Operating Instructions for

EK1960

TwinSAFE Compact Controller

Version: 1.3.1
Date: 2019-01-28

BECKHOFF

Table of contents

1 Foreword

1.1 Notes on the documentation

Intended audience

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

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

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

Origin of the document

This documentation was originally written in German. All other languages are derived from the German original.

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/english/download/twinsafe.htm. In case of doubt, please contact Technical Support [▶ 139].

Product features

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

Disclaimer

The documentation has been prepared with care. The products described are subject to cyclical revision. For that reason the documentation is not in every case checked for consistency with performance data, standards or other characteristics. We reserve the right to revise and change the documentation at any time and without prior announcement. No claims for the modification of products that have already been supplied may be made on the basis of the data, diagrams and descriptions in this documentation.

Trademarks

Beckhoff®, TwinCAT®, EtherCAT®, EtherCAT P®, Safety over EtherCAT®, TwinSAFE®, XFC® and XTS® are registered trademarks of and licensed by Beckhoff Automation GmbH.
Other designations used in this publication may be trademarks whose use by third parties for their own purposes could violate the rights of the owners.

Patent Pending

The EtherCAT Technology is covered, including but not limited to the following patent applications and patents: EP1590927, EP1789857, DE102004044764, DE102007017835 with corresponding applications or registrations in various other countries.

The TwinCAT Technology is covered, including but not limited to the following patent applications and patents: EP0851348, US6167425 with corresponding applications or registrations in various other countries.

1.2 Safety instructions

1.2.1 Delivery state

All the components are supplied in particular hardware and software configurations appropriate for the application. Modifications to hardware or software configurations other than those described in the documentation are not permitted, and nullify the liability of Beckhoff Automation GmbH & Co. KG.

1.2.2 Operator's obligation to exercise diligence

The operator must ensure that

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

1.2.3 Description of safety symbols

In these operating instructions the following instructions are used.
These instructions must be read carefully and followed without fail!

⚠ DANGER

Serious risk of injury!

Failure to follow this safety instruction directly endangers the life and health of persons.

⚠ WARNING

Risk of injury!

Failure to follow this safety instruction endangers the life and health of persons.

⚠ CAUTION

Personal injuries!

Failure to follow this safety instruction can lead to injuries to persons.

NOTE

Damage to the environment/equipment or data loss

Failure to follow this instruction can lead to environmental damage, equipment damage or data loss.

Tip or pointer

This symbol indicates information that contributes to better understanding.

1.3 Documentation issue status

Version	Comment
1.3.1	• Layout corrected at chapter *Sample program for parameterization*
1.3.0	• Description of *Module Fault Link active* parameter added • Description of *Multiple Download* added • Description of input and output signals expanded • Description of error response times added • Version history of TwinSAFE product added • Description of firmware update added
1.2.0	• Description of inductive load and free-wheeling diode changed • New features TwinCAT 3.1 Build 4022 added • Diagnosis history described • Reaction times BumperMode and ambient conditions added • Description TwinSAFE SC updated • Description of Behavior when restarting added • Project design limits adjusted • Note to the permissible loads on the relay contacts added
1.1.0	• Note to the input and output process image added • Description for Sync Manager configuration added • TwinSAFE SC description updated
1.0.0	• Certificate added • General document revision • Description of input module 9 and 10 updated
0.7.0	• Load characteristics for inductive loads added • Backup/Restore flow chart added
0.6.1	• User administration screenshots updated • State and Diag of the TwinSAFE group updated
0.6.0	• Safety parameters adopted from review report
0.5.0	• Safety parameters revised • Parameter values revised • Diag messages added
0.4.0	• Safety concept requirements for the manual implemented
0.3.0	• Update of the designation of the contact points • Addendum: illustration of the TwinSAFE compact controller without relay option
0.2.0	• Extension of the general description • Description of diagnostic and status LEDs added
0.1.0	• Migration, layout adaptation

1.4 Version history of the TwinSAFE product

This version history lists the releases of the software and hardware versions. A description of the respective changes to the previous version is also listed.

Updated hardware and software

The TwinSAFE products are subject to a cyclical revision. We reserve the right to revise and change the TwinSAFE products at any time and without notice.

These hardware and/or software changes do **not** give rise to any claims for changes to products that have already been delivered.

A description of how a firmware update (software) can be carried out can be found in the chapter Firmware update of TwinSAFE products [▶ 136].

Date	SW-Version	HW-Version	Changes
2017-05-02	01	00	• First Release
2017-07-14	02	01	• Optimized safety mat function • Added support for backup/restore mode • Protective circuit of the outputs changed
2018-09-19	03	01	• Local logic projects can now also be created without a linked RUN signal. • Time stamp for diagnostic messages corrected. • FB Muting: After an FB error in the backwards operating mode, the FB error can be acknowledged without restarting the TwinSAFE group. • An error acknowledgement is now required after a user has logged in to the Logic without deleting the project. • Support of *Module Fault Link active* parameter added. • Firmware and vendor data CRCs can be read out in CoE objects.

2 System description TwinSAFE

2.1 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.

2.2 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.

3 Product description

3.1 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.

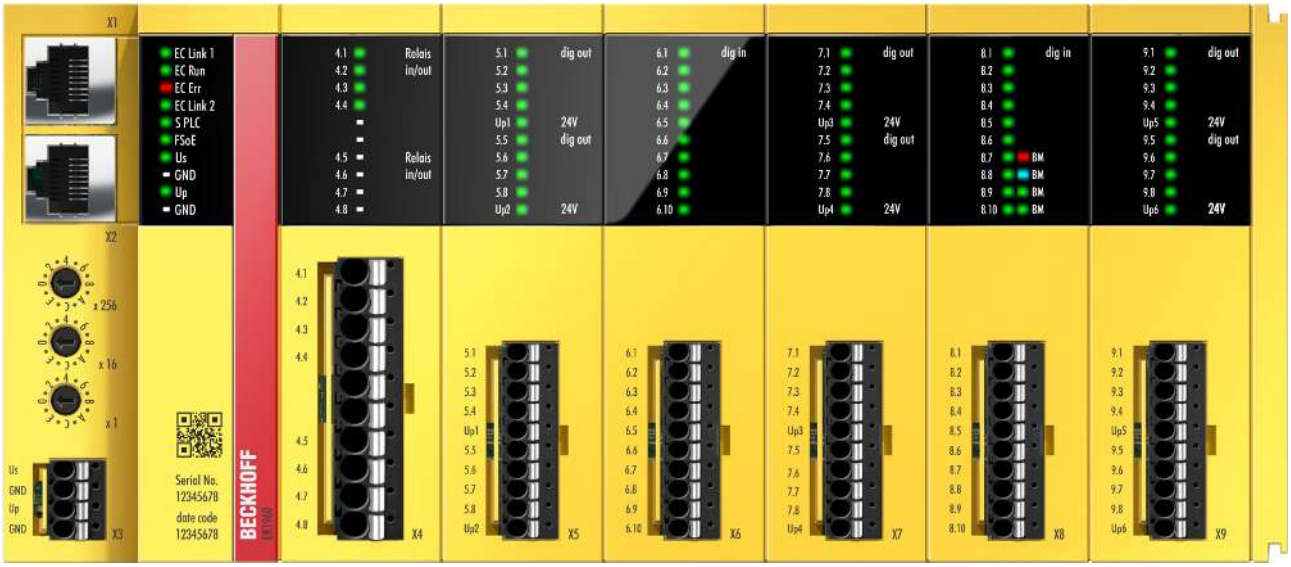


Fig. 1: EK1960-260x TwinSAFE-Compact-Controller

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

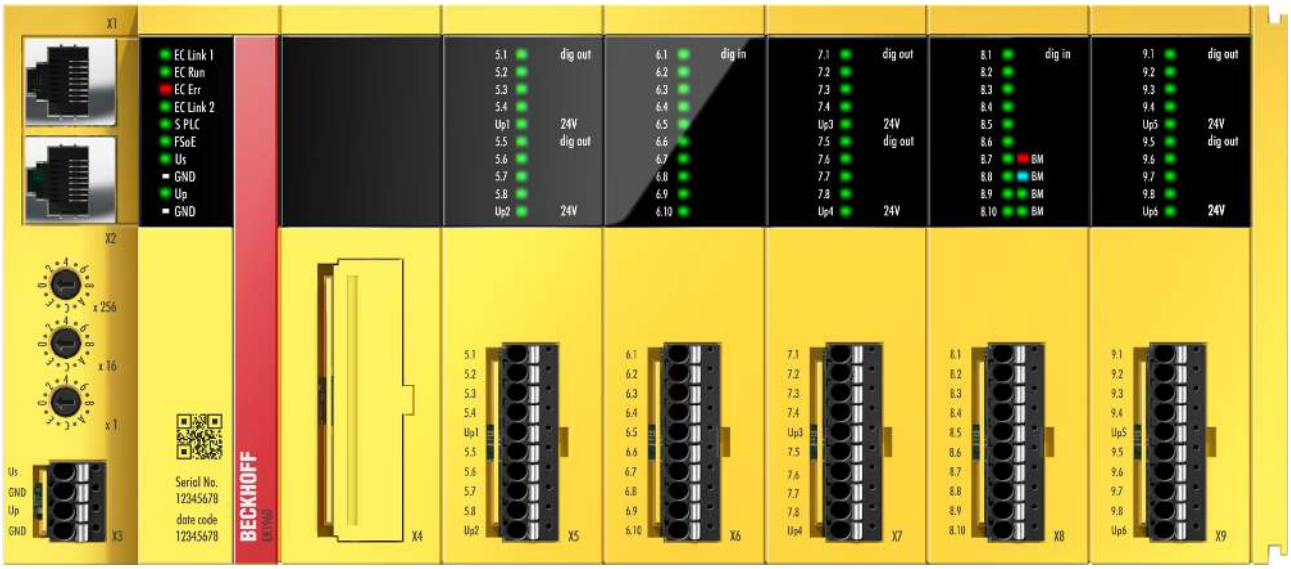


Fig. 2: EK1960-000x TwinSAFE compact controller without relay option

3.2 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)

3.3 Inputs and outputs of the EK1960

NOTE

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 (X1)		EtherCAT 1	EtherCAT connection 1 (RJ45 or M8)
EtherCAT (X2)		EtherCAT 2	EtherCAT connection 2 (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)

plug	contact	Name	Description
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)
	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 - *Digital Mode On*, safety mat operation mode (resistance change) - *Bumper Mode On*) (Channel16.FSIN Module 9.Channel1.Input)
	8	8.8	Input 18 (digital - *Digital Mode On*, safety mat operation mode (resistance change) - *Bumper Mode On*) (Channel16.FSIN Module 9.Channel2.Input)
	9	8.9	Input 19 (digital - *Digital Mode On*, safety mat operation mode (resistance change) - *Bumper Mode On*) (Channel17.FSIN Module 10.Channel1.Input)
	10	8.10	Input 20 (digital - *Digital Mode On*, safety mat operation mode (resistance change) - *Bumper Mode On*) (Channel17.FSIN Module 10.Channel2.Input)

plug	contact	Name	Description
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)
	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)

NOTE

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.

3.4 Connection technology

3.4.1 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 mm²
Wire cross-section (fine-wire)	0.2 – 1.5 mm²
Conductor cross-sectional area – fine wire (with wire-end ferrules with plastic collars)	0.25 – 0.75 mm²
Conductor cross-sectional area – fine wire (with wire-end ferrules without plastic collars)	0.25 – 1.5 mm²
Strip length	8 - 9 mm

3.4.2 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 mm²
Wire cross-section (fine-wire)	0.2 – 1.5 mm²
Conductor cross-sectional area – fine wire (with wire-end ferrules with plastic collars)	0.25 – 0.75 mm²
Conductor cross-sectional area – fine wire (with wire-end ferrules without plastic collars)	0.25 – 1.5 mm²
Strip length	8 - 9 mm

3.4.3 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 mm²
Wire cross-section (fine-wire)	0.2 – 2.5 mm²
Conductor cross-sectional area – fine wire (with wire-end ferrules with plastic collars)	0.25 – 1.5 mm²
Conductor cross-sectional area – fine wire (with wire-end ferrules without plastic collars)	0.25 – 2.5 mm²
Strip length	9 - 10 mm

3.5 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.

3.6 Technical data

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 mm² are used)
Cable length between output and actuator	30 m (if cables with a cross-sectional area of 0.75 mm² are used)
Minimum/maximum logic cycle time	approx. 1 ms / according the project size
Fault response time	≤ watchdog times
Watchdog time	min. 2 ms, max. 60,000 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 a 2 A fuse for U_S and U_P
E-bus power supply (5 V)	max. 500 mA (In the case of higher current consumption, please use the EL9410 power feed terminals in addition!)
Signal voltage inputs	see Characteristic curve of the inputs [▶ 27]
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 a test pulse length of 400 µs and resistive load Simultaneity factor 50% per module Provide 5 A fuse for each U_{Px} Diagnostic thresholds: > 4 V -> high signal is detected < 2.4 V -> low signal is detected
Permissible actuators	• inductive loads (see also Load characteristic curve – inductive load [▶ 29]) (A free-wheeling diode must be provided on the load) • resistive loads • capacitive loads
Current consumption of the modular 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 mm x 100 mm x 58.6 mm
Weight	approx. 560 g (EK1960-260x) / approx. 500 g (EK1960-000x)
Permissible ambient temperature (operation)	-25 °C to +55 °C
Permissible ambient temperature (transport/ storage)	-40 °C to +70 °C
Permissible humidity	5% to 95%, non-condensing
permissible air pressure (operation/storage/transport)	750 hPa to 1100 hPa (this corresponds to an altitude of approx. -690 m to 2450 m above sea level, assuming an international standard atmosphere)

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 level of contamination according to EN 60664-1	level of contamination 2 (comply with the chapter Cleaning [▶ 133])
Inadmissible operating conditions	TwinSAFE controllers must not be used under the following operating conditions: • under the influence of ionizing radiation (exceeding the natural background radiation) • in corrosive environments • 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 class as per IEC 60529	IP20
Permitted operating environment	In the control cabinet or terminal box, with minimum protection class IP54 according to IEC 60529
Correct installation position	see chapter Installation position and minimum distances [▶ 38]
Technical approvals	CE, TÜV SÜD

NOTE

Protective circuit

No protective circuit is integrated in the output circuit of the EK1960, so 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 an amount of less than 29V. Thus, R/C circuits and varistors are typically unsuitable.

3.6.1 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 DC13	 250 V_{AC} / 3 A 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)

NOTE

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

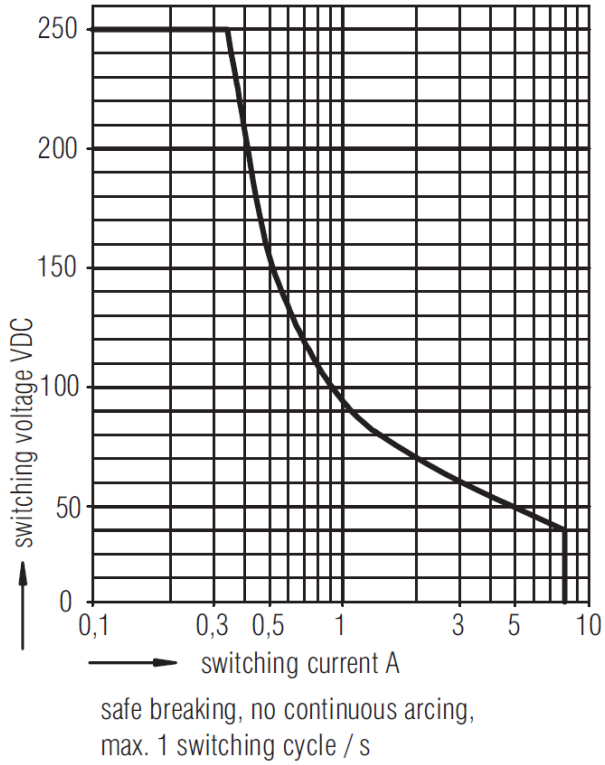


Fig. 3: Load limit curve, make contact

Operating lifetime for contact material AgNi

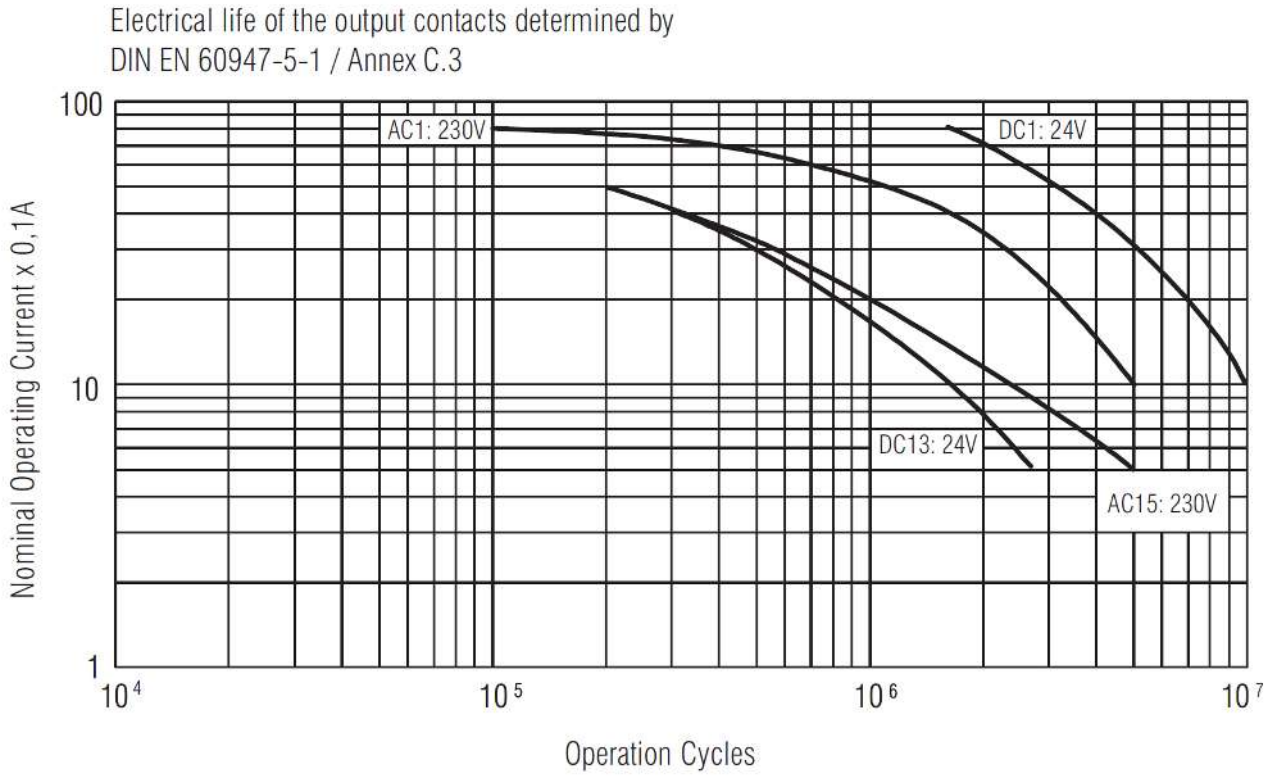


Fig. 4: Operating lifetime of the AgNi NO contact for DC1, DC13, AC1 and AC15

Reduction factor for inductive loads

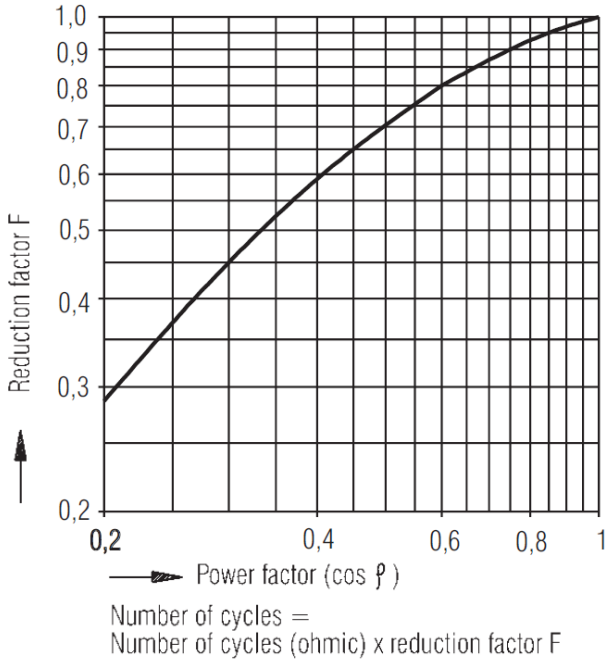


Fig. 5: Reduction factor for inductive loads

3.7 Safety parameters

In the following tables the safety parameters 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

EK1960 category and performance level 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**.

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 safety parameters (Cat. 4 – two-channel)

The following table contains the safety parameters 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
PFD_G	1.48 E-06
$MTTF_D$	high
DC_{avg}	high
Performance Level	PL e
Category	4
SIL	3

Relay output safety parameters (Cat. 2 – single-channel)

The following table contains the safety parameters 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
PFD_G	6.42 E-05
$MTTF_D$	high
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 $I_{max} \leq 2$ A)	1,500,000 [switching cycles]
B_{10D} value (AD15 230 V_{AC} and $I_{max} \leq 1$ A)	750,000 [switching cycles]
B_{10D} value (AD15 230 V_{AC} and $I_{max} \leq 3$ A)	300,000 [switching cycles]

Digital input safety parameters

The following table contains the safety parameters 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
PFD_G	6.1 E-06
$MTTF_D$	high
DC_{avg}	high
Performance Level	PL e
Category	4
SIL	3

Safety mat input safety parameters

The following table contains the safety parameters 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
PFD_G	7.5 E-05
$MTTF_D$	high
DC_{avg}	medium
Performance Level	PL d
Category	2
SIL	2

Logic safety parameters

The following table contains the safety parameters 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
PFD_G	4.32 E-05
$MTTF_D$	high
DC_{avg}	high
Performance Level	PL e
Category	4
SIL	3

Output safety parameters

The following table contains the safety parameters 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
PFD_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 PFH_D/ Performance Level / Category			**6.18 E-09 PLd, Cat. 2**	**5.39 E-09 PLe, Cat. 4**	**7.49 E-09 PLd, Cat. 2**	**6.75 E-09 PLd, Cat. 2**

3.8 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.

3.9 Characteristic curve of the inputs

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

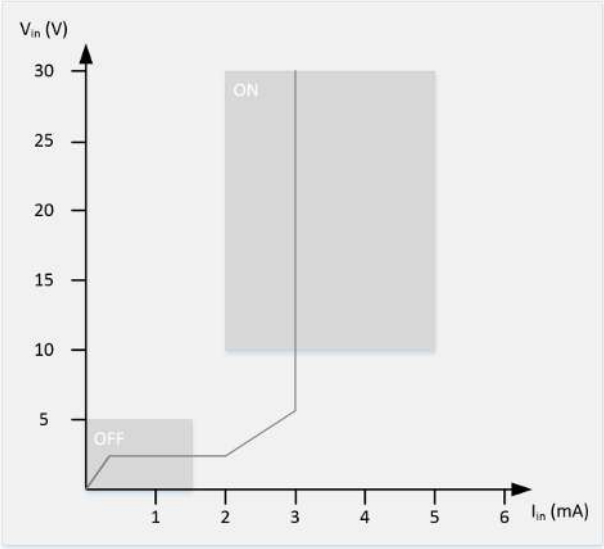


Fig. 6: EK1960 input characteristic curve

3.10 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:

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

For the relay module the resulting time is:

Relay module time = 100 * internal cycle time * 1.25

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

b = 6 x module time + 1x relay module time + 10 x internal cycle time x 1.25 (for the input modules)

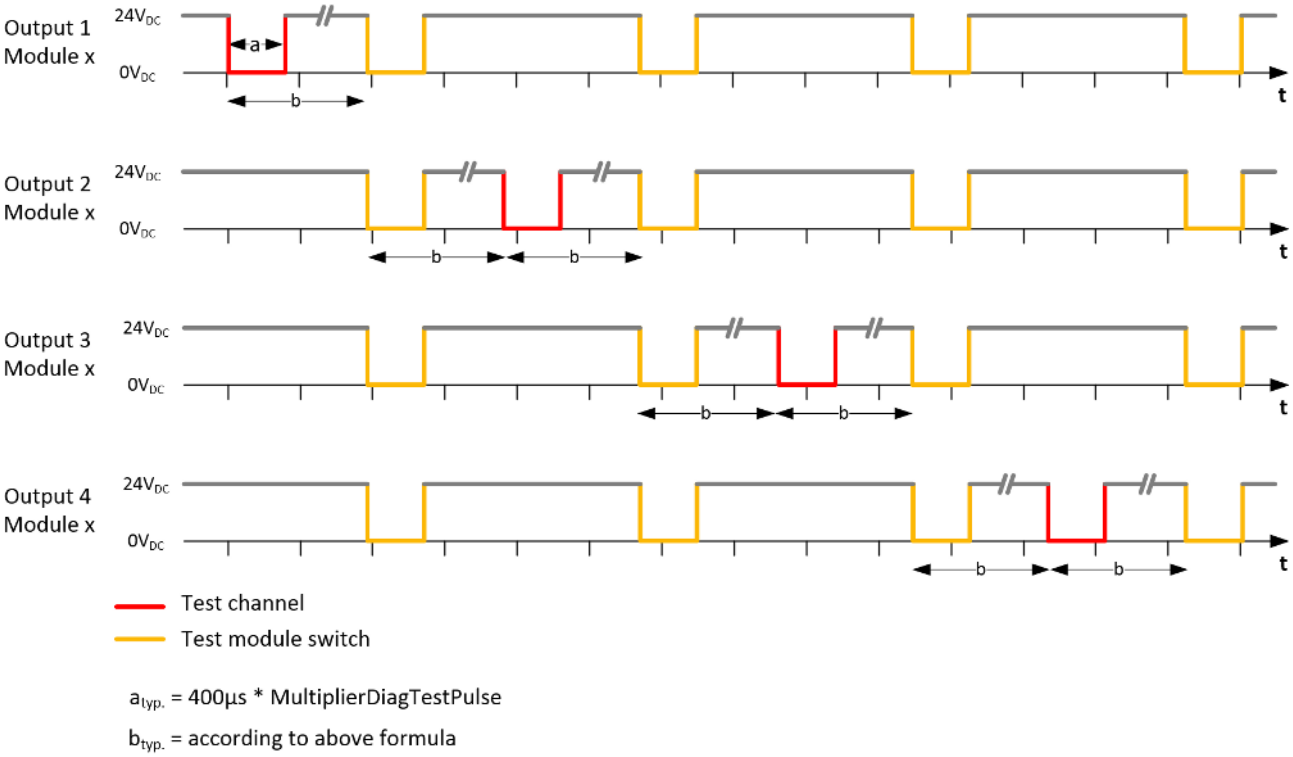
Inserting the values, this produces:

b= (6 * 80 ms) + (100 * 2 ms * 1.25) + (10 * 2 ms * 1.25) = 480 ms + 250 ms + 25 ms = 755 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
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)



NOTE

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.

3.11 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.

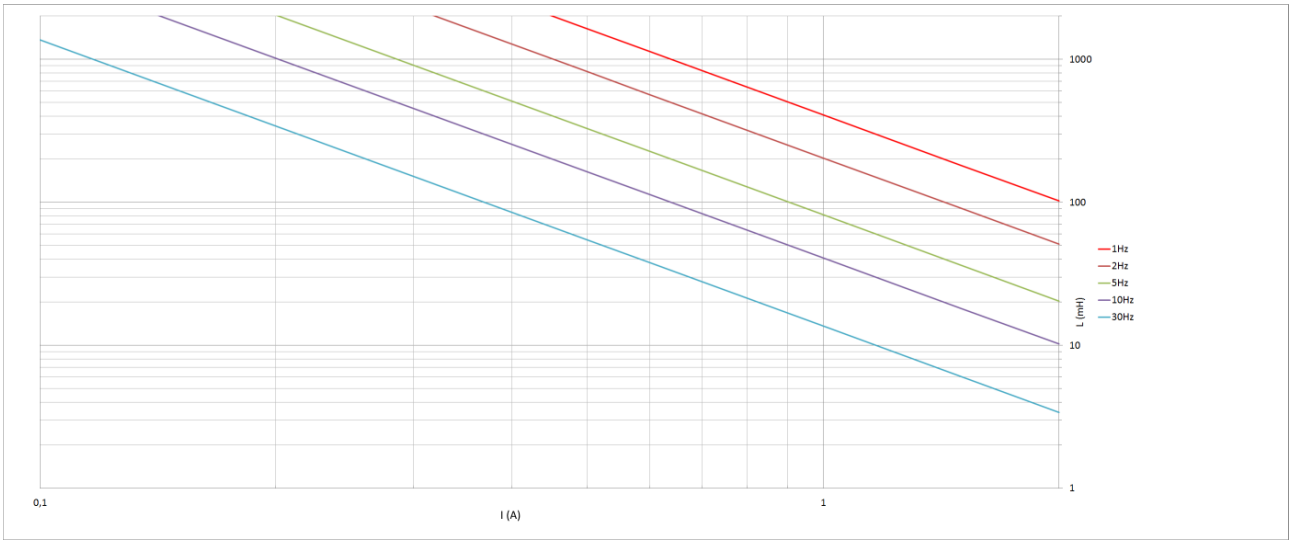


Fig. 7: Characteristic curve - inductive load

3.12 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.

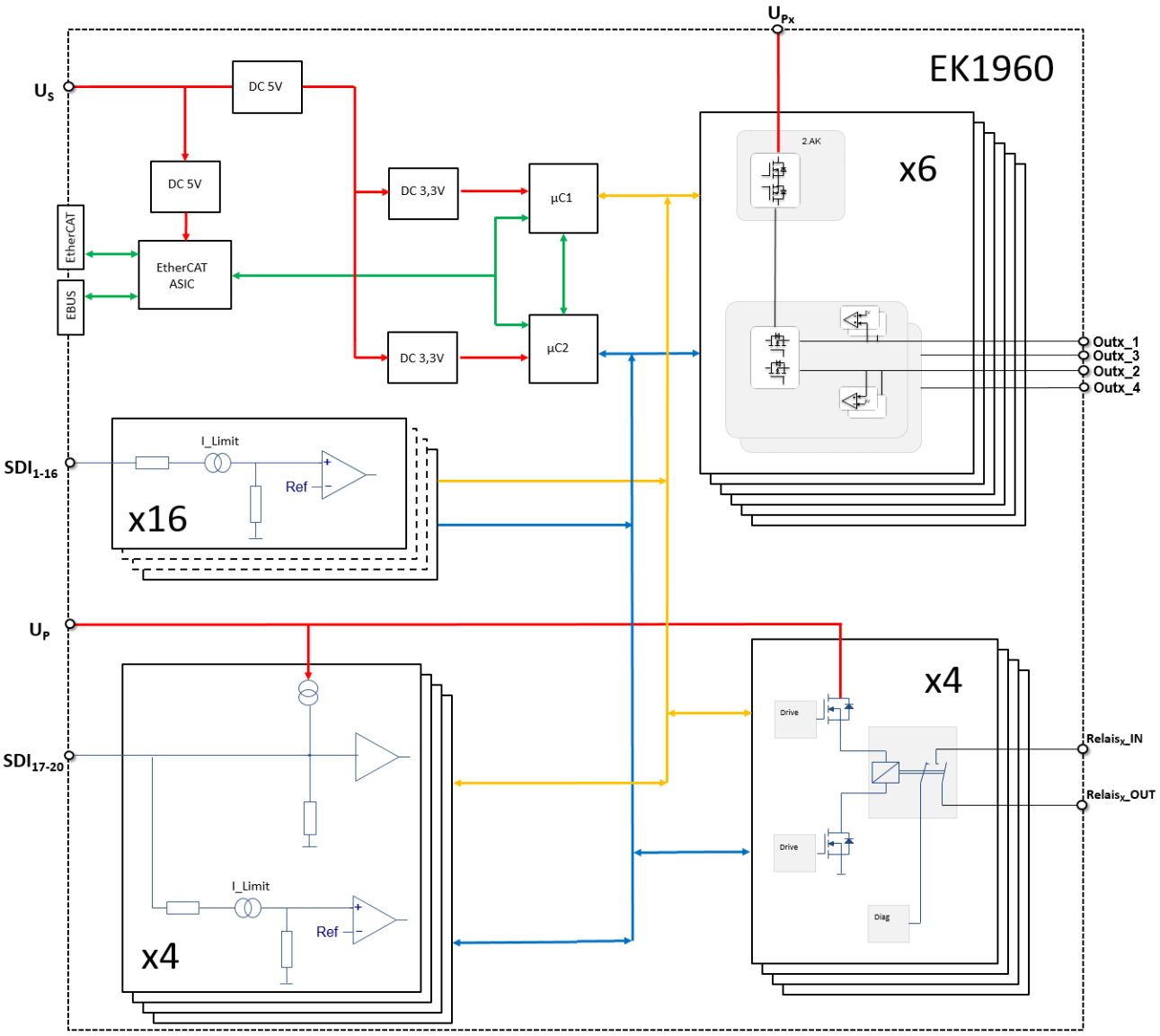


Fig. 8: Block diagram EK1960

3.13 Address setting of the TwinSAFE compact controller

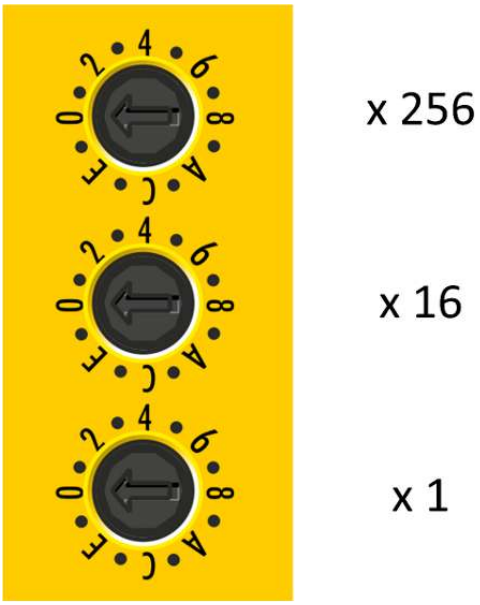


Fig. 9: Address selection switch of the EK1960

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.

3.14 Dimensions

Fig. 10: EK1960 dimensions

Width: 230.5 mm
Height: 100 mm
Depth: 58.6 mm

3.15 Wiring examples

3.15.1 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.

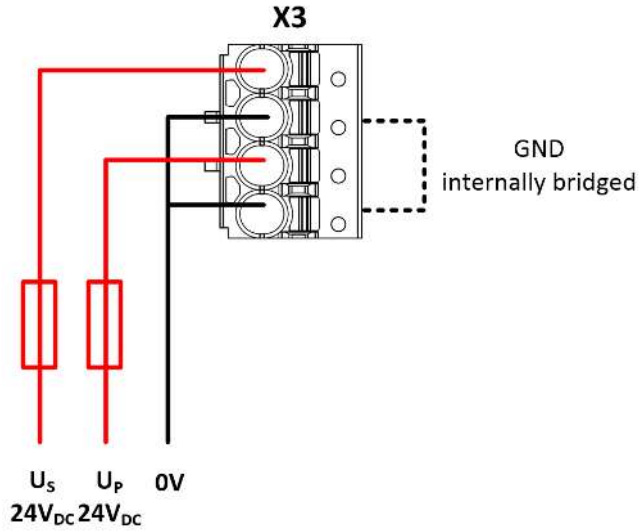


Fig. 11: Power supply X3

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.

