BECKHOFF New Automation Technology

Operating Instructions | EN

EP2918-0032 and EP2918-2232

TwinSAFE EtherCAT Box with 8 fail-safe outputs

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1 Notes on the documentation

1.1 Disclaimer

Beckhoff products are subject to continuous further development. We reserve the right to revise the documentation 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.

In this documentation, we define all permissible use cases whose properties and operating conditions we can guarantee. The use cases we define are fully tested and certified. Any other use cases not described in this documentation, require the approval of Beckhoff Automation GmbH & Co KG.

1.1.1 Trademarks

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

The use of other brand names or designations by third parties may lead to an infringement of the rights of the owners of the corresponding designations.

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

Safety over EtherCAT® is a registered trademark and patented technology, licensed by Beckhoff Automation GmbH.

1.1.2 Limitation of liability

All components in this product as described in the operating instructions are delivered in a specific configuration of hardware and software, depending on the application regulations. Modifications and changes to the hardware and/or software configuration that go beyond the documented options are prohibited and nullify the liability of Beckhoff Automation GmbH & Co. KG.

The following is excluded from the liability:

- Failure to observe these operating instructions
- Improper use
- Use of untrained personnel
- Use of unauthorized spare parts

1.1.3 Copyright

1.1.4 Third-party trademarks

Trademarks of third parties may be used in this documentation. You can find the trademark notices here: https://www.beckhoff.com/trademarks.

1.2 Documentation issue status

Version	Comment
2.1.0	• Editorially revised • Chapter "Notes on information security" and "Laser image" added • Chapter "System description" removed • "Safety parameters" changed to "Target failure measures " • Cable length removed in chapter "Technical data" • In chapter "Address settings on the TwinSAFE EtherCAT Box" information and link to STP file with switch added • Appendix extended with links to certificates and declarations of conformity
2.0.0	• Foreword changed to "Notes on the documentation" and "For your safety" • "Service life" moved • "Maintenance and cleaning" and "Decommissioning" adapted • Appendix adapted and extended
1.2.1	• Typo in “Technical data” corrected
1.2.0	• Added a link to certificate download page in chapter "Technical data" • Chapter "Firmware update of TwinSAFE products" removed • I/O component EP2918-2232 added as variant of EP2918-0032 • Chapter "Temperature measurement" renamed • Chapter "Project design limits of the EP2918" moved • Some figures renamed
1.1.0	• Chapter "Decommissioning" updated
1.0.0	• First release
0.6	• Safety-related data updated • EN81 notes removed • Maximum temperature entered
0.5	• Data for the functional overcurrent cut-off added
0.4	• Technical data updated
0.3	• Note on commissioning test added • Note on safe output added
0.2	• Revision following review • EN81 notes on TwinSAFE EtherCAT Boxes adapted • Derating information added
0.1	• First draft

Currentness

Check whether you are using the current and valid version of this document. The current version can be downloaded from the Beckhoff homepage at http://www.beckhoff.com/twinsafe. In case of doubt, contact Support and Service [▶ 10].

Origin of the document

The original documentation is written in German. All other languages are derived from the German original.

Product features

Only the product properties specified in the current operating instructions are valid. Further information given on the product pages of the Beckhoff homepage, in emails or in other publications is not authoritative.

1.3 Version history of the TwinSAFE product

This version history lists the software and hardware version numbers. You will also find a description of the changes to previous versions contained in each case. See the table below for more information.

Updated hardware and software

TwinSAFE products are subject to a cyclical revision. We reserve the right to revise and change the TwinSAFE products at any time and without prior notice.
No claims for changes to products already delivered can be asserted from these hardware and/or software changes.

Software version	Hardware version	Modifications
01	01	• Product maintenance
01	00	First release of the EP2918-2232
01	00	First release of the EP2918-0032

1.4 References

No.	Version	Description
[1]	/	Not used.
[2]	/	Not used.
[3]	1.4.1 or newer	**Operating Manual for EL6910 TwinSAFE Logic Module** The document contains a description of the logic functions of the EL6910 and its programming.
[4]	3.1.0 or newer	**Dokumentation TwinSAFE-Logic-FB** The document describes the safety-related function blocks that are available in the EL6910 and thus also in the TwinSAFE card and form the safety-related application.
[5]	3.1.0 or newer	**TwinSAFE Application Guide** The application guide provides the user with examples for the calculation of safety-related parameters for safety functions according to the standards DIN EN ISO 13849-1 and EN 62061 or EN 61508:2010, as they are typically used on machines.
[6]	2023/1230	**Regulation (EU) 2023/1230 of the European Parliament and of the Council of 14 June 2023 on machinery and repealing Directive 2006/42/EC of the European Parliament and of the Council and Council Directive 73/361/EEC** This regulation, also known as the Machinery Regulation, defines requirements for placing machinery and machine-like components, such as safety components, on the market.
[7]	2017	**EN 61511-1:2017** The standard serves as a basic safety standard for functional safety in the process industry and is tailored to its safety-related systems.

1.5 Staff qualification

These operating instructions are intended exclusively for trained specialists in control technology and automation with the relevant knowledge.

The trained specialist personnel must ensure that the applications and use of the described product meet all safety requirements. This includes all applicable and valid laws, regulations, provisions and standards.

Trained specialists

Trained specialists have extensive technical knowledge from studies, apprenticeships or technical training. Understanding of control technology and automation is available. Trained specialists can:

- Independently identify, avoid and eliminate sources of hazard.
- Apply relevant standards and directives.
- Implement specifications from accident prevention regulations.
- Evaluate, prepare and set up the workplaces.
- Evaluate, optimize and execute work independently.

1.6 Safety and instruction

Read the contents that refer to the activities you have to perform with the product. Always read the chapter For your safety [▶ 12] in the operating instructions.

Observe the warnings in the chapters so that you can handle and work with the product as intended and safely.

Explanation of symbols

Various symbols are used for a clear arrangement:

1. The numbering indicates an action that should be taken.
• The bullet point indicates an enumeration.
[…] The square brackets indicate cross-references to other text passages in the document.
[1] The number in square brackets indicates the numbering of a referenced document.

The signal words used in the documentation are classified below.

Signal words

Warning of personal injuries

⚠ 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

Notes

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.

1.7 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.

Download finder

Our download finder contains all the files that we offer you for downloading. You will find application reports, technical documentation, technical drawings, configuration files and much more.

The downloads are available in various formats.

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 our internet page: www.beckhoff.com

You will also find further documentation for Beckhoff components there.

Beckhoff Support

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

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

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

Beckhoff Service

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

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

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1.8 Notes on information security

The products of Beckhoff Automation GmbH & Co. KG (Beckhoff), insofar as they can be accessed online, are equipped with security functions that support the secure operation of plants, systems, machines and networks. Despite the security functions, the creation, implementation and constant updating of a holistic security concept for the operation are necessary to protect the respective plant, system, machine and networks against cyber threats. The products sold by Beckhoff are only part of the overall security concept. The customer is responsible for preventing unauthorized access by third parties to its equipment, systems, machines and networks. The latter should be connected to the corporate network or the Internet only if appropriate protective measures have been set up.

In addition, the recommendations from Beckhoff regarding appropriate protective measures should be observed. Further information regarding information security and industrial security can be found in our https://www.beckhoff.com/secguide.

Beckhoff products and solutions undergo continuous further development. This also applies to security functions. In light of this continuous further development, Beckhoff expressly recommends that the products are kept up to date at all times and that updates are installed for the products once they have been made available. Using outdated or unsupported product versions can increase the risk of cyber threats.

To stay informed about information security for Beckhoff products, subscribe to the RSS feed at https://www.beckhoff.com/secinfo.

2 For your safety

Read this chapter containing general safety information. In addition, always observe the safety instructions and warnings in these operating instructions for your own safety, the safety of other persons and the safety of the product.

When working with control and automation products, many dangers can result from careless or incorrect use. Work particularly thoroughly, not under time pressure and responsibly towards other people.

2.1 Duty of care

Read entire documentation for TwinSAFE component

- TwinSAFE application manual
- EL6910 TwinSAFE logic terminal operating manual
- TwinSAFE Logic FB documentation manual

The operator must comply with all the requirements and notes specified in these operating instructions in order to fulfill his duty of care. This includes in particular that you

- comply with the provisions defined in the chapter Limitation of liability [▶ 5].
- only operate the TwinSAFE component when it is in perfect working order.
- provide the operating instructions in a legible condition and complete at the place of use of the TwinSAFE component.
- do not remove the safety markings attached to the TwinSAFE component and maintain their legibility.

The operator is also responsible for the safe operation of the system. This includes risk assessment. The following standards apply for risk assessment:

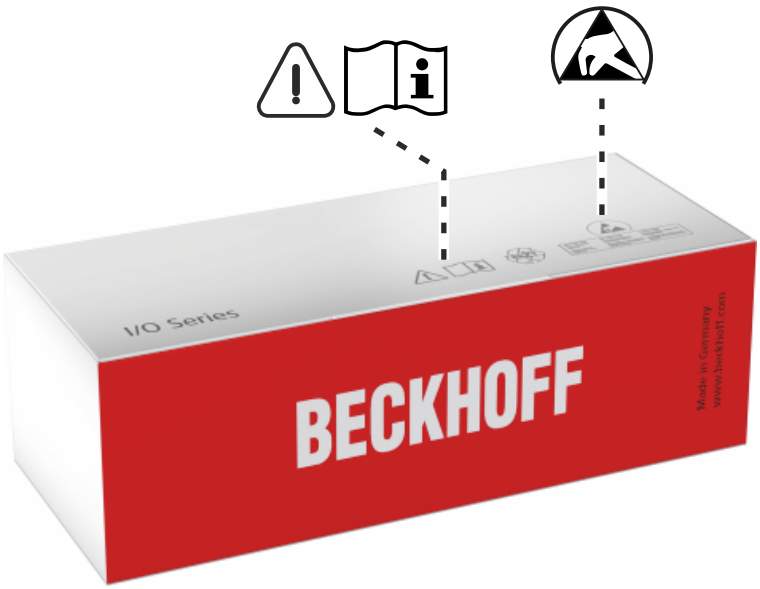
- EN ISO 12100:2010, Safety of machinery – General principles for design – Risk assessment and risk reduction
- ISO 13849-1, Safety of machinery – Safety-related parts of control systems – Part 1: General principles for design

Beckhoff is not responsible for the safe operation of the system.

No disposal in domestic waste
Products marked with a crossed-out waste bin must not be disposed of with domestic waste. The device is considered waste electrical and electronic equipment when it is disposed of. Observe the national regulations for the disposal of waste electrical and electronic equipment.

2.2 Safety image signs

Beckhoff products feature safety pictograms, either on stickers or printed, which vary depending on the product. They serve to protect people and to prevent damage to the products. Safety pictograms may not be removed and must be legible for the user.



Read and observe the operating instructions
Commissioning is only permitted if the operating instructions have been read and understood beforehand. This applies in particular to the safety instructions and the warnings.

Electrostatic sensitive components
Work with and on the TwinSAFE component is only permitted at protected workplaces.

2.3 General safety instructions

2.3.1 Before operation

Use in machines according to the Machinery Regulation and EN 61511

Only use the TwinSAFE component in machines that comply with the Machinery Directive and the EN 61511 standard for the process industry. This will ensure safe operation.

Refer to the documents [6] and [7] under References [▶ 7].

Ensure traceability

Ensure the traceability of the TwinSAFE component via the serial number.

Use SELV/PELV power supply

Use a SELV/PELV power supply unit with an output-side voltage limit of U_{max} = 36 V_{DC} to supply the TwinSAFE component with 24 V_{DC}.

Failure to observe this will endanger the safety function of the product. Depending on the machine, death and danger to life, serious physical injury and damage to the machine may result.

Carry out commissioning test

Before commissioning, wiring faults to the sensors must be excluded. Before commissioning, carry out a commissioning test. After a successful commissioning test, you can use the TwinSAFE component for the intended safety-related task.

In case of wiring errors, the safety function of the product is at risk. Depending on the machine, death and danger to life, serious bodily injury and damage to the machine may result.

Use of permissible engineering tools and procedures

The TÜV SÜD certificate applies to these TwinSAFE components, the function blocks available in it, the documentation and the engineering tool. Engineering tools allowed are TE9000 - TwinCAT 3 Safety Editor and TE9200 - TwinSAFE Loader. Use only the latest versions of the engineering tools. You will find this on the Beckhoff website.

Procedures or engineering tools that deviate from this are not covered by the certificate. This is especially true for externally generated xml files for the TwinSAFE import.

2.3.2 During operation

Interference due to emitted interference

Do not operate the following devices in the vicinity of the TwinSAFE component: for example, radio telephones, radios, transmitters or high-frequency systems.

TwinSAFE components comply with the requirements of the applicable electromagnetic compatibility standards with regard to interference emission and immunity. If you exceed the limits for emitted interference specified in the standards, the function of the TwinSAFE component may be impaired.

2.3.3 After operation

De-energize and switch off components before working on them

Check all safety-relevant equipment for functionality before working on the TwinSAFE component. Secure the working environment. Secure the machine or plant against being inadvertently started up. Observe the chapter Decommissioning [▶ 53].

3 Product description

3.1 EP2918-0032 & EP2918-2232

The EP2918 is an EtherCAT Box with digital outputs for 24 V_{DC} actuators. The EtherCAT Box has 8 fail-safe outputs, each with a maximum output current of 2 A (at 24 V_{DC}).

