

Operating Instructions | EN

EK1960

TwinSAFE Compact Controller



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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 operating instructions at any time and without prior announcement. No claims for the modification of products that have already been supplied may be made on the basis of the data, diagrams and descriptions in these operating instructions.

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

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The EtherCAT technology is protected by patent rights through the following registrations and patents with corresponding applications and registrations in various other countries:

- EP1590927
- EP1789857
- EP1456722
- EP2137893
- DE102015105702



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1.1.3 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

1.1.4 Copyright

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1.2 Version numbers

Version	Comment
2.1.0	<ul style="list-style-type: none"> • Firmware 04 added • Chapter Notes on information security [► 14] added • Chapters Safety and instruction [► 12] and Lifetime [► 138] revised • Corrections • “Safety parameters” and “Service life” renamed to “Target failure measures” and “Lifetime”
2.0.0	<ul style="list-style-type: none"> • Editorially revised • In chapter Technical data [► 25] Link to the certificate overview added • Chapter "Firmware update of TwinSAFE products" removed • Appendix adapted and extended • Designation of EtherCAT connections corrected
1.3.0	<ul style="list-style-type: none"> • Description of <i>Module Fault Link active</i> parameter added. • Description <i>Multiple Download</i> added • Description of the input and output signals extended • Description of error response times added • Version history of the TwinSAFE product added • Description of firmware update added
1.2.0	<ul style="list-style-type: none"> • Description of inductive load and free-wheeling diode changed • New features TwinCAT 3.1 Build 4022 added • Diagnosis history described • Response times BumperMode and environmental conditions added • TwinSAFE SC description updated • Description of behavior on restart added • Project design limits adapted • Added information text on permissible loads on the relay contacts
1.1.0	<ul style="list-style-type: none"> • Note for input and output process image added • Description added to Sync Manager configuration • TwinSAFE SC description updated
1.0.0	<ul style="list-style-type: none"> • Certificate added • General revision • Description of input modules 9 and 10 updated
0.7.0	<ul style="list-style-type: none"> • Load characteristics for inductive loads added • Backup/Restore flow chart added
0.6.1	<ul style="list-style-type: none"> • User administration screenshots updated • State and Diag of the TwinSAFE group updated
0.6.0	<ul style="list-style-type: none"> • Safety parameters adopted from review report
0.5.0	<ul style="list-style-type: none"> • Safety parameters revised • Parameter values revised • Diag messages added
0.4.0	<ul style="list-style-type: none"> • Safety concept requirements for the manual implemented
0.3.0	<ul style="list-style-type: none"> • Update of the designation of the contact points • Addendum: illustration of the TwinSAFE compact controller without relay option
0.2.0	<ul style="list-style-type: none"> • Extension of the general description • Description of diagnostic and status LEDs added
0.1.0	<ul style="list-style-type: none"> • Migration, layout adaptation

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.

Currentness

Please 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, please contact Technical Support (see [Beckhoff Support and Service \[▶ 13\]](#)).

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 following table.

● Updated hardware and software

i 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
04	02	<ul style="list-style-type: none"> • New support for the SLP, SBT and XOR function blocks • The logic program is now not restarted in the event of mailbox communication problems. • Improved behavior for cross-circuit detection and automatic shutdown of linked input and output modules (Automatic ModuleFaultLink). • Internal memory tests are now completed in good time during permanent mailbox communication, for example during Online View.
03	01	<ul style="list-style-type: none"> • Local logic projects can now also be created without a linked RUN signal. • Timestamps for diagnostic messages have been corrected. • FB Muting: After an FB error in Backwards mode, the FB error can be acknowledged without restarting the TwinSAFE group. • An error acknowledgement is now required after a user has logged into the logic without deleting the project. • Added support for the <i>Module Fault Link active</i> parameter. • Firmware and vendor data CRCs can be read out in CoE objects.
02	01	<ul style="list-style-type: none"> • Safety mat function optimized • Backup/restore mode added • Protective circuit of the outputs changed
01	00	<ul style="list-style-type: none"> • First release

1.4 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.

1.5 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 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.

1.6 Beckhoff Support and Service

Support

Beckhoff Support offers technical advice on the use of individual Beckhoff products and system planning. The employees support you in the programming and commissioning of sophisticated automation systems.

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Training in Germany takes place in our training center at the Beckhoff headquarters in Verl, at subsidiaries or, by arrangement, at the customer's premises.

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The Beckhoff Service Center supports you with after-sales services such as on-site service, repair service or spare parts service.

Hotline: +49 5246/963-460
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Download area

In the download area you can obtain product information, software updates, the TwinCAT automation software, documentation and much more.

Web: www.beckhoff.com/download

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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

2.1 Duty of care

i 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](#) [► 8].
- 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 instructions

2.2.1 Before operation

Ensure traceability

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

Use in machines according to the Machinery Directive

Only use the TwinSAFE component in machines that comply with the Machinery Directive. This is how you ensure safe operation.

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 SELV/PELV power supply

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

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.

Use permissible engineering tools and procedures

The TÜV SÜD certificate applies to the TwinSAFE component, the function blocks available in it, the documentation and the engineering tool. Approved engineering tools are *TwinCAT 3.1*, the *TwinSAFE Loader* and *CODESYS Safety for EtherCAT Safety Module*.

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 or externally generated automatic project creation procedures.

2.2.2 In 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.

2.2.3 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 \[► 140\]](#).

3 System description TwinSAFE

3.1 Extension of the Beckhoff I/O system with safety functions

The TwinSAFE products from Beckhoff enable convenient expansion of the Beckhoff I/O system with safety components, and integration of all the cabling for the safety circuit within the existing fieldbus cable. Safe signals can be mixed with standard signals as required. The transfer of safety-related TwinSAFE telegrams is handled by the standard controller. Maintenance is simplified significantly thanks to faster diagnosis and simple replacement of components.

The following basic functionalities are included in the TwinSAFE components: digital inputs (e.g. EL19xx, EP1908), digital outputs (e.g. EL29xx), drive components (e.g. AX5805) and logic units (e.g. EL6900, EL6910). For a large number of applications, the complete safety sensor and actuator technology can be wired on these components. The required logical link of the inputs and the outputs is handled by the EL69xx. In addition to Boolean operations, the EL6910 now also enables analog operations.

3.2 Safety concept

TwinSAFE: Safety and I/O technology in one system

- Extension of the familiar Beckhoff I/O system with TwinSAFE components
- Safe and non-safe components can be combined as required
- Logical link of the I/Os in the EL69xx TwinSAFE logic terminal
- Suitable for applications up to SIL 3 according to EN 61508:2010 and Cat 4, PL e according to EN ISO 13849-1:2015
- Safety-relevant networking of machines via bus systems
- In the event of an error, all TwinSAFE components always switch to the wattless and therefore safe state
- No safety requirements for the higher-level standard TwinCAT system

Safety over EtherCAT protocol (FSoE)

- Transfer of safety-relevant data via any media (“genuine black channel”)
- TwinSAFE communication via fieldbus systems such as EtherCAT, Lightbus, PROFIBUS, PROFINET or Ethernet
- IEC 61508:2010 SIL 3 compliant
- FSoE is IEC standard (IEC 61784-3-12) and ETG standard (ETG.5100)

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.

CAUTION

Safe state

For all TwinSAFE components the safe state is always the switched-off, wattless state.

4 Product description

4.1 General description

EK1960 – TwinSAFE-Compact-Controller

The EK1960 is a TwinSAFE controller with 20 fail-safe inputs and 24 fail-safe outputs. The EK1960-2600 and EK1960-2608 variants feature an additional four relays, each with one make contact.

The EK1960 TwinSAFE compact controller is suitable for safety applications up to SIL 3 according to IEC 62061 and IEC 61508 and up to Cat. 4, PL e according to EN ISO 13849-1:2015. (See following list for restrictions):

- The single-channel relay output is suitable up to Cat. 2, PL d
- The two-channel relay output (use of two relay contacts in series) is suitable up to Cat. 3, PL d or Cat. 4, PL e, depending on the number of actuations. Cat. 4, PL e requires an actuation at least once per month, Cat. 3, PL d at least once per year.
- The safe input for the safety mat operation mode is limited to Cat. 2, PL d.

Special proof tests are not necessary during the entire lifetime of the EK1960 on account of the high level of diagnostic coverage.

The EK1960 can be used in three different application cases:

- As a stand-alone TwinSAFE compact controller without the use of an EtherCAT network with 20 inputs and 24 outputs. An extension with terminals to the right of the EK1960 on the E-bus is not possible in this operation mode.
- As a TwinSAFE compact controller integrated into an EtherCAT network. The EK1960 can be extended with standard and safety terminals on the E-bus connection and via the EtherCAT network.
- As a TwinSAFE I/O module. The logic on the TwinSAFE compact controller is not used. The coupler can be addressed by a TwinSAFE logic terminal as an I/O module with 20 inputs and 24 outputs.

The inputs of the EK1960 can be used as digital 24 V inputs. They can be fed to the safe input either with static 24 V_{DC} or with a clock from one of the TwinSAFE outputs of the EK1960 or via an external clock source via, for example, a switch contact. Inputs 17 to 20 can additionally be switched to a safety mat operation mode (*Bumper Mode On*). Only safety mats operating according to the resistance-change principle are supported. The safety mats can also be cascaded in accordance with the manufacturer's specifications. The inputs can be parameterized in groups of two.

The outputs can be parameterized in groups of four. It is possible to set the mark-to-space-ratio and the activation as a clock source for the safe inputs.



Fig. 1: EK1960-260x TwinSAFE-Compact-Controller

The EK1960 without relay option has a dummy cap on X4.

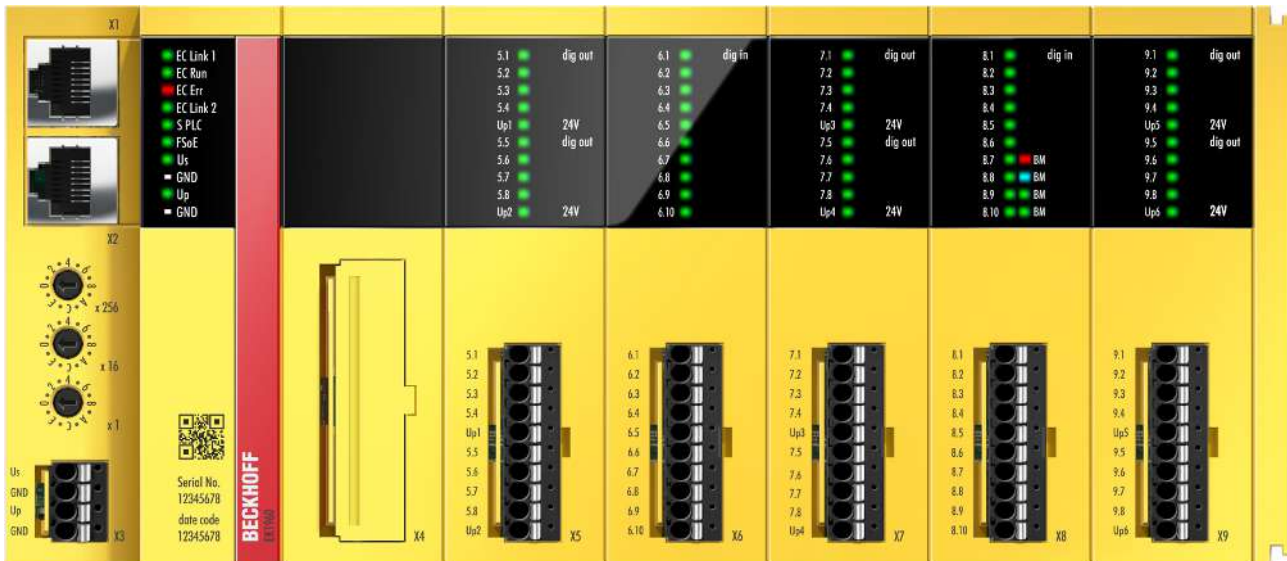


Fig. 2: EK1960-000x TwinSAFE compact controller without relay option

4.2 Product designations

Product designation	Description
EK1960-0000	EK1960 with EtherCAT RJ45 connections – without relay option
EK1960-0008	EK1960 with EtherCAT M8 connections – without relay option
EK1960-2600	EK1960 with EtherCAT RJ45 connections – with four potential-free contacts (NO)
EK1960-2608	EK1960 with EtherCAT M8 connections – with four potential-free contacts (NO)
ZS2003-0001	Spare part, power supply spring contact strip, 4-pole Contact spacing 3.5 mm
ZS2003-0002	Spare part, input/output spring contact strip, 10-pole Contact spacing 3.5 mm
ZS2003-0003	Spare part, relay contact spring contact strip, 10-pole Contact spacing 5.0 mm (EK1960-260x only)

4.3 Inputs and outputs of the EK1960

NOTICE

Fuses for the EK1960

Fuses must be provided for the power supplies of the EK1960 2 A each for U_s and U_p (X3) and 5 A each for U_{P1} to U_{P6} (X5, X7, X9).

plug	contact	Name	Description
EtherCAT IN (X1)		EtherCAT 1	EtherCAT connection 1 (EtherCAT IN) (RJ45 or M8)
EtherCAT OUT (X2)		EtherCAT 2	EtherCAT connection 2 (EtherCAT OUT) (RJ45 or M8)
Power (X3)	1	U_s	Control voltage 24 V _{DC} (SELV/PELV) Supply of power for internal logic and E-bus connection
	2	0 V	GND
	3	U_p	Peripheral voltage 24 V _{DC} (SELV/PELV) Supply of power for relays and inputs in the safety mat operation mode
	4	0 V	GND
Relais (X4) (EK1960-260x only)	1	4.1	Input to Relay 1 make contact (Channel7.FSOUT RelaisModule.Channel1.Output)
	2	4.2	Input to Relay 2 make contact (Channel7.FSOUT RelaisModule.Channel2.Output)
	3	4.3	Input to Relay 3 make contact (Channel7.FSOUT RelaisModule.Channel3.Output)
	4	4.4	Input to Relay 4 make contact (Channel7.FSOUT RelaisModule.Channel4.Output)
	5	n.c.	not used
	6	n.c.	not used
	7	4.5	Output to Relay 1 make contact (Channel7.FSOUT RelaisModule.Channel1.Output)
	8	4.6	Output to Relay 2 make contact (Channel7.FSOUT RelaisModule.Channel2.Output)
	9	4.7	Output to Relay 3 make contact (Channel7.FSOUT RelaisModule.Channel3.Output)
	10	4.8	Output to Relay 4 make contact (Channel7.FSOUT RelaisModule.Channel4.Output)
Output (X5)	1	5.1	Output 1 from U_{P1} (Channel1.FSOUT Module 1.Channel1.Output)
	2	5.2	Output 2 from U_{P1} (Channel1.FSOUT Module 1.Channel2.Output)
	3	5.3	Output 3 from U_{P1} (Channel1.FSOUT Module 1.Channel3.Output)
	4	5.4	Output 4 from U_{P1} (Channel1.FSOUT Module 1.Channel4.Output)
	5	U_{P1}	Peripheral voltage U_{P1} 24 V _{DC} (SELV/PELV)
	6	5.5	Output 5 from U_{P2} (Channel2.FSOUT Module 2.Channel1.Output)
	7	5.6	Output 6 from U_{P2} (Channel2.FSOUT Module 2.Channel2.Output)
	8	5.7	Output 7 from U_{P2} (Channel2.FSOUT Module 2.Channel3.Output)
	9	5.8	Output 8 from U_{P2} (Channel2.FSOUT Module 2.Channel4.Output)
	10	U_{P2}	Peripheral voltage U_{P2} 24 V _{DC} (SELV/PELV)
Input (X6)	1	6.1	Input 1 (Channel8.FSIN Module 1.Channel1.Input)
	2	6.2	Input 2 (Channel8.FSIN Module 1.Channel2.Input)
	3	6.3	Input 3 (Channel9.FSIN Module 2.Channel1.Input)
	4	6.4	Input 4 (Channel9.FSIN Module 2.Channel2.Input)
	5	6.5	Input 5 (Channel10.FSIN Module 3.Channel1.Input)

plug	contact	Name	Description
	6	6.6	Input 6 (Channel10.FSIN Module 3.Channel2.Input)
	7	6.7	Input 7 (Channel11.FSIN Module 4.Channel1.Input)
	8	6.8	Input 8 (Channel11.FSIN Module 4.Channel2.Input)
	9	6.9	Input 9 (Channel12.FSIN Module 5.Channel1.Input)
	10	6.10	Input 10 (Channel12.FSIN Module 5.Channel2.Input)
Output (X7)	1	7.1	Output 9 from U_{P3} (Channel3.FSOUT Module 3.Channel1.Output)
	2	7.2	Output 10 from U_{P3} (Channel3.FSOUT Module 3.Channel2.Output)
	3	7.3	Output 11 from U_{P3} (Channel3.FSOUT Module 3.Channel3.Output)
	4	7.4	Output 12 from U_{P3} (Channel3.FSOUT Module 3.Channel4.Output)
	5	U_{P3}	Peripheral voltage $U_{P3} 24 V_{DC}$ (SELV/PELV)
	6	7.5	Output 13 from U_{P4} (Channel4.FSOUT Module 4.Channel1.Output)
	7	7.6	Output 14 from U_{P4} (Channel4.FSOUT Module 4.Channel2.Output)
	8	7.7	Output 15 from U_{P4} (Channel4.FSOUT Module 4.Channel3.Output)
	9	7.8	Output 16 from U_{P4} (Channel4.FSOUT Module 4.Channel4.Output)
	10	U_{P4}	Peripheral voltage $U_{P4} 24 V_{DC}$ (SELV/PELV)
Input (X8)	1	8.1	Input 11 (Channel13.FSIN Module 6.Channel1.Input)
	2	8.2	Input 12 (Channel13.FSIN Module 6.Channel2.Input)
	3	8.3	Input 13 (Channel14.FSIN Module 7.Channel1.Input)
	4	8.4	Input 14 (Channel14.FSIN Module 7.Channel2.Input)
	5	8.5	Input 15 (Channel15.FSIN Module 8.Channel1.Input)
	6	8.6	Input 16 (Channel15.FSIN Module 8.Channel2.Input)
	7	8.7	Input 17 (digital - <i>Digital Mode On</i> , safety mat operation mode (resistance change) - <i>Bumper Mode On</i>) (Channel16.FSIN Module 9.Channel1.Input)
	8	8.8	Input 18 (digital - <i>Digital Mode On</i> , safety mat operation mode (resistance change) - <i>Bumper Mode On</i>) (Channel16.FSIN Module 9.Channel2.Input)
	9	8.9	Input 19 (digital - <i>Digital Mode On</i> , safety mat operation mode (resistance change) - <i>Bumper Mode On</i>) (Channel17.FSIN Module 10.Channel1.Input)
	10	8.10	Input 20 (digital - <i>Digital Mode On</i> , safety mat operation mode (resistance change) - <i>Bumper Mode On</i>) (Channel17.FSIN Module 10.Channel2.Input)
Output (X9)	1	9.1	Output 17 from U_{P5} (Channel5.FSOUT Module 5.Channel1.Output)
	2	9.2	Output 18 from U_{P5} (Channel5.FSOUT Module 5.Channel2.Output)
	3	9.3	Output 19 from U_{P5} (Channel5.FSOUT Module 5.Channel3.Output)
	4	9.4	Output 20 from U_{P5} (Channel5.FSOUT Module 5.Channel4.Output)
	5	U_{P5}	Peripheral voltage $U_{P5} 24 V_{DC}$ (SELV/PELV)
	6	9.5	Output 21 from U_{P6} (Channel6.FSOUT Module 6.Channel1.Output)

plug	contact	Name	Description
	7	9.6	Output 22 from U _{P6} (Channel6.FSOUT Module 6.Channel2.Output)
	8	9.7	Output 23 from U _{P6} (Channel6.FSOUT Module 6.Channel3.Output)
	9	9.8	Output 24 from U _{P6} (Channel6.FSOUT Module 6.Channel4.Output)
	10	U _{P6}	Peripheral voltage U _{P6} 24 V _{DC} (SELV/PELV)

NOTICE

Protected wiring

If the wiring of the outputs or the connected actuators leaves the control cabinet, the user must ensure that the wiring is protected.

⚠ WARNING

Active loads

The use of active loads (with their own power supply) is not permissible unless the manufacturer of the load ensures the non-reactivity of the power supply to the control signal.

⚠ DANGER

Clocked signals within a sheathed cable

Are clocked signals of different output modules used within a sheathed cable, a failure of a module, such as cross-circuit or external power supply must lead to a switch off of all these modules. This switch off must be performed by the user program.

From firmware version 03 and revision -0021 the parameter *Module Fault Link active* is available. If the parameter is set to TRUE for all modules involved, all these modules are set to the error state in the event of a module error. This parameter is set to TRUE by default.

4.4 Connection technology

4.4.1 Power supply spring contact strip

The power supply spring contact strip is required for the X3 connection.

Item number	ZS2003-0001
Number of contacts	4
Contact spacing	3.5 mm
Connection methods	Spring-loaded terminal technology
Wire cross-section (solid-wire)	0.2 – 1.5 mm ²
Wire cross-section (fine-wire)	0.2 – 1.5 mm ²
Conductor cross-sectional area – fine wire (with wire-end ferrules with plastic collars)	0.25 – 0.75 mm ²
Conductor cross-sectional area – fine wire (with wire-end ferrules without plastic collars)	0.25 – 1.5 mm ²
Strip length	8 - 9 mm

4.4.2 Input and output spring contact strip

The input and output spring contact strip is required for the connection X5 to X9.

Item number	ZS2003-0002
Number of contacts	10
Contact spacing	3.5 mm
Connection methods	Spring-loaded terminal technology
Wire cross-section (solid-wire)	0.2 – 1.5 mm ²
Wire cross-section (fine-wire)	0.2 – 1.5 mm ²
Conductor cross-sectional area – fine wire (with wire-end ferrules with plastic collars)	0.25 – 0.75 mm ²
Conductor cross-sectional area – fine wire (with wire-end ferrules without plastic collars)	0.25 – 1.5 mm ²
Strip length	8 - 9 mm

4.4.3 Relay contact spring contact strip

The relay contact spring contact strip is required for the connection X4 (EK1960-260x only).

Item number	ZS2003-0003
Number of contacts	10
Contact spacing	5.0 mm
Connection methods	Spring-loaded terminal technology
Wire cross-section (solid-wire)	0.2 – 2.5 mm ²
Wire cross-section (fine-wire)	0.2 – 2.5 mm ²
Conductor cross-sectional area – fine wire (with wire-end ferrules with plastic collars)	0.25 – 1.5 mm ²
Conductor cross-sectional area – fine wire (with wire-end ferrules without plastic collars)	0.25 – 2.5 mm ²
Strip length	9 - 10 mm

4.5 Intended use

WARNING

Caution - Risk of injury!

The TwinSAFE compact controller may only be used for the purposes described below!

The TwinSAFE compact controller expands the application range of the Beckhoff EtherCAT system by functions that enable it to be used in the field of machine safety as well. The TwinSAFE compact controller is designed for machine safety functions and the directly associated industrial automation tasks. It is therefore approved only for applications with a defined fail-safe state. This safe state is the wattless state.

The EK1960 TwinSAFE compact controller is suitable for operation as

- Stand-alone Safety Controller
- a safety controller within an EtherCAT network
- a safety I/O device within an EtherCAT network with, for example, an EL6910 as TwinSAFE Master

WARNING

System limits

The TÜV-Süd certificate applies to the EK1960, the function blocks available in it, the documentation and the engineering tool. Approved engineering tools are *TwinCAT 3.1*, *TwinSAFE Loader* and *CODESYS Safety for EtherCAT Safety Module*. Any deviations from the procedures or tools, particularly externally generated xml files for TwinSAFE import or externally generated automatic project creation procedures, are not covered by the certificate.

WARNING

Power supply

The TwinSAFE compact controller must be supplied with 24 V_{DC} by an SELV/PELV power supply unit with an output voltage limit U_{max} of 36 V_{DC}. Failure to observe this can result in a loss of security.

WARNING

Commissioning test

Before the EK1960 can be used for the safety task, the user must carry out a commissioning test so that sensor and actuator wiring errors can be ruled out.

CAUTION

Note the Machinery Directive

The TwinSAFE compact controller may only be used in machines within the meaning of the Machinery Directive.

CAUTION

Ensure traceability

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

4.6 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	EK1960
Number of inputs	20
Number of outputs	24 (+ 4 optional relay outputs)
Cable length between sensor and input	30 m (if cables with a cross-sectional area of 0.75 mm ² are used)
Cable length between output and actuator	30 m (if cables with a cross-sectional area of 0.75 mm ² are used)
Minimum/maximum logic cycle time	approx. 1 ms / according the project size
Fault reaction time	≤ watchdog times
Watchdog time	min. 2 ms, max. 60000 ms
Input process image	Dynamic, according to the TwinSAFE configuration in TwinCAT 3
Output process image	Dynamic, according to the TwinSAFE configuration in TwinCAT 3
Supply voltage (SELV/PELV)	24 V _{DC} (-15% / +20%) Provide 2A protection for U _S and U _P
E-bus power supply (5 V)	max. 500 mA (For higher current consumption, please use additional EL9410 power supply terminals!)
Signal voltage inputs	see Characteristic curve of the inputs [► 32]
Output module (4 channels)	24 V _{DC} (-15% / +20%) SELV/PELV for U _{P1} to U _{P6} max. 2 A per channel min. 30 mA with test pulse length 400 μs and ohmic load Simultaneity factor 50% per module Provide protection 5A for each U _{Px} Diagnostic thresholds: > 4 V -> high signal is detected < 2.4 V -> low signal is detected
Permissible actuators	<ul style="list-style-type: none"> • inductive loads (see also Load characteristic curve – inductive load [► 34]) (a free-wheeling diode must be provided on the load) • ohmic loads • capacitive loads
Current consumption of the module electronics at 24 V _{DC} (without current consumption of sensors/ actuators)	U _S typ. 80 mA U _P typ. 2 mA U _{P1} to U _{P6} each typ. 2 mA
Dimensions (W x H x D)	230.5 x 100 x 58.6 mm
Weight	approx. 560 g (EK1960-260x) / approx. 500 g (EK1960-000x)
Permissible ambient temperature (operation)	-25 °C ... + 55 °C
Permissible ambient temperature (transport/ storage)	-40 °C ... + 70 °C
Permissible air humidity	5% ... 95%, non-condensing
Permissible air pressure (operation/storage/transport)	750 hPa ... 1100 hPa (this is equivalent to an altitude of approx. -690 m to 2450 m above sea level assuming an international standard atmosphere)
Product designation	EK1960

Product designation	EK1960
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 degree of pollution conforms to EN 60664-1	Degree of pollution 2 (comply with the chapter Cleaning [▶ 137])
Inadmissible operating conditions	TwinSAFE controllers must not be used under the following operating conditions: <ul style="list-style-type: none"> • under the influence of ionizing radiation (exceeding the natural background radiation) • in corrosive environments¹ • in an environment that leads to impermissible soiling of the controller
Vibration / shock resistance	conforms to EN 60068-2-6 / EN 60068-2-27
EMC immunity / emission	conforms to EN 61000-6-2 / EN 61000-6-4
Shocks	15 g with pulse duration 11 ms in all three axes
Protection rating as per IEC 60529	IP 20
Permitted operating environment	In the control cabinet or terminal box, with minimum protection rating IP54 according to IEC 60529
Permissible installation position	see chapter Installation position and minimum distances [▶ 43]
Approvals	CE, TÜV SÜD

¹ A corrosive environment exists when corrosion damage becomes apparent.

NOTICE

Protective circuit

No protective circuit is integrated in the output circuit of the EK1960, therefore it is necessary to provide a free-wheeling diode on the actuator for inductive loads. However, it must be borne in mind that the free-wheeling diode may prolong the switch-off times of the actuator.

The protective circuit must limit the induced voltage at the output to less than 29V. R/C elements and varistors are therefore typically unsuitable.

4.6.1 Technical data – relay option

Product designation	EK1960-260x
Contacts	1 NO / 1 NC
Make contact material (NO)	AgNi + 0.2 µm Au
Feedback contact material (NC)	AgNi + 5 µm Au
Coil voltage	24V _{DC}
Maximum continuous current, NO contact (when used in safety applications)	DC13 (24 V _{DC}) I = 2 A AC15 (230 V _{AC}) I = 3 A
Maximum switching current (NO contact)	8 A
Minimum switching current (NO contact)	10 mA (AgNi)
Switching capacity according to IEC/EN 60947-5-1	
AC15	250 V _{AC} / 3 A
DC13	24 V _{DC} / 2 A
Switching frequency (maximum)	20 switching cycles / s
Response time	≤ 15 ms (typically 10 ms)
Release time	≤ 5 ms (typically 2 ms)

NOTICE

Allowed loads of the relay option

The potential-free contacts of the relay option (X4) may only be connected to resistive and inductive loads. Capacitive loads are not permissible.

Load limit curve

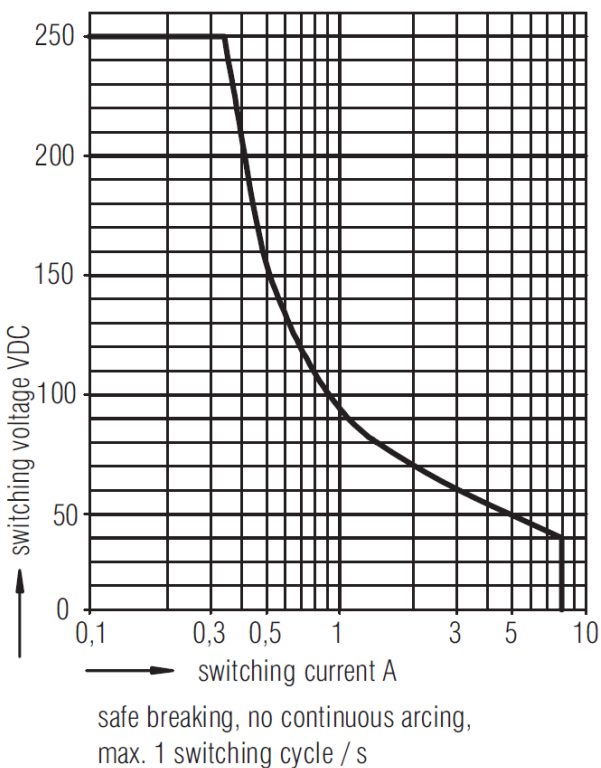


Fig. 3: Load limit curve, make contact

Operating lifetime for contact material AgNi

Electrical life of the output contacts determined by
DIN EN 60947-5-1 / Annex C.3

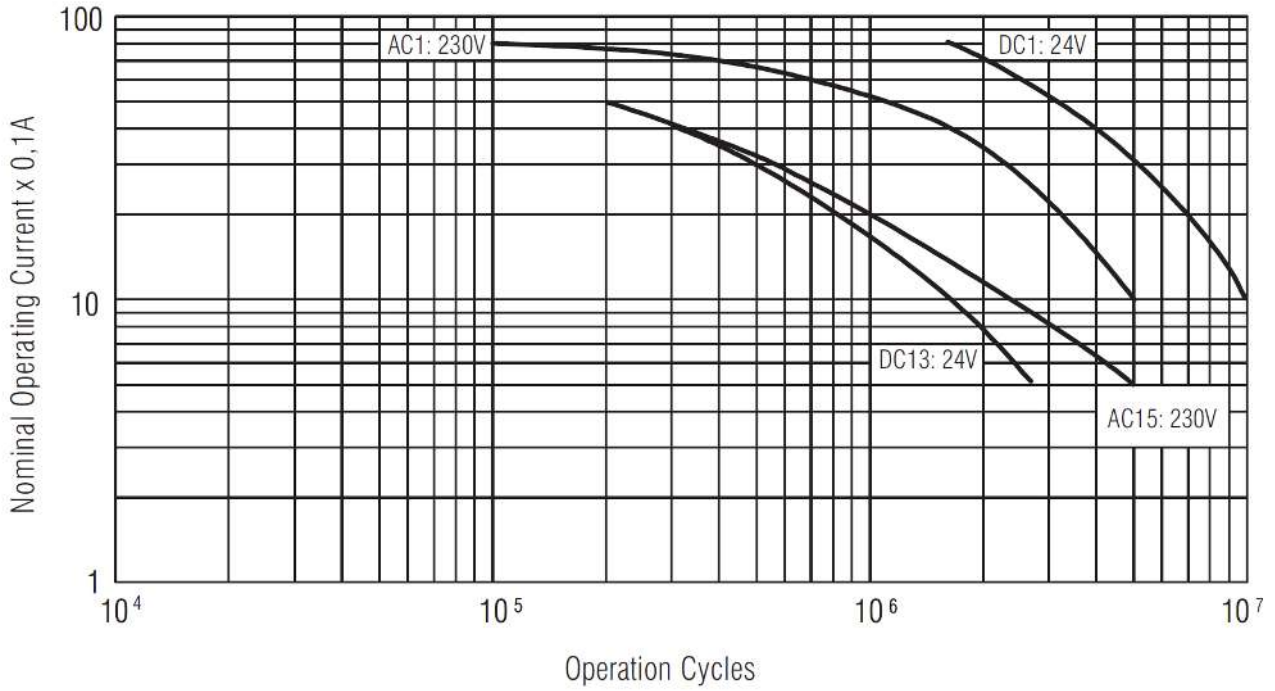


Fig. 4: Operating lifetime of the AgNi NO contact for DC1, DC13, AC1 and AC15

Reduction factor for inductive loads

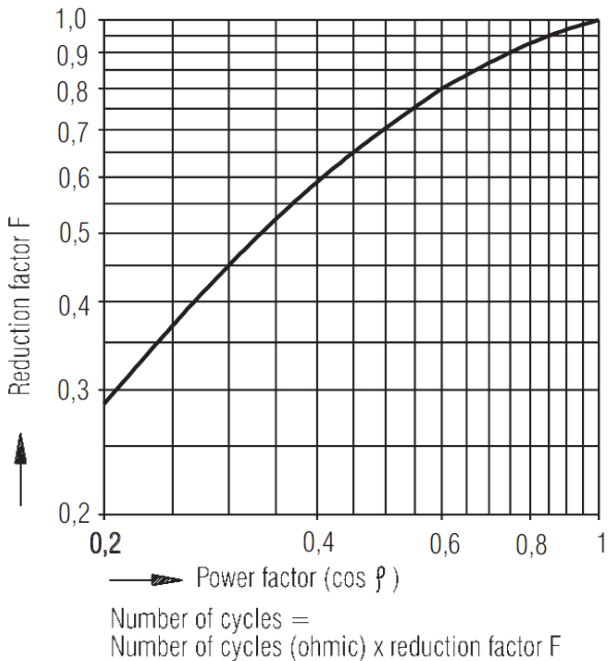


Fig. 5: Reduction factor for inductive loads

4.7 Target failure measures

In the following tables the target failure measures are shown separately for inputs, logic and outputs. The PFH values for the inputs, logic and outputs used must be added together for the complete safety loop. The Safety-over-EtherCAT communication is included in the logic part.

General parameters	EK1960
Lifetime [a]	20
Prooftest Intervall [a]	- ¹⁾
HFT	1
Classification element ²⁾	Type B

1. Special proof tests are not necessary during the entire lifetime of the EK1960 TwinSAFE compact controller on account of the high level of diagnostic coverage.
2. Classification according to IEC 61508-2:2010 (see chapters 7.4.4.1.2 and 7.4.4.1.3)

The EK1960 TwinSAFE compact controller can be used for safety-related applications within the meaning of IEC 62061:2005/A2:2015 up to SILCL3 and IEC 61508:2010 up to SIL 3 and EN ISO 13849-1:2015 up to Cat. 4, PL e. (See following note for restrictions):

⚠ CAUTION
<p>EK1960 category and performance level restrictions</p> <ul style="list-style-type: none"> • The single-channel relay output is suitable up to Cat. 2, PL d • The two-channel relay output (use of two relay contacts in series) is suitable up to Cat. 3, PL d or Cat. 4, PL e, depending on the number of actuations. Cat. 4, PL e requires an actuation at least once per month, Cat. 3, PL d at least once per year. • The safe input for the safety mat operation mode is limited to Cat. 2, PL d.

Further information on calculating or estimating the $MTTF_D$ value from the PFH_D value can be found in the TwinSAFE application manual or in EN ISO 13849-1:2015, Table K.1.

Relay output target failure measures (Cat. 4 – two-channel)

The following table contains the target failure measures for the two-channel relay output. This must be added to the logic and input value to determine the total PFH value.

One actuation of the relay per hour is assumed for the calculation.

Relay output parameters (Cat. 4 – two-channel)	Value
PFH_D	1.46 E-09
PFH_G	1.48 E-06
$MTTF_D$	high
DC_{avg}	high
Performance Level	PL e
Category	4
SIL	3

Relay output target failure measures (Cat. 2 – single-channel)

The following table contains the target failure measures for the single-channel relay output. This must be added to the logic and input value to determine the total PFH value.

One actuation of the relay per hour is assumed for the calculation.

Relay output parameters (Cat. 2 – single-channel)	Value
PFH_D	7.25 E-10
PFH_G	6.42 E-05
$MTTF_D$	high

Relay output parameters (Cat. 2 – single-channel)	Value
DC _{avg}	high
Performance Level	PL d
Category	2
SIL	2

B_{10D} relay option values

Characteristic numbers	EK1960-260x
B _{10D} value (DC13 24 V _{DC} and I _{max} ≤ 2 A)	1,500,000 [switching cycles]
B _{10D} value (AD15 230 V _{AC} and I _{max} ≤ 1 A)	750,000 [switching cycles]
B _{10D} value (AD15 230 V _{AC} and I _{max} ≤ 3 A)	300,000 [switching cycles]

Digital input target failure measures

The following table contains the target failure measures for the digital input of the EK1960. This must be added to the logic and input value to determine the total PFH value.

Digital input parameters	Value
PFH _D	6.4 E-11
PF _{DG}	6.1 E-06
MTTF _D	high
DC _{avg}	high
Performance Level	PL e
Category	4
SIL	3

Safety mat input target failure measures

The following table contains the target failure measures for the analog input in the safety mat operation mode of the EK1960. This must be added to the logic and input value to determine the total PFH value.

Safety mat input parameters	Value
PFH _D	8.84 E-10
PF _{DG}	7.5 E-05
MTTF _D	high
DC _{avg}	medium
Performance Level	PL d
Category	2
SIL	2

Logic target failure measures

The following table contains the target failure measures for the logic module of the EK1960. This must be added to the input and output value to determine the total PFH value. The Safety-over-EtherCAT communication is included in the logic part.

Logic parameters	Value
PFH _D	5.18 E-09
PF _{DG}	4.32 E-05
MTTF _D	high
DC _{avg}	high
Performance Level	PL e
Category	4
SIL	3

Output target failure measures

The following table contains the target failure measures for the digital output of the EK1960. This must be added to the input and logic value to determine the total PFH value.

Digital output parameters	Value
PFH _D	1.5 E-10
PFH _G	2.62 E-07
MTTF _D	high
DC _{avg}	high
Performance Level	PL e
Category	4
SIL	3

Examples of safety loops

Characteristic numbers			Sample 1	Sample 2	Sample 3	Sample 4
Safety mat input	PLd, Cat. 2	8.48 E-10	8.48 E-10		8.48 E-10	8.48 E-10
Digital input	PLe, Cat. 4	6.4 E-11		6.4 E-11		
Logic	PLe, Cat. 4	5.18 E-09	5.18 E-09	5.18 E-09	5.18 E-09	5.18 E-09
Digital output	PLe, Cat. 4	1.5 E-10	1.5 E-10	1.5 E-10		
Relay output (Cat. 4)	PLe, Cat. 4	1.46 E-09			1.46 E-09	
Relay output (Cat. 2)	PLd, Cat. 2	7.25 E-10				7.25 E-10
Overall result			6.18 E-09	5.39 E-09	7.49 E-09	6.75 E-09
PFH_D / Performance Level / Category			PLd, Cat. 2	PLe, Cat. 4	PLd, Cat. 2	PLd, Cat. 2

4.8 Error response times

The error response times depend, among other things, on the logic program used and the settings of the *MultiplierDiagTestPulse* and *ModuloDiagTestPulse* parameters.

An error reaction for the tests of the I/O signals is realized by a weighted counter, therefore the switch-off does not occur immediately at the first error of the diagnostic tests.

The maximum error reaction time results from the duration of the longest lasting test, this is the RAM test and this is several hours.

4.9 Characteristic curve of the inputs

The characteristic curve of the inputs of the EK1960 is similar to type 3 according to EN 61131-2.

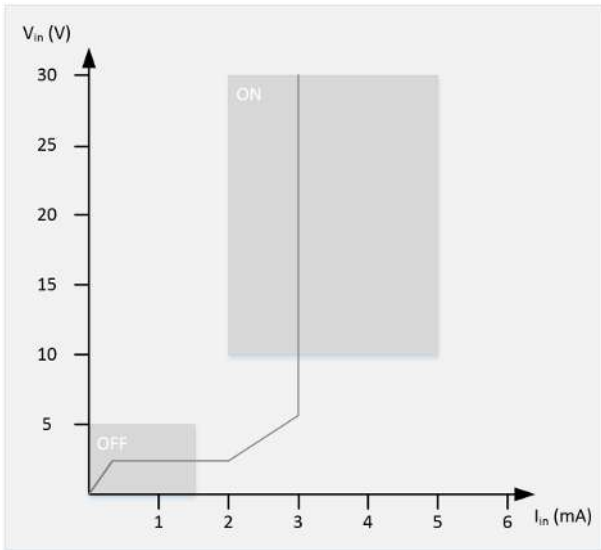


Fig. 6: EK1960 input characteristic curve

4.10 Test pulses for the outputs

The output signals of each module of the EK1960 can be determined via the parameter *Diag TestPulse Active*. The test pulses generated have a length of 400 μs, which is multiplied by the factor *MultiplierDiagTestPulse*. This factor should be set to at least 2 for outputs with no load or only a small load, so that a test pulse length of 800 μs results. The frequency of the test pulses results from the processing of the input and output modules and the cycle time of the internal logic. For example, if the logic has a cycle time of 2 ms and a *ModuloDiagTestpulse* of 0, a typical time b results in accordance with the following calculation.

For each output module the resulting time is:

$$\text{module time} = (4 \text{ cycles feedback test} + (4 \text{ cycles diagnostic test} * (\text{ModuloDiagTestPulse} + 1))) * \text{internal cycle time} * 1.25 * 4 \text{ outputs} = (4 + (4 * 1)) * 2 \text{ ms} * 1.25 * 4 = 80 \text{ ms}$$

For the relay module the resulting time is:

$$\text{Relay module time} = 100 * \text{internal cycle time} * 1.25$$

The input modules each require one cycle. This results in a total time b of:

$$b = 6 * \text{module time} + 1 * \text{relay module time} + 10 * \text{internal cycle time} * 1.25 \text{ (for the input modules)}$$

Inserting the values, this produces:

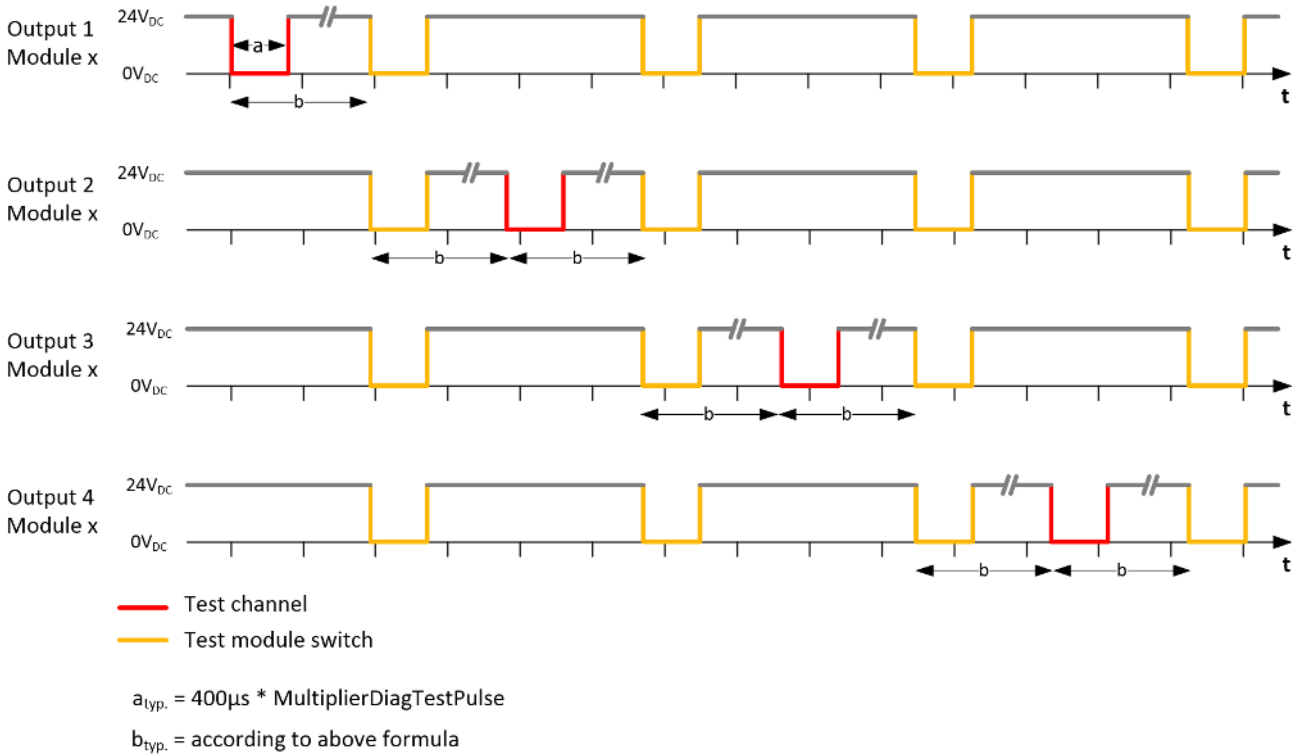
$$b = (6 * 80 \text{ ms}) + (100 * 2 \text{ ms} * 1.25) + (10 * 2 \text{ ms} * 1.25) = 480 \text{ ms} + 250 \text{ ms} + 25 \text{ ms} = 755 \text{ ms}$$

The test pulse sequence is shown in the following table, where the time b typically elapses between a channel test and a module switch test. The tests start over once they have been performed for all four channels.

If the parameter *Diag TestPulse for Inputs active* is set in addition, all outputs of the module are switched on and the test pulses shown here are similarly applied to the individual output channels. These signals can then be used as clocked signals for the safe inputs. The module switch test is not performed in this operation mode; instead, the four channels are tested directly in succession, leading to the time interval b between the tests of the individual channels.

Test	Time until next test
Channel 1 (only channel 1 is tested)	b

Test	Time until next test
Module switch (all four channels are tested)	b
Channel 2 (only channel 2 is tested)	b
Module switch (all four channels are tested)	b
Channel 3 (only channel 3 is tested)	b
Module switch (all four channels are tested)	b
Channel 4 (only channel 4 is tested)	b
Module switch (all four channels are tested)	b (next test channel 1)



NOTICE

Length of the test pulses

When setting the test pulses, make sure that the connected actuator is not switched due to the test pulse length.

The output signal must be 0 V for at least 200 μs within a test pulse. This is independent of the setting of the parameter *MultiplierDiagTestPulse*.



Minimum load

The test pulse length of the outputs is set by default to 2 x 400 μs . This setting is suitable for typical actuators with and without a protective circuit. The test pulse length can typically be reduced to 400 μs with a resistive load and a current of at least 30 mA.

Please observe the violation counter in the diagnostic history. If messages are displayed for the corresponding output module, this means that the setting of the test pulse length is borderline and may need to be increased.

For electronic contactors that tend towards a capacitive behavior, it may be necessary to set the parameter *MultiplierDiagTestPulse* to 3 or higher.

4.11 Load characteristic curve – inductive load

If an external freewheeling diode is not used for inductive loads, the permissible maximum load can be taken from the following characteristic curve.

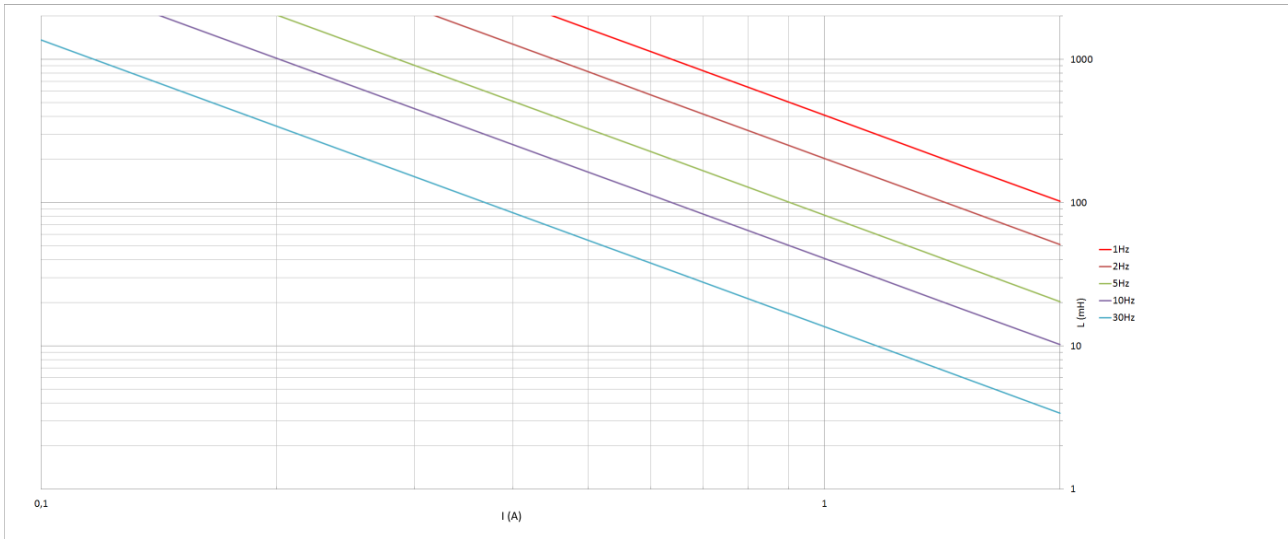


Fig. 7: Characteristic curve - inductive load

4.12 Block diagram of the EK1960

The following block diagram shows the basic structure of the EK1960. The sub-modules shown exist several times according to the information on the sub-modules.

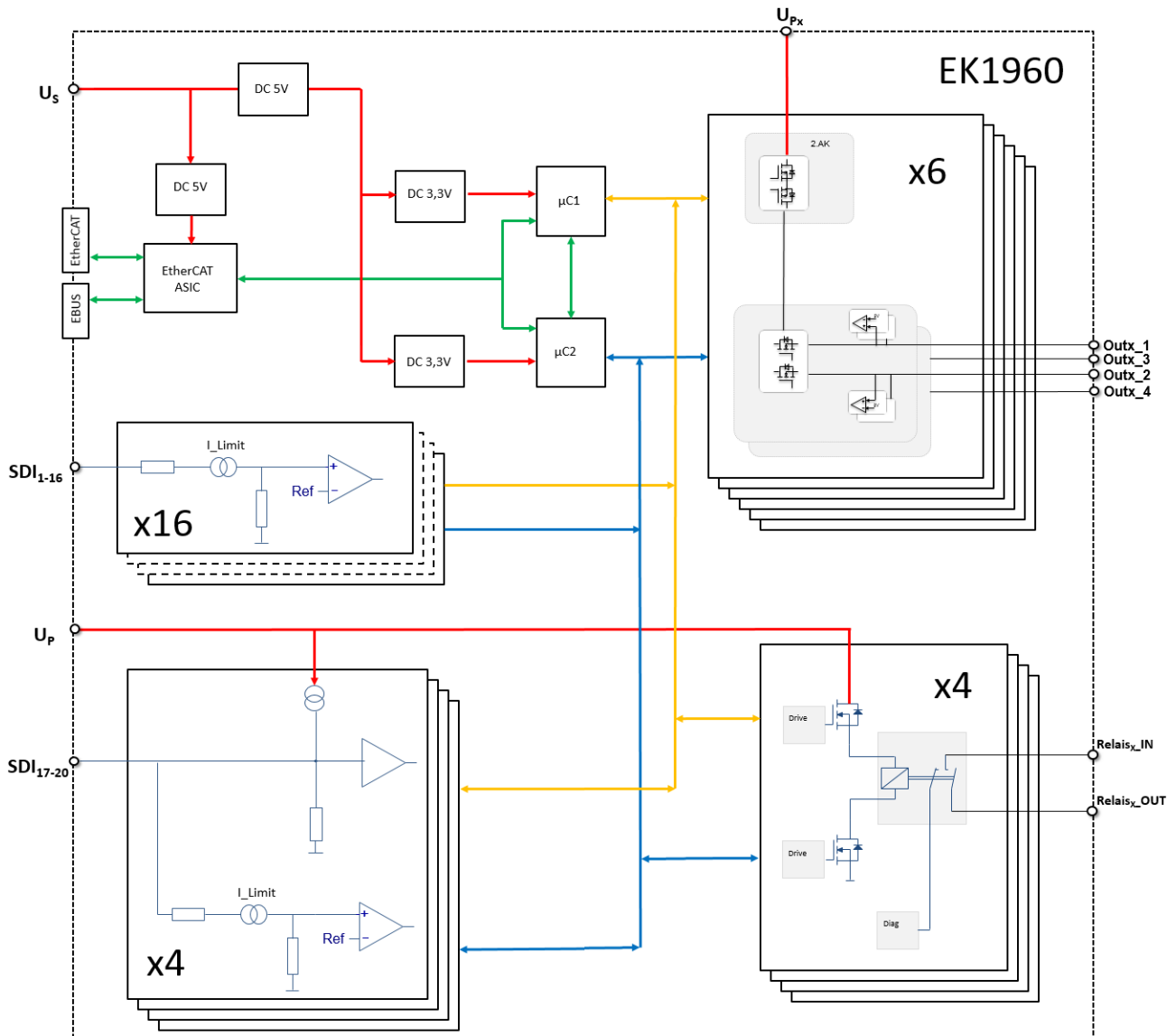


Fig. 8: Block diagram EK1960

4.13 Address setting of the TwinSAFE compact controller

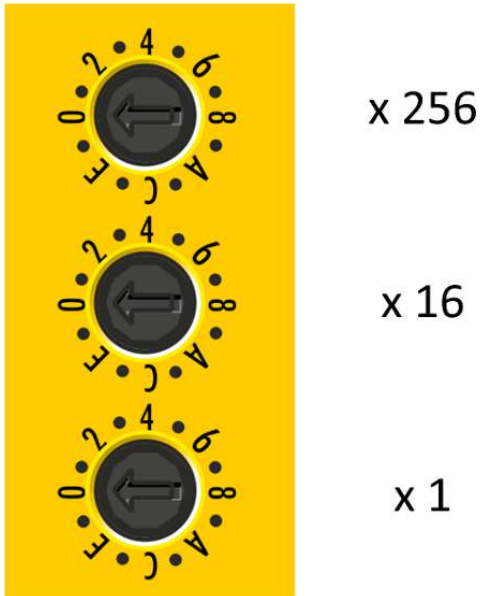


Fig. 9: Address selection switch of the EK1960

The TwinSAFE address of the controller must be set with the three rotary switches on the housing of the EK1960 TwinSAFE controller. TwinSAFE addresses between 1 and 4095 are available.