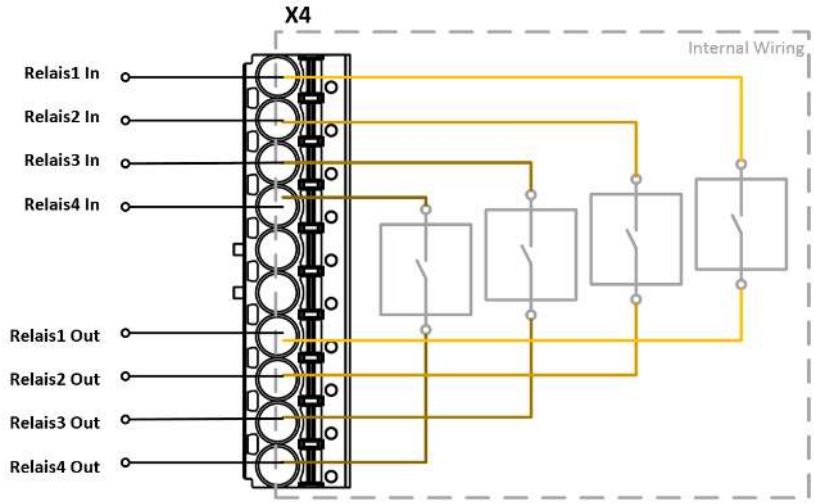


Fig. 12: Relay contact X4 (EK1960-260x only)

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.

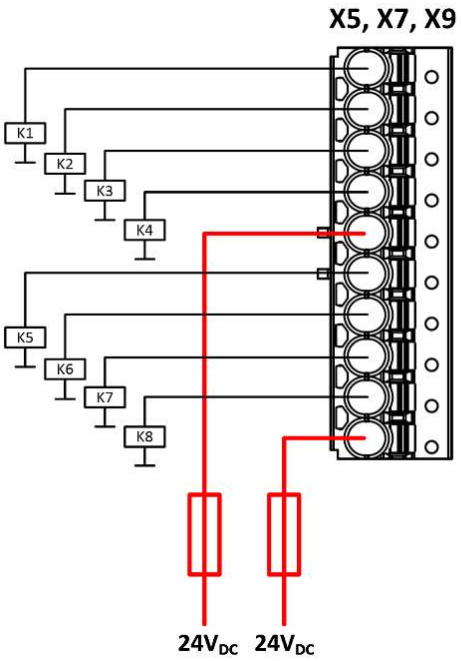


Fig. 13: Digital outputs X5, X7 and X9

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.

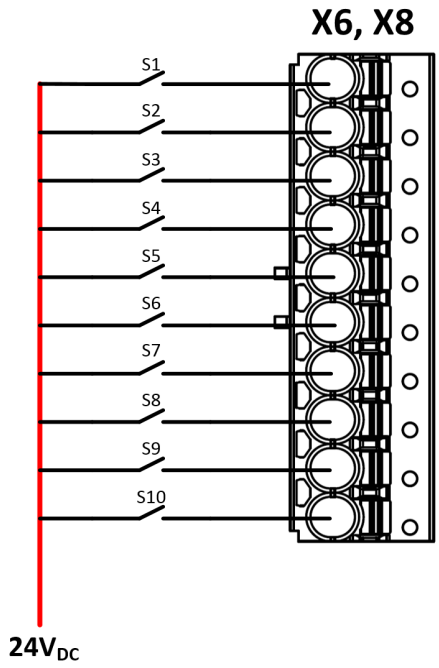


Fig. 14: Digital inputs X6 and X8

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 kΩ) 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.

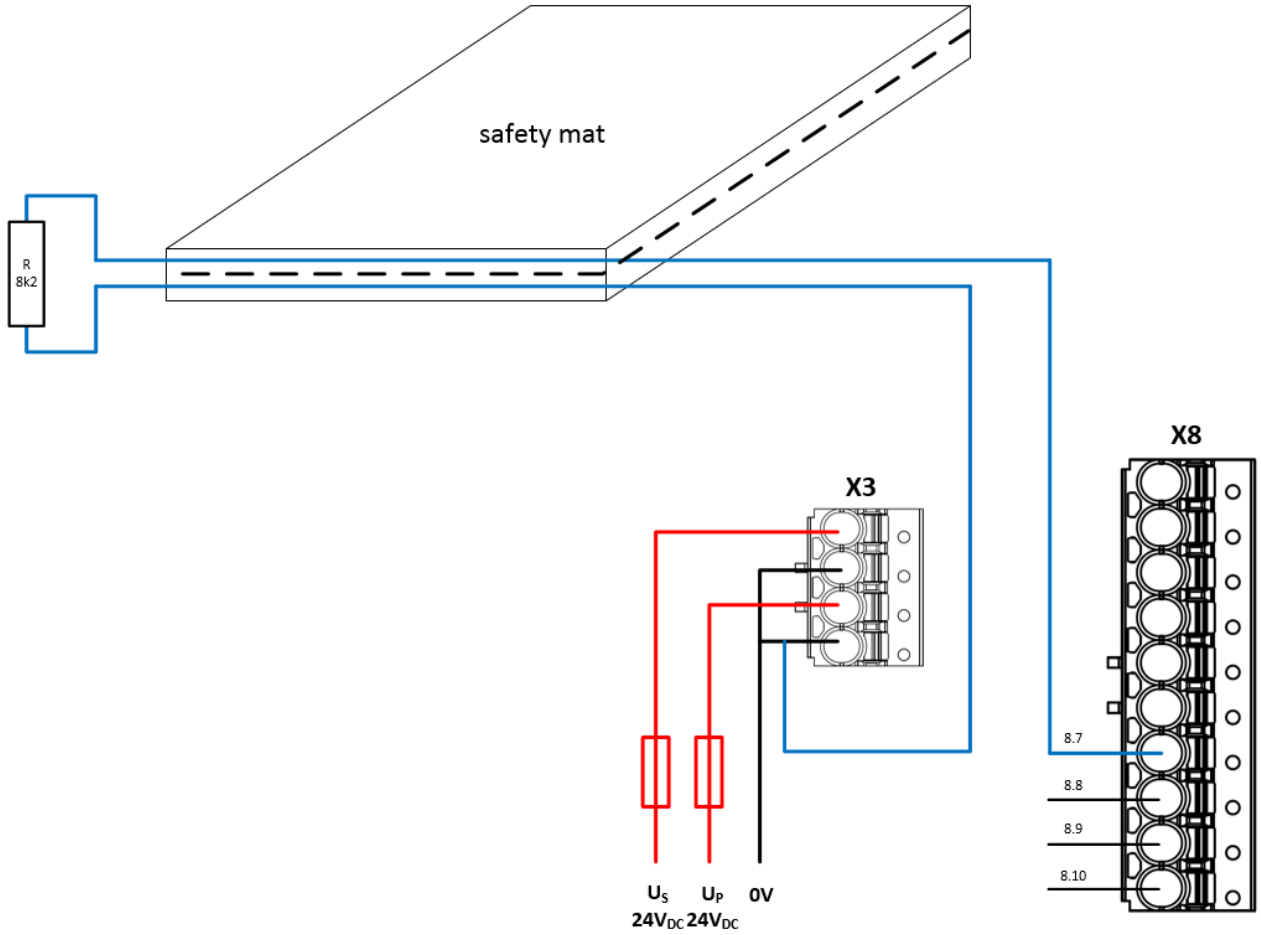


Fig. 15: Safety mat wiring

3.15.2 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.

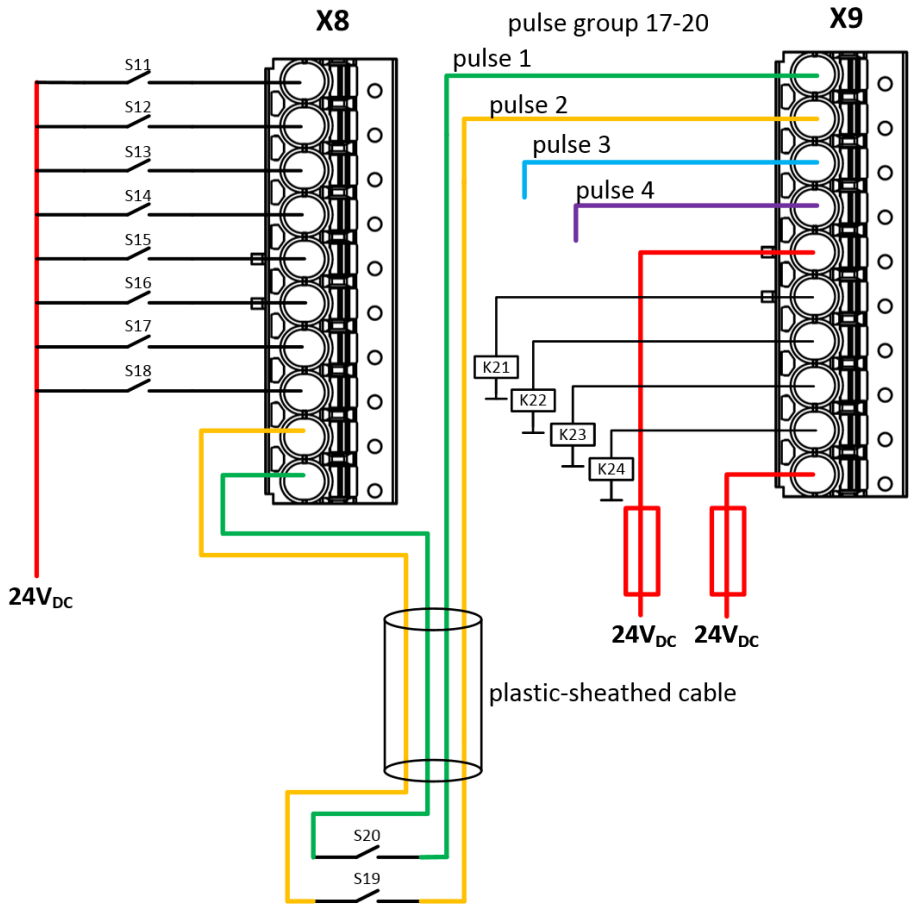


Fig. 16: Wiring example – clock outputs to inputs

4 Operation

4.1 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

NOTE

Electromagnetic compatibility

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

4.2 Installation

4.2.1 Safety instructions

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

4.2.2 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).

4.2.3 Mechanical installation

4.2.3.1 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!

4.2.3.2 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.

4.2.3.3 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.

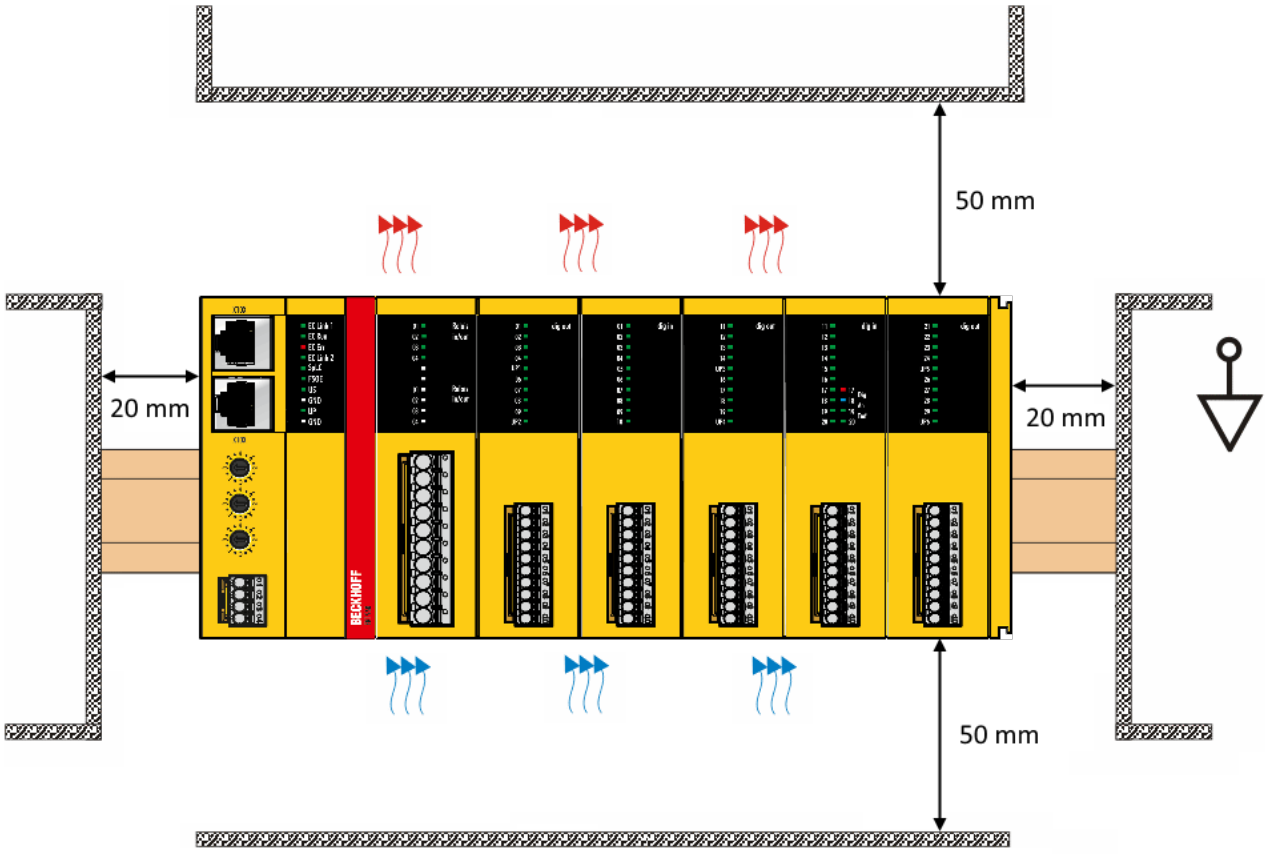


Fig. 17: Installation position and minimum distances

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.

4.2.3.4 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.

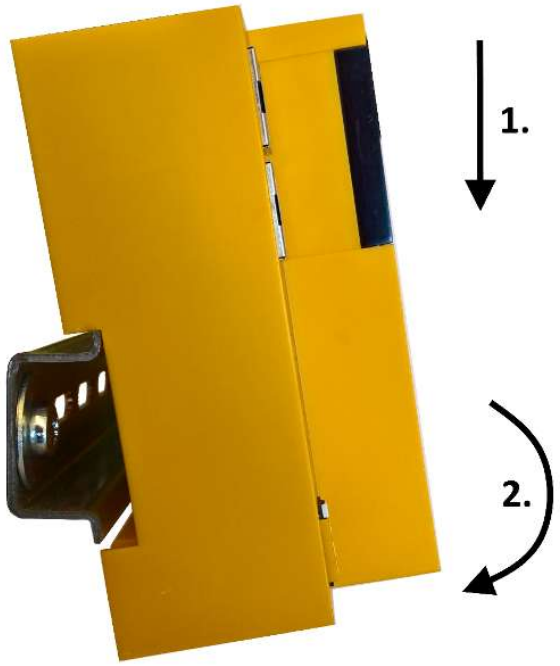


Fig. 18: Mounting the EK1960 on the DIN rail

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

4.2.4 Electrical installation

4.2.4.1 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.

4.2.4.2 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.

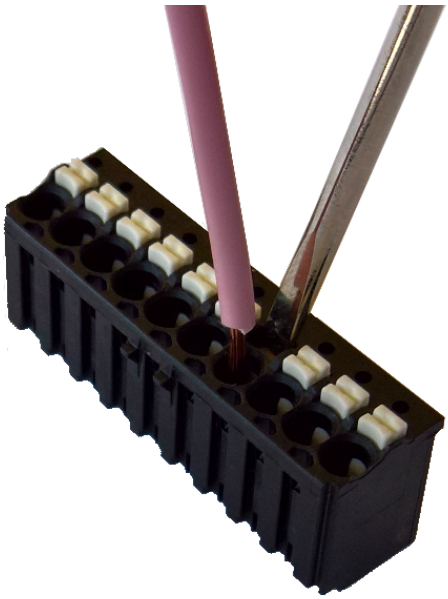


Fig. 21: ZS2003-0002 Depressing the latch

4.2.4.3 Signal cables

Cable routing

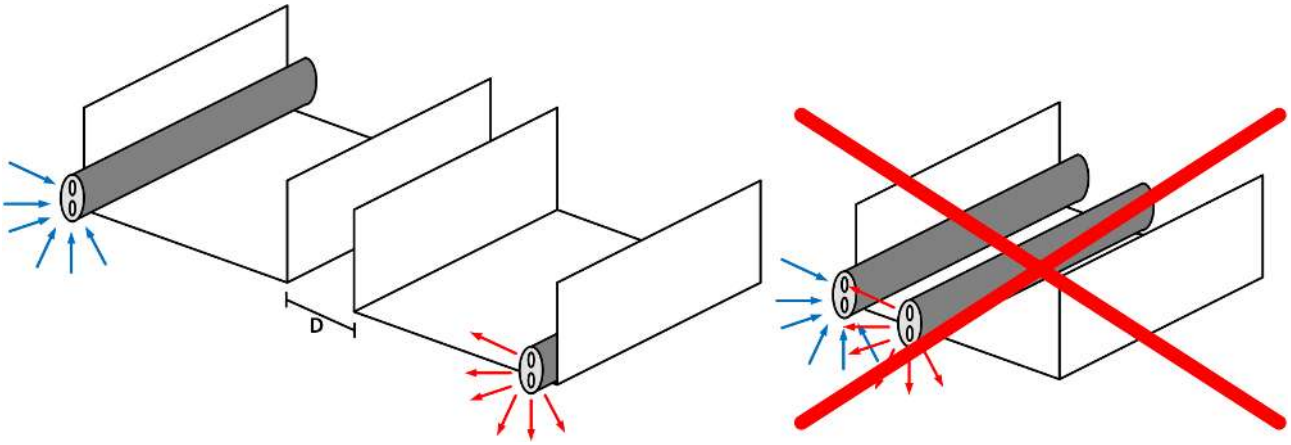


Fig. 22: Cable routing

NOTE

Route the signal cable separately

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

The common routing of signals together with other clocked signals in a common cable also reduces the maximum propagation, since crosstalk of the signals can occur over long cable lengths and cause diagnostic messages.

4.3 Configuration of the 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!

4.3.1 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

The EK1960 cannot be used under TwinCAT 2

4.3.2 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.

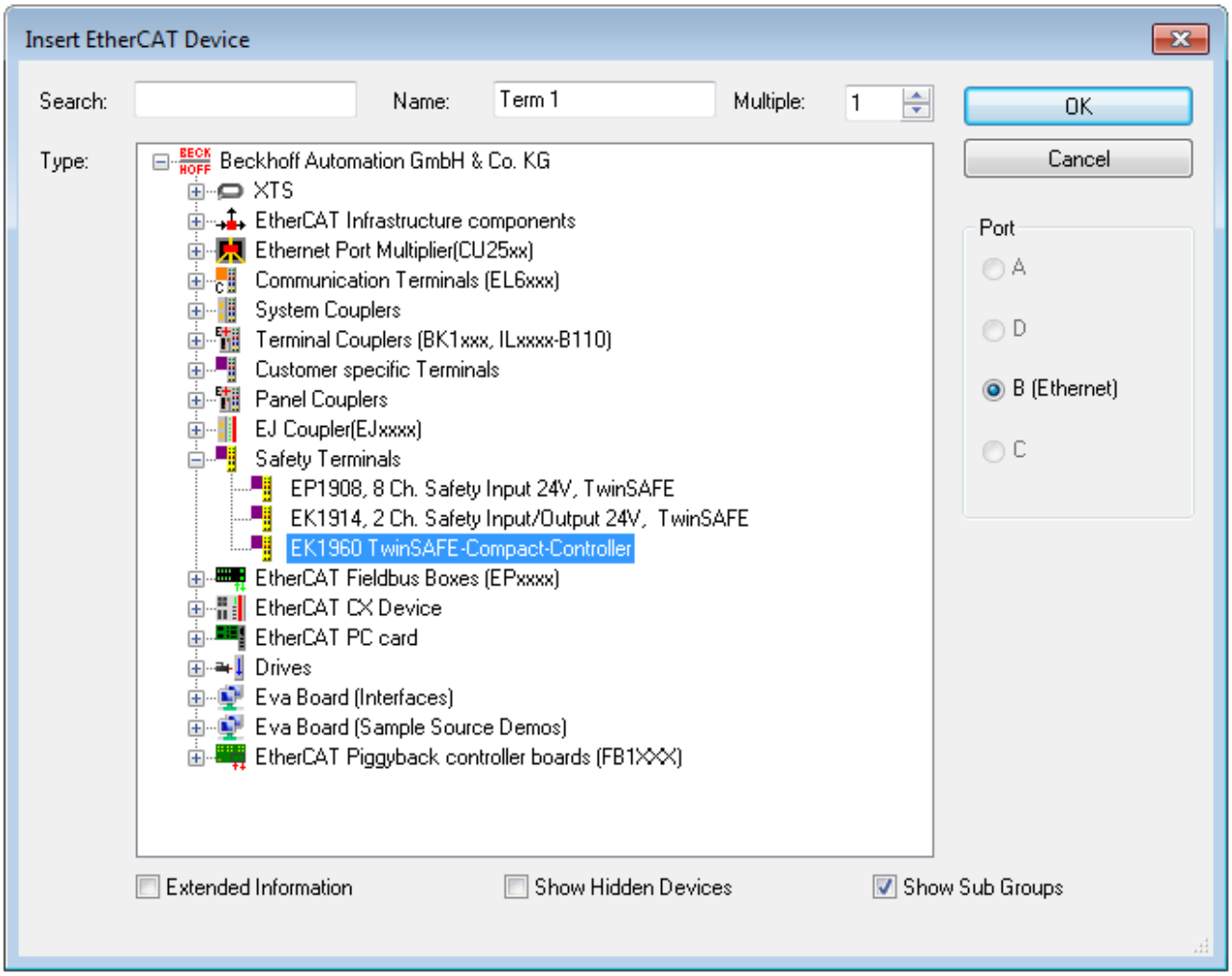


Fig. 23: Inserting an EK1960

Size of the process image

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

4.3.3 Creating a safety project in TwinCAT 3

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.

4.3.3.1 Add new item

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

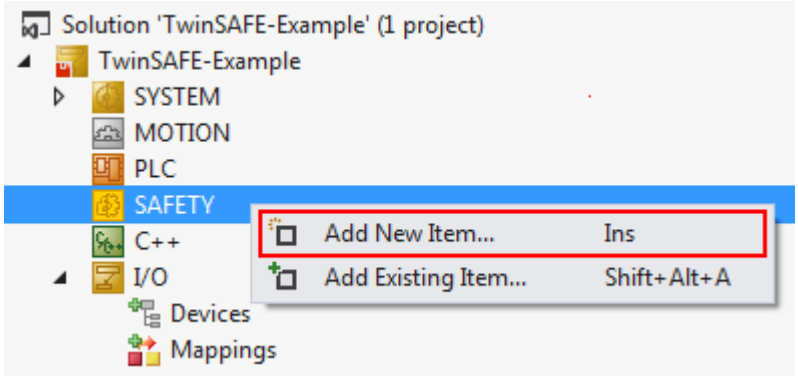


Fig. 24: Creating a safety project - Add New Item

The project name and the directory can be freely selected.

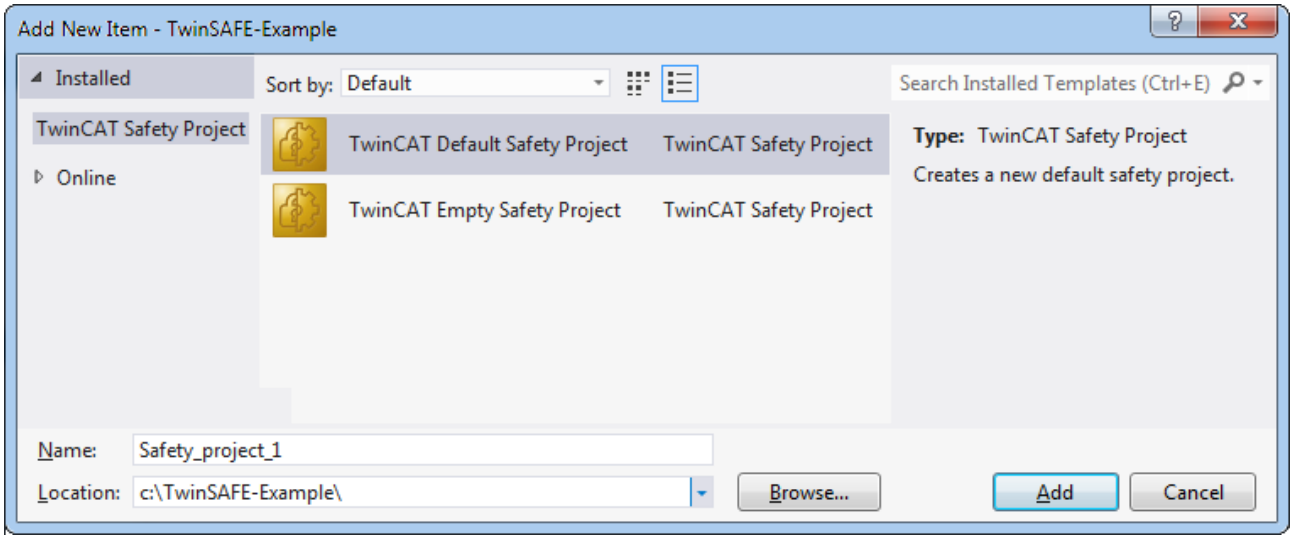


Fig. 25: Creating a safety project - project name and directory

4.3.3.2 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.

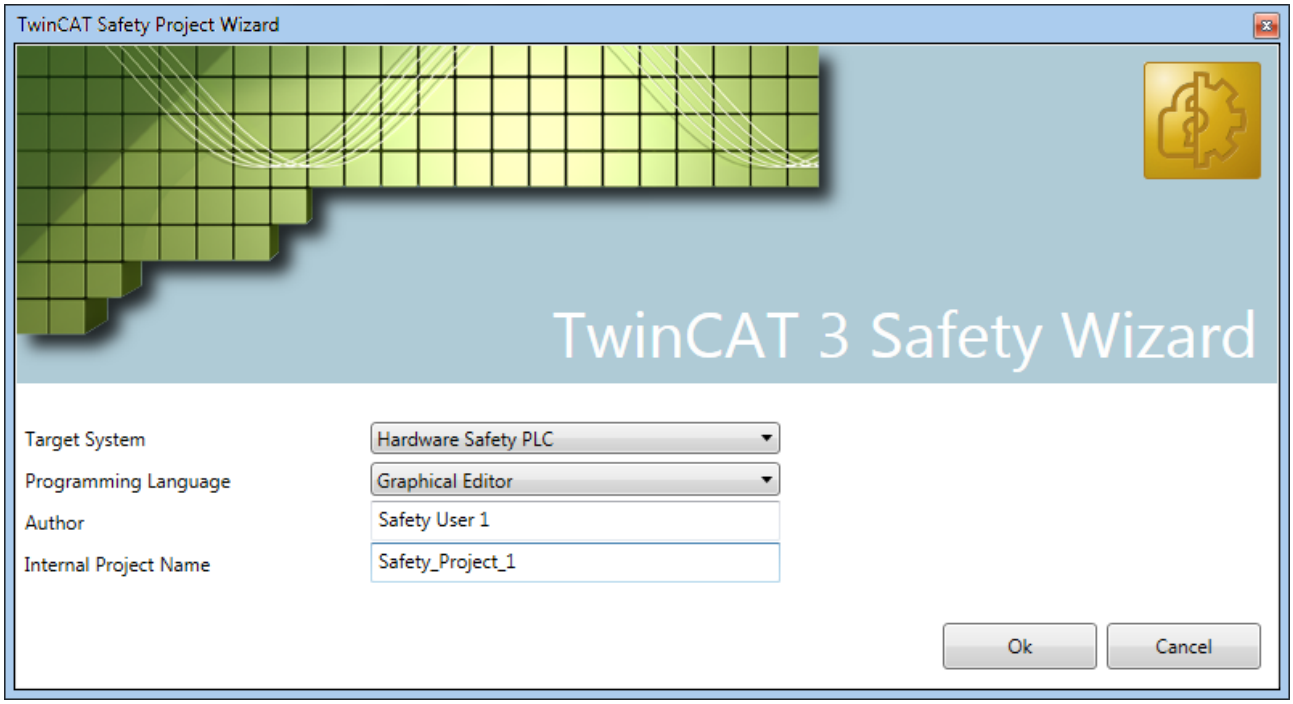


Fig. 26: TwinCAT Safety Project Wizard

4.3.3.3 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.

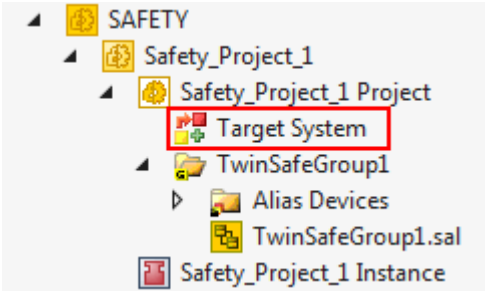


Fig. 27: Selecting the Target System node

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.

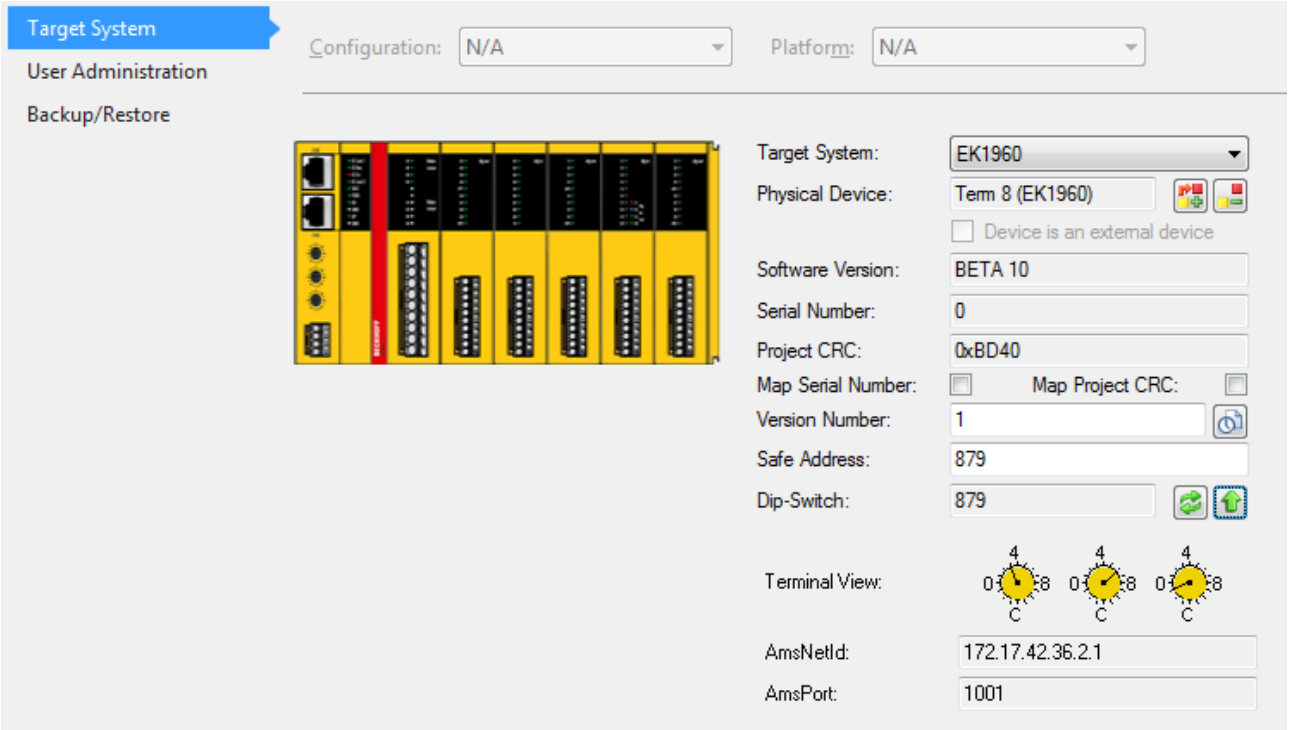


Fig. 28: Linking of target system and TwinSAFE compact controller

4.3.3.4 Alias devices

The communication between the safety logic and the I/O level is realized via an alias level. At this alias level (subnode *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.

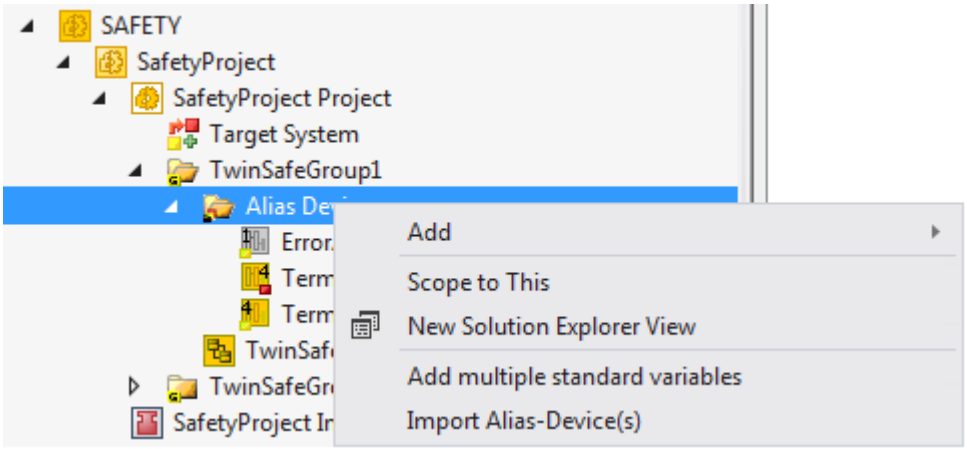


Fig. 29: Starting the automatic import from the I/O configuration

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.