The EL2918 meets the requirements of the following standards:

- EN 61508:2010 (SIL 3)
- EN 62061:2005/A2:2015 (SIL CL 3)
- EN ISO 13849-1:2023 (Cat. 4, PL e)

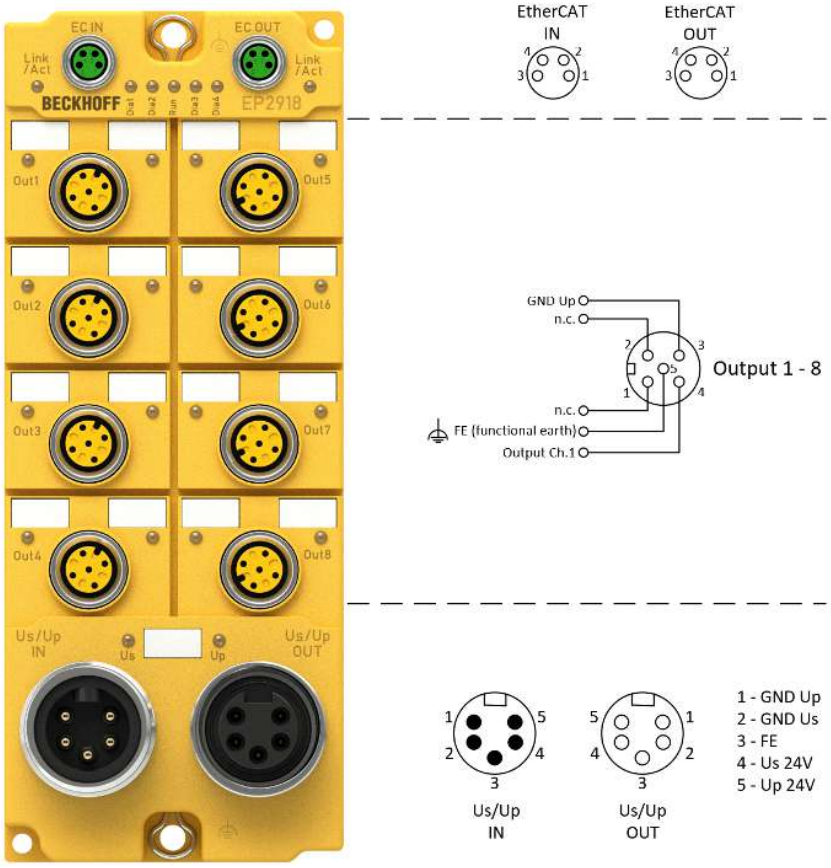


Fig. 1: EP2918 – TwinSAFE EtherCAT Box with 8 fail-safe outputs

The TwinSAFE EtherCAT Box has the usual design of an EtherCAT Box with a width of 60 mm and a height of 150 mm.

EP2918 variants

The EP2918 has an integrated safety control that can be used for user-specific applications directly on the component. The variant EP2918-2232 does not have this functionality and represents a pure I/O component.

3.2 Intended use

Operate the TwinSAFE component exclusively for the intended activities defined in this documentation, taking into account the prescribed values.

The functions allow the Beckhoff TwinSAFE components to be used in the field of machine safety and as safety devices for the process industry. The intended field of application for TwinSAFE components is safety functions on machines and process control technology in accordance with EN 61511 and the directly associated tasks in industrial automation.

TwinSAFE components are therefore only approved for applications with a defined "fail-safe state". This safe state is the de-energized. Fail-safety according to the relevant standards is required.

The TwinSAFE EtherCAT Box allows the connection of:

24 V_{DC} actuators such as

- contactors, protective door switches with tumblers, valves etc.

⚠ WARNING

Improper use

Any use which exceeds the permissible written values from the chapter Technical data [▶ 18] or which does not observe other specifications from these operating instructions or other documents of the overall documentation is considered to be not in accordance with the intended use and is therefore prohibited.

This applies in particular to the use cases defined by Beckhoff Automation, which have been fully tested and certified and whose properties and operating conditions can be guaranteed. Use cases beyond this are regarded as inappropriate and require the approval of Beckhoff Automation.

Improper use will result in loss of safety and invalidation of certifications and approval.

3.3 Laser image

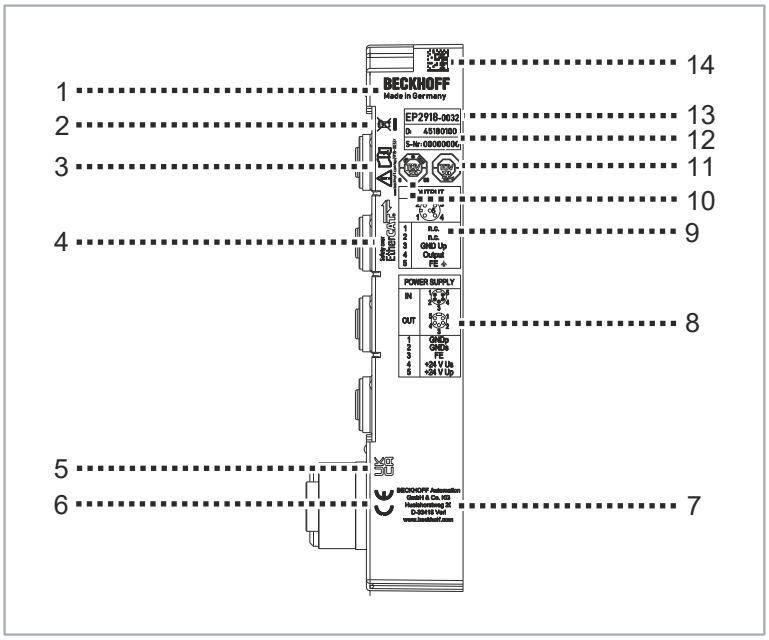


Fig. 2: EP2918 laser image

Item number	Explanation
1	Manufacturer logo, country of manufacture
2	Labeling of products that must not be disposed of with domestic waste in accordance with Directive 2012/19/EU
3	Product label “Read operating instructions”, website
4	Safety over EtherCAT logo
5	UKCA conformity mark
6	CE conformity mark
7	Address of the manufacturer, country of manufacture, website
8	Illustration of the pin assignment for the power supply
9	Illustration of the pin assignment for the outputs
10	TÜV-SÜD conformity mark for NRTL
11	TÜV-SÜD conformity mark for functional safety
12	Serial number Date code WW = Calendar week of manufacture YY = Year of manufacture SW = Software version HW = Hardware version
13	Product designation
14	Data matrix code of the serial number

3.4 Technical data

The current certificates of all TwinSAFE products with the underlying standards and directives can be found at https://www.beckhoff.com/en-en/support/download-finder/certificates-approvals/.

Product designation	EP2918-0032 and EP2918-2232
Fieldbus	EtherCAT
Number of outputs	8
Connection of the outputs	M12
Status display	8 (one green LED per output), 5 diagnostic LEDs, 2 LEDs for Us/Up, 2 LEDs for EtherCAT Link/Act
Response time (read input/write to E-bus)	typical: 4 ms (in default setting without local TwinSAFE logic), maximum: see fault reaction time
Watchdog time	adjustable from 2 ms to 60 s
Fault reaction time	≤ watchdog time
Cable length between actuator and EtherCAT Box	Unshielded: max. 100 m (0.75 or 1 mm²)
	Shielded: max. 100 m (0.75 or 1 mm²)
Safe outputs	max. 2.0 A (at 24 V_{DC}) per channel Diagnostic thresholds: > 4.7 V -> high signal is detected < 1.0 V -> low signal is detected
Outputs (functional)	Functional overcurrent switch-off of the output driver: typically between 2.9 A and 6.3 A (This overcurrent switch-off is implemented purely functionally and cannot be loaded from a safety aspect.)
Input process image	6 bytes (via FSoE if using the default project)
Output process image	7 bytes (via FSoE if using the default project)
EP2918 supply voltage	24 V_{DC} (–15% / +20%)
Current consumption U_S (8 output channels switched)	8 channels occupied: typically 120 mA 0 channels occupied: typically 80 mA (provide a 4 A fuse)
Current consumption U_P (8 output channels switched, plus load current)	8 channels occupied: approx. 70 mA 0 channels occupied: approx. 20 mA (provide a 16 A fuse)
Power loss of the EtherCAT Box	typically 4.9 watts
Electrical isolation (between the channels)	no
Electrical isolation (between the channels and EtherCAT)	yes
Insulation voltage (between the channels and EtherCAT, under common operating conditions)	Insulation tested with 500 V_{DC}
Dimensions (W x H x D)	60 (+0.5) mm x 150 (+0.5) mm x 26.5 mm
Housing material	PBT+PET (Valox 855) Flame Class: V-0
Sealing compound	Polyurethane PU552L Flame Class: V-0
Weight	approx. 470 g
Permissible ambient temperature (operation)	-25 °C to +60 °C
Permissible ambient temperature (transport/storage)	-40 °C to +85 °C
Permissible air pressure (operation/storage/transport)	750 hPa to 1100 hPa (this is equivalent to an altitude of approx. -690 m to 2450 m above sea level assuming an international standard atmosphere)
Inadmissible operating conditions	TwinSAFE EtherCAT Boxes must not be used under the following conditions: • under the influence of ionizing radiation (exceeding the natural background radiation) • in corrosive environments
EMC tests according to	EN 61326-3-1:2017 (SIL 3) IEC 61131-2:2017 Chapter 6.2 and 7 (Zone B)
Vibration resistance	conforms to EN 60068-2-6 5 Hz ≤ f < 8.4 Hz (3.5 mm peak) 8.4 Hz ≤ f < 150 Hz (10 m/s^2 peak)
Shock resistance	conforms to EN 60068-2-27 15 g with pulse duration 11 ms in all three axes
Protection rating (when screwed together)	IP67 (according to EN 60529)

Product designation	EP2918-0032 and EP2918-2232
Correct installation position	variable
Approvals	CE, TÜV SÜD

Derating table for altitudes above 2000 m

The derating table (table 8) from the IEC 61131-2:2017 standard can be referred to for the use of the TwinSAFE components above the specified maximum altitude.

Altitude in m	Derating factor for the temperature[1]
0 to 2000[2]	1.0
3000	0.9
4000	0.8
5000	0.7
Note: Linear interpolation is permissible between the altitudes [1)] Ambient temperature of the device at an altitude of 2000 m [2)] The air pressure and air density increase as the altitude decreases. Therefore the derating factor for 0 to 2000 m (1.0) is used for altitudes below sea level.	

Calculation example

In the following example the calculation is performed for a TwinSAFE component at an operating altitude of 4000 m.

Permissible ambient temperature up to 2000 m above sea level = 55 °C

Permissible ambient temperature up to 4000 m above sea level = 55 °C * 0.8 = **44 °C**

⚠ CAUTION

Compliance with the temperature limits

The TwinSAFE component has a maximum internal temperature at which a switch-off takes place. This is designed for the maximum permissible ambient temperature. If the derating factor for the temperature for higher altitudes is used, the user is solely responsible for ensuring that the calculated maximum ambient temperature is complied with.

3.5 Target failure measures

Calculation of the $MTTF_D$ value from the PFH_D value

For calculation and estimation of the values described in the following table, refer to the following documentation:

- TwinSAFE Application Guide
- EN ISO 13849-1:2023; table K.1.

In terms of target failure measures, the FSoE communication is considered with 1 % of SIL 3 according to the protocol specification.

The TwinSAFE component is intended for use in safety-related applications. It meets the following standards:

- IEC 61508:2010 up to SIL 3
- EN ISO 13849-1:2023 up to PL e, category 4

Target failure measures		Explanation
Lifetime	20 a	
Prooftest interval	/	Special proof tests during the entire lifetime of the TwinSAFE card are not required.
PFH_D	4.16E-09	
PFD_{avg}	2.00E-05	
$MTTF_D$	high	
DC	high	
Performance level	e	according to EN ISO 13849-1:2023.
CAT	4	according to EN ISO 13849-1:2023.
SFF	> 99 %	
HFT	1	
Element classification	Type B	according to EN 61508-2:2010, chapter 7.4.4.1.2 and 7.4.4.1.3.

For further information, please refer to the chapter Lifetime [▶ 22].

3.6 Safe output

The safe outputs are implemented as a single channel per module. It is essential to pay attention to the following note if two or more outputs run in a common sheathed cable.

⚠ DANGER

Clocked signals inside a sheathed cable

If clocked signals from different modules are used inside a single sheathed cable, then a module error such as a cross-circuit or external power supply must lead to the switch-off of all of these modules. This is achieved by setting the *Module Fault Link active* parameter for all modules involved. This parameter is set to TRUE by default.

3.7 Dimensions

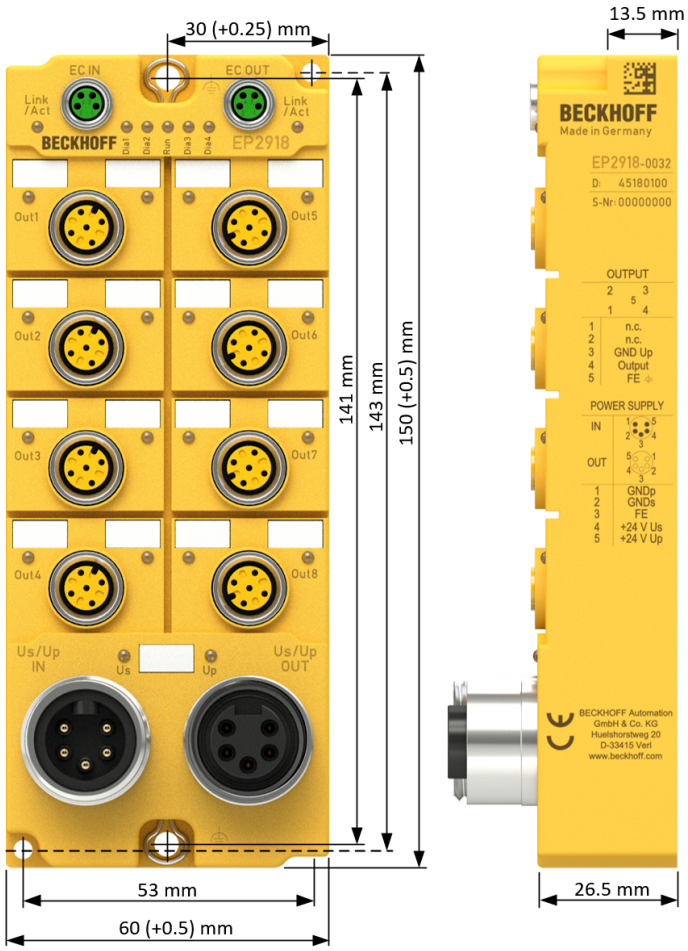


Fig. 3: Dimensions

The EtherCAT Box has the following dimensions:

Width	60.0 (+0.5) mm
Height	150.0 (+0.5) mm
Depth	26.5 mm

When fully wired, the connected cables increase the total depth of the module.

3.8 Lifetime

TwinSAFE components have a lifetime of 20 years, during which the target failure measures are guaranteed. For more information, see the chapter Target failure measures [▶ 20].

The lifetime starts from the date of manufacture according to the Date Code.

⚠ WARNING

Replace TwinSAFE component after 20 years

After a lifetime of 20 years, the target failure measures are no longer guaranteed.

Use beyond the lifetime may result in loss of safety.

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

Date Code

The TwinSAFE EtherCAT Box modules have a Date Code (D:), which is structured as follows:

Date Code: WW YY SW HW

Key:	Example: Date Code 16 18 01 02
WW: calendar week of manufacture	Calendar week: 16
YY: year of manufacture	Year: 2018
SW: software version	Software version: 01
HW: hardware version	Hardware version: 02

Serial number (S. no.)

In addition, the TwinSAFE EtherCAT Boxes have a unique serial number (S. no.).