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

4.14 Dimensions



Fig. 10: EK1960 dimensions

Width: 230.5 mm

Height: 100 mm

Depth: 58.6 mm

4.15 Wiring examples

4.15.1 Inputs and outputs

Examples of the wiring of the individual connections of the EK1960 are shown in the following.

Power supply X3

The X3 connection is for the supply of power to the EK1960. The internal logic and the E-bus connection are supplied via U_S , while U_P supplies the relays and the safe inputs (safety mat operation mode). The GND connections are internally bridged.

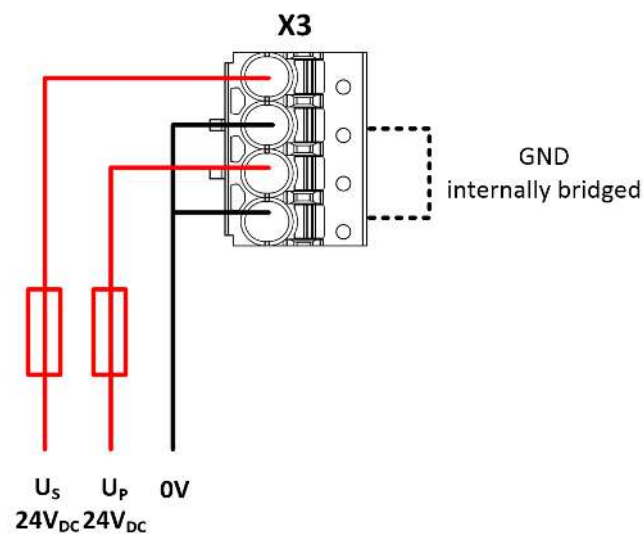


Fig. 11: Power supply X3

Potential-free relay contacts C4 (EK1960-260x)

The relay contacts (four relays each with one make contact) are fed out to the X4 connection. The area surrounded by the dotted line shows the make contacts of the individual relays.

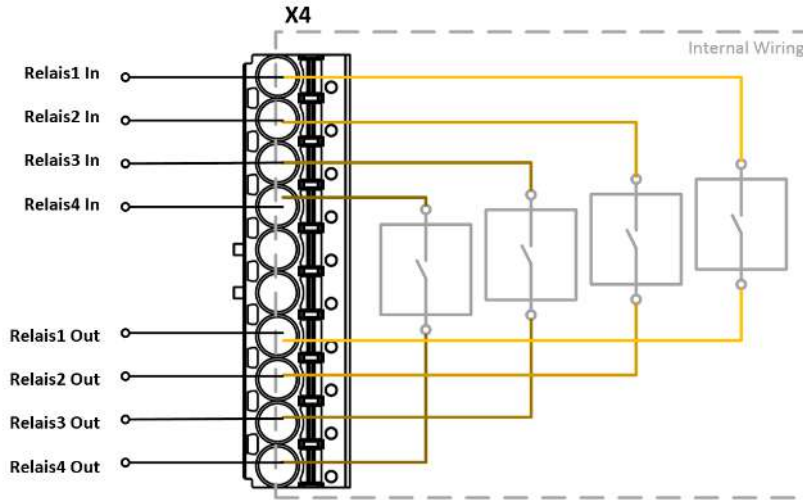


Fig. 12: Relay contact X4 (EK1960-260x only)

Digital outputs X5, X7 and X9

Connection X5, X7 and X9 must be supplied with 24 V_{DC} on contacts 5 and 10. These each supply four outputs. The connected actuator is not fed back to the EK1960; instead it is wired directly to GND.

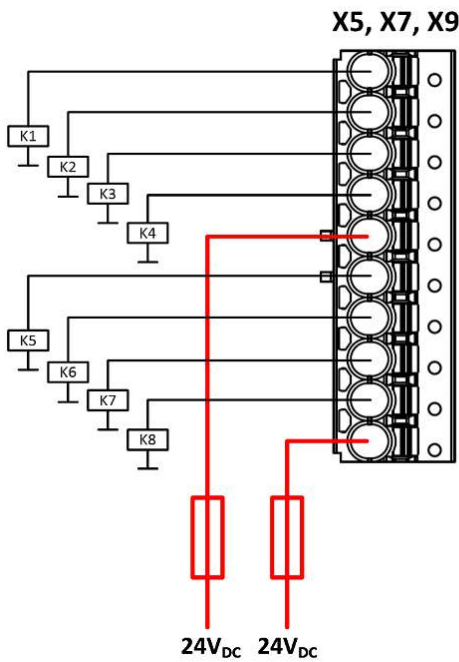


Fig. 13: Digital outputs X5, X7 and X9

Digital inputs X6, X8

The digital inputs are supplied with 24V_{DC} signals. In the default setting, static or clocked signals are supported. Safe outputs of the EK1960 can also be selected as the clock signal source.

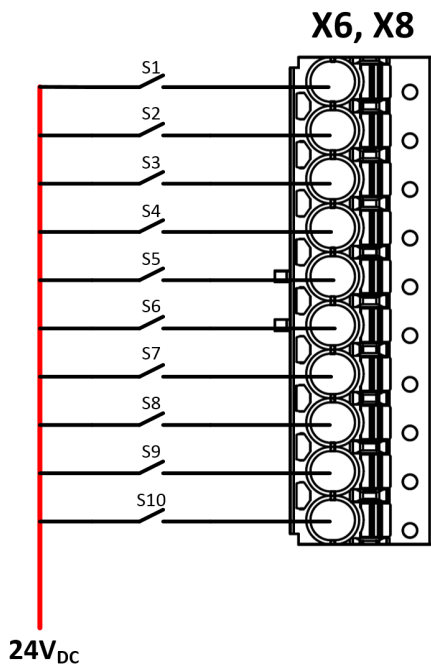


Fig. 14: Digital inputs X6 and X8

Safety mat connection example

Inputs 8.7 to 8.10 on connection X8 of the EK1960 can be configured for a safety mat operation mode. Only safety mats operating according to the resistance-change principle may be used. Only 8K2 (8.2 k Ω) termination resistors are supported.

⚠ CAUTION**Safety mat wiring**

The ground connection of the safety mat used must be fed back to the EK1960 in accordance with the following diagram.

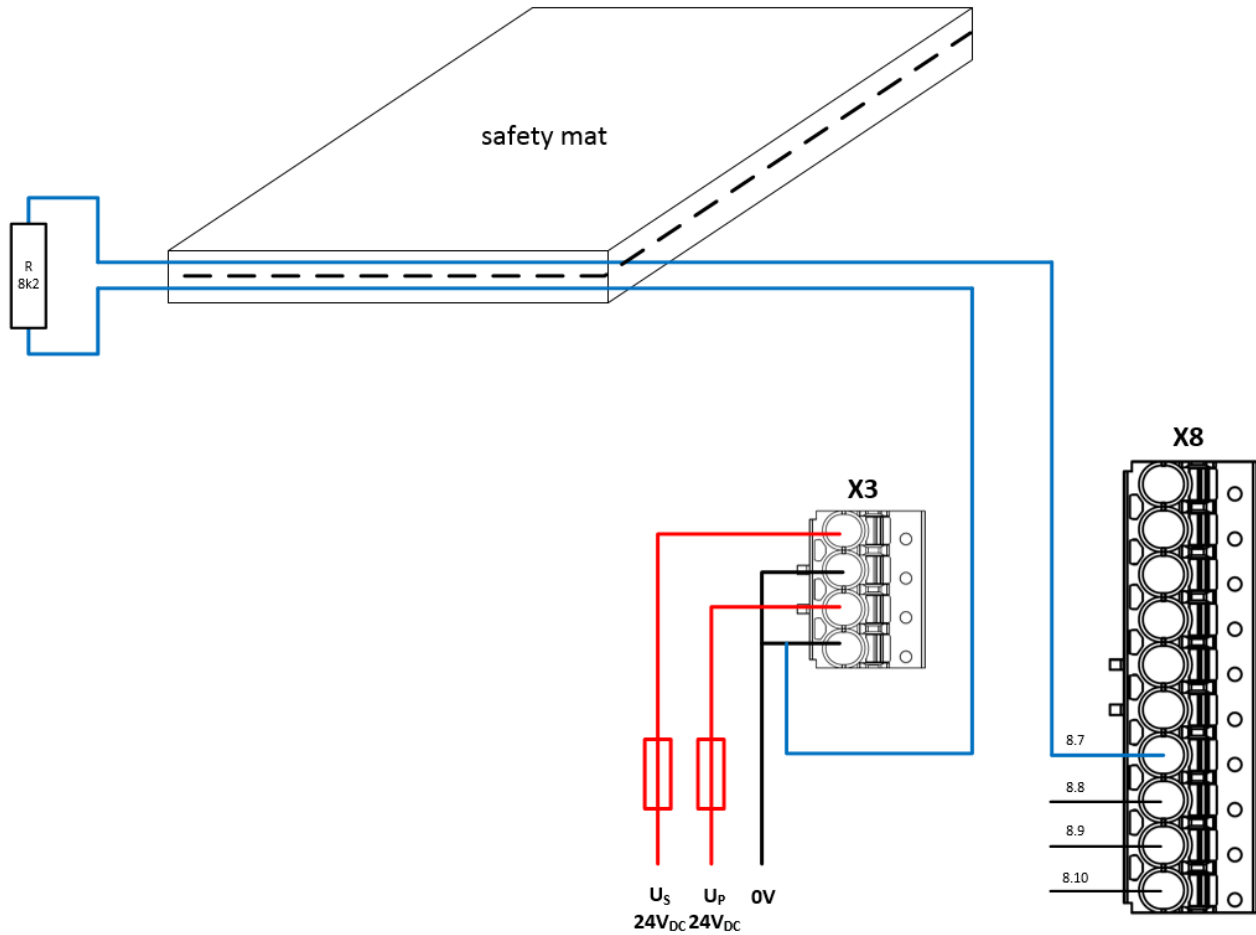


Fig. 15: Safety mat wiring

4.15.2 Clocked signals

All output groups (four outputs each) can be configured as clock outputs. The test pulses of the groups can be set accordingly via parameters.

If a sensor such as a key switch (represented here by S19 and S20) is two-channel wired within one single non-metallic sheathed cable, the two channels must be fed from different clock sources. This makes it possible to detect cross-circuits or external power supplies within the common non-metallic sheathed cable and to achieve a high level of diagnostic coverage.

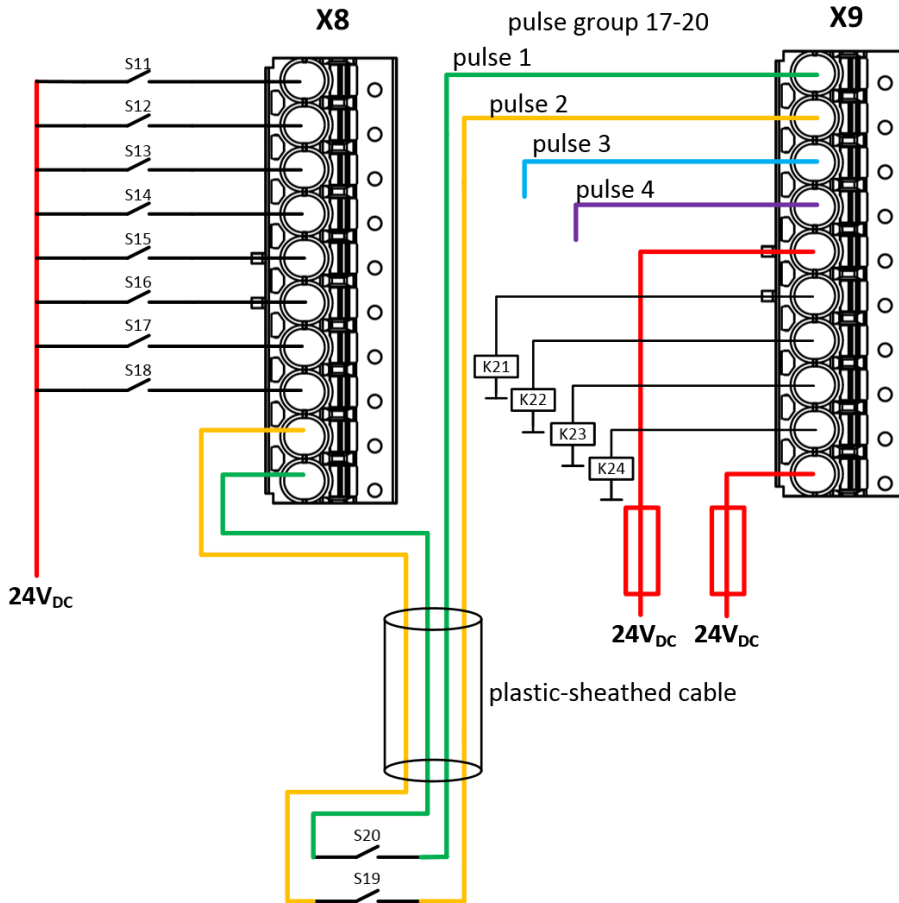


Fig. 16: Wiring example – clock outputs to inputs

5 Operation

5.1 Environmental conditions

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

WARNING

Risk of injury!

The TwinSAFE components 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 TwinSAFE component

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.

5.2 Installation

5.2.1 Safety instructions

Before installing and commissioning the TwinSAFE components please read the safety instructions in the foreword of this documentation.

5.2.2 Transport / storage

Use the original packaging in which the components were delivered for transporting and storing the TwinSAFE components.

CAUTION

Note the specified environmental conditions

Please ensure that the digital TwinSAFE components are only transported and stored under the specified environmental conditions (see technical data).

5.2.3 Mechanical installation

5.2.3.1 De-energized condition

DANGER

Serious risk of injury!

Bring the bus system and the controller into a safe, de-energized state before installing, disassembling or wiring of the controller!

5.2.3.2 Control cabinet / terminal box

For operation, the TwinSAFE compact controller must be installed in a control cabinet or terminal box with IP54 protection class according to IEC 60529 as a minimum.

5.2.3.3 Installation position and minimum distances

For the prescribed installation position the mounting rail is installed horizontally and the mating surfaces of the TwinSAFE compact controller point towards the front (see illustration below). The controller is 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.

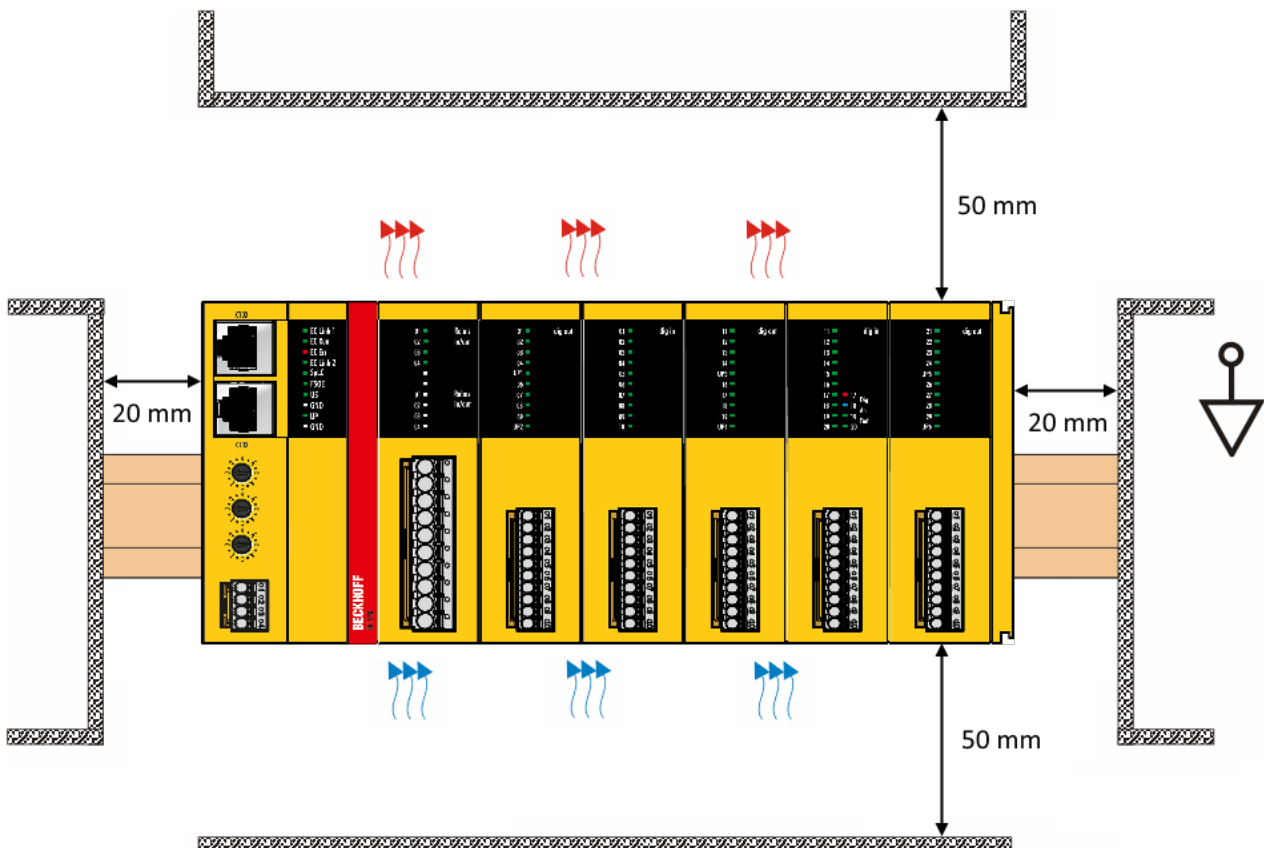


Fig. 17: Installation position and minimum distances

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.

5.2.3.4 Installation on mounting rails

The EK1960 is mounted on a DIN rail by inserting the device onto the DIN rail and then pressing it down onto the rail as shown in the diagram below. In the case of flat DIN rails it may be better to position the controller to the DIN rail from below and to snap it upwards onto the rail.

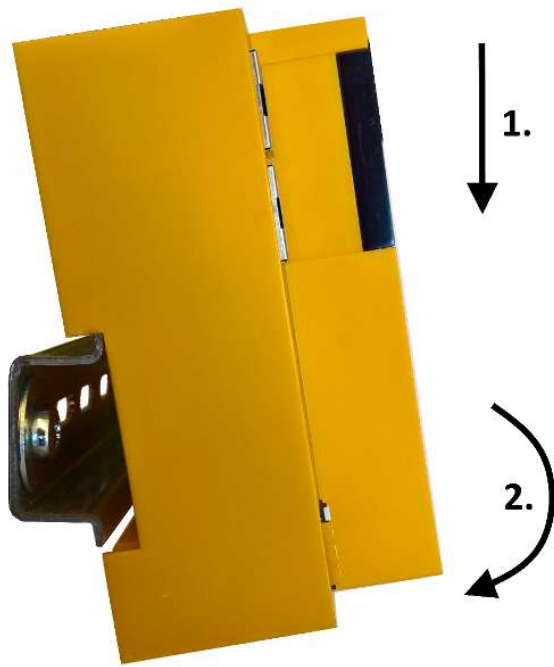


Fig. 18: Mounting the EK1960 on the DIN rail

The EK1960 is released from the DIN rail by opening the two clamps on top of or underneath the device. To do this, insert a screwdriver into the recess provided and open the clamp until it latches.



Fig. 19: DIN rail clamp closed

Once the two upper or lower clamps are unlocked, the device can be taken off the DIN rail in an upward or downward direction.



Fig. 20: DIN rail clamp opened

5.2.4 Electrical installation

5.2.4.1 Overvoltage protection

If protection against overvoltage is necessary in your system, provide an overvoltage protective circuit (surge filter) for the power supply to the TwinSAFE compact controller.

5.2.4.2 Wiring

The connectors support the push-in wiring of individual wires and fine-wire conductors with wire-end sleeves. In the case of multi-wire and fine-wire conductors, the latch must be depressed to connect the conductor with the contact point.

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

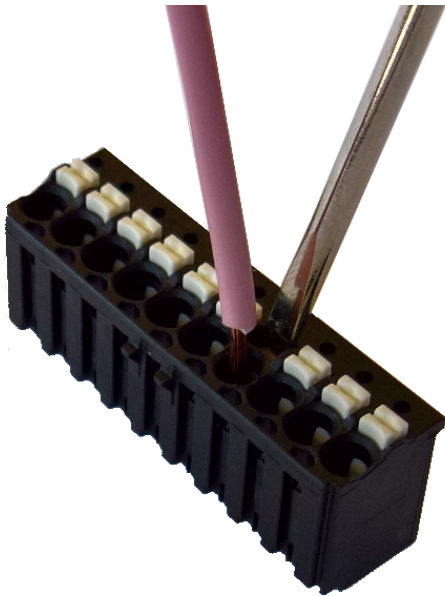


Fig. 21: ZS2003-0002 Depressing the latch

5.2.4.3 Signal cables

Cable routing

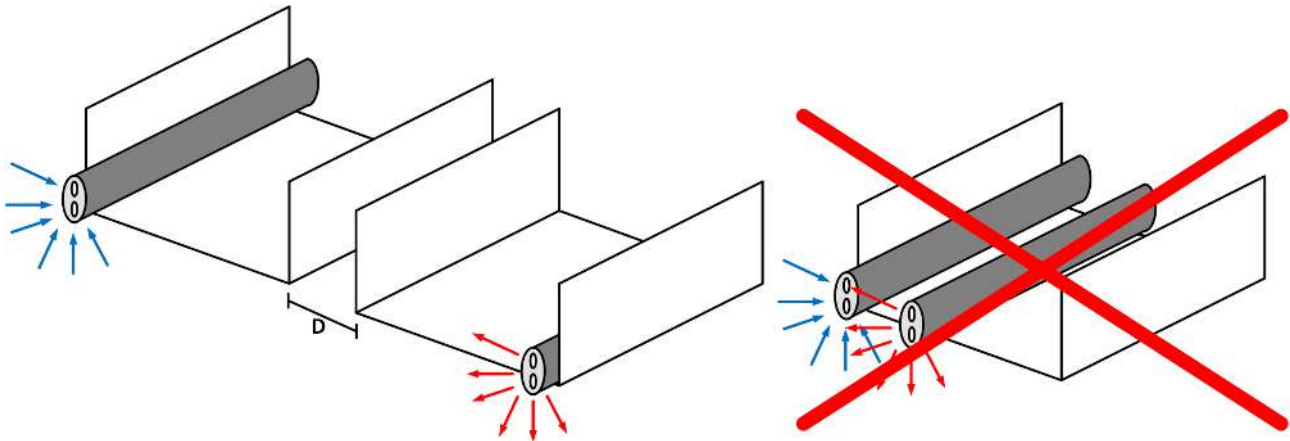


Fig. 22: Cable routing

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.

5.3 Configuration of the controller in TwinCAT

⚠ CAUTION

Do not change CoE objects!

Do not make modifications to the CoE objects of the TwinSAFE compact controller. Any modifications of the CoE objects (e.g. via TwinCAT 3) will permanently set the controller to the Fail-Stop state or lead to unexpected behavior of the controller!

5.3.1 Configuration requirements

Version 3.1 build 4020 or higher of the TwinCAT automation software is required for configuring the EL6910. The current version is available for download from the Beckhoff website (www.beckhoff.de).

- TwinCAT support**
- i** The EK1960 cannot be used under TwinCAT 2

5.3.2 Insertion of a controller

An EK1960 is inserted in exactly the same way as any other Beckhoff EtherCAT device. In the list, open *Safety Terminals* and select the EK1960.

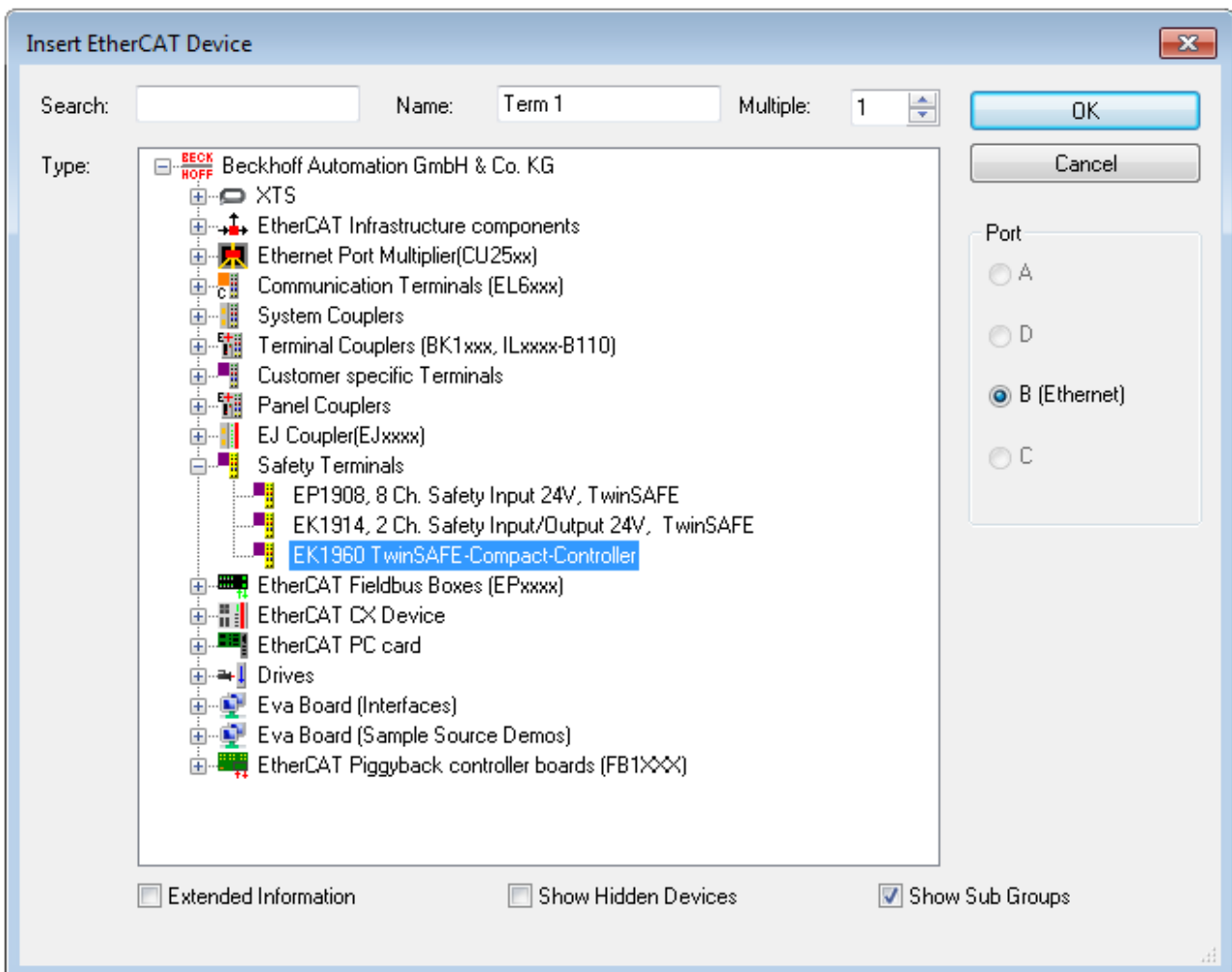


Fig. 23: Inserting an EK1960

i **Size of the process image**

The process image of the EL6910 is adjusted dynamically, based on the TwinSAFE configuration created in TwinCAT 3.

5.3.3 Creating a safety project in TwinCAT 3

i **Further documentation**

Information regarding the TwinSAFE-blocks, -groups and -connections can be found in the *TwinSAFE-Logik-FB* Documentation available on the Beckhoff website under <http://www.beckhoff.de/german/download/twinsafe.htm>.

5.3.3.1 Add new item

In TwinCAT 3 a new project can be created via *Add New Item...* in the context menu of the *Safety* node.

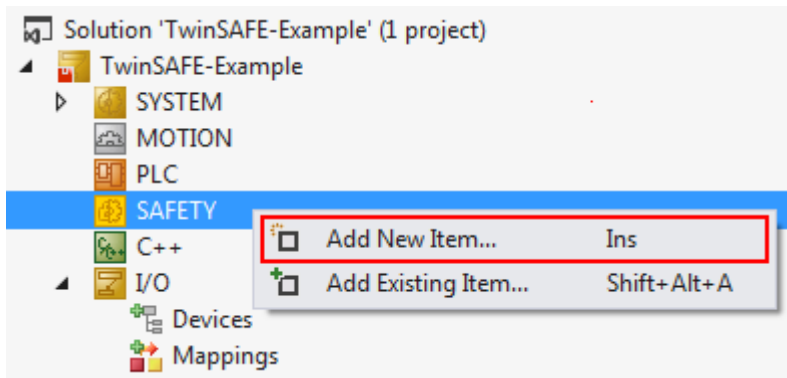


Fig. 24: Creating a safety project - Add New Item

The project name and the directory can be freely selected.

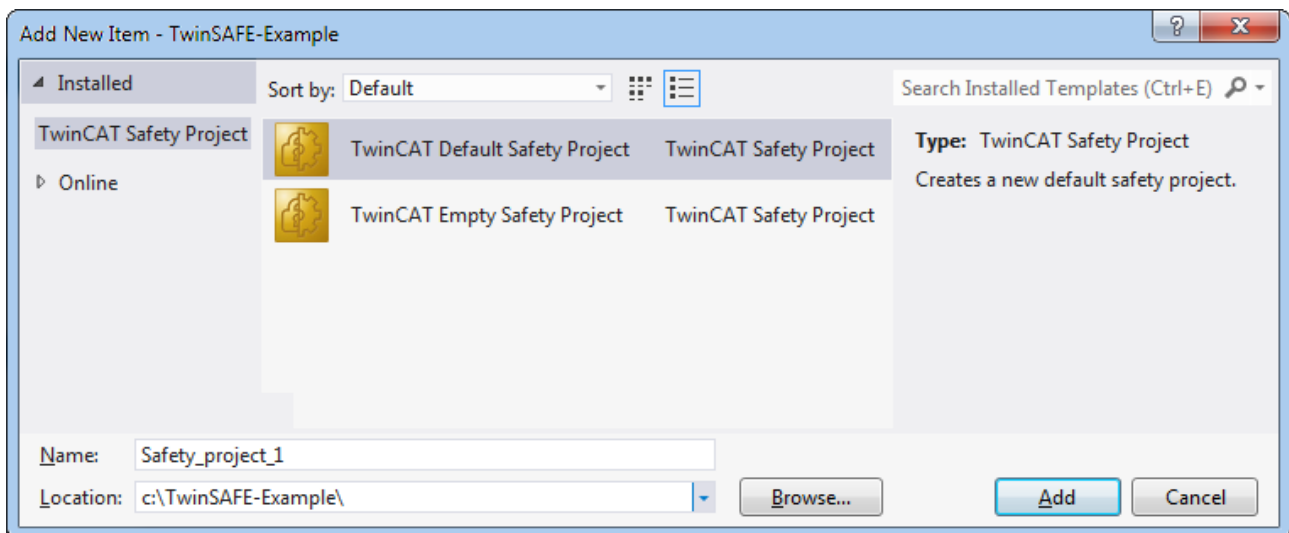


Fig. 25: Creating a safety project - project name and directory

5.3.3.2 TwinCAT Safety Project Wizard

In the TwinCAT Safety Project wizard you can then select the target system, the programming language, the author and the internal project name. Select the setting *Hardware Safety PLC* as the target system and the graphical editor as the programming language. The author and the internal project name can be freely selected by the user.

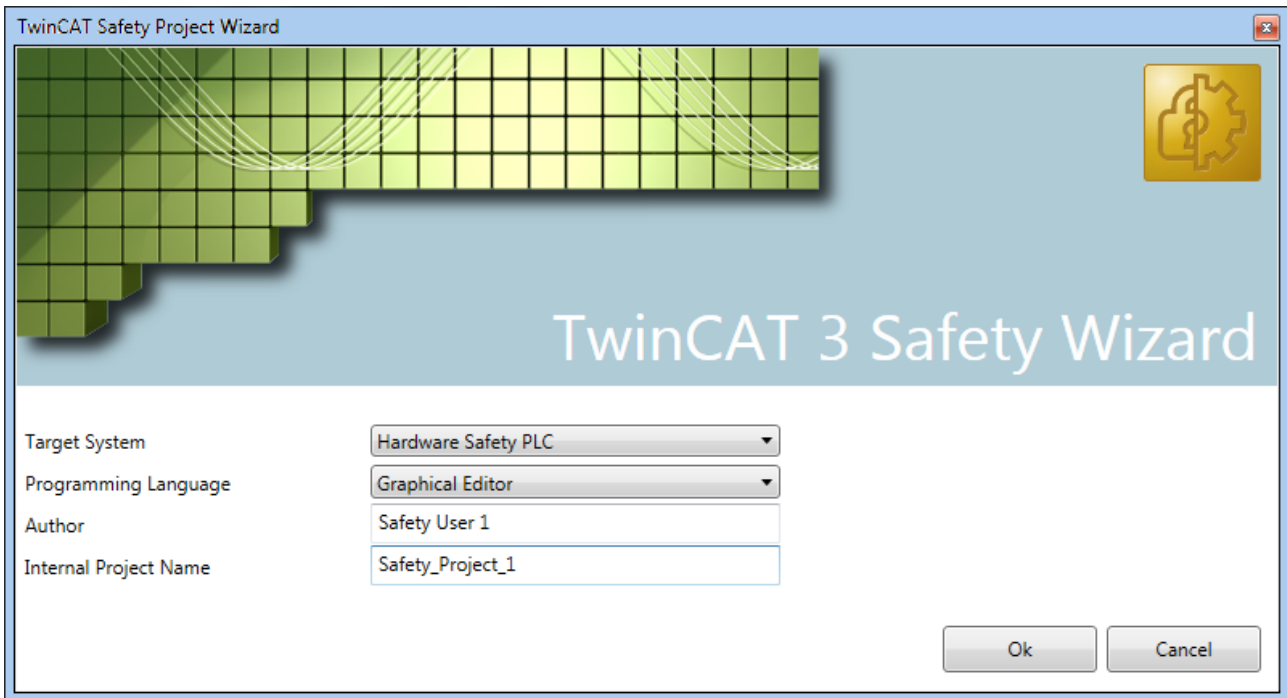


Fig. 26: TwinCAT Safety Project Wizard

5.3.3.3 Target System

After creating the project with the Project Wizard, the safety project can be assigned to the physical EK1960 TwinSAFE controller by selecting the *Target System* node.

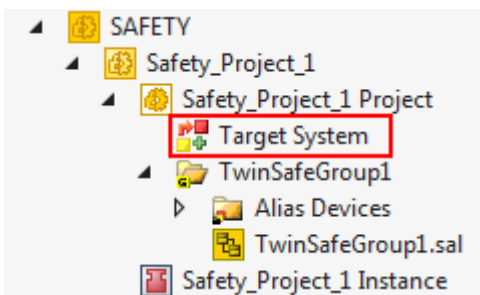



Fig. 27: Selecting the Target System node

The target system is set to EK1960 via the drop-down list and linked with the EK1960 controller via the link

button  next to *Physical Device*. If online ADS access to the controller is possible, the software version, serial number, online project CRC and rotary switch address are automatically read from the controller. The rotary switch address must correspond to the *Safe Address* set by the user.

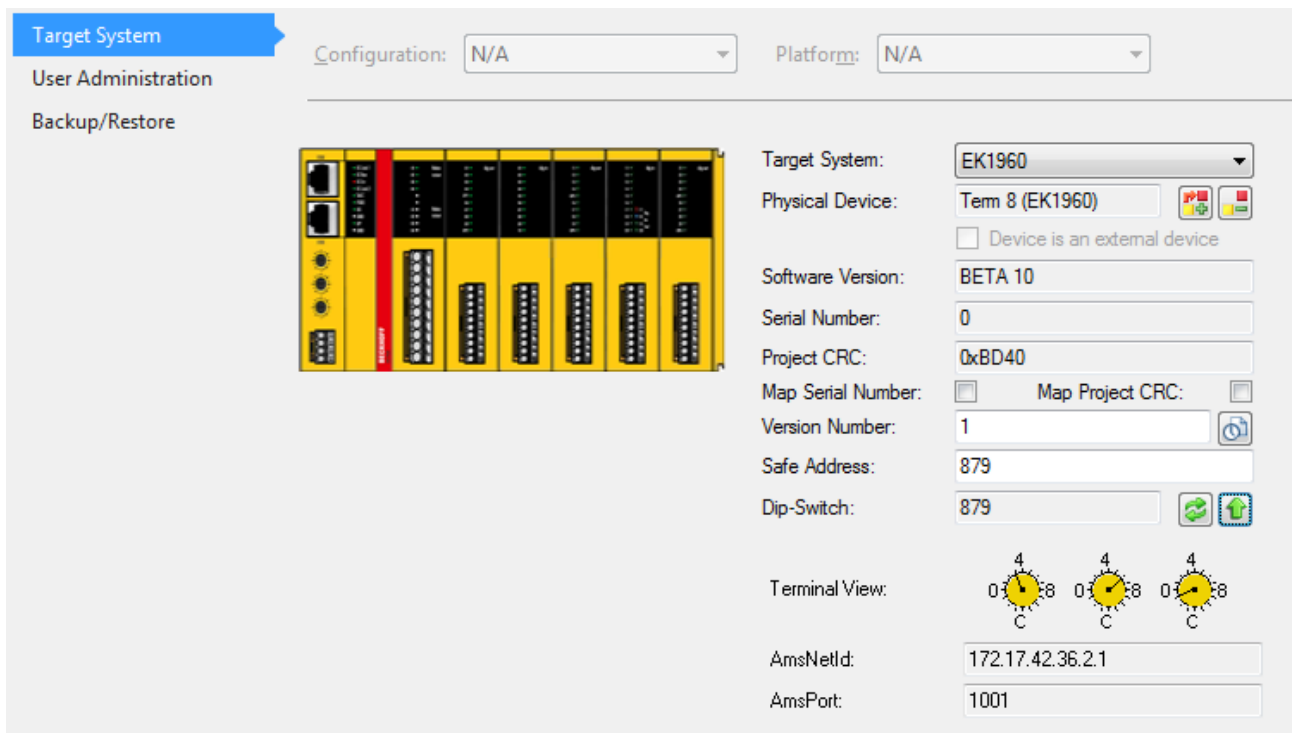
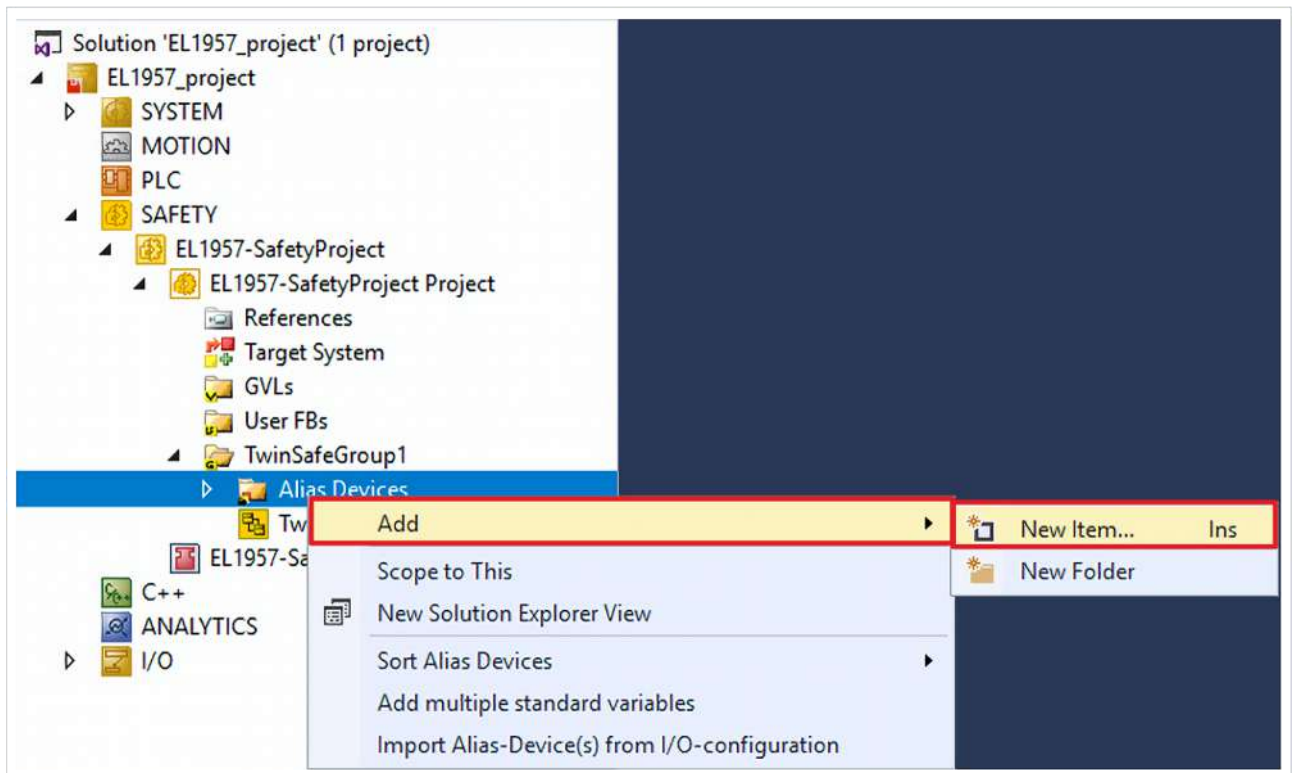


Fig. 28: Linking of target system and TwinSAFE compact controller

5.3.3.4 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.

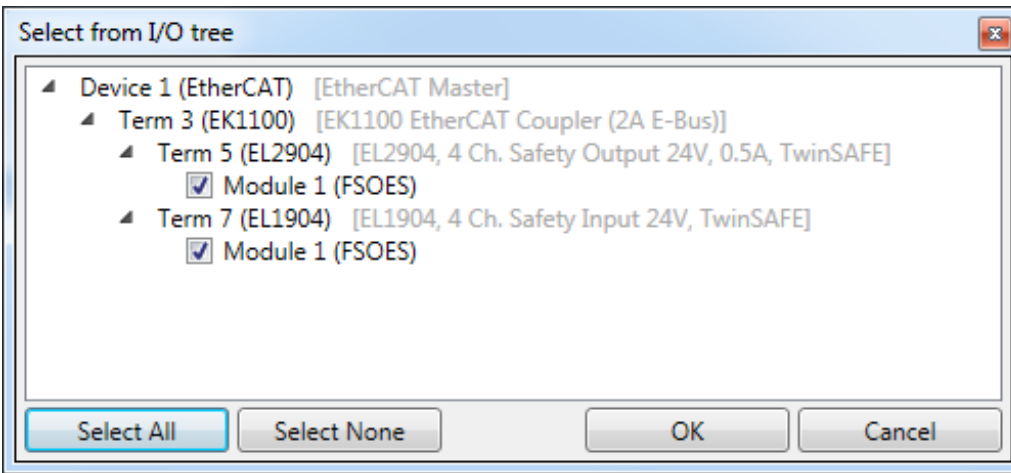


Fig. 29: Selection from the I/O tree

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.

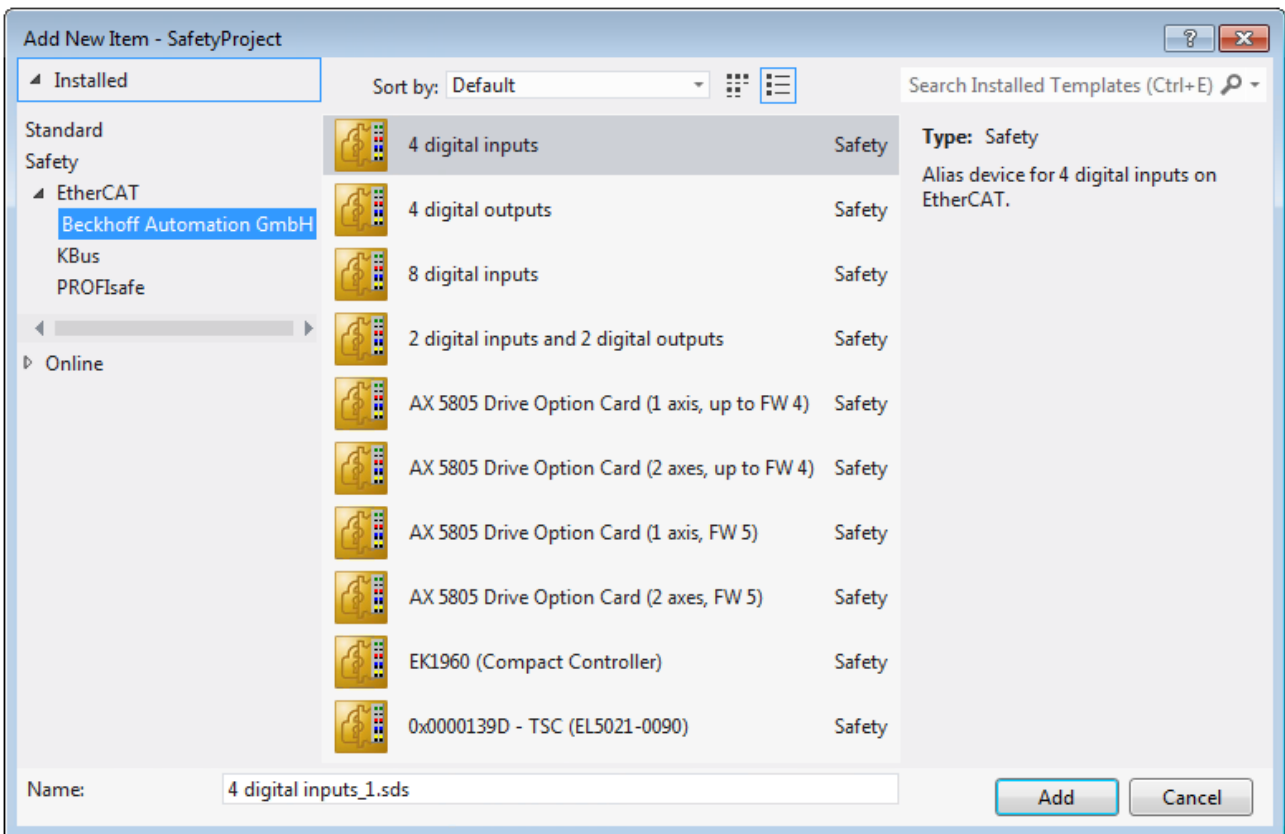


Fig. 30: Creating alias devices by the user

5.3.3.5 Parameterization of the alias device

The settings can be opened by double-clicking on the Alias Device in the safety project structure.

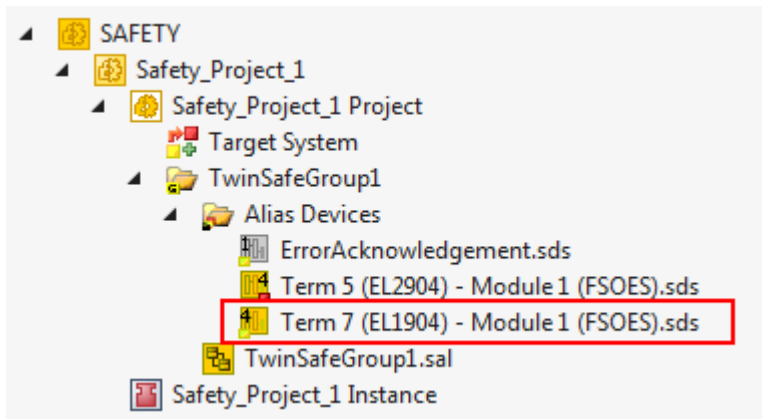


Fig. 31: Alias Device in the safety project structure

The *Linking* tab contains the FSoE address, the checkbox for setting as *External Device* and the link to the physical I/O device. If an ADS online connection to the physical I/O device exists, the DIP switch setting is

displayed. Re-reading of the setting can be started via the button . The links to the EL6910/EJ6910 process image are displayed under *Full Name (input)* and *Full Name (output)*.

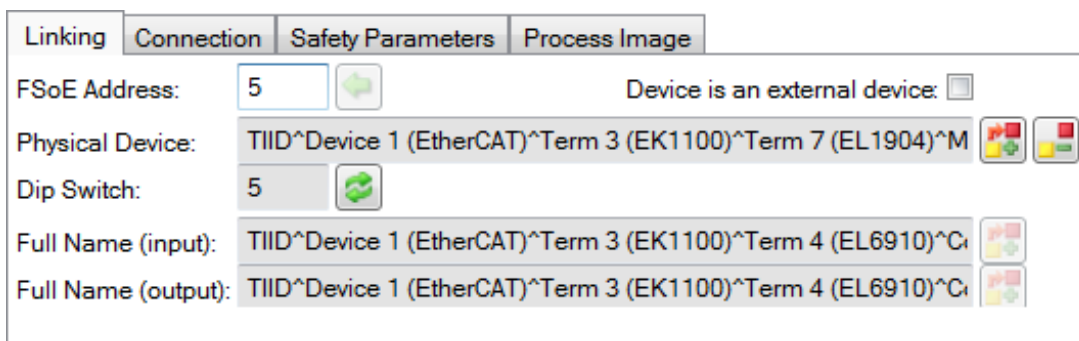


Fig. 32: Links to EL6910/EJ6910 process image

The *Connection* tab shows the connection-specific parameters.

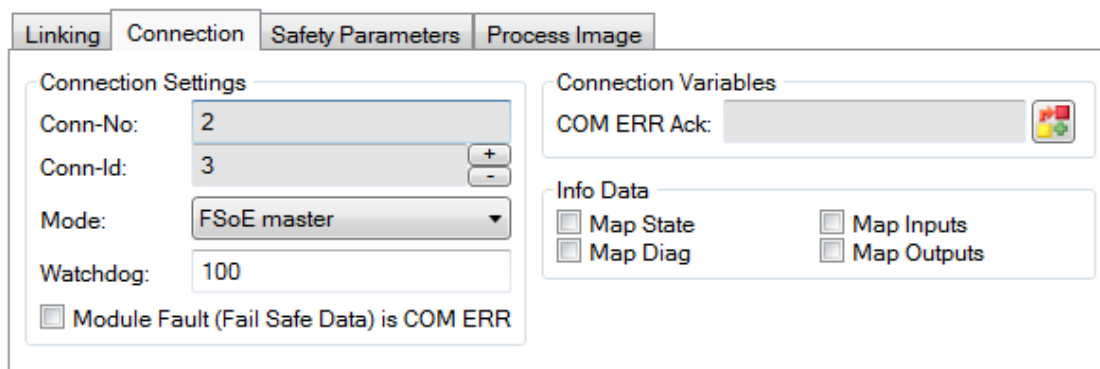



Fig. 33: Connection-specific parameters

Parameter	Description	User interaction required
Conn. no.	Connection number - automatically assigned by the TwinCAT system	No

Parameter	Description	User interaction required
Conn ID	Connection ID: preallocated by the system, but can be changed by the user. A Conn ID must be unique within a configuration. Duplicate connection IDs result in an error message.	Check
Mode	FSoE master: EL6910/EJ6910 is FSoE master for this device. FSoE slave: EL6910/EJ6910 is FSoE slave for this device.	Check
Watchdog	Watchdog time for this connection. A ComError is generated if the device fails to return a valid telegram to the EL6910/EJ6910 within the watchdog time.	Yes
Module Fault is ComError	This checkbox is used to specify the behavior in the event of an error. If the checkbox is ticked and a module error occurs on the Alias Device, this also leads to a connection error and therefore to disabling of the TwinSAFE group, in which this connection is defined.	Yes
ComErrAck	If ComErrAck is linked to a variable, the connection must be reset via this signal in the event of a communication error.	Yes
Info data	The info data to be shown in the process image of the EL6910/EJ6910 can be defined via these checkboxes. Further information can be found in the documentation for <i>TwinCAT function blocks for TwinSAFE Logic terminals</i> .	Yes

The EL6910/EJ6910 support activation of a ComErrAck at each connection. If this signal is connected, the respective connection must be reset after a communication error via the signal ComErrAck, in addition to the

ErrAck of the TwinSAFE group. This signal is linked via the link button  next to COM ERR Ack. The following dialog can be used for selecting an alias device. The signal can be cancelled via the *Clear* button in the *Map to* dialog.