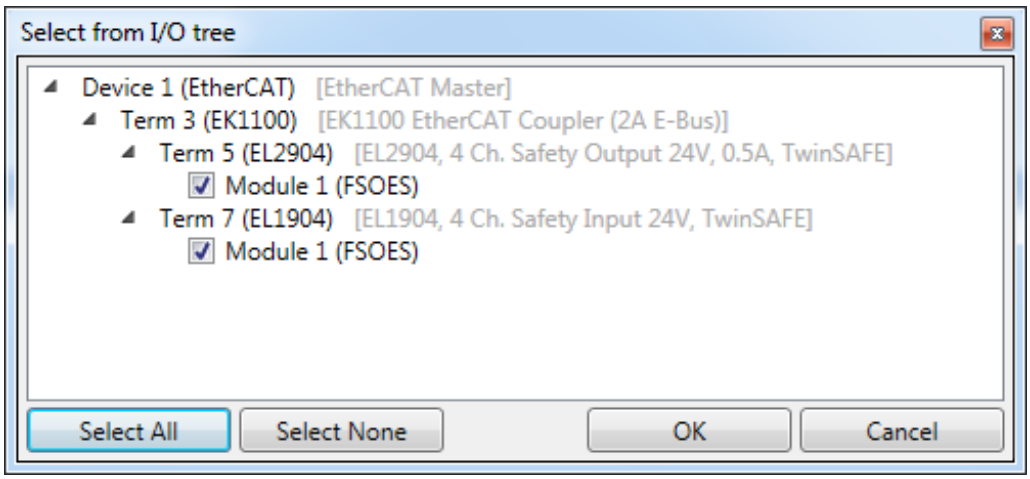


Fig. 30: Selection from the I/O tree

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.

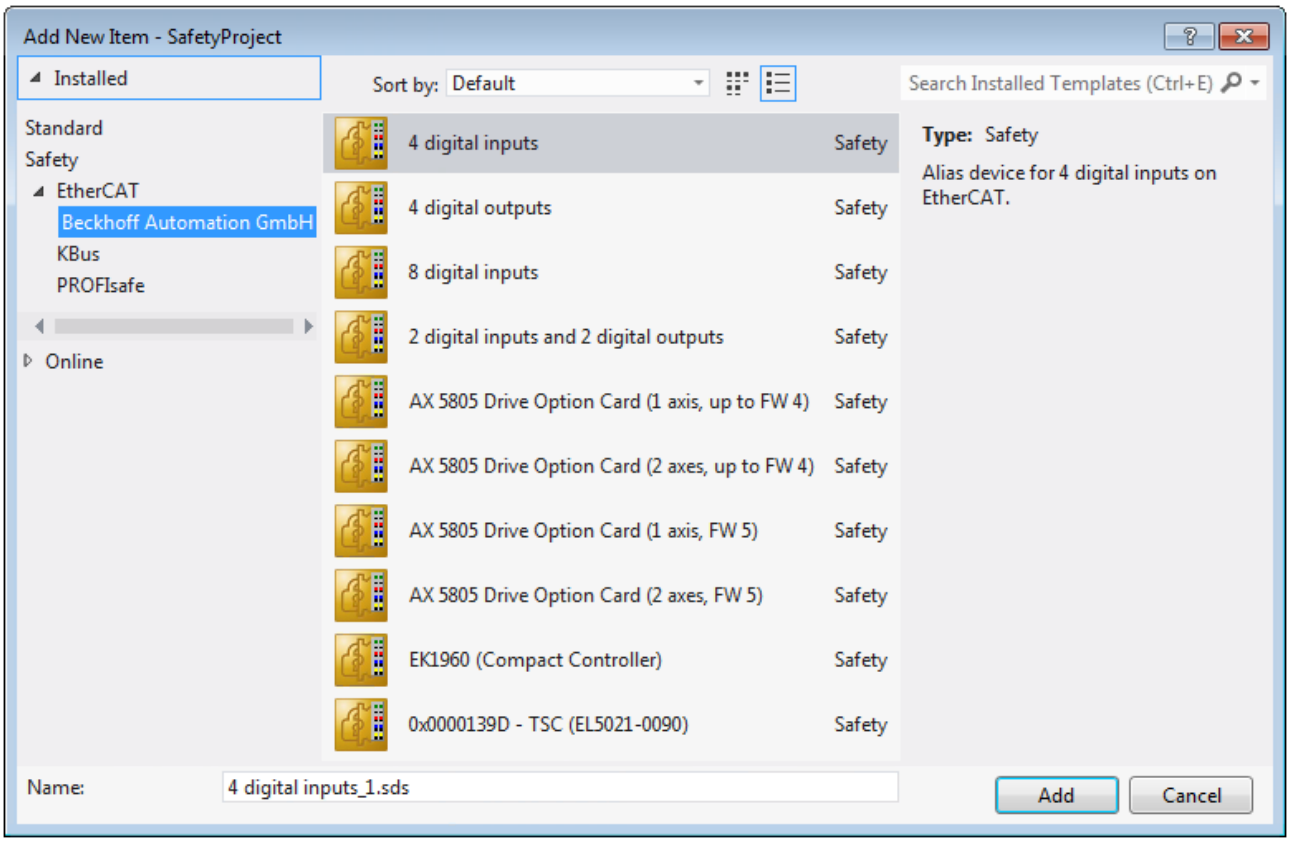


Fig. 31: Creating alias devices by the user

4.3.3.5 Parameterization of the alias device

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

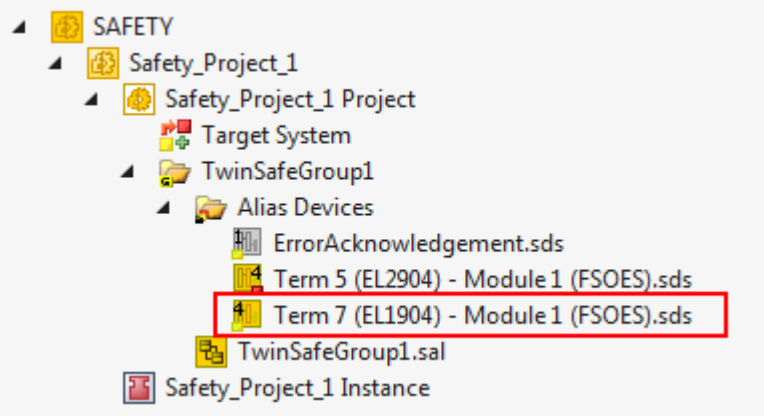


Fig. 32: Alias Device in the safety project structure

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)*.

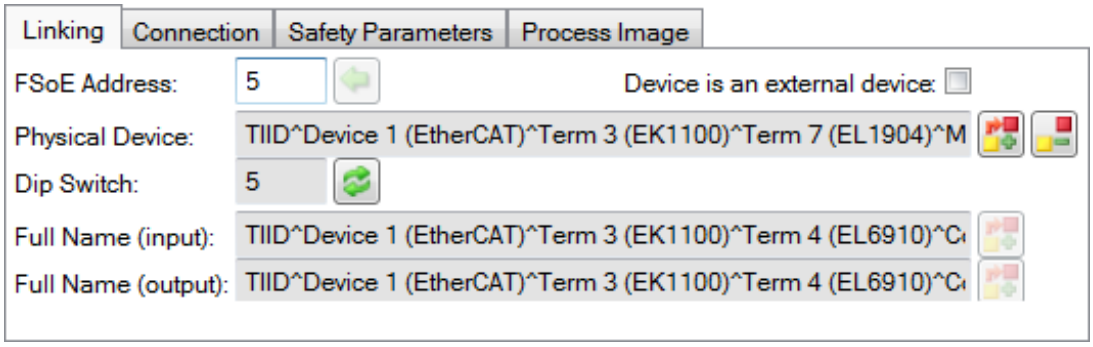


Fig. 33: Links to EL6910/EJ6910 process image

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

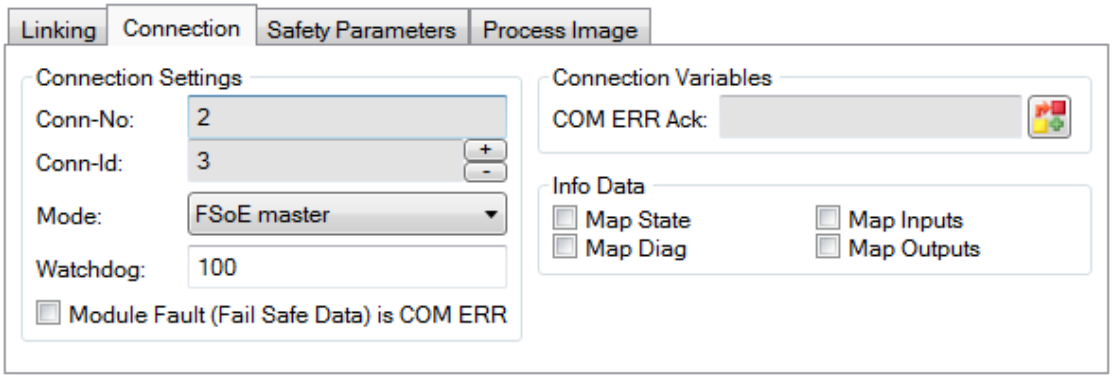


Fig. 34: Connection-specific parameters

Parameter	Description	User interaction required
Conn. no.	Connection number - 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
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 *TwinCAT function blocks for TwinSAFE Logic terminals*.	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.

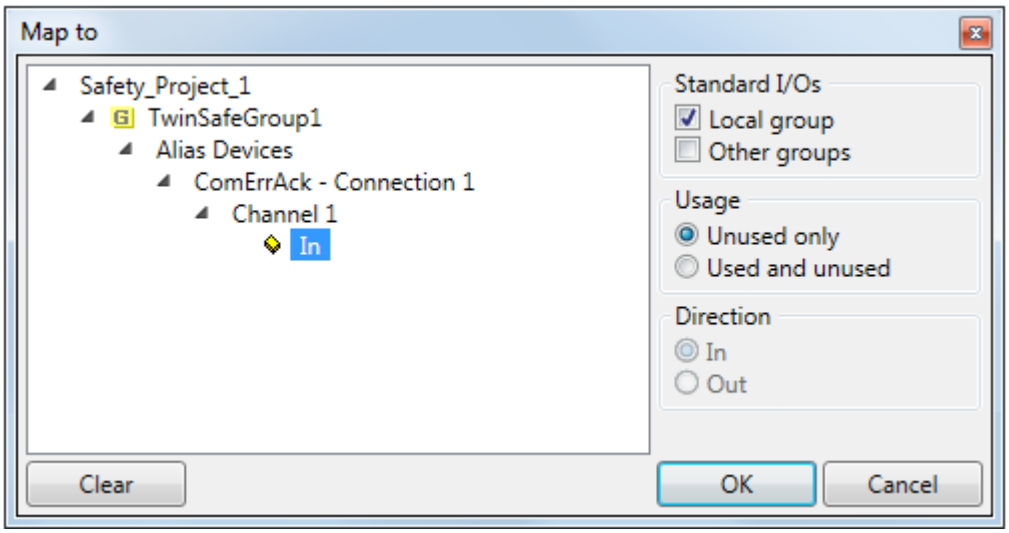


Fig. 35: Selecting an alias device

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.

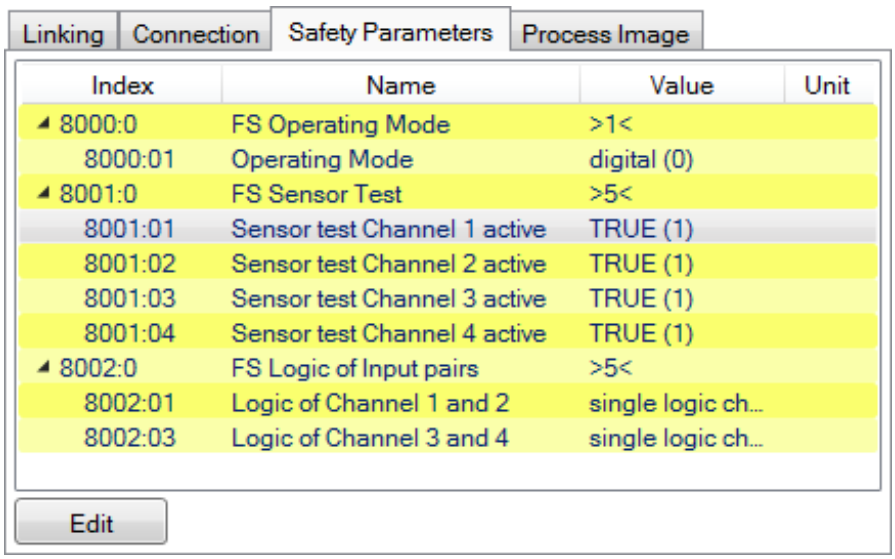


Fig. 36: Safety parameter for the device

4.3.3.6 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.

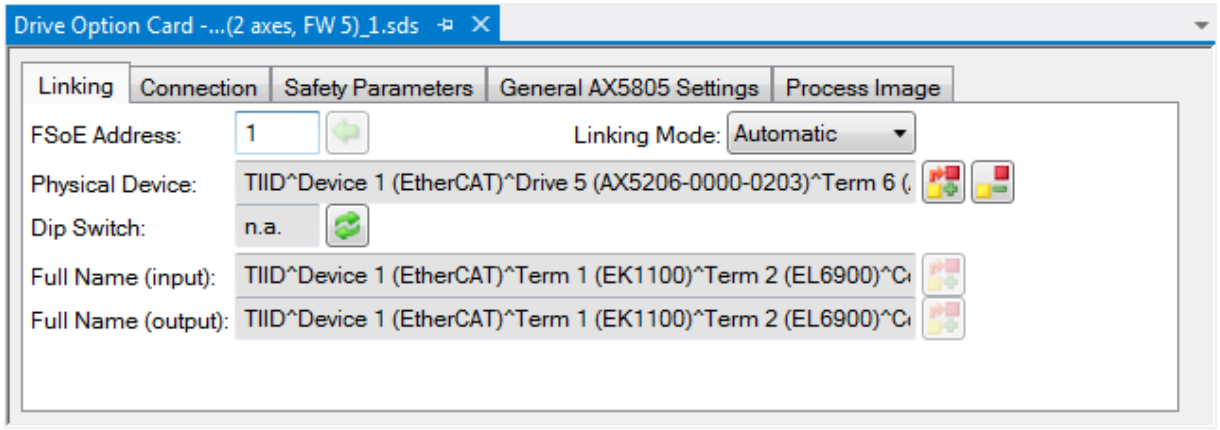


Fig. 37: AX5000 safety drive functions

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.

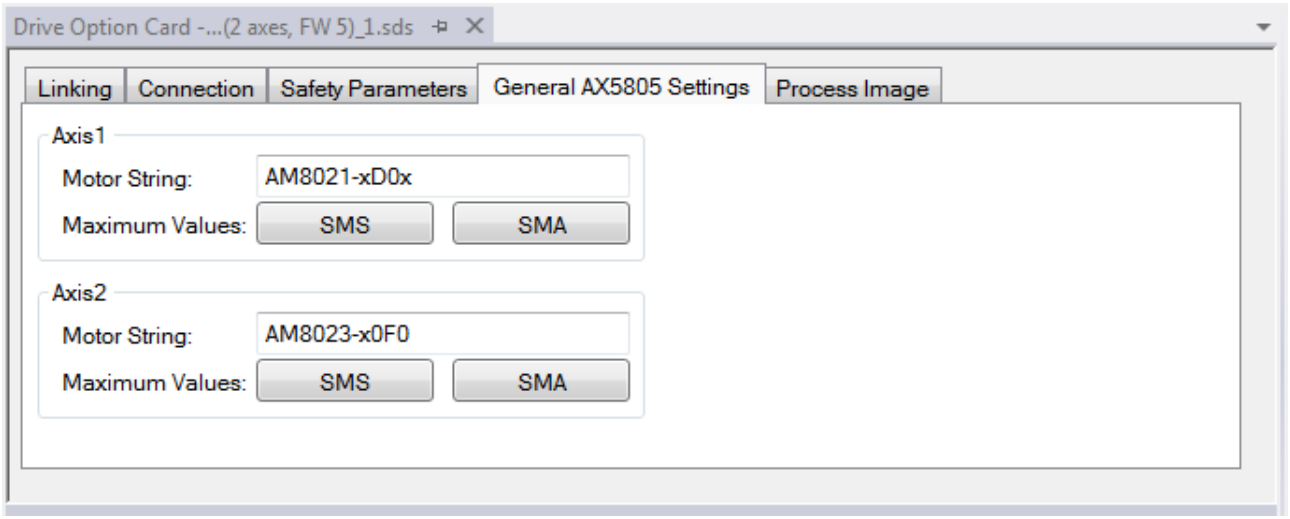


Fig. 38: AX5000 safety drive options - general AX5805 settings

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

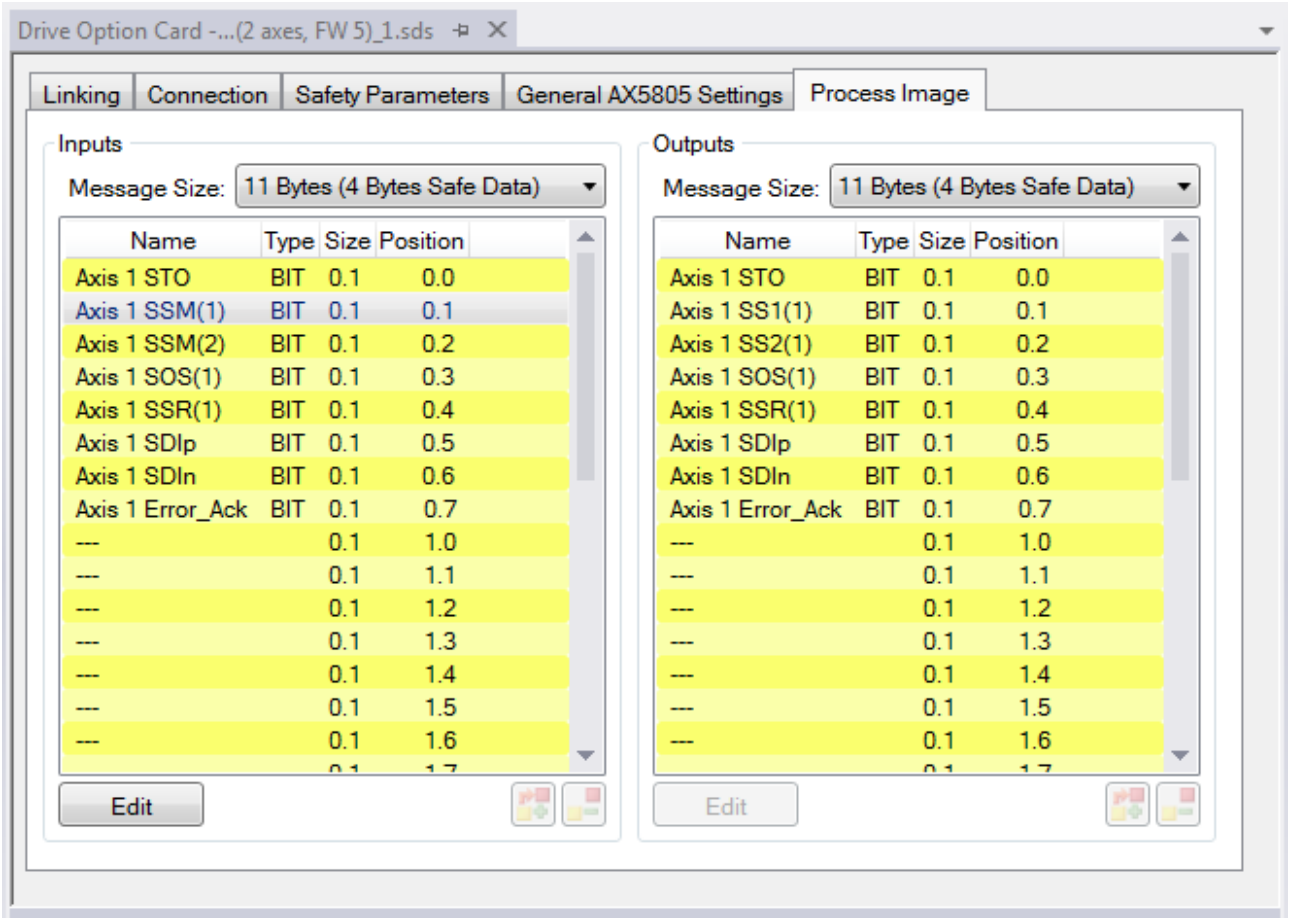


Fig. 39: AX5000 safety drive options - Process Image

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.

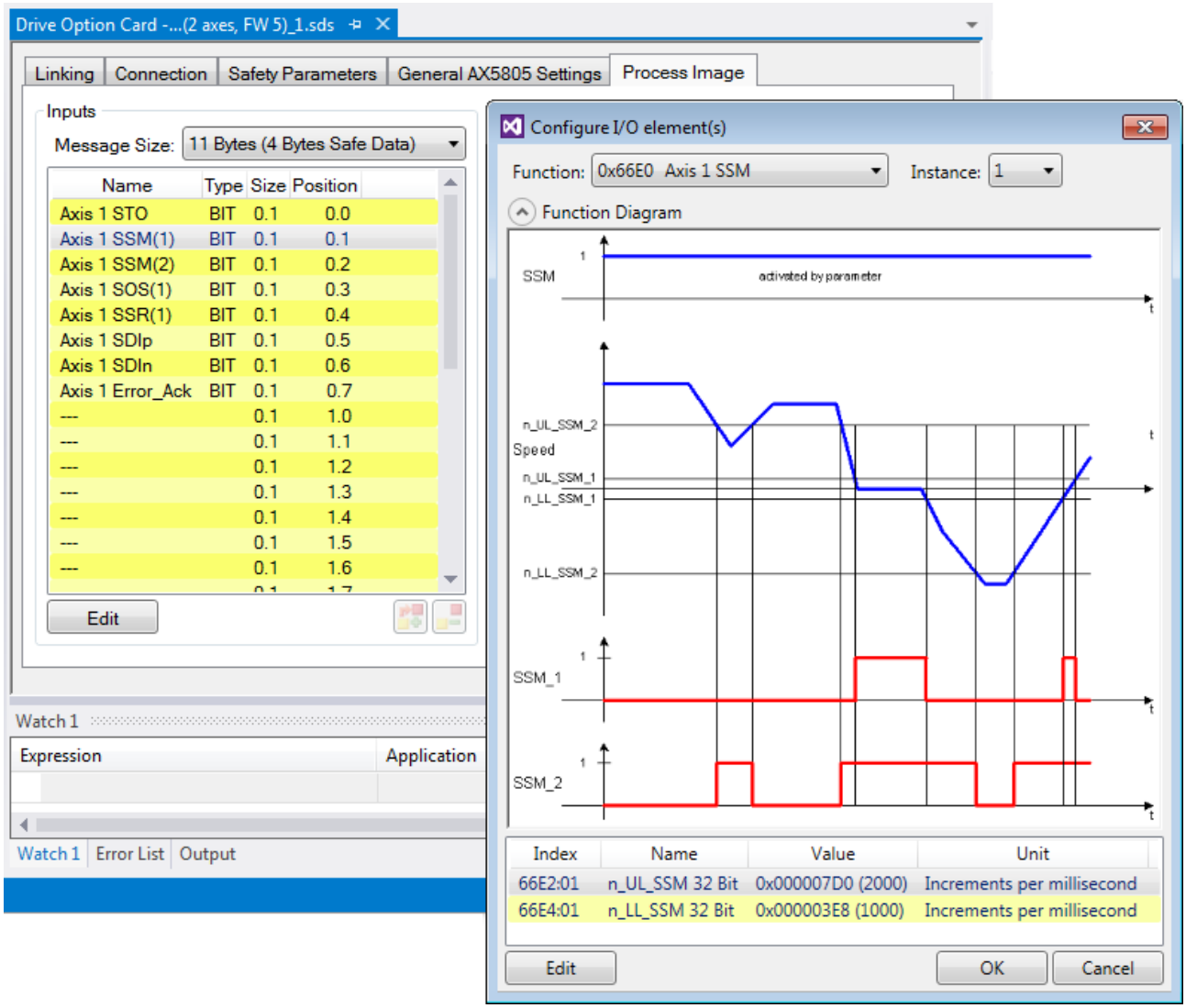


Fig. 40: AX5000 safety drive options - Function Diagram

4.3.3.7 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.

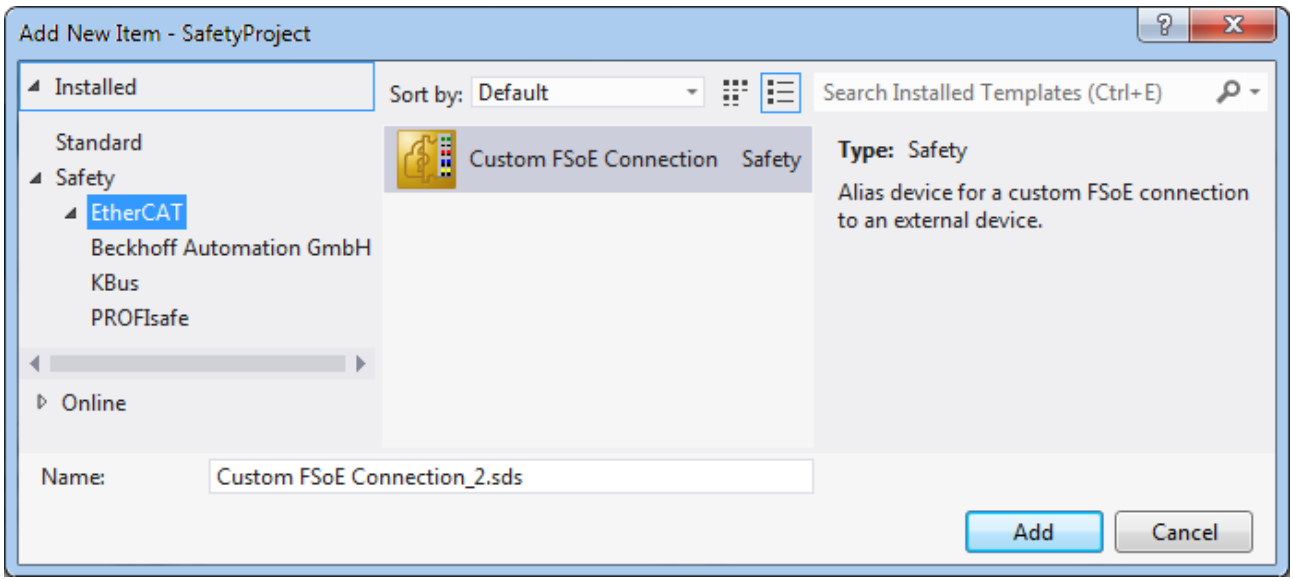


Fig. 41: Creating an external connection (Custom FSoE Connection)

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.

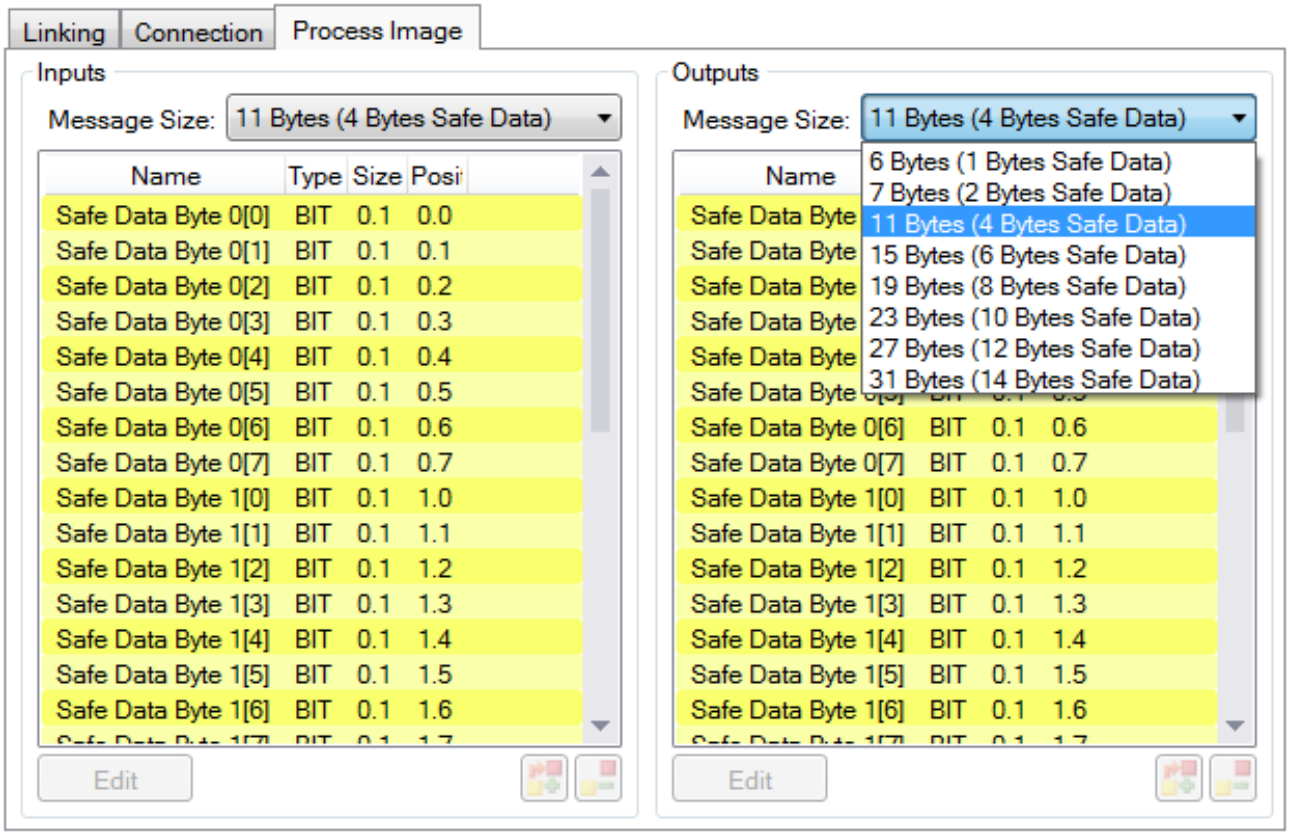


Fig. 42: Parameterization of the process image size

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], …).

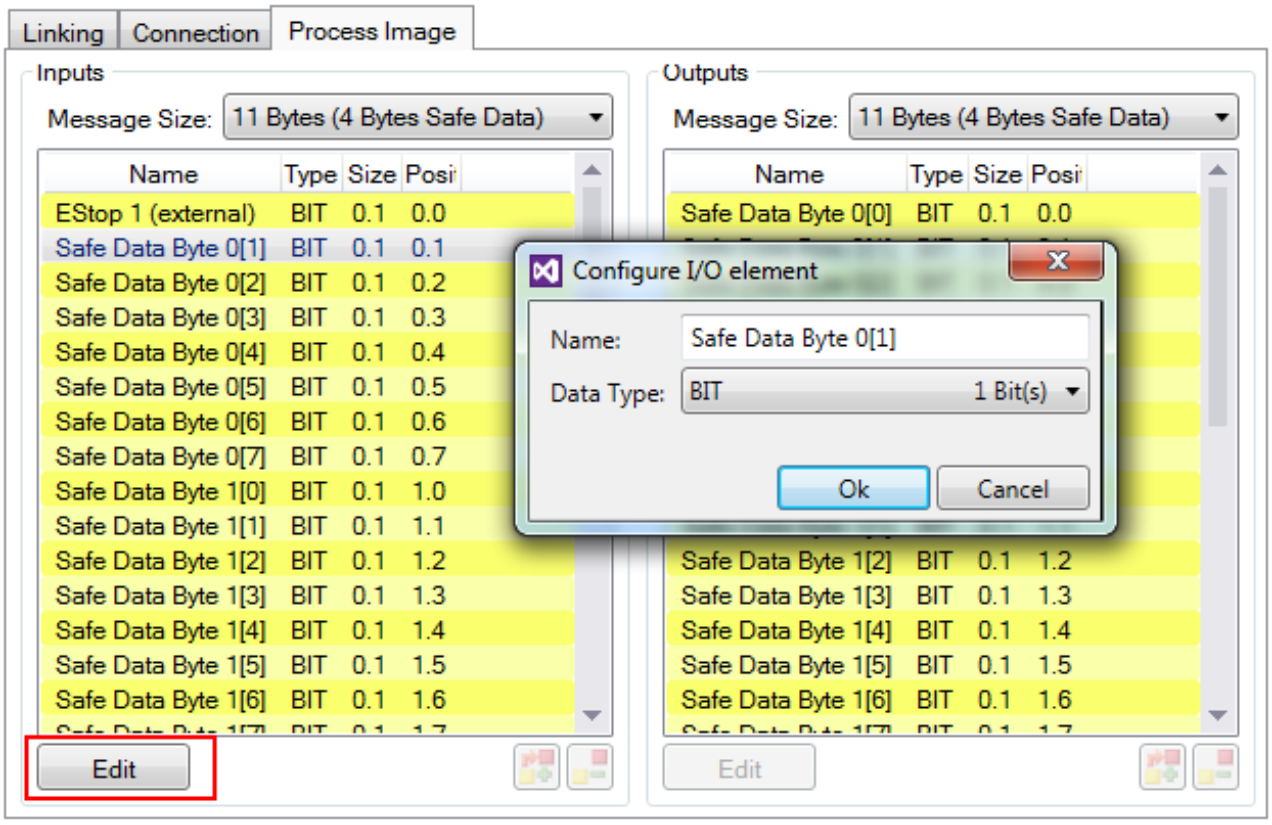


Fig. 43: Renaming the individual signals within the telegram

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.

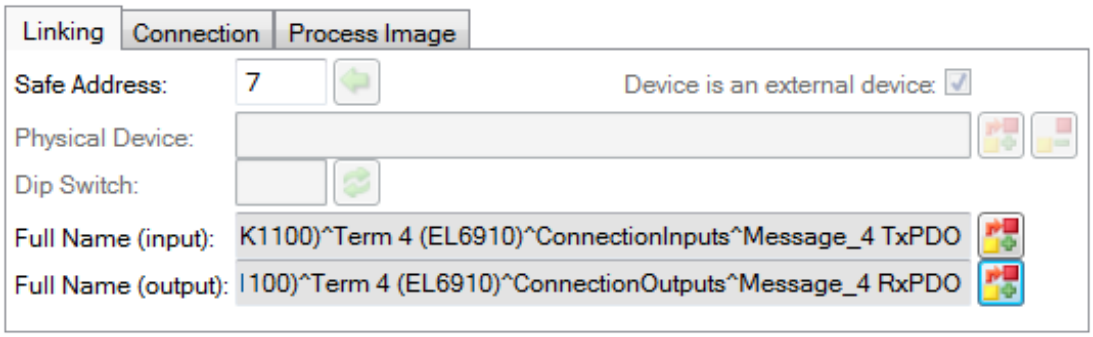


Fig. 44: Selecting the variables

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).