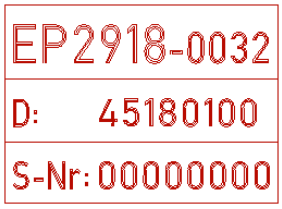


Fig. 4: EP2918 serial number and data code

4 Operation

4.1 Environmental conditions

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

⚠ WARNING

Risk of injury!

The TwinSAFE EtherCAT boxes must not be used under the following conditions.

- under the influence of ionizing radiation (that exceeds the level of the natural environmental radiation)
- in corrosive environments

NOTICE

Electromagnetic compatibility

The TwinSAFE components comply with the current standards on electromagnetic compatibility with regard to spurious radiation and immunity to interference in particular.
However, in cases where devices such as mobile phones, radio equipment, transmitters or high-frequency systems that exceed the interference emissions limits specified in the standards are operated near TwinSAFE components, the function of the TwinSAFE components may be impaired.

4.2 Installation

4.2.1 Fixing

NOTICE

Protect connectors against soiling!

Protect all connections from contamination during installation and operation of the modules! Protection class IP67 is only guaranteed if all cables and plug connectors are connected, and unused connections are protected with the appropriate cover plugs!
Connector sets see catalog.

- Modules with narrow housing are installed with two M3 screws.
- Modules with wide housing are installed with two M3 screws in the mounting holes in the corners or two M4 screws in the central fastening holes (see also chapter Power connection and grounding).
- The bolts must be longer than 15 mm. The fastening holes in the modules have no thread.
- Note when mounting that the overall height is increased further by the fieldbus connections.

4.2.2 Connection

4.2.2.1 Nut torque for connectors

M8 connector

We recommend fastening the M8 connector with a torque of **0.4 Nm**. A max. torque of **0.5 Nm** is also permissible if using a torque screwdriver (Beckhoff article ZB8800).

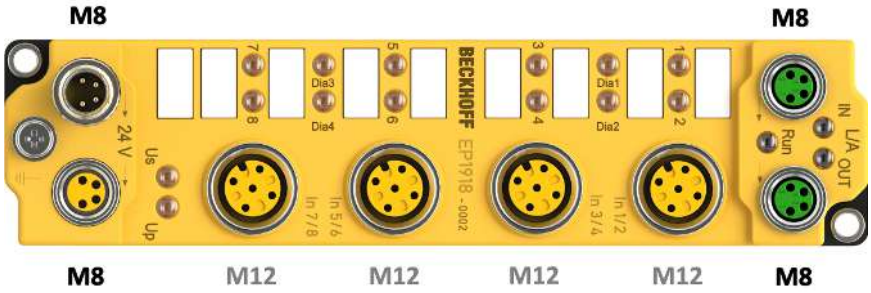


Fig. 5: EtherCAT Box with M8 plug connectors

M12 connector

We recommend fastening the M12 connector with a torque of **0.6 Nm**.

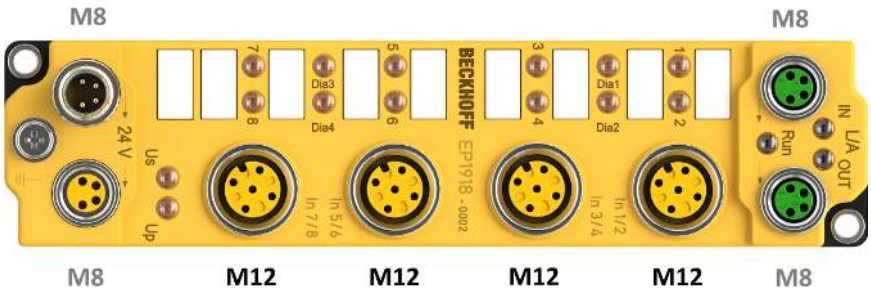


Fig. 6: EtherCAT Box with M8 and M12 connectors

7/8" plug connectors

We recommend fastening the 7/8" plug connectors with a torque of **1.5 Nm**.

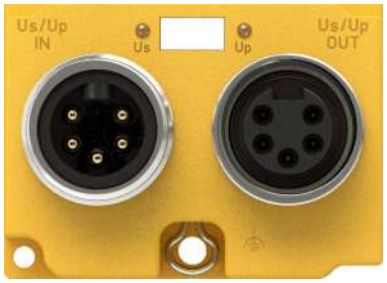


Fig. 7: 7/8" plug connectors

Torque wrench

Fig. 8: Torque wrench ZB8801

NOTICE

Ensure the proper torque is used

Use torque wrenches available from Beckhoff to tighten the connectors (see accessories)!

4.2.2.2 EtherCAT connection

The EtherCAT Box (EPxxxx) has two M8 connectors marked **green** for the incoming and outgoing EtherCAT connection.

Fig. 9: EtherCAT connection 30 mm housing M8

Connection

There are various different standards for the assignment and colors of connectors and cables for EtherCAT.

EtherCAT		Connector	Cable		Standard
Signal	**Description**	**M8**	**ZB9010, ZB9020, ZK1090-6292**	**ZB903x, ZK1090-31xx**	**TIA-568B**
Tx +	Transmit Data+	Pin 1	yellow[1]	orange/white[2]	white/orange
Tx -	Transmit Data-	Pin 4	orange[1]	orange[2]	orange
Rx +	Receive Data+	Pin 2	white[1]	blue/white[2]	white/green
Rx -	Receive Data-	Pin 3	blue[1]	blue[2]	green
Shield	Shield	Housing	Shield	Shield	Shield

[1)] Core colors according to EN 61918

[2)] Core colors

4.2.2.3 EtherCAT cables

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

Wiring recommendations

Detailed recommendations for EtherCAT wiring can be found in the documentation "Design recommendations for EtherCAT/Ethernet infrastructure", which is available for download from www.Beckhoff.de.

EtherCAT uses four cable wires for signal transmission. Due to automatic cable detection (auto-crossing) symmetric (1:1) or cross-over cables can be used between EtherCAT devices from BECKHOFF.

4.2.2.4 Power connection and grounding

This chapter provides basic information about the power supply and grounding of the TwinSAFE EtherCAT Box. In particular, please note that the *General information on connecting the functional earth* only serves as an example.

Supply voltages (power connection)

The supply and distribution of the supply voltages takes place via the connections:

- **Us/Up IN** for feeding in the supply voltages
- **Us/Up OUT** for forwarding the supply voltages.

Both connections have a 7/8" thread and are located to the left (Us/Up IN) and right (Us/Up OUT) of the TwinSAFE EtherCAT Box (see figure: *EP2918 - power connection*).

Information: An overview of pin assignment for the two connections can be found later in this chapter.

General information for connecting the functional earth

The grounding lugs of the EP2918 are internally connected to the safe outputs (pin 5 of the M12 connections).

To provide functional earthing ⏚ , if possible the connection should:

- have a large surface
- have low resistance and
- be permanent.

In order to establish a permanent connection, all operating states of the machine, such as vibrations, must be taken into account.

The connection can be established using the following two methods:

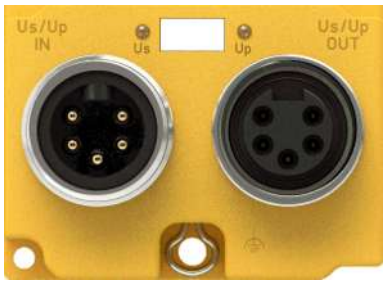
1. via a bolted connection from the TwinSAFE EtherCAT Box to the machine bed
2. through a ring terminal (hole dia. 4.3 mm) with cable connection to the functional earth

A grounding lug is available at the upper and lower mounting points (hole dia. 5 mm for M4 thread) on the housing.

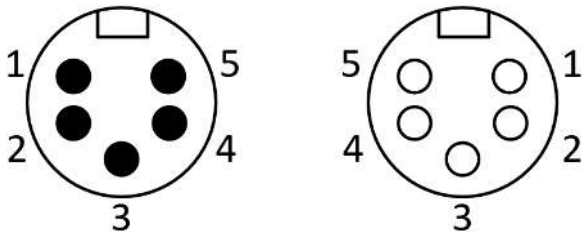
NOTICE

Connecting the functional earth

The functional earth connection should have low resistance and a large surface.



Power connection



7/8-inch connector pin assignment

Contact	Voltage
1	GND Up
2	GND Us
3	Connecting the functional earth ⏚
4	Control voltage Us, +24 V_{DC} (provide a 4 A fuse)
5	Peripheral voltage Up, +24 V_{DC} (provide a 16 A fuse)

The contacts of the 7/8" plug connectors can conduct a maximum current of 16 A.

Two LEDs indicate the status of the supply voltages.

NOTICE

Do not confuse the power port with EtherCAT port!

Never connect the power cables (M8, 24 V_{DC}) to the green-marked EtherCAT sockets of the EtherCAT Box modules. This can cause the destruction of the modules!

Control voltage Us

The fieldbus and the processor logic are supplied from the 24 V_{DC} control voltage Us. The control voltage is electrically isolated from the fieldbus circuitry.

Peripheral voltage Up

The peripheral voltage Up supplies the digital safe outputs.

Redirection of the supply voltages

The power IN and OUT connections are bridged in the module. Hence, the supply voltages Us and Up can be passed from EtherCAT Box to EtherCAT Box in a simple manner.

⚠ CAUTION

Note the maximum current!

Also ensure when forwarding the supply voltages Us and Up that the maximum permissible current of 16 A for each contact of the 7/8" plug connector is not exceeded!

4.2.2.5 Signal connection for outputs

The EtherCAT Box has 8 fail-safe outputs with a maximum output current of 2.0 A each (at 24 V_{DC}).

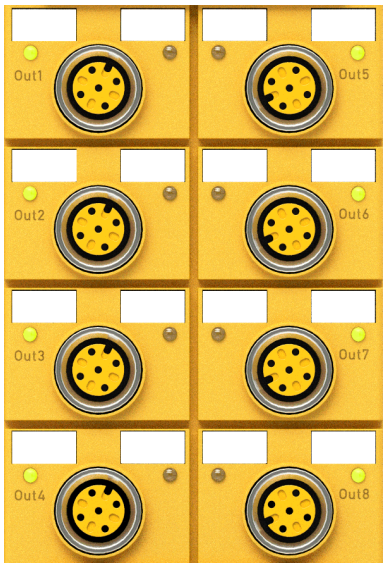


Fig. 10: Safe outputs 1 to 8

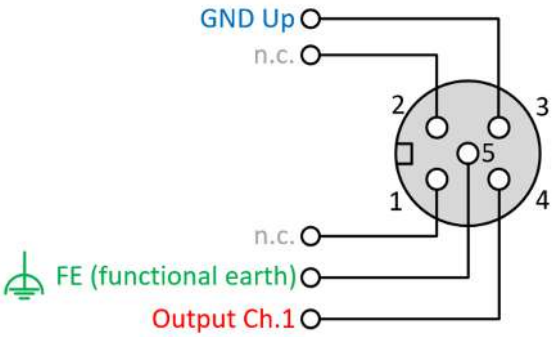


Fig. 11: PinOut safe output

M12 connection	Contact	Channel	Signal
1	1	-	not connected
	2		not connected
	3	1	GND Up
	4		Output 1
	5	-	Functional earth FE
2	1	-	not connected
	2		not connected
	3	2	GND Up
	4		Output 2
	5	-	Functional earth FE
3	1	-	not connected
	2		not connected
	3	3	GND Up
	4		Output 3
	5	-	Functional earth FE
4	1	-	not connected
	2		not connected
	3	4	GND Up
	4		Output 4
	5	-	Functional earth FE
5	1	-	not connected
	2		not connected

M12 connection	Contact	Channel	Signal
	3	5	GND Up
	4		Output 5
	5	-	Functional earth FE
6	1	-	not connected
	2		not connected
	3	6	GND Up
	4		Output 6
	5	-	Functional earth FE
7	1	-	not connected
	2		not connected
	3	7	GND Up
	4		Output 7
	5	-	Functional earth FE
8	1	-	not connected
	2		not connected
	3	8	GND Up
	4		Output 8
	5	-	Functional earth FE

Functional earth

The functional earth on pin 5 of the M12 connections of the outputs is internally connected to the grounding lugs of the EtherCAT Box.

4.2.2.6 Overvoltage protection

If protection against overvoltage is necessary in your system, provide a protective circuit (surge filter) against overvoltage for the power supply to the EtherCAT Box.

4.2.3 Temperature measurement

The temperature measurement of the TwinSAFE EtherCAT Box consists of a single EtherCAT Box that is wired with corresponding supply and communication cables. The inputs and/or outputs of the EtherCAT Box are switched on for the test.

NOTICE

External heat sources / radiant heat / impaired convection

The maximum permissible ambient temperature of 60°C was checked with the example configuration described above. Impaired convection or an unfavorable location near heat sources may have a negative effect on the internal heating of the TwinSAFE components.

The key parameter is always the maximum permitted internally measured temperature of 95°C, above which the TwinSAFE components switch to safe state and report an error. The internal temperature can be read from the TwinSAFE components via CoE.

4.2.4 Signal cables

Permitted cable length

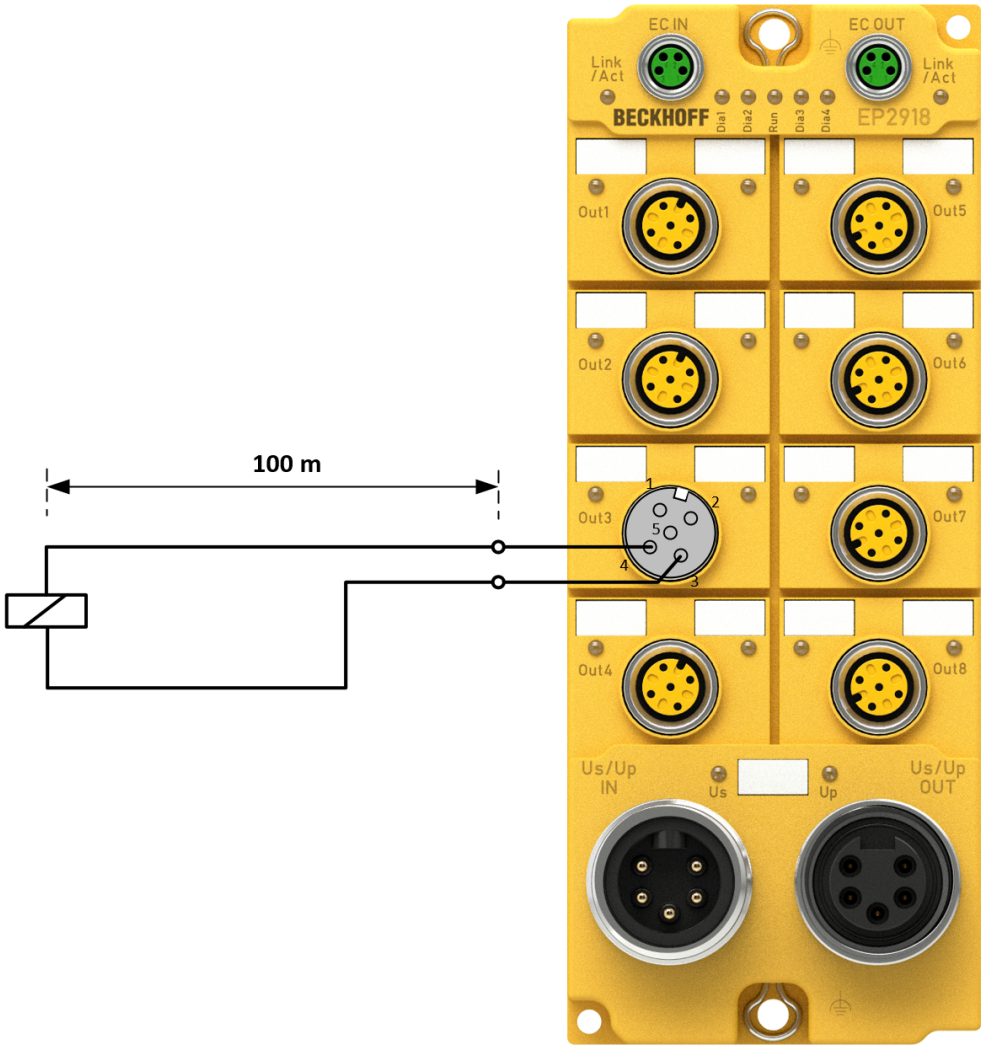


Fig. 12: Signal lines

When connecting a single switching contact via its own continuous cabling (or via a sheathed cable), the maximum permitted cable length with test pulses activated is 100 meters.