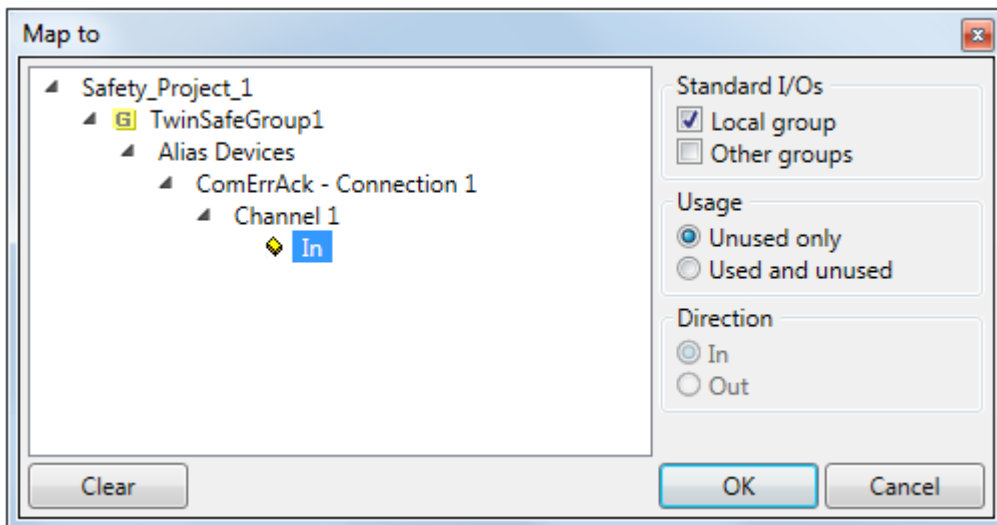


Fig. 34: Selecting an alias device

The safety parameters matching the device are displayed under the *Safety Parameters* tab. They have to be set correctly to match the required performance level. Further information can be found in the TwinSAFE application manual.

Index	Name	Value	Unit
8000:0	FS Operating Mode	>1<	
8000:01	Operating Mode	digital (0)	
8001:0	FS Sensor Test	>5<	
8001:01	Sensor test Channel 1 active	TRUE (1)	
8001:02	Sensor test Channel 2 active	TRUE (1)	
8001:03	Sensor test Channel 3 active	TRUE (1)	
8001:04	Sensor test Channel 4 active	TRUE (1)	
8002:0	FS Logic of Input pairs	>5<	
8002:01	Logic of Channel 1 and 2	single logic ch...	
8002:03	Logic of Channel 3 and 4	single logic ch...	

Edit

Fig. 35: Safety parameter for the device

5.3.3.6 Connection to AX5805/AX5806

There are separate dialogs for linking an AX5805 or AX5806 TwinSAFE Drive option card, which can be used to set the safety functions of the AX5000 safety drive options.

Creating and opening of an alias device for an AX5805 results in five tabs; the *Linking*, *Connection* and *Safety Parameters* tabs are identical to other alias devices.

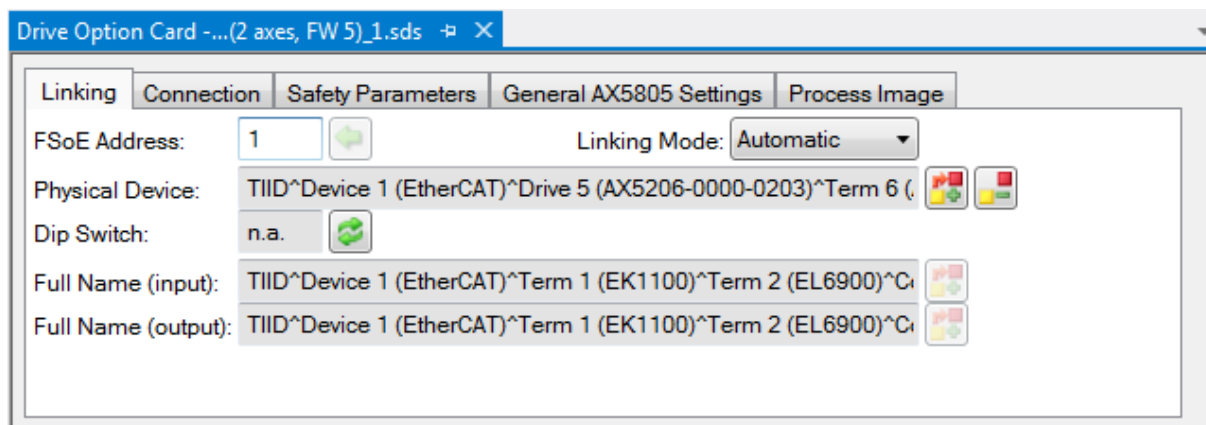


Fig. 36: AX5000 safety drive functions

The *General AX5805 Settings* tab can be used to set the motor string and the SMS and SMA functions for one or two axes, depending on the added alias device.

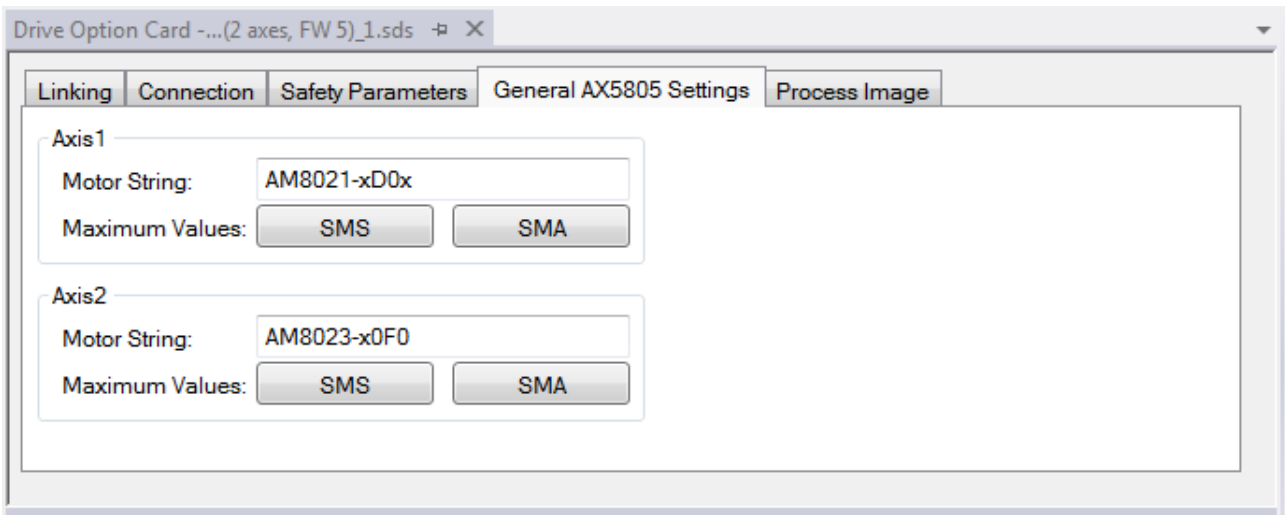


Fig. 37: AX5000 safety drive options - general AX5805 settings

The Process Image tab can be used to set the different safety functions for the AX5805.

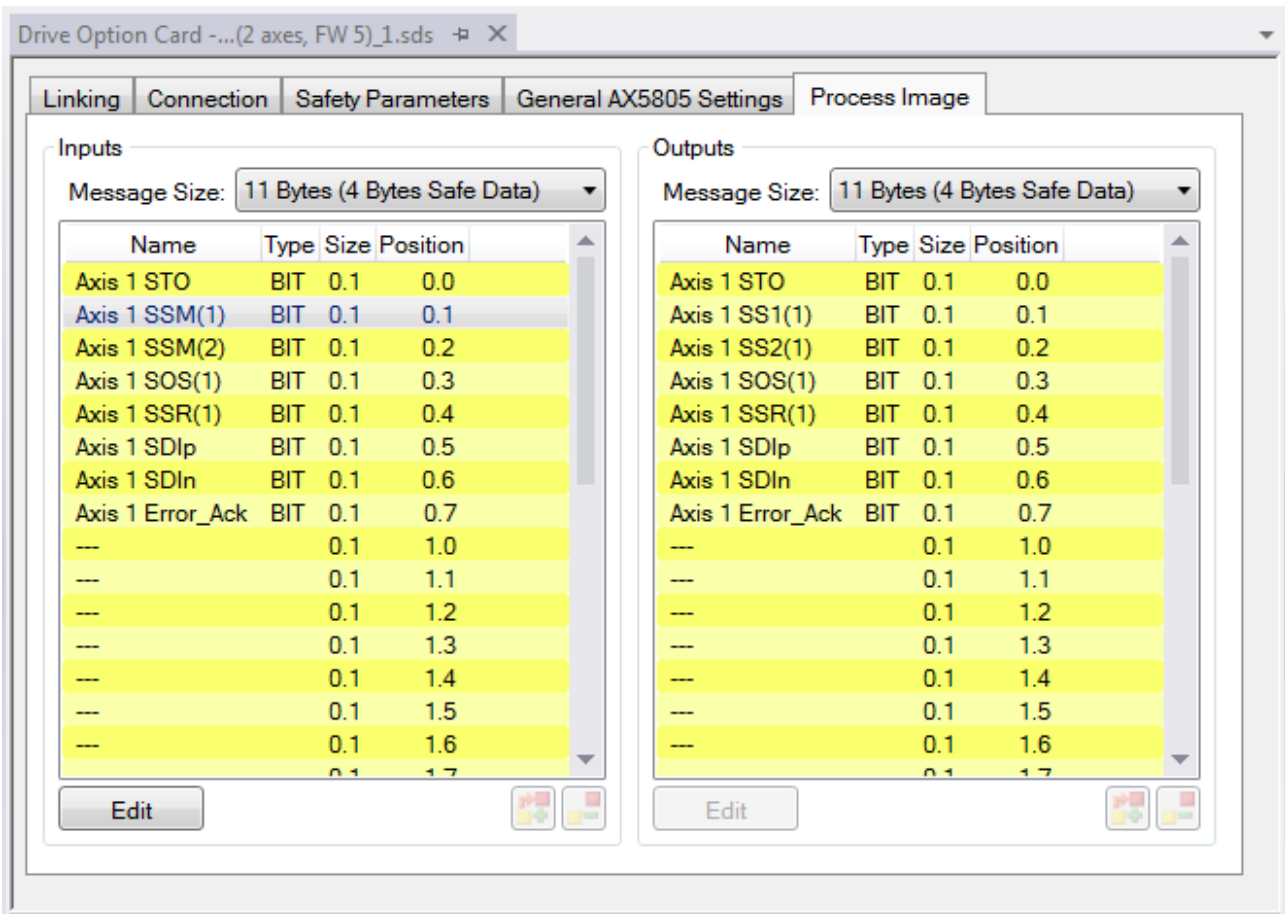


Fig. 38: AX5000 safety drive options - Process Image

The parameters under the *General AX5805 Settings* and *Process Image* tabs are identical to the parameters under the *Safety Parameters* tab. Offers user-friendly display and editing of the parameters. The parameters under the *Safety Parameters* tab can also be edited.

The parameters for this function can be set by selecting a function in the inputs or outputs and pressing the *Edit* button. New safety functions can be added in the process image by selecting an empty field (---) and pressing *Edit*.

The parameter list corresponding to the safety function can be shown; in addition, an optional diagram of the function can be shown. At present the diagram is still static and does not show the currently selected values.

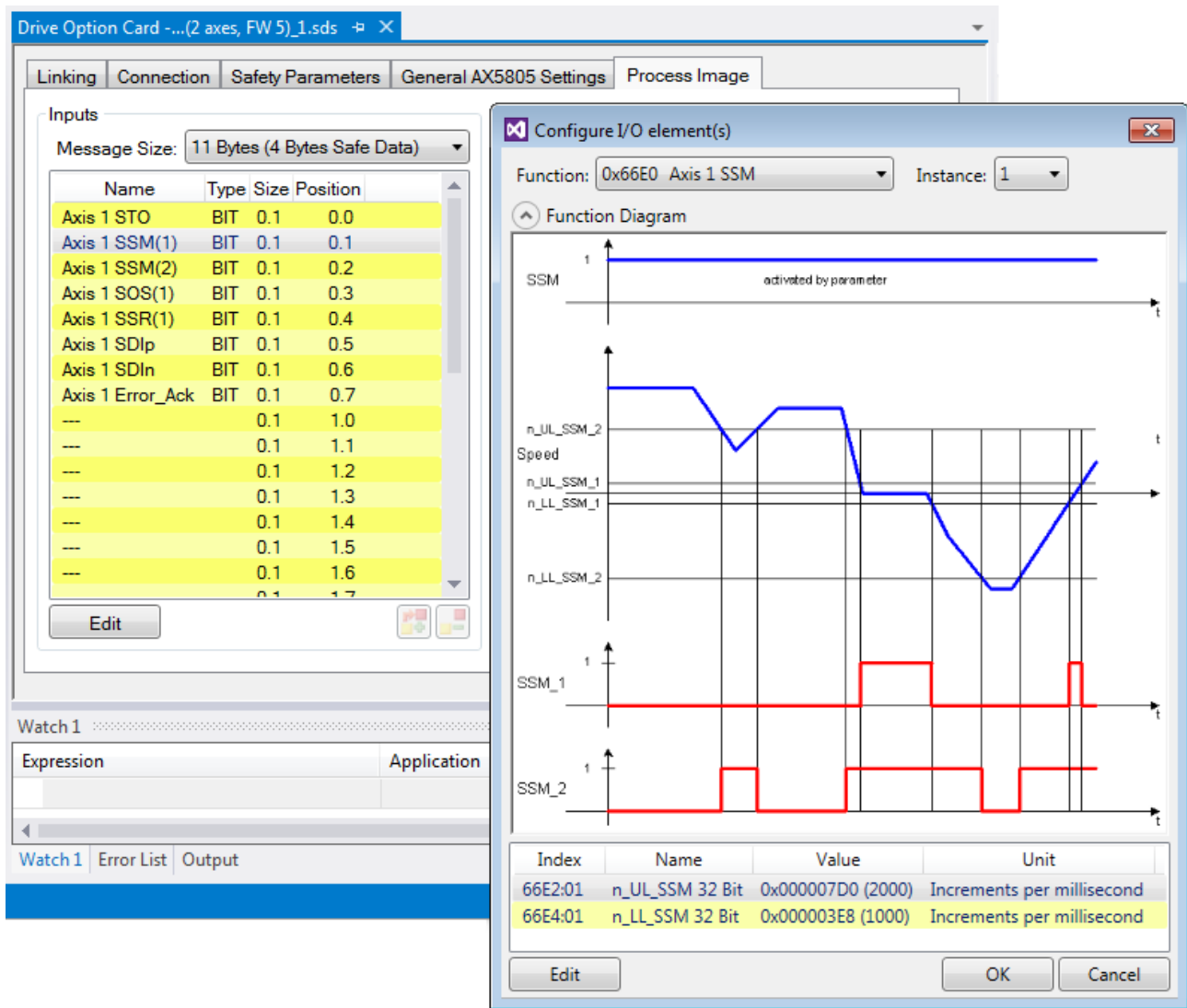


Fig. 39: AX5000 safety drive options - Function Diagram

5.3.3.7 External connection

An external *Custom FSoE Connection* can be created for a connection to a further EL69x0, EJ6910, KL6904 or third-party device. If a dedicated ESI file exists for a third-party device, the device is listed as a selectable safety device, and the *Custom FSoE Connection* option is not required.

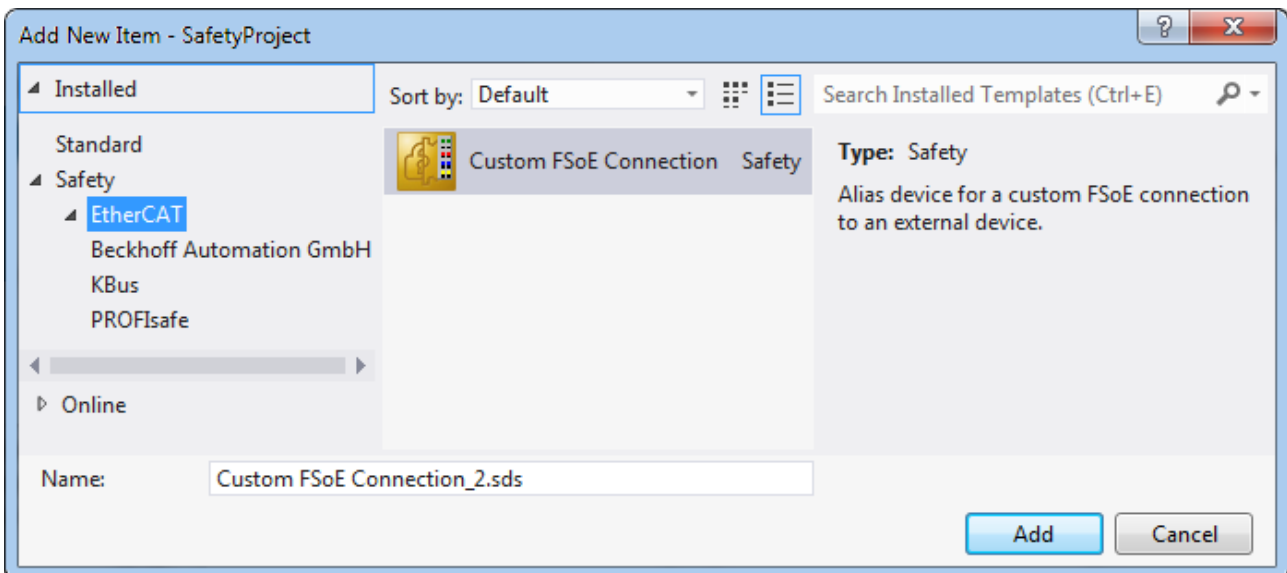


Fig. 40: Creating an external connection (Custom FSoE Connection)

Before the connection can be used and linked further, the process image size must be parameterized. This can be set under the *Process Image* tab. Suitable data types for different numbers of safety data are provided in the dropdown lists for the input and output parameters.

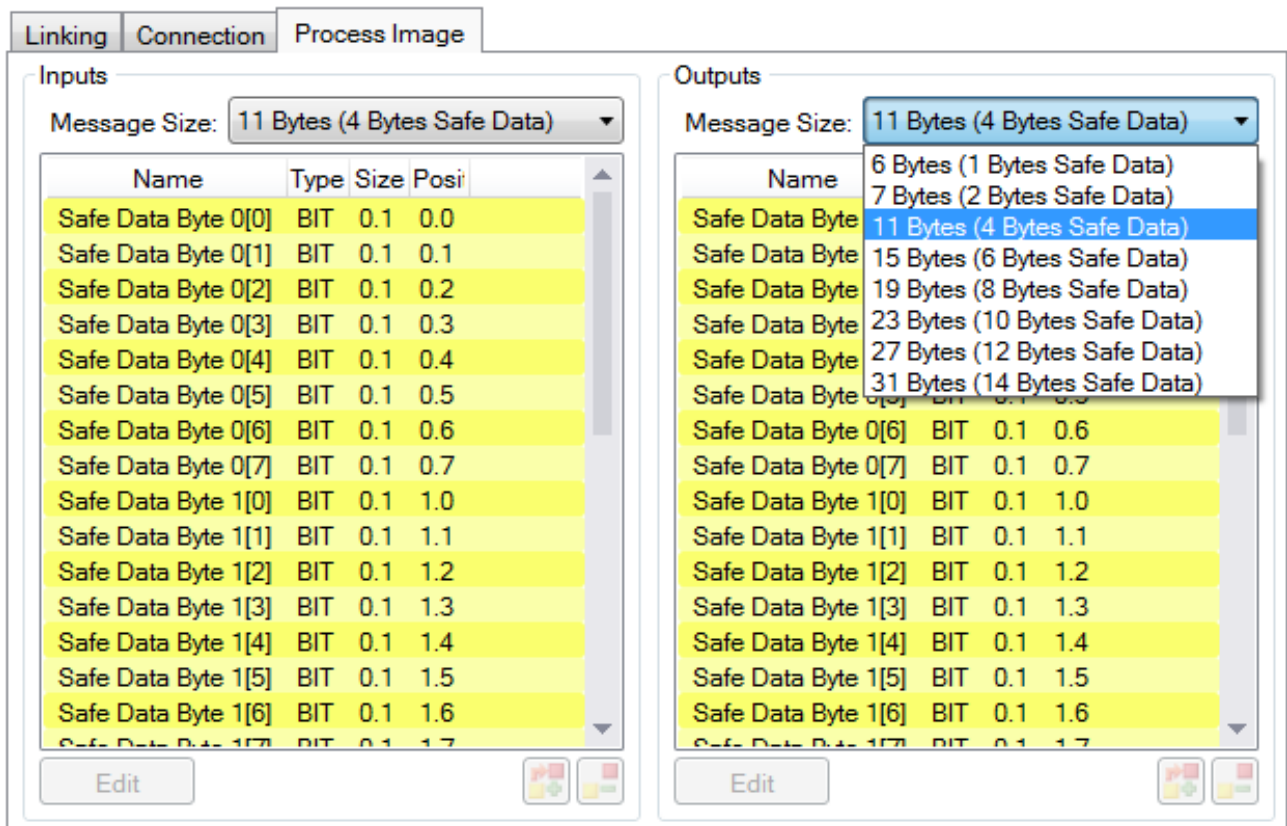


Fig. 41: Parameterization of the process image size

Once the size is selected, the individual signals within the telegram can be renamed, so that a corresponding plain text is displayed when these signals are used in the logic. If the signals are not renamed, the default name is displayed in the editor (Safe Data Byte 0[0], ...).

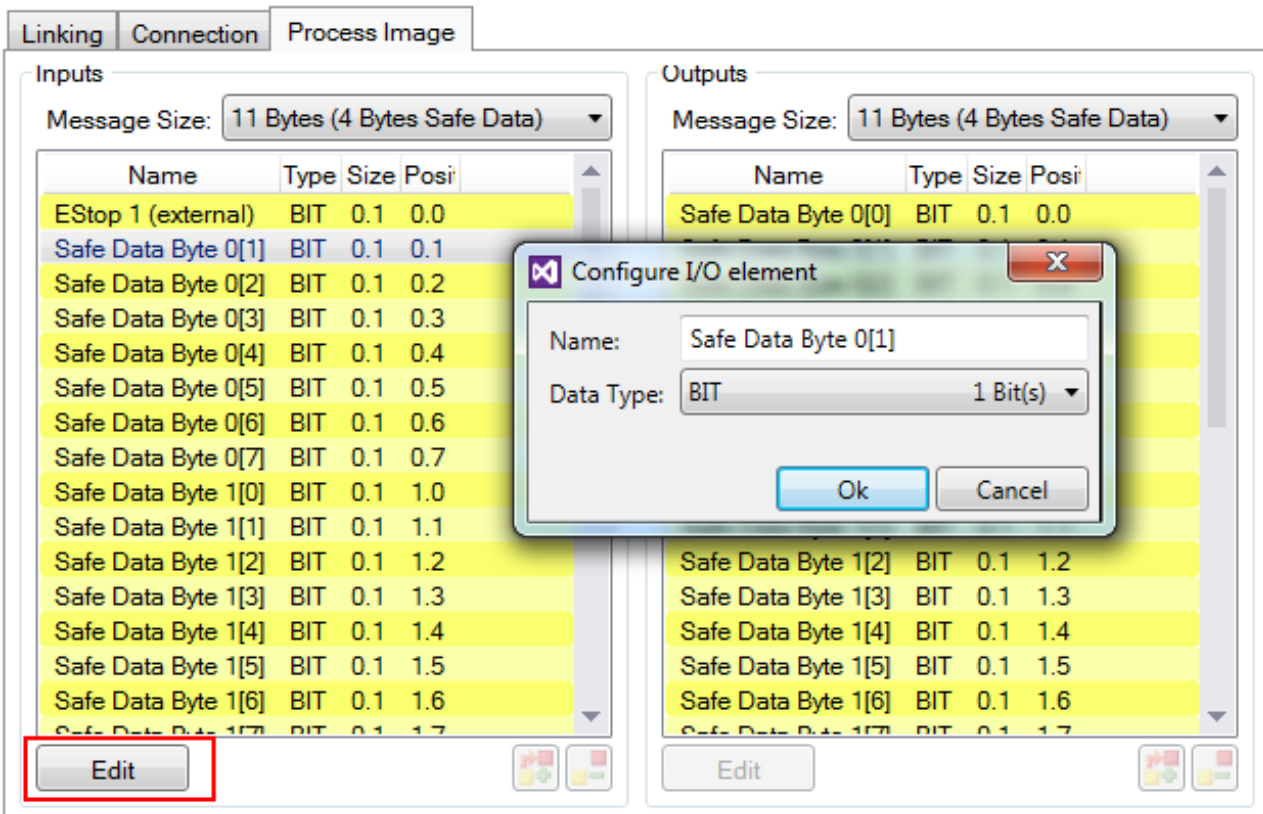



Fig. 42: Renaming the individual signals within the telegram

The connection is linked under the *Linking* tab. The Link button  next to *Full Name (input)* and *Full Name (output)* can be used to select the corresponding variable.

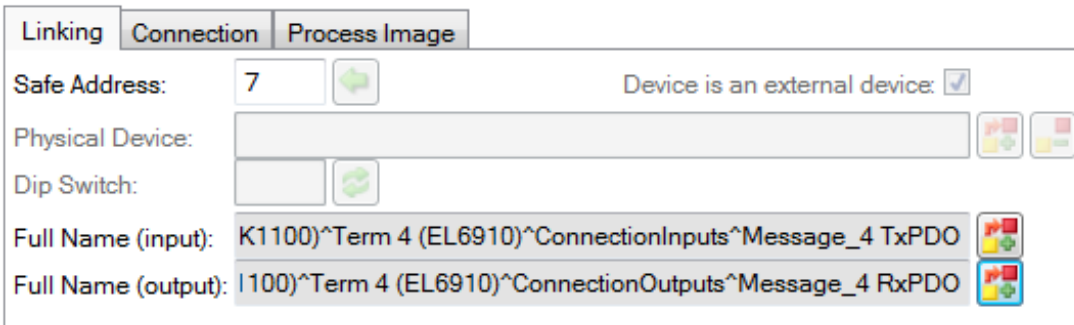


Fig. 43: Selecting the variables

This can be a PLC variable, for example, which is then forwarded to the remote device or can be linked directly with the process image of an EtherCAT Terminal (e.g. EL69x0 or EL6695).

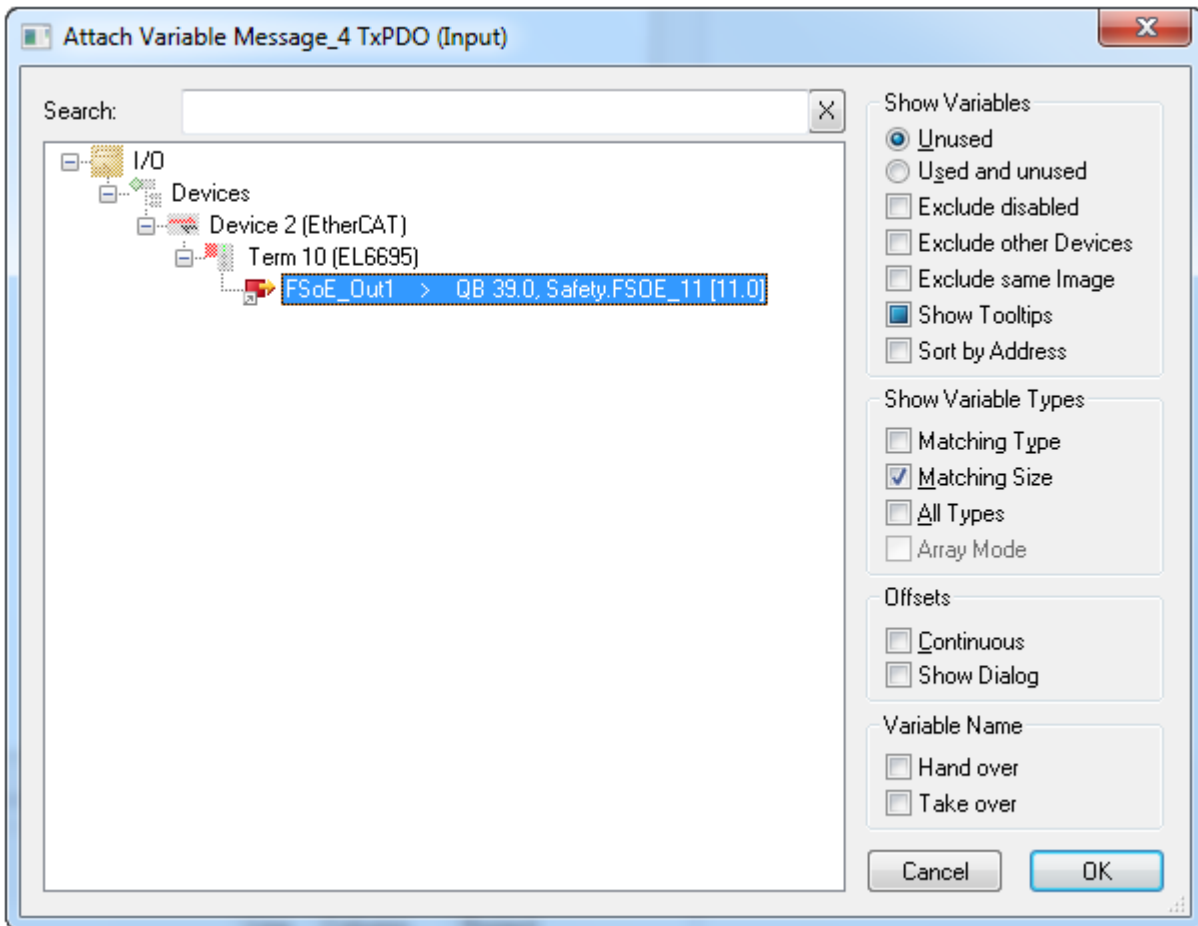


Fig. 44: Direct linking with the process image of an EtherCAT Terminal

Further information can be found in the TwinCAT documentation for the variable selection dialog.

The *Connection* tab is used to set the connection-specific parameters.

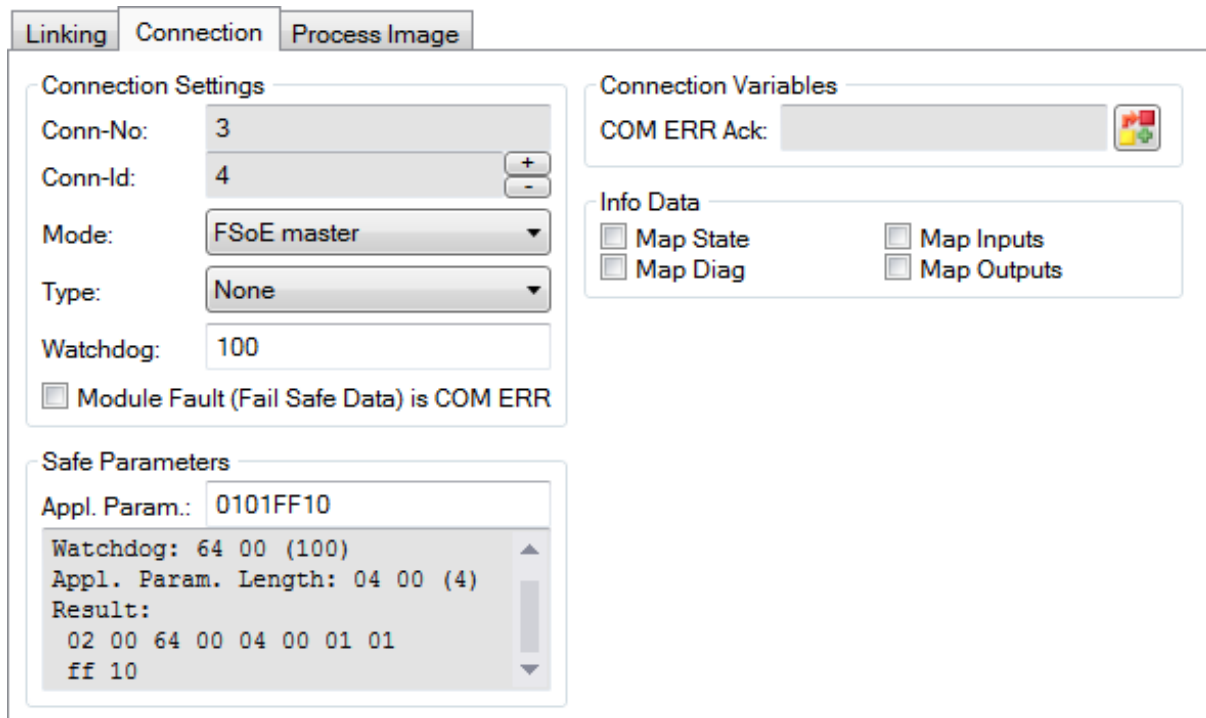


Fig. 45: Connection-specific parameters

Detailed information about the individual settings can be found in the following table.

Parameter	Description	User interaction required
Conn. no.	Connection number: is automatically assigned by the TwinCAT system	No
Conn ID	Connection ID: preallocated by the system, but can be changed by the user. A Conn ID must be unique within a configuration. Duplicate connection IDs result in an error message	Check
Mode	FSoE master: EL6910/EJ6910 is FSoE master for this device. FSoE slave: EL6910/EJ6910 is FSoE slave for this device.	Check
Type	None: Setting for third-party equipment, for which no ESI file is available. KL6904: Setting for KL6904 (safety parameter inactive) EL69XX: Setting for EL6900/EL6930/EL6910/EJ6910 (safety parameter inactive)	Yes
Watchdog	Watchdog time for this connection: A ComError is generated, if the device fails to return a valid telegram to the EL6910 within the watchdog time.	Yes
Module Fault is ComError	This checkbox is used to specify the behavior in the event of an error. If the checkbox is ticked and a module error occurs on the Alias Device, this also leads to a connection error and therefore to disabling of the TwinSAFE group, in which this connection is defined.	Yes
Safe Parameters (Appl. Param)	Device-specific parameters: The parameter length is automatically calculated from the number of characters that is entered. This information will typically be provided by the device manufacturer.	Yes
ComErrAck	If ComErrAck is linked to a variable, the connection must be reset via this signal in the event of a communication error.	Yes
Info data	The info data to be shown in the process image of the EL6910/EJ6910 can be defined via these checkboxes. Further information can be found in the documentation for <i>TwinCAT function blocks for TwinSAFE Logic terminals</i> .	Yes

5.3.3.8 Local safe inputs and outputs of the EK1960

An alias device must also be created for the local safe inputs and outputs of the EK1960. To do this, a new alias device is created and the EK1960 selected via *Add New item*. The name of the alias device can be freely assigned.

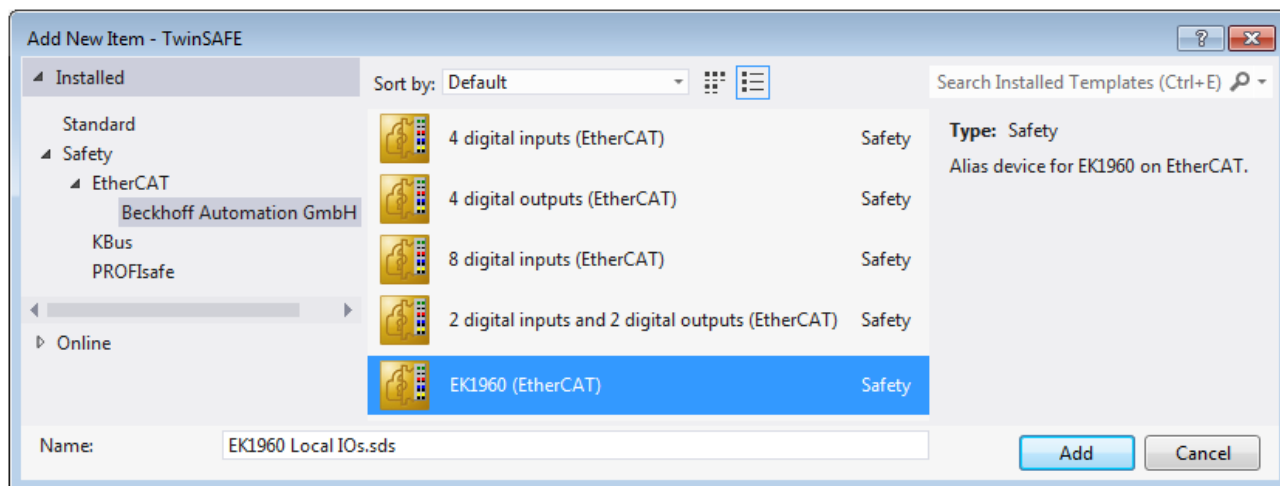


Fig. 46: Insertion of an EK1960 alias device

After opening the alias device the *Linking Mode* must be set to *Local*. The result of this is that all settings that are not relevant for this mode are grayed out.

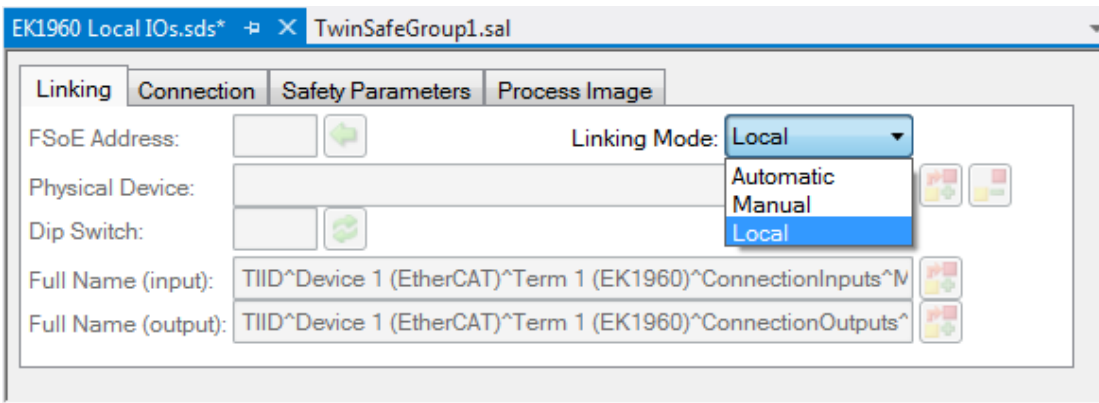


Fig. 47: Switching the alias device to *Local*

Only the info data for inputs and outputs can be activated on the *Connection* tab.

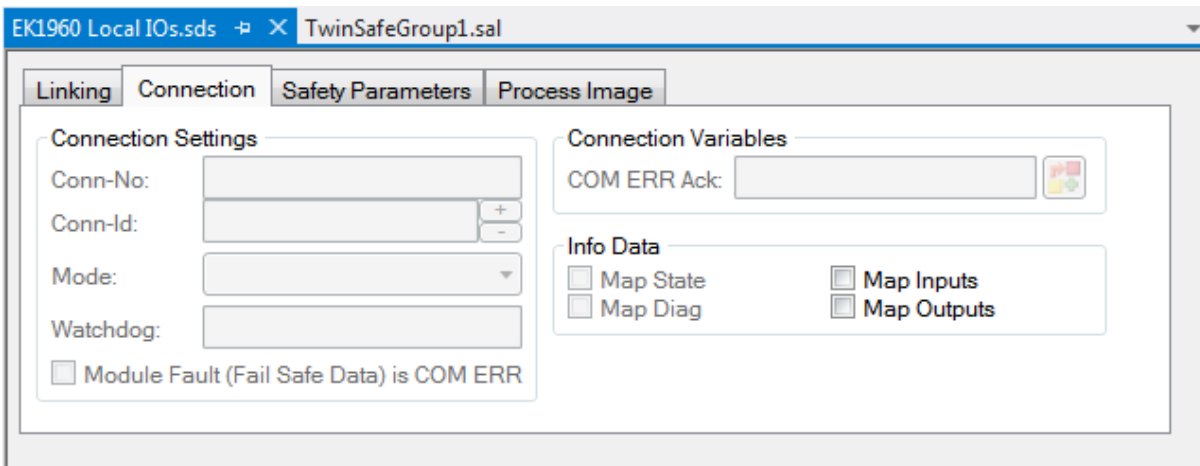


Fig. 48: Info data for local connection

The corresponding parameters are set for each input and output module on the Safety Parameter tab.

Index	Name	Value	Unit
8000:0	FSOUT Module 1 Settings Common	>5<	
8000:01	ModuloDiagTestPulse	0x00 (0)	
8000:02	MultiplierDiagTestPulse	0x04 (4)	
8000:03	Standard Outputs active	FALSE (0)	
8000:04	Diag TestPulse active	FALSE (0)	
8000:05	Diag TestPulse for Inputs active	TRUE (1)	
8010:0	FSOUT Module 2 Settings Common	>5<	
8020:0	FSOUT Module 3 Settings Common	>5<	
8030:0	FSOUT Module 4 Settings Common	>5<	
8040:0	FSOUT Module 5 Settings Common	>5<	
8050:0	FSOUT Module 6 Settings Common	>5<	
8060:0	FSOUT Relais Module Settings Common	>3<	
8071:0	FSIN Module 1 Settings Channel	>6<	
8071:01	Channel 1.InputFilterTime	0x000A (10)	×10 ⁻⁴ second
8071:02	Channel 1.DiagTestPulseFilterTime	0x0003 (3)	×10 ⁻⁴ second
8071:03	Channel 1.Testpulse Diag Mode	Testpulse Detection Output Module 1, Channel 1 (257)	
8071:04	Channel 2.InputFilterTime	0x000A (10)	×10 ⁻⁴ second
8071:05	Channel 2.DiagTestPulseFilterTime	0x0003 (3)	×10 ⁻⁴ second
8071:06	Channel 2.Testpulse Diag Mode	External Testpulse (0)	

Edit

Fig. 49: Safety parameters of the output and input modules

Overview of output parameters

PrmName	Index	Meaning	Value
FSOUT Module 0 Settings Common	80x0:00	Settings for output module 0 (outputs 01 - 04)	-
ModuloDiag TestPulse	80x0:01	Test frequency of the clocking All modules used are processed in succession in one logic cycle respectively. With Modulo=0 the test is carried out in each cycle in the respectively current module; with Modulo=1 only every second pass and so on.	0
MultiplierDiag TestPulse	80x0:02	Duration of the clocking 1 = 400 µs (this value will need to be increased according to the connected load if the outputs are open circuit or in the case of very small output currents)	1
Standard Outputs active	80x0:03	FALSE = standard outputs deactivated TRUE = standard outputs are ANDED with the safe outputs	FALSE
Diag TestPulse active	80x0:04	FALSE: Clocking of the outputs deactivated TRUE: Clocking of the outputs activated	FALSE
Diag TestPulse for Inputs active	80x0:05	FALSE: Clocking of the outputs for local inputs deactivated TRUE: Clocking of the outputs for local inputs activated. If TRUE is set here the parameter DiagTestPulseActive is also set to TRUE.	FALSE
Module Fault Link active	80x0:07	In the event of a module error of this module, all other modules of this TwinSAFE component, where this parameter is also set to TRUE, are set to a module error. This parameter is available from FW03 and ESI revision -0021. For projects, which are created with a firmware smaller than 03 and a revision smaller than 0021, the behavior remains unchanged.	TRUE

⚠ WARNING

Parameter *Diag TestPulse for Inputs active*

If this parameter is activated, all outputs of this module are switched on and can be used as test pulses for controller inputs. In this setting the parameter *DiagTestPulseActive* must be set to TRUE.

Corresponding parameters exist under the indices 8000:0 to 8050:0 for the output modules 0 to 5. The module 8060:0 exists for the relay module.

The corresponding parameters are set for each input module on the Safety Parameter tab.

Index	Name	Value	Unit
> 8071:0	FSIN Module 1 Settings Channel	>6<	
> 8081:0	FSIN Module 2 Settings Channel	>6<	
> 8091:0	FSIN Module 3 Settings Channel	>6<	
> 80A1:0	FSIN Module 4 Settings Channel	>6<	
> 80B1:0	FSIN Module 5 Settings Channel	>6<	
> 80C1:0	FSIN Module 6 Settings Channel	>6<	
> 80D1:0	FSIN Module 7 Settings Channel	>6<	
> 80E1:0	FSIN Module 8 Settings Channel	>6<	
▲ 80F0:0	FSIN Module 9 Settings Common	>3<	
80F0:03	InputMode	Digital Mode On (0)	
▲ 80F1:0	FSIN Module 9 Settings Channel	>6<	
80F1:01	Channel 1.InputFilterTime	0x000A (10)	× 10 ⁻⁴ second
80F1:02	Channel 1.DiagTestPulseFilterTime	0x0003 (3)	× 10 ⁻⁴ second
80F1:03	Channel 1.Testpulse Diag Mode	External Testpulse (0)	
80F1:04	Channel 2.InputFilterTime	0x000A (10)	× 10 ⁻⁴ second
80F1:05	Channel 2.DiagTestPulseFilterTime	0x0003 (3)	× 10 ⁻⁴ second
80F1:06	Channel 2.Testpulse Diag Mode	External Testpulse (0)	
> 8100:0	FSIN Module 10 Settings Common	>3<	
> 8101:0	FSIN Module 10 Settings Channel	>6<	

Edit

Fig. 50: Safety parameters of the input modules

Overview of input parameters

PrmName	Index	Meaning	Value
FSIN Module 9 Settings Common	80F0:00	Settings for input module 9 (inputs 17 - 18) This setting exists only for modules 9 and 10	-
InputMode	80F0:03	Only input modules 9 and 10 support the parameters <i>Digital Mode On</i> and <i>Bumper Mode On</i> . All other modules are set to <i>Digital Mode On</i> and cannot be changed by the user.	- Digital Mode On - Bumper Mode On
FSIN Module 1 Settings Channel	8071:00	Settings for input module 1 (inputs 01 - 02)	-
Channel1. InputFiltertime	8071:01	Filter time for an input in the unit 100 μs. After the expiry of this time the signal state is transmitted to the logic on an edge change at the input. This value must be adapted to the length of the test pulses if they are used.	10 (1 ms)
Channel1. DiagTestPulse FilterTime	8071:02	Filter time for an input in the unit 100 μs. This time must elapse before a measurement of the momentary signal state is carried out after an edge change. This value should be adapted to the length of the test pulses if they are used.	3 (300 μs)
Channel1. TestPulse Diag Mode	8071:03	The output channel from which the test pulse is expected must be set here	<i>External Testpulse</i> or drop-down list of the EK1960 outputs
Channel2. InputFiltertime	8071:04	Filter time for an input in the unit 100 μs. After the expiry of this time the signal state is transmitted to the logic on an edge change at the input. This value must be adapted to the length of the test pulses if they are used.	10 (1 ms)
Channel2. DiagTestPulse FilterTime	8071:05	Filter time for an input in the unit 100 μs. This time must elapse before a measurement of the momentary signal state is carried out after an edge change. This value should be adapted to the length of the test pulses if they are used.	3 (300 μs)

PrmName	Index	Meaning	Value
Channel2. TestPulse Diag Mode	8071:06	The output channel from which the test pulse is expected must be set here	<i>External Testpulse</i> or drop-down list of the EK1960 outputs

Corresponding parameters are available for input modules 1 to 10 (inputs 01 to 20) under the indices 8071:0 to 80E1:0 (in 10_{hex} steps - 8071, 8081, 8091, 80A1 and so on).

The input modules 9 and 10 have additional parameters under indices 80F0:0 and 8100:0 with which the operation modes *Digital Mode On* and *Bumper Mode On* can be set.

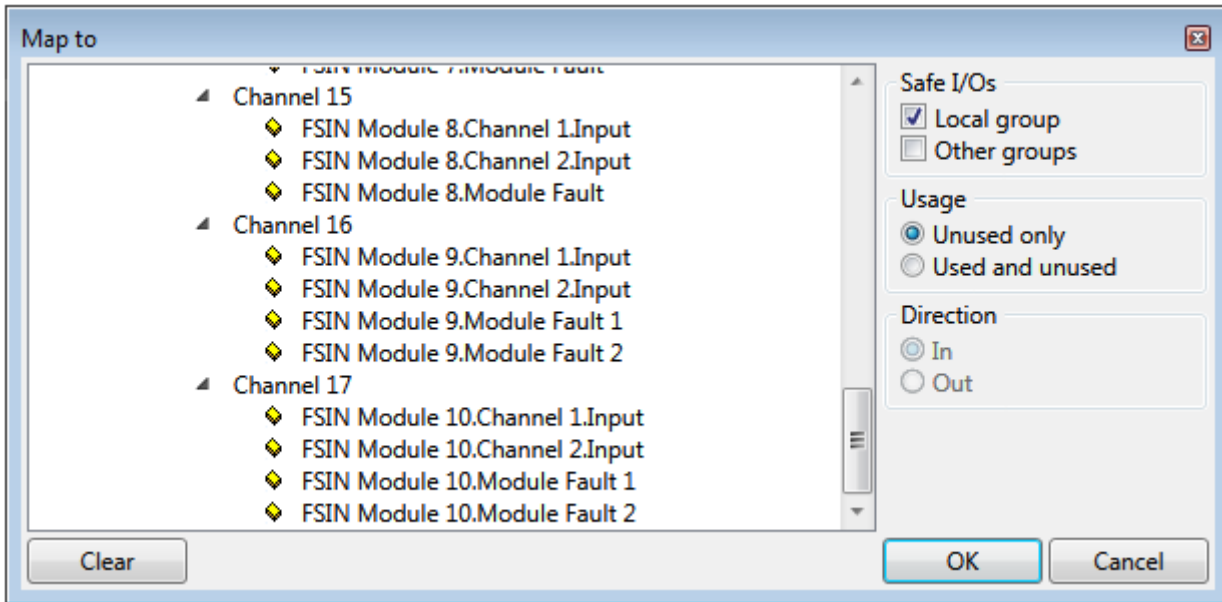


Fig. 51: Process data of input modules 9 and 10

The input modules 9 and 10 have a fault evaluation per channel when using the Bumper Mode, so there are also 2 separate ModuleFault signals. When using the digital mode, both signals are set in the case of a module fault.

● Module use within the safety logic

i Other than with external alias devices, only the corresponding module (two inputs or four outputs) is assigned to the respective TwinSAFE group when selecting an input or output signal of the local alias device. All other modules can be assigned to further TwinSAFE groups. A decoupler FB can be used to make the inputs of a module available to a further group.

5.3.3.9 Creating the safety application

The safety application is realized in the SAL worksheet pertaining to the TwinSAFE group (SAL - **S**afety **A**pplication **L**anguage).

The toolbox provides all the function blocks available on the EL6910/EJ6910.

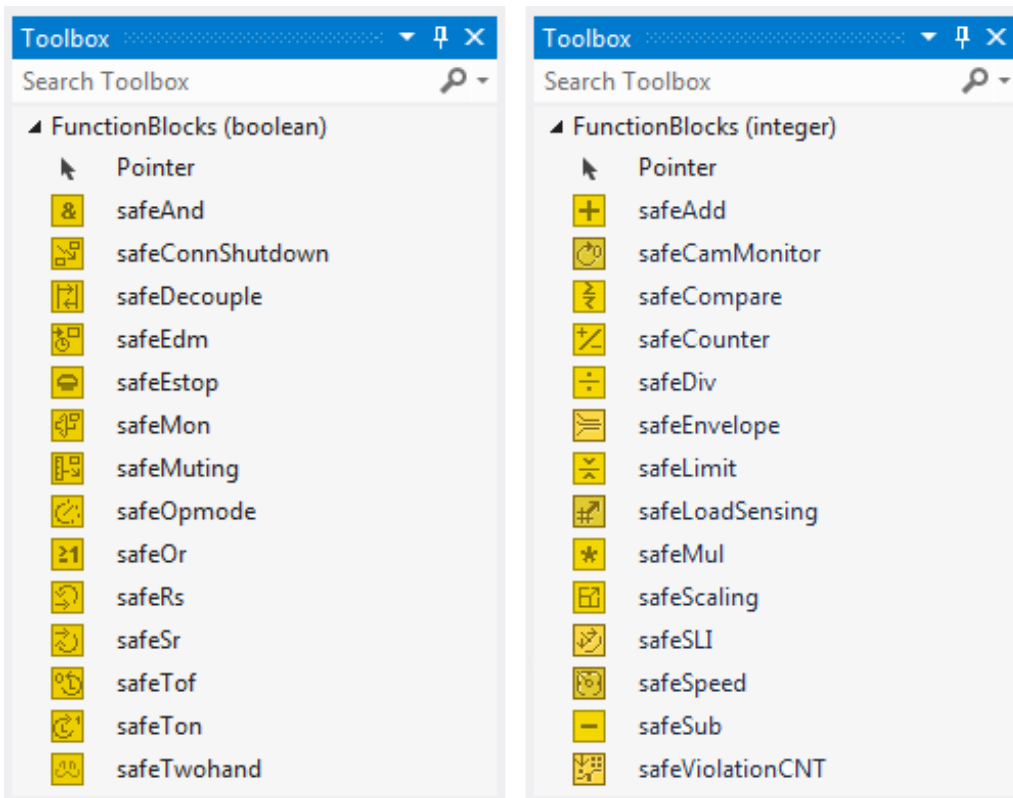


Fig. 52: Function blocks available for EL6910/EJ6910

The function blocks can be moved from the toolbox into the SAL worksheet via drag and drop. Variables can be created by clicking next to a function block input or output, which can then be linked with alias devices in the *Variable Mapping* dialog.