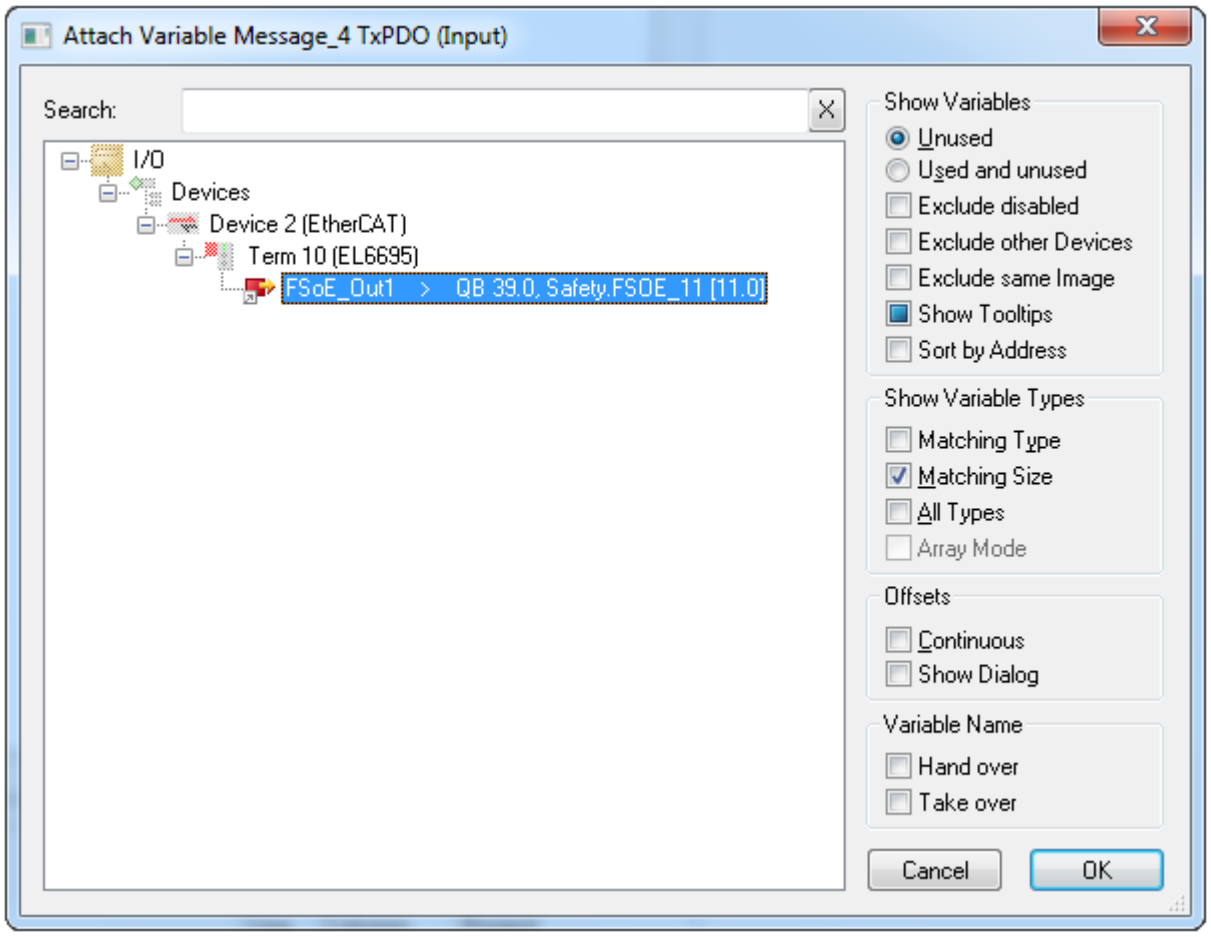


Fig. 45: Direct linking with the process image of an EtherCAT Terminal

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.

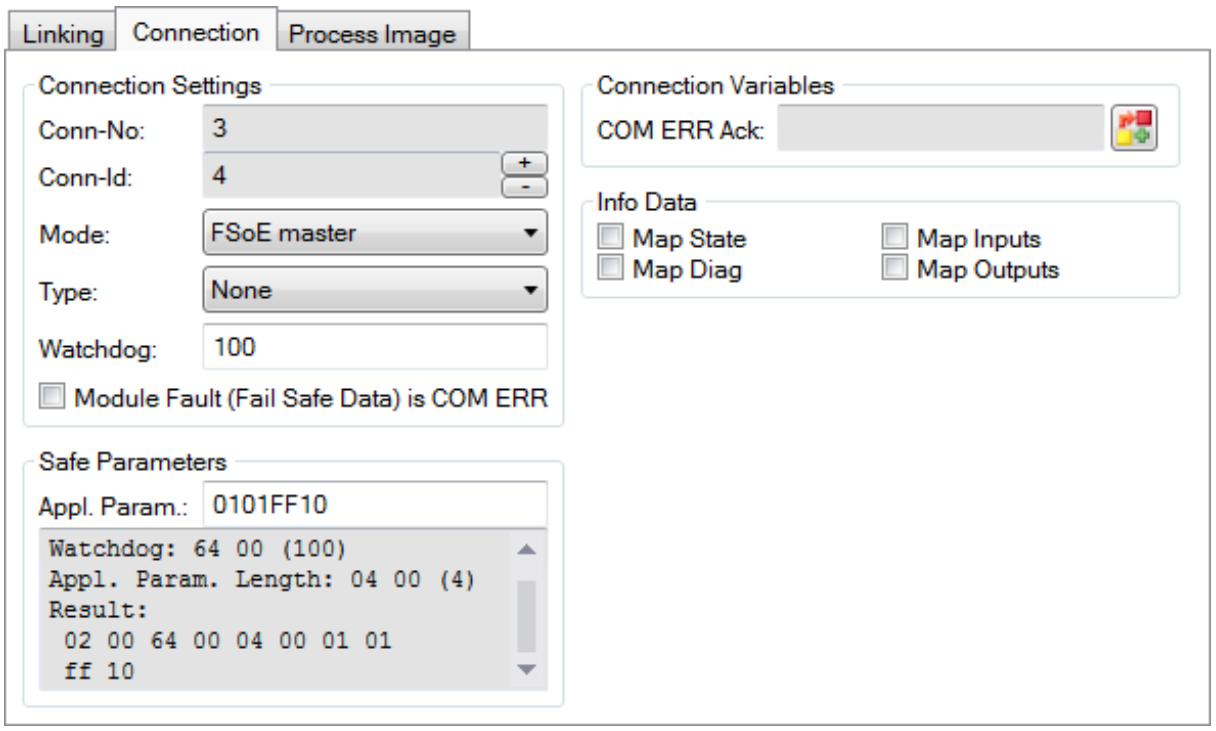


Fig. 46: Connection-specific parameters

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 *TwinCAT function blocks for TwinSAFE Logic terminals*.	Yes

4.3.3.8 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.

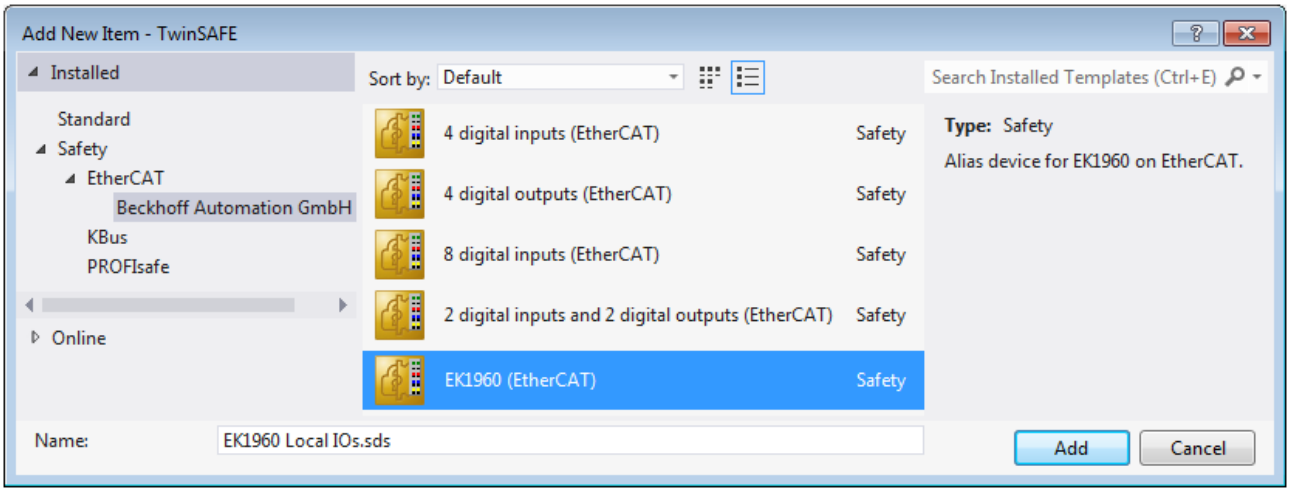


Fig. 47: Insertion of an EK1960 alias device

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.

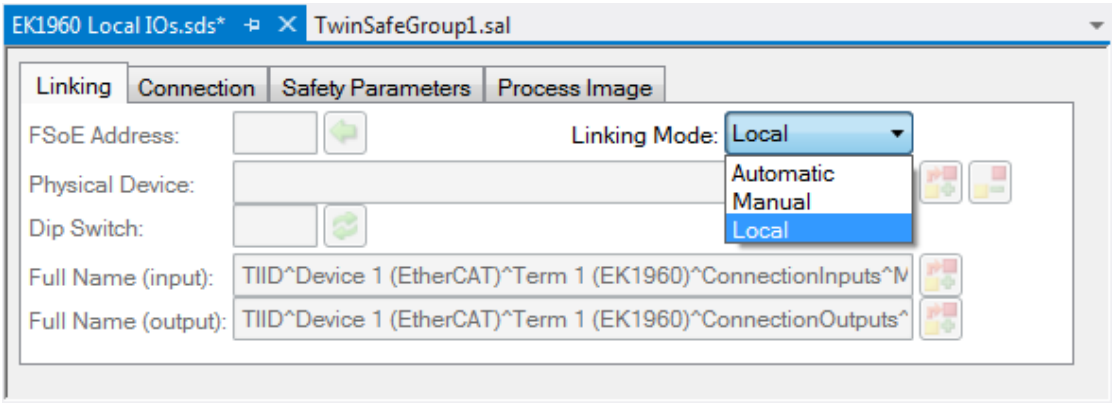


Fig. 48: Switching the alias device to *Local*

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

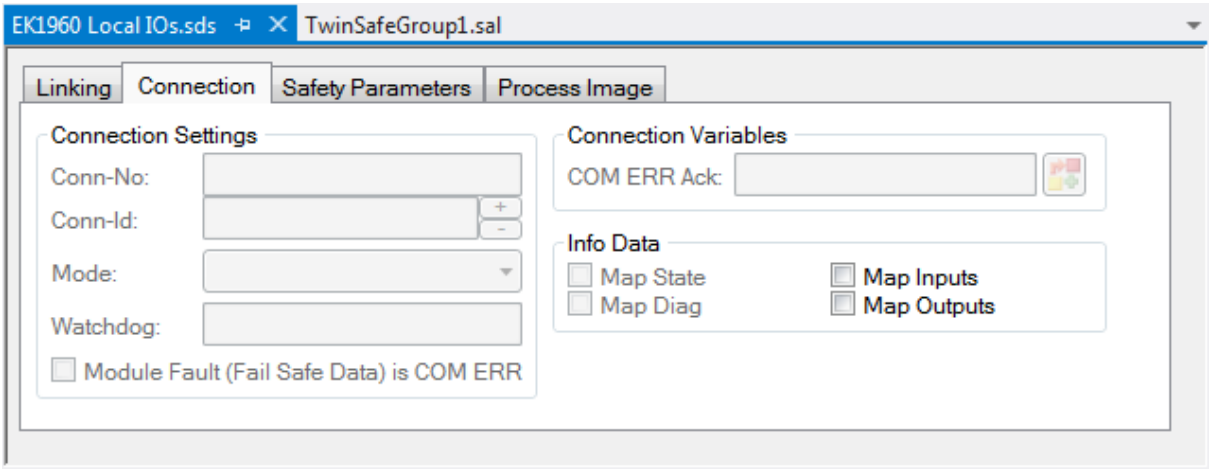


Fig. 49: Info data for local connection

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

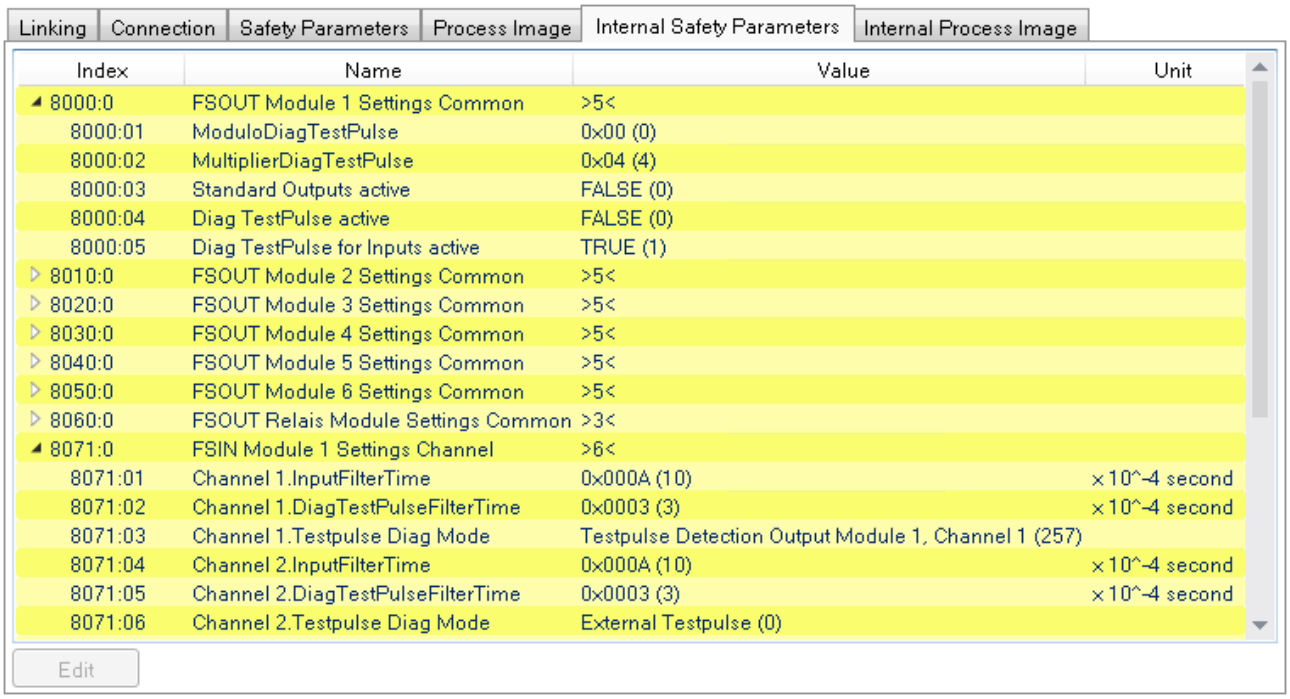


Fig. 50: Safety parameters of the output and input modules

Overview of output parameters

PrmName	Index	Meaning	Value
FSOUT Module 0 Settings Common	8000:00	Settings for output module 0 (outputs 01 - 04)	-
ModuloDiag TestPulse	8000:01	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	8000:02	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	8000:03	FALSE = standard outputs deactivated TRUE = standard outputs are ANDed with the safe outputs	FALSE
Diag TestPulse active	8000:04	FALSE: Clocking of the outputs deactivated TRUE: Clocking of the outputs activated	FALSE
Diag TestPulse for Inputs active	8000:05	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

⚠ 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.

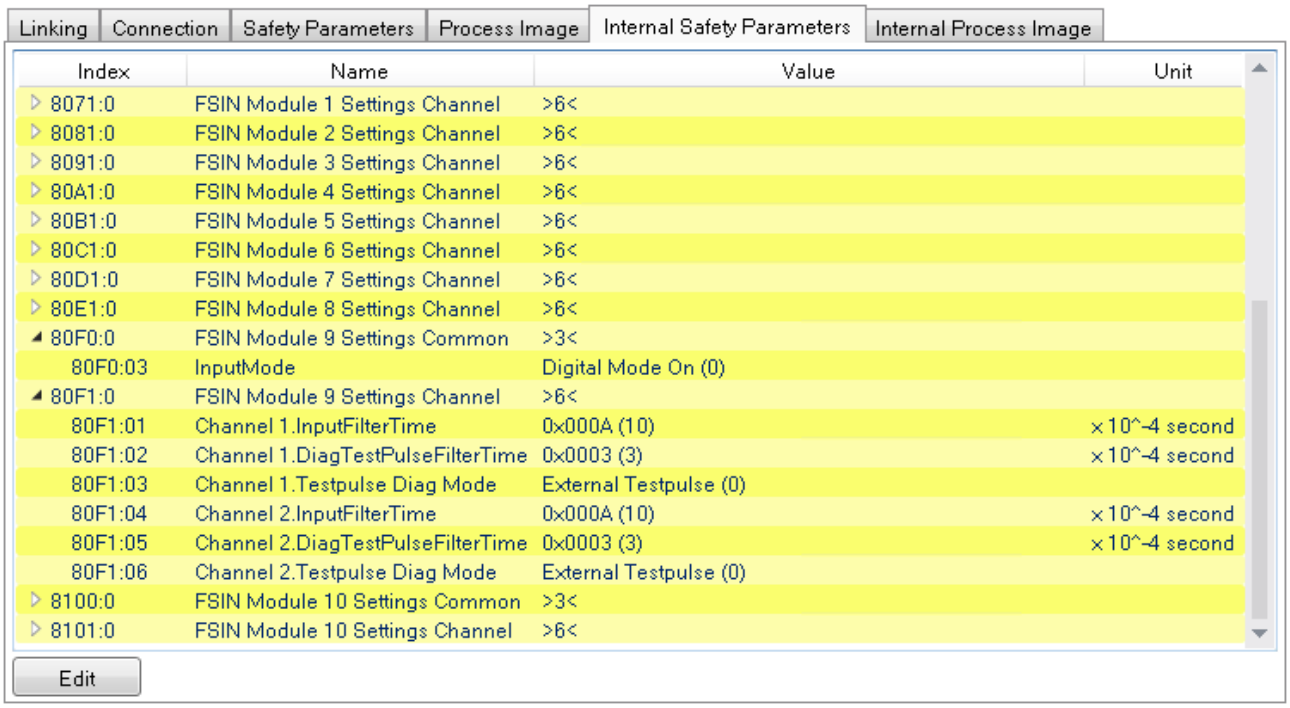


Fig. 51: Safety parameters of the input modules

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 *Digital Mode On* and *Bumper Mode On*. All other modules are set to *Digital Mode On* 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	*External Testpulse* 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)
Channel2. TestPulse Diag Mode	8071:06	The output channel from which the test pulse is expected must be set here	*External Testpulse* 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.

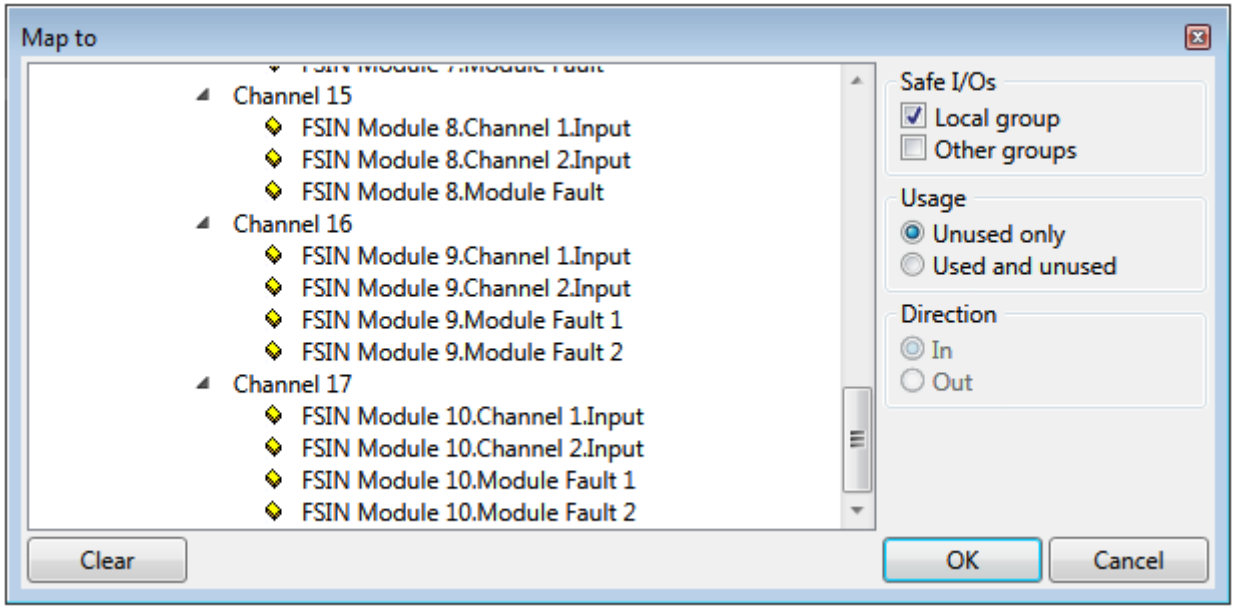


Fig. 52: Process data of input modules 9 and 10

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

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.

4.3.3.9 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.

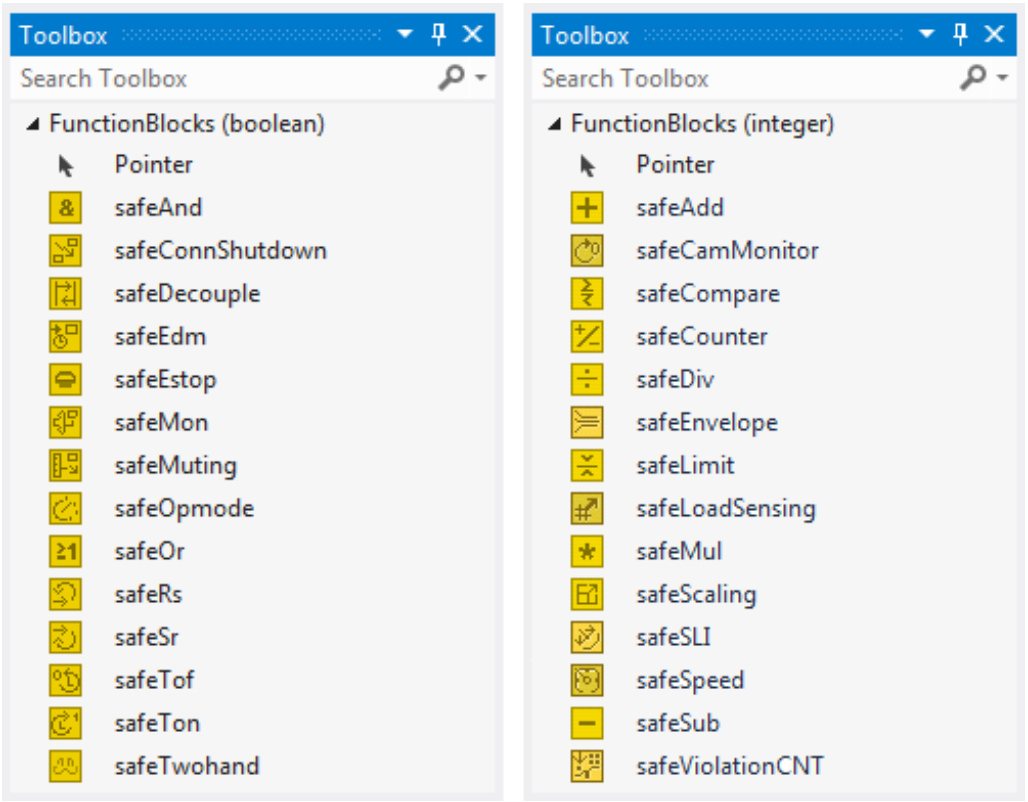


Fig. 53: Function blocks available for EL6910/EJ6910

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.

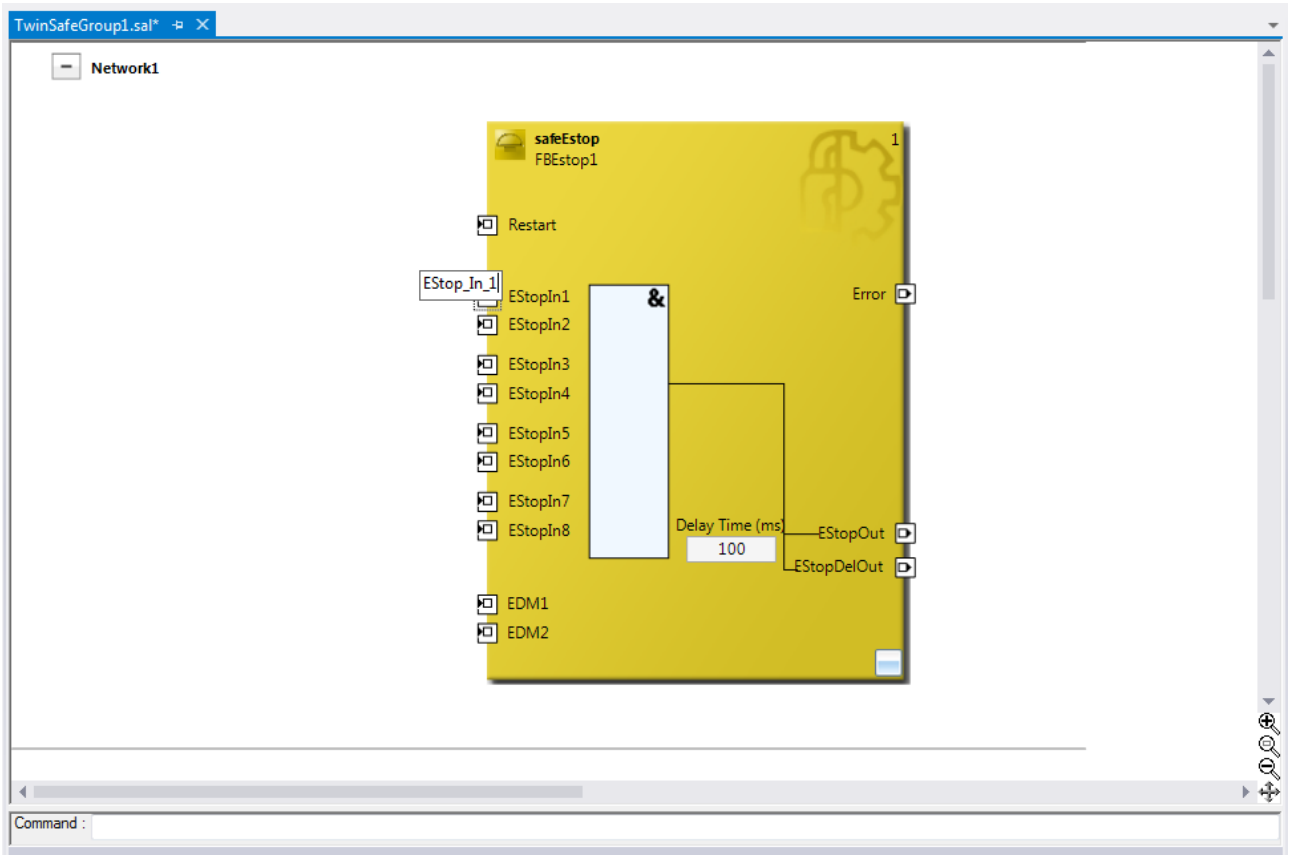


Fig. 54: Function block on the SAL worksheet

Once the pointer connector 

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

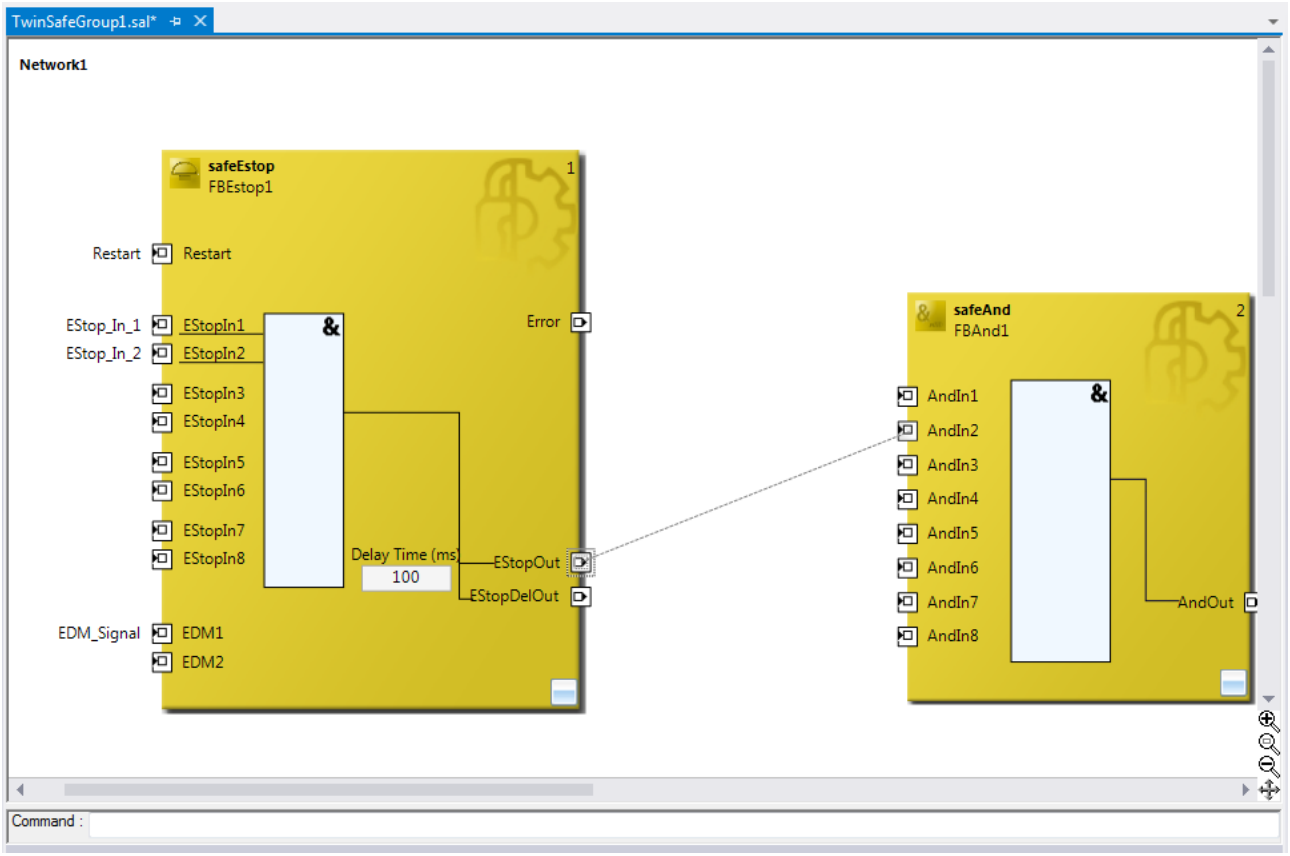


Fig. 55: Dragging a connection between two function blocks

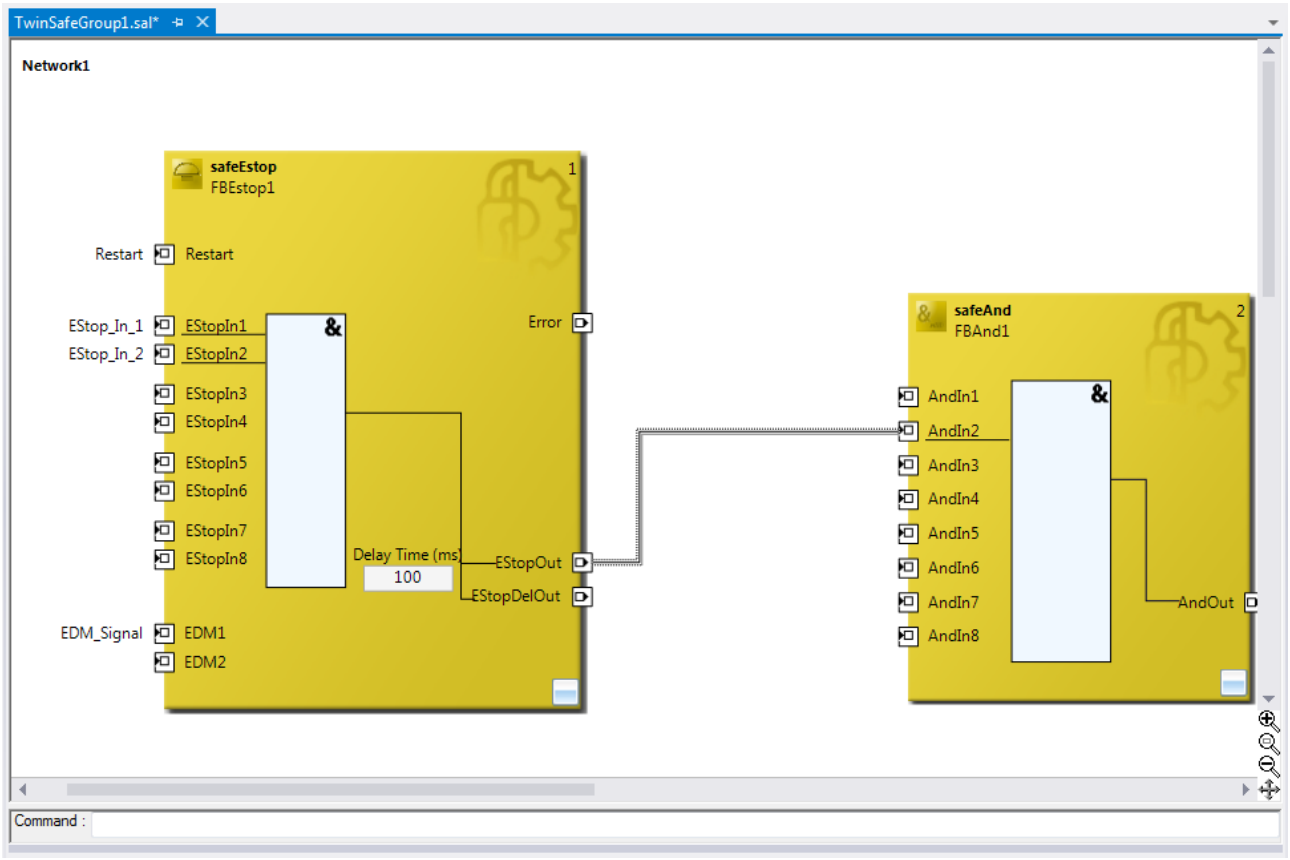


Fig. 56: Connection between two function blocks

4.3.3.10 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.