The use of contact points, connectors or additional switching contacts in the cabling reduces the maximum propagation.

Cable routing

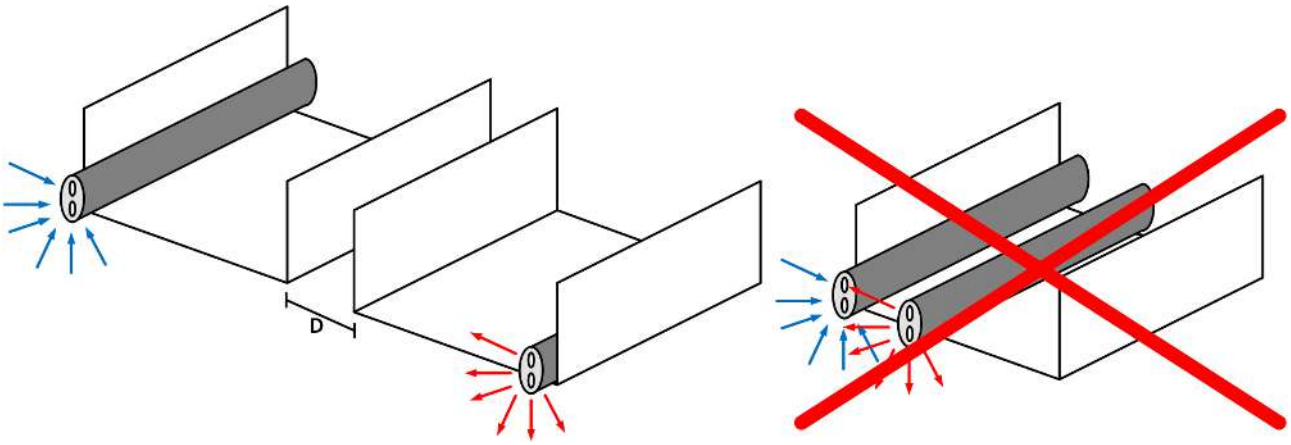


Fig. 13: Cable routing

NOTICE

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 or OpenLoad 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.

4.3 Configuration of the EtherCAT Box in TwinCAT

Identical configuration

The configuration of the EtherCAT Box in TwinCAT is identical for the variant EP2918-2232.

⚠ CAUTION

Do not change CoE objects!

Do not change any of the CoE objects in the TwinSAFE terminals. Any modifications (e.g. via TwinCAT) of the CoE objects will permanently set the terminals to the Fail-Stop state or lead to unexpected behavior of the terminals!

4.3.1 Adding an EtherCAT device

See TwinCAT automation software documentation.

4.3.2 Inserting an EP2918

An EP2918 is inserted in exactly the same way as any other Beckhoff EtherCAT Box. Open the *TwinSAFE Fieldbus Boxes* item in the list and select the EP2918.

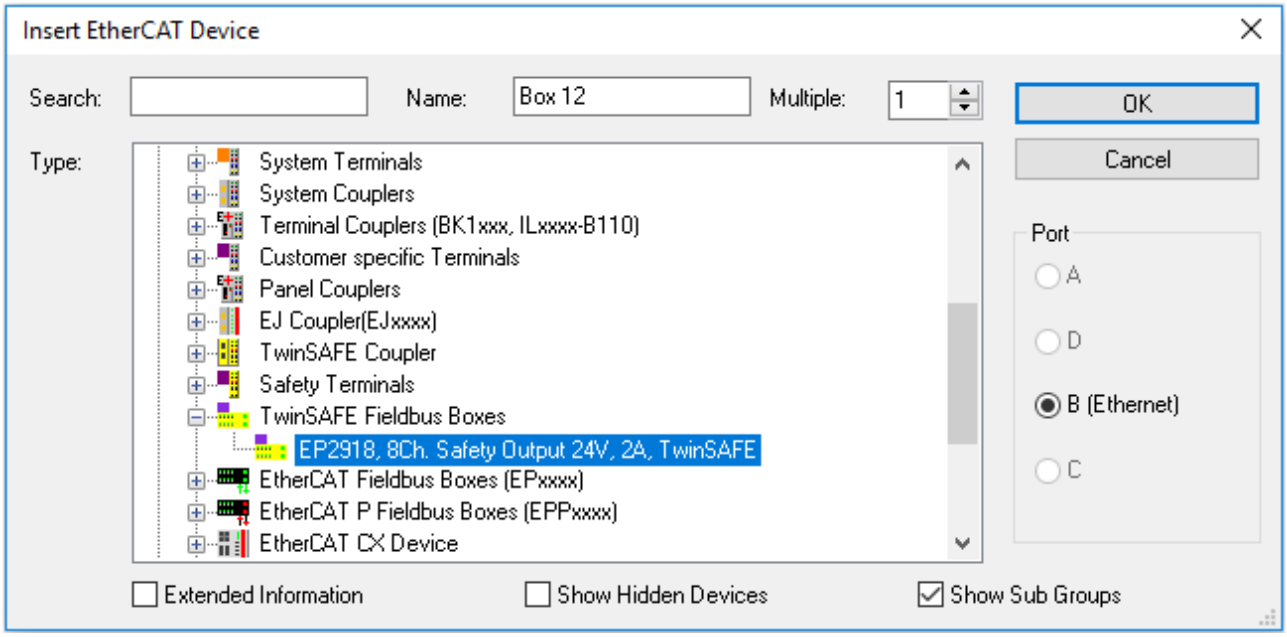


Fig. 14: Inserting an EP2918

4.3.3 EP2918-0032: using the integrated TwinSAFE Logic functions

On delivery, the EP2918 behaves like a safe TwinSAFE I/O slave, which can be used as an alias device within a TwinSAFE Logic, e.g. EL6910.

Alternatively, the local logic function of the EP2918 can be used. To this end please create a TwinSAFE project in the Safety Editor and select the EP2918 as the target system. Further information on creating a project can be found in the EL6910 documentation and the description of the function blocks under http://www.beckhoff.de/german/download/twinsafe.htm.

In order to be able to use the EP2918 again as a safe TwinSAFE I/O slave, please delete the logic, the mapping and the parameter data on the EtherCAT Box and switch the voltage off and on again.

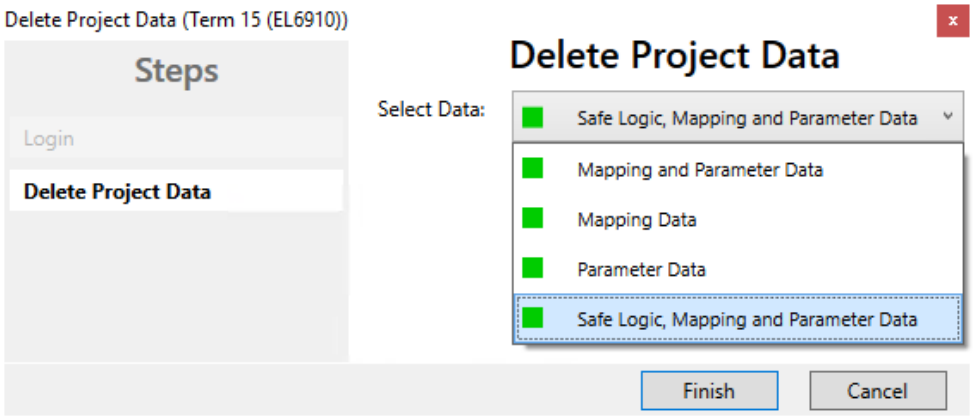


Fig. 15: EP2918 - Delete Project Data

4.3.3.1 Project design limits of the EP2918

Project design limits

The maximum project design size of the EP2918 is limited by the available memory. This is managed dynamically. The values specified in the following table are therefore only guide values and may differ from the actual values, depending on the safety project.

NOTICE

Execution time of the logic function

Compared to the EL6910 with an identical logic program, the execution time will be typically longer as the safe I/O signals have to be processed in addition. Accordingly this also affects the processing of the I/O signals, as they can only be evaluated less frequently as the size of the project increases.

Process image size	max. 1486 bytes per data direction (Max. memory size 0x1E00 for 3 buffers, i.e. with the same size of input and output process data a maximum size of 1280 bytes per data direction results. Only even-numbered start addresses are possible, therefore padding bytes may have to be included.)
TwinSAFE connections	maximum 212 (Maximum 255 CRCs in total - 1 CRC is required for a TwinSAFE connection with 1 or 2 bytes of safe data.)
Safe data per TwinSAFE connection	maximum 126 bytes (telegram length 255 bytes)
TwinSAFE function blocks	maximum 512 (For using ESTOP function blocks with complete input and output mapping. Other function blocks may lead to a lower maximum number.)
TwinSAFE groups	maximum 128
TwinSAFE user	maximum 40
Standard PLC inputs	dynamic (memory-dependent), max. 1483 bytes
Standard PLC outputs	dynamic (memory-dependent), max. 1483 bytes

NOTICE

Project planning

TwinCAT 3.1 Build 4022.28 or later is required for the use of the internal logic functions. If the EP2918 is used as a TwinSAFE slave with the default project, at least an EL6910, EK1960 or newer logic components are required as a TwinSAFE master.

4.3.4 Address settings on the TwinSAFE EtherCAT Box

Position of the rotary switch

The exact position of the rotary switch on the TwinSAFE component can be found in the STP file on the product page and in the download finder on the Beckhoff website.

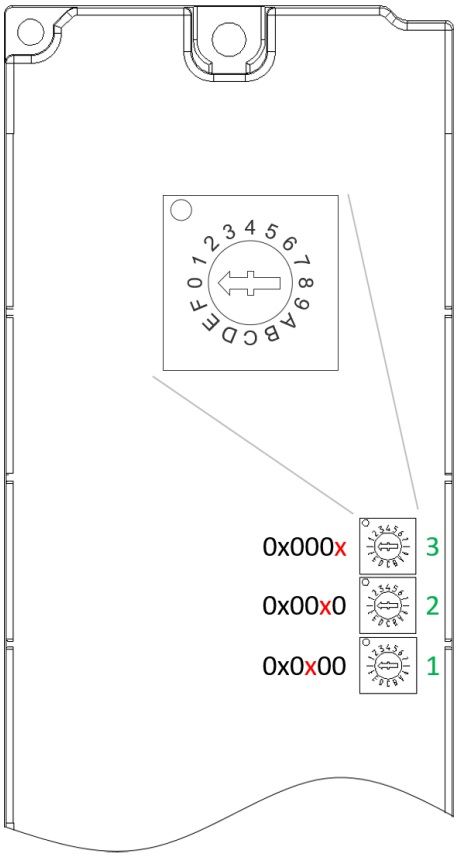


Fig. 16: EtherCAT Box - Rotary switches on the underside

The TwinSAFE address of the Box must be set using the three rotary switches on the underside of the TwinSAFE-EP Box. TwinSAFE addresses between 1 and 4095 are available.

Rotary switch			Address
1 (bottom)	2 (center)	3 (top)	
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

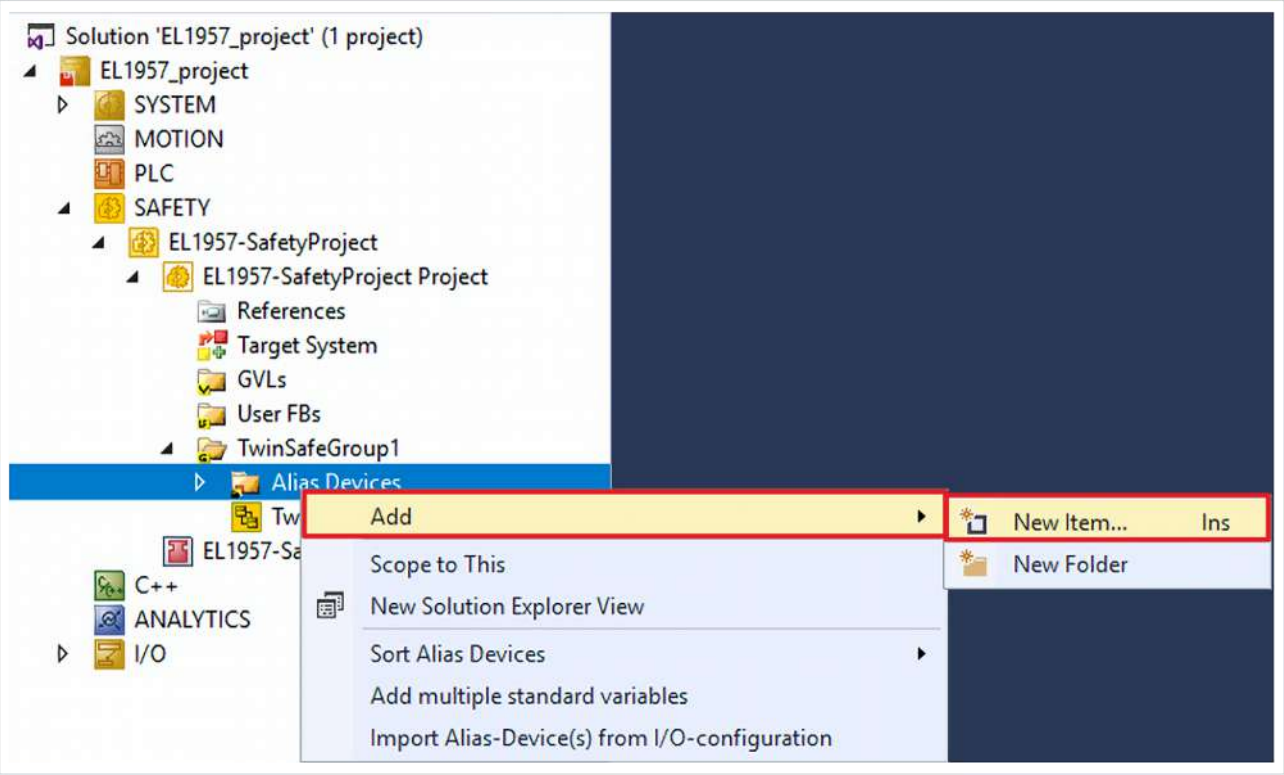
TwinSAFE address

Each TwinSAFE address must be unique within a network!
The address 0 is not a valid address.