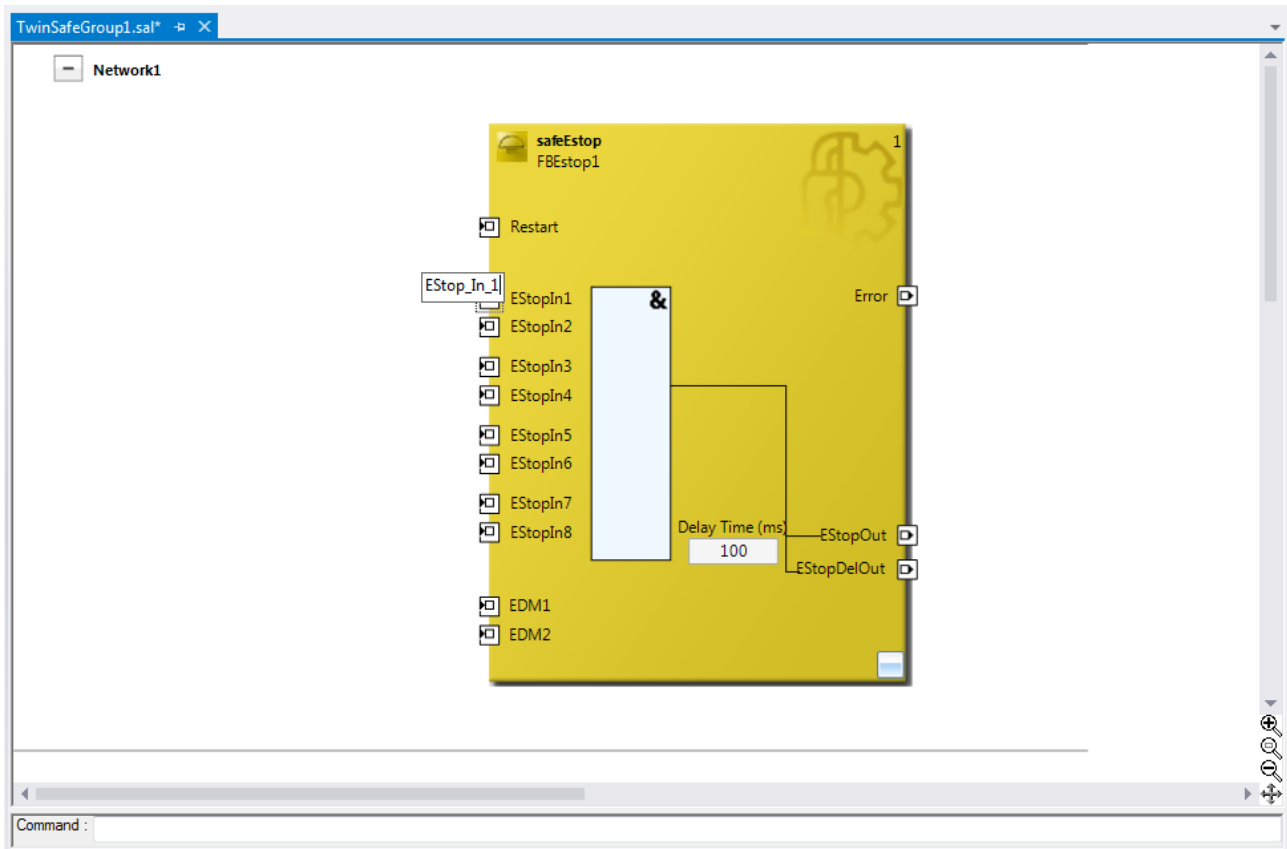



Fig. 53: Function block on the SAL worksheet

Once the pointer connector  **Pointer** has been selected from the toolbox, connections between the input and output ports of the function blocks can be dragged with the mouse.

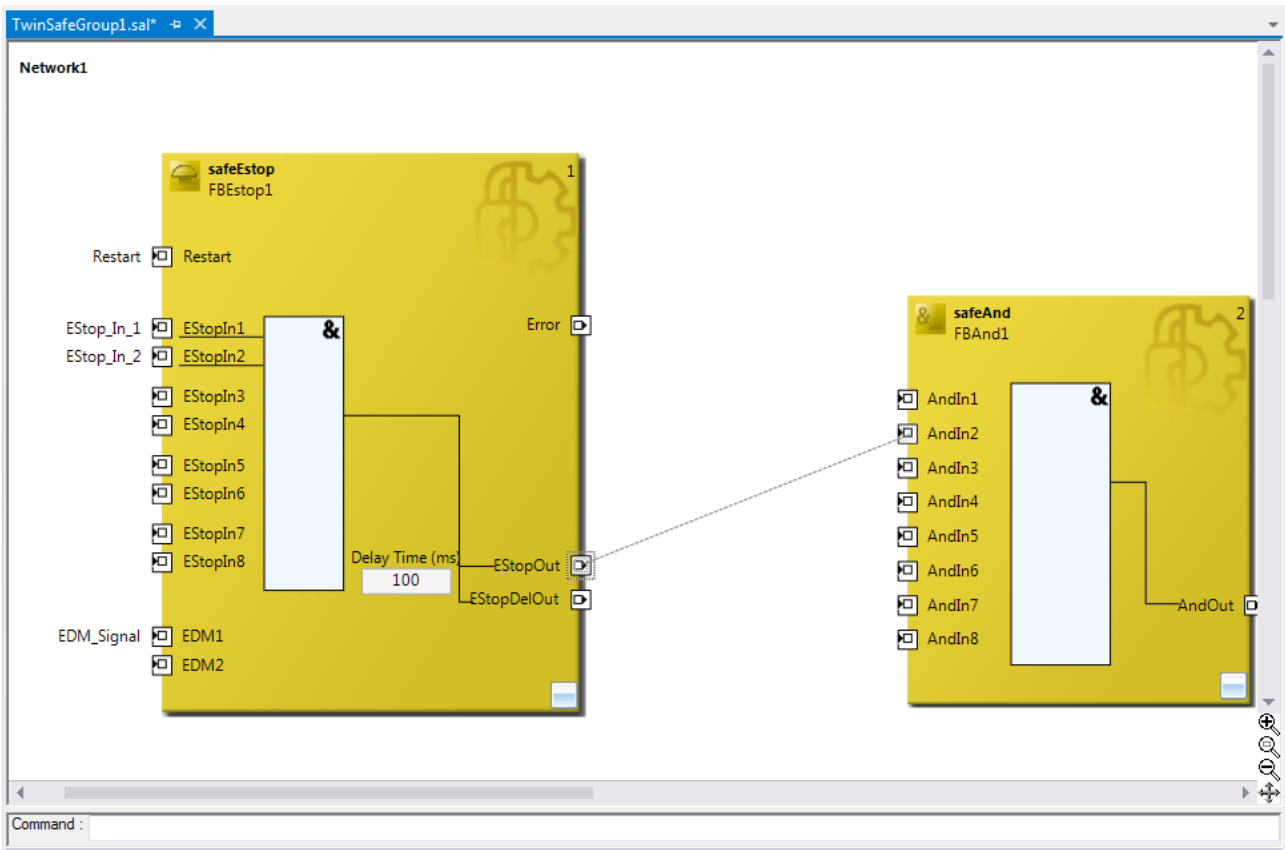


Fig. 54: Dragging a connection between two function blocks

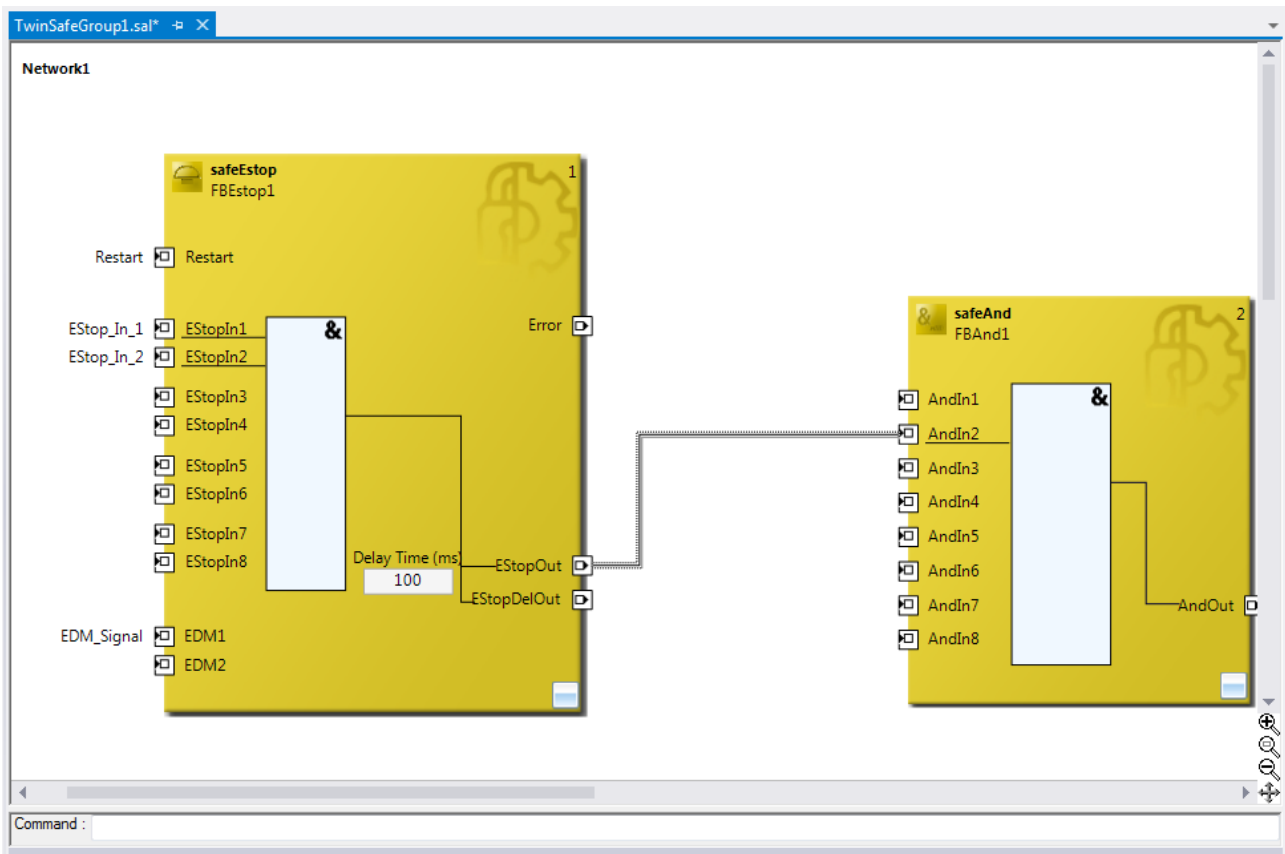


Fig. 55: Connection between two function blocks

5.3.3.10 Networks

For structuring the safety application, several networks can be created within a sal worksheet. Right-click in the worksheet and select *Add After* and *Network* or *Add Before* and *Network* to create a network after or before the current network.

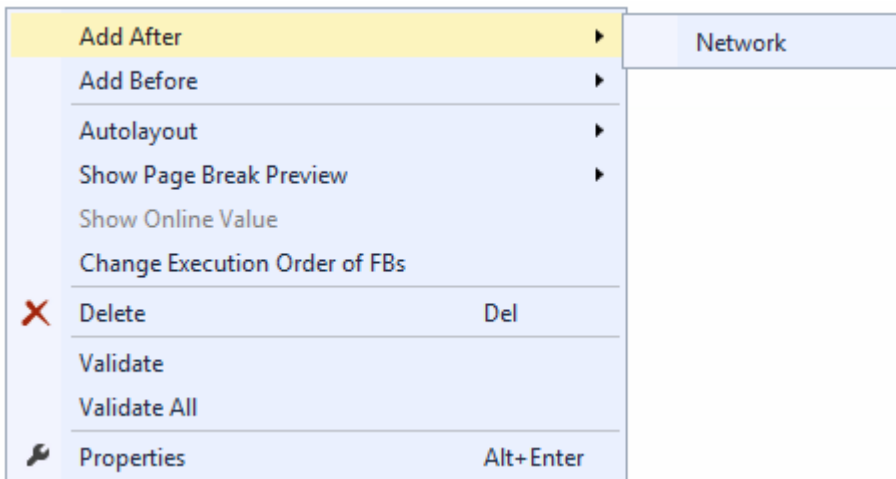


Fig. 56: Creating a network

The instance path to the FB port to be linked can be specified, in order to exchange signals between the networks. The instance path consists of the network name, the FB name and the FB port, each separated by a dot. The input of the instance path is case-sensitive.

<Network name>.<FB name>.<FB port name>

Sample: Network1.FBEstop1.EStopIn3

Alternatively, *Change Link* can be selected by opening the context menus next to the FB port.

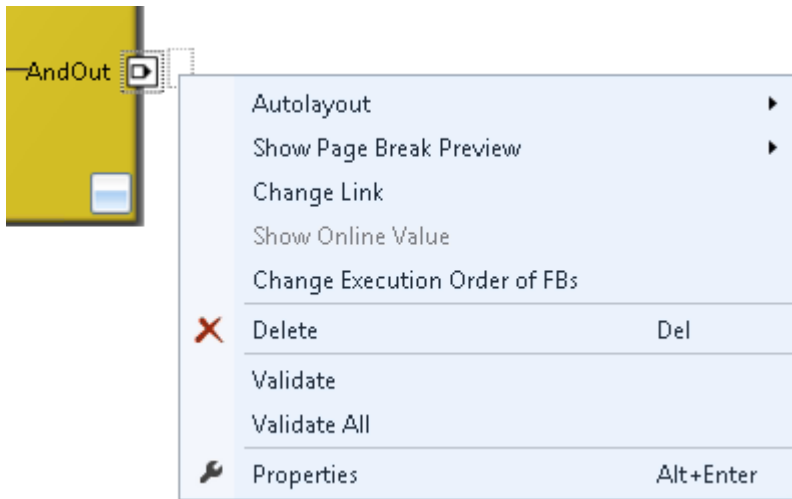


Fig. 57: Change Link

This function opens a dialog for selecting a suitable FB port.

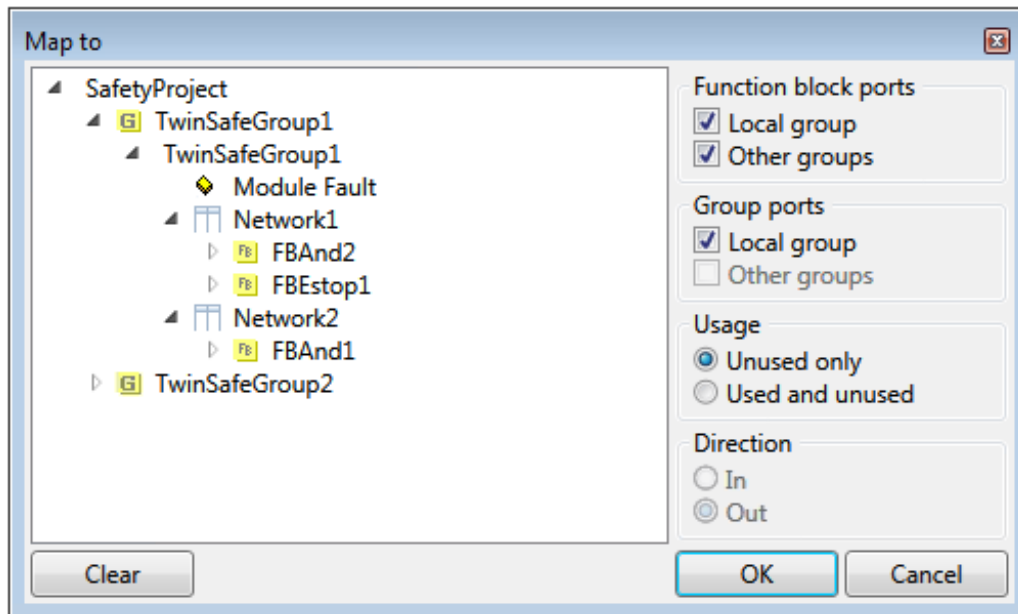


Fig. 58: Dialog for selecting a suitable FB port

Once the link has been created on one side of the connection, the link is automatically set/displayed on the opposite side.

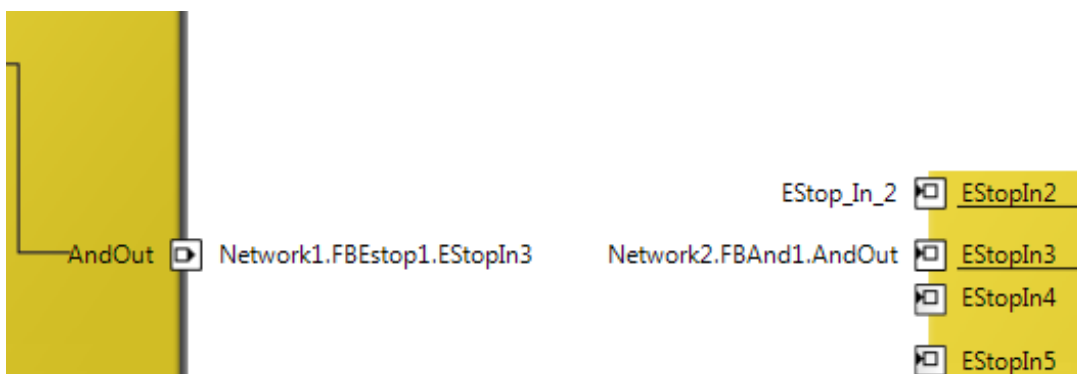


Fig. 59: Link display

5.3.3.11 TwinSAFE groups

It makes sense to create TwinSAFE groups in cases where different machine safety zones are to realize, or simply in order to separate the fault behavior. Within a group, a FB or connection error (here: alias device) leads to a group error and therefore to switching off all outputs for this group. If an error output of an FB is set, it will be forwarded as a logical 1 signal.

A group can be created by opening the context menu of the safety project and selecting *Add and New Item....*

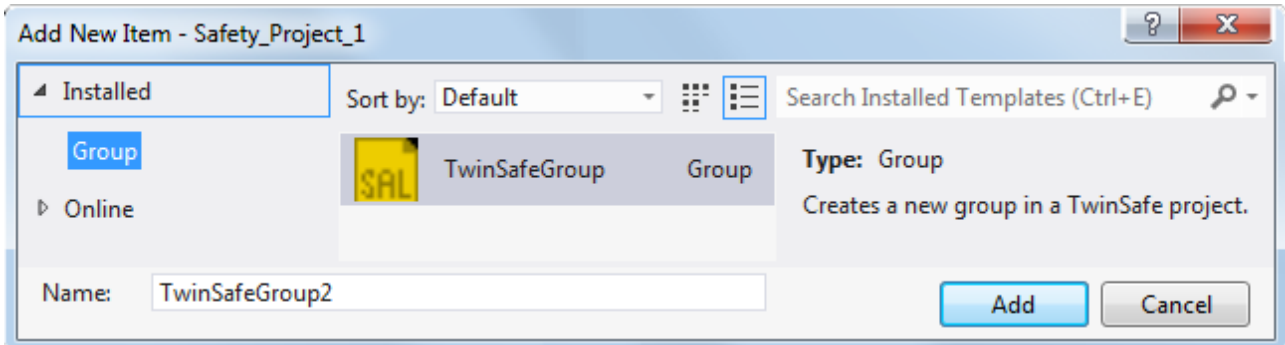


Fig. 60: Creating a TwinSAFE group

Like the first group, the group of a subitem for the alias devices and a sal worksheet.

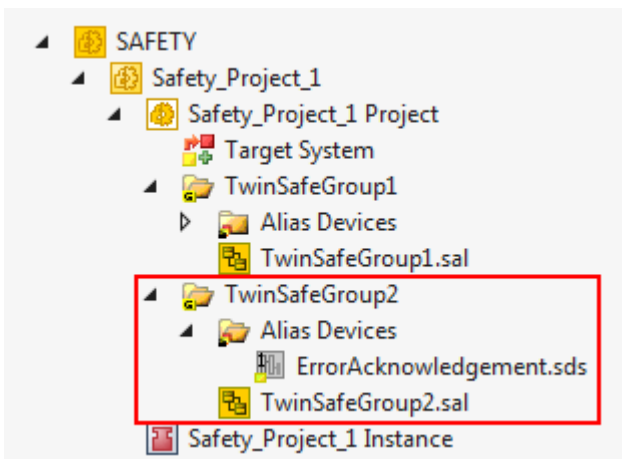


Fig. 61: Components of the TwinSAFE group

The instance path to the FB port to be linked can be specified, in order to exchange signals between the groups. The instance path consists of the group name, the FB name and the FB port, each separated by a dot. The input of the instance path is case-sensitive.

<group name>.<network name>.<FB name>.<FB port name>

Sample: TwinSafeGroup1.Network1.FBStop1.EStopIn3

Alternatively, *Change Link* can be selected by opening the context menus next to the FB port.

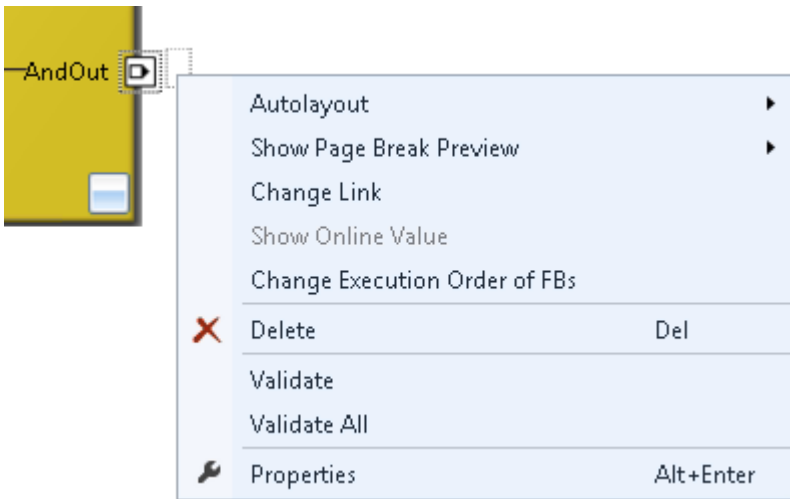


Fig. 62: Change Link

This function opens a dialog for selecting a suitable FB port.

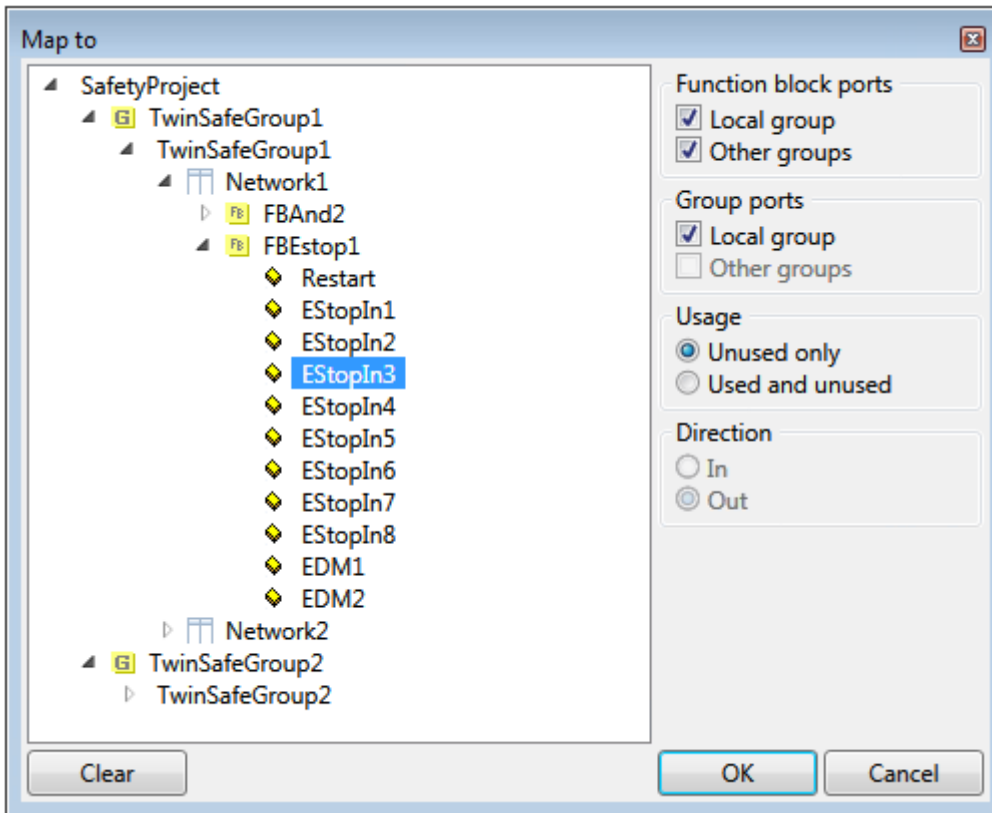


Fig. 63: Dialog for selecting a suitable FB port

Once the link has been created on one side of the connection, the link is automatically set/displayed on the opposite side.



Fig. 64: Link display

5.3.3.12 Variables of the TwinSAFE group

The inputs and outputs of the TwinSAFE groups are consolidated under the *Group Ports* tab of the *Variable Mapping* dialog.

Group inputs EL6910/EJ6910



For a project to be valid, as a minimum the signals *Run/Stop* and *ErrAck* must be linked.

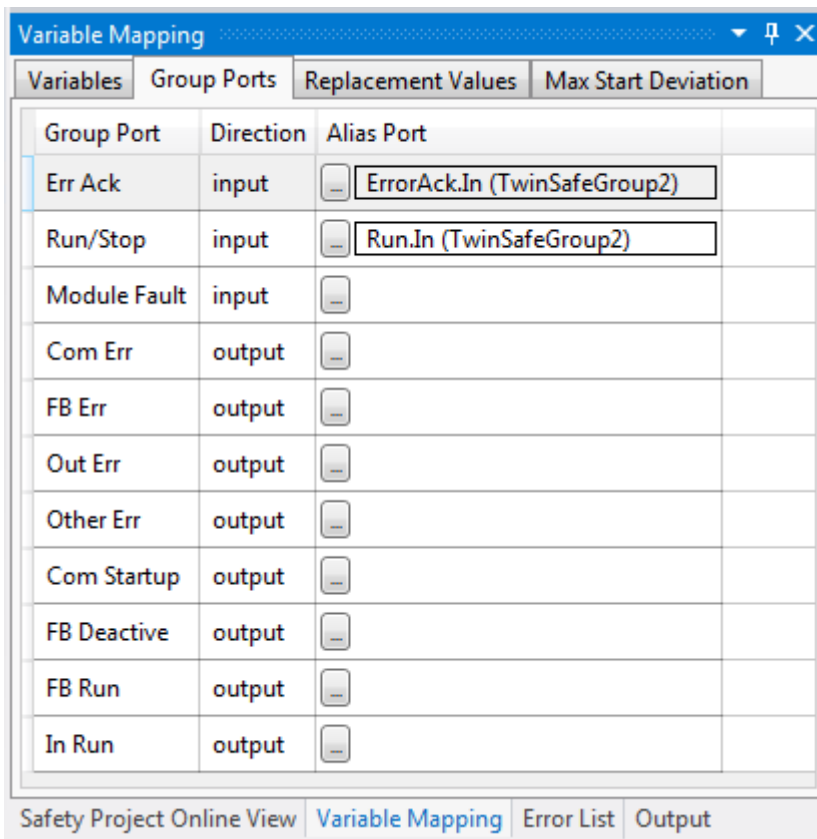


Fig. 65: The Variable Mapping dialog

Group Port	Direction	Description
Err Ack	IN	Error Acknowledge for resetting errors within the group - Signal must be linked with a standard variable
Run/Stop	IN	1 - Run; 0 – Stop - Signal must be linked with a standard variable
Module Fault	IN	Input for an error output of another module that is connected, e.g. EK1960

Group Port	Direction	Description
Com Err	OUT	Communication error in one of the connections
FB Err	OUT	Error at one of the FBs used
Out Err	OUT	not used
Other Err	OUT	ModuleFault OR AnalogValueFault OR WaitComTimeoutFault
Com Startup	OUT	At least one of the connections of this group is in startup
FB Deactive	OUT	The group was deactivated. (See also chapter Customizing / disabling TwinSAFE groups [► 100])
FB Run	OUT	FBs of the TwinSAFE group are processed
In Run	OUT	TwinSAFE group is in RUN state

Group State

Value	Status	Description
1	RUN	Input RUN=1, no error in the group, and all connections have started up without error
2	STOP	Input RUN = 0
4	ERROR	Group is in error, see Diagnostic information
5	RESET	After an error has occurred, all errors have been rectified and the Err Ack signal is 1
6	START	The group remains in this state as long as not all connections have started up after the start of the group (RUN=1)
7	STOPERROR	When the group is started or initialized, it assumes the STOPERROR status if the TwinSAFE connections are assigned to the group. The group switches from STOPERROR state into ERROR state if the Run input is TRUE.
16	DEACTIVE	Group was deactivated via customizing
17	WAITCOMERROR	This state is set when the customizing function "Passivate" is selected and the system waits for ComError of the group

Group Diag

Value	Status	Description
0	-	No error
1	FBERROR	at least one FB is in ERROR state
2	COMERROR	at least one connection is faulty
3	MODULEERROR	the input ModuleFault is 1
4	CMPERROR	On startup, at least one analog FB input deviates from the last saved value (Power-On Analog Value Check Error)
5	DEACTIVATE ERROR	In "passivate manual control unit" mode the timeout has elapsed while waiting for the COM error
6	RESTARTERROR	The TwinSAFE Logic program was restarted because the EtherCAT connection was restarted or a user logged in without reloading the TwinSAFE Logic program (or parts of it).

5.3.3.13 Order of the TwinSAFE groups

The order of the groups can be changed, in order to realize a defined processing sequence of the safety application.

To this end, select the entry *Edit TwinSAFE Group Order* via the node menu of the safety project node. A dialog opens, in which the order of the groups can be changed. The individual groups do not necessarily have to be numbered in consecutive ascending order. The numbering can contain gaps.

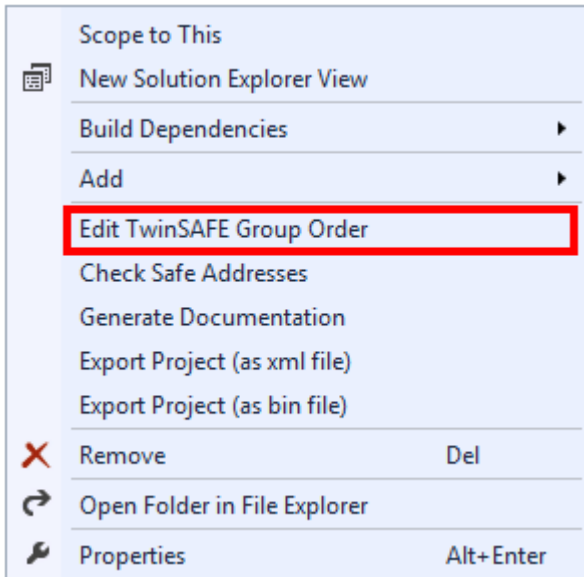


Fig. 66: Context menu Edit TwinSAFE Group Order

The current group order is shown in the column *Current Value*. The new order is specified by entering a value in the column *New Value*, followed by *OK*.

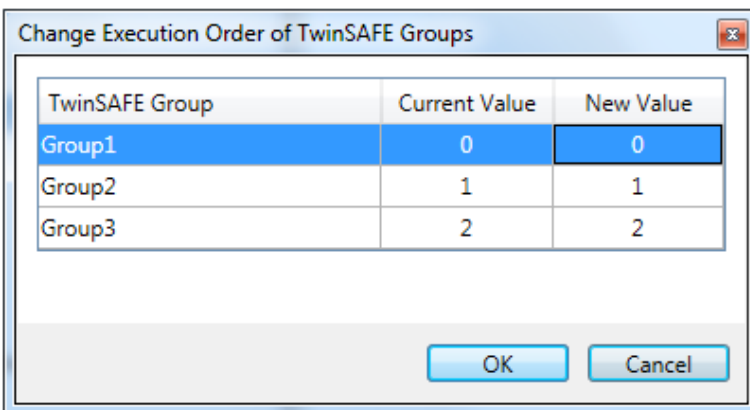


Fig. 67: Dialog Change Execution Order of TwinSAFE Groups

5.3.3.14 Command line

The *command line* below the SAL worksheet can be used to enter commands for executing functions.

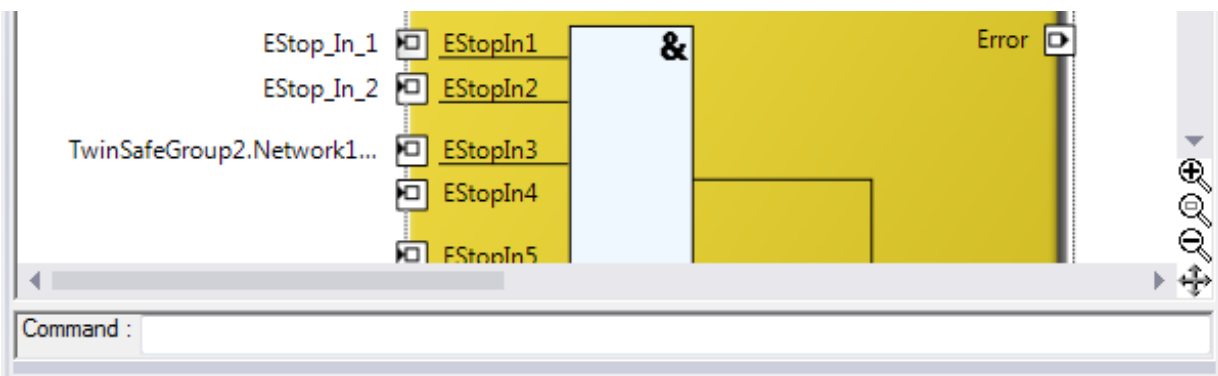


Fig. 68: The command line below the SAL worksheet

Currently the commands listed in the following table are supported.

Command	Description
FBNAME FB_INSTANCENAME NETWORKNAME;	Adding a function block Sample: safeAnd FBAnd1 Network1
FB_INSTANCENAME->PORTNAME = VARIABLE_NAME;	Creating a variable mapping Sample: FBAnd1->AndIn1 = testVariable
FB_INSTANCENAME->PORTNAME = FB_INSTANCENAME->PORTNAME;	Creating a connection between two FBs Sample: FBAnd1->AndIn1 = FBOr1->OrOut;

5.3.3.15 FB port properties

The behavior of the inputs can be parameterized by opening the properties for the upper input of an input pair or an individual input of the function block. For an input group, such as the function block ESTOP, the individual inputs to be activated or deactivated, and single- or two-channel evaluation can be set.

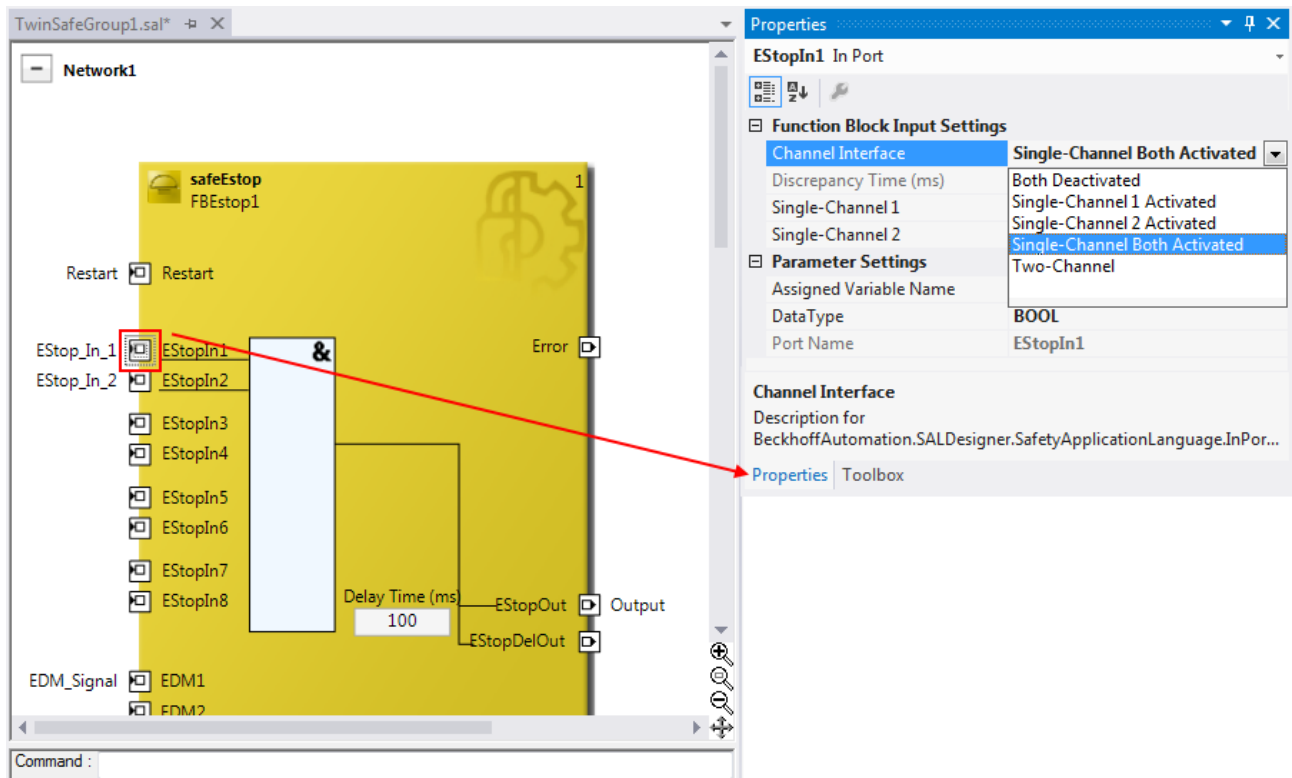


Fig. 69: FB port properties

Channel Interface	Description
Both Deactivated	Both inputs are deactivated
Single-Channel 1 Activated	Channel 1: Single-channel evaluation Channel 2: deactivated
Single-Channel 2 Activated	Channel 1: deactivated Channel 2: Single-channel evaluation
Single-Channel Both Activated	Channel 1: Single-channel evaluation Channel 2: Single-channel evaluation
Two-Channel	Both inputs are activated, and two-channel evaluation with <i>Discrepancy Time (ms)</i>

If the *Two-Channel* evaluation is enabled, the corresponding *Discrepancy time (ms)* can be set in milliseconds. For each input there is a setting to indicate whether the input should be evaluated as *Break Contact (NC)* or *Make Contact (NO)*. When a variable or a connecting line is connected to the function block, the corresponding channel is enabled automatically.

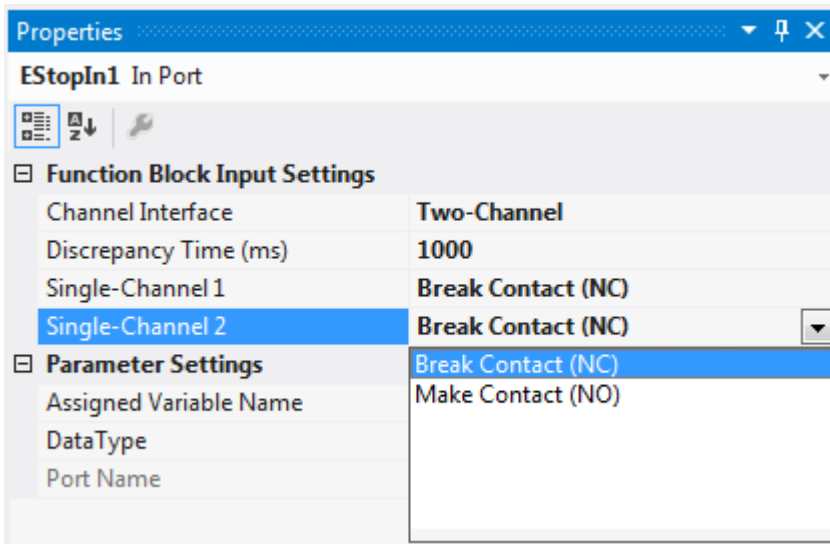


Fig. 70: Make Contact (NO) / Break Contact (NC) setting

These settings are also accessible for each individual port of an FB via the context menu item *Change InPort Settings*.

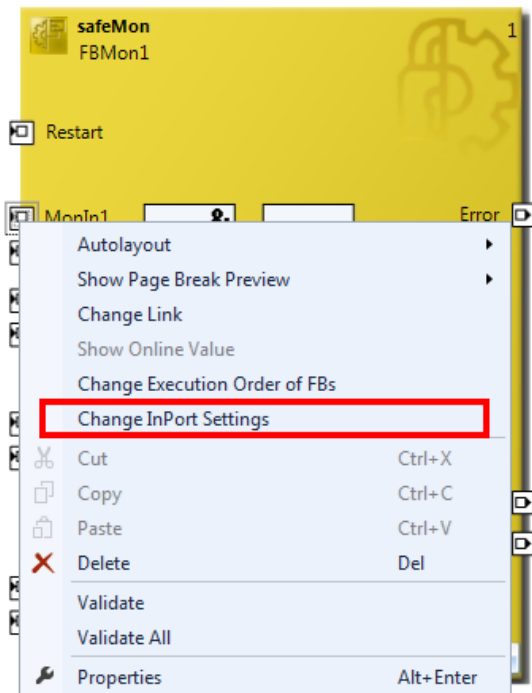


Fig. 71: Menu Change Inport Settings

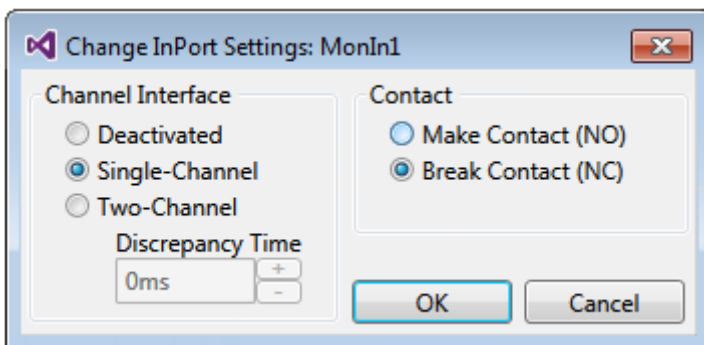



Fig. 72: Dialog Change InPort Settings

5.3.3.16 Variable Mapping

Variable Mapping						
Variables	Group Ports	Replacement Values	Max Start Deviation			
Assigned Variable	Direction	Alias Port		Port Name	Instance Name	Function Name
EStop_In_1	input	Term 7 (EL1904) - Module 1 (FSOES).InputChannel1 (TwinSafeGroup1)		EStopIn1	FBEstop1	safeEstop
EStop_In_2	input			EStopIn2	FBEstop1	safeEstop
Restart	input	RestartForEstop.In (TwinSafeGroup1)		Restart	FBEstop1	safeEstop
EDM_Signal	input			EDM1	FBEstop1	safeEstop
Output	output			EStopOut	FBEstop1	safeEstop

Safety Project Online View | Variable Mapping | Error List | Output

Fig. 73: Variable Mapping

Variables are linked to the alias devices in the *Variable Mapping* window. Use the Link button  to open the selection dialog for the alias port. Safe only signal types or safe and standard signal types are offered in the selection dialog, depending on the port setting of the FB. Safe Boolean signals are shown with a yellow background, standard signal types with a white background.

If several outputs are to be written by one variable, these signals can be assigned by holding down the CTRL key and selecting the channels.

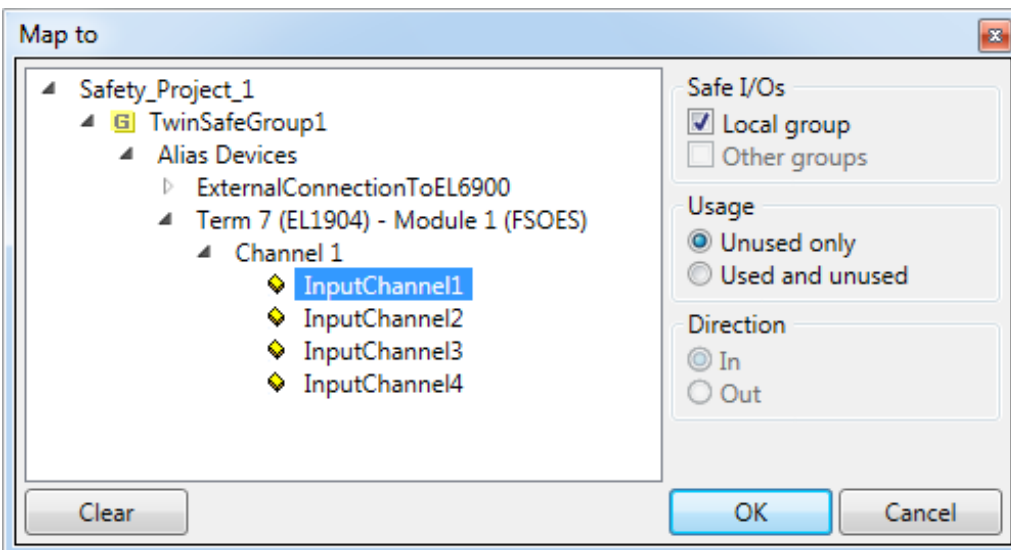


Fig. 74: Selection dialog for the alias port

5.3.3.17 Safety toolbars

Once the development of the safety project is complete, the project has to be loaded onto the target system, in this case EL6910/EJ6910. To this end the toolbars *TwinCAT Safety* and *TwinCAT Safety CRC* have to be added.

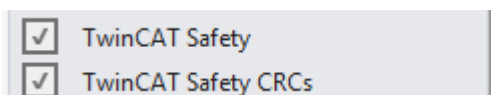








Fig. 75: Activation of the TwinCAT Safety and TwinCAT Safety CRC toolbars








Fig. 76: Display of the TwinCAT Safety and TwinCAT Safety CRC toolbars

Toolbar TwinCAT Safety

Icon	Name	Description
	Verify Safety Project	The safety project is checked for validity.
	Verify Complete Safety Project	The safety project including the hardware level is checked for validity.
	Download Safety Project	Loading the safety project onto the target system, here EL6910/EJ6910
	Delete Safety Project	Deleting the safety project from the target system, here EL6910/EJ6910
	Show Online Data of Safety Project	Switching on the Online View for the safety project.
	Customize Safety Project	Customizing the safety project (switching off TwinSAFE groups and setting of safe substitute values for the group outputs). This is possible if the online and offline CRC are the same and at least one group has been configured for customizing.

Toolbar TwinCAT Safety CRC

Icon	Name	Description
 CRCs:	CRC Toolbar	Left-click on the toolbar to initiate an update of the CRCs by the user. Red icon: CRCs are different
 CRCs:	CRC Toolbar	Green icon: All CRCs are identical
 0x9135 0x9135 0x9135	Online CRC	CRC of the safety project on EL6910/EJ6910. This value is read online by the EL6910/EJ6910. In the absence of an ADS connection to the EL6910/EJ6910, this value is displayed with 0x---- .
 0x9135 0x9135 0x9135	Downloaded CRC	CRC of the safety project that was loaded last. If no safety project is loaded when the TwinCAT project is opened, the value is displayed with 0x---- .
 0x9135 0x9135 0x9135	Offline CRC	CRC of the current safety project, as stored in the safety editor. A CRC is displayed, if the stored project is valid. If the project is invalid, 0x---- is displayed as CRC.

5.3.3.18 Checking the TwinSAFE addresses

The hardware addresses of the alias devices used can be checked and set via the dialog *Check Safe Addresses*.

To this end, select the entry *Check Safe Addresses* via the node menu of the safety project node. A dialog opens, which lists all alias devices that use hardware addresses. The addresses set in the software (*Safe/FSoE Address*) and the hardware addresses (*Hardware Address*) are shown in separate columns for each alias device and for the target system. In the column *Take Hardware Address* the user can specify whether the hardware addresses for the alias devices settings are applied when the dialog is closed via the *OK* button.

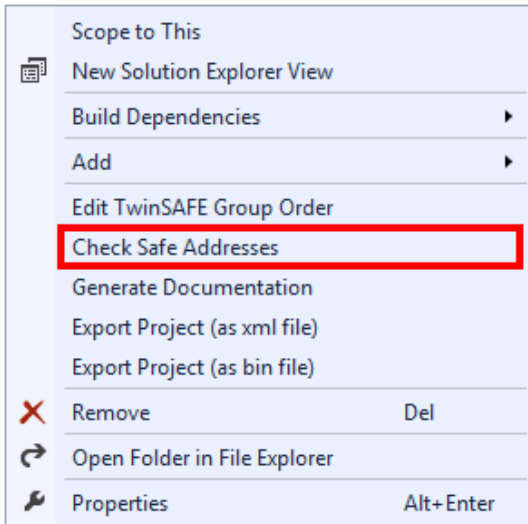


Fig. 77: Check Safe Addresses context menu

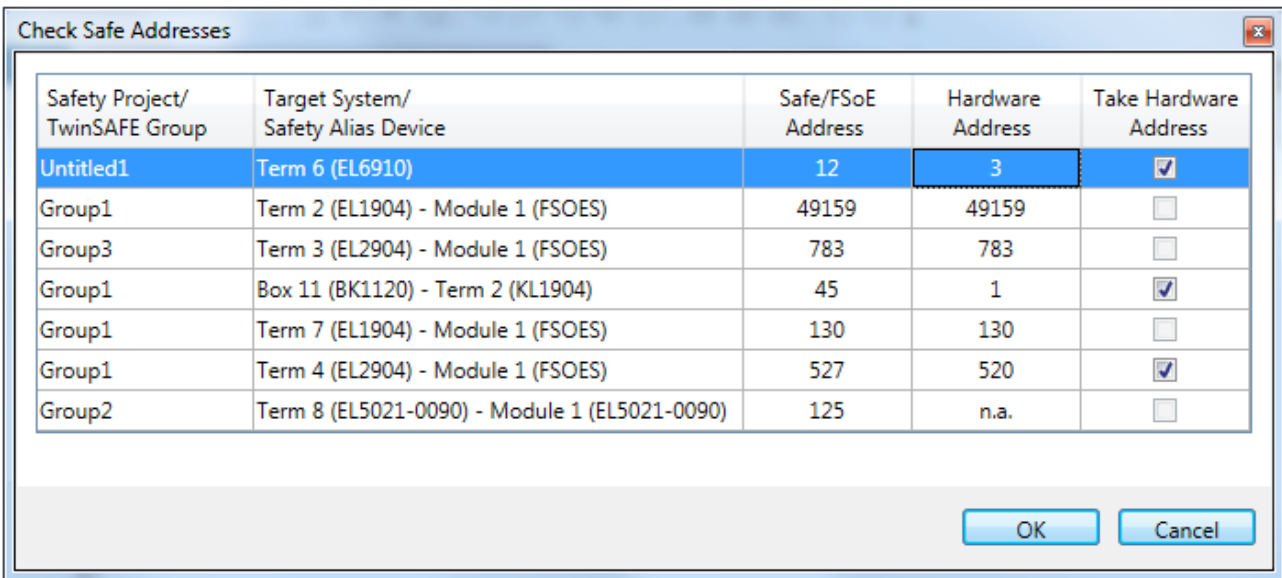





Fig. 78: Check Safe Addresses dialog

5.3.4 Downloading the safety application

Before downloading the safety project to the EL6910/EJ6910 or a logic component, the project should first be checked for validity. If the hardware is complete, the hardware level  can be used for checking, or checking can take place at the project level , if online access is only available for the EL6910/EJ6910 or the logic component. If the check returns no errors, the project download  can continue.

⚠ CAUTION

Use only qualified tools

Only use a qualified tool (see note on system limits) for loading, verifying and enabling the project on the EL6910/EJ6910 or the logic component!

- i User name and password are case-sensitive**
Pay attention to upper/lower case characters for the user name and password. The standard user is *Administrator*, the standard password is *TwinSAFE*.

NOTICE

Power supply during download

Make sure that the TwinSAFE Logic is not switched off during the download. This can lead to unexpected behavior or permanently disable the TwinSAFE Logic.

⚠ WARNING

Execution of the safety application

During a login or download of a safety application, the execution of the current project is stopped on the TwinSAFE Logic.