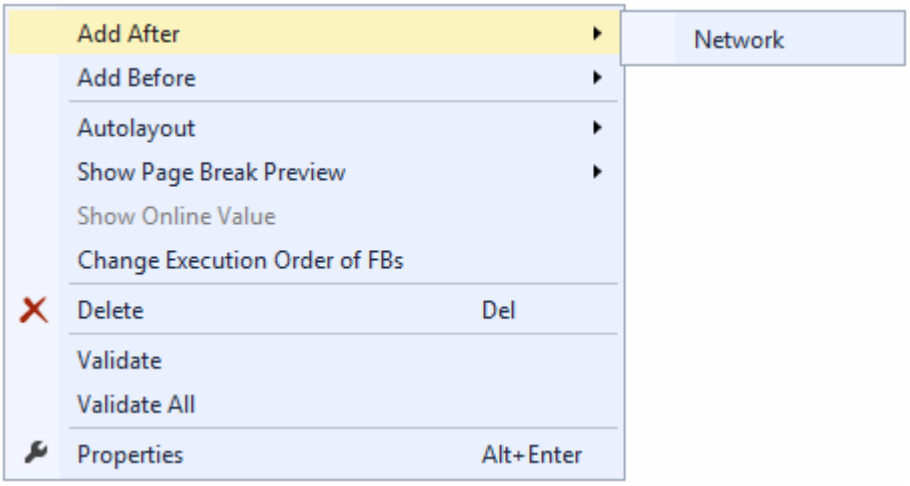


Fig. 57: Creating a network

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.

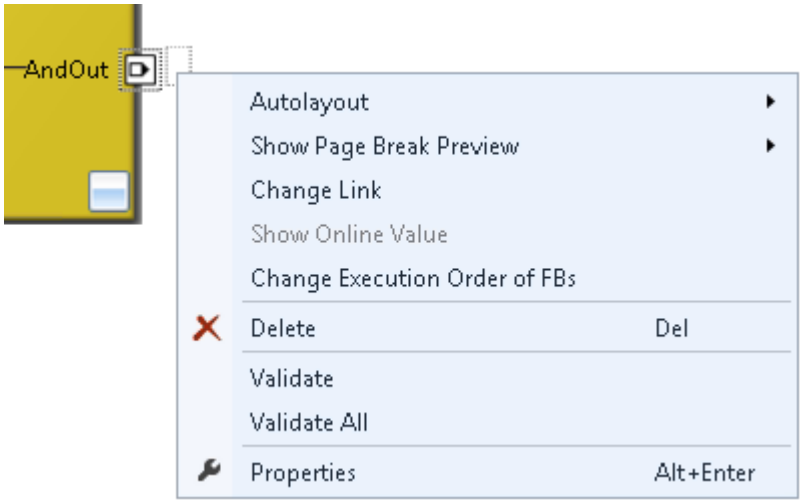


Fig. 58: Change Link

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

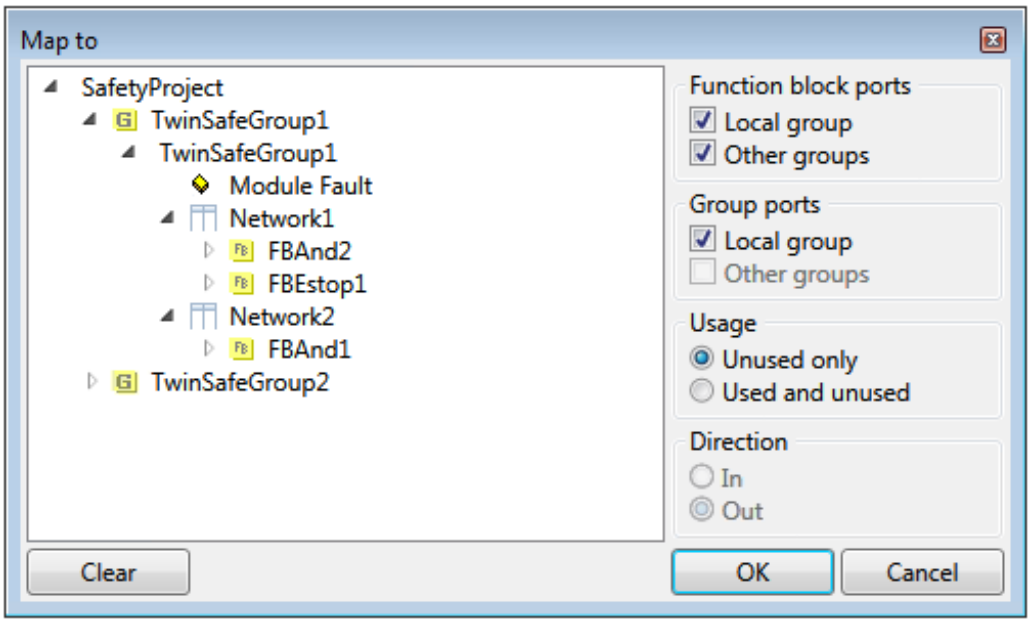


Fig. 59: Dialog for selecting a suitable FB port

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

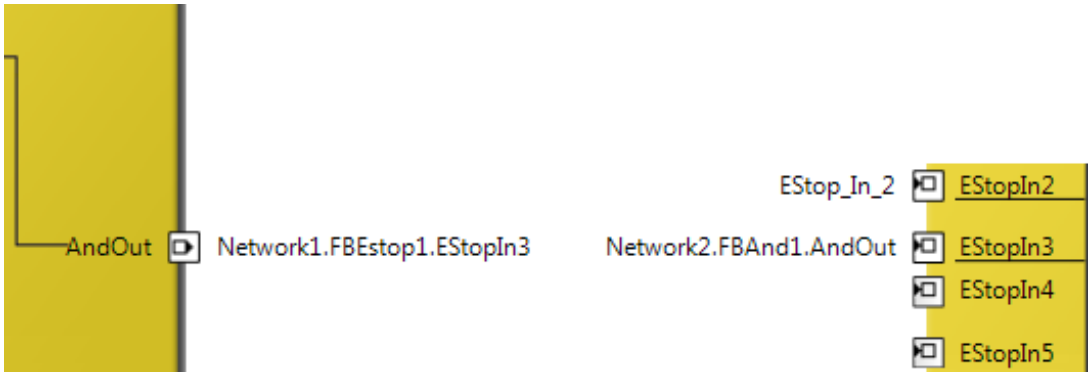


Fig. 60: Link display

4.3.3.11 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...*.

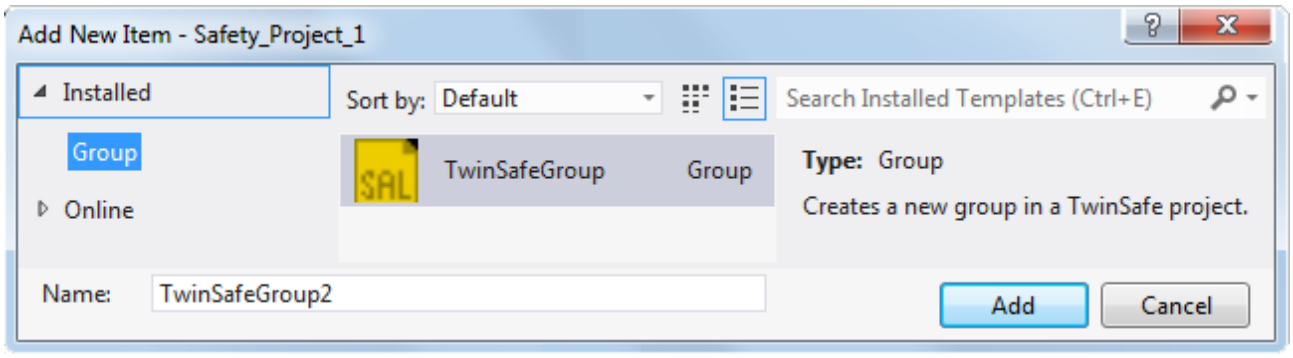


Fig. 61: Creating a TwinSAFE group

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

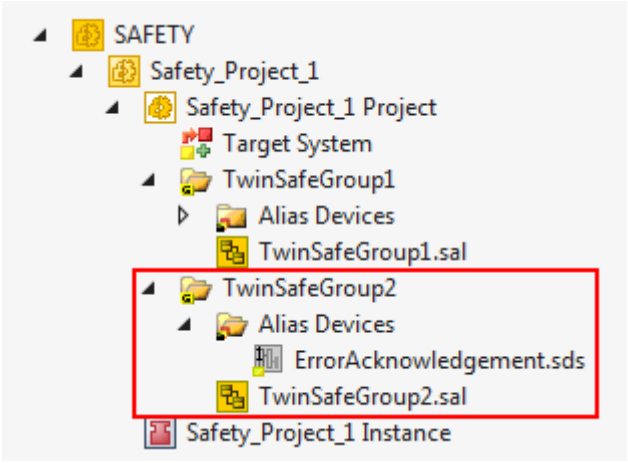


Fig. 62: Components of the TwinSAFE group

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.FBEstop1.EStopIn3

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

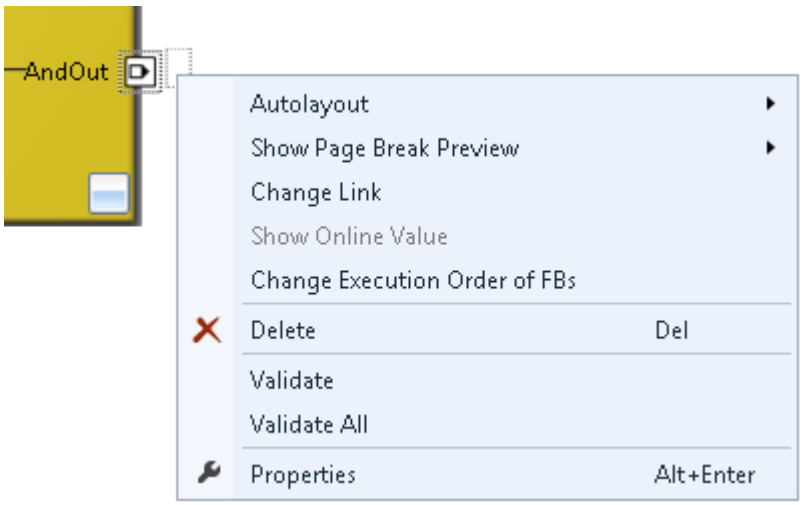


Fig. 63: Change Link

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

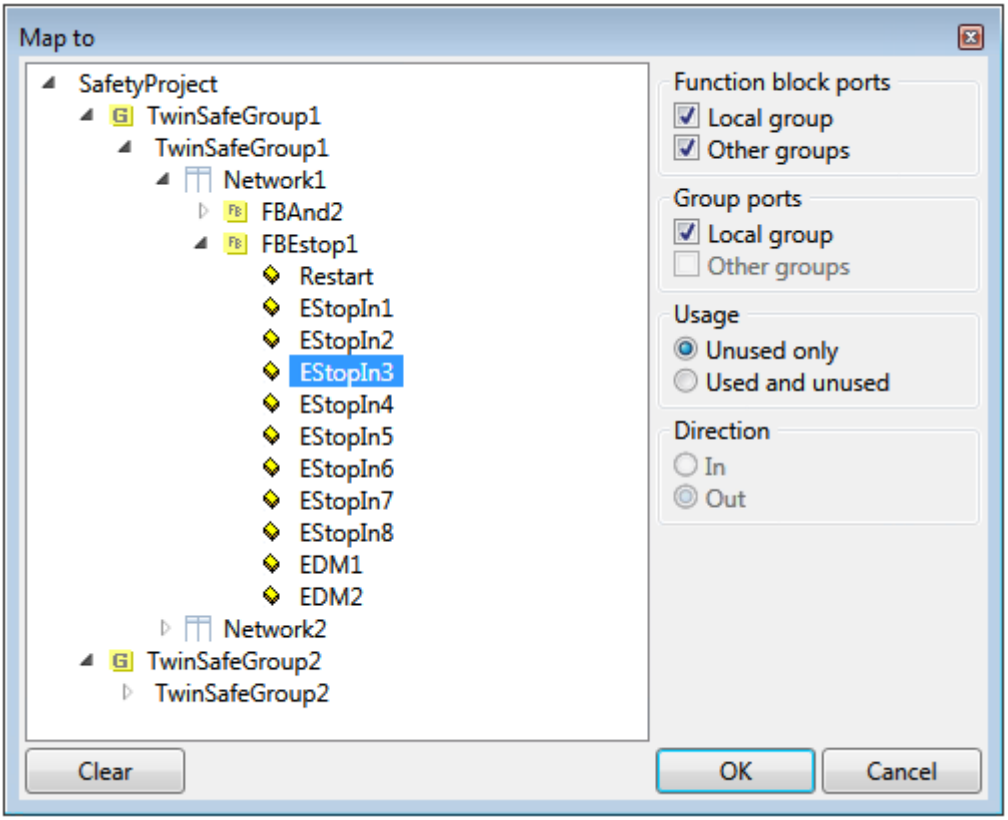


Fig. 64: Dialog for selecting a suitable FB port

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

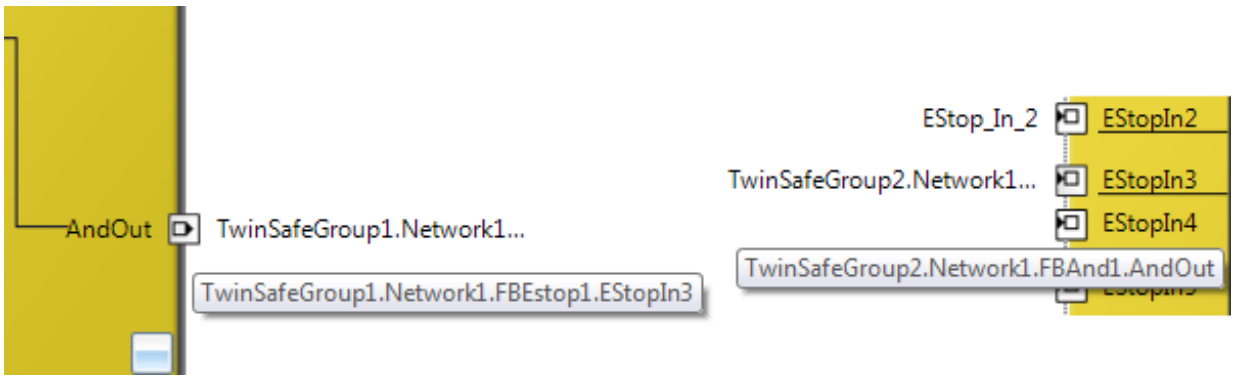


Fig. 65: Link display

4.3.3.12 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.

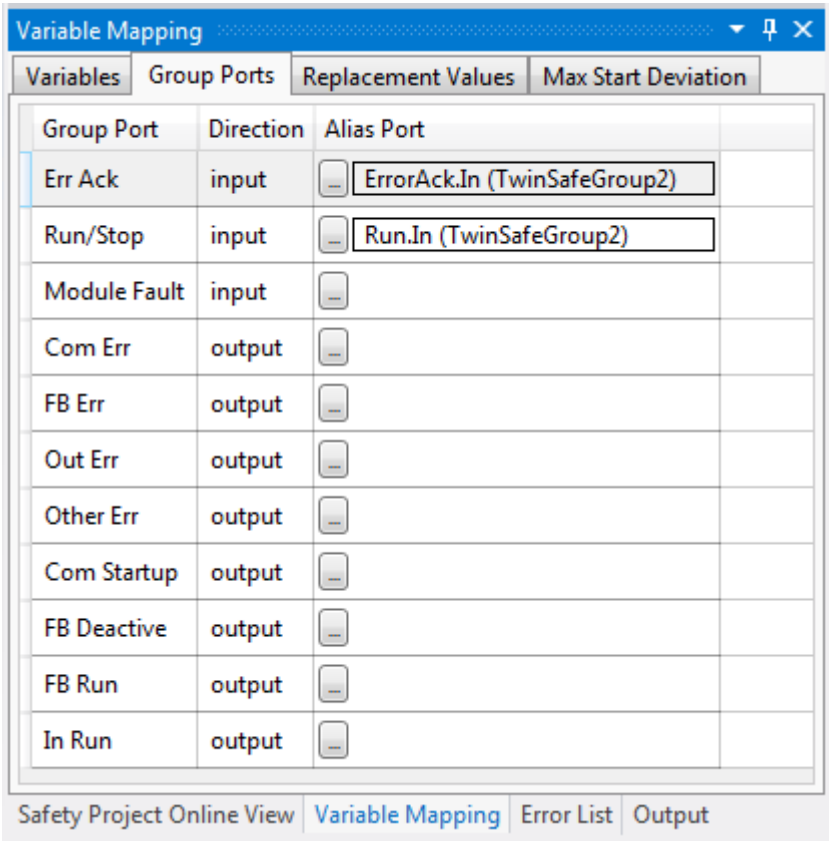


Fig. 66: The Variable Mapping dialog

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
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 [▶ 97])
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).

4.3.3.13 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.

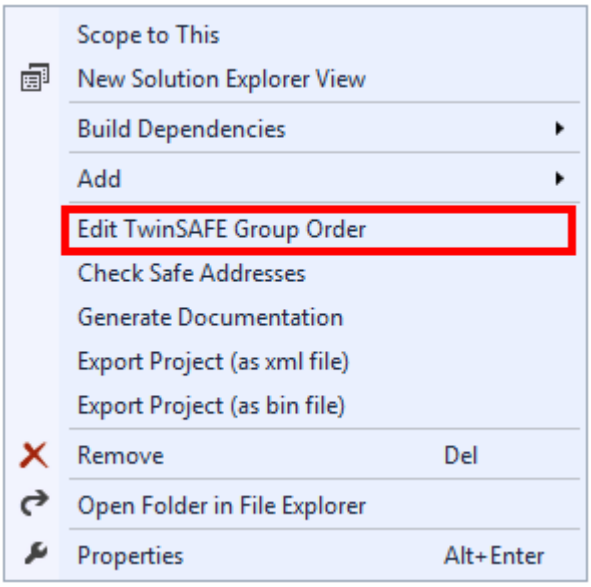


Fig. 67: Context menu Edit TwinSAFE Group Order

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*.

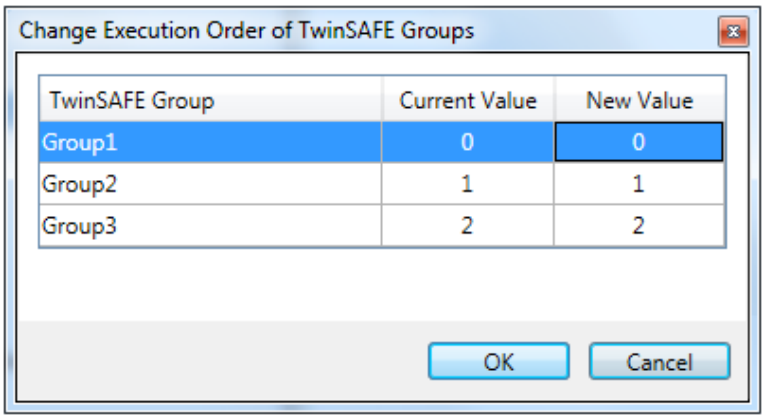


Fig. 68: Dialog Change Execution Order of TwinSAFE Groups

4.3.3.14 Command line

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

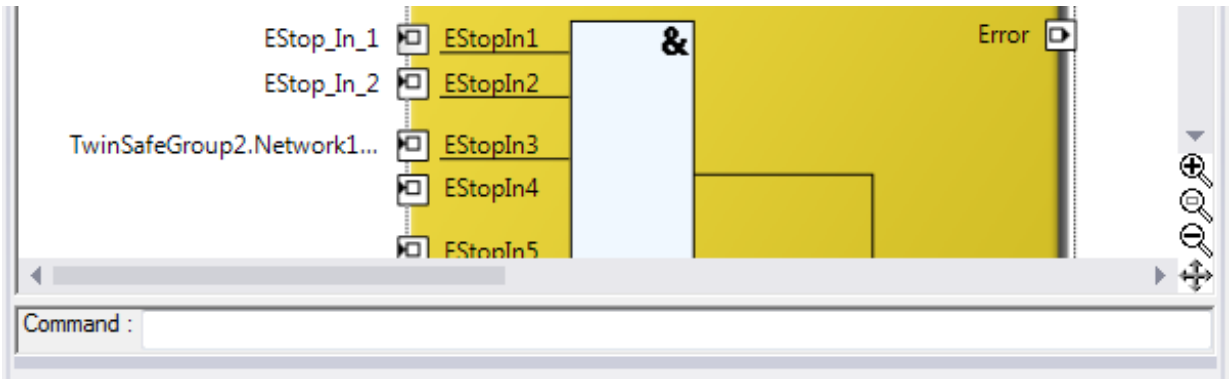


Fig. 69: The command line below the SAL worksheet

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;

4.3.3.15 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.

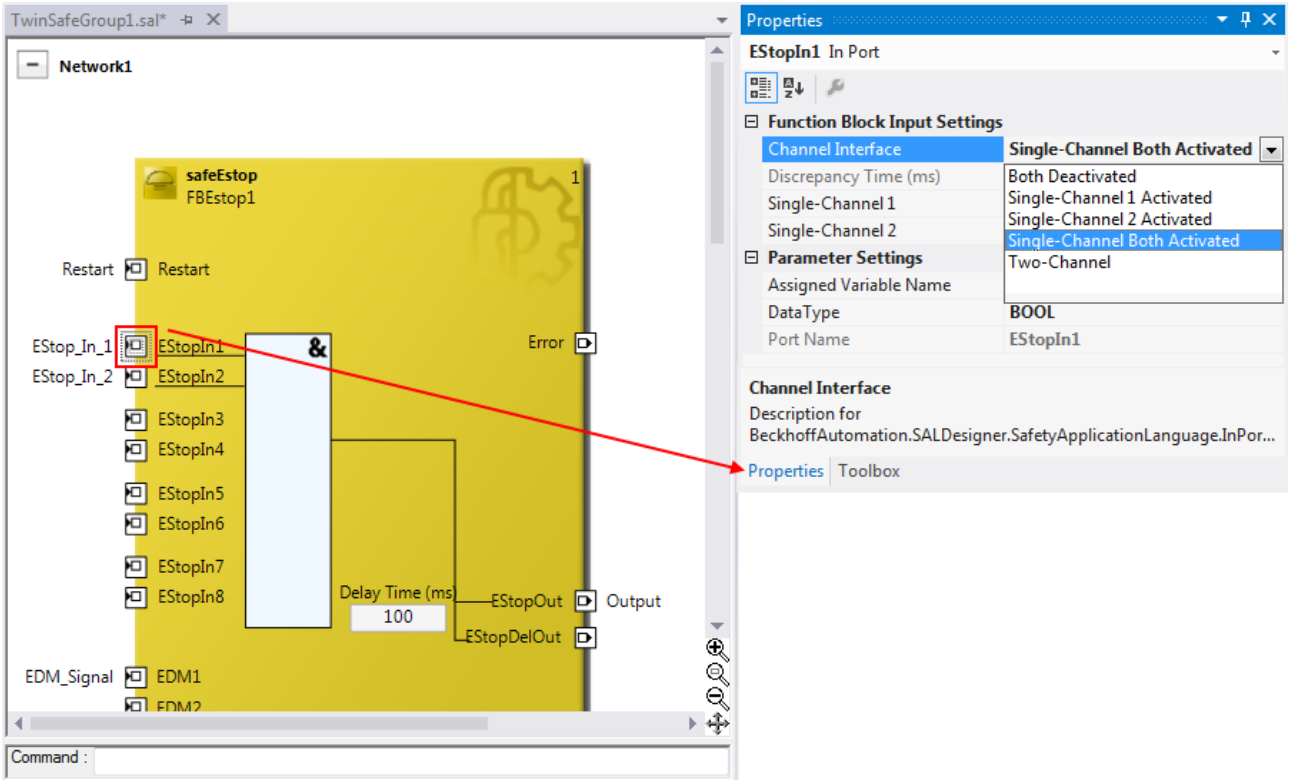


Fig. 70: FB port properties

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 *Discrepancy Time (ms)*

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.

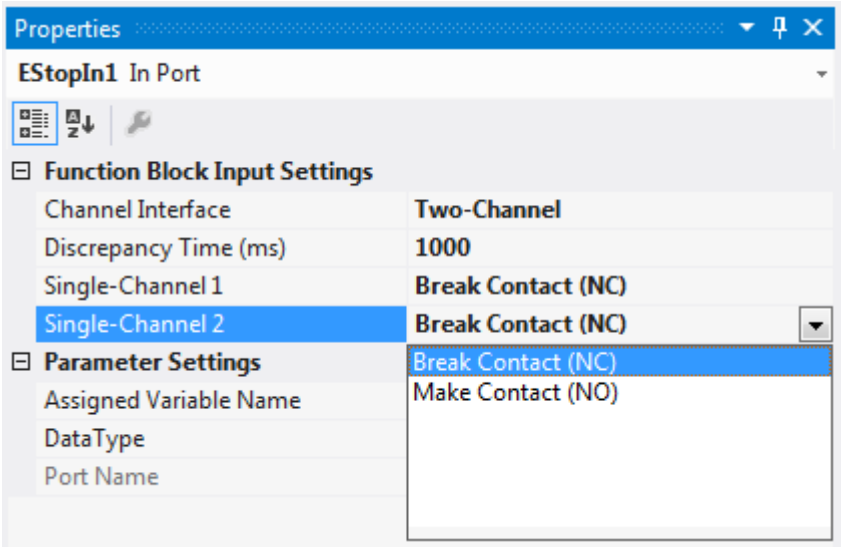


Fig. 71: Make Contact (NO) / Break Contact (NC) setting

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

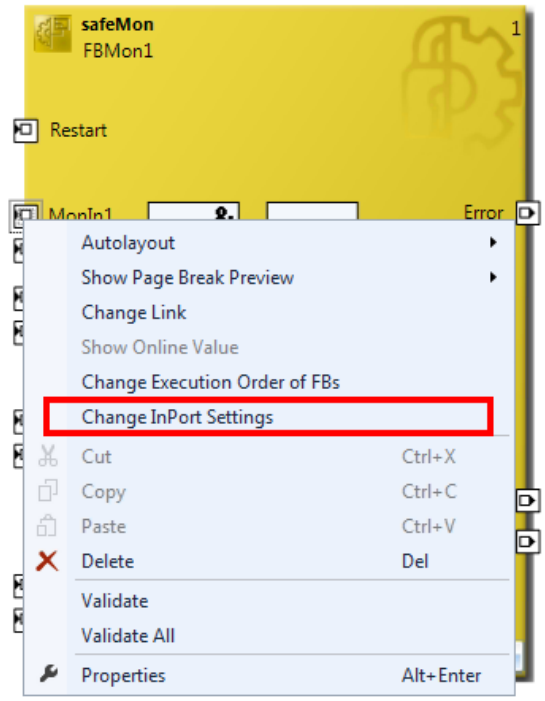


Fig. 72: Menu Change Inport Settings

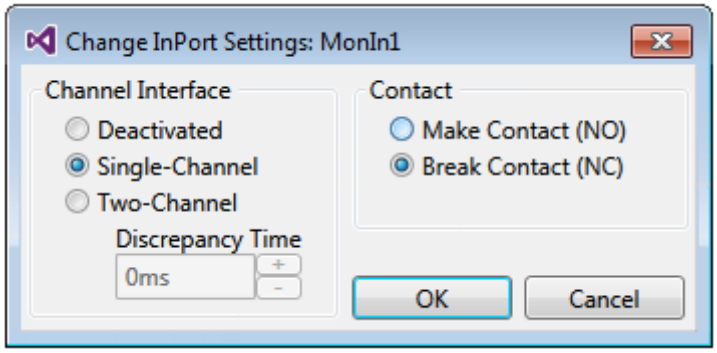


Fig. 73: Dialog Change InPort Settings

4.3.3.16 Variable Mapping

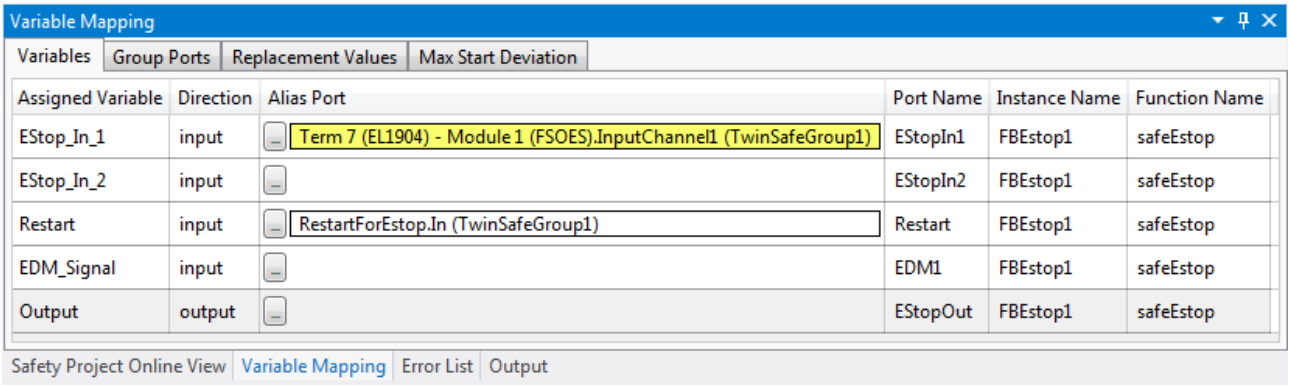


Fig. 74: Variable Mapping

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.

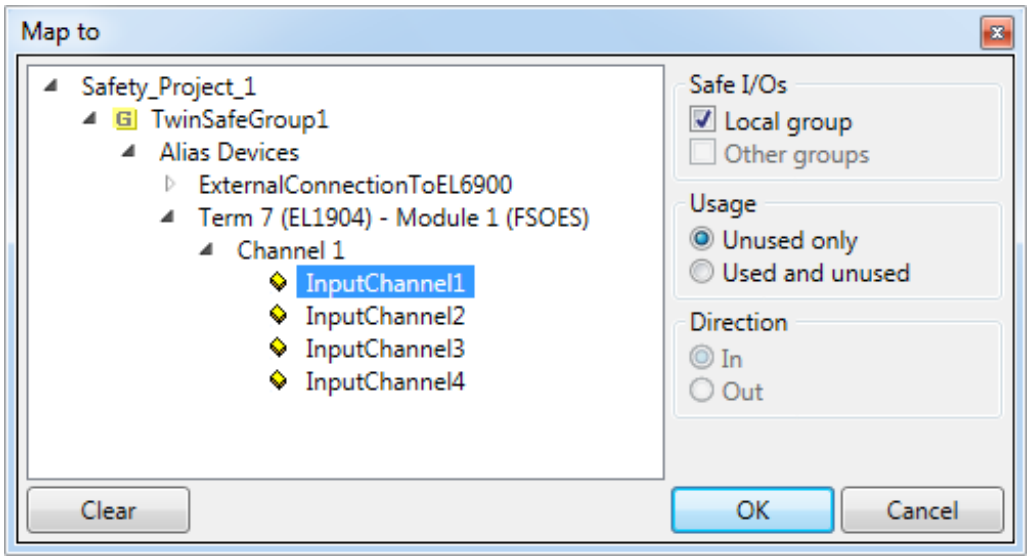


Fig. 75: Selection dialog for the alias port

4.3.3.17 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.

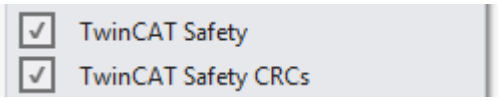


Fig. 76: Activation of the TwinCAT Safety and TwinCAT Safety CRC toolbars

Fig. 77: 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
	CRC Toolbar	Left-click on the toolbar to initiate an update of the CRCs by the user. Red icon: CRCs are different
	CRC Toolbar	Green icon: All CRCs are identical
	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  .
	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  .
	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,  is displayed as CRC.

4.3.3.18 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.

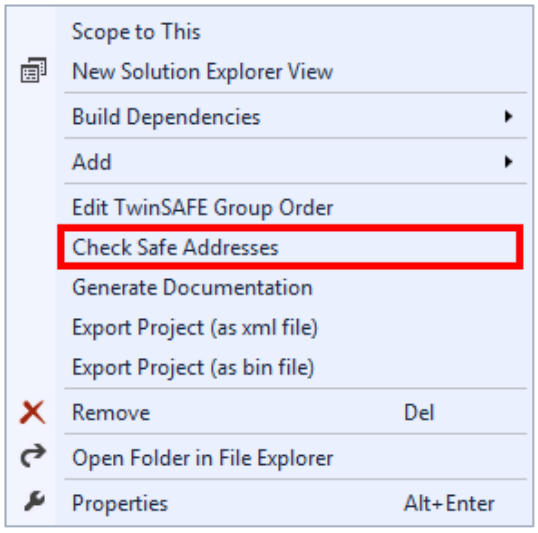


Fig. 78: Check Safe Addresses context menu

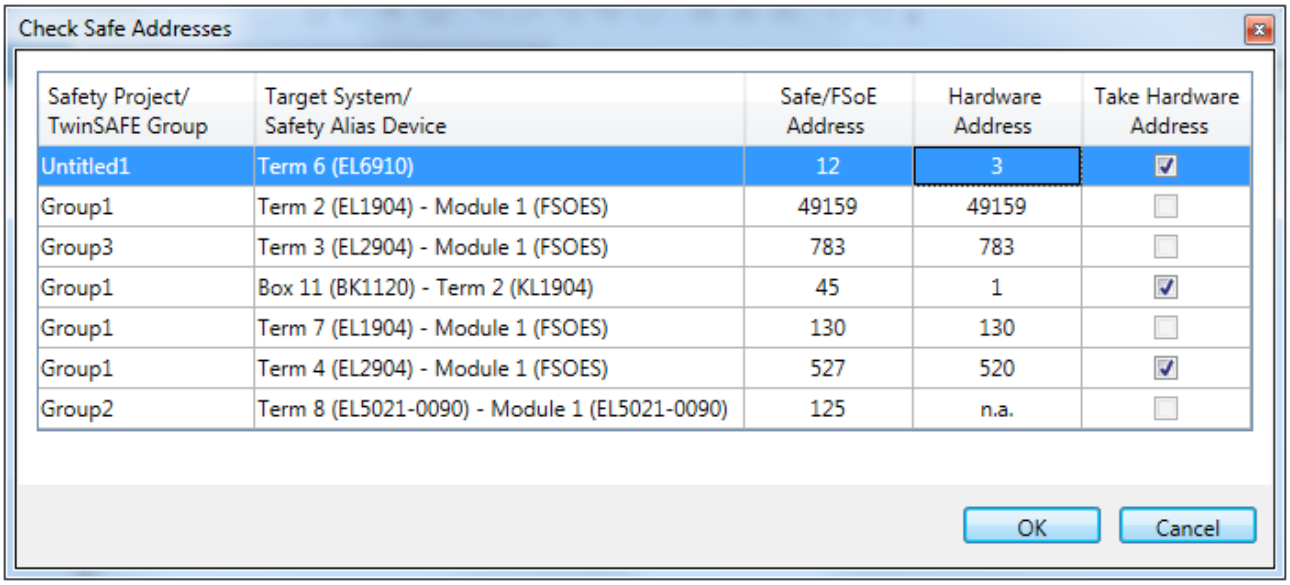


Fig. 79: Check Safe Addresses dialog

4.3.4 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!

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*.

NOTE

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.