4.3.5 Alias devices

The communication between the safety logic and the I/O level is realized via an alias level. At this alias level (sub-node *Alias Devices*) corresponding alias devices are created for all safe inputs and outputs, and also for standard signal types. For the safe inputs and outputs, this can be done automatically via the I/O configuration.

The connection- and device-specific parameters are set via the alias devices.



If the automatic import is started from the I/O configuration, a selection dialog opens, in which the individual terminals to be imported can be selected.

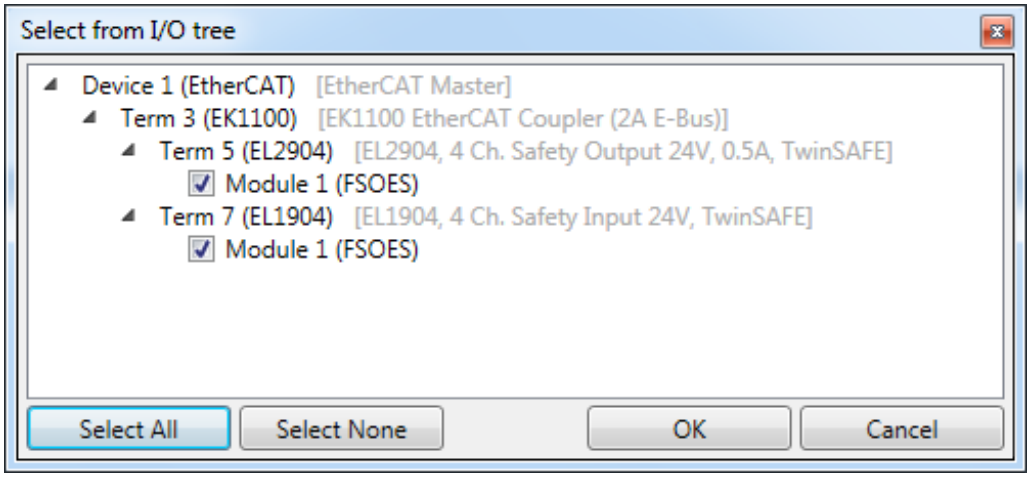


Fig. 17: Selection from the I/O tree

The alias devices are created in the safety project when the dialog is closed via OK.

Alternatively, the user can create the alias devices individually. To this end select *Add* and *New* item from the context menu, followed by the required device.

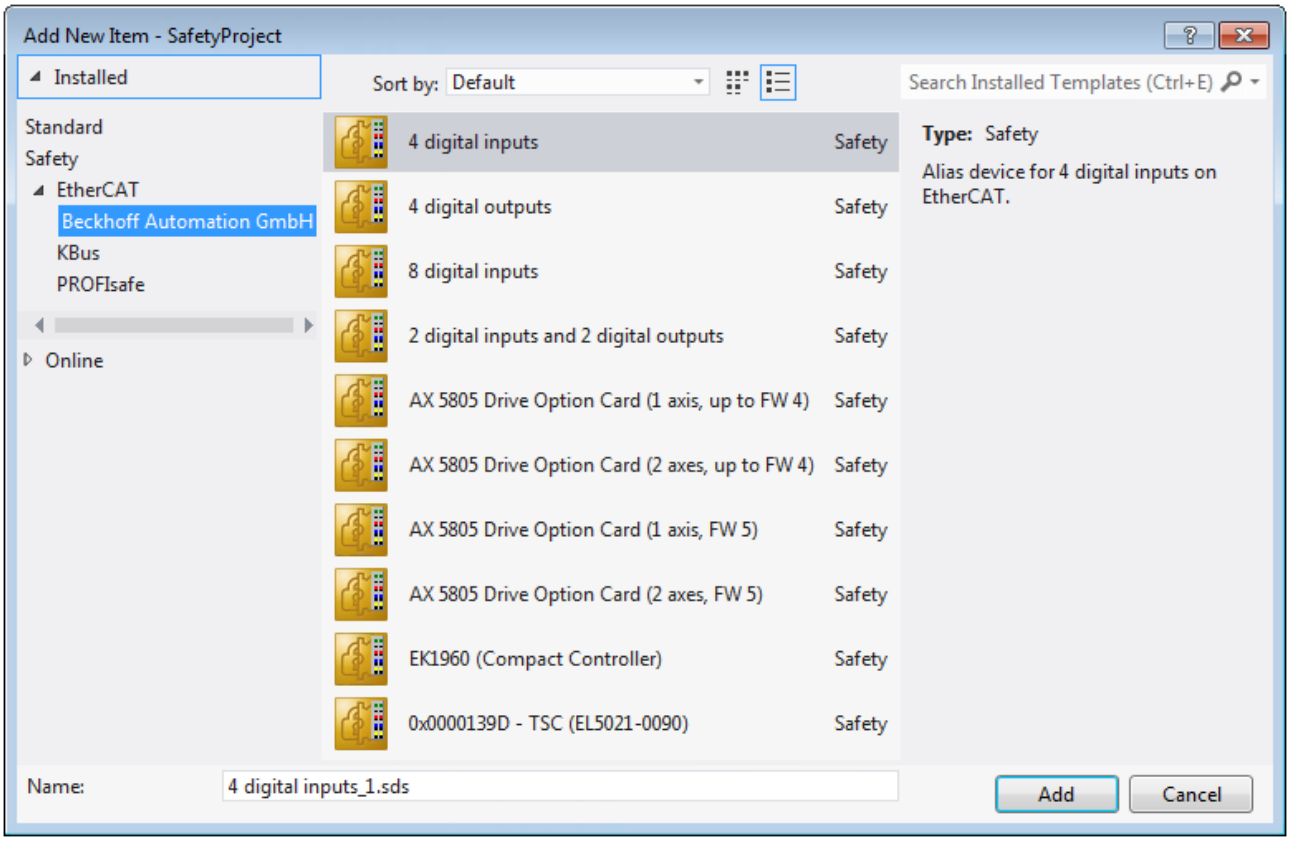


Fig. 18: Creating alias devices by the user

4.3.6 EP2918 parameters

After creating the alias device, it can be parameterized according to the user specifications. The FSoE address is set under the *Linking* tab, and the link to the physical device is created.

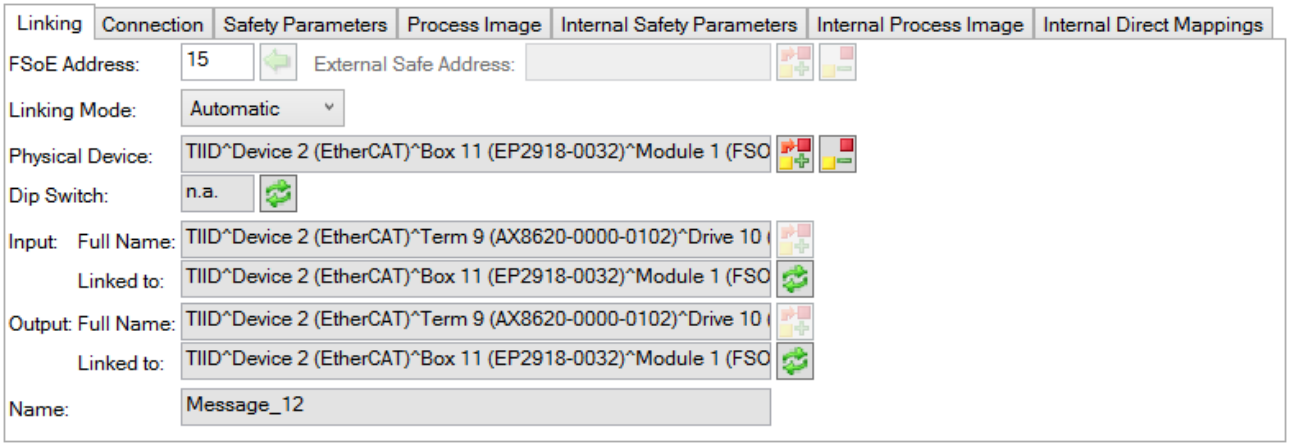


Fig. 19: EP2918 – *Linking* tab

Name	Description
FSoE address	Parameterized FSoE address (to be set by the user)
External safe address	currently not supported
Linking mode	• Automatic (automatic linking to the physical device) • Manual (manual linking, e.g. to network variables) • Local (signals are used in the local logic)
Physical device	Link to the TwinSAFE component within the TwinCAT solution
DIP switch	DIP or rotary switch address read from the TwinSAFE component
Input: Full name	In manual mode: Display of the variables below the TwinSAFE Logic, e.g. EL6910
Input: Linked to:	In manual mode: Display of the linked variables
Output: Full name	In manual mode: Display of the variables below the TwinSAFE Logic, e.g. EL6910
Output: Linked to	In manual mode: Display of the linked variables
Name	In manual mode: Name of the TwinSAFE message below the TwinSAFE Logic and for the info data

Under the *Connection* tab you can make further settings, e.g. the mapping of the info data or the behavior in case of a module error.

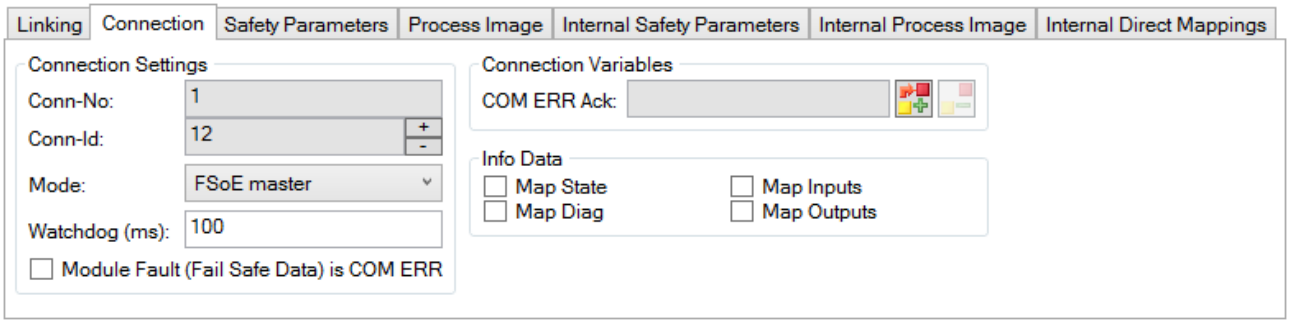


Fig. 20: EP2918 - *Connection* tab

Name	Description
Conn. no.	Connection number (issued by the system)
Conn. Id	Connection ID: Pre-allocated by system, can be changed by the user. The connection ID must be unique within the TwinCAT project.
Mode	• FSoE master (the logic is the master for this alias device) • FSoE slave (the logic is a slave for this alias device)
Watchdog	Setting the watchdog time in ms for this connection. This setting directly affects the fault response time.
Module Fault is ComError	If the checkbox is checked, module error also triggers a ComError, which switches the TwinSAFE group where the connection was created to the error state.
Com ERR Ack	For each connection, an additional error acknowledge can be configured. In this case, the connection must also be acknowledged, in addition to the Err Ack for the respective group.
Map state	The connection state is placed in the cyclic process data.
Map diag	The connection diagnostics is placed in the cyclic process data.
Map inputs	The safe input information of the connection is placed in the cyclic process data.
Map outputs	The safe output information of the connection is placed in the cyclic process data.

The *Safety Parameters* tab contains the parameters of the EP2918 to be set. The outputs are parameterized via the objects 0x8000 etc.