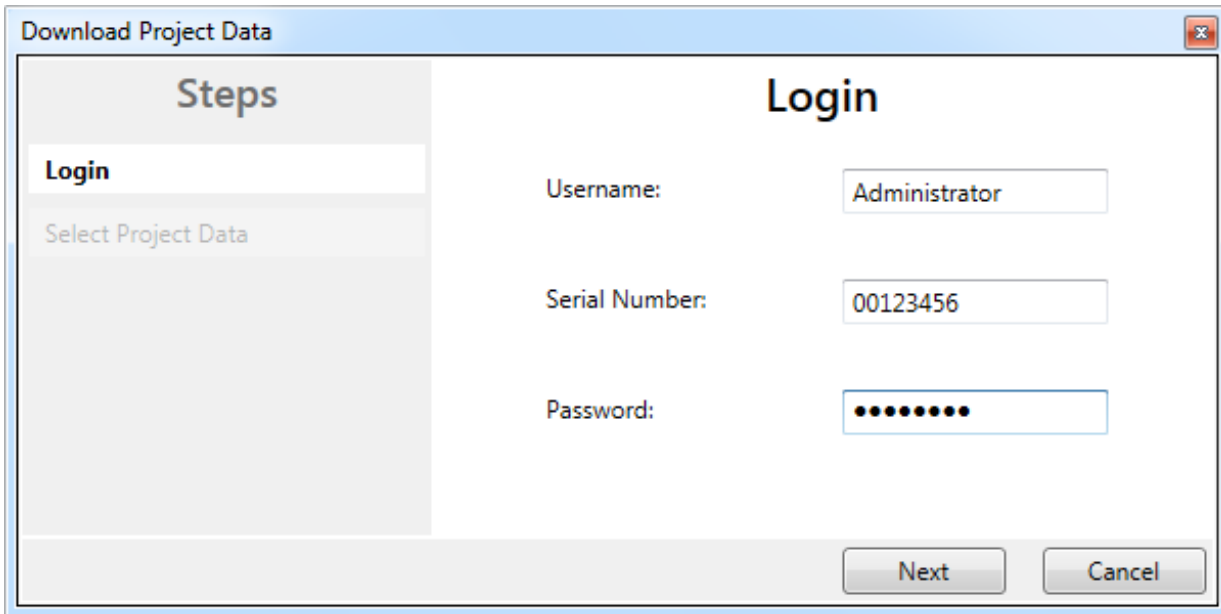


Fig. 79: Download Project Data – The Login dialog

In the *Download Project Data* dialog specify the user name, the serial number of the EL6910/EJ6910 or the logic component onto which the project is to be loaded, and the user password. The default user name is *Administrator*, the default-password is *TwinSAFE*. Use the *Next* button to move to the next dialog.

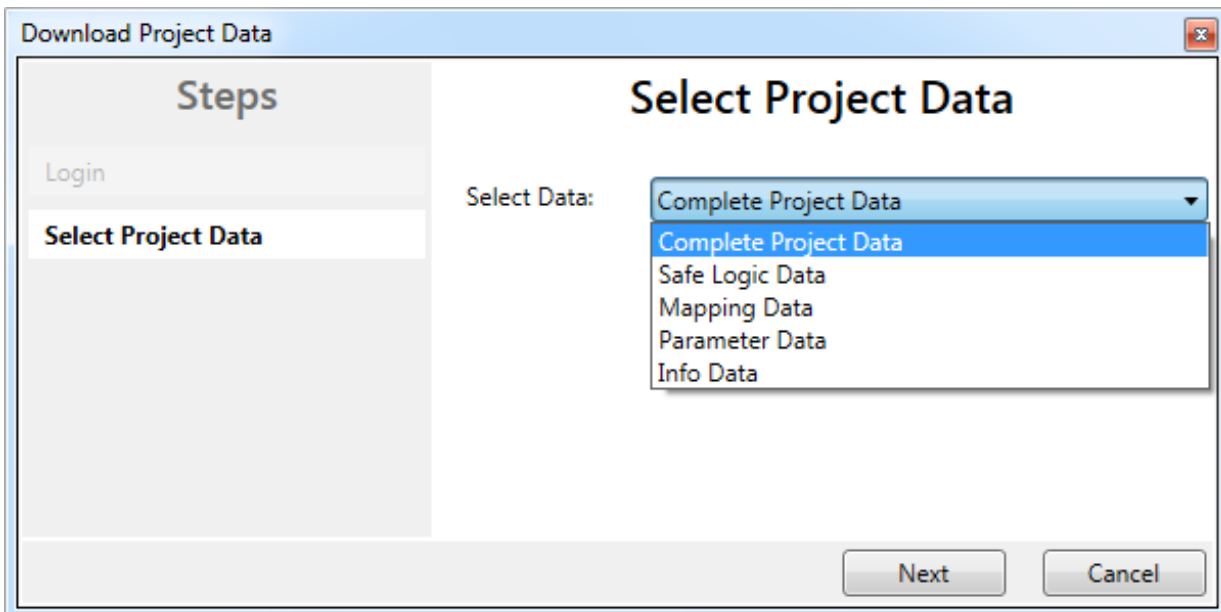


Fig. 80: Download Project Data – The Select Project Data dialog

In the *Select Project Data* dialog select *Complete Project Data* to load the whole project onto the EL6910/EJ6910 or the logic component. Use the *Next* button to move to the next dialog.

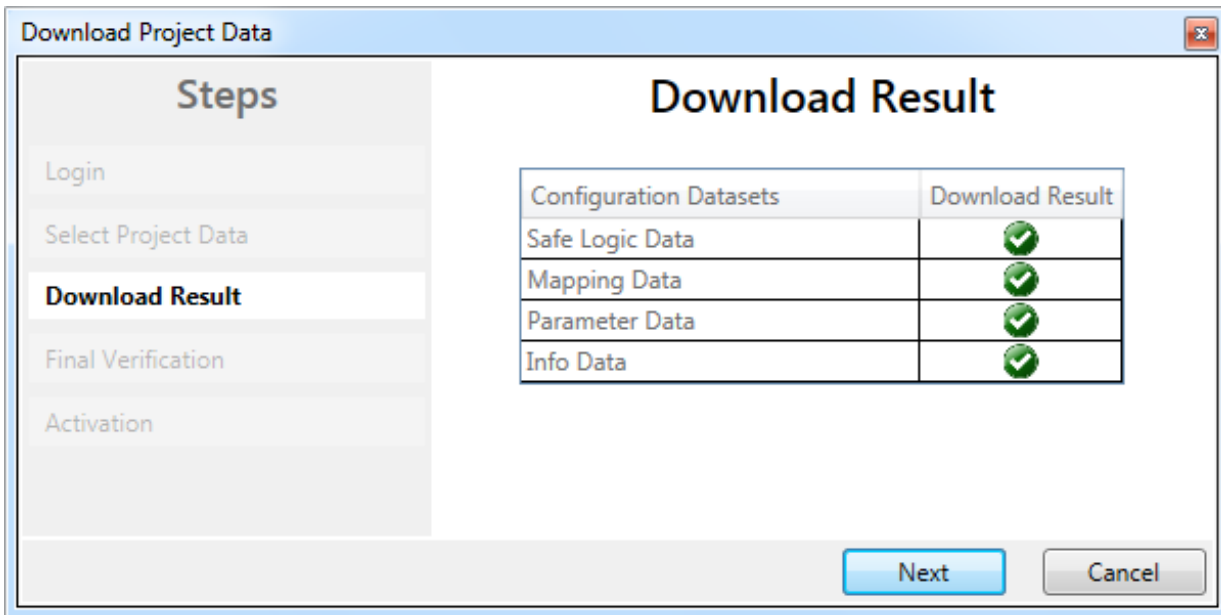


Fig. 81: Download Project Data – The Download Result dialog

Once the download is complete, the download results are displayed. Use the *Next* button to move to the next dialog.

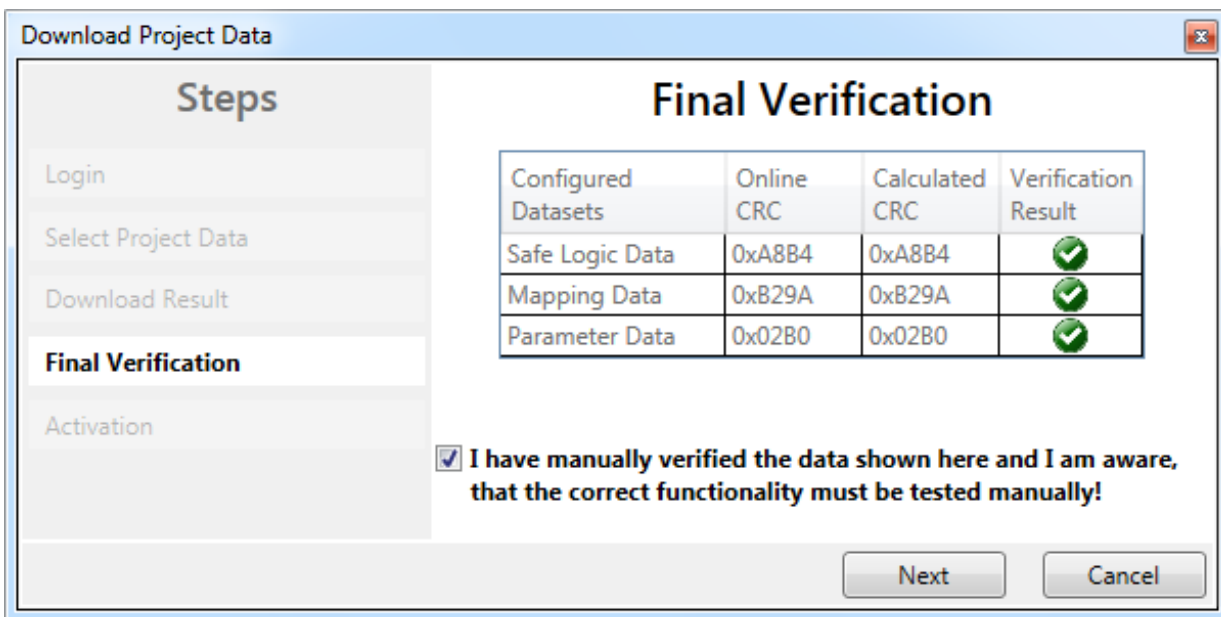


Fig. 82: Download Project Data – The Final Verification dialog

The locally calculated CRCs and the online CRCs of the safety project are displayed in the *Final Verification* dialog. They are automatically checked for equality and displayed via the column *Verification Result*. The user must also check these data for equality and then confirm this by ticking the checkbox. Use the *Next* button to move to the next dialog.

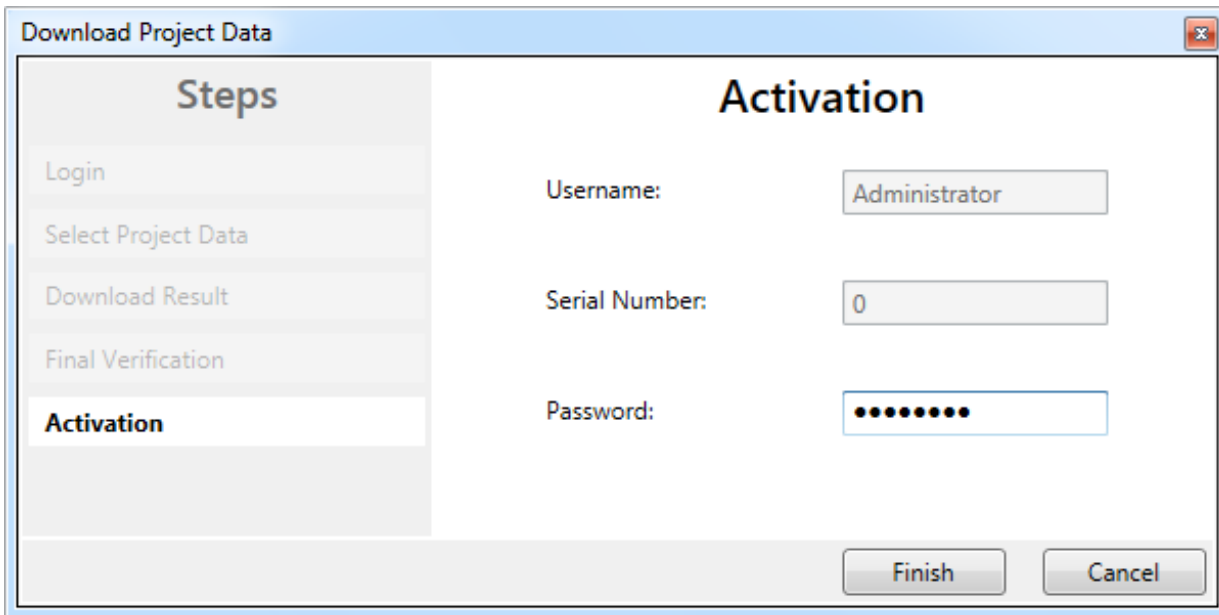


Fig. 83: Download Project Data – The Activation dialog

In the *Activation* dialog the user re-enters the password to activate the safety project on the EL6910/EJ6910 or the logic component. Use the *Finish* button to complete the download of the safety project.

⚠ WARNING

Verification of the input and output process data

After downloading the safety-related program to the TwinSAFE logic, the user must check that the input and output process data of the TwinSAFE logic are plausible, within the valid value range and in the expected magnitude. This is especially true for analog signals, which are transmitted via e.g. PROFIsafe, FSoE sensors, TwinSAFE SC terminals or external control systems to the TwinSAFE logic. It is particularly important to check whether the device uses the Motorola or the Intel format or Big or Little Endian.

Project data	Description
Safe Logic Data	Safe Logic Data contains the safety related program.
Mapping Data	Mapping Data contains the link data for inputs, outputs, function blocks, connections etc.
Parameter Data	Parameter Data contains the safe user parameters that are stored on the TwinSAFE Logic. These can be safe substitute values and the user parameters of the connections.
Info Data	Info Data contains the settings which Info Data for connections, function blocks, groups etc. are activated and have to be filled by the TwinSAFE Logic.

● Info Data of the safety project

i The Info Data will NOT take effect to the calculation of the project CRC. This allows the Info Data to be changed at a later stage without changing the project CRC. If the Info Data for an existing project are changed, a project download including at least the Info Data must be carried out, despite the fact that the CRC is unchanged, otherwise the Info Data will not be filled. In addition, the TwinCAT configuration must be activated so that the process image size in TwinCAT matches the expected size within the TwinSAFE Logic.

5.4 Info data

5.4.1 Info data for the connection

Info data for connections can be enabled on the *Connection* tab of the alias device.

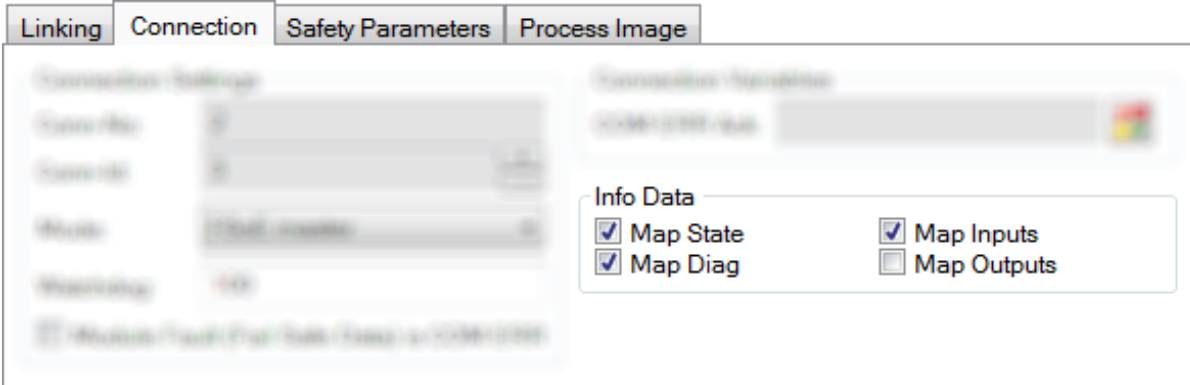


Fig. 84: Enabling the info data for connections

The info data are shown in the I/O tree structure below the EL6910 in the process image. From here, these signals can be linked with PLC variables. Further information on the included data can be found in the documentation for *TwinCAT function blocks for TwinSAFE logic terminals*. Use the checkbox *Show Input/Output Data as byte array* under *Target System* to adjust the process image.

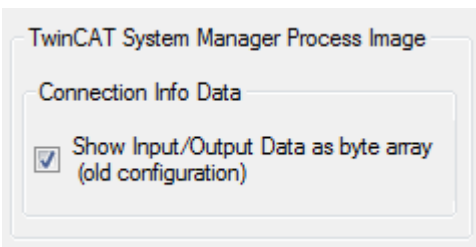


Fig. 85: Checkbox for the connection info data

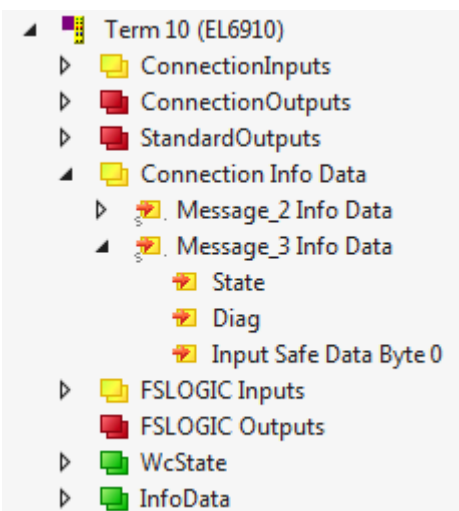


Fig. 86: Info data for the connection in the I/O tree structure as byte array

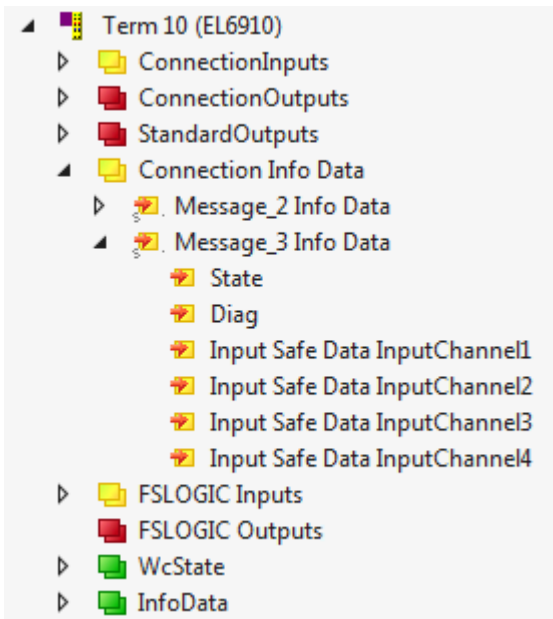


Fig. 87: Info data for the connection in the I/O tree structure as individual data

5.4.2 Info data for function blocks

For function blocks, info data can be enabled in the properties of the function block.

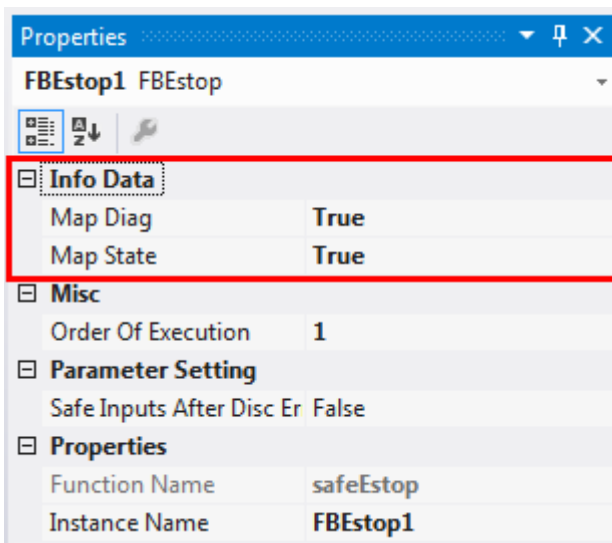


Fig. 88: Enabling the info data for function blocks

The info data are shown in the I/O tree structure below the EL6910 in the process image. From here, these signals can be linked with PLC variables. Further information on the included data can be found in the documentation for *TwinCAT function blocks for TwinSAFE logic terminals*.

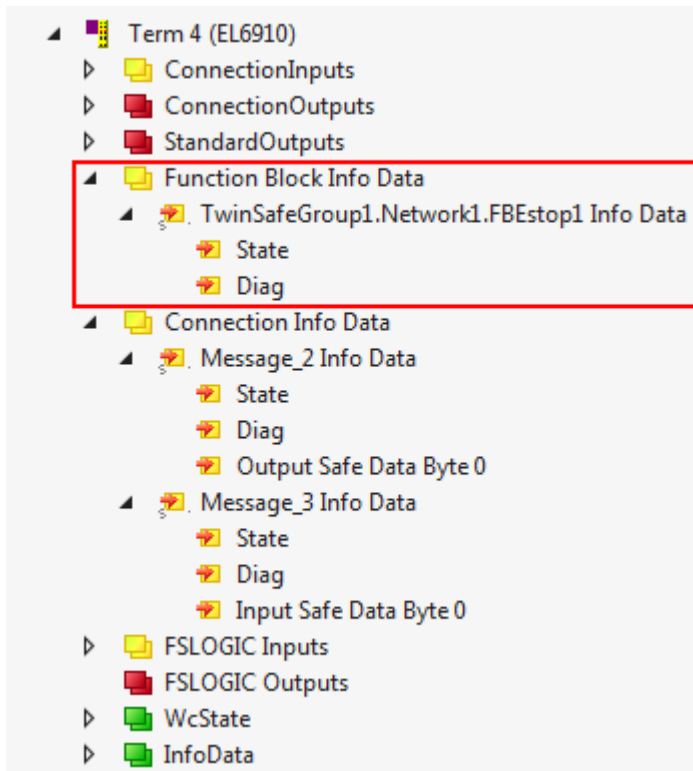


Fig. 89: Info data for the function block in the I/O tree structure

5.4.3 Info data for the TwinSAFE group

For TwinSAFE groups, info data can be enabled via the properties of the TwinSAFE group.

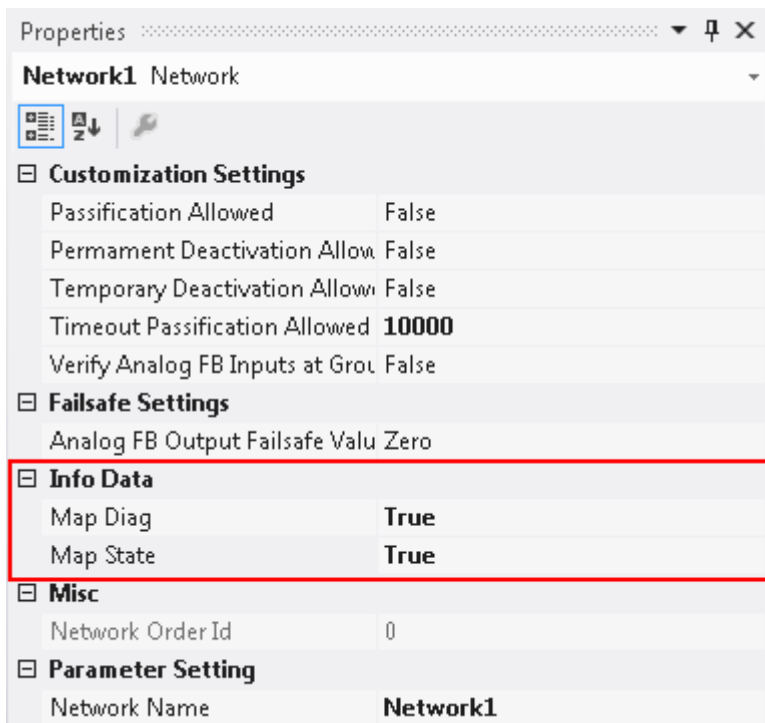


Fig. 90: Enabling the info data in the properties of the TwinSAFE group

The info data are shown in the I/O tree structure below the I/O device in the process image. From here, these signals can be linked with PLC variables. Further information on the included data can be found in the documentation for *TwinCAT function blocks for TwinSAFE logic terminals*.

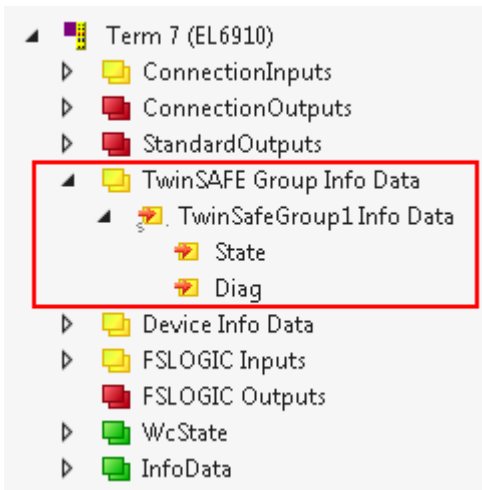


Fig. 91: Info data for the TwinSAFE group in the tree structure

5.4.4 Info data for the device

The info data for the EK1960 can be activated on the *Target System* tab. These are the serial number of the EK 1960 and the current online-CRC of the safety project.

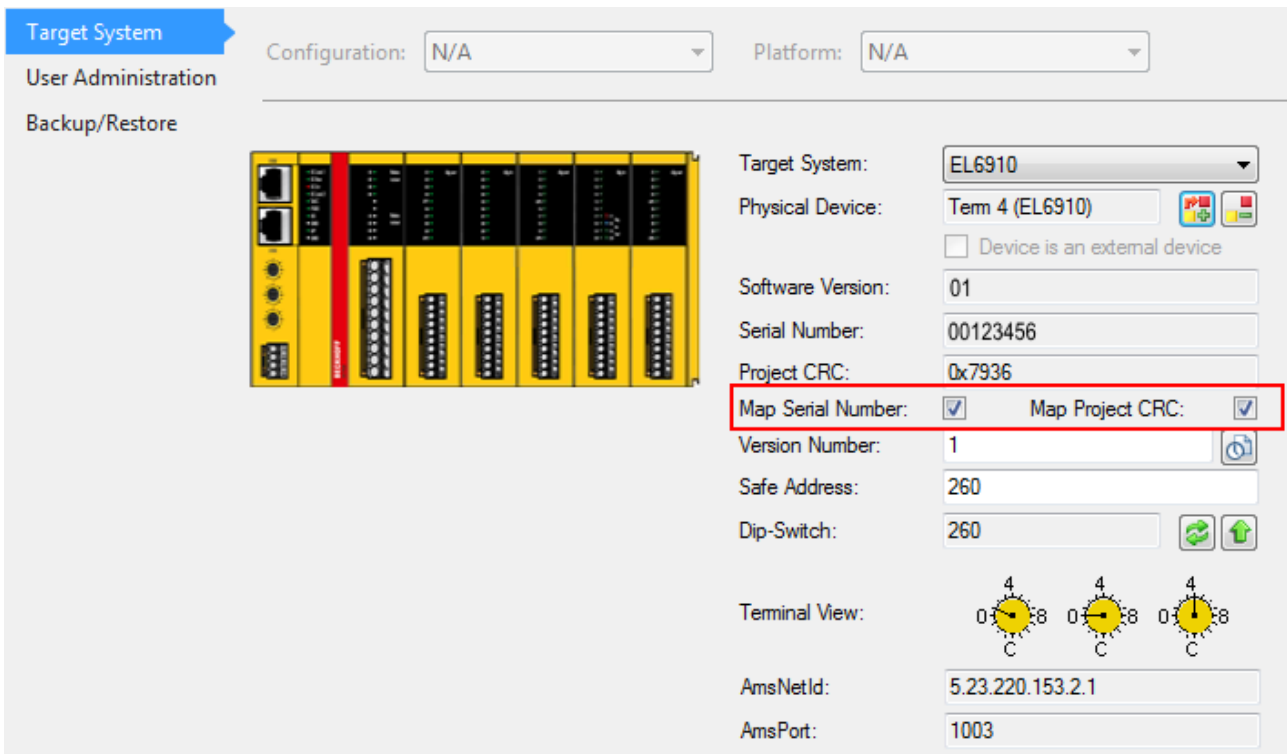


Fig. 92: Activation of the info data for the EK1960

The info data are shown in the I/O tree structure below the EK1960 in the process image. From here, these signals can be linked with PLC variables.

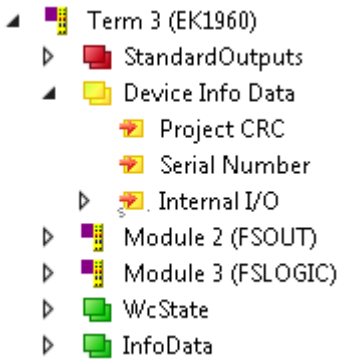


Fig. 93: Info data in the EK1960 tree structure

Info data of the internal EK1960 inputs and outputs

In addition to the project CRC and the serial number, the local inputs and outputs of the EK1960 connection are shown under *Device Info Data*. The inputs, outputs, module errors and module ErrAck signals are shown below the entry *Internal I/O*.

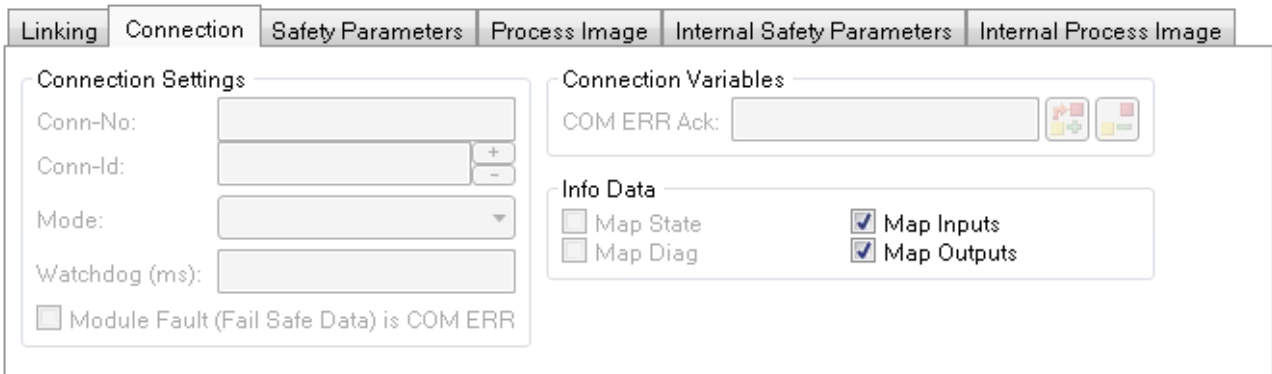



Fig. 94: Activating the info data for the local EK1960 connection

5.5 Version history

The *version history* button  under *Target System* can be used to read the version history of the EL6910, EJ6910 or EK1960. It includes the user, the date, the version and the CRC of the safety projects loaded on the EL6910, EJ6910 or EK1960.

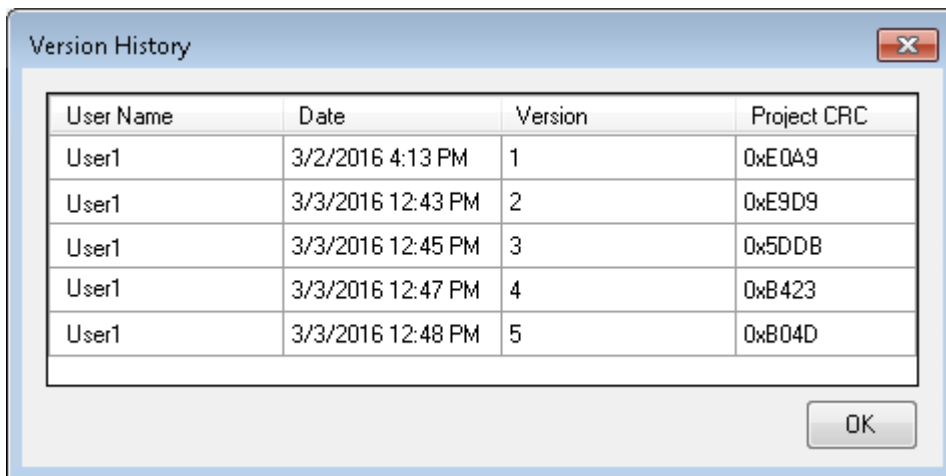


Fig. 95: Version History

5.6 User Administration

User administration is called up via the *Target System* tree item. Use *Get User List* to read the current list of users of the EL6910, EJ6910 or EK1960. The user *Administrator* cannot be deleted. The default password can and should be replaced with a customer-specific password. This is done via the *Change Password* button. The default password is *TwinSAFE*. The password must be at least 6 characters long. A maximum of 40 users can be created.

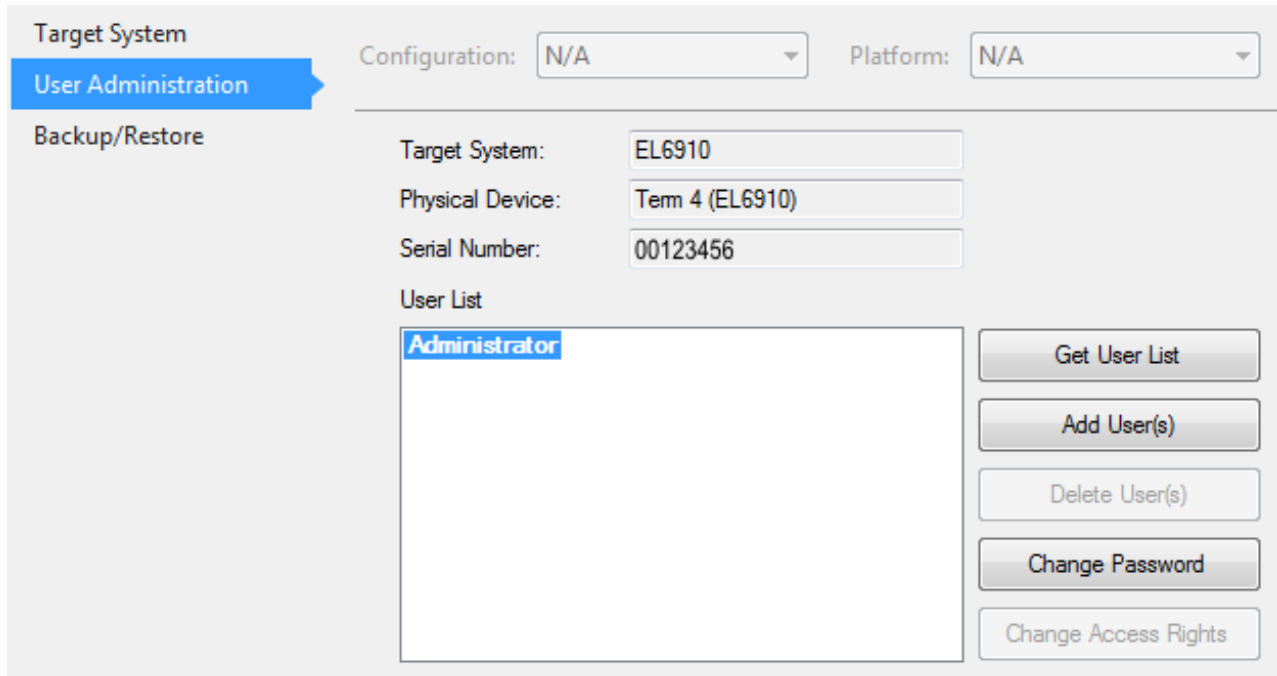


Fig. 96: User Administration

The administrator password is required to create or delete users. Open the *Login* dialog by left-clicking on *Add User(s)*.

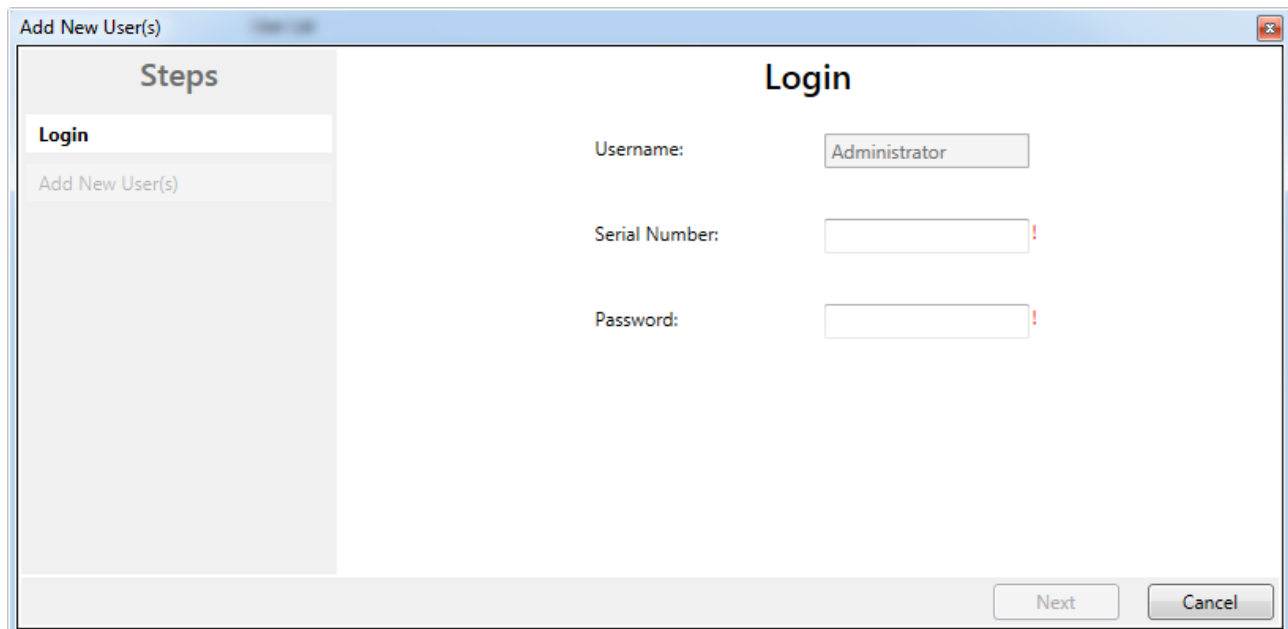


Fig. 97: User Administration - Login

The *Add User* dialog opens once the correct serial number and administrator password have been entered.

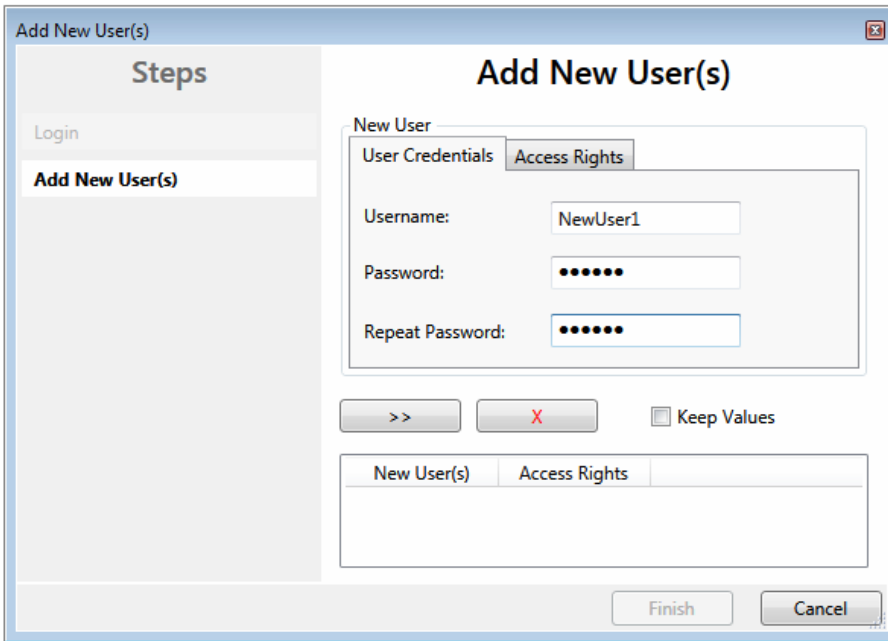


Fig. 98: User Administration - Add New User(s) - User Credentials

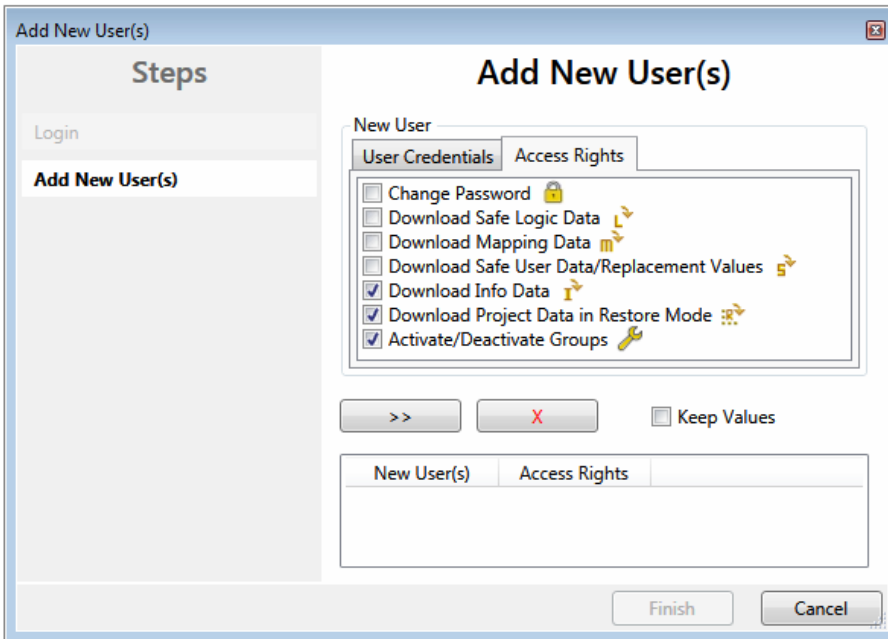
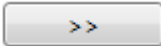


Fig. 99: User Administration - Add New User(s) - Access Rights

Enter the new user and the corresponding password (twice). The password must be at least 6 characters

long. In addition, select the rights for the new user. Use the  button to apply these data and display them in the New User list.

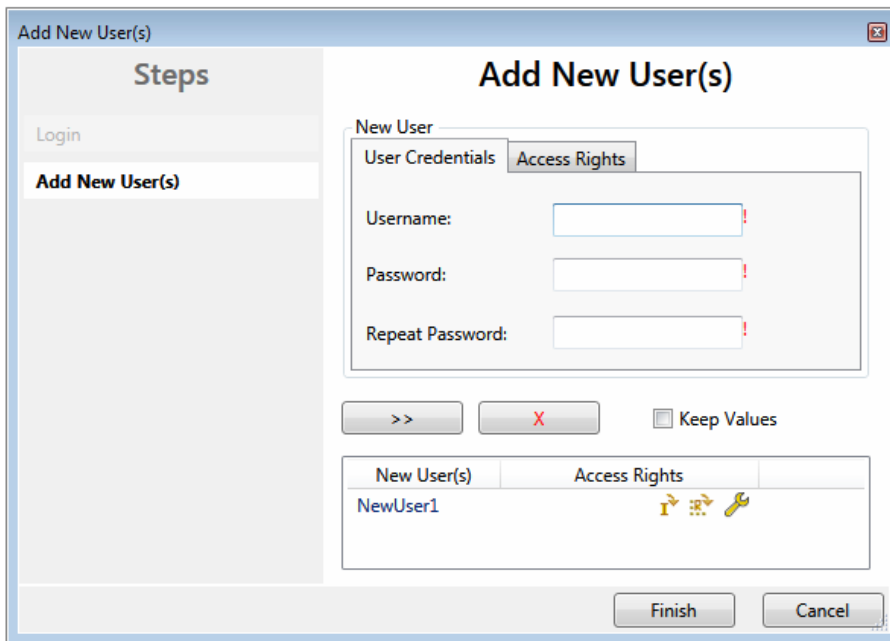


Fig. 100: User Administration - New User added

Several users can be created before leaving the dialog via the *Finish* button.

Access Rights	Description
Change Password	Users can change their password.
Download Safe Logic Data	The user can load the safety-related program onto the EL6910, EJ6910 or EK1960.
Download Mapping Data	The user can load the mapping data for inputs, outputs, FBs etc. onto the EL6910, EJ6910 or EK1960.
Download Safe User Data / Replacement Values	The user can change safe user parameters on the EL6910, EJ6910 or EK1960 and also change and load safe substitute values
Download Info Data	The user can activate and load the info data for connections and FBs on the EL6910, EJ6910 or EK1960.
Download Project Data in Restore Mode	The user can perform a restore. Not currently supported.
Activate / Deactivate Groups	The user can execute Customizing (enable and disable TwinSAFE groups) on the EL6910, EJ6910 or EK1960.

5.7 Backup/Restore

Following the exchange of an EL6910, EJ6910 or EK1960, the previous project can be loaded to the new device using the *Backup/Restore* mechanism.

In order to be able to use this functionality, the *Backup/Restore* mechanism must be enabled in the safety project, and the terminals must be selected, on which the current CRC of the safety project is to be stored.

For a restore operation the user can specify the minimum number of selected terminals on which the correct CRC must be stored.

Using the checkbox *Restore User Administration* the user can specify whether the user administration should be transferred to the new device via the restore mechanism.

Fig. 101: Backup/Restore

In order to be able to use the *Backup/Restore* mechanism, create a backup of the current safety project and store it on the hard disk of the controller, for example. To carry out a restore, the user can either check when starting the controller whether the serial number of the EL6910, EJ6910 or EK1960 has changed, or start the restore manually via a service menu, e.g. in the visualization.

i Restore

If a project that doesn't match the system is loaded during a *restore*, this will only be detected when the distributed CRCs are checked. The previous project is then deleted from the logic terminal. This cannot be undone.

One possible sequence for checking whether a restore is carried out is shown in the following sequence chart.

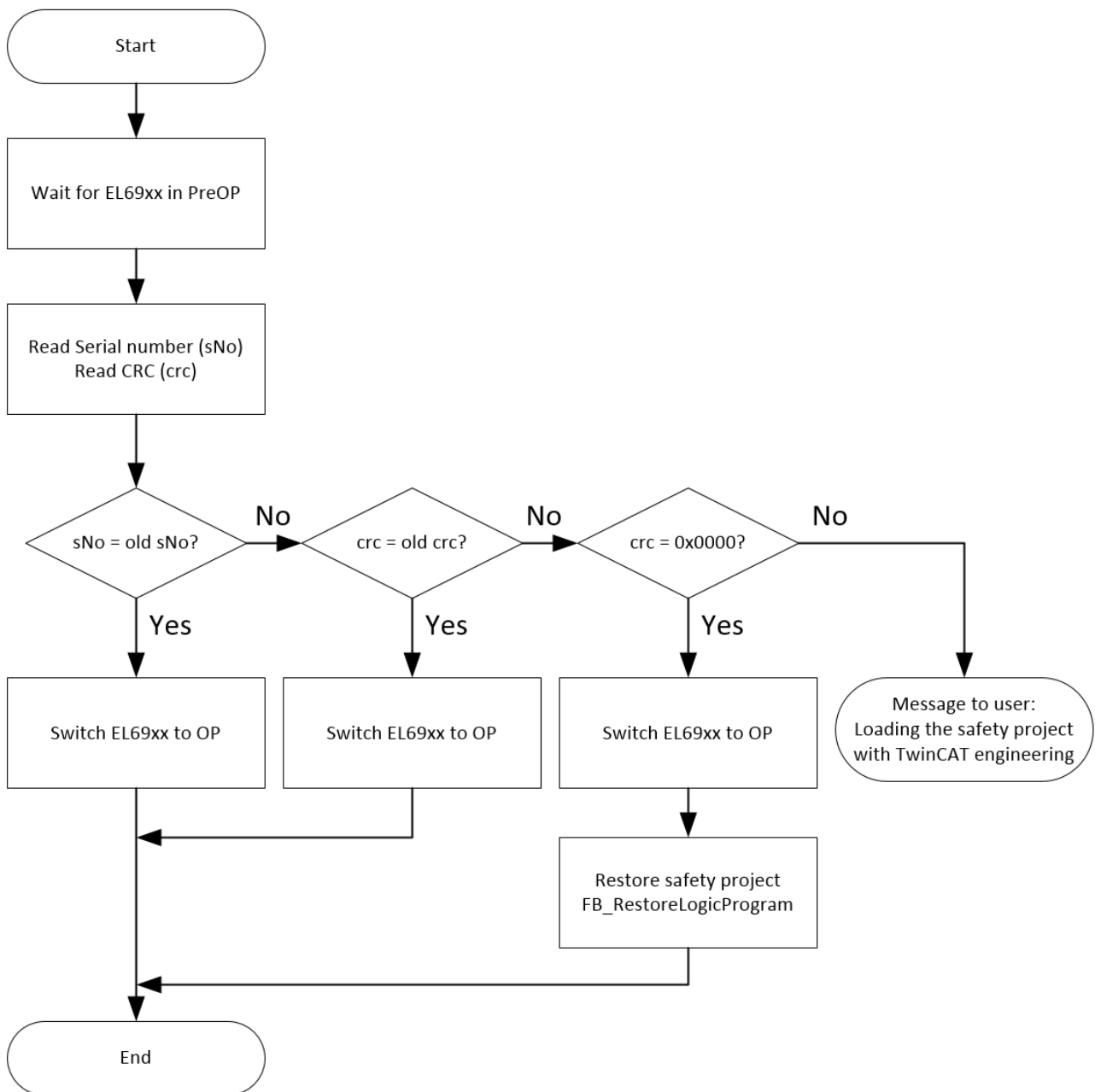


Fig. 102: Restore check sequence chart

Function blocks for backup/restore

The PLC function blocks with which a backup and restore can be performed on a TwinSAFE logic component (currently EL6910, EJ6910 or EK1960), can be found on the Beckhoff homepage. This is a compiled library that can be installed in the TwinCAT Library Repository.

The TC3_EL6910_Backup_Restore library contains 2 PLC function blocks. FB_SAVELOGICPROGRAM and FB_RESTORELOGICPROGRAM.

FB_SAVELOGICPROGRAM

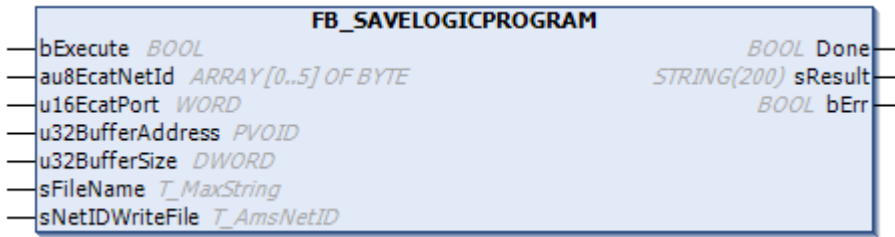


Fig. 103: FB_SAVELOGICPROGRAM illustration

FUNCTION_BLOCK **FB_SAVELOGICPROGRAM**

Name	Type	Inherited from	Address	Initial	Comment
bExecute	BOOL			FALSE	Positive edge starts the backup process
au8EcatNetId	ARRAY [0..5] OF BYTE				EtherCAT Net-ID of the TwinSAFE Logic - link to e.g. EL6910/InfoData/AdsAddr/netId
u16EcatPort	WORD				Port of TwinSAFE-Logic - link to e.g. EL6910/InfoData/AdsAddr/port
u32BufferAddress	PVOID				Address of buffer, in which the TwinSAFE Logic program should be stored temporarily - buffer e.g. ARRAY[0..16#FFFF] OF BYTE
u32BufferSize	DWORD				size of buffer
sFileName	T_MaxString				File, in which the TwinSAFE Logic program should be stored
sNetIDWriteFile	T_AmsNetID				AmsNetID of device where the file should be written to
Done	BOOL			FALSE	User information that the FB finished the operation
sResult	STRING(200)				FB Result
bErr	BOOL				An error occurred during operation, details in sResult

Fig. 104: FB_SAVELOGICPROGRAM parameters

FB_RESTORELOGICPROGRAM

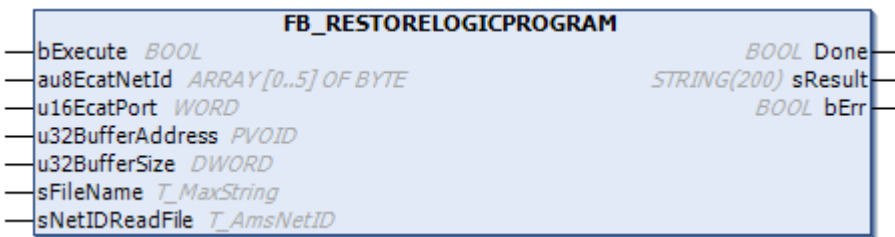


Fig. 105: FB_RESTORELOGICPROGRAM illustration

FUNCTION_BLOCK **FB_RESTORELOGICPROGRAM**

Name	Type	Inherited from	Address	Initial	Comment
bExecute	BOOL			FALSE	Positive edge starts the restore process
au8EcatNetId	ARRAY [0..5] OF BYTE				EtherCAT-Net-ID of the TwinSAFE Logic - link to e.g. EL6910/InfoData/AdsAddr/netId
u16EcatPort	WORD				Port of TwinSAFE-Logic - link to e.g. EL6910/InfoData/AdsAddr/port
u32BufferAddress	PVOID				Address to buffer, in which the TwinSAFE Logic program should be stored - buffer e.g. ARRAY[0..16#FFFF] OF BYTE
u32BufferSize	DWORD				size of buffer
sFileName	T_MaxString				File which contains the TwinSAFE logic program and should be restored
sNetIDReadFile	T_AmsNetID				AmsNetID of device where the file is stored
Done	BOOL			FALSE	User information that the FB finished the operation
sResult	STRING(200)				FB result
bErr	BOOL				An error occurred during operation, details in Result

Fig. 106: FB_RESTORELOGICPROGRAM parameters

Sample

```
PROGRAM MAIN
VAR
    fb_save: FB_SAVELOGICPROGRAM;
    fb_restore: FB_RESTORELOGICPROGRAM;
    StartBackup: BOOL;
    EL6910AmsNetID AT %I*: ARRAY [0..5] OF BYTE;
    EL6910port AT %I*: WORD;
    internalBuffer: array[0..16#FFFF] of byte;
    FileString: T_MaxString := 'c:\temp\safety\complibTest_EL6910.bin';
    LocalAmsNetID: T_AmsNetID := '172.55.76.53.1.1';
    SaveDone: BOOL;
    SaveResult: STRING(200);
    SaveErr: BOOL;
    StartRestore: BOOL;
    internalbuffer2: array[0..16#FFFF] of Byte;
    RestoreDone: BOOL;
```

```

RestoreResult: STRING(200);
RestoreErr: BOOL;
END_VAR

// Backup of the TwinSAFE logic program
fb_save(
    bExecute:=          StartBackup,
    au8EcatNetId:=      EL6910AmsNetID,
    u16EcatPort:=       EL6910port,
    u32BufferAddress:=  ADR(internalBuffer),
    u32BufferSize:=    SIZEOF(internalBuffer),
    sFileName:=         FileString,
    sNetIDWriteFile:=   LocalAmsNetID,
    Done=>              SaveDone,
    sResult=>          SaveResult,
    bErr=>              SaveErr);

// Restore of the TwinSAFE logic program
fb_restore(
    bExecute:=          StartRestore,
    au8EcatNetId:=      EL6910AmsNetID,
    u16EcatPort:=       EL6910port,
    u32BufferAddress:=  ADR(internalbuffer2),
    u32BufferSize:=    SIZEOF(internalBuffer2),
    sFileName:=         FileString,
    sNetIDReadFile:=    LocalAmsNetID,
    Done=>              RestoreDone,
    sResult=>          RestoreResult,
    bErr=>              RestoreErr);

```

5.8 Export/import of the safety project

The safety project can be archived via the context menu of the safety project. The data type of this archive is *.tfzip.