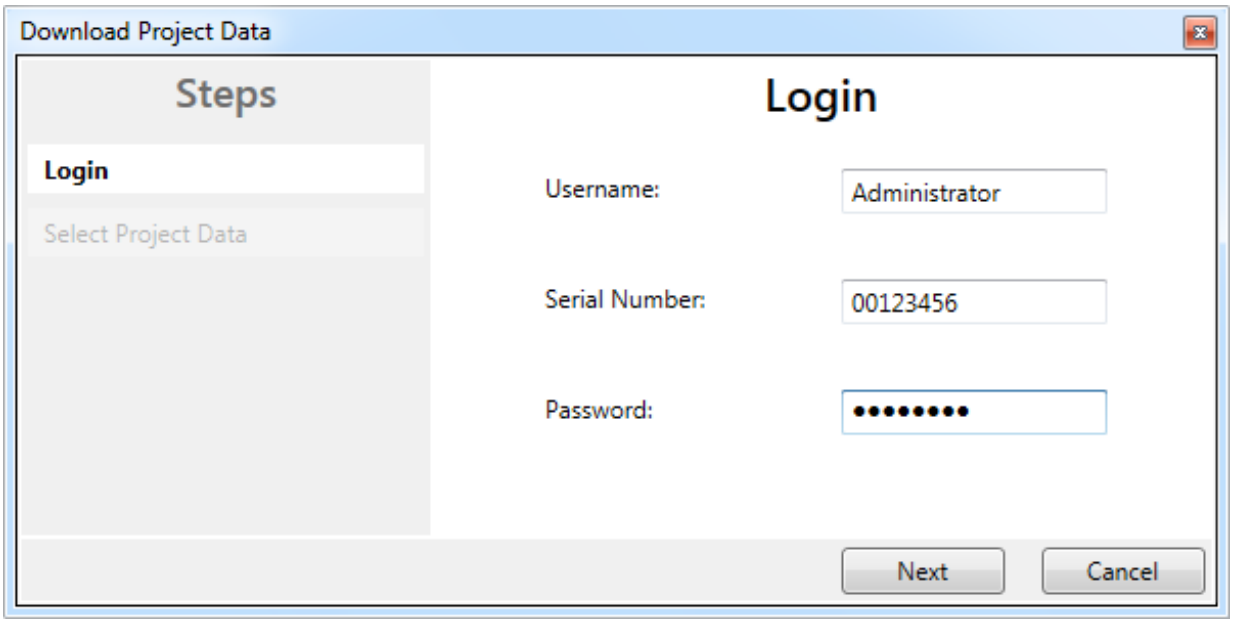


Fig. 80: Download Project Data – The Login dialog

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.

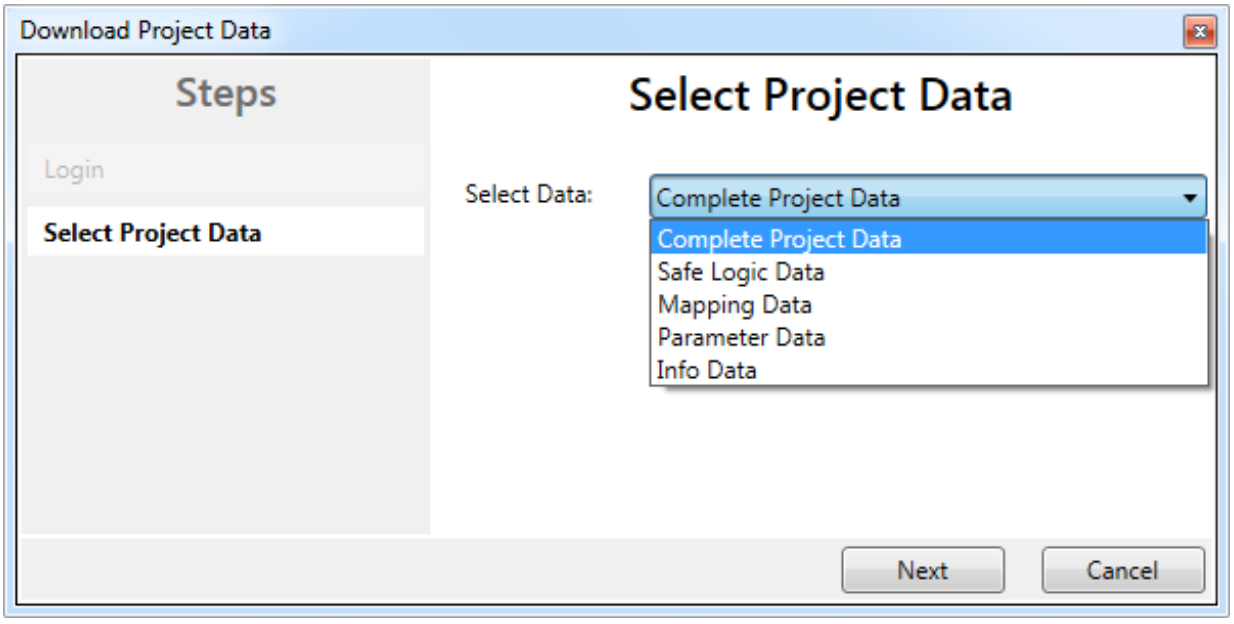


Fig. 81: Download Project Data – The Select Project Data dialog

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.

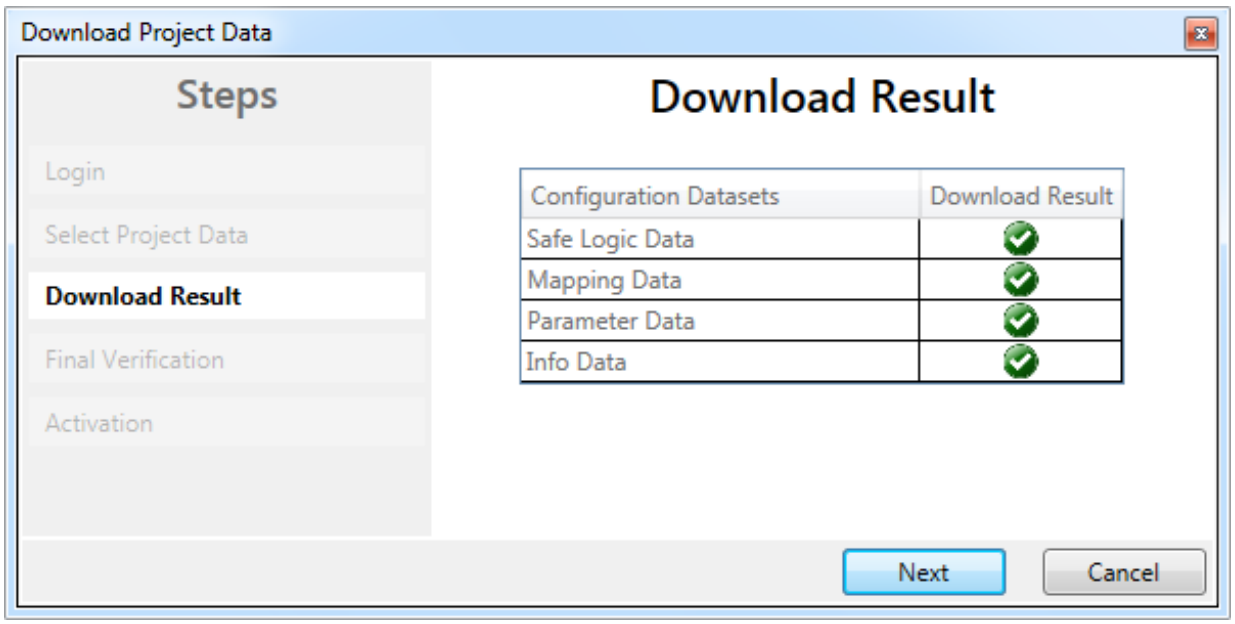


Fig. 82: Download Project Data – The Download Result dialog

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

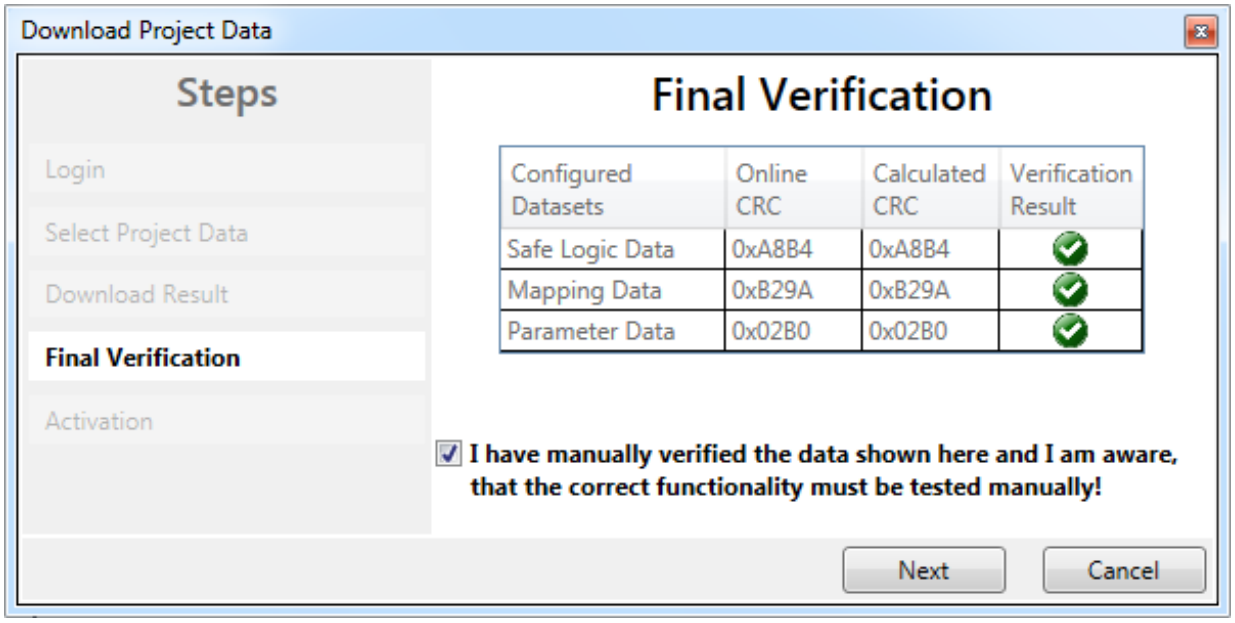


Fig. 83: Download Project Data – The Final Verification dialog

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.

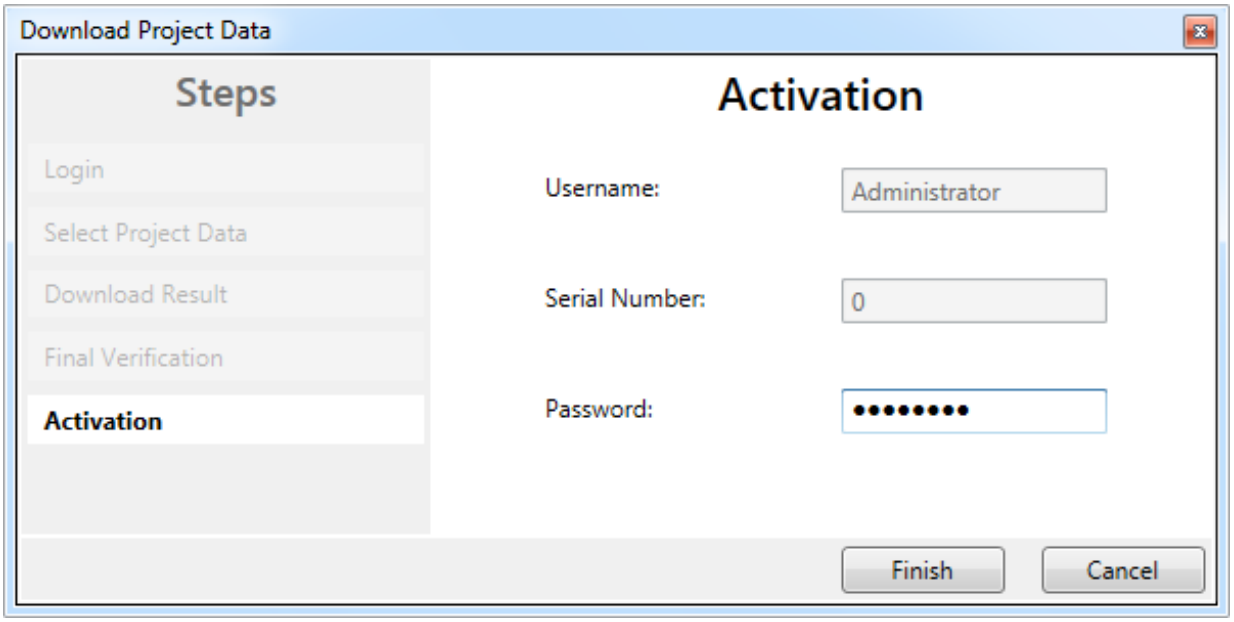


Fig. 84: Download Project Data – The Activation dialog

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

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.

4.4 Info data

4.4.1 Info data for the connection

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

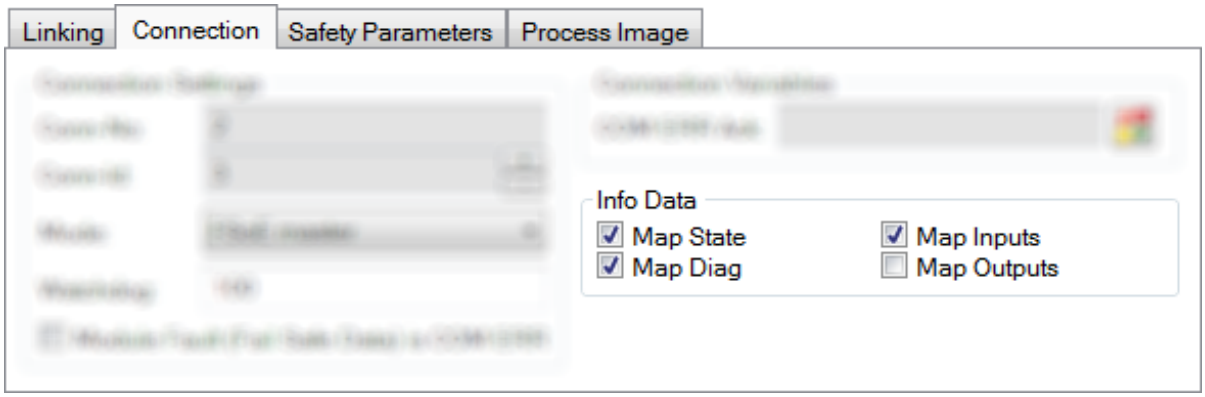


Fig. 85: Enabling the info data for connections

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.

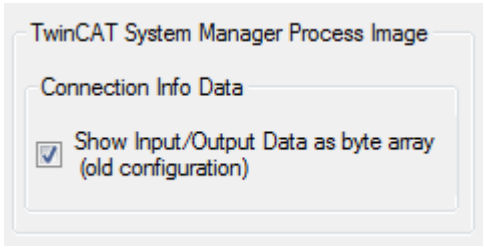


Fig. 86: Checkbox for the connection info data

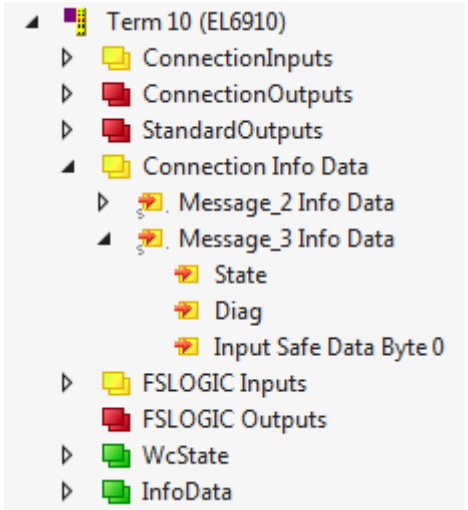


Fig. 87: Info data for the connection in the I/O tree structure as byte array

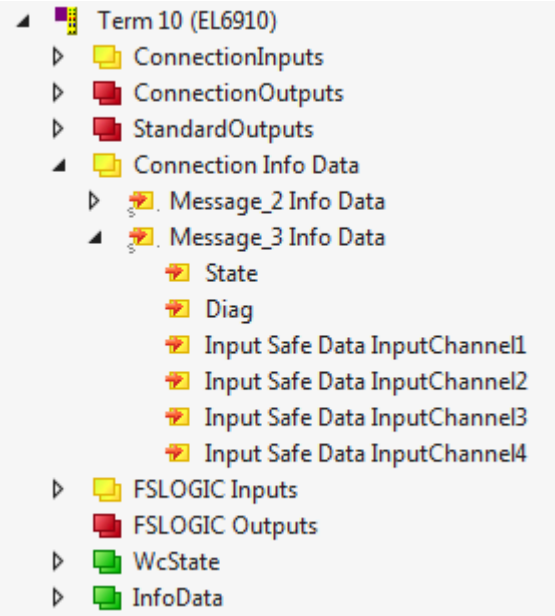


Fig. 88: Info data for the connection in the I/O tree structure as individual data

4.4.2 Info data for function blocks

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

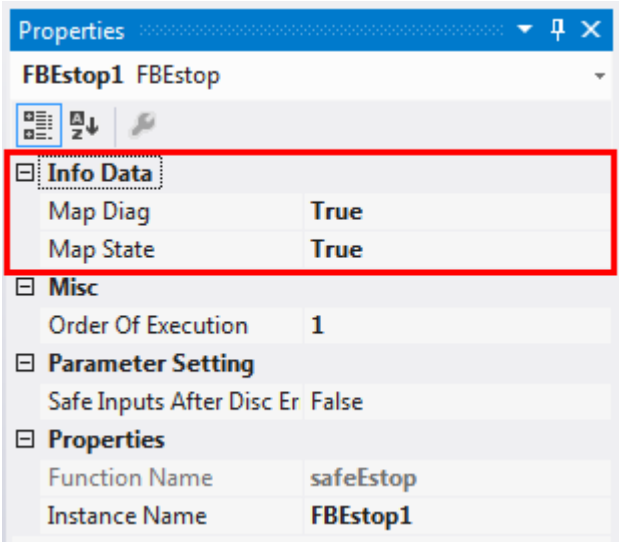


Fig. 89: Enabling the info data for function blocks

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*.

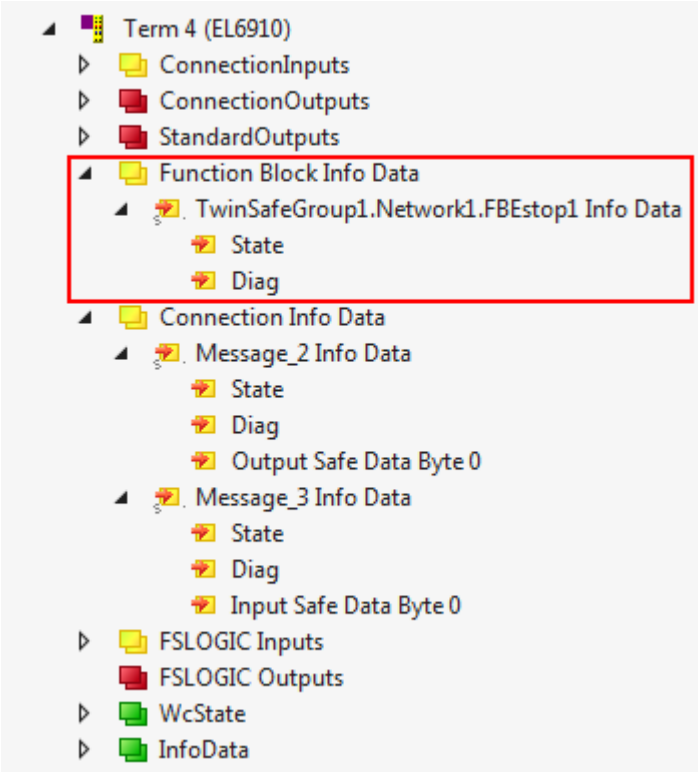


Fig. 90: Info data for the function block in the I/O tree structure

4.4.3 Info data for the TwinSAFE group

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

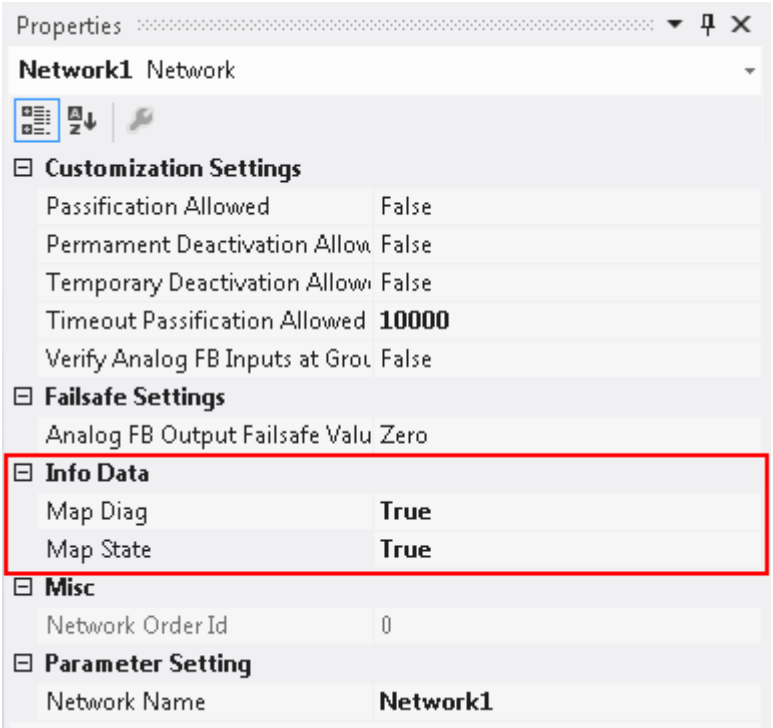


Fig. 91: Enabling the info data in the properties of the TwinSAFE group

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*.

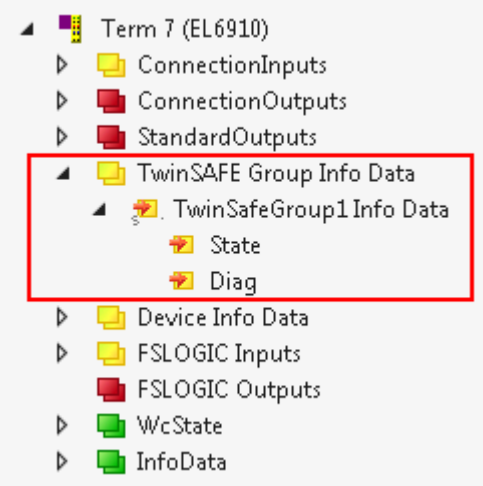


Fig. 92: Info data for the TwinSAFE group in the tree structure

4.4.4 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.

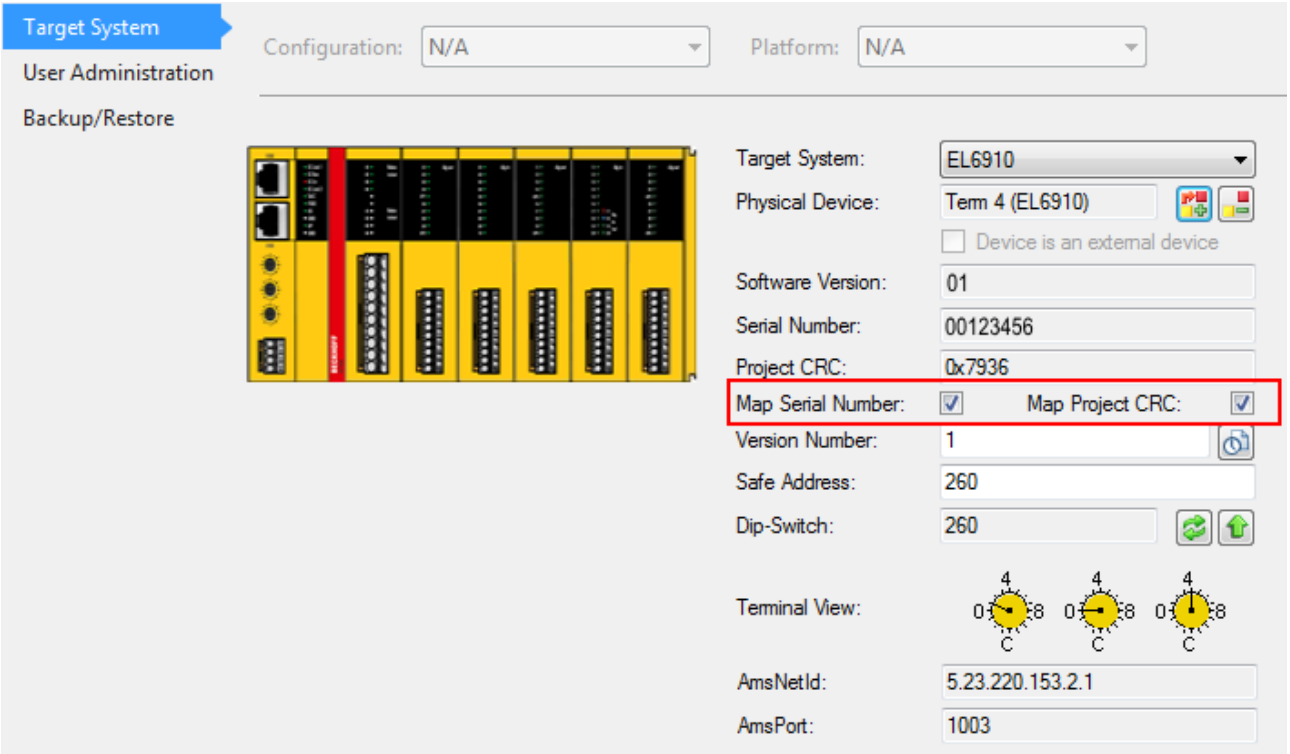


Fig. 93: Activation of the info data for the EK1960

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.

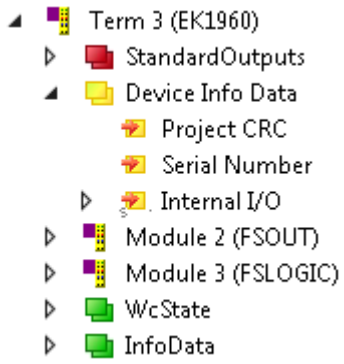


Fig. 94: Info data in the EK1960 tree structure

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*.

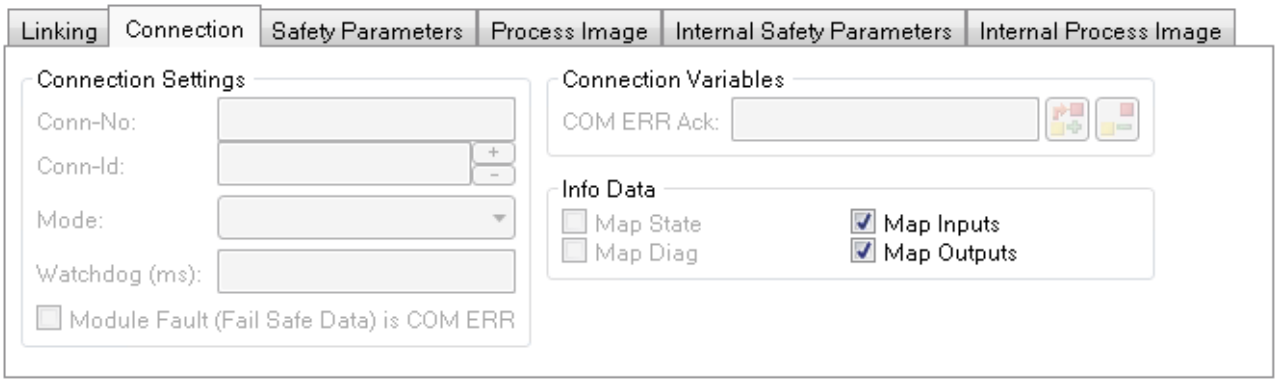


Fig. 95: Activating the info data for the local EK1960 connection

4.5 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.

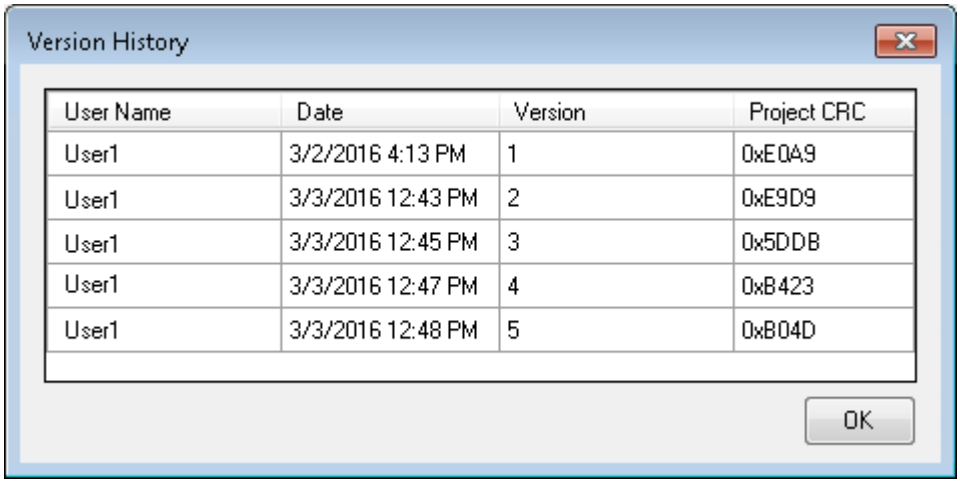


Fig. 96: Version History

4.6 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.

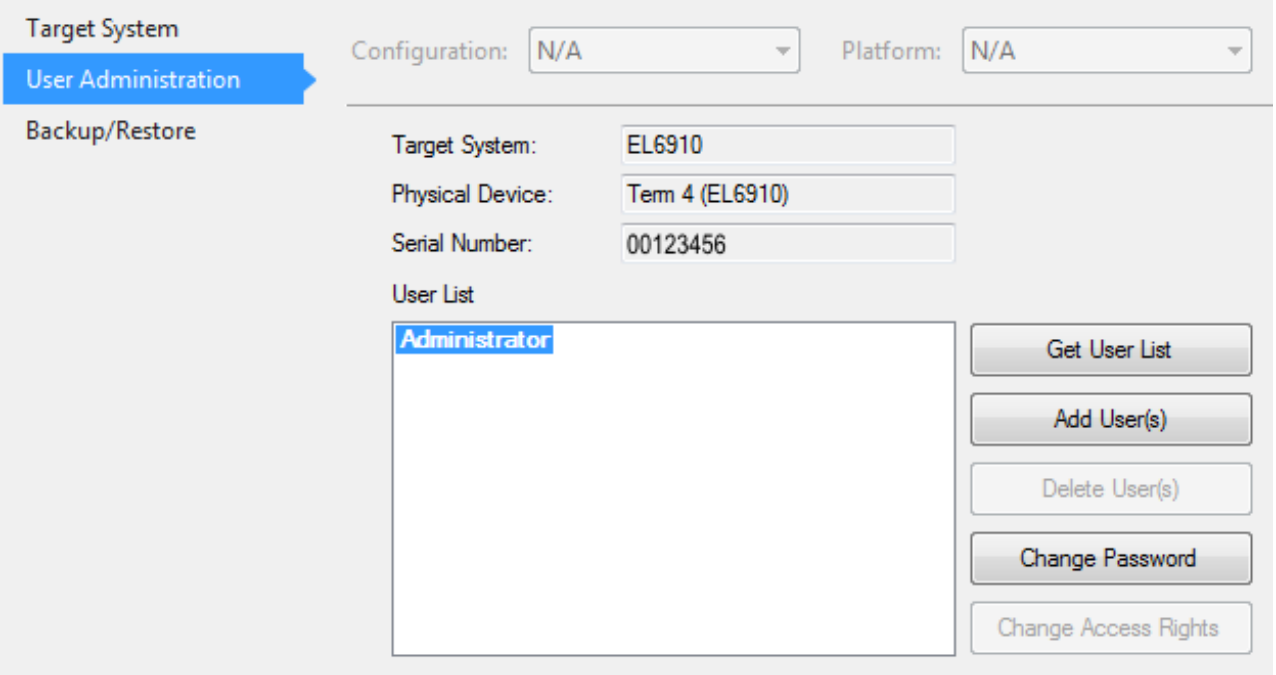


Fig. 97: User Administration

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

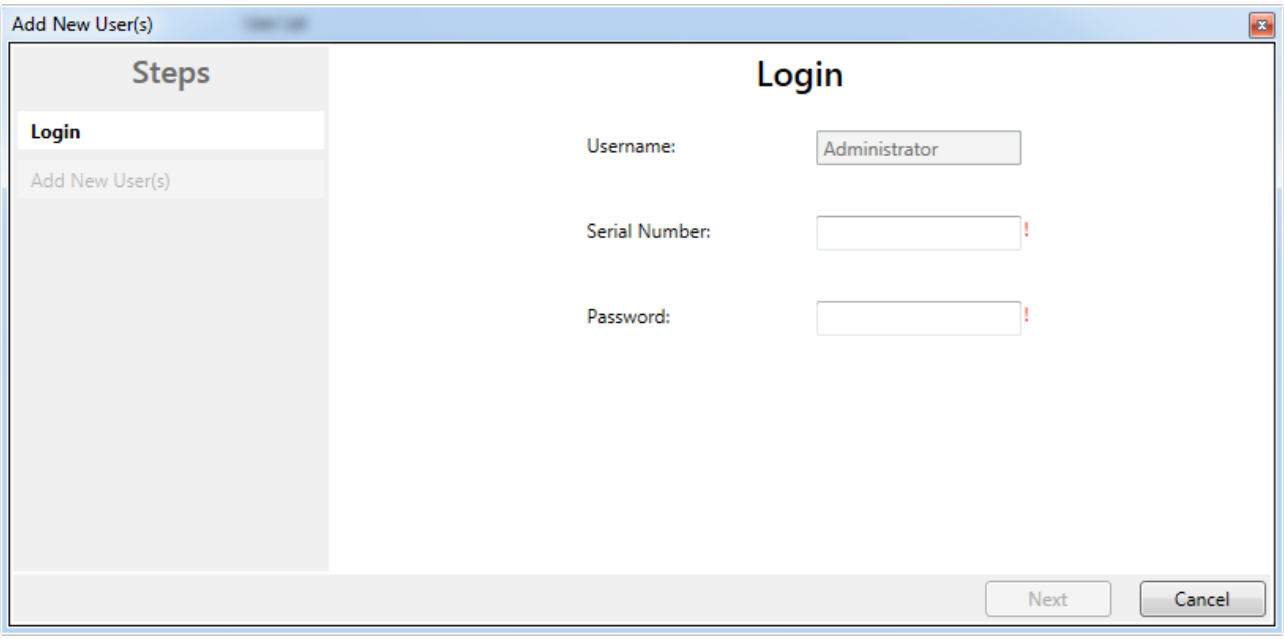


Fig. 98: User Administration - Login

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

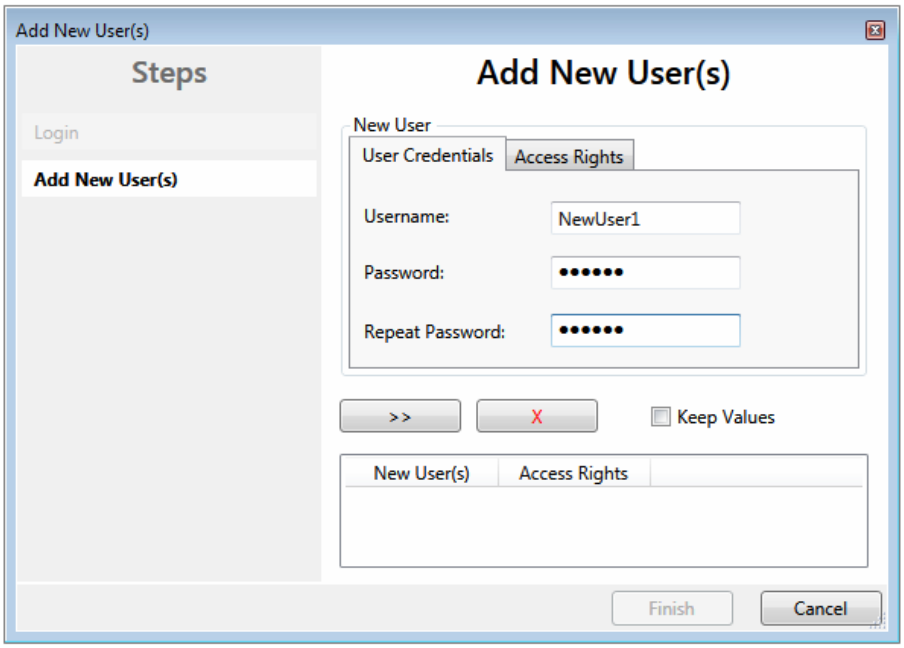


Fig. 99: User Administration - Add New User(s) - User Credentials

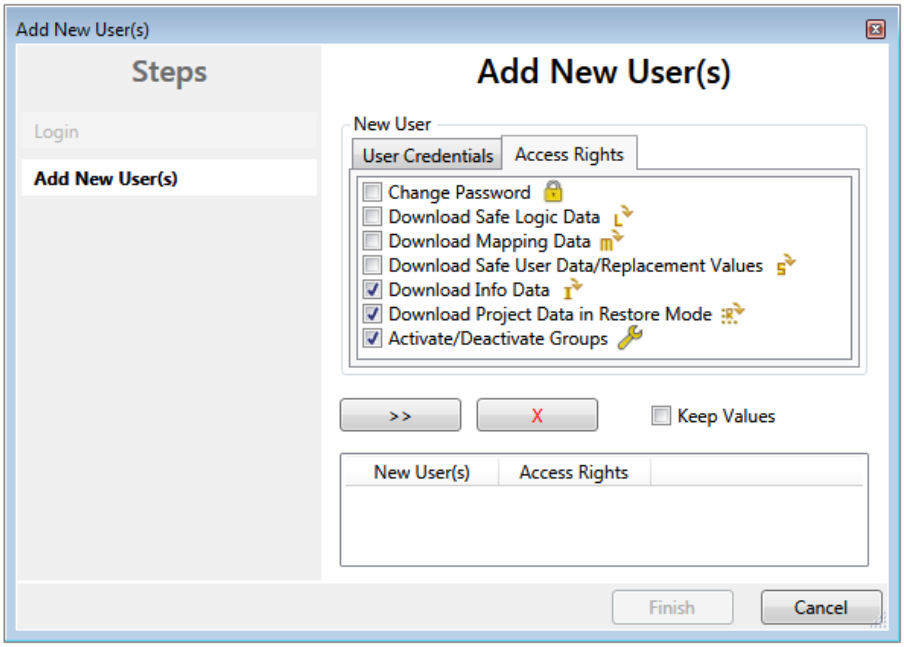
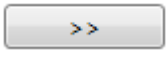


Fig. 100: User Administration - Add New User(s) - Access Rights

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.