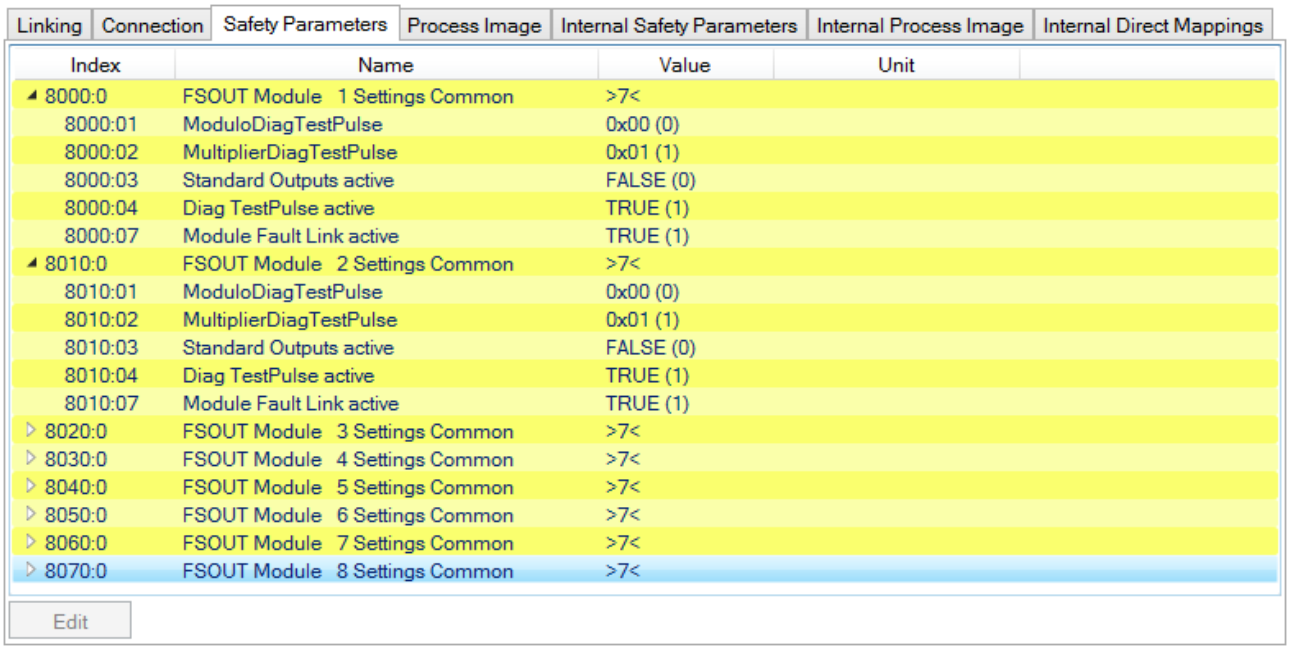


Fig. 21: EP2918 - Parameters

Index	Name	Default value/ unit	Description
8000:01	ModuloDiagTestPulse (FSOUT module 1)	0x00 / integer	Modulo value for the frequency of the generation of a test pulse. 0 -> every time 1 -> every second time and so on
8000:02	MultiplierDiagTestPulse (FSOUT module 1)	0x01 / integer	Length of the test pulse in multiples of 400 µs
8000:03	Standard outputs active (FSOUT module 1)	FALSE / Boolean	Activation of the logical AND operator of the safe and standard outputs of the module
8000:04	Diag test pulse active (FSOUT module 1)	TRUE / Boolean	Activation of test pulses for the corresponding output module
8000:07	Module Fault Link active (FSOUT Module 1)	TRUE / Boolean	If a module error occurs in this module, a module error is also set for all other output modules of this TwinSAFE component for which this parameter is also set to TRUE.
8010:01-07	Parameters for FSOUT module 2	see module 1	see module 1
8020:01-07	Parameters for FSOUT module 3	see module 1	see module 1
8030:01-07	Parameters for FSOUT module 4	see module 1	see module 1
8040:01-07	Parameters for FSOUT module 5	see module 1	see module 1
8050:01-07	Parameters for FSOUT module 6	see module 1	see module 1
8060:01-07	Parameters for FSOUT module 7	see module 1	see module 1
8070:01-07	Parameters for FSOUT module 8	see module 1	see module 1

4.3.7 Process image of the EP2918

The process image of EP2918 consists of 6 bytes of input data and 7 bytes of output data. The 6-byte telegram contains 1 byte of safe data, while the 7-byte telegram contains 2 bytes of safe data.

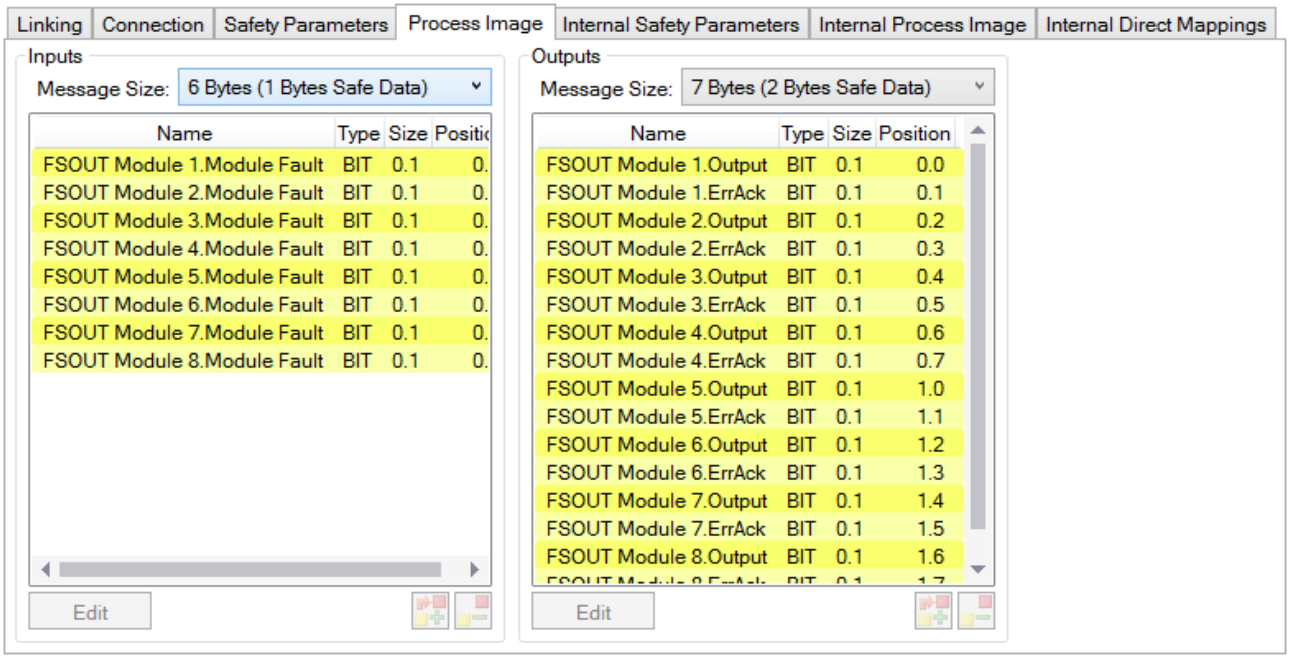


Fig. 22: EP2918 Process image

The assignment of the individual signals in the safe data is listed in the following table.

Name	Process image	Bit position	Description
FSOUT module 1. module fault	IN	0.0	Module error information for safe output 1
FSOUT module 2. module fault	IN	0.1	Module error information for safe output 2
FSOUT module 3. module fault	IN	0.2	Module error information for safe output 3
FSOUT module 4. module fault	IN	0.3	Module error information for safe output 4
FSOUT module 5. module fault	IN	0.4	Module error information for safe output 5
FSOUT module 6. module fault	IN	0.5	Module error information for safe output 6
FSOUT module 7. module fault	IN	0.6	Module error information for safe output 7
FSOUT module 8. module fault	IN	0.7	Module error information for safe output 8
FSOUT Module1.Output	OUT	0.0	Safe output 1
FSOUT Module1.ErrAck	OUT	0.1	Error acknowledge for safe output module 1
FSOUT Module2.Output	OUT	0.2	Safe output 2
FSOUT Module2.ErrAck	OUT	0.3	Error acknowledge for safe output module 2
FSOUT Module3.Output	OUT	0.4	Safe output 3
FSOUT Module3.ErrAck	OUT	0.5	Error acknowledge for safe output module 3
FSOUT Module4.Output	OUT	0.6	Safe output 4
FSOUT Module4.ErrAck	OUT	0.7	Error acknowledge for safe output module 4
FSOUT Module5.Output	OUT	1.0	Safe output 5
FSOUT Module5.ErrAck	OUT	1.1	Error acknowledge for safe output module 5
FSOUT Module6.Output	OUT	1.2	Safe output 6
FSOUT Module6.ErrAck	OUT	1.3	Error acknowledge for safe output module 6
FSOUT Module7.Output	OUT	1.4	Safe output 7
FSOUT Module7.ErrAck	OUT	1.5	Error acknowledge for safe output module 7
FSOUT Module8.Output	OUT	1.6	Safe output 8
FSOUT Module8.ErrAck	OUT	1.7	Error acknowledge for safe output module 8

4.4 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.

Typical response time

The typical response time is the time required for transferring a piece of information from the sensor to the actuator, when the whole system operates normally, without error.

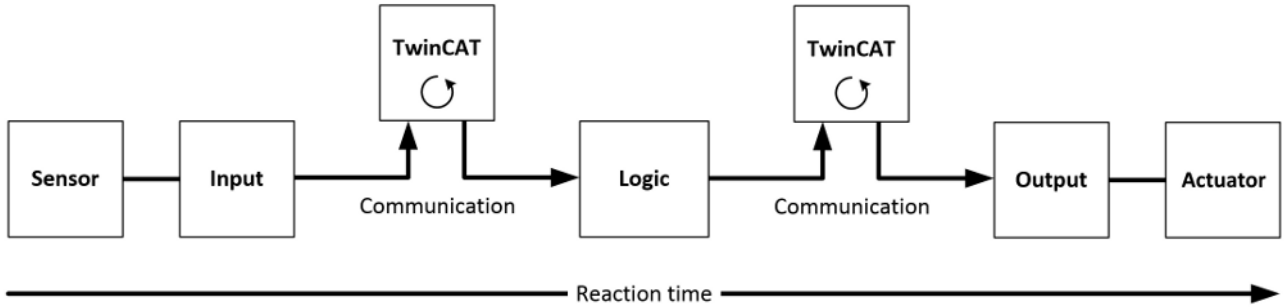


Fig. 23: Typical response time

Definition	Description
RT_{Sensor}	Response time of the sensor, until the signal is made available at the interface. Typically provided by the sensor manufacturer.
RT_{Input}	Response time of the safe input, e.g. EL1904 or EP1908. This time can be found in the technical data. In the case of the EL1904 it is 4 ms.
RT_{Comm}	Response time of the communication. This is typically 3 times the EtherCAT cycle time, since a new Safety-over-EtherCAT telegram has to be generated before new data can be sent. These times depend directly on the higher-level standard controller (cycle time of the PLC/NC).
RT_{Logic}	Response 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}	Response time of the output terminal. This is typically between 2 and 3 ms.
$RT_{Actuator}$	Response time of the actuator. This information is typically provided by the actuator manufacturer
WD_{Comm}	Watchdog time of the communication

The typical response time is based on the following formula:

$$ReactionTime_{typ} = RT_{Sensor} + RT_{Input} + 3 * RT_{Comm} + RT_{Logic} + 3 * RT_{Comm} + RT_{Output} + RT_{Actuator}$$

with

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

Worst case response time

The worst-case response time is the maximum time required for switching off the actuator in the event of an error.

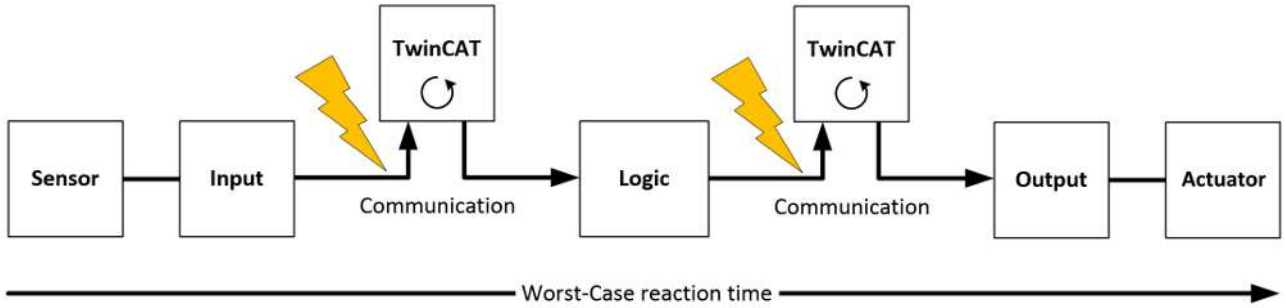


Fig. 24: Worst case response time

It is assumed that a signal change takes place at the sensor, and that this is passed to the input. A communication error occurs just at the moment when the signal is to be passed to the communication interface. This is detected by the logic once the watchdog time of the communication link has elapsed. This information should then be passed on to the output, resulting in a further communication error. This fault is detected at the output once the watchdog time has elapsed, resulting in shutdown.

This results in the following formula for the worst-case response time:

$$ReactionTime_{\max} = WD_{Comm} + WD_{Comm} + RT_{Actuator}$$

with

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

4.5 Diagnostics

4.5.1 EtherCAT- Fieldbus LEDs

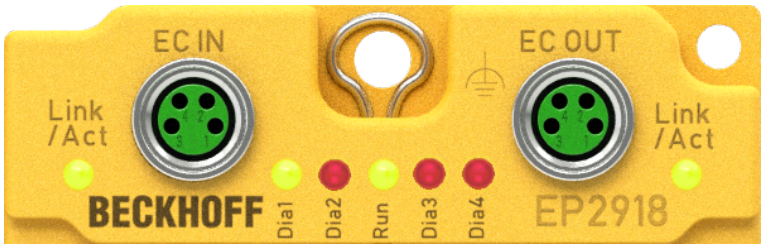


Fig. 25: EP2918 Diagnostic LEDs

LED displays

LED	Display	Meaning
IN Link/Act	off	no connection to the preceding EtherCAT module
	lit	LINK: connection to the preceding EtherCAT module
	flashes	ACT: communication with the preceding EtherCAT module
OUT Link/Act	off	no connection to the following EtherCAT module
	lit	LINK: connection to the following EtherCAT module
	flashes	ACT: Communication with the following EtherCAT module
Run	off	Status of the EtherCAT module is Init
	flashes quickly	Status of the EtherCAT module is pre-operational
	flashes slowly	Status of the EtherCAT module is safe-operational
	lit	Status of the EtherCAT module is operational

4.5.2 Status LEDs

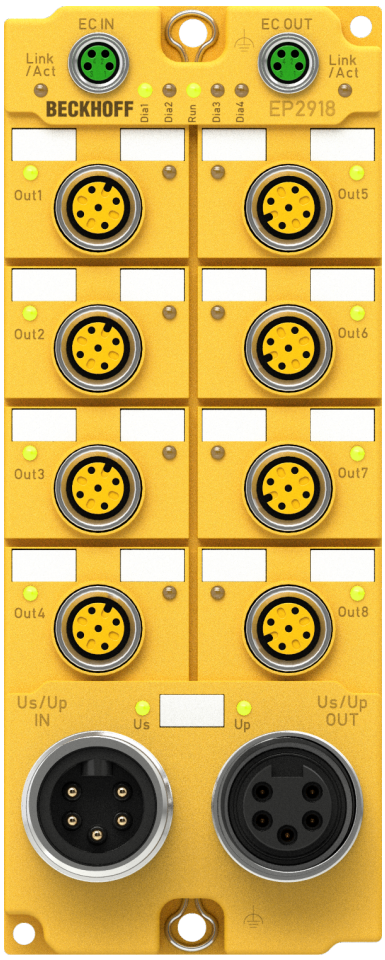


Fig. 26: EP2918 Status LEDs

LED	Display	Meaning
Out 1	on	Output 1 is connected
	off	Output 1 is not connected
Out 2	on	Output 2 is connected
	off	Output 2 is not connected
Out 3	on	Output 3 is connected
	off	Output 3 is not connected
Out 4	on	Output 4 is connected
	off	Output 4 is not connected
Out 5	on	Output 5 is connected
	off	Output 5 is not connected
Out 6	on	Output 6 is connected
	off	Output 6 is not connected
Out 7	on	Output 7 is connected
	off	Output 7 is not connected
Out 8	on	Output 8 is connected
	off	Output 8 is not connected
Us	on	Control voltage Us is available
	off	Control voltage Us is not available
Up	on	Peripheral voltage Up is present
	off	Peripheral voltage Up is not present

4.5.3 Diagnostic LEDs

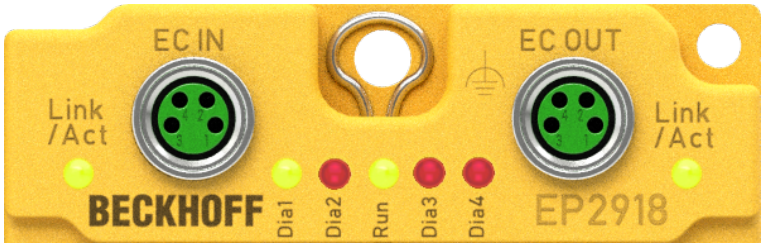


Fig. 27: EP2918 - Diagnostic LEDs

LED displays

LED	lit	flashes	flickering	off
Dia1 (green)	Environment variables, operating voltage and internal tests are in the valid range • If Dia2 flashes, a logic error code applies	-		Environment variables, operating voltage and internal tests are outside the valid range • If Dia2 flashes, an environment error code applies
Dia2 (red)	Together with Dia3 and 4: Global shutdown[1)] has occurred. (see diag history of the TwinSAFE components)	Logic or environment error code according to Dia1 and tables below is output	fault in a safe input or output module	Together with Dia3 and 4: Global fault[1)] has occurred. (see diag history of the TwinSAFE components)
Dia3 (red)	Global fault or global shutdown on µC1[1)]	-		No global fault or global shutdown on µC1[1)]
Dia4 (red)	Global fault or global shutdown on µC2[1)]	-		No global fault or global shutdown on µC2[1)]
[1)] A global fault permanently disables the TwinSAFE component, so that it has to be replaced. A global shutdown temporarily disables the TwinSAFE component. The error can be reset by switching off and back on again.				