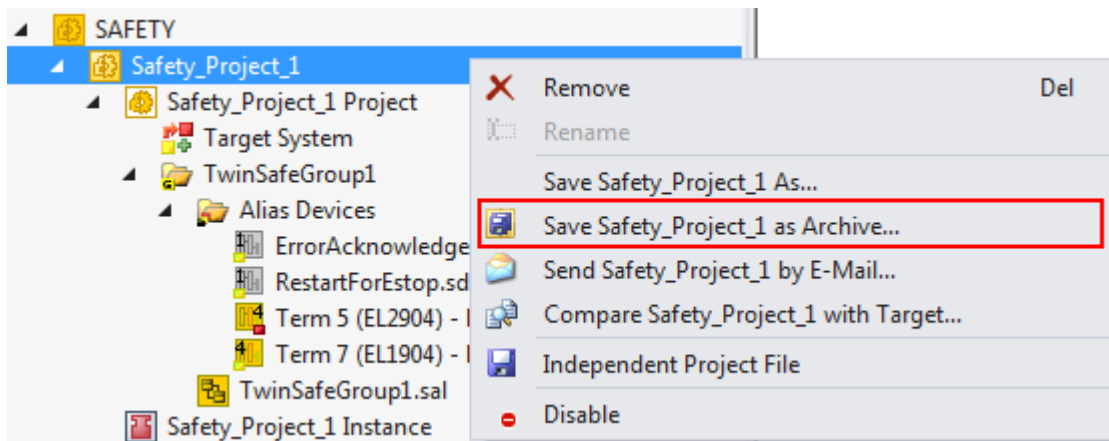


Fig. 107: Archiving the safety project

The safety project can be exported to XML format one level below the safety project node. This XML format can be used for exchange between TwinCAT 3 and TwinCAT 2.

The menu item *Export project (as bin file)* can be used to save the safety project in a binary format, so that it can be used by the TwinSAFE loader, for example.

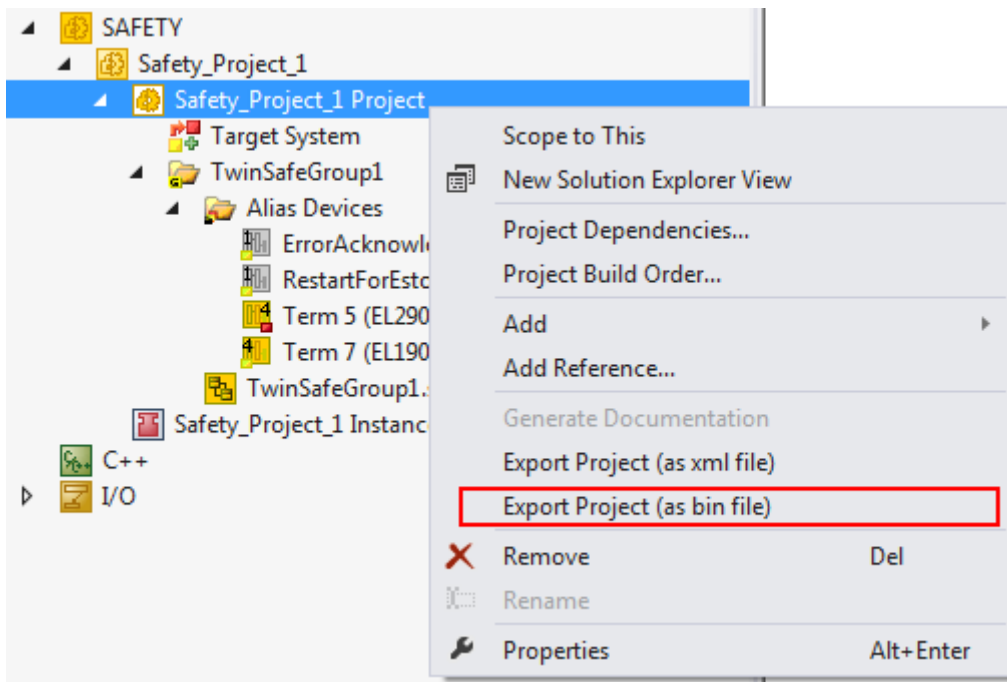


Fig. 108: Saving the safety project in a binary format (e.g. for the TwinSAFE loader)

A previously exported safety project can be imported via the context menu of the main Safety entry in the TwinCAT project structure. *Add Existing Item...* can be used to select the file type for the import.

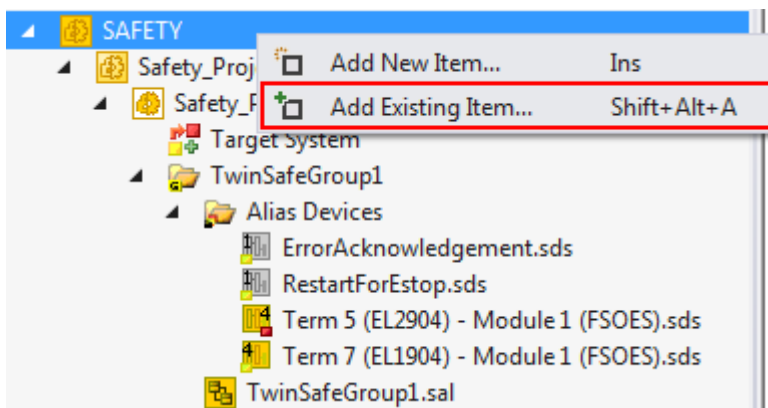


Fig. 109: Selecting the file type for importing a safety project

The following file types are supported:

- Safety project files *.splc,
- Safety project archives *.tfzip
- Safety projects in XML format

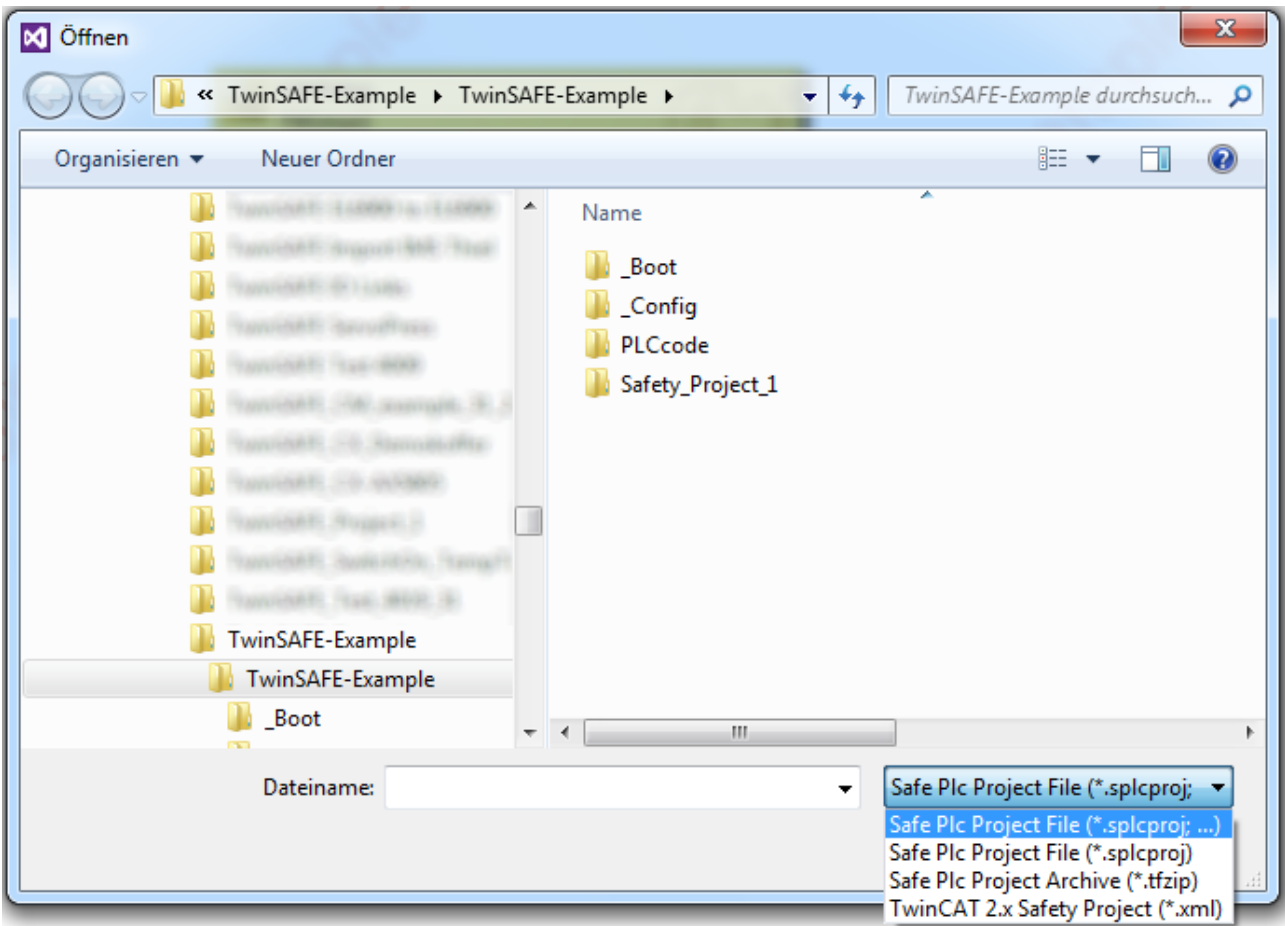


Fig. 110: Importing a safety project

5.9 Diag History tab

Any errors that occur in the EL6910, EJ6910 or EK1960 are stored in their diag history. The diag history can be viewed by selecting the EL6910, EJ6910 or EK1960 in the I/O tree structure and then selecting the *Diag History* tab. Use the *Update History* button to fetch the current from the EL6910, EJ6910 or EK1960. Error within the logic; the function blocks and the connections are stored with a corresponding timestamp.

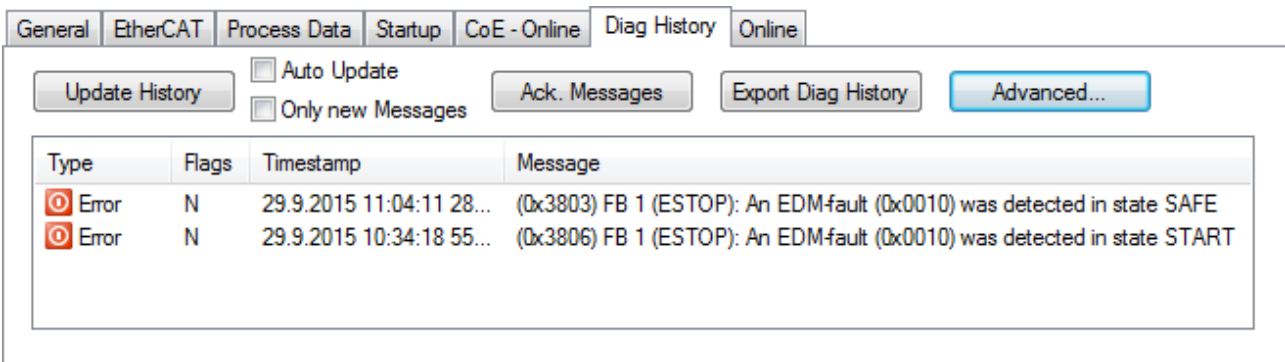


Fig. 111: Diag History

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

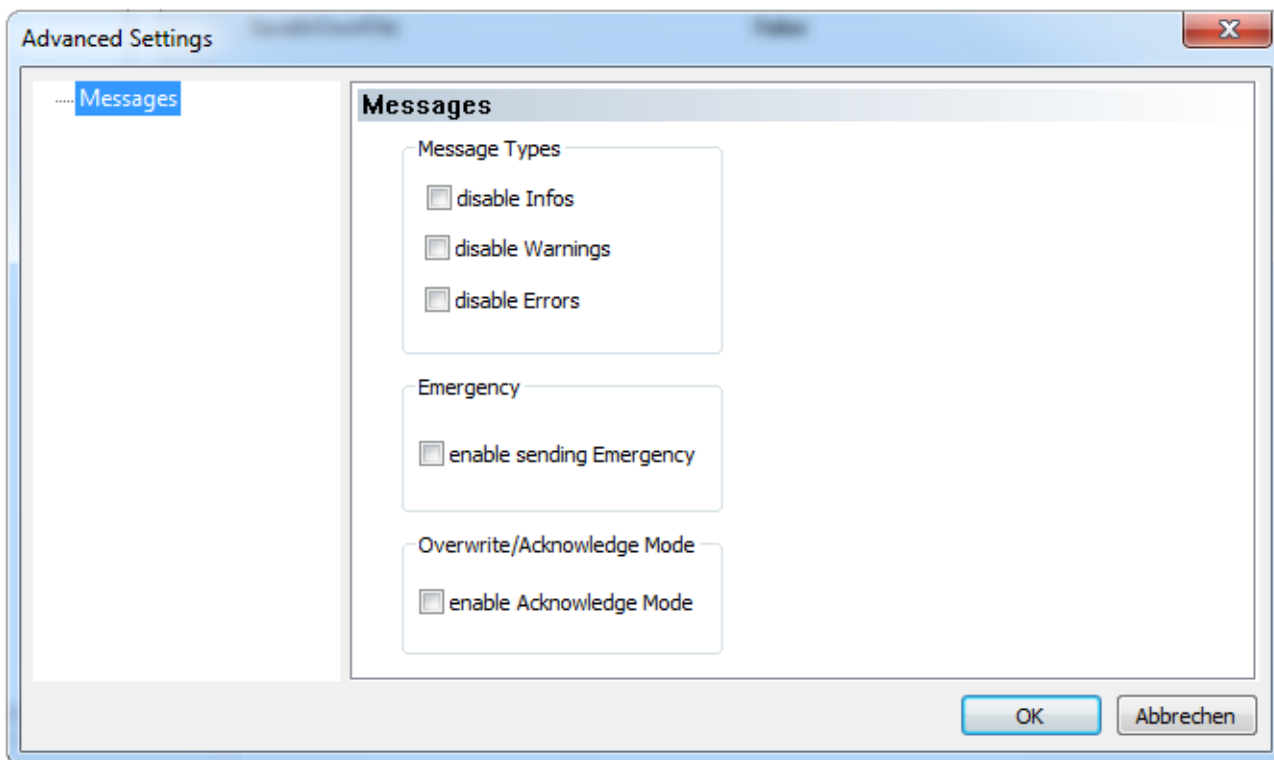


Fig. 112: Diag History - Advanced Settings

Advanced Settings

Setting	Description
Message Types	<ul style="list-style-type: none"> • disable Info Messages with status <i>Info</i> are not stored in the diag history • disable Warnings Messages with status <i>Warning</i> are not stored in the diag history • disable Errors Messages with status <i>Error</i> are not stored in the diag history
Emergency	In addition to saving the message in the diag history, an emergency object is sent, which is displayed in the logger window of TwinCAT.
Overwrite / Acknowledge Mode	This setting is currently not supported.

5.10 TwinSAFE SC - configuration

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

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

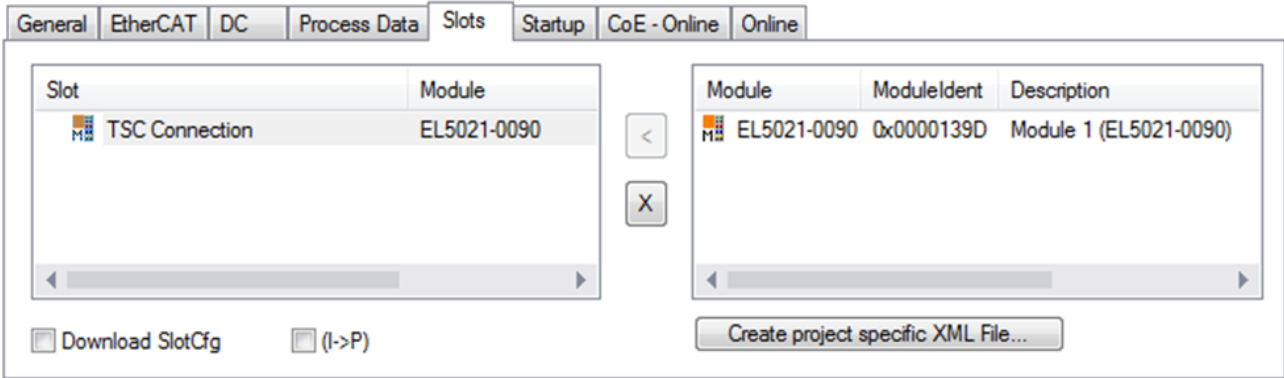


Fig. 113: Adding the TwinSAFE SC process data under the component, e.g. EL5021-0090

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

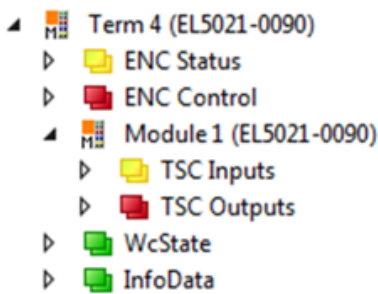


Fig. 114: TwinSAFE SC component process data, example EL5021-0090

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

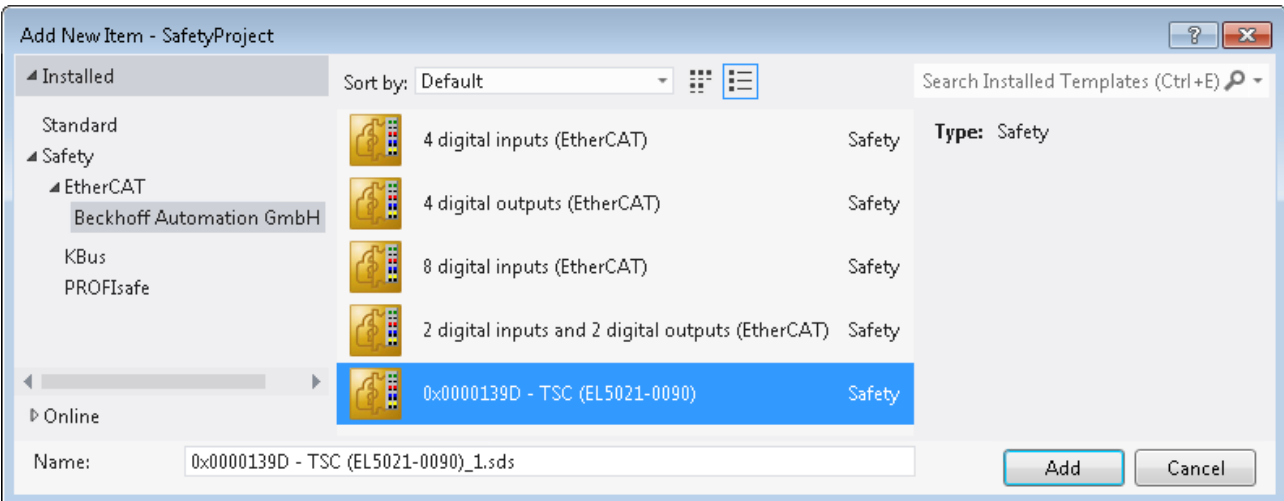



Fig. 115: Adding a TwinSAFE SC connection

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

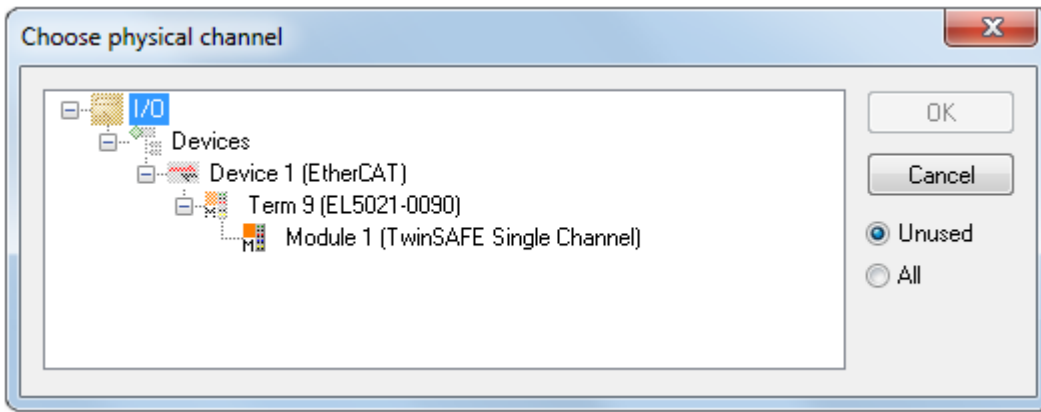


Fig. 116: Creating a link to TwinSAFE SC terminal

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

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

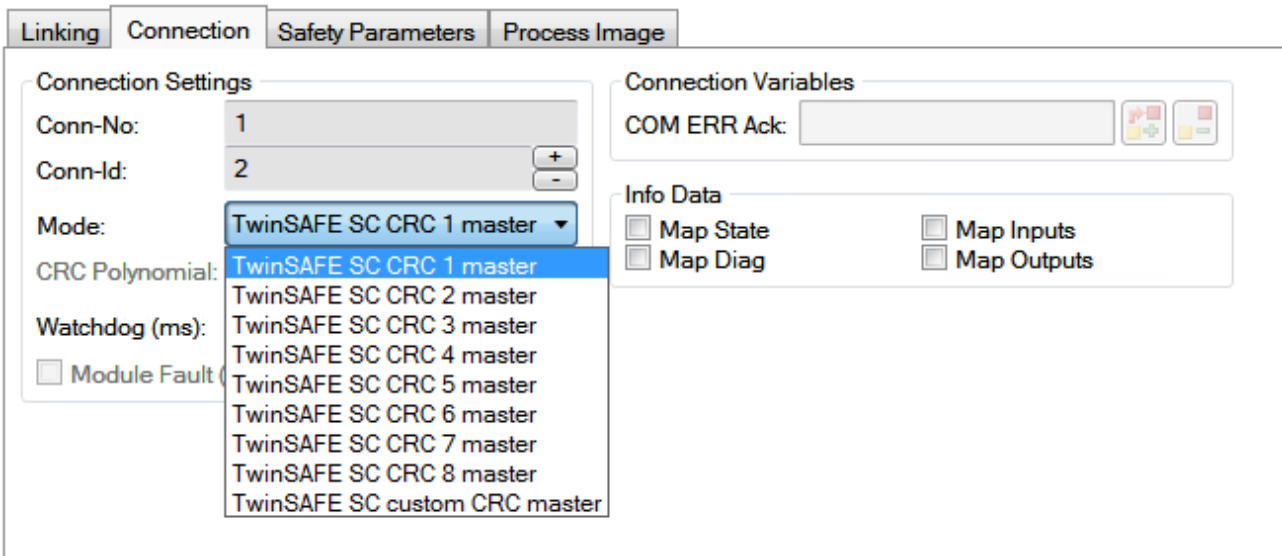


Fig. 117: Selecting a free CRC

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

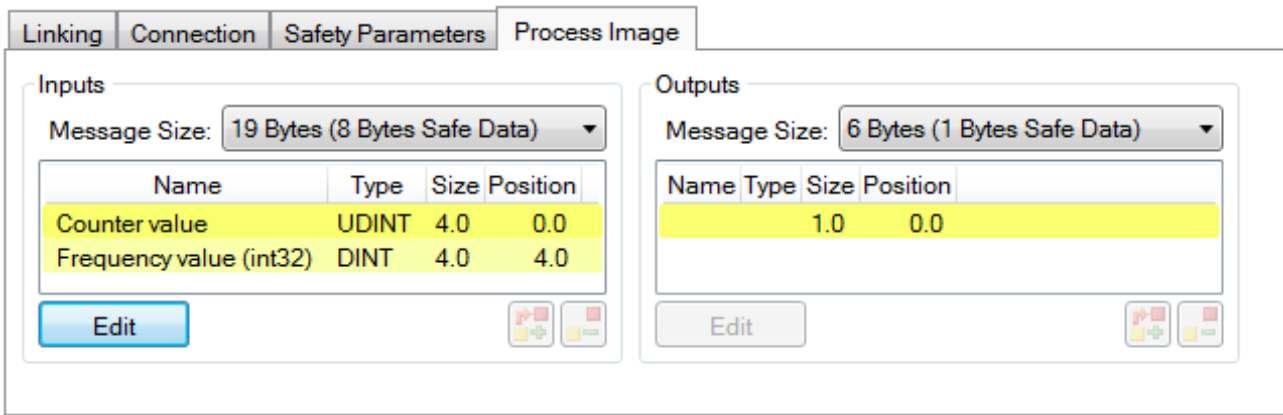


Fig. 118: Selecting the process data size and the process data

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

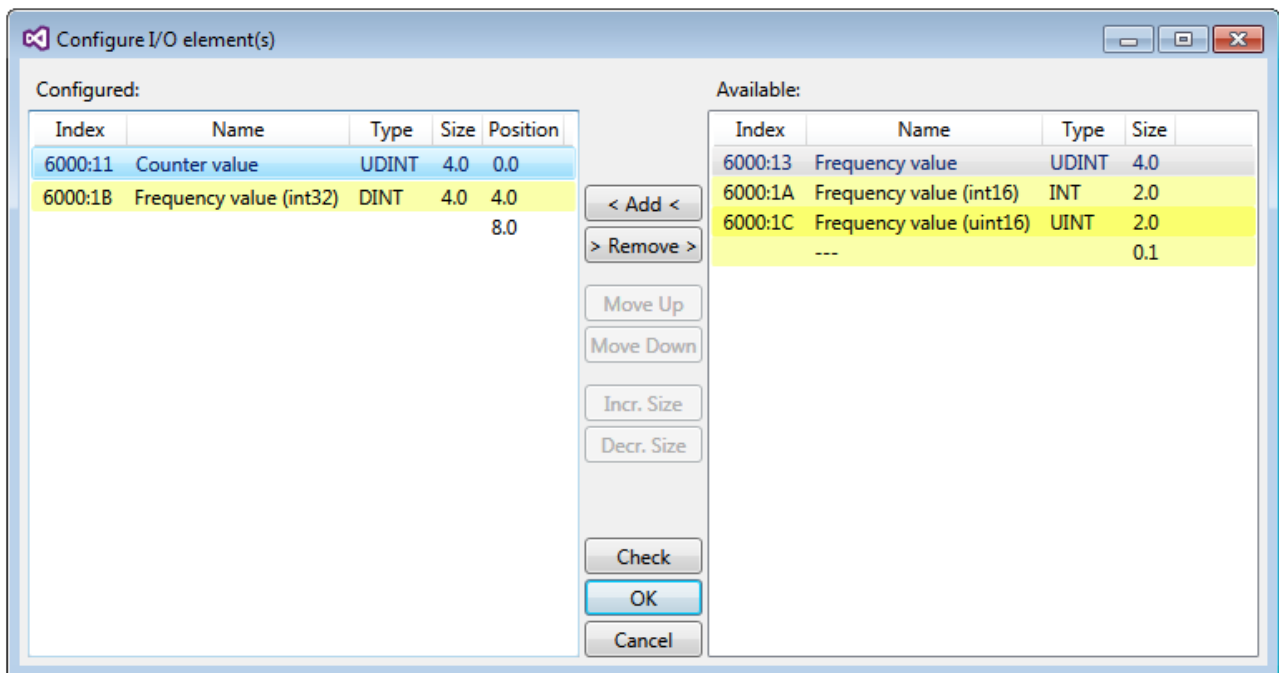


Fig. 119: Selection of the process data

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

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

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

Fig. 120: CoE objects 0x8010:01 and 0x8010:02

● Object TSC Settings

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

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

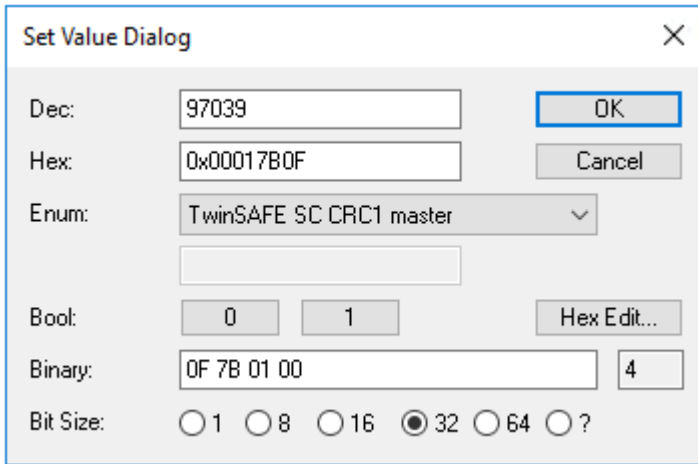



Fig. 121: Entering the safety address and the CRC

● TwinSAFE SC connections

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

5.11 Customizing / disabling TwinSAFE groups

The function Customizing  can be selected in the safety toolbars or via the TwinSAFE menu. It can be used to enable and disable groups. There are different deactivation methods, as shown in the following table.

Deactivation	Description
Permanent deactivation	The TwinSAFE group is permanently disabled by the user. The substitute values parameterized for the group are set for the group outputs. If this group is enabled again, the RUN signal for this group must change from 0 to 1, in order for the group to start. Parameter: <i>Permanent Deactivation Allowed</i> : TRUE/FALSE
Deactivation until the EL6910 is switched off and back on again	The TwinSAFE group is disabled until the EL6910 is switched on again. The substitute values parameterized for the group are set for the group outputs. This setting cannot be used as default setting for the safety program download. If this group is enabled again (other than by switching off and on again), the RUN signal for this group must change from 0 to 1, in order for the group to start. Parameter: <i>Temporary Deactivation Allowed</i> : TRUE/FALSE
Deactivation of manual control unit	After starting the deactivation, the connection defined in the group must report a COM error after a period of 10 seconds, for example (default setting). If this is not the case, a group error set and corresponding diagnostic message is generated. Only one connection may be defined in the group, which must be a master connection. Parameter: <i>Passification Allowed</i> : TRUE/FALSE <i>Timeout Passification Allowed</i> : Time in ms

The customization can also be carried out during the download of the safety application.

In order to be able to perform a customization, the groups must be set accordingly. This is done via the group properties.

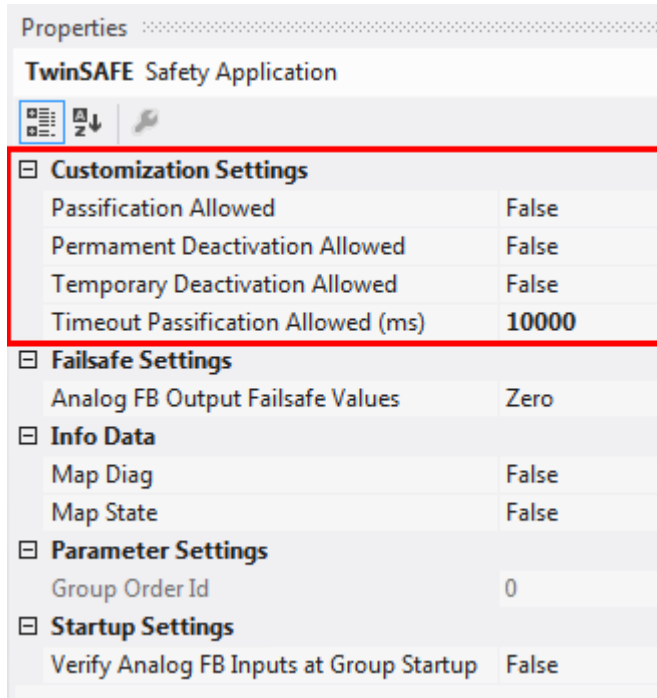


Fig. 122: Properties of the TwinSAFE group

If one of the Customizing parameters (*Passification Allowed*, *Permanent Deactivation Allowed* or *Temporary Deactivation Allowed*) is set to TRUE, all outputs of the TwinSAFE group that are not Safety Alias Devices are listed in the list of *Replacement Values*. Here you can parameterize the substitute values to be written to the output in the event of deactivation of the group.

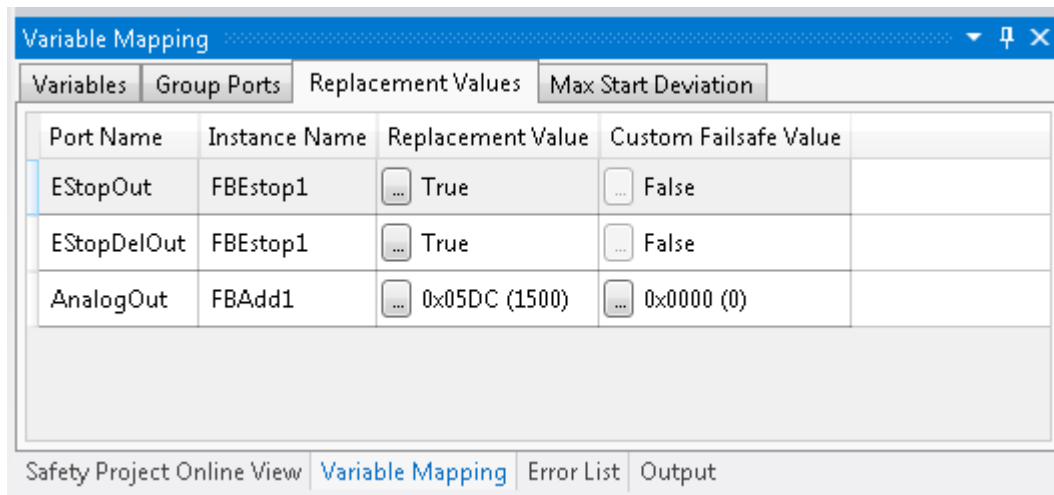



Fig. 123: Replacement values for the TwinSAFE group

When the Customizing function  is selected, the login dialog opens for the user to enter their login data. This login must give permission for customizing.

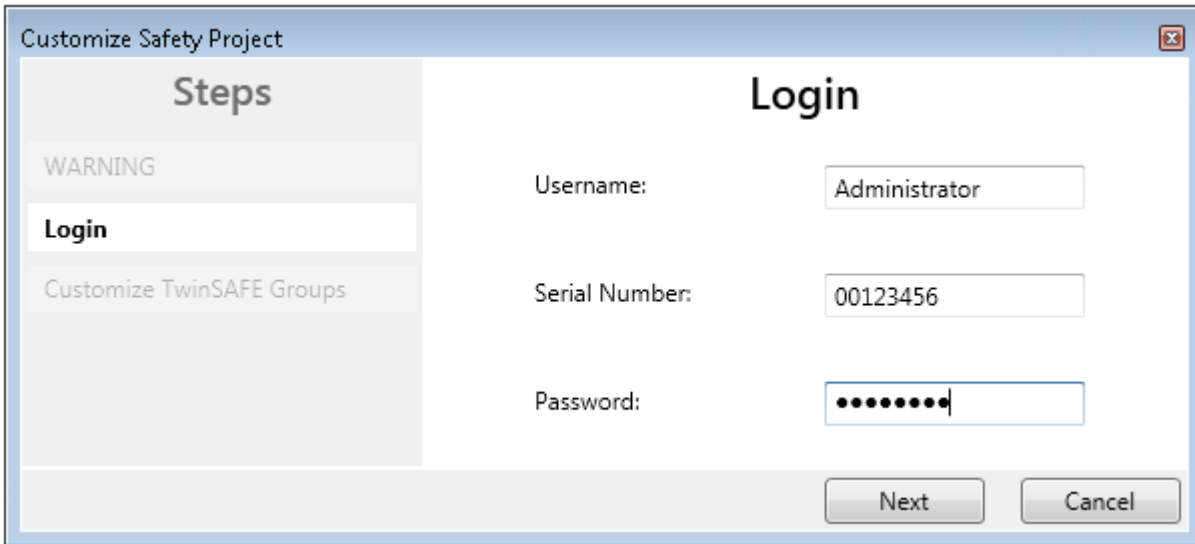


Fig. 124: Login

The Customizing dialog opens once the user has entered the data and selected *Next*.

The current group status is indicated with a green background.



Fig. 125: Customizing TwinSAFE Groups

The user can select the new status via the option area. In the sample below *Deactivate Temporarily* is selected. Use the *Finish* button to close the dialog and execute the required option.



Fig. 126: Customized TwinSAFE Group

i TwinSAFE Logic in PreOP state

If Customizing is carried out on a TwinSAFE Logic with EtherCAT status PreOP, the customizing of a group does not become active. Customizing must be carried out again if the TwinSAFE Logic is in the EtherCAT status SafeOP or OP.

5.12 Saving the analog group inputs persistently

EL6910, EJ6910 and EK1960 support persistent saving of analog input values in an internal memory. When the group starts up, the stored data are compared with the current data. Under the tab *Max Start Deviation*, a corresponding deviation can be specified for each defined analog input value of the group.

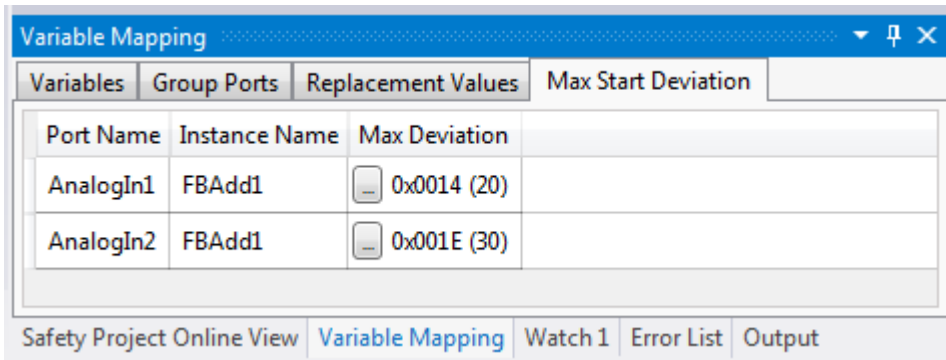


Fig. 127: Specifying deviations for analog input values

In the group properties the general settings for setting substitute values and checking the analog values on group startup can be parameterized. Setting the parameter *Verify Analog FB Inputs at Group Startup* to TRUE activates saving of all analog group inputs.

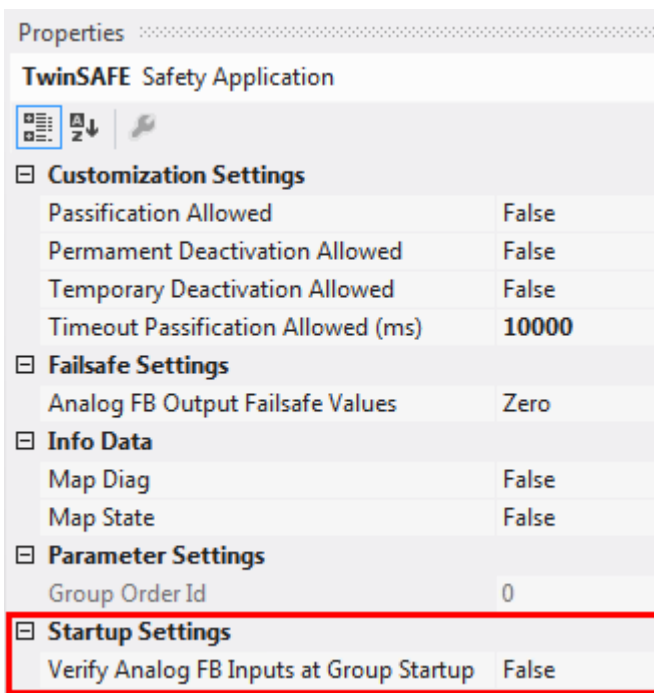


Fig. 128: Activate saving of all analog group inputs

5.13 New features in TC3.1 Build 4022

In the TwinCAT Version 3.1 Build 4022 some extensions have been implemented for the TwinSAFE editor. With the release of the TwinCAT version, these are available to the user. This chapter lists the new features.

5.13.1 Group status

The status of the TwinSAFE group is displayed as a color-coded frame in online mode.

The RUN state is marked with a green one, the ERROR state with a red frame, and all other states with a blue frame.

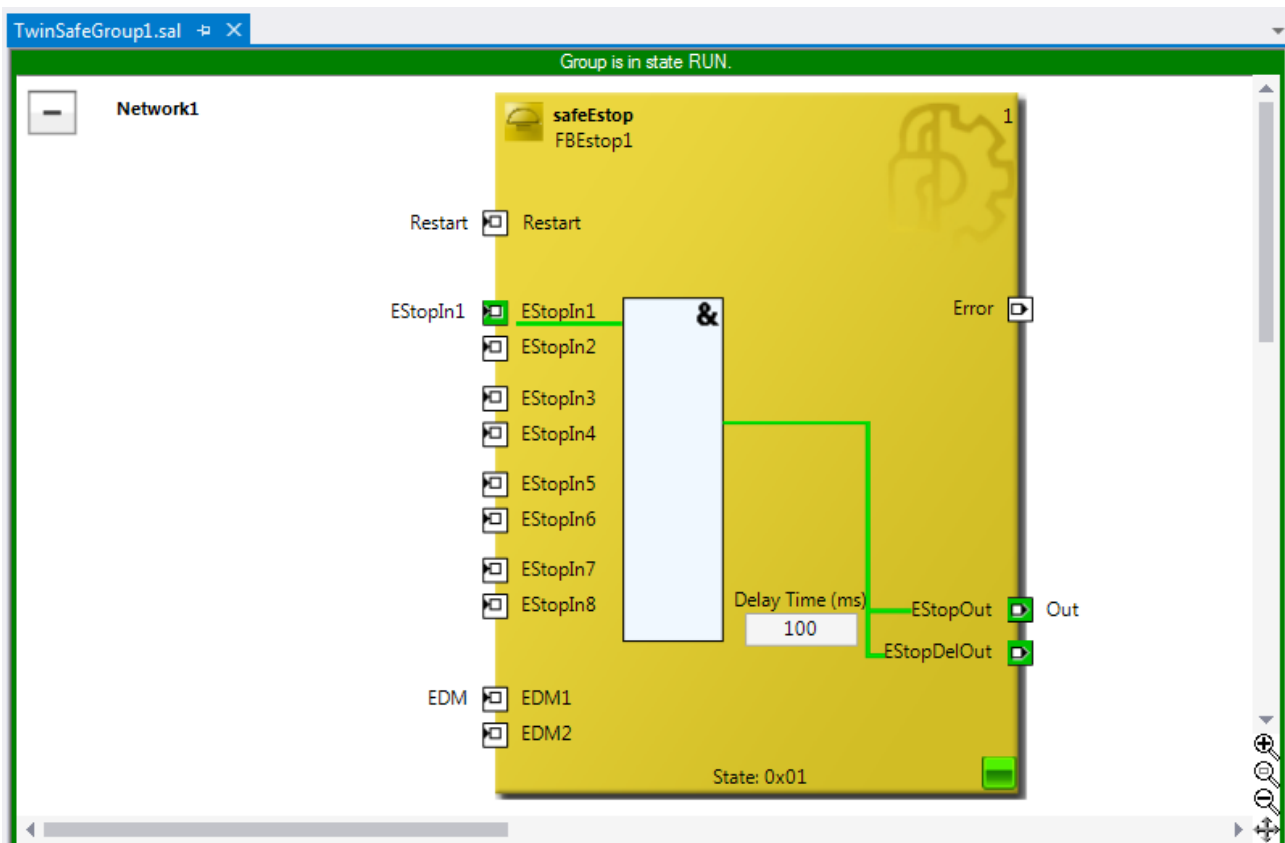


Fig. 129: Group Status Online RUN

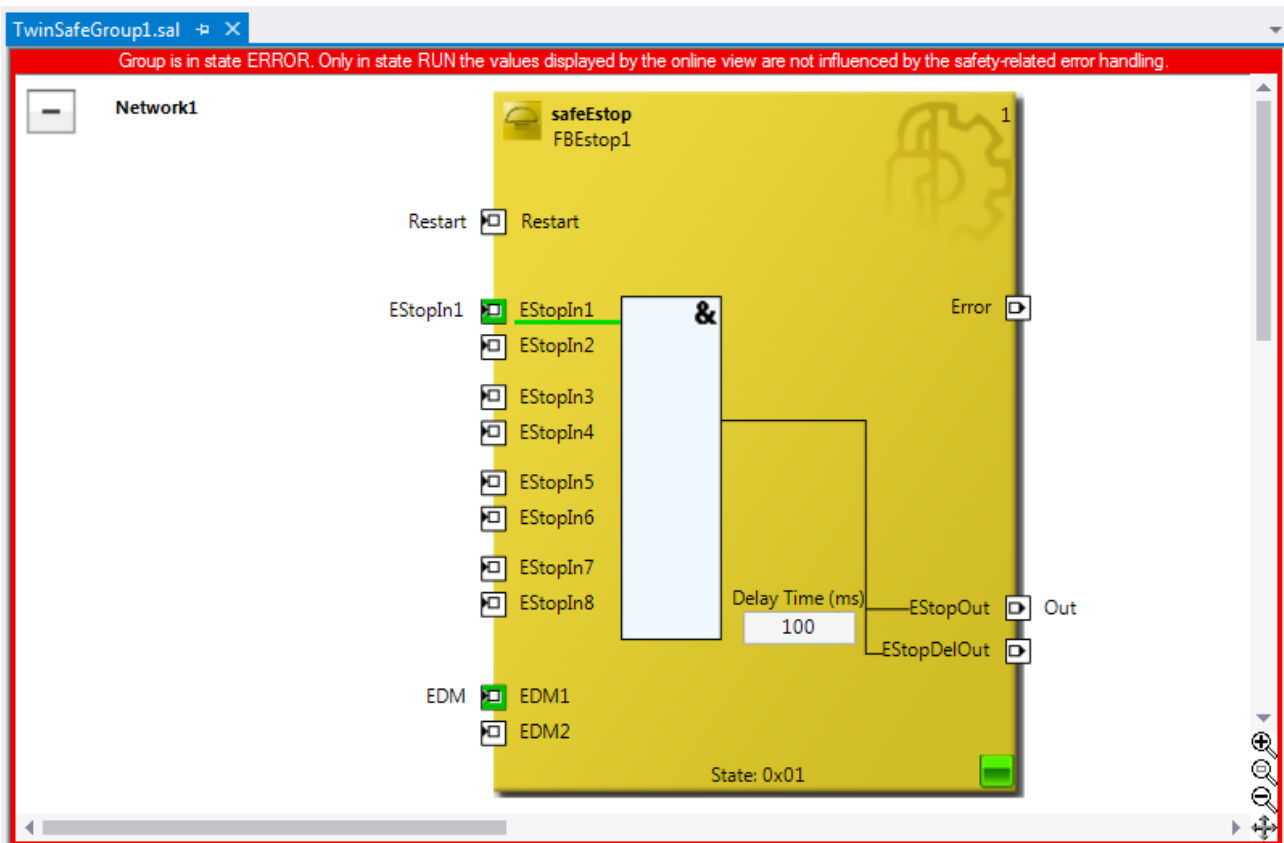


Fig. 130: Group Status Online ERROR

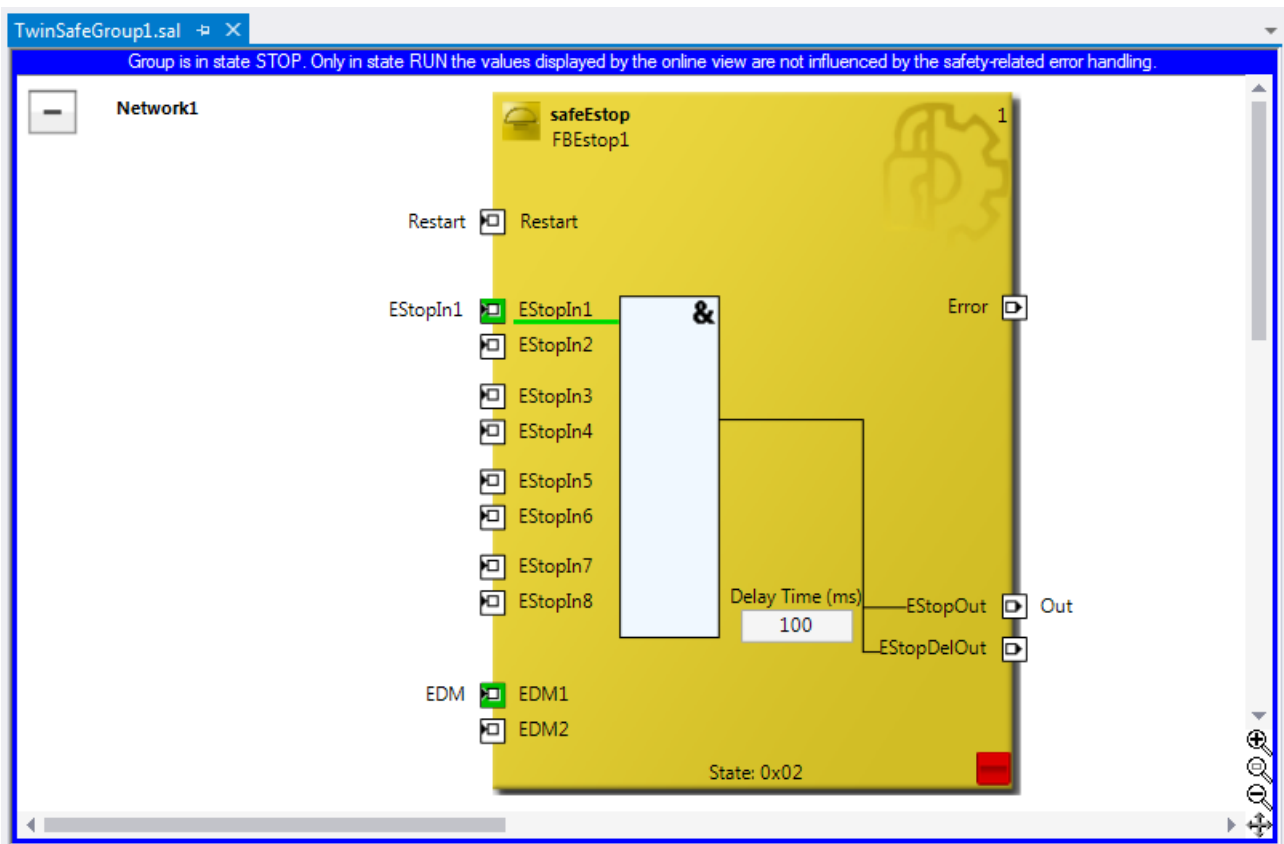


Fig. 131: Group Status Online STOP

5.13.2 Online view group ports

In online mode the group inputs and outputs are marked according to their signal status. A logical 1 of the signal is represented with a green background, a logical 0 with a white background. Error information is displayed with a red background.

Group Port	Online Value	Direction	Alias Port
Err Ack	False	input	ErrAck.In (TwinSafeGroup1)
Run/Stop	True	input	Run.In (TwinSafeGroup1)
Module Fault	False	input	
Com Err	True	output	
FB Err	True	output	
Other Err	False	output	
Com Startup	False	output	
FB Deactive	False	output	
FB Run	True	output	
In Run	False	output	

Fig. 132: Online View Group Ports

5.13.3 Group templates

The user has a choice between three templates.

The templates differ by the number of already existing links (none, ErrAck created and linked to group port, ErrAck and Run created and linked to group ports).