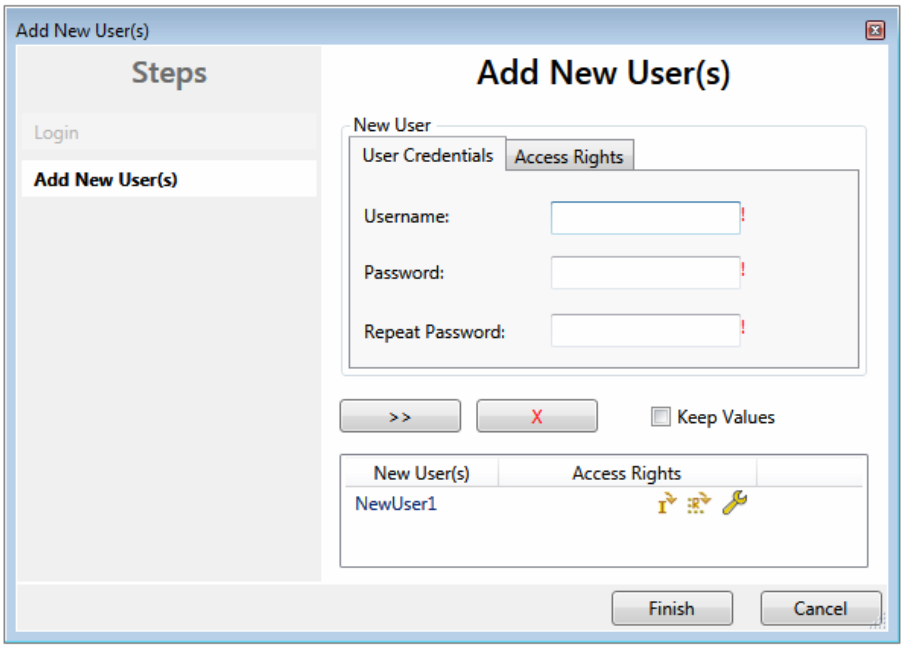


Fig. 101: User Administration - New User added

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.

4.7 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.

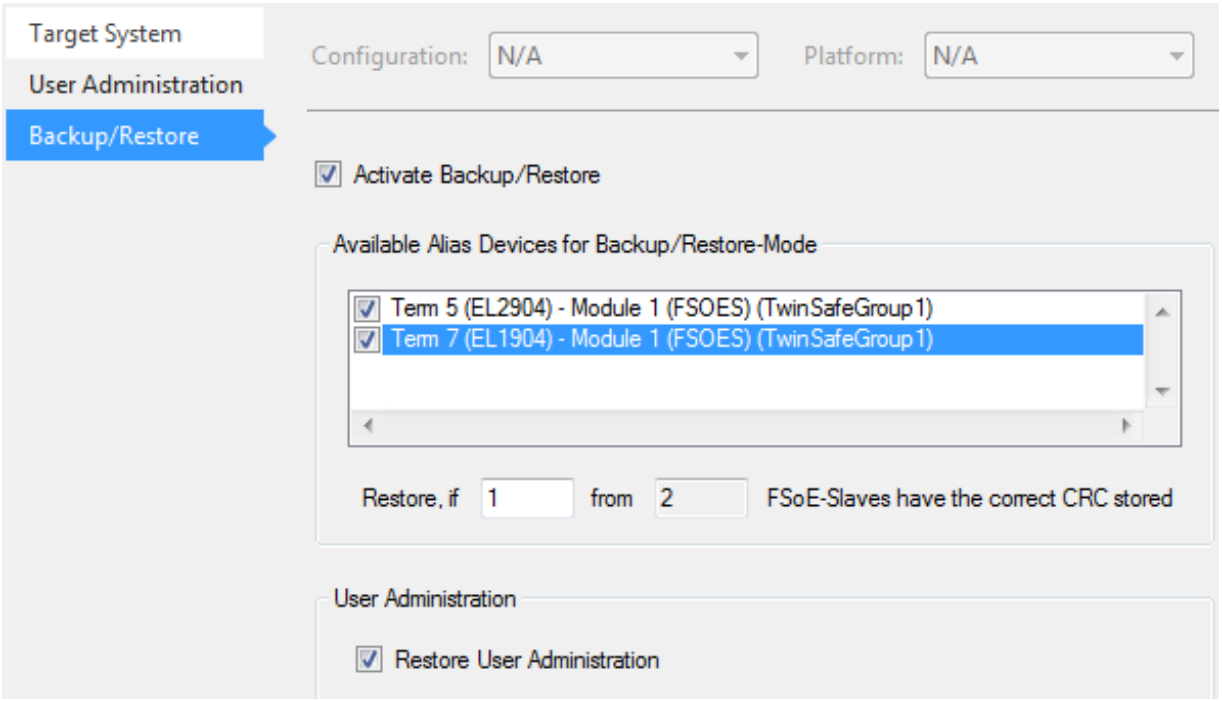


Fig. 102: Backup/Restore

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 sample. 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. Detailed information about the *Backup/Restore* mechanism is available from Beckhoff Support.

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.

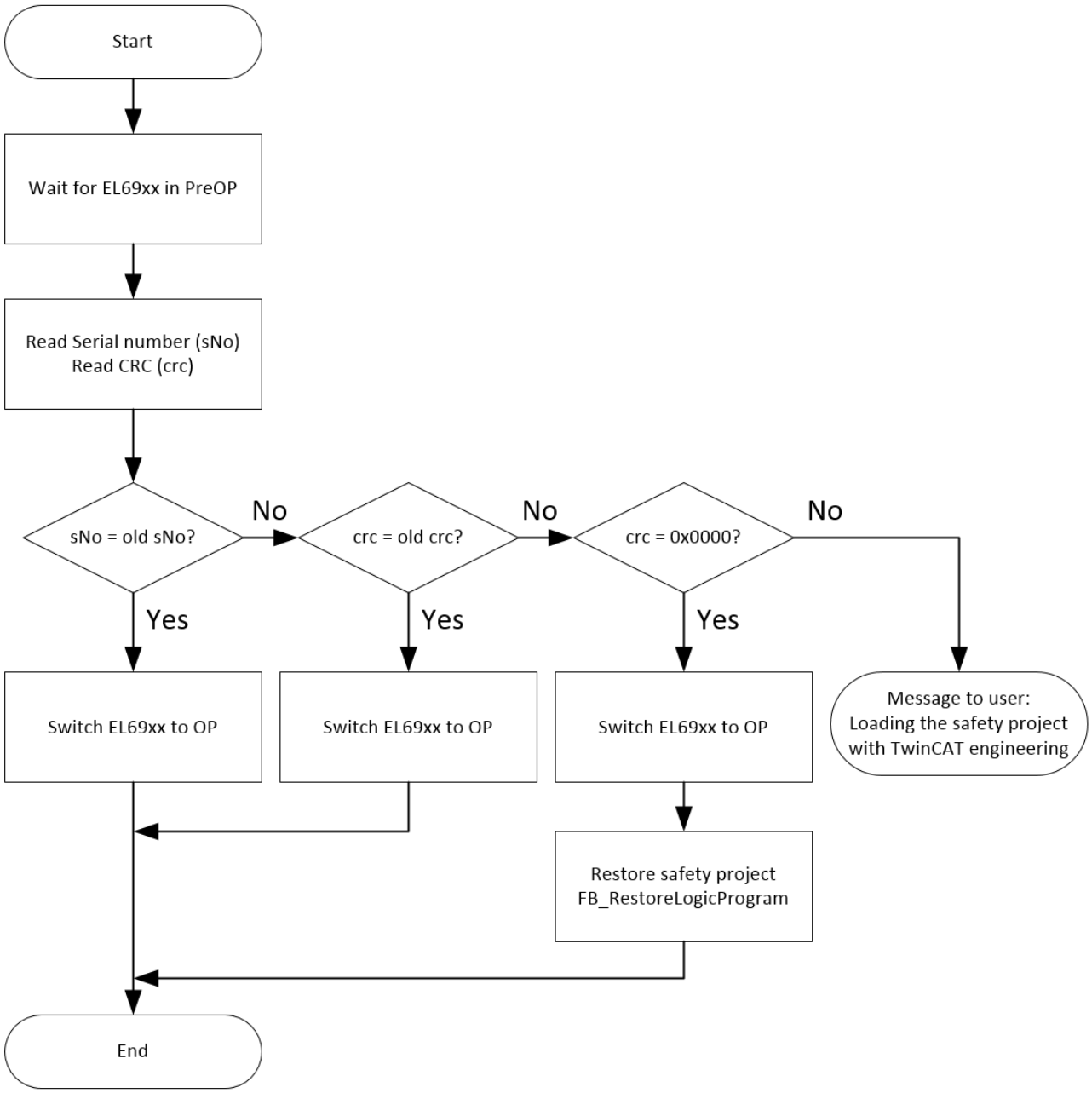


Fig. 103: Restore check sequence chart

Function blocks for backup/restore

The PLC function blocks with which a backup and restore to a TwinSAFE logic component (currently EL6910, EJ6910 or EK1960) can be carried out are available through Beckhoff Support. This is a compiled library that can be installed in the TwinCAT Library Repository.

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

FB_SAVELOGICPROGRAM

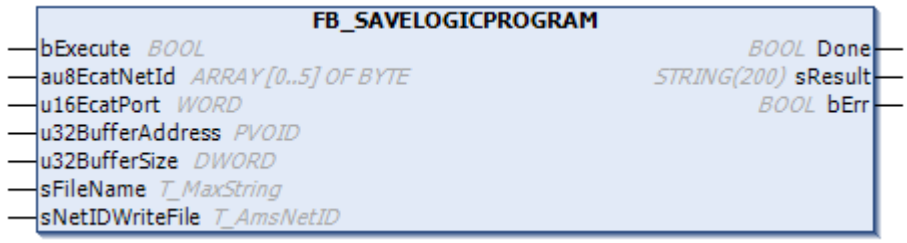


Fig. 104: FB_SAVELOGICPROGRAM illustration

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 occured during operation, details in sResult

Fig. 105: FB_SAVELOGICPROGRAM parameters

FB_RESTORELOGICPROGRAM

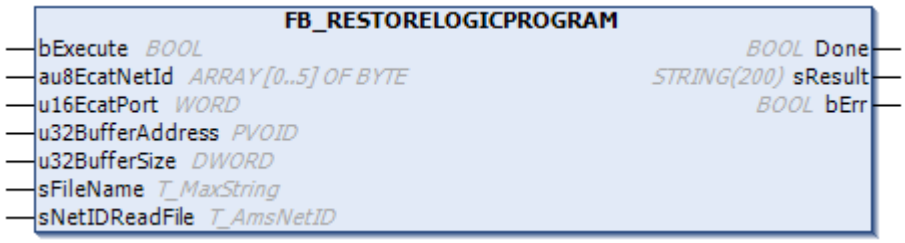


Fig. 106: FB_RESTORELOGICPROGRAM illustration

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 occured during operation, details in Result