Logic error codes of LED Dia2 (if LED Dia1 is lit)

Flashing Code	Description
1	Function block error in one of the TwinSAFE groups
2	Communication error in one of the TwinSAFE groups
3	Error combination: Function block and communication
4	General error in one of the TwinSAFE groups
5	Error combination: General and function block
6	Error combination: General and communication
7	Error combination: General, function block and communication

Environment error codes of LED Dia2 (if LED Dia1 is off)

Flashing Code	Description
1	Maximum supply voltage µC1 exceeded
2	Supply voltage µC1 below minimum value
3	Maximum supply voltage µC2 exceeded
4	Supply voltage µC2 below minimum value
5	Maximum internal temperature exceeded
6	Internal temperature below minimum value
7	Valid temperature difference between µC1 and µC2 exceeded
8	not used

Flashing Code	Description
9	not used
10	General error

4.5.4 Flash code display

LED	Display	Description
flashing		400 ms ON / 400 ms OFF 1 second pause between the flash codes
flickering		50 ms ON / 50 ms OFF

4.5.5 Diagnostic objects

⚠ CAUTION

Do not change CoE objects!

Do not make any modifications to the CoE objects in the TwinSAFE components! Any modifications (e.g. using TwinCAT) of the CoE objects will permanently set the TwinSAFE components to the Fail-Stop state.

Index $F984_{hex}$: Device Info Data C1

CoE object $F984_{hex}$ currently displays internal temperature and voltage values for the TwinSAFE component.

Index	Name	Meaning	Flags	Default
F984:01	Voltage C2	Voltage µC2	RO	0_{dec}
F984:02	Temperature C1	Temperature µC1	RO	0_{dec}
F984:03	Firmware CRC C1	CRC of the firmware on µC1	RO	-
F984:04	Vendor data CRC C1	CRC of the vendor data on µC1	RO	-

Index $F985_{hex}$: Device Info Data C2

CoE object $F985_{hex}$ currently displays internal temperature and voltage values for the TwinSAFE component.

Index	Name	Meaning	Flags	Default
F985:01	Voltage C1	Voltage µC1	RO	0_{dec}
F985:02	Temperature C2	Temperature µC2	RO	0_{dec}
F985:03	Firmware CRC C2	CRC of the firmware on µC2	RO	-
F985:04	Vendor data CRC C2	CRC of the vendor data on µC2	RO	-

Diagnostics history

Any errors, which occur during operation of the TwinSAFE component, such as overtemperature or undervoltage, are entered in the diagnostics history with a corresponding timestamp.

Index $F100_{hex}$: FSLOGIC status

The CoE object $F100_{hex}$ shows the current status of the TwinSAFE component.

Index	Name	Meaning	Flags	Default
F100:01	Safe Logic State	Status of the internal logic: 0: OFFLINE 1: RUN 3: SAFE 6: START 8: PREPARE 10: RESTORE 11: PROJECT-CRC-OK	RO	0_{bin}

Index	Name	Meaning	Flags	Default
F100:02	Cycle Counter	Life cycle counter, which is incremented with each TwinSAFE logic cycle.	RO	0_{bin}

The following table contains a description of all values of the index $F100_{hex}$ SubIndex 01.

Index	Value	Description
F100:01	0: OFFLINE	In the OFFLINE state no TwinSAFE logic program is loaded. No TwinSAFE groups and no TwinSAFE connections are processed.
	1: RUN	In the RUN state all TwinSAFE groups and all TwinSAFE connections configured in the TwinSAFE logic program are processed.
	3: SAFE	The SAFE state is assumed from the RUN state when the TwinSAFE logic program is stopped. If the TwinSAFE logic program is restarted without a new TwinSAFE logic program having been transferred, the TwinSAFE logic should switch again from SAFE to RUN. All TwinSAFE groups should be initialized with the initial state STOPERROR, so that an error acknowledgement occurs before safe outputs are connected again. In the SAFE state no TwinSAFE groups and no TwinSAFE connections are processed.
	6: START	The START state is assumed if the TwinSAFE logic program is loaded but the standard communication channel (e.g. EtherCAT) is not yet in process data exchange or the process data lengths configured via the standard communication channel do not match the process data lengths calculated using the TwinSAFE logic program. The START state is also assumed when a user is logged in for the purpose of deleting the current TwinSAFE logic program or transferring the user list. In the START state no TwinSAFE groups and no TwinSAFE connections are processed.
	8: PREPARE	The PREPARE state is assumed at the transition from START to RUN or from SAFE to RUN. In the PREPARE state, the stored data read in from the FRAM is checked and then the RUN state is assumed. If an error is detected during checking of the stored data, all TwinSAFE groups assume the initial state STOPERROR. If no error is detected during checking of the stored data, all TwinSAFE groups assume the initial state STOP.
	10: RESTORE	In the RESTORE state the loaded TwinSAFE restore program is to be checked by comparing its project CRC with the project CRCs read in via the corresponding TwinSAFE connections. In the RESTORE state all TwinSAFE connections configured in the TwinSAFE Restore program are processed.
	11: PROJECT-CRC-OK	The PROJECT-CRC-OK state is assumed once the project CRC of the loaded TwinSAFE restore program has been successfully checked via the TwinSAFE connections. In the PROJECT-CRC-OK state no TwinSAFE groups and no TwinSAFE connections are processed.

This CoE object is additionally copied into the cyclic process image of the TwinSAFE component. From there, this information can be directly linked into the PLC.

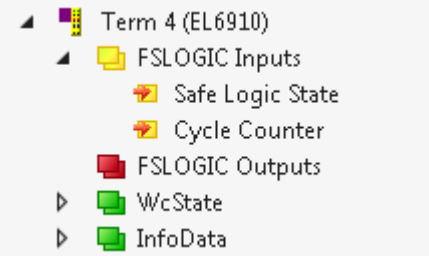


Fig. 28: Diagnostic object - FSLOGIC Status ($F100_{hex}$) in the process image of the TwinSAFE component

4.5.6 Cycle time of the safety project

The execution time of the TwinSAFE logic can be read from the CoE objects listed below. To determine the cycle time, it has to be multiplied with 1.25, because this is the factor used internally for generating a delay time before the next cycle.

Index FEA0$_{hex}$: CTRL Diag Data

Index	Name	Meaning	Flags	Default
FEA0:09	Actual Safety Control Task Execution Time	Current execution time of the TwinSAFE logic with a logic state of 1 (RUN) Cycle time = 1.25 * value (average value of 64 cycles)	RO	0_{hex}
FEA0:0A	Min Safety Control Task Execution Time	Minimum execution time of the TwinSAFE logic with a logic state of 1 (RUN) Cycle time = 1.25 * value	RO	0_{hex}
FEA0:0B	Max Safety Control Task Execution Time	Maximum execution time of the TwinSAFE logic with a logic state of 1 (RUN) Cycle time = 1.25 * value	RO	0_{hex}
FEA0:15	Actual Safety Control Task Execution Time	Current execution time of the TwinSAFE logic with a logic state of <> 1 Cycle time = 1.25 * value (average value of 64 cycles)	RO	0_{hex}
FEA0:16	Min Safety Control Task Execution Time	Minimum execution time of the TwinSAFE logic with a logic state of <> 1 Cycle time = 1.25 * value	RO	0_{hex}
FEA0:17	Max Safety Control Task Execution Time	Maximum execution time of the TwinSAFE logic with a logic state of <> 1 Cycle time = 1.25 * value	RO	0_{hex}

Resetting the values

The max. and min. values can be reset by writing a value to the CoE object 0x1C32:08.

4.5.7 Diag History tab

All errors occurring within the TwinSAFE components are stored in their diag history. The diag history can be viewed by selecting the corresponding TwinSAFE component in the I/O tree structure and then selecting the *Diag* History tab. Use the *Update History* button to fetch the current data from the TwinSAFE component. Errors within the logic, the function blocks, the connections or the component itself are stored with a corresponding time stamp.

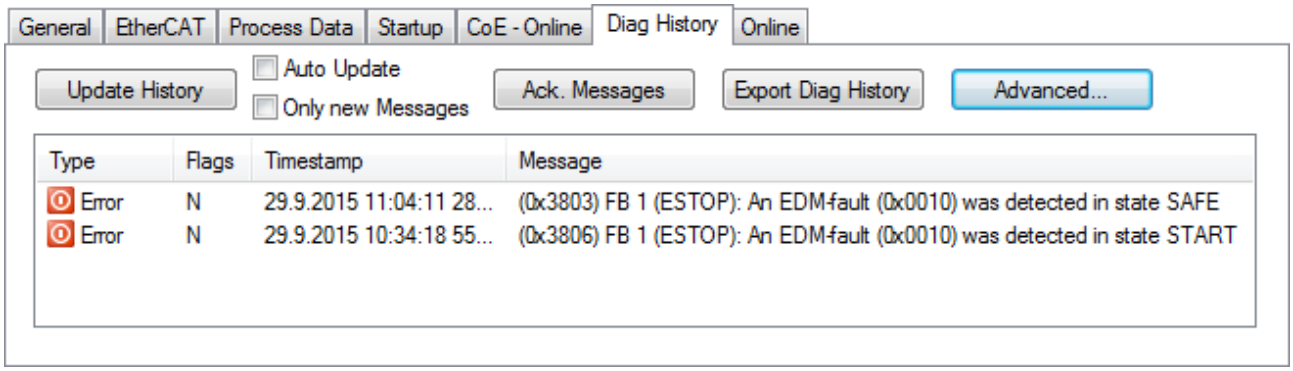


Fig. 29: Diag history

Use the *Advanced…* button to open the advanced settings. Here, the user can customize the behavior of the diag history.

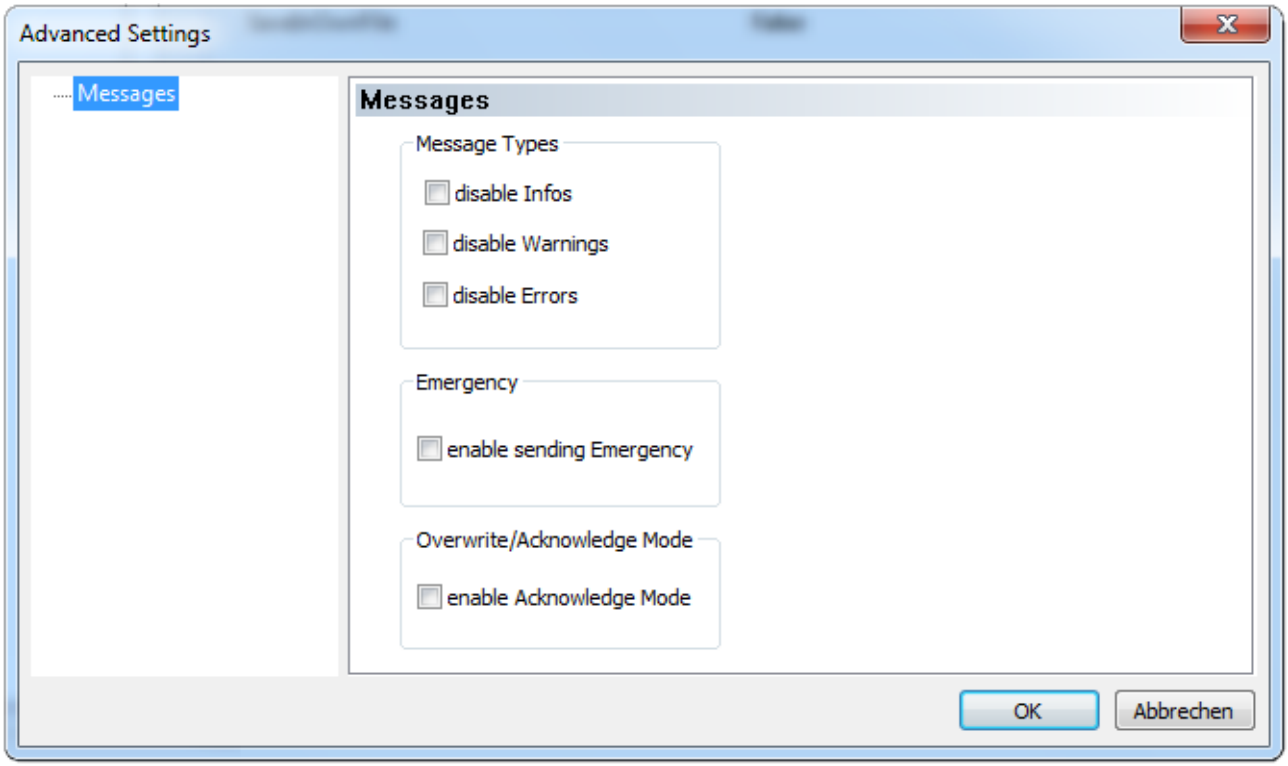


Fig. 30: Diag history – advanced settings

Advanced Settings

Setting	Description
Message Types	• disable Info Messages with the *Info* status are not saved in the diag history • disable Warnings Messages with the *Warning* status are not saved in the diag history • disable Errors Messages with the *Error* status are not saved in the diag history
Emergency	In addition to saving the message in the diag history, an emergency object is also sent and displayed in the TwinCAT logger window.
Overwrite / Acknowledge Mode	This setting is currently not supported.