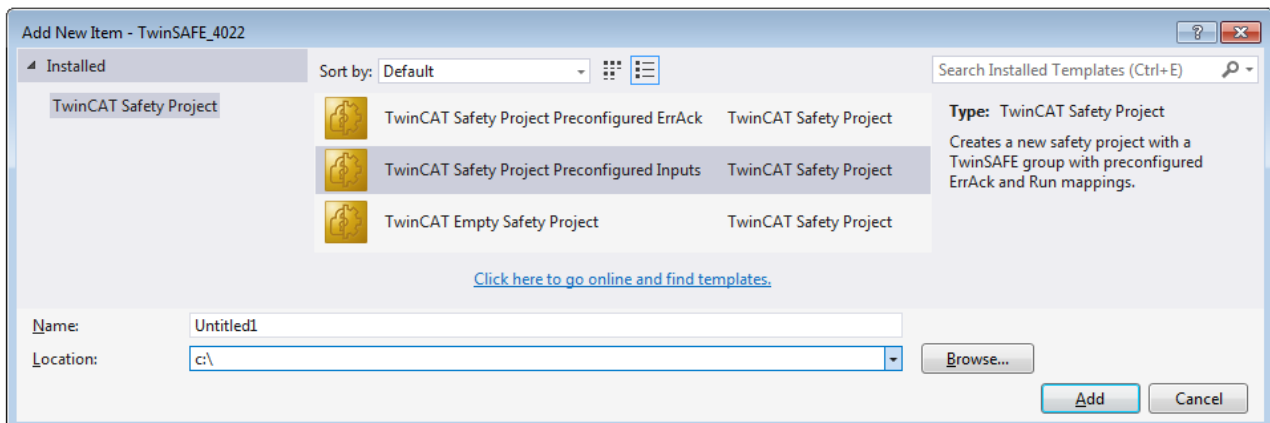


Fig. 133: Templates for Safety Projects

5.13.4 Networks collapsable

The networks defined in a TwinSAFE group can be collapsed.

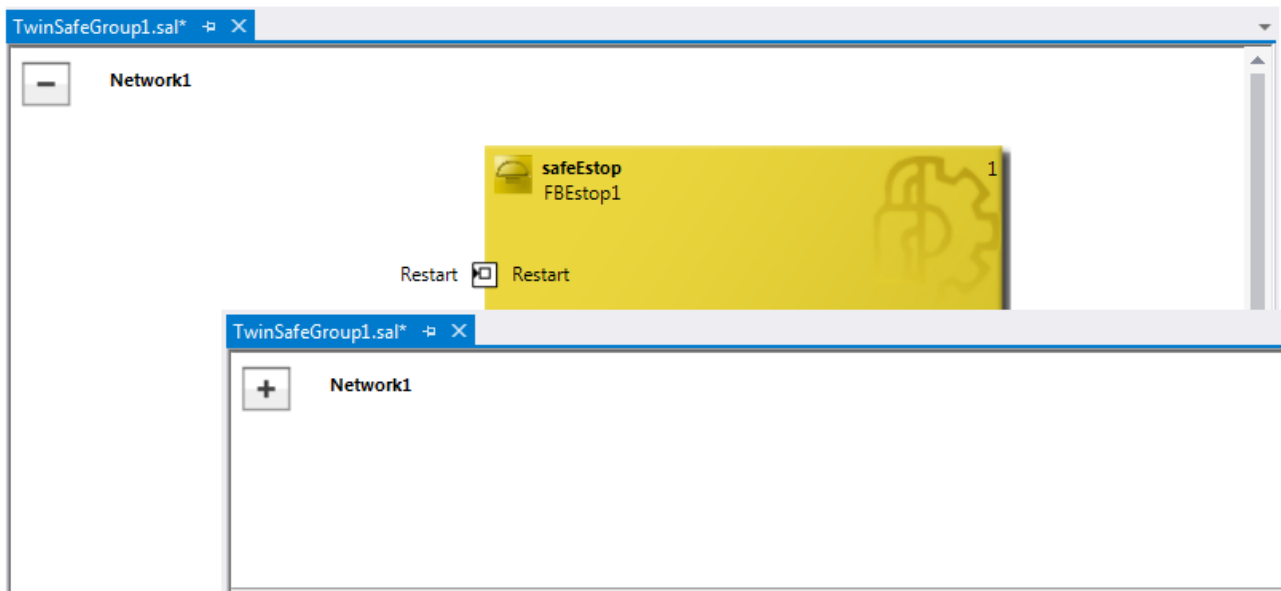


Fig. 134: Collapsing networks

5.13.5 Subfolder Alias Devices

Under the node *Alias Devices*, further subfolders can be created. After the subfolder has been created, it can be renamed, here for example to *Drives*.

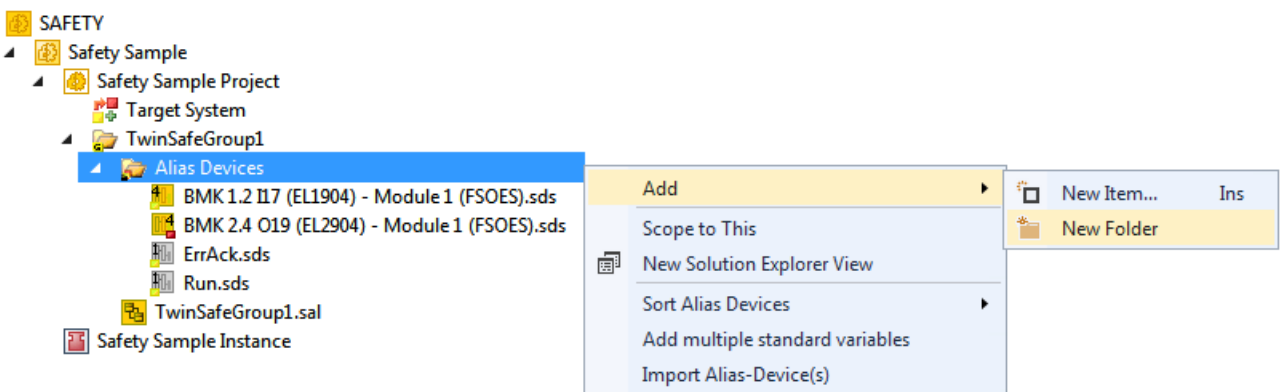


Fig. 135: Adding a subfolder

After adding a subfolder, *Alias Devices* can be added in this folder.

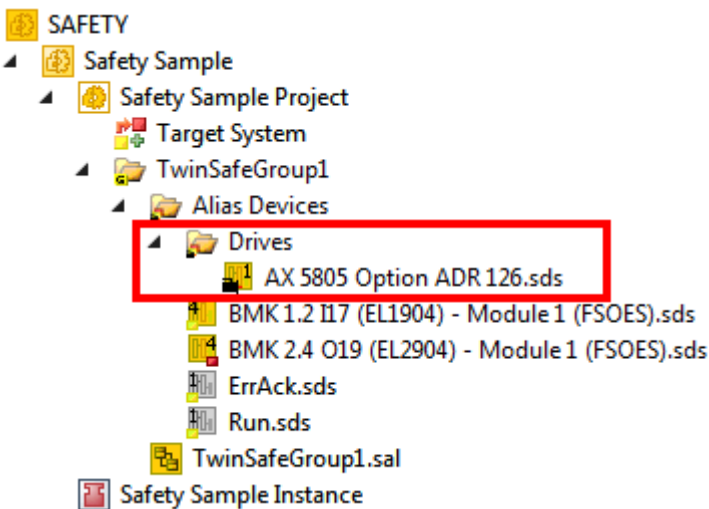


Fig. 136: Subfolder e.g. Drives

5.13.6 Goto linked element

The entry *Goto Linked Element* can be called via the context menu. All links and variables used on that port are listed. Selecting an entry triggers a jump to the corresponding position in the network, a TwinSAFE group or variable mapping.

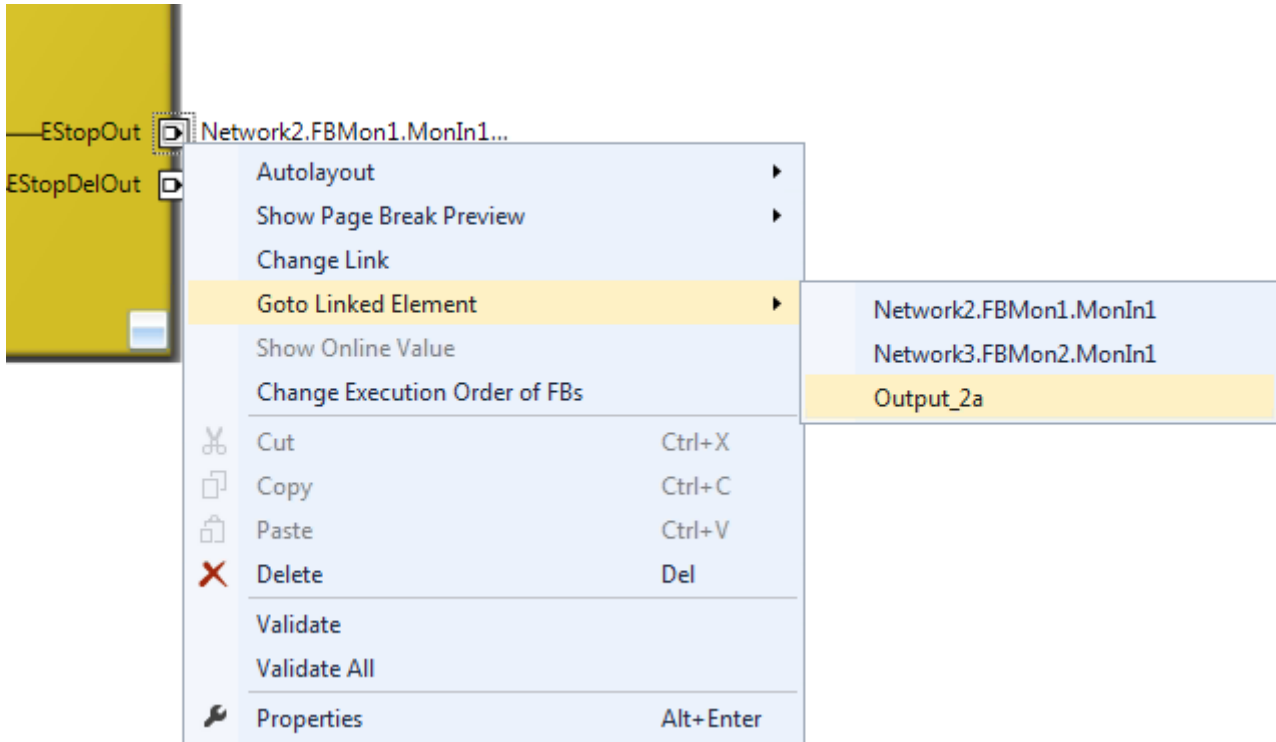


Fig. 137: Goto Linked Element

5.13.7 Path view to linked signal

The *Linking* tab of the *Alias Devices* displays the links to the PLC and to the I/O devices. The name in the process image of the TwinSAFE logic is displayed under the entry *Name*.

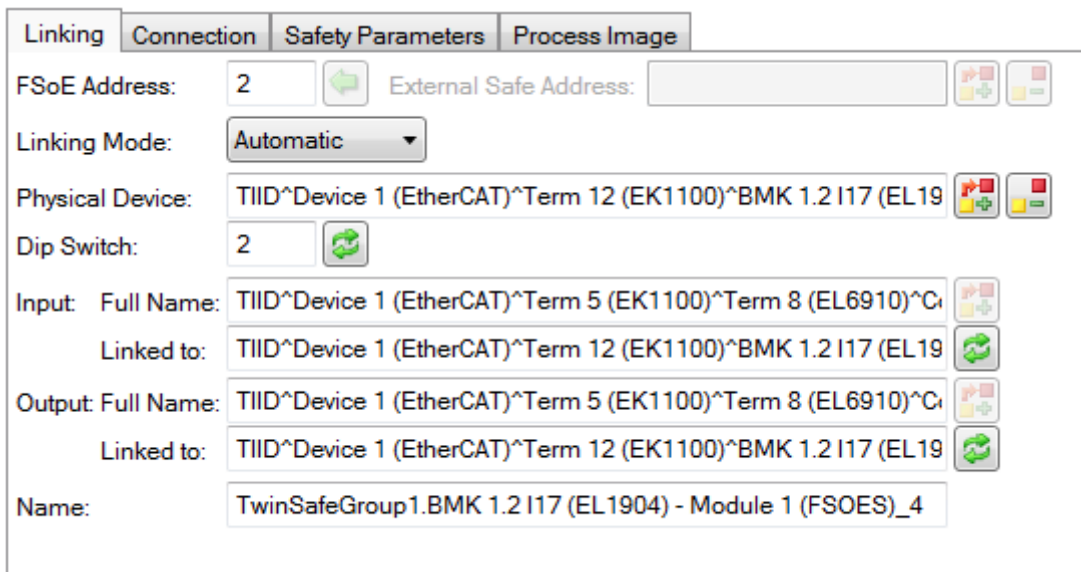


Fig. 138: Path view for safety Alias Devices

For the *Standard Alias Devices*, the path to the signal below the TwinSAFE logic (full name), the link to the PLC (Linked to), and the name in the process image of the TwinSAFE logic are displayed.

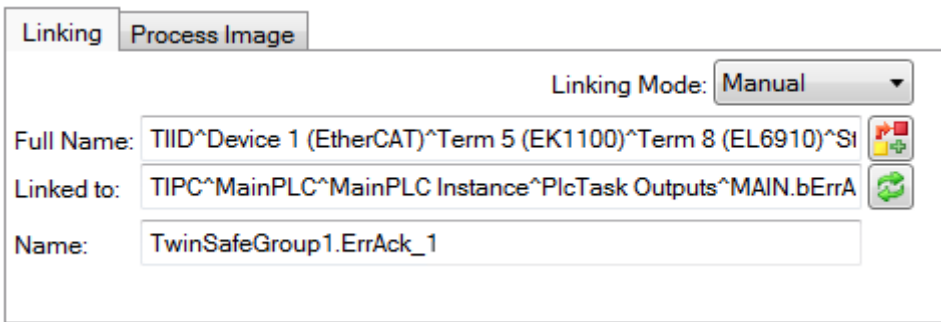


Fig. 139: Path view for Standard Alias Devices

5.13.8 Multiline comments

Comments in the TwinSAFE project may now be multiline.

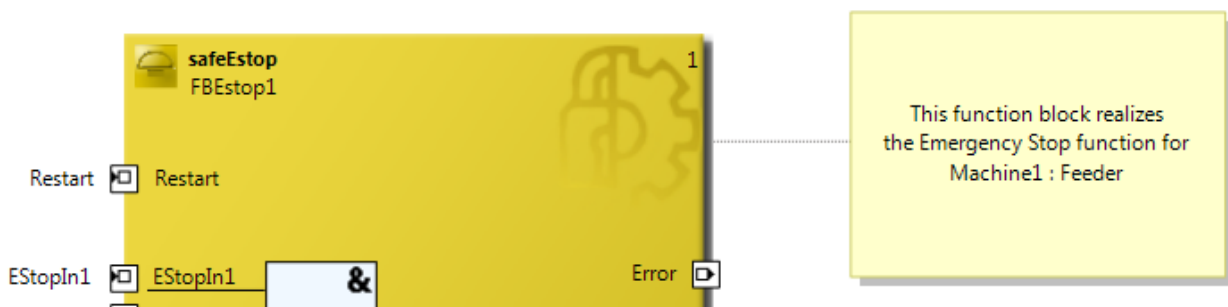


Fig. 140: Multiline comments

5.13.9 Names of Alias Devices in the process image

The user has now the option of adapting the naming of process data below the TwinSAFE logic in the I/O tree. For this purpose, checkboxes are available on the *Target System* dialog to accept the naming of TwinSAFE connections and standard inputs and outputs from the respective *Alias Device* names.

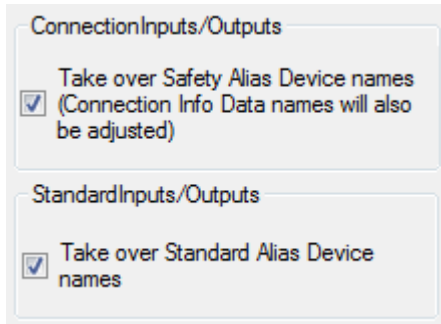


Fig. 141: Properties under Target System

After the checkboxes are set, the names of the alias devices are taken.

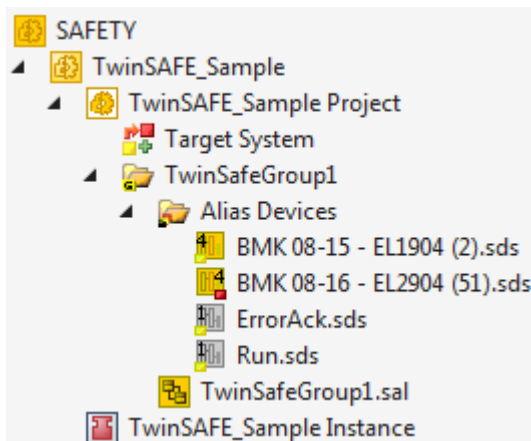


Fig. 142: Take Alias Device Name - Safety Project

In the I / O tree below the TwinSAFE logic, the project is shown in the following screenshot. The name consists of the group name, alias device name, and a running index.

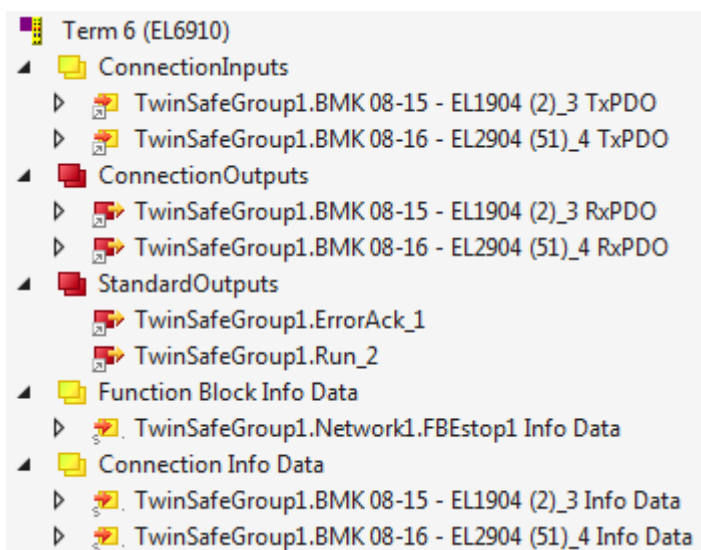


Fig. 143: Take Alias Device Name - TwinSAFE logic process image

5.13.10 Project settings - Verification

The project settings can be found below the target system.

Safe Address Verification

The *Safe Address Verification* entry is used to set how the safety addresses are checked.

- Project wide unique (recommended) - Unique safety addresses within the entire solution
- Similar to TwinCAT 2 - Unique addresses per TwinSAFE Logic
- Allow multiple usage - Multiple safety addresses are possible (user evaluation required)

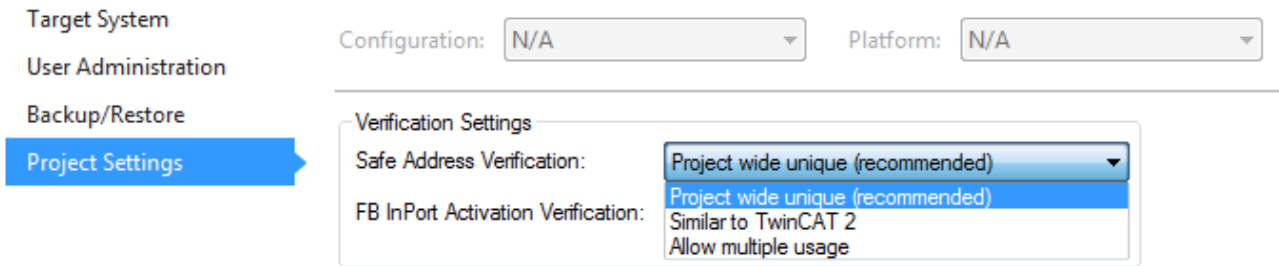


Fig. 144: Safe Address Verification

FB InPort Activation Verification

The *FB InPort Activation Verification* entry is used to set how the input ports of TwinSAFE FBs are checked.

- Strict activated & connected (recommended) - Each activated port must be connected, and each connected port must be activated.
- Activated or connected allowed - If a port is only activated or only connected, this does not lead to an error message.

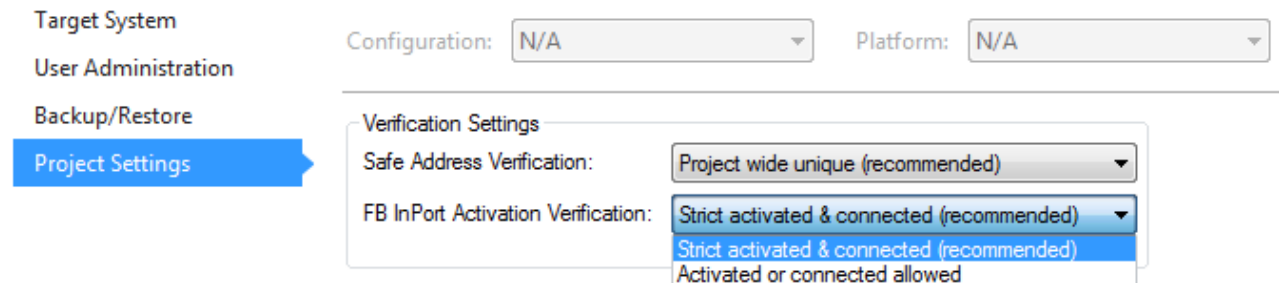


Fig. 145: FB InPort Activation Verification

NOTICE

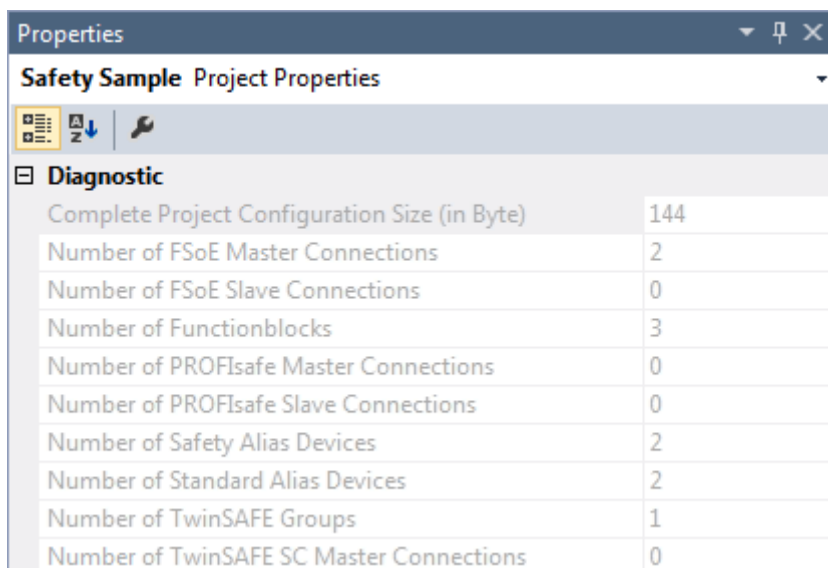
Support of project settings

The settings are supported from software version 03 of the EL6910 (SW03) and EK1960 (SW03). Furthermore, all newer logic components, such as the EL1918, are supported.

5.13.11 Displaying the project size

Diagnostic Properties of the project node

If the project node of the TwinSAFE project is selected, the properties under the entry Diagnostic show the current project parameters. These are e.g. the project size in bytes, the number of connections, the number of function blocks, or the number of TwinSAFE groups.

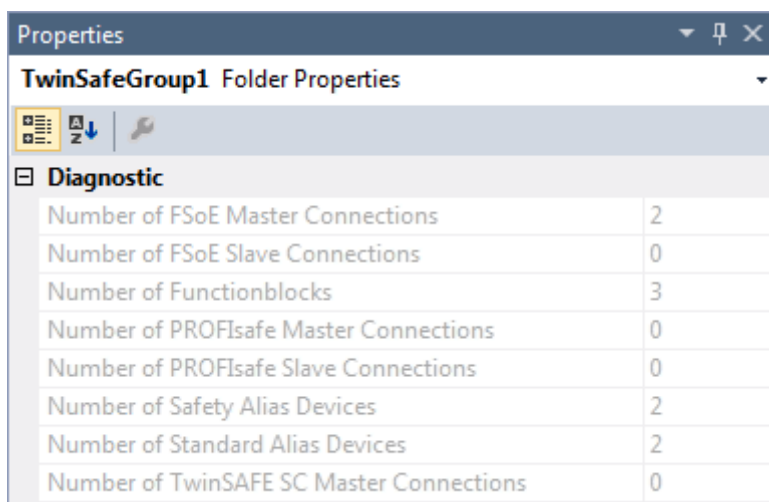


Safety Sample Project Properties	
Diagnostic	
Complete Project Configuration Size (in Byte)	144
Number of FSoE Master Connections	2
Number of FSoE Slave Connections	0
Number of Functionblocks	3
Number of PROFIsafe Master Connections	0
Number of PROFIsafe Slave Connections	0
Number of Safety Alias Devices	2
Number of Standard Alias Devices	2
Number of TwinSAFE Groups	1
Number of TwinSAFE SC Master Connections	0

Fig. 146: Project Properties - Diagnostic

Diagnostic Properties of the group node

If the group node of the TwinSAFE project is selected, the properties under the entry Diagnostic display the current TwinSAFE group parameters. These are e.g. the number of connections, the number of function blocks, or the number of standard signals.



TwinSafeGroup1 Folder Properties	
Diagnostic	
Number of FSoE Master Connections	2
Number of FSoE Slave Connections	0
Number of Functionblocks	3
Number of PROFIsafe Master Connections	0
Number of PROFIsafe Slave Connections	0
Number of Safety Alias Devices	2
Number of Standard Alias Devices	2
Number of TwinSAFE SC Master Connections	0

Fig. 147: Group Properties - Diagnostic

5.13.12 Copy and Paste for FBs and comments

The copy and paste function refers to function blocks, comments and connections between function blocks. The copied variable names and links remain unchanged, the FB instances are automatically incremented (here FBEstop1 becomes FBEstop2).

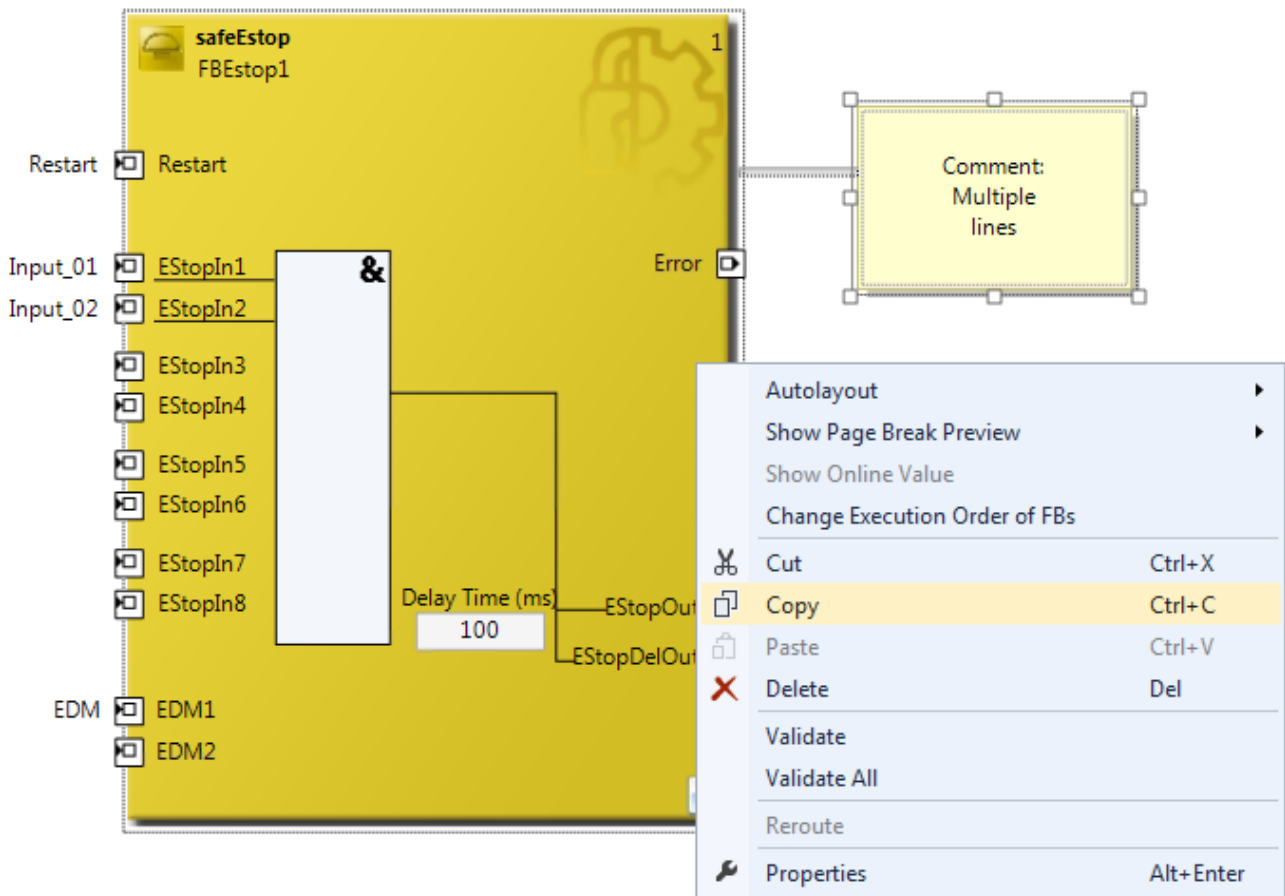


Fig. 148: Copying the data

After inserting the data, the following message appears. The user may have to adjust copied variable names.

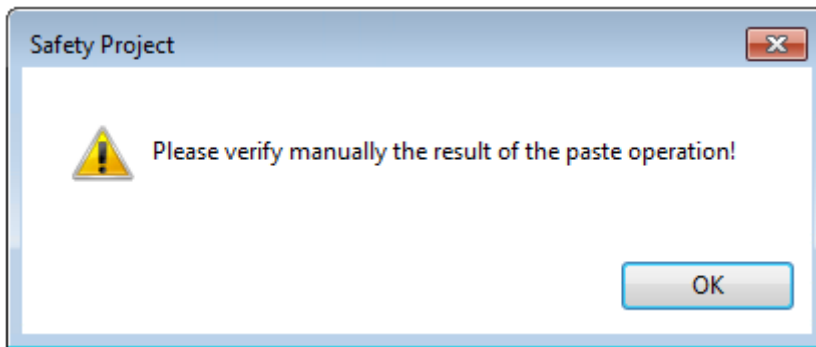


Fig. 149: Message box after inserting the data

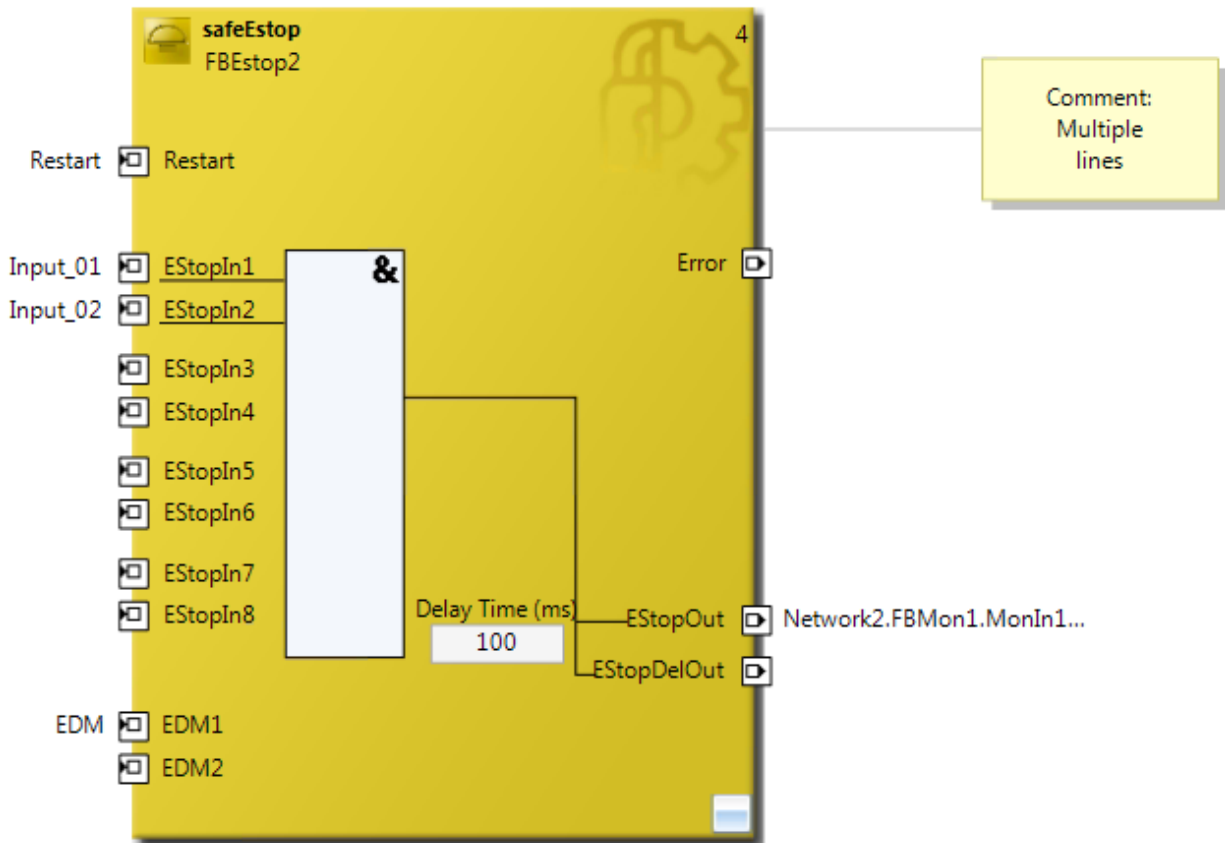


Fig. 150: Inserted data

Here, in the example, the user must adapt the links of the output EStopOut and change the variable names Restart, Input_01, Input_02 and EDM so that no duplicate names are assigned.

5.13.13 Global settings in Visual Studio

Options can be selected under the Tools menu in Visual Studio. In these options, settings for the TwinSAFE environment can be made.

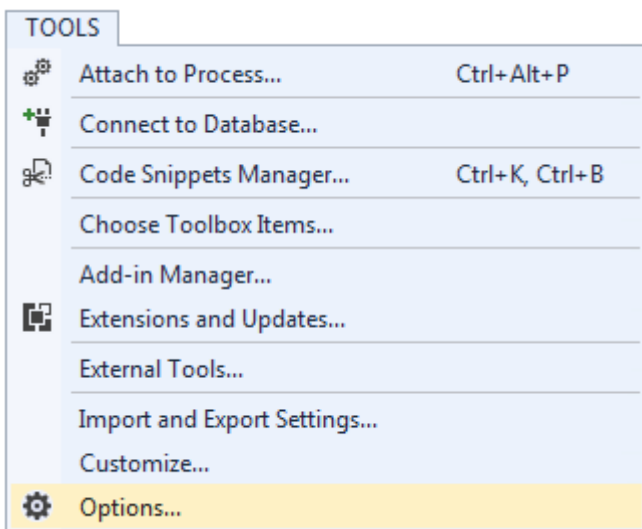


Fig. 151: Visual Studio - Menu Tools / Options

Under *TwinCAT / TwinSAFE Environment / Default Info Data* you can configure which info data should be activated automatically when TwinSAFE projects, groups, connections or FBs are created.

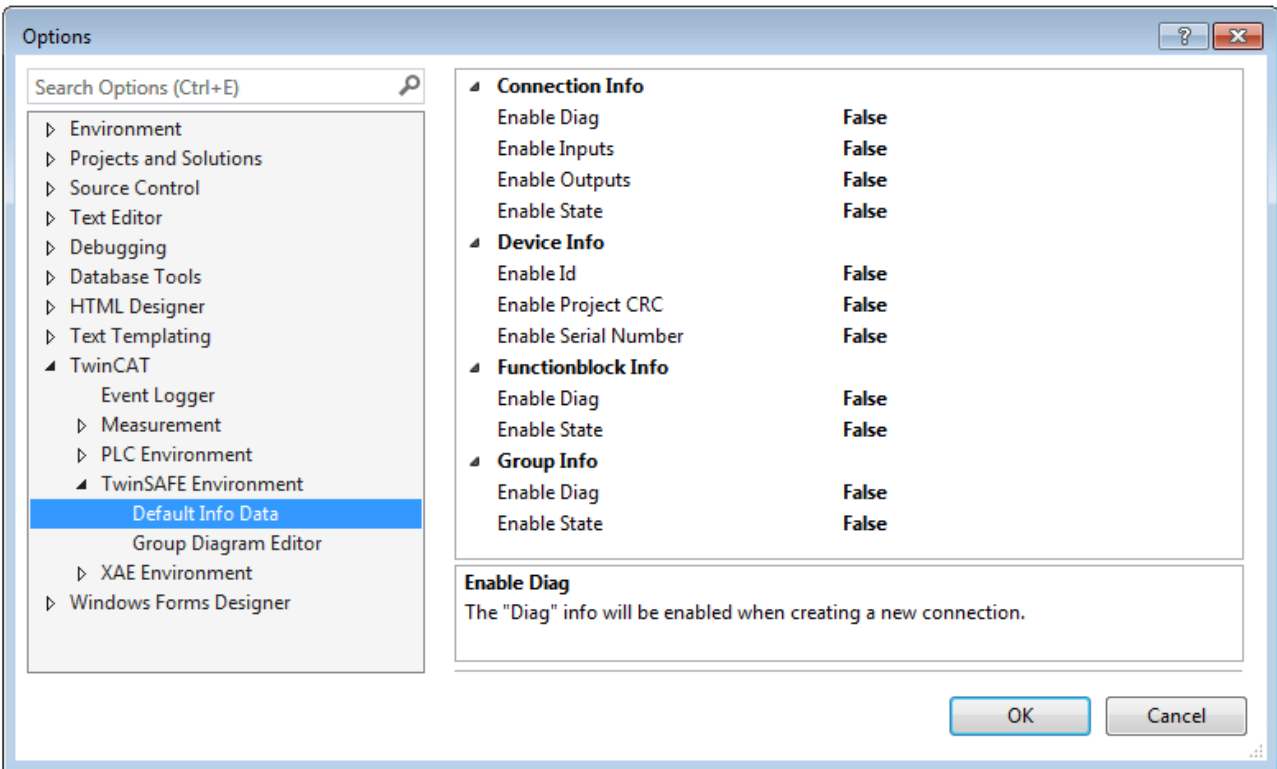


Fig. 152: Global setting - Default Info Data

Under *TwinCAT / TwinSAFE Environment / Group Diagram Editor* you can specify whether the Undo / Redo function should automatically zoom and scroll into the area that has changed.

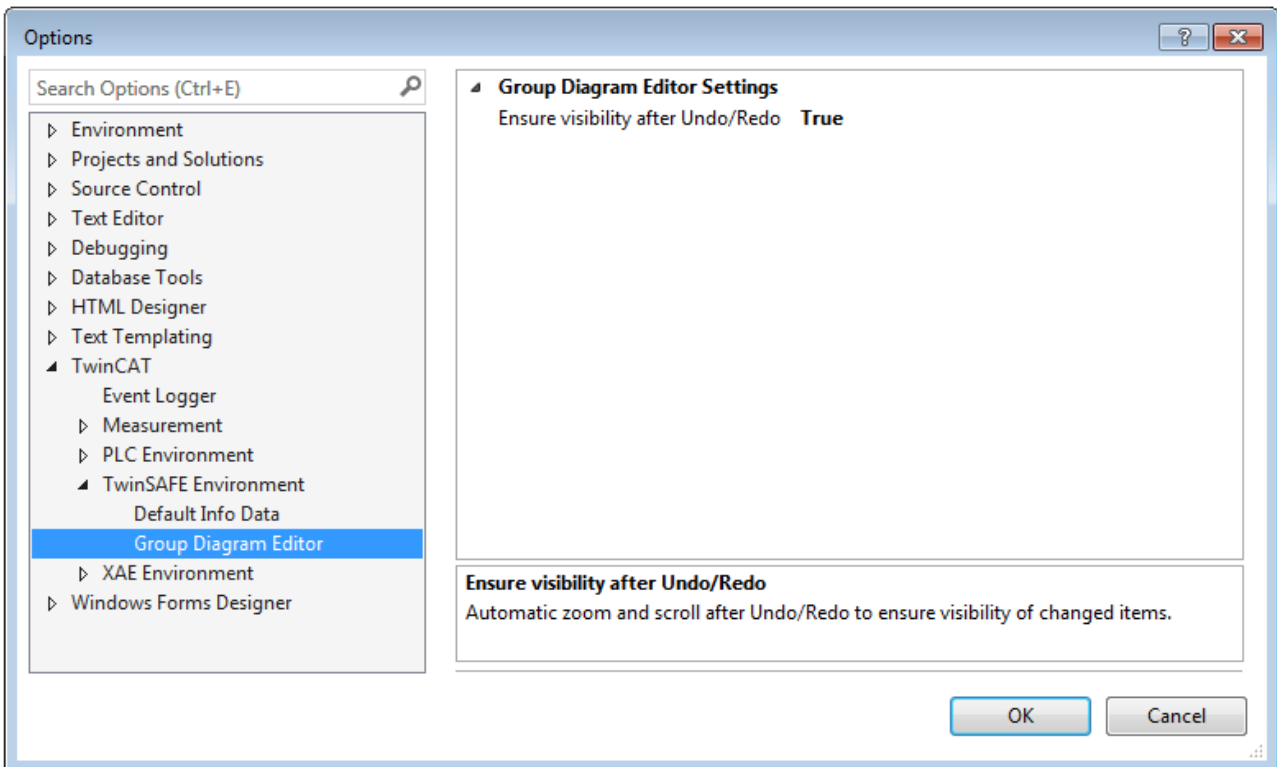


Fig. 153: Global Setting - Group Diagram Editor

5.13.14 Sorting

Setting the execution order of the groups via dialog

The context menu of the project node can be used to access the execution order of the TwinSAFE groups.

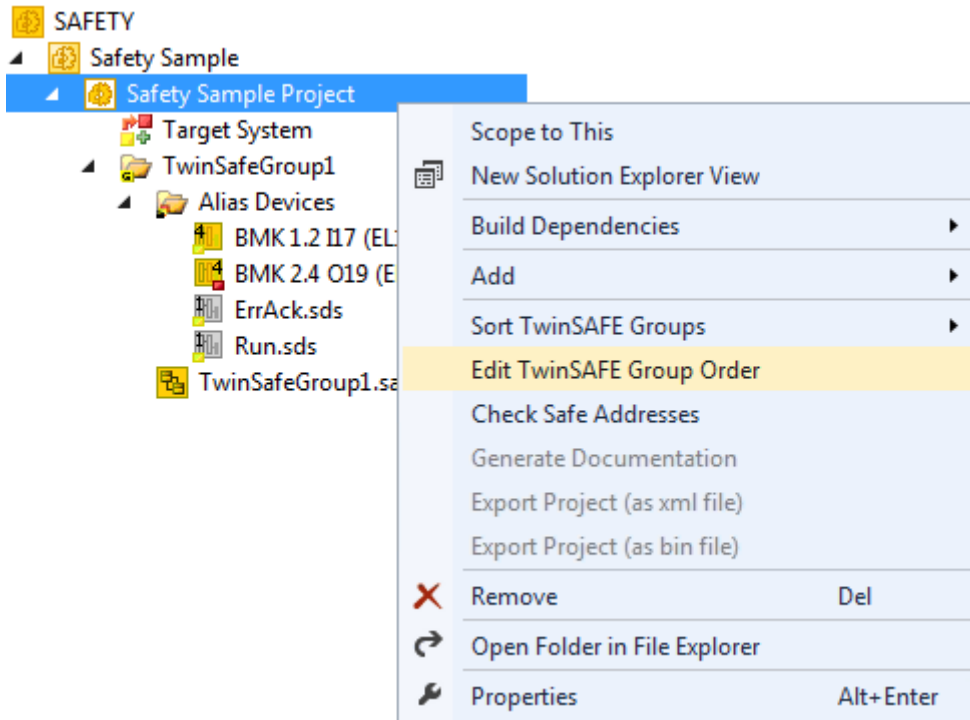


Fig. 154: Context menu - Edit TwinSAFE Group Order

By selecting a group and then holding and dragging an entry with the mouse, the execution order of the groups can be changed. The new order is accepted with the OK button.

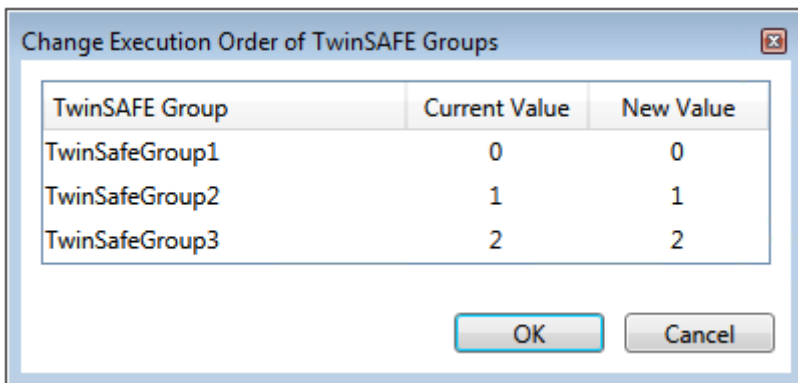


Fig. 155: Execution order for TwinSAFE groups

Sorting of Alias Devices

You can use the context menu of the Alias Devices node to configure the display order of the alias devices.

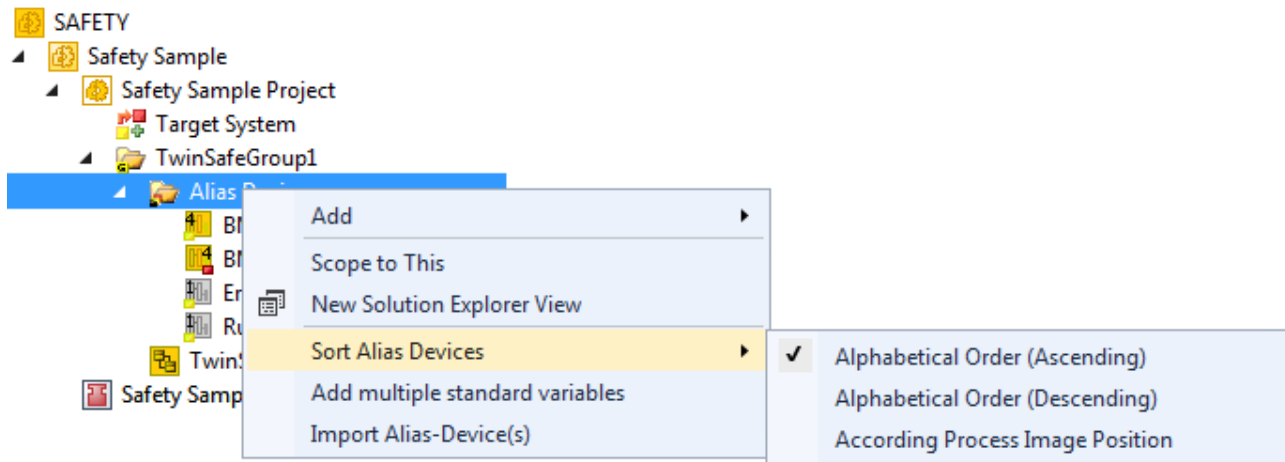


Fig. 156: Sorting of Alias Devices

Sorting of FBs (execution order)

The execution order of the function blocks can be accessed via the context menu within the graphical worksheet.

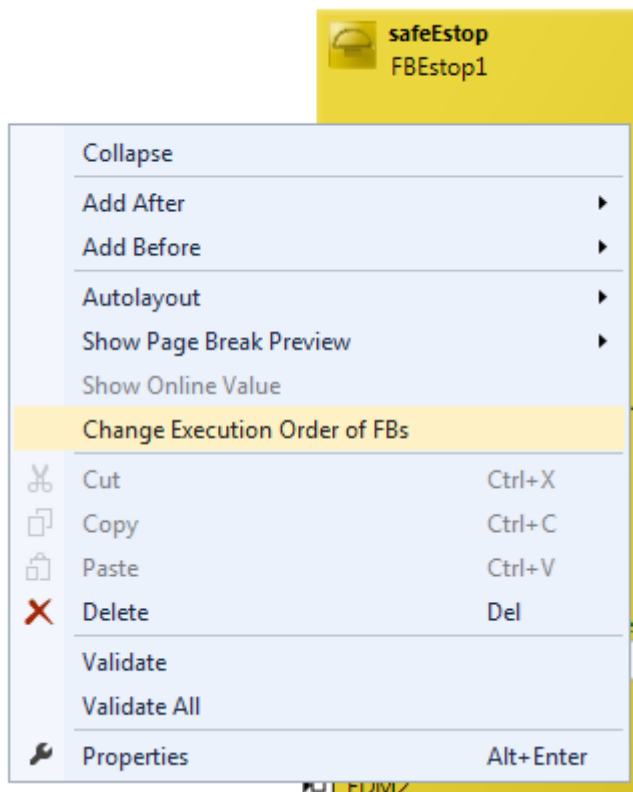


Fig. 157: Context Menu - Change Execution Order of FBs

By selecting an FB and then holding and dragging an entry with the mouse, the execution order of the function blocks can be changed. The new order is accepted with the OK button.

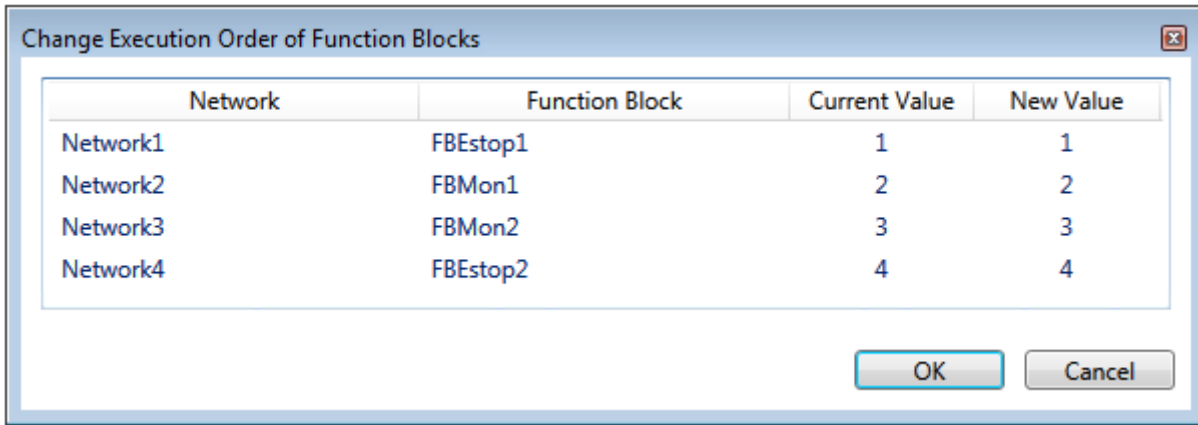


Fig. 158: Execution order FBs

5.13.15 Direct mapping of local I/Os

If a TwinSAFE Logic has local inputs and outputs, e.g. an EK1960, an assignment to safe and non-safe signals can be made by the user via the *Internal Direct Mapping* tab of the alias device. These direct assignments have the advantage that no logic program has to be created by the user for this purpose.

To be able to use the internal direct mapping, the Linking mode of the Alias Device must be set to *local*.

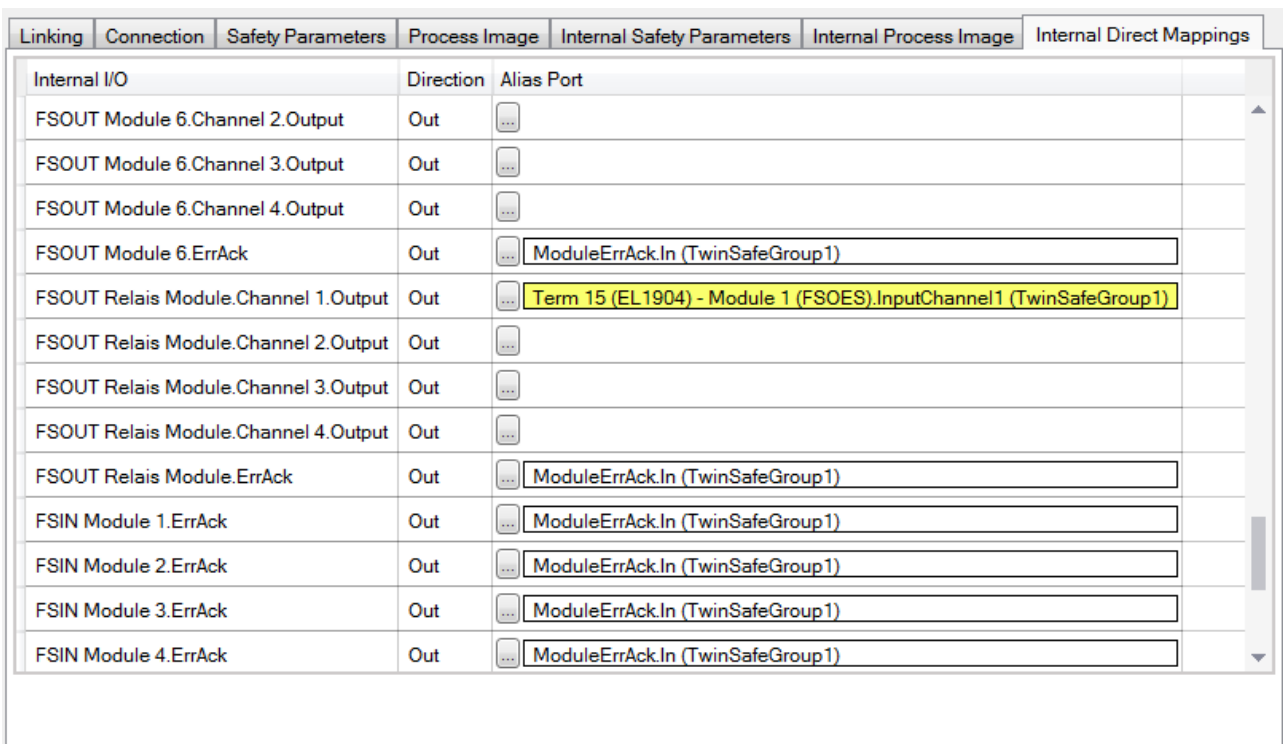


Fig. 159: Dialog - Internal Direct Mapping

Typical applications are linking the ErrAck signals of the modules with a Standard Alias Device or switching an output due to a safe input signal.

