

Diagnostics	Possible cause	Remedial actions
Diag 2 LED 800E:0E / 800E:0F set to: 10	Field potential too high. Voltage on the power contacts too high.	Decrease Bus Coupler supply voltage and reset error display by power-on reset of the Bus Coupler
	Voltage briefly too high due to external influences, such as switching contactors off.	Use an R/C or diode-based protective circuit on the actuators
	EMC faults	Take suitable EMC measures
	Internal defect	Exchange Bus Coupler

4.5 Maintenance

The TwinSAFE Bus Couplers are maintenance-free!

WARNING	**Observe the specified environmental conditions!** Please ensure that the TwinSAFE Bus Couplers are only stored and operated under the specified conditions (see technical data).

If the Bus Coupler is operated outside the permitted temperature range it will switch to *Global Fault* state.

4.5.1 Cleaning

Protect the TwinSAFE Bus Couplers from unacceptable soling during operation and storage!

If the TwinSAFE Bus Couplers were subjected to unacceptable soiling they may no longer be operated!

WARNING	**Have soiled Bus Couplers checked!** Cleaning of the TwinSAFE Bus Coupler by the user is not permitted! Please send soiled Bus Couplers to the manufacturer for inspection and cleaning!

4.5.2 Service life

The TwinSAFE Bus Couplers are designed for a service life of 20 years.

Due to the high diagnostic coverage within the lifecycle no special proof tests are required.

The TwinSAFE Bus Couplers bear a date code, which is composed as follows:

Date Code: CW YY SW HW

Legend:		Example: Date Code	27 14 01 00
CW:	Calendar week of manufacture	Calendar week:	27
YY:	Year of manufacture	Year:	2014
SW:	Software version	Software version:	01
HW:	Hardware version	Hardware version:	00

In addition the TwinSAFE Bus Couplers bear a unique serial number.

4.6 Decommissioning

 **DANGER**	**Serious risk of injury!** Bring the bus system into a safe, de-energized state before starting disassembly of the Bus Couplers!

4.6.1 Disposal

In order to dispose of the device, it must be removed and fully dismantled.

- Housing components (polycarbonate, polyamide (PA6.6)) are suitable for plastic recycling.
- Metal parts can be sent for metal recycling.
- Electronic parts such as disk drives and circuit boards must be disposed of in accordance with national electronics scrap regulations.

5 Appendix

5.1 Beckhoff 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.

5.1.1 Beckhoff branches and partner companies Beckhoff Support

Please contact your Beckhoff branch office or partner company for local support and service on Beckhoff products!
The contact addresses for your country can be found in the list of Beckhoff branches and partner companies: www.beckhoff.com. You will also find further documentation for Beckhoff components there.

5.1.2 Beckhoff company headquarters

Beckhoff Automation GmbH & Co.KG
Huelshorstweg 20
33415 Verl
Germany

Phone: + 49 (0) 5246/963-0
Fax: + 49 (0) 5246/963-198
E-mail: info@beckhoff.com
Web: www.beckhoff.com

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Fax: + 49 (0) 5246/963-9157
E-mail: support@beckhoff.com

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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 (0) 5246/963-460
Fax: + 49 (0) 5246/963-479
E-mail: service@beckhoff.com

5.2 Certificate

Reliability of EK1914

Test and Certification body

TÜV SÜD Rail GmbH
Rail Automation - IQSE
Barthstraße 16
D-80339 Munich

Manufacturer

Beckhoff Automation GmbH & Co. KG
Huelshorstweg 20
D-33415 Verl

Safety parameters EK1914

Key figures	EK1914
Lifetime [a]	20
Prooftest Intervall [a]	not required [1)]
PFH_D	2.64E-09
%SIL3	2.64%
PFD	3.92E-05
%SIL3	3.92%
$MTTF_d$	High
B10d (cycles)	-
DC	High
Performance level	PL e
Category	4
HFT	1
Element classification*	Type B

*) Classification according to IEC 61508-2:2010 (see chapters 7.4.4.1.2 and 7.4.4.1.3)

The EK1914 EtherCAT coupler can be used for safety-related applications within the meaning of EN ISO 13849-1 up to PL e (Cat4).

[1)] Special proof tests for the product are not required during the lifetime of the EK1914 EtherCAT coupler as a result of the high diagnostic coverage of the system.

Munich, 2016-03-07

Günter Greil

Digital unterschrieben von Guenter Greil
DN: c=DE, o=TUEV SUED Rail GmbH, ou=Rail & Automation, cn=Guenter Greil, email=guenter.greil@tuev-sued.de
Datum: 2016.03.07 17:52:23 +01'00'

ZERTIFIKAT ◆ CERTIFICATE ◆ 認証書 ◆ СЕРТИФИКАТ ◆ CERTIFICADO ◆ CERTIFICAT

Product Service

CERTIFICATE

No. Z10 15 03 62386 032

Holder of Certificate: **Beckhoff Automation GmbH & Co. KG**
Hülshorstweg 20
33415 Verl
GERMANY

Factory(ies): 62386

Certification Mark:

Product: **Safety components**

Model(s): **EK 1914**

Parameters:

Supply voltage:	24VDC (-15%...+20%)
Power dissipation:	1,7W
Protection class:	IP20

Tested according to:
DIN EN ISO 13849-1:2008 (Cat 4, PL e)
DIN EN 61000-6-2:2006
DIN EN 61000-6-4:2007

The product was tested on a voluntary basis and complies with the essential requirements. The certification mark shown above can be affixed on the product. It is not permitted to alter the certification mark in any way. In addition the certification holder must not transfer the certificate to third parties. See also notes overleaf.

Test report no.: BV85712T

Valid until: 2020-03-03

Date, 2015-03-04 (Günter Greil)

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TÜV SÜD Product Service GmbH · Zertifizierstelle · Ridlerstraße 65 · 80339 München · Germany

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