4.5.8 Diagnosis History

The diagnostic history of the TwinSAFE devices that support this function is implemented in accordance with the ETG guideline ETG.1020 Chapter 13 "Diagnosis Handling". The diagnostic messages are saved by the TwinSAFE device in a dedicated CoE object under 0x10F3 and can be read out by the application or by TwinCAT.

Both the control entries and the history itself can be found in the CoE object 0x10F3. The entry Newest Message (0x10F3:02) contains the subindex of 0x10F3, which contains the latest diagnostic message, e.g. 0x06 for diagnostic message 1.

Index $10F3_{hex}$ Diagnosis History

Index (hex)	Name	Meaning	Data type	Flags	Default
10F3:0	Diagnosis History				

Index (hex)	Name	Meaning	Data type	Flags	Default
10F3:01	Maximum Messages	Maximum number of stored messages. A maximum of 64 messages can be stored. After that the respective oldest messages are overwritten.	UINT8	RO	0x40 (64_{dec})
10F3:02	Newest Message	Subindex of the latest message	UINT8	RO	0x00 (0_{dec})
10F3:03	Newest Acknowledged Message	Subindex of the last confirmed message	UINT8	RW	0x00 (0_{dec})
10F3:04	New Messages Available	Indicates that a new message is available	BOOLEAN	RO	0x00 (0_{dec})
10F3:05	Flags	Set via the startup list. If set to 0x0001, the diagnostic messages are additionally sent by emergency to the EtherCAT master	UINT16	RW	0x0000 (0_{dec})
10F3:06	Diagnosis Message 001	Diagnosis message 1	BYTE[32]	RO	{0}
...	...	...	...	...	...
10F3:45	Diagnosis Message 064	Diagnosis message 64	BYTE[32]	RO	{0}

Structure of the diagnosis messages

- DiagCode (4 bytes) – in this case always 0x 0000 E000
- Flags (2 bytes) - diagnosis type (info, warning or error), time stamp and number of parameters contained (see the following table)
- Text ID (2 bytes) – ID of the diagnosis message as a reference to the message text from the ESI/XML
- Time stamp (8 bytes) – local slave time in ns since switching on the TwinSAFE device
- dynamic parameters (16 bytes) – parameters that can be inserted in the message text (see following table)

Flags in diagnosis messages

Data type	Offset	Description	
UINT16	Bit 0…3	DiagType (value)	
		0	Info message
		1	Warning message
		2	Error message
		3…15	reserved
	Bit 4	If the bit = 1, the time stamp contained in the message is the local time stamp of the TwinSAFE device. The age of the diagnosis message can be deduced by calculation with the current time stamp from the CoE object 0x10F8.	
	Bit 5…7	reserved	
	Bit 8…15	Number of parameters in this diagnosis message	

Dynamic parameters in the diagnosis messages

Type	Data type	Description	
Flags parameter 1	UINT16	Describes the type of parameter 1	
		Bit 12…15 = 0	Bit 0…11 = data type of parameter 1 0x0001 - BOOLEAN 0x0002 - INT8 0x0003 - INT16 0x0004 - INT32 0x0005 - UINT8

Type	Data type	Description	
			0x0006 - UINT16 0x0007 - UINT32 0x0008 - REAL32 0x0011 - REAL64 0x0015 - INT64 0x001B - UINT64 Text parameters and formats are specified in ETG.2000.
Parameter 1	Data type in accordance with flags	Value of parameter 1	
Flags parameter 2	UINT16	see Flags parameter 1	
Parameter 2	Data type in accordance with flags	Value of parameter 2	
...			

The diagnostic messages are saved in text form in the ESI/XML file belonging to the TwinSAFE device. On the basis of the Text ID contained in the diagnostic message, the corresponding plain text message can be found in the respective languages. The parameters can be inserted in the appropriate positions. In the following example, %x is used for a hexadecimal representation of the parameters.

Fig. 31: ESI/XML message text

Via the entry *New Messages Available* the user receives information that new messages are available. The messages can be read out via CompleteAccess (a CoE read command for the complete CoE object 0x10F3). The *New Messages Available* bit is reset after reading the messages.

The sending of emergency messages to the EtherCAT master is activated by adding the CoE object 0x10F3:05 to the startup list (Transition IP, value 0x0001). If new diagnostic messages arrive, they are entered in object 0x10F3 and additionally sent by emergency to the EtherCAT master.

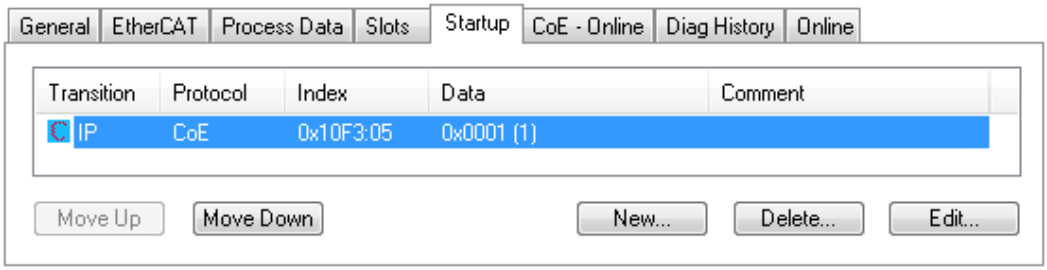


Fig. 32: Startup list

5 Maintenance and cleaning

Unacceptable contamination

Do not operate the TwinSAFE component if it is unacceptably dirty. Refer to the technical data for the protection class.

TwinSAFE components are basically maintenance-free.

6 Decommissioning

6.1 Disposal

NOTICE

Correct disposal

Observe the applicable national laws and guidelines for disposal.

Incorrect disposal may result in environmental damage.

Remove the TwinSAFE component for disposal.

Depending on your application and the products used, make sure that the respective components are disposed of properly:

Cast iron and metal

Hand over cast iron and metal parts to scrap metal recycling.

Cardboard, wood and polystyrene

Dispose of packaging materials made of cardboard, wood or Styrofoam in accordance with regulations.

Plastic and hard plastic

You can recycle parts made of plastic and hard plastic via the waste management center or reuse them in accordance with the component regulations and markings.

Oils and lubricants

Dispose of oils and lubricants in separate containers. Hand over containers to the waste oil collection point.

Batteries and accumulators

Batteries and accumulators may also be marked with the crossed-out wheeled garbage can symbol. You must separate these components from waste. You are legally obliged to return used batteries and accumulators within the EU. Outside the validity of the EU Directive 2006/66/EC, observe the respective regulations.

6.1.1 Returning to the vendor

In accordance with the WEEE-2012/19/EU directives, you can return used devices and accessories for professional disposal. The transport costs are borne by the sender.

Send the used devices with the note "For disposal" to:

Beckhoff Automation GmbH & Co. KG
Gebäude „Service“
Stahlstraße 31
D-33415 Verl

In addition, you have the option to contact a local certified specialist company for the disposal of used electrical and electronic appliances. Dispose of the old components in accordance with the regulations applicable in your country.

7 Appendix

7.1 Protection classes according to IP code

The levels of protection are defined and divided into different classes in the IEC 60529 standard (DIN EN 60529). The designation follows the scheme below.

1st digit: Protection against ingress of dust and access to hazardous parts

1st digit	Meaning
0	Non-protected
1	Protection against access to hazardous parts with back of hand. Protection against ingress of solid foreign objects = 50 mm diameter
2	Protection against access to hazardous parts with a finger. Protection against ingress of solid foreign objects = 12.5 mm diameter
3	Protection against access to hazardous parts with a tool. Protection against ingress of solid foreign objects = 2.5 mm diameter
4	Protection against access to hazardous parts with a wire. Protection against ingress of solid foreign objects = 1 mm diameter
5	Protection against access to hazardous parts with a wire. Protection against ingress of dust. Ingress of dust is not prevented completely, although the quantity of dust able to penetrate is limited to such an extent that the proper function of the device and safety are not impaired
6	Protection against access to hazardous parts with a wire. Dust-proof. No ingress of dust

2nd digit: Protection against ingress of water*

2nd digit	Meaning
0	Non-protected.
1	Protection against dripping water.
2	Protection against dripping water when housing tilted up to 15°.
3	Protection against spraying. Water sprayed at an angle of up to 60° from vertical must not have any adverse effect.
4	Protection against splashing. Water splashing against the housing from any direction must not have any adverse effects.
5	Protection against jetting.
6	Protection against powerful jetting.
7	Protection against the effects of temporary immersion. The quantity of water being able to penetrate if the housing is submerged in water for 30 minutes at a depth of 1 m must not have any adverse effects.

*) These protection classes only define protection against water, not against other liquids.

7.2 Volatility

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

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

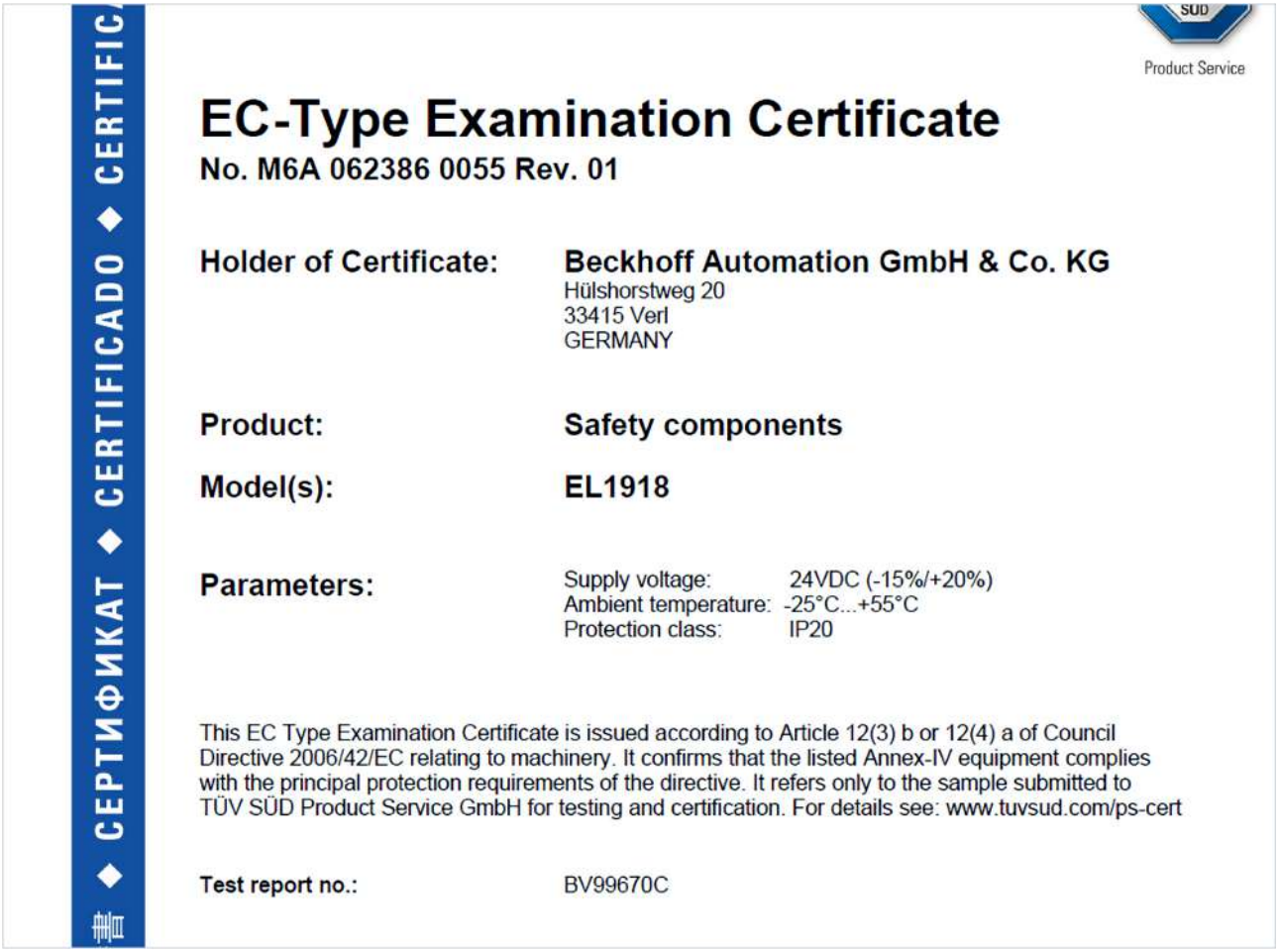
If there is customer specific data saved on the product, it cannot be ensured that this data might not be restored through for example forensic measures, even after the data is deleted through the provided tool chain. If this data is confidential, the scrapping of the product after usage is recommended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

7.3 Focus of certificates

The most decisive document for certified components of the TwinSAFE department is the EC type examination certificate. The document contains both the test coverage and the regarded component and component family.

The current certificates of all TwinSAFE components with the underlying standards and directives can be found at https://www.beckhoff.com/en-en/support/download-finder/certificates-approvals/.

If the document refers only to the first four figures of a product (ELxxxx), the certificate is valid for all available variants of the component (ELxxxx-abcd). This is applicable for all components like EtherCAT Terminals, EtherCAT Boxes, EtherCAT plug-in modules and Bus Terminals.



◆ СЕРТИФИКАТ ◆ CERTIFICADO ◆ CERTIFIC

Product Service

EC-Type Examination Certificate

No. M6A 062386 0055 Rev. 01

Holder of Certificate:	**Beckhoff Automation GmbH & Co. KG** Hülshorstweg 20 33415 Verl GERMANY
Product:	**Safety components**
Model(s):	**EL1918**
Parameters:	Supply voltage: 24VDC (-15%/+20%) Ambient temperature: -25°C...+55°C Protection class: IP20

This EC Type Examination Certificate is issued according to Article 12(3) b or 12(4) a of Council Directive 2006/42/EC relating to machinery. It confirms that the listed Annex-IV equipment complies with the principal protection requirements of the directive. It refers only to the sample submitted to TÜV SÜD Product Service GmbH for testing and certification. For details see: www.tuvsud.com/ps-cert

Test report no.: BV99670C

If you regard the example EL1918 in the picture, the certificate is valid for both the EL1918 and the available variant EL1918-2200.

7.4 Declarations of conformity and certificates

The EC Declaration of Conformity can be found at EC Declaration of Conformity.

The UKCA Declaration of Conformity can be found at (website link to UKCA Declaration of Conformity).

Further certificates can be found under EP2918 certificates.

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Trademark statements

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