In the figure the relay output *FSOUT Relay Module Channel 1.Output* is switched by the safe input *Term(15) (EL1904) - Module 1 (FSOES) InputChannel 1*.

5.13.16 Backup/Restore settings

Backup/restore settings have been extended so that TwinSAFE logic components can also be used to store a TwinSAFE project CRC. The following table describes the settings for each TwinSAFE connection listed in the Backup/Restore dialog.

Checkbox	Description	Available in
Store Project CRC in Slave	<p>Only active when FSoE Connection Type is set to Master.</p> <p>The CRC of the local project is stored on the target slave and can be used for the backup/restore mechanism.</p> <p>Now, besides the EL1904 and EL2904, TwinSAFE logics are also supported for storing the CRC.</p>	EL69xx, EL1904, EL2904, EP1908
Store Slave Project CRC in Master	<p>Only active when FSoE Connection Type is set to Master.</p> <p>If the target slave is a logic component that uses the backup/restore mechanism, the project CRC of the logic project of the target slave must be entered manually here.</p>	EL691x, EK1960, EJx9xx and newer products
Store Master Project CRC in Slave	<p>Only active if FSoE Connection Type is set to Slave.</p> <p>The FSoE master sends a CRC to be stored on the local TwinSAFE component so that it can be used for a restore function on the remote FSoE master. This checkbox can be used even if the local backup/restore function is not active.</p>	EL691x, EK1960, EJx9xx and newer products
Read Project CRC from Master	<p>Only active if FSoE Connection Type is set to Slave.</p> <p>The CRC, which is entered on the FSoE master (see Store Slave Project CRC in Master), can be read by the FSoE slave for the local restore function.</p>	EL691x, EK1960, EJx9xx and newer products

Target System Configuration: Platform:

User Administration

Backup/Restore

Project Settings Activate Backup/Restore

Available Alias Devices for Backup/Restore-Mode

Alias Device	Store Project CRC in Slave	Store Slave Project CRC in Master	Store Master Project CRC in Slave	Read Project CRC from Master
Term 13 (EL1904) - Module 1 (FSOES) (TwinSafeGroup1)	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Term 15 (EL2904) - Module 1 (FSOES) (TwinSafeGroup1)	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Term 16 (EL1904) - Module 1 (FSOES) (TwinSafeGroup1)	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Term 17 (EL1904) - Module 1 (FSOES) (TwinSafeGroup1)	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
EL6910 FSoE Connection (TwinSafeGroup1)	<input checked="" type="checkbox"/>	0x67A6	<input type="checkbox"/>	<input type="checkbox"/>

Restore, if from FSoE-Connections have the correct CRC stored

User Administration Restore User Administration

Fig. 160: Backup/Restore settings

5.13.17 Multiple download

New TwinSAFE products typically also support the use of a local logic function. Thus the number of necessary downloads can increase significantly. In TwinCAT 3.1 Build 4022 it is now also possible to load several safety projects simultaneously onto the corresponding logic components via the *Multiple Download* feature.

This feature can be selected in the toolbar and via the TwinSAFE menu.



Fig. 161: Multiple Download - Toolbar

After selecting the function, select the projects for which a simultaneous download of the safety project is to be carried out and confirm the selection with the *Next* button.

NOTICE

Multiple downloads for different users

If safety projects are to be loaded onto logic components with different users, the multiple download with selection of the respective suitable logic components must be carried out several times.

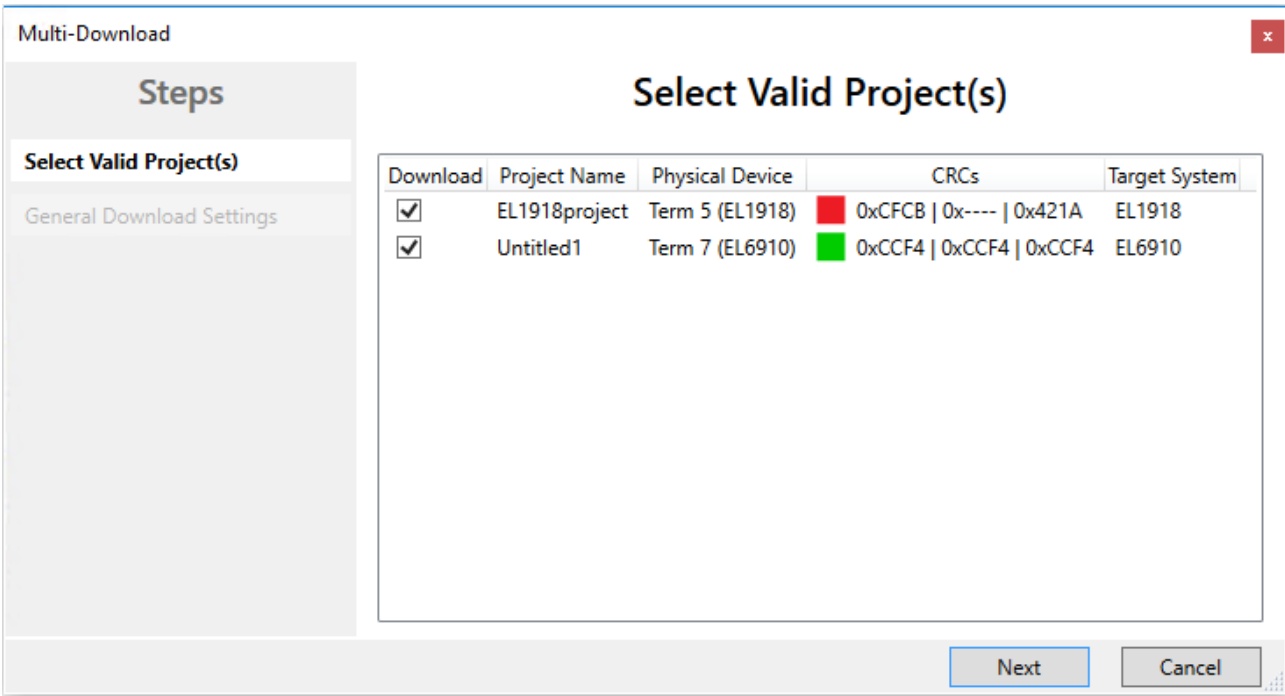


Fig. 162: Multiple Download - Selection of projects

In the general settings, enter the user name and password and check the displayed serial numbers of the logic components. Use the *Verified* checkbox to confirm that the correct serial numbers are displayed and used. Click the *Next* button to start the download.

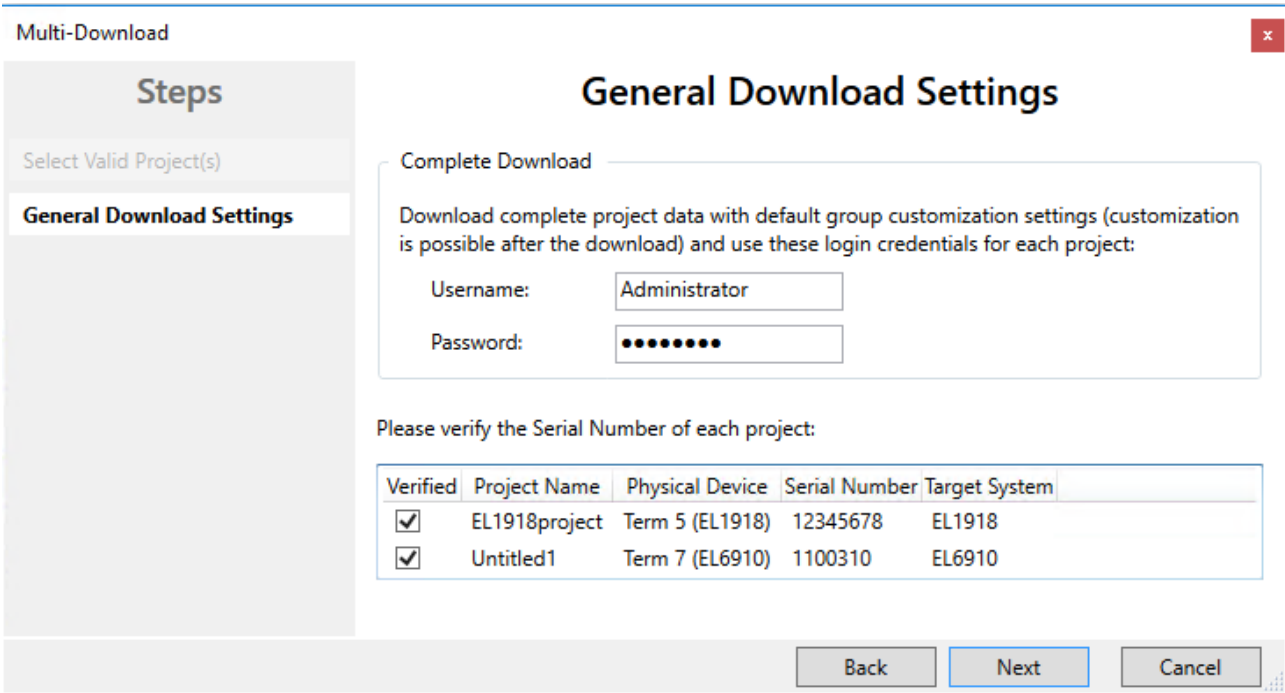


Fig. 163: Multiple Download - general settings

In the Final Verification dialog confirm the correctness of the online and calculated CRCs by checking the checkbox. Click the *Next* button to switch to the Activation dialog.

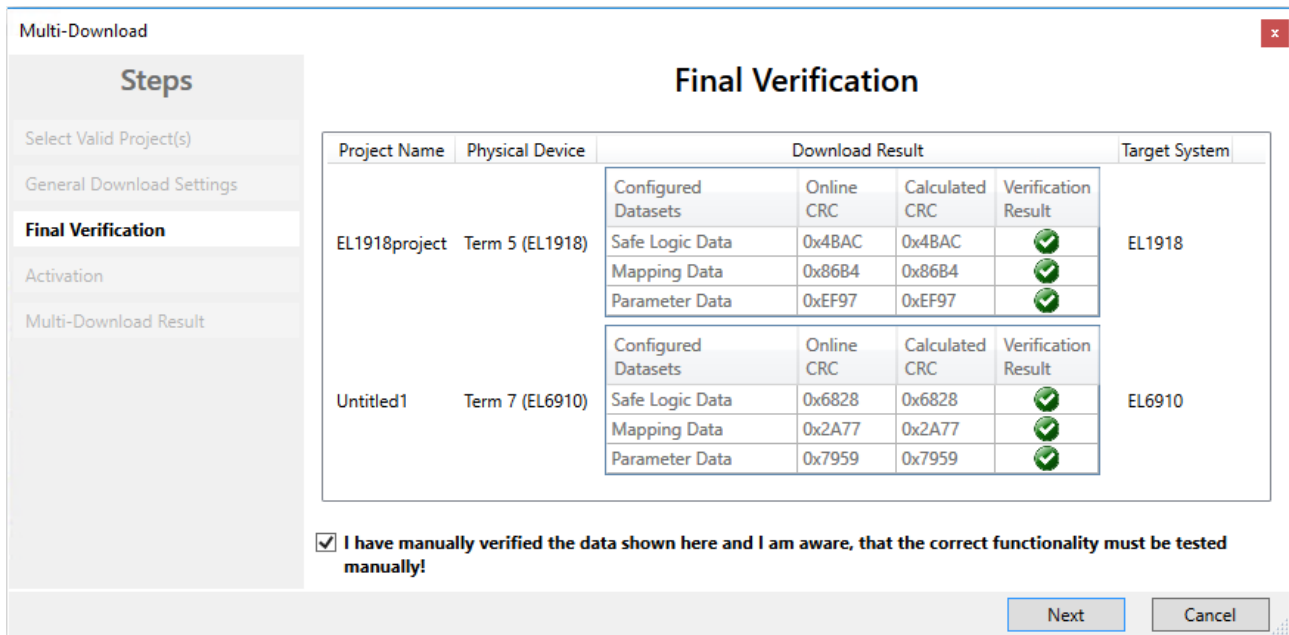


Fig. 164: Multiple Download - Final Verification

To activate the safety projects, enter the password for the current user again and confirm with the *Next* button.

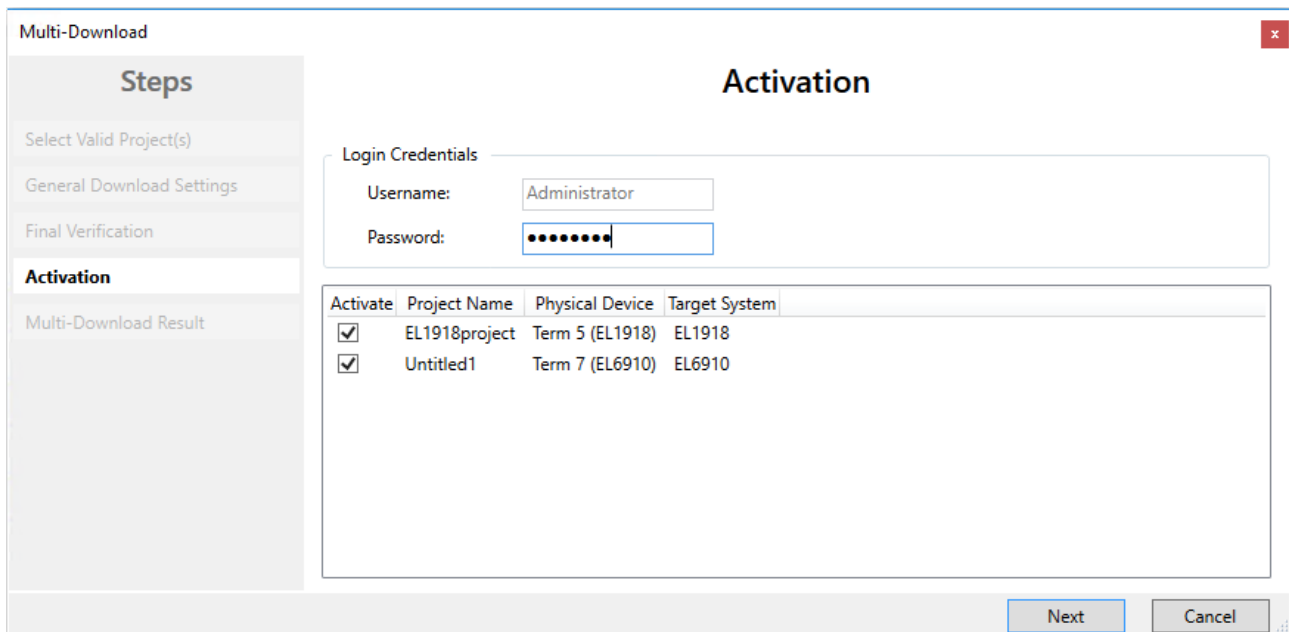


Fig. 165: Multiple Download - Activation

The Result dialog lists all safety projects with the status *Activated* and *Downloaded*. Click the *Finish* button to finish the multiple download.

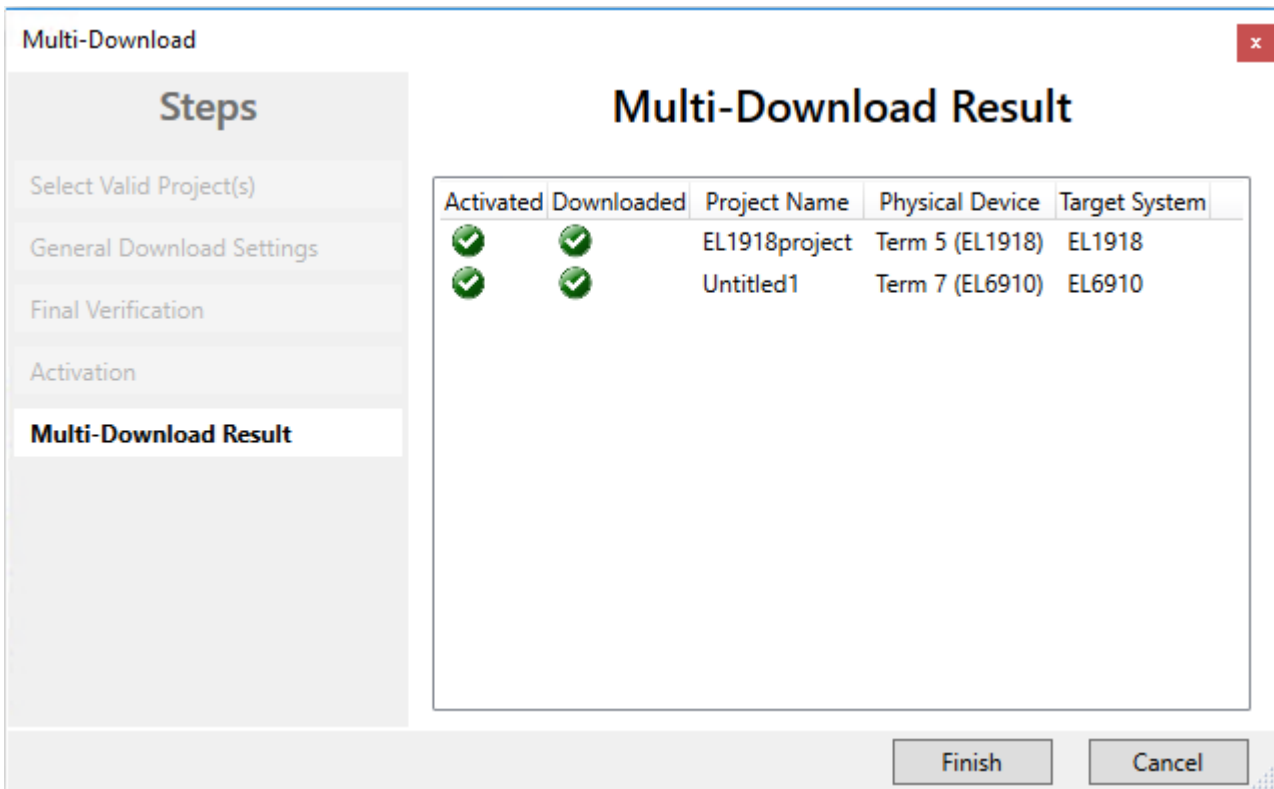


Fig. 166: Multiple Download - Result

5.14 Diagnostics

5.14.1 Diagnostic LEDs

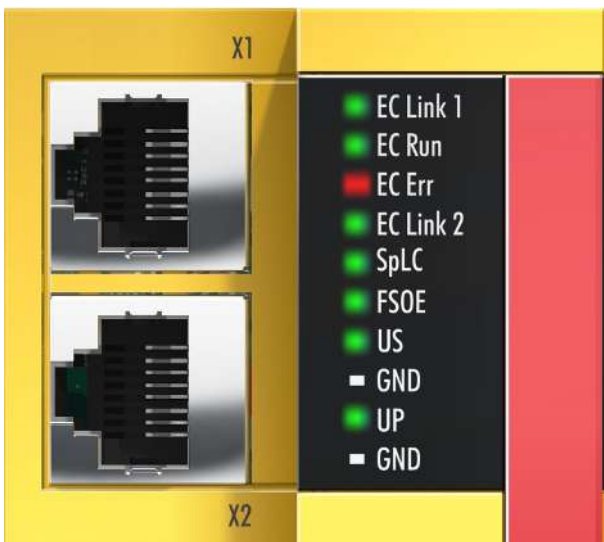





Fig. 167: Diagnostic LED

LED EC Link1 (green)

LED	State	Meaning
EC Link 1	off	No connection on the incoming EtherCAT segment
	on	upstream EtherCAT device or EtherCAT Master connected
	flashes	communication with upstream EtherCAT device or EtherCAT Master

LED EC RUN (green)

Display		Meaning
	permanently off	EtherCAT State INIT (Initialisation)
	flashing uniformly	EtherCAT State PREOP (Pre-Operational)
	flashing slowly	EtherCAT State SAFEOP (Safe-Operational)
	permanently on	EtherCAT State OP (Operational)
	flashing rapidly	EtherCAT State BOOT (Bootstrap Modus)

LED EC Err (red)

The LED lights up red when there is an EtherCAT error.

LED EC Link2 (green)

LED	State	Meaning
EC Link 2	off	no connection to the downstream EtherCAT line
	on	downstream EtherCAT device connected
	flashes	Communication with downstream EtherCAT device

LED SpIc (green/red) / FSoE

SpIc (green)	SpIc (red)	FSoE	Meaning
off	off	off	No safety-projekt on the EK1960
off	blink code	on	Error code of Safety Logic 1 - Function block error in Safety Logic 2 - Communication error in Safety Logic 4 - Other error in Safety Logic (Combinations are possible, error code numbers are added)
off	permanent flashing	on	Global Shutdown or Global Fault
blink code	off	on	Safety Logic loaded but not in RUN
permanent flashing	off	on	Safety Logic loaded and in RUN Customized Mode active
on	off	on	Safety Logic loaded and in RUN Customized Mode NOT active

LED Us

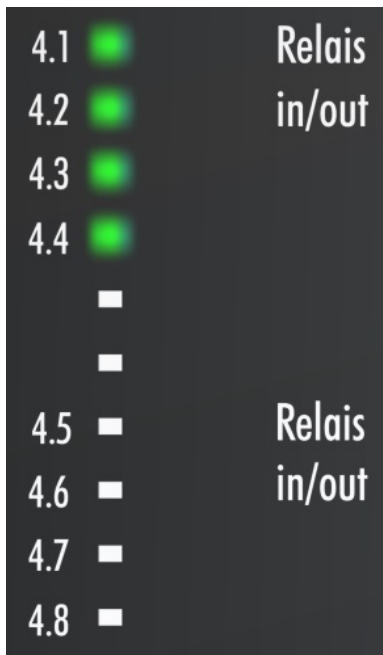
The U_s LED lights up as soon as the $24 V_{DC}$ voltage is present at the U_s connection.

LED Up

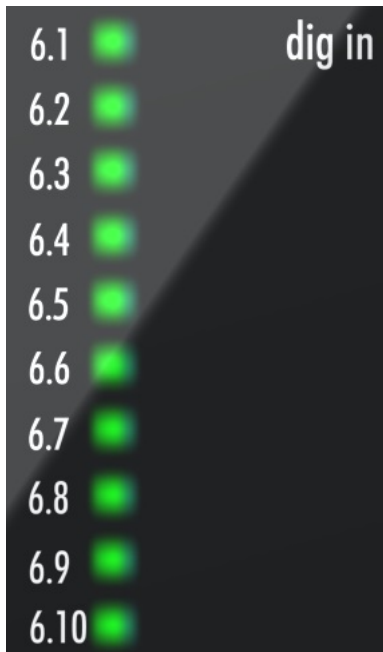
The U_p LED lights up as soon as the $24 V_{DC}$ voltage is present at the U_p connection.

5.14.2 Status LEDs

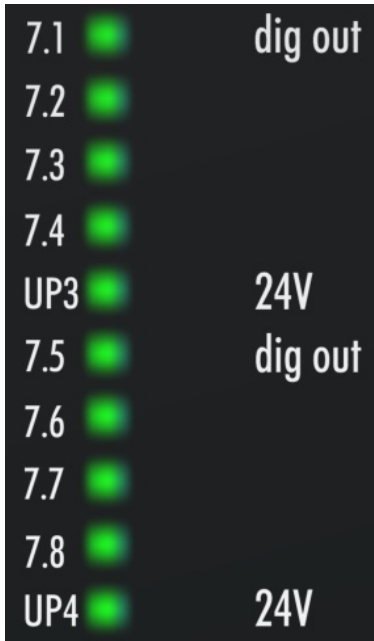
Relais LEDs



Digital inputs



Digital outputs



Inputs 17 - 20

LED left green - Digital Mode On

LED right blue - Bumper Mode On



5.14.3 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 μ C2	RO	0 _{dec}
F984:02	Temperature C1	Temperature μ C1	RO	0 _{dec}
F984:03	Firmware CRC C1	CRC of the firmware on μ C1	RO	-
F984:04	Vendor data CRC C1	CRC of the vendor data on μ C1	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 μ C1	RO	0 _{dec}
F985:02	Temperature C2	Temperature μ C2	RO	0 _{dec}
F985:03	Firmware CRC C2	CRC of the firmware on μ C2	RO	-
F985:04	Vendor data CRC C2	CRC of the vendor data on μ C2	RO	-

i **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.

5.14.4 Cycle time of the safety project

The processing time of the EK1960 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	Description	Flags	Default
FEA0:09	Actual Safety Control Task Execution Time	Current execution time of the EK1960, when Logic State = 1 (RUN) Cycle time = 1.25 * value (Mean value over 64 cycles)	RO	0 _{hex}
FEA0:0A	Min Safety Control Task Execution Time	Minimum execution time of the EK1960, when Logic State = 1 (RUN) Cycle time = 1.25 * value	RO	0 _{hex}
FEA0:0B	Max Safety Control Task Execution Time	Maximum execution time of the EK1960, when Logic State = 1 (RUN) Cycle time = 1.25 * value	RO	0 _{hex}
FEA0:15	Actual Safety Control Task Execution Time	Current execution time of the EK1960, when Logic State <> 1 Cycle time = 1.25 * value (Mean value over 64 cycles)	RO	0 _{hex}
FEA0:16	Min Safety Control Task Execution Time	Minimum execution time of the EK1960, when Logic State <> 1 Cycle time = 1.25 * value	RO	0 _{hex}
FEA0:17	Max Safety Control Task Execution Time	Maximum execution time of the EK1960, when Logic State <> 1 Cycle time = 1.25 * value	RO	0 _{hex}

Ein Rücksetzen der Min- und Max-Werte ist über das Schreiben eines Wertes auf CoE Objekt 0x1C32:08 möglich.

5.14.5 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				
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	Diagnostic message 1	BYTE[32]	RO	{0}
...
10F3:45	Diagnosis Message 064	Diagnostic message 64	BYTE[32]	RO	{0}

Structure of the diagnostic messages

- DiagCode (4 bytes) – in this case always 0x 0000 E000
- Flags (2 bytes) - diagnosis type (info, warning or error), timestamp and number of parameters contained (see the following table)
- Text ID (2 bytes) – ID of the diagnostic message as a reference to the message text from the ESI/XML
- Timestamp (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 diagnostic messages

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

Dynamic parameters in the diagnostic messages

Type	Data type	Description
Flags parameter 1	UINT16	Describes the type of parameter 1
		Bits 12 to 15 = 0 Bits 0 to 11 = data type of parameter 1

Type	Data type	Description
		0x0001 - BOOLEAN 0x0002 - INT8 0x0003 - INT16 0x0004 - INT32 0x0005 - UINT8 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. 168: 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.

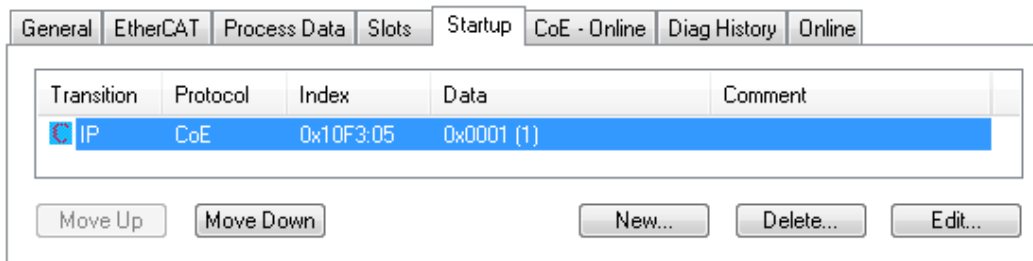


Fig. 169: Startup list

5.15 Project design limits of the EK1960

● Project design limits



The maximum project design size of the EK1960 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.

Process image size	max. 1486 bytes per data direction (maximum memory size 0x1E00 for 3 buffers, ie with the same size of input and output process data, a maximum size of 1280 bytes per data direction is possible. Only straight start addresses are possible, so fill bytes must be taken into account)
TwinSAFE connections	128 max. (up to 255 CRCs in total; 1 CRC is required for a TwinSAFE connection with 1 or 2 byte safe data.)
Supported hardware for EK1960 TwinSAFE connections	EL1904 (all) EL2904 (all) EL2902 (all) EL6900 (all - max. 14 byte safe data) EL6930 (all - max. 14 byte safe data) EL6910 (all - max. 126 byte safe data) EJ6910 (all - max. 126 byte safe data) KL1904 (from 2008) KL2904 (from 2008) KL6904 as slave (from 2008) AX5805 (all) AX5806 (all)
Safe data per TwinSAFE connection	maximum 126 byte (telegram length 255 byte)
TwinSAFE blocks	maximum 512 (ESTOP with complete input and output mapping)
TwinSAFE groups	128 max.
TwinSAFE user	40 max.
Standard PLC inputs	dynamic (memory-dependent), max. 1024 byte
Standard PLC outputs	dynamic (memory-dependent), max. 1024 byte

● TwinSAFE connection



Only one TwinSAFE connection is possible between two TwinSAFE components. For communication with a EL6900, for sample, a connection with up to 14 bytes safe user data can be used.

5.16 Behavior when restarting

If the TwinSAFE logic program is restarted due to an EtherCAT restart or a login / logout on the logic component (without a download), all TwinSAFE groups to which TwinSAFE Connections are assigned go to the ERROR state.

TwinSAFE logic components with local inputs and outputs can have TwinSAFE groups that have no TwinSAFE connections assigned. If these TwinSAFE groups use local outputs, these would be set after an EtherCAT restart without error acknowledgment. If this behavior is not wanted, this must be taken into account in the corresponding TwinSAFE logic.

⚠ CAUTION

Local outputs in TwinSAFE groups without TwinSAFE connections

If local outputs are not allowed to be switched on automatically after a restart of the TwinSAFE logic (in TwinSAFE groups in which no TwinSAFE connections are created), this must be taken into account by the user application.

5.17 Sync-Manager Configuration

Depending on the size of the TwinSAFE project on the TwinSAFE logic, it may be necessary to adjust the sync manager configuration.

As soon as the following message appears during the saving or downloading of the project, the sync manager configuration for the device has to be adapted.

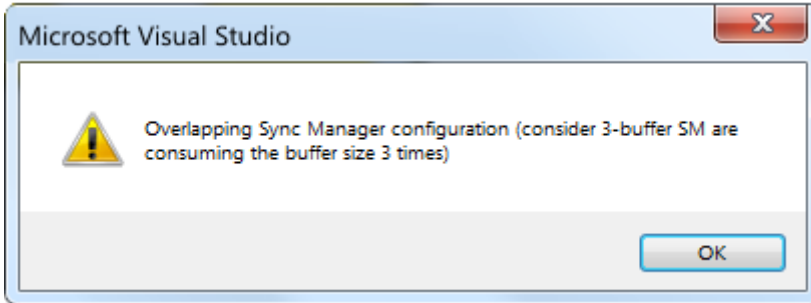


Fig. 170: Overlapping Sync Manager

Adapting the Sync-Manager configuration

The Sync Manager settings can be made via the *Advanced Settings...* of the TwinSAFE logic.

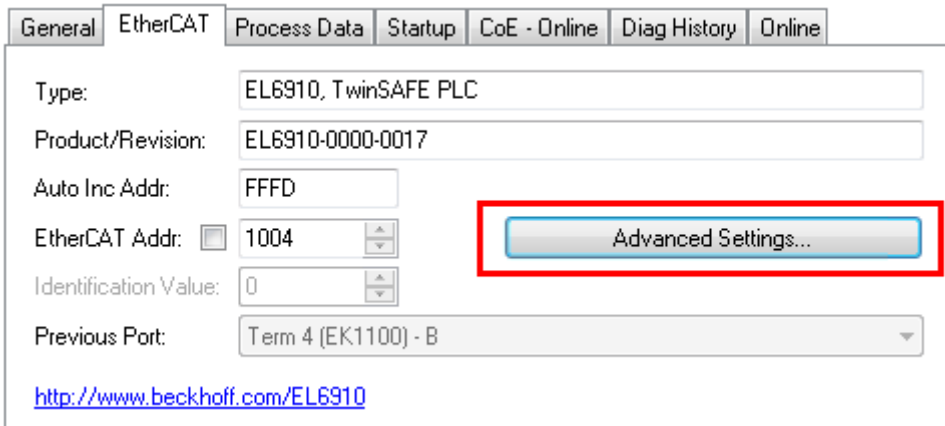


Fig. 171: EtherCAT Advanced Settings

To calculate the smallest start address of SM3, the length of SM2 is multiplied by 3 and added to the start address of SM2.

$$\text{Start SM3} \geq \text{Start SM2} + 3 * \text{Length SM2}$$

In addition, the starting address, together with 3 times the length of SM3, must not be larger than the address 0x3000.

$$\text{Start SM3} + 3 * \text{Length SM3} \leq 0x3000$$

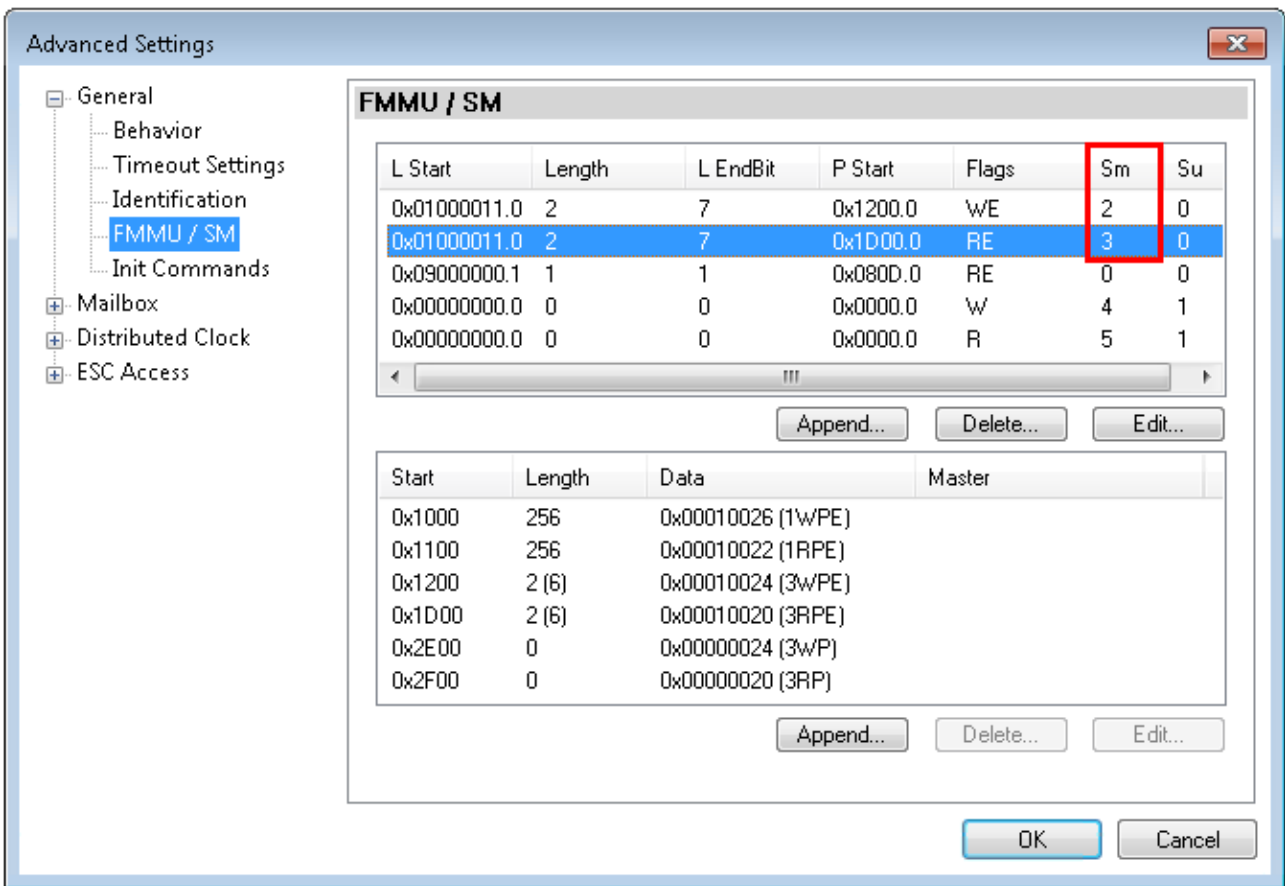


Fig. 172: Sync Manager settings

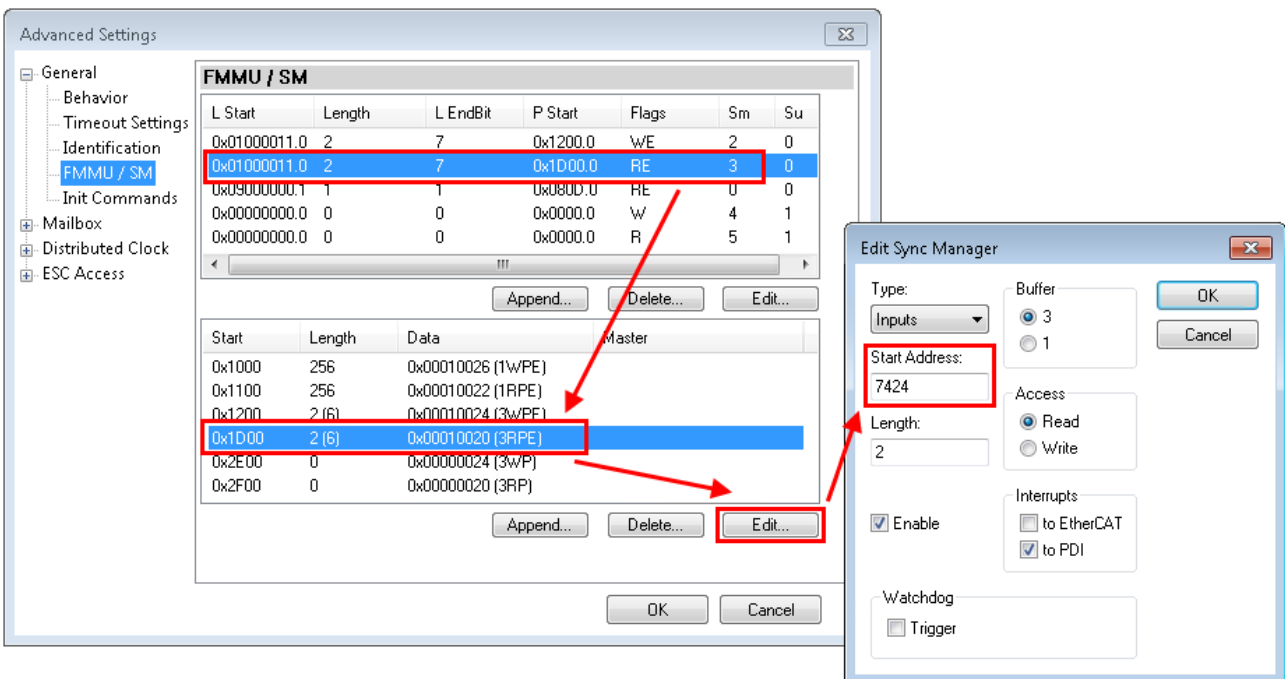


Fig. 173: Setting the start address for SM3

After changing the start address, all dialogs are closed with OK, the TwinCAT project is saved and the configuration is activated. If the calculation was carried out correctly, no error message should now be displayed and the project should be executed without errors.

5.18 Reaction times of local signals

Typical reaction time of the local input and output

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.

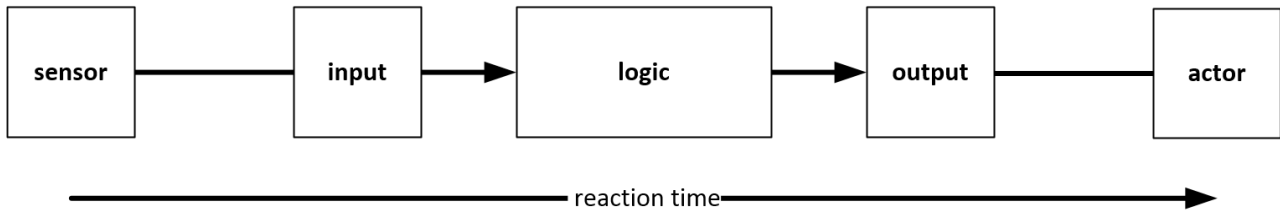


Fig. 174: Reaction time of local signals

Definition	Description
RTSensor	Response time of the sensor, until the signal is made available at the interface. Typically provided by the sensor manufacturer.
RTInput	Reaction time of the EK1960 safe input. This time depends on the parameter settings of the input module. In this case from the setting Channel x.InputFilterTime.
RTLogic	Reaction time of the controller. This is the internal cycle time of the controller and typically ranges from 500 μs to 10 ms for the EK1960, depending on the size of the safety project. The actual cycle time can be read from the controller.
RTOutput	Reaction time of the output. This is typically between 2 and 3 ms.
RTActor	Response time of the actuator. This information is typically provided by the actuator manufacturer

The typical response time is based on the following formula:

$$RT_{Gesamt} = RT_{Sensor} + RT_{Input} + RT_{Logic} + RT_{Output} + RT_{Actor}$$

5.19 TwinSAFE reaction times

5.19.1 Typical response 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.

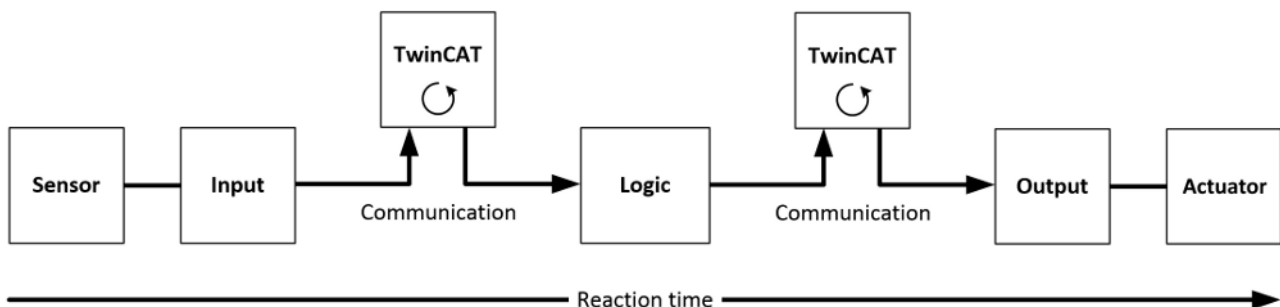


Fig. 175: Typical response time

Definition	Description
RTSensor	Response time of the sensor, until the signal is made available at the interface. Typically provided by the sensor manufacturer.
RTInput	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.

Definition	Description
RTComm	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).
RTLogic	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 TwinSAFE logic terminal, depending on the size of the safety project. The actual cycle time can be read from the terminal.
RTOutput	Response time of the output terminal. This is typically between 2 and 3 ms.
RTActor	Response time of the actuator. This information is typically provided by the actuator manufacturer
WDComm	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

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

5.19.2 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.

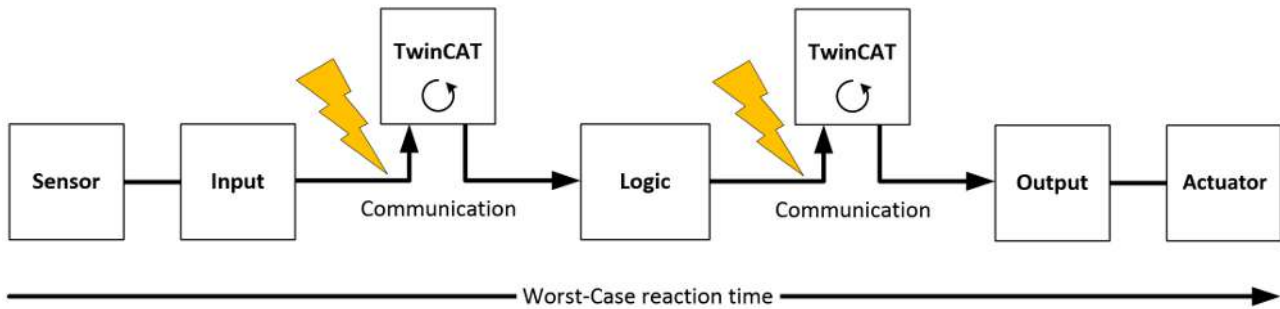


Fig. 176: Worst case response time

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 connection 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

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

5.20 Reaction times Bumper mode

If the operating mode BumperMode is set for inputs 8.7 to 8.10, safety mats or safety bumpers can be evaluated at these inputs. The connection diagram can be found under [Inputs and outputs \[▶ 37\]](#).

In this operation mode, the inputs give out a pulsed voltage. The pulse-pause-ratio and thus also the typical response times are dependent on the internal cycle time of the EK1960.

Typical reaction times can be found in the following table. The given times indicate the reaction time from switching the input to the response at the local output of the EK1960.

Cycle time EK1960 (value from 0xFEAO:09)	typical pulse-pause-ratio (Switch On- / Switch Off time)	typical reaction time
1,1 - 2,5 ms	20 ms / 10 ms	9 ms - 31 ms
4,2 - 6,0 ms	50 ms / 30 ms	27 ms - 94 ms
7,2 - 9,0 ms	80 ms / 50 ms	40 ms - 139 ms
9,8 - 13,0 ms	100 ms / 70 ms	56 ms - 186 ms
13,4 - 19,5 ms	170 ms / 100 ms	86 ms - 292 ms

For a maximum possible configuration of the EK1960, a value of 350ms can be used as a worst case estimate for the response time.

5.21 Reaction times ambient conditions

The TwinSAFE logic components check the environmental conditions, such as all internal and external voltages and the temperature, within the logic cycle time. In the case of a maximum configuration on the TwinSAFE logic, an error reaction can be expected typically after 10 seconds for over- or undervoltage, as well as over- or under-temperatures.

6 Maintenance

The EK1960 TwinSAFE compact controller is maintenance-free!

WARNING

Observe the specified environmental conditions!

Make sure that the TwinSAFE compact controller is stored and operated only within the specified environmental conditions (see Technical Data).

If the TwinSAFE compact controller is operated outside the permitted temperature range it will switch to the *Global Fault* state (see chapter [Diagnostics](#) [▶ 123]).

6.1 Cleaning

Protect the TwinSAFE compact controller from impermissible soiling during operation and storage!

The TwinSAFE Compact Controller may not be operated any longer if it has been exposed to impermissible soiling!

WARNING

Have dirty TwinSAFE compact controllers inspected!

The user is not permitted to clean the TwinSAFE controller!
Please send dirty TwinSAFE controllers to the manufacturer for inspection and cleaning!

7 Lifetime

The TwinSAFE compact controllers have a lifetime of 20 years, during which the target failure measures are guaranteed. For more information, see the chapter [Target failure measures \[► 29\]](#).

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.

The TwinSAFE controllers carry a Date Code, which is composed as follows:

Date Code: CW YY SW HW

Key		Example: Date Code: 08160201	
CW	Calendar week of manufacture	Calendar week	08
YY	Year of manufacture	Year	2016
SW	Software version	Software version	02
HW	Hardware version	Hardware version	01

In addition, the TwinSAFE compact controllers carry a unique serial number. The serial number and date code are lasered on the front of the device. The postal address and model designation are laser-engraved on the back.

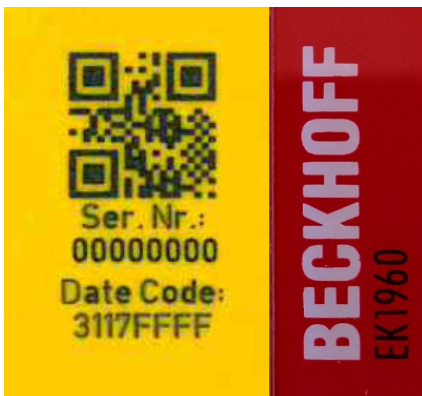


Fig. 177: EK1960: Laser image - serial number / Date Code



Fig. 178: EK1960: Laser image back

7.1 Decommissioning

DANGER

Serious risk of injury!

Bring the bus system and the TwinSAFE compact controller into a safe, de-energized state before starting with the disassembly of the TwinSAFE compact controller!

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.

8 Decommissioning

8.1 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.

8.1.1 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.

9 Appendix

9.1 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.

9.3 Certificates


<p>BECKHOFF New Automation Technology</p>	<p>Originalerklärung Original declaration</p>
<p>EG-Konformitätserklärung <i>EC Declaration of Conformity</i></p>	
<p>Nummer: 2017039EK1960-2, Datum: 19.06.2018 <i>Number, Date</i></p>	
<p>Hersteller <i>Manufacturer</i></p>	<p>Beckhoff Automation GmbH & Co. KG Hülshorstweg 20, 33415 Verl, Germany</p>
<p>erklärt, dass das Produkt <i>declares that the product</i></p>	<p>TwinSAFE-Compact-Controller EK1960 Compact-Controller mit 20 sicheren Eingängen und 24 sicheren Ausgängen <i>Compact-Controller with 20 safe inputs and 24 safe outputs</i></p>
<p>Sicherheitsbauteil nach EG-Richtlinie 2006/42/EG, Anhang IV <i>safety component according to EC directive 2006/42/EC, annex IV</i></p>	
<p>den einschlägigen Bestimmungen der Maschinenrichtlinie 2006/42/EG entspricht. <i>complies with the relevant requirements of the machinery directive 2006/42/EC.</i></p>	
<p>Angewandte Normen <i>Applied Standards</i></p>	
<p>EN 62061:2005+A2:2015</p>	<p>Sicherheit von Maschinen – Funktionale Sicherheit sicherheitsbezogener elektrischer, elektronischer und programmierbarer elektronischer Steuerungssysteme <i>Safety of machinery – Functional safety of safety-related electrical, electronic and programmable electronic control systems</i></p>
<p>EN 61131-2:2007</p>	<p>Speicherprogrammierbare Steuerungen - Teil 2: Betriebsmittelanforderungen und Prüfungen <i>Industrial-process control systems - Instruments with analogue inputs and two- or multi-state outputs - Part 2: Guidance for inspection and routine testing</i></p>
<p>EN 50581:2012</p>	<p>Technische Dokumentation zur Beurteilung von Elektro- und Elektronikgeräten hinsichtlich der Beschränkung gefährlicher Stoffe <i>Technical documentation for the assessment of electrical and electronic products with respect to the restriction of hazardous substances</i></p>
<p>EN ISO 13849-1:2015</p>	<p>Sicherheit von Maschinen – Sicherheitsbezogene Teile von Steuerungen <i>Safety of machinery – Safety-related parts of control systems</i></p>
<p>EN 61000-6-2:2011</p>	<p>Elektromagnetische Verträglichkeit (EMV) – Störfestigkeit für Industriebereiche <i>Electromagnetic compatibility (EMC) – Immunity for industrial environments</i></p>
<p>EN 61000-6-4:2011</p>	<p>Elektromagnetische Verträglichkeit (EMV) - Störaussendung für Industriebereiche <i>Electromagnetic compatibility (EMC) - Emission standard for industrial environments</i></p>
<p>Die Übereinstimmung eines Baumusters des bezeichneten Produkts mit der EG-Richtlinie wurde bescheinigt von <i>The accordance of a production sample of the designated product with the EC directive is certified by</i></p>	
<p>Benannte Stelle <i>Notified body</i></p>	<p>TÜV SÜD Product Service GmbH Ridlerstraße 65, 80339 München, Germany</p>
<p>EG-Baumusterprüfbescheinigung <i>EC-type examination certificate</i></p>	<p>M6A 17 07 62386 039, 05.07.2017</p>
<p>Verantwortlich für die Zusammenstellung der technischen Unterlagen <i>Responsible for the compilation of technical documentation</i></p>	
<p>Bevollmächtigter <i>Authorised person</i></p>	<p>Beckhoff Automation GmbH & Co. KG Hülshorstweg 20, 33415 Verl, Germany</p>
<p>Verl, 19.06.2018</p>	
<p> Dipl.-Phys. Hans Beckhoff</p>	<p>Geschäftsführer Beckhoff Automation GmbH & Co. KG <i>CEO Beckhoff Automation GmbH & Co. KG</i></p>

Fig. 179: EK1960 EG-Konformitätserklärung

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