Fig. 107: 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);
```

4.8 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.

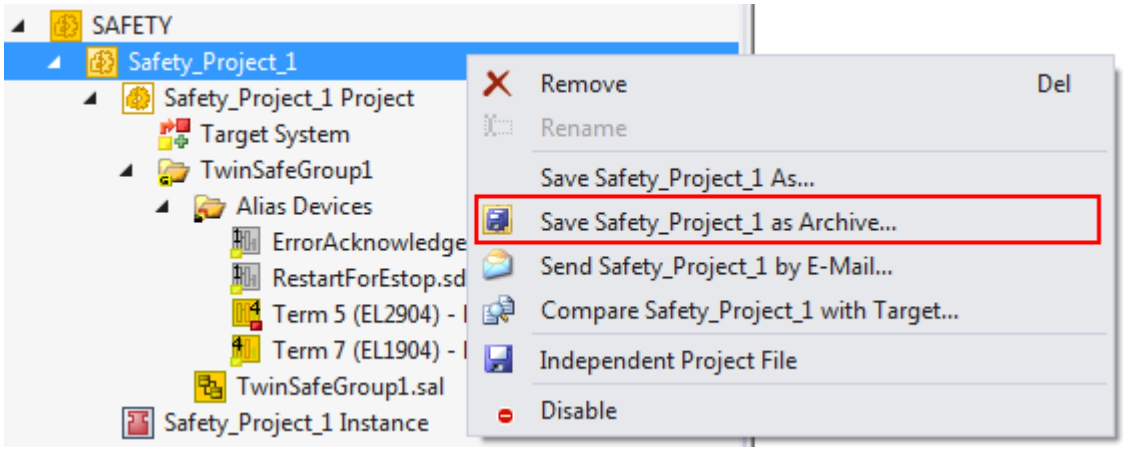


Fig. 108: Archiving the safety project

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 sample.

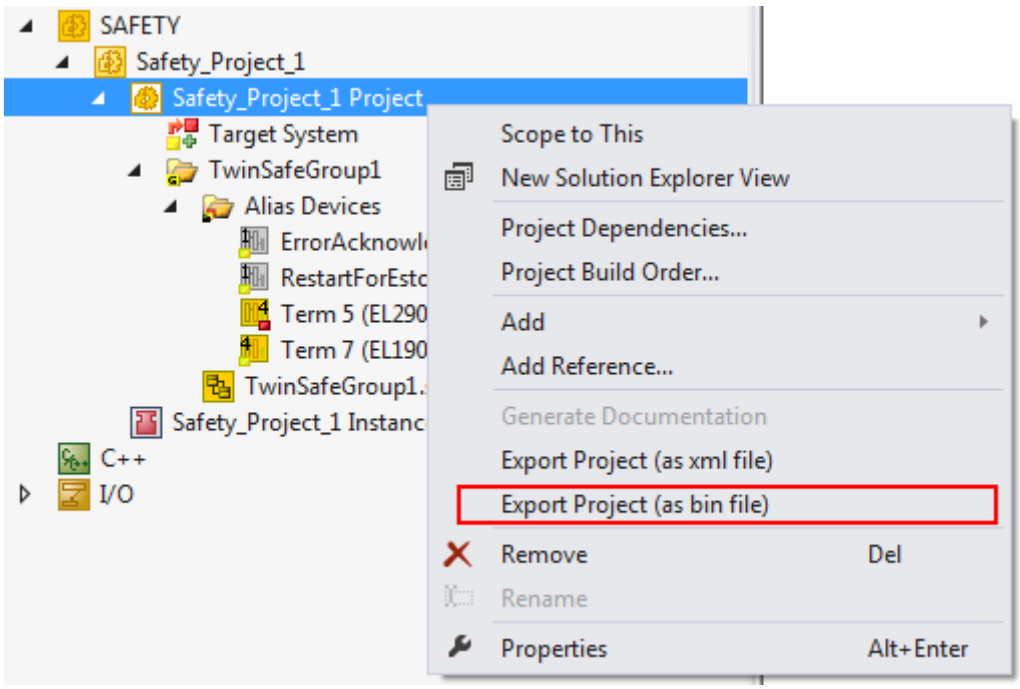


Fig. 109: Saving the safety project in a binary format (e.g. for the TwinSAFE loader)

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.

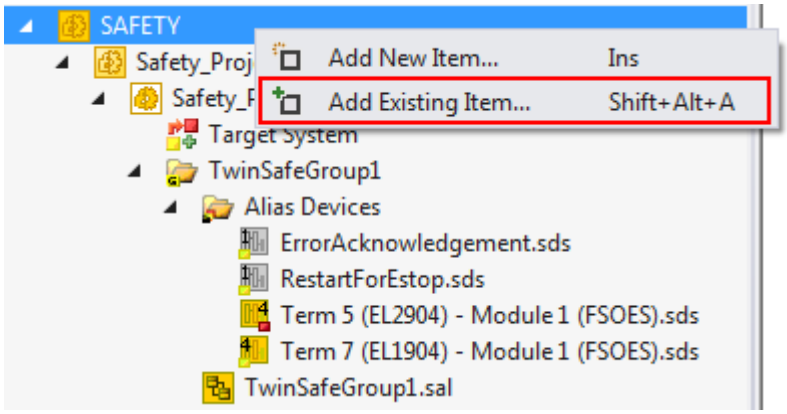


Fig. 110: Selecting the file type for importing a safety project

The following file types are supported:

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

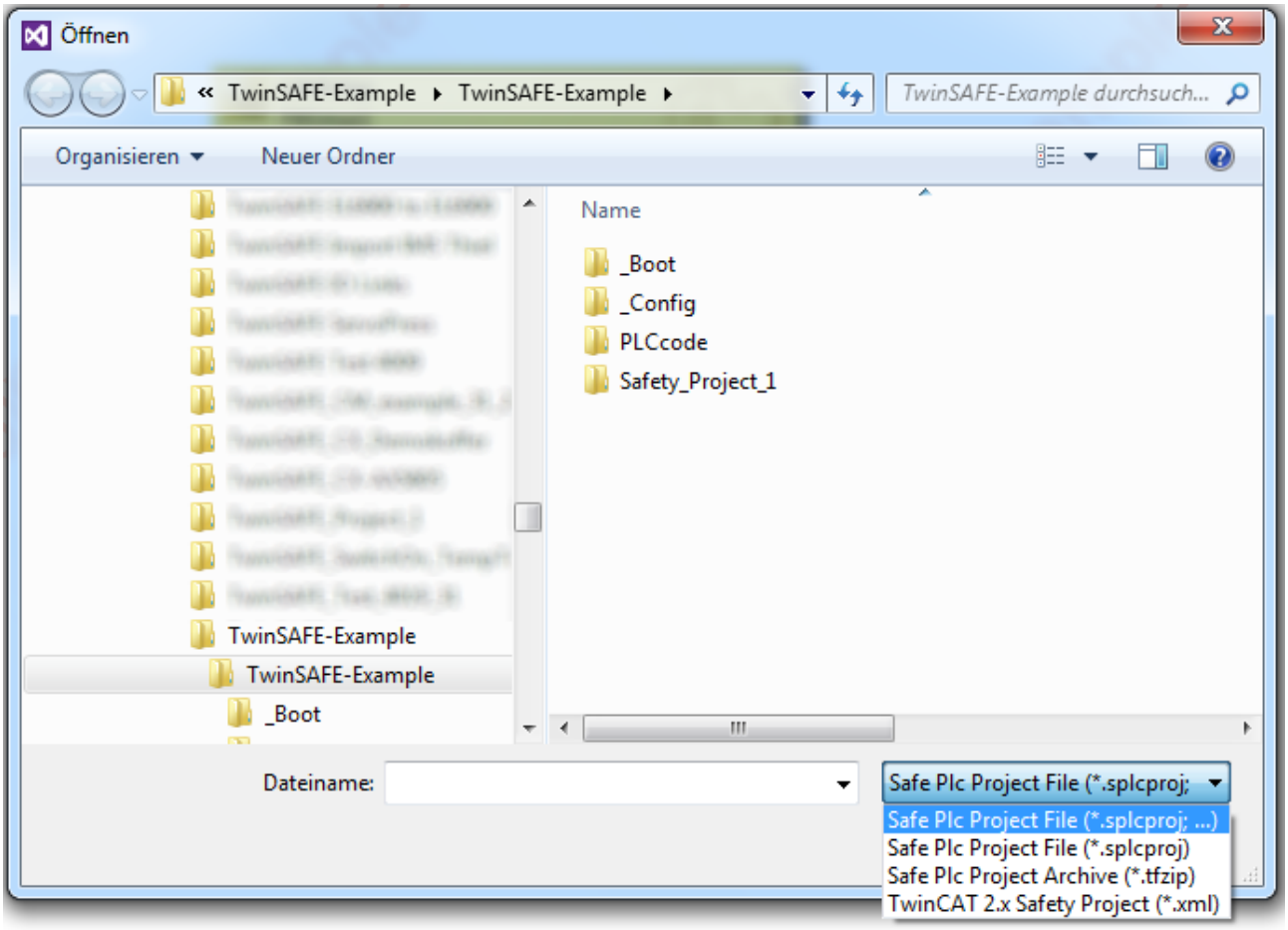


Fig. 111: Importing a safety project

4.9 Diag History tab

Any errors that occur in the EL6910, EJ6910 or EK1960 are stored in the 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.

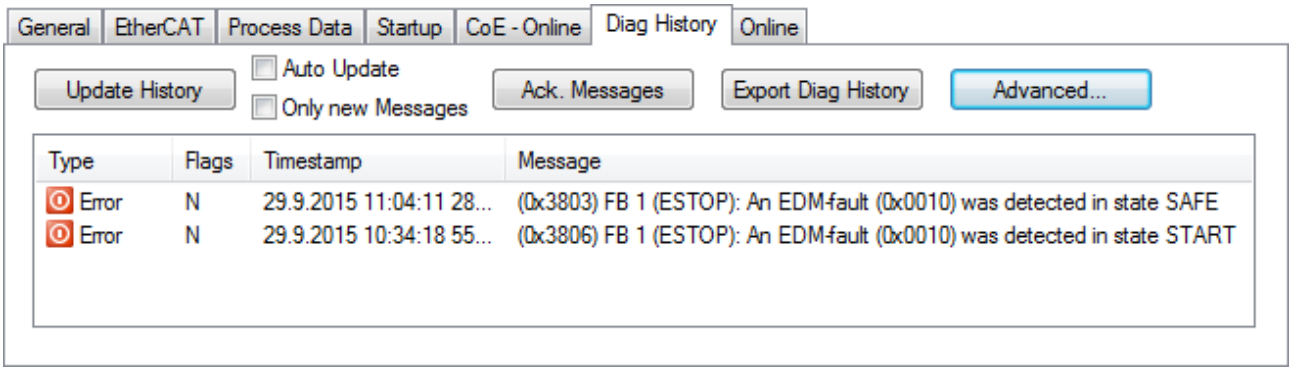


Fig. 112: Diag History

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

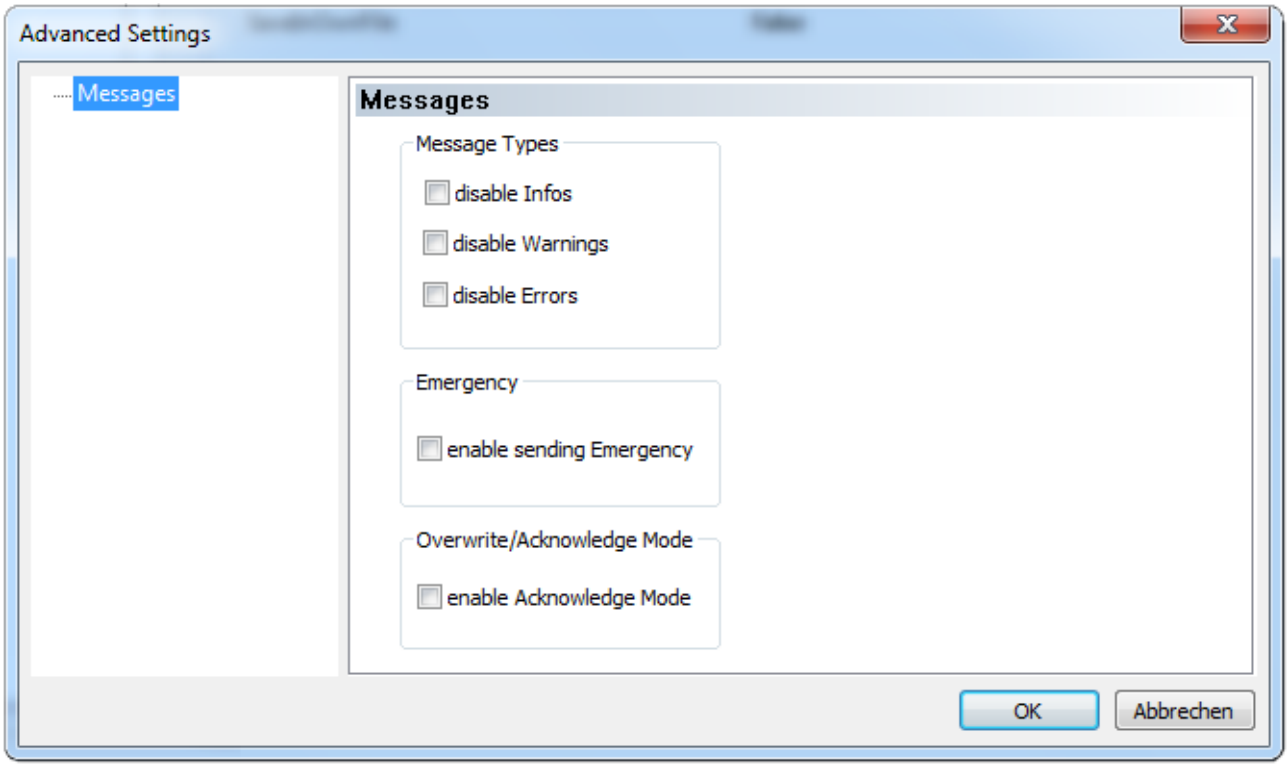


Fig. 113: Diag History - Advanced Settings

Advanced Settings

Setting	Description
Message Types	• disable Info Messages with status *Info* are not stored in the diag history • disable Warnings Messages with status *Warning* are not stored in the diag history • disable Errors Messages with status *Error* 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.

4.10 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.

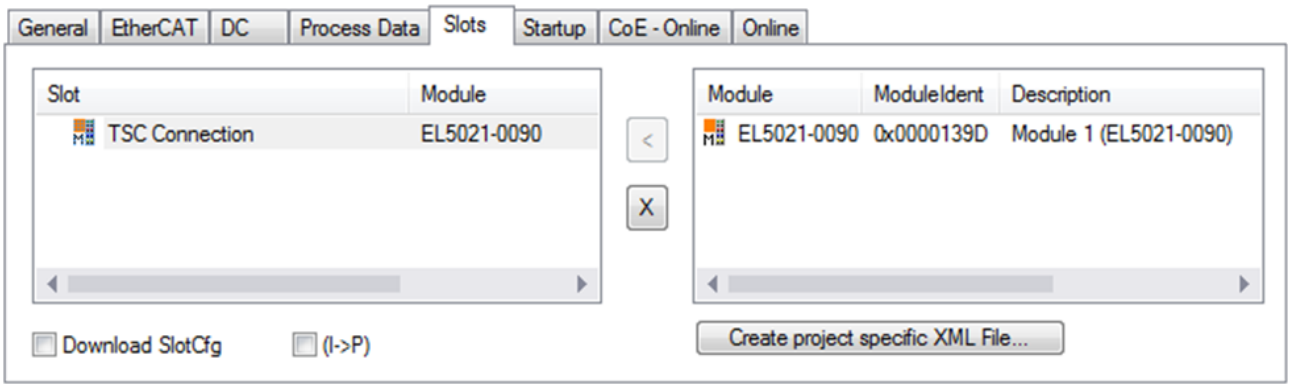


Fig. 114: Adding the TwinSAFE SC process data under the component, e.g. EL5021-0090

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

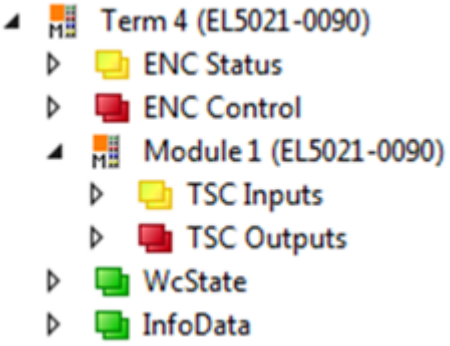


Fig. 115: TwinSAFE SC component process data, example EL5021-0090

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

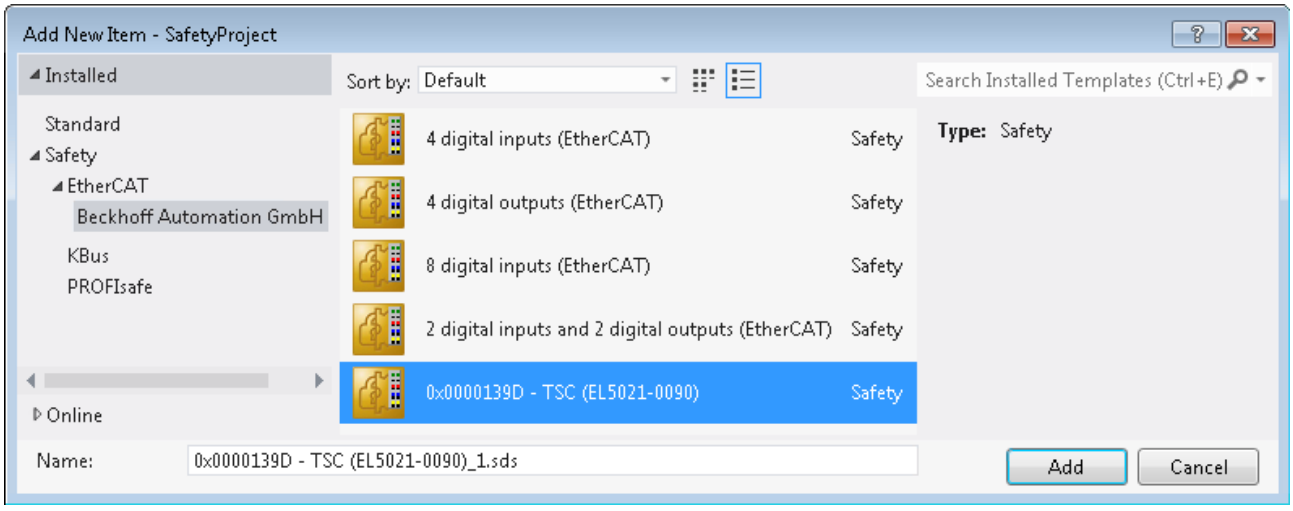


Fig. 116: Adding a TwinSAFE SC connection

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.

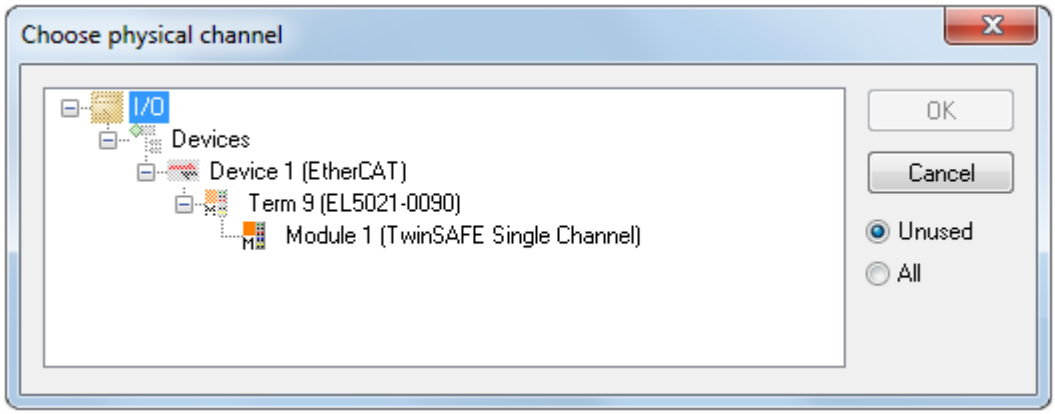


Fig. 117: Creating a link to TwinSAFE SC terminal

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

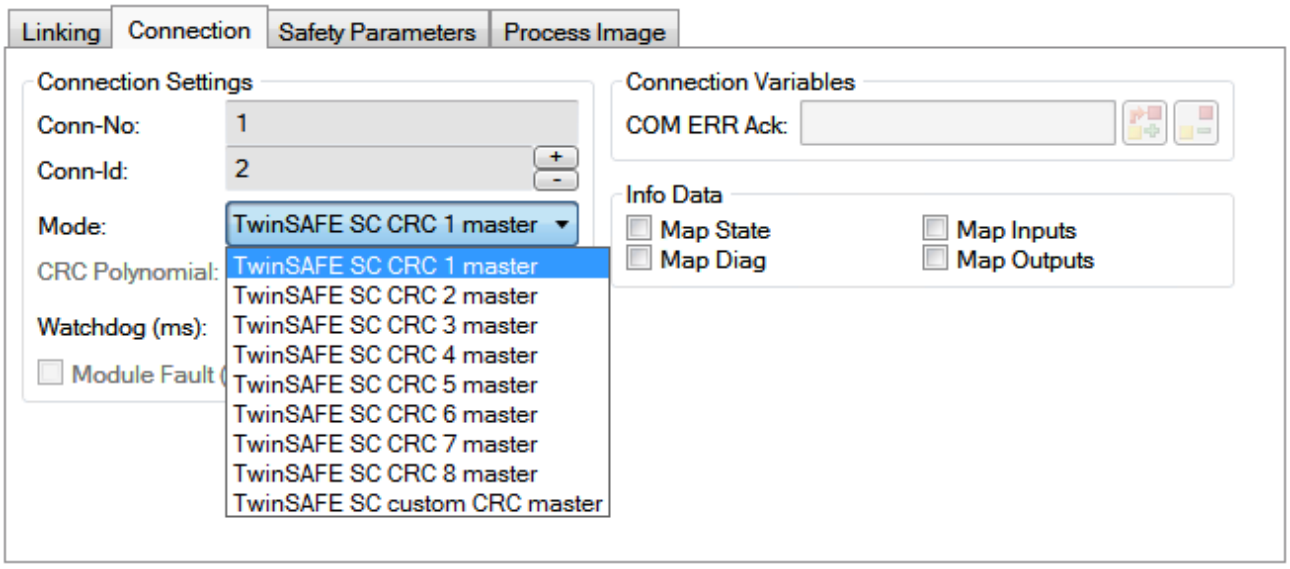


Fig. 118: Selecting a free CRC

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.

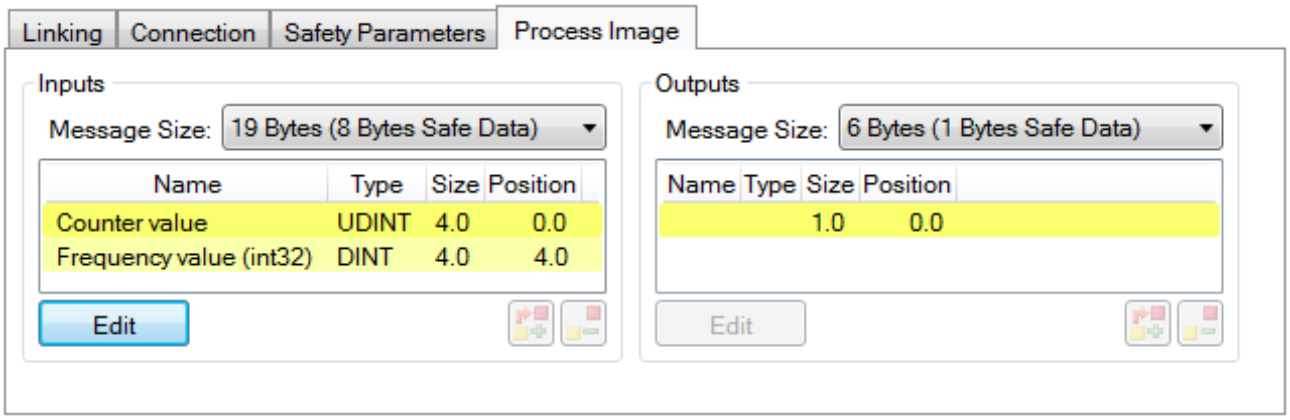


Fig. 119: Selecting the process data size and the process data

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)*.

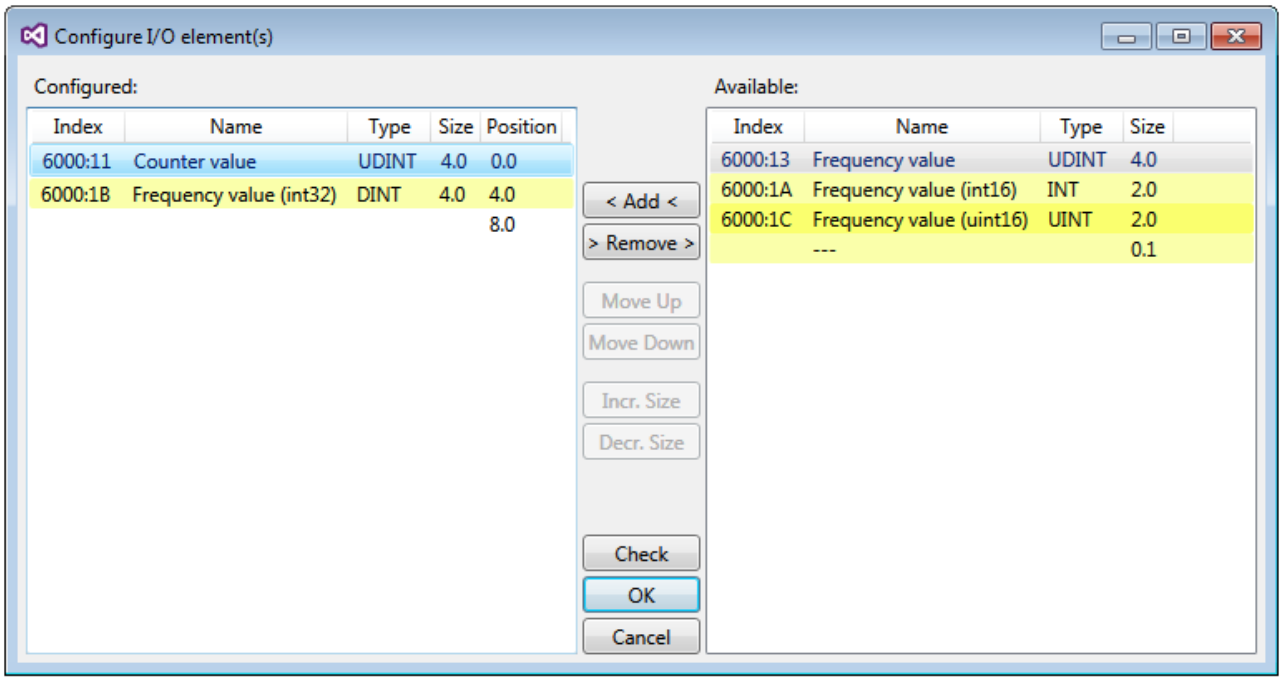


Fig. 120: Selection of the process data

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.

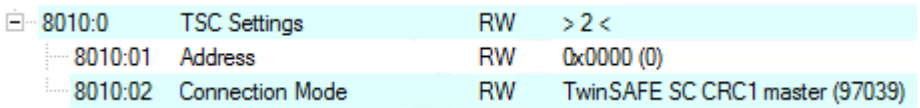


Fig. 121: CoE objects 0x8010:01 and 0x8010:02

Object „TSC Settings”

Depending on the terminal, the index designation of the configuration object „TSC Settings“ can vary.
Example:
- EL3214-0090 and EL3314-0090, „TSC Settings“, Index 8040
- EL5021-0090, „TSC Settings“, Index 8010
- EL6224-0090, „TSC Settings“, Index 800F

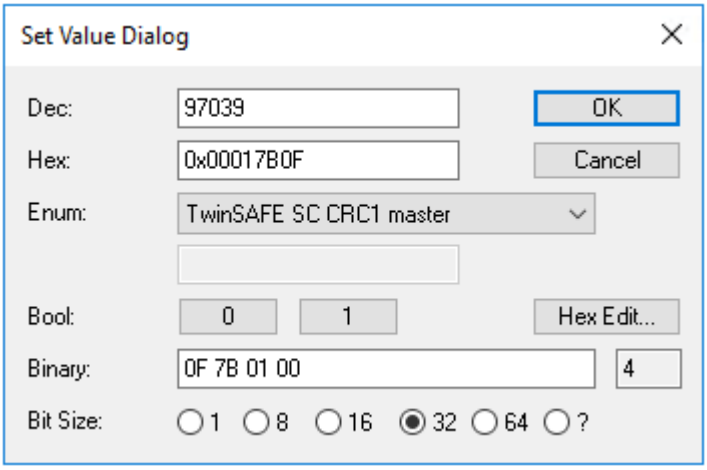


Fig. 122: Entering the safety address and the CRC

TwinSAFE SC connections

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

4.11 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: *Permanent Deactivation Allowed*: 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: *Temporary Deactivation Allowed*: 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 sample (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: *Passification Allowed* : TRUE/FALSE *Timeout Passification Allowed*: 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.

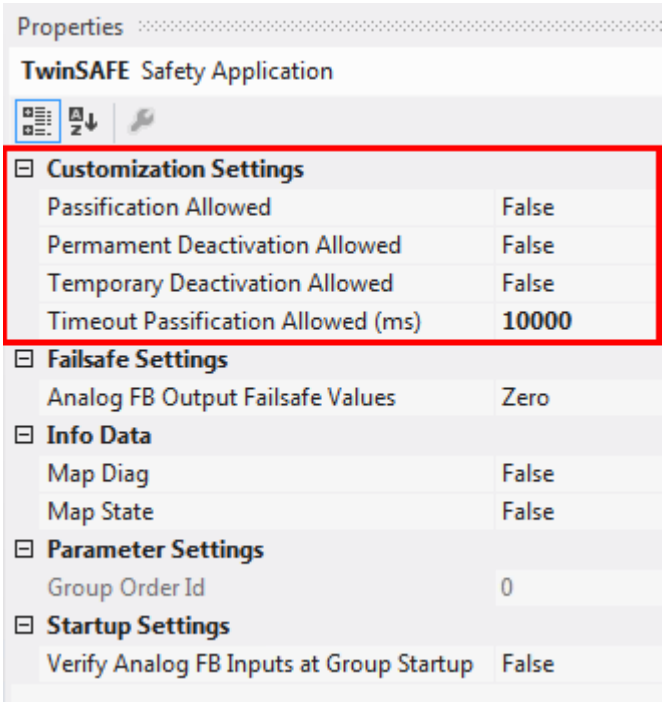


Fig. 123: Properties of the TwinSAFE group

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.

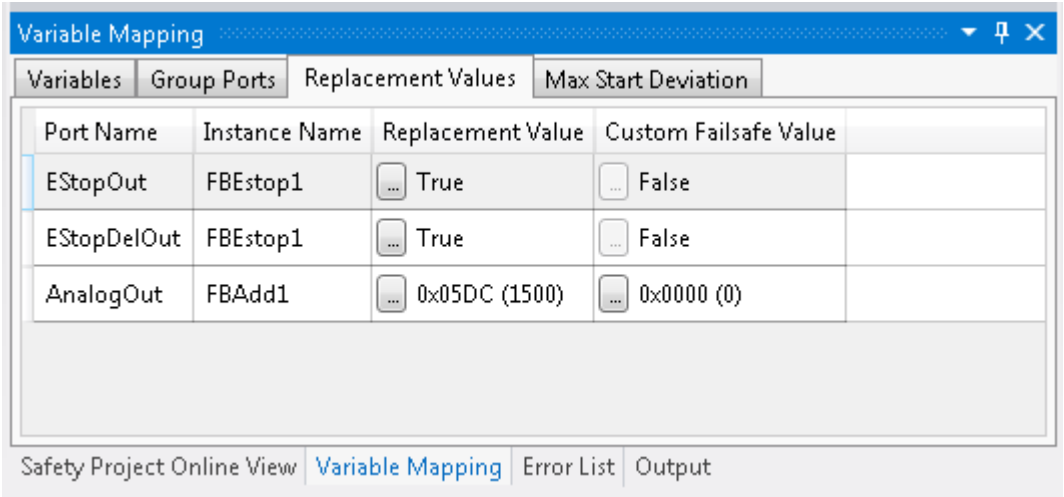


Fig. 124: Replacement values for the TwinSAFE group

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.

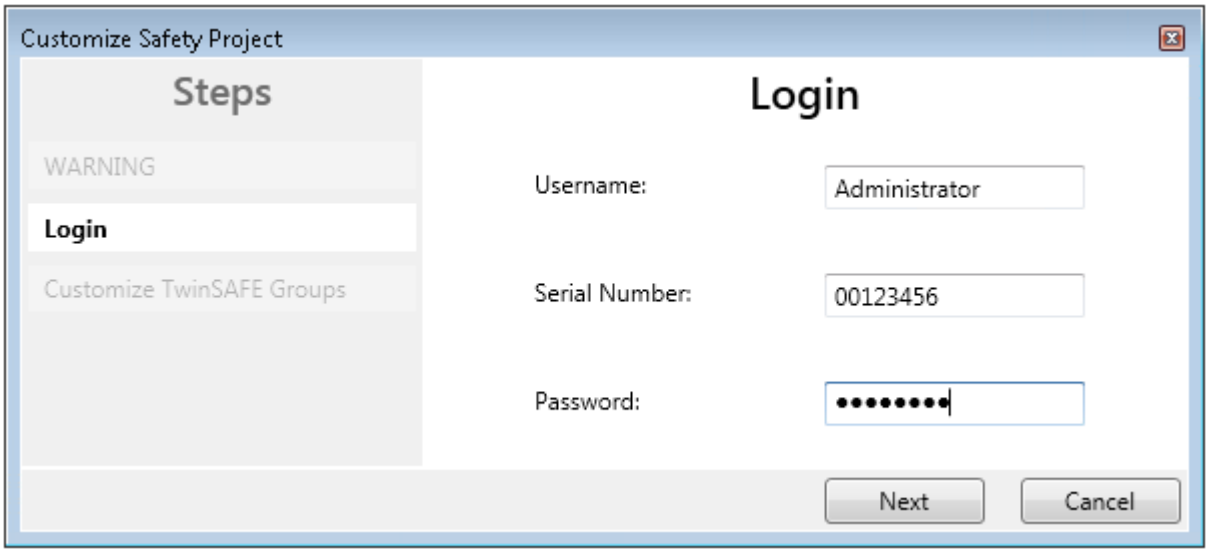


Fig. 125: Login

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. 126: 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. 127: Customized TwinSAFE Group

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.

4.12 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.

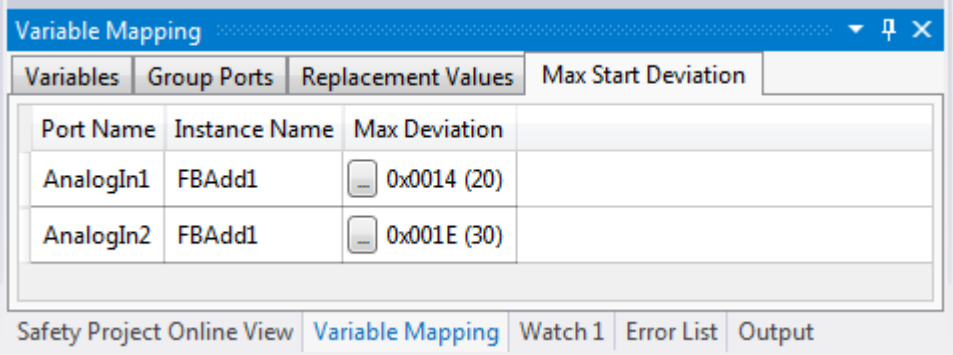


Fig. 128: Specifying deviations for analog input values

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.

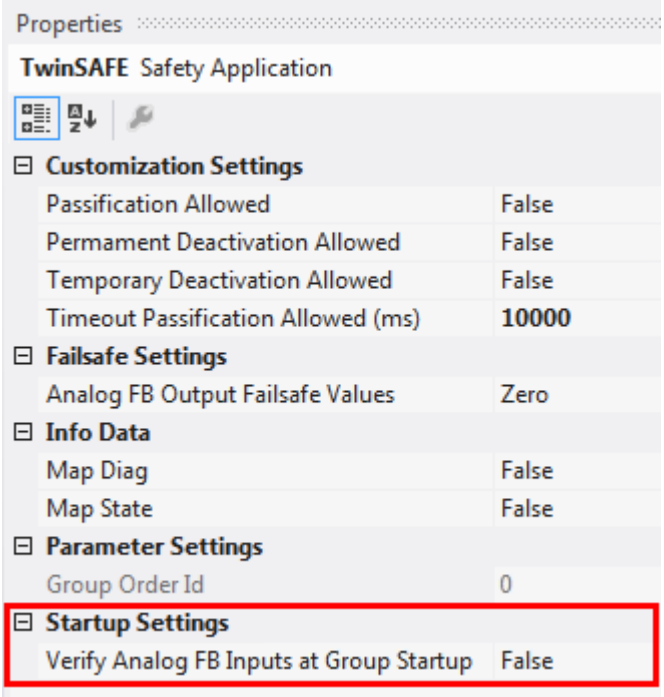


Fig. 129: Activate saving of all analog group inputs

4.13 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.

4.13.1 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.

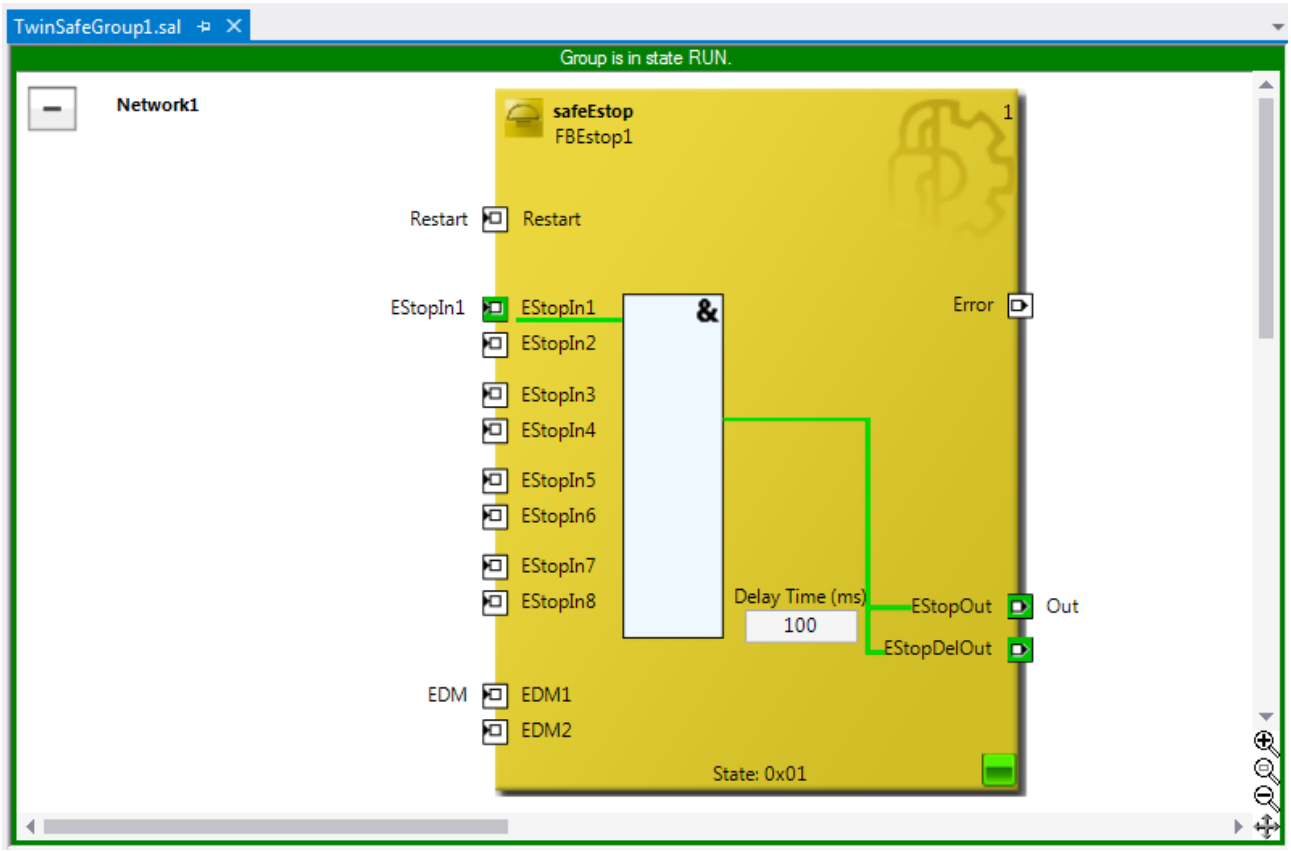


Fig. 130: Group Status Online RUN

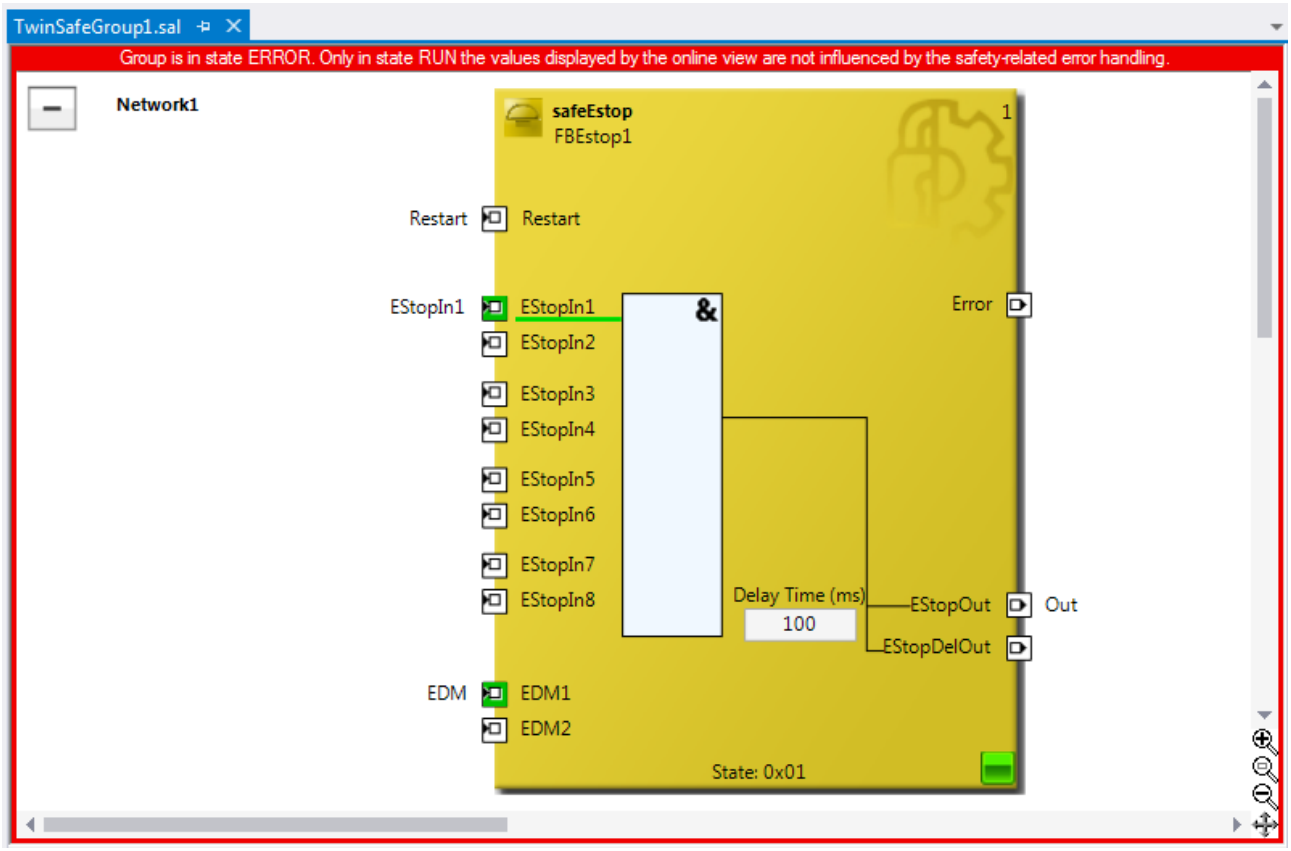


Fig. 131: Group Status Online ERROR

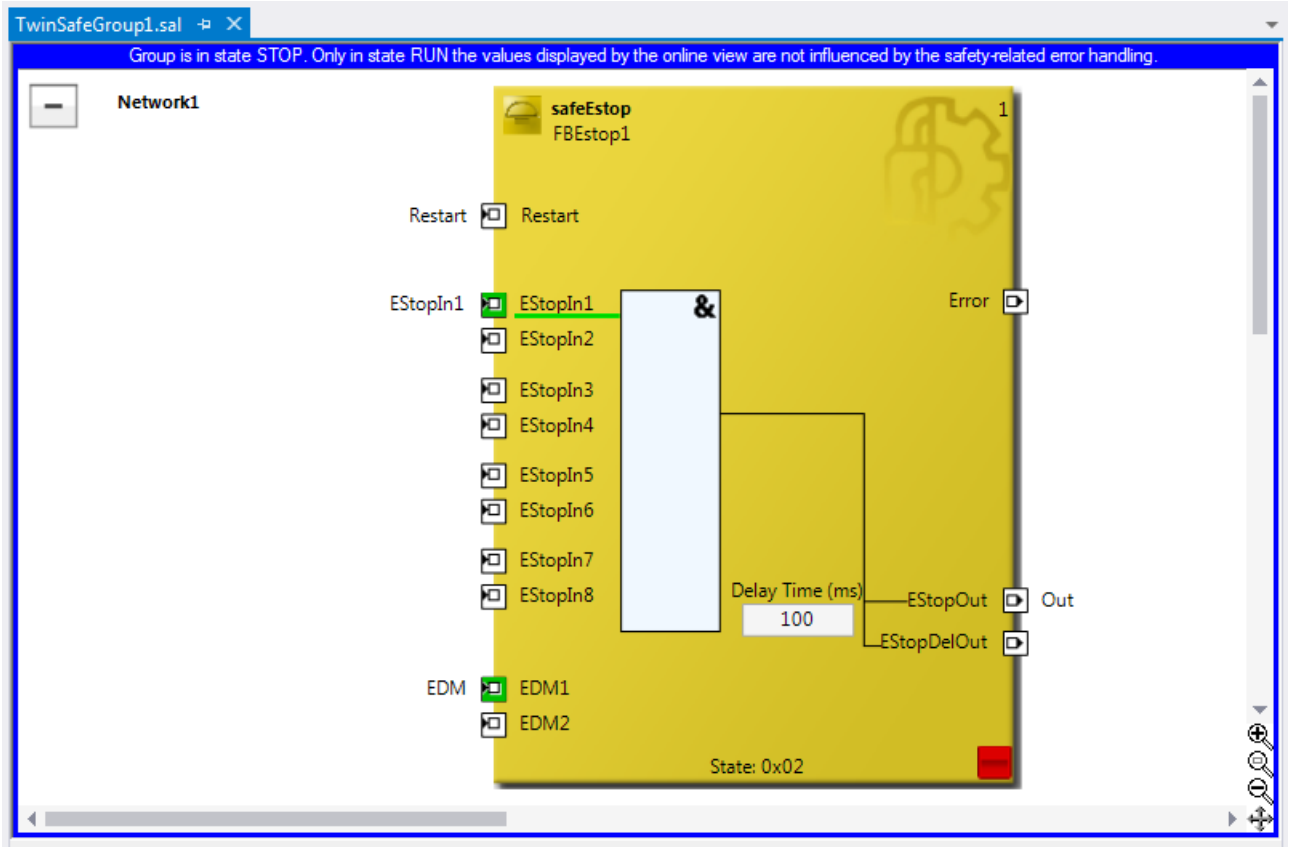


Fig. 132: Group Status Online STOP

4.13.2 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.

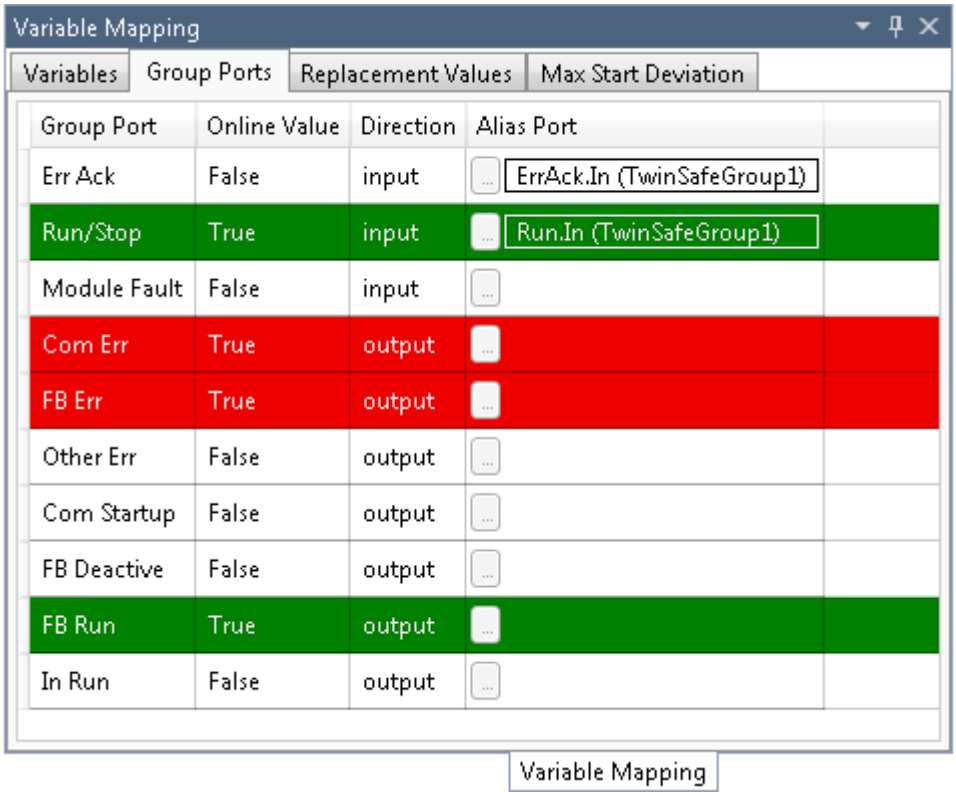


Fig. 133: Online View Group Ports

4.13.3 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).

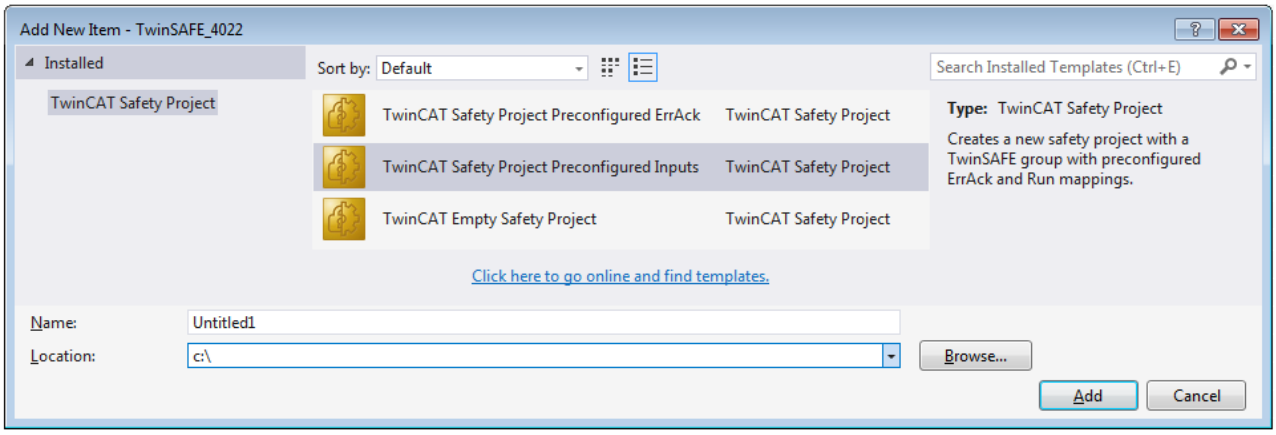


Fig. 134: Templates for Safety Projects

4.13.4 Networks collapsable

The networks defined in a TwinSAFE group can be collapsed.

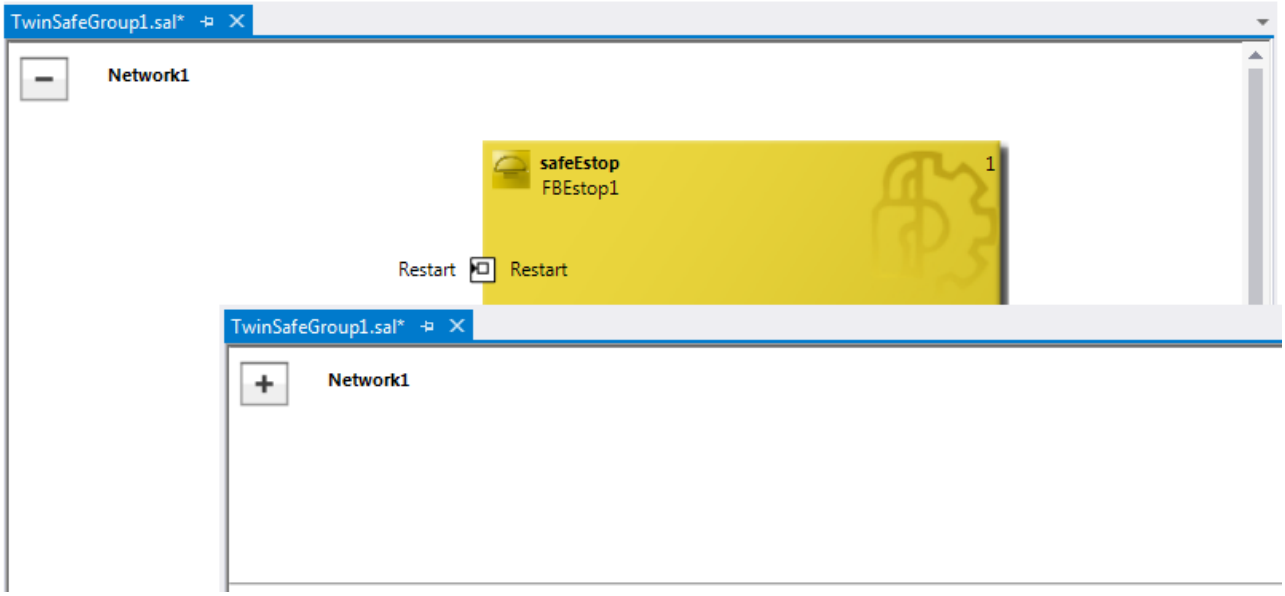


Fig. 135: Collapsing networks

4.13.5 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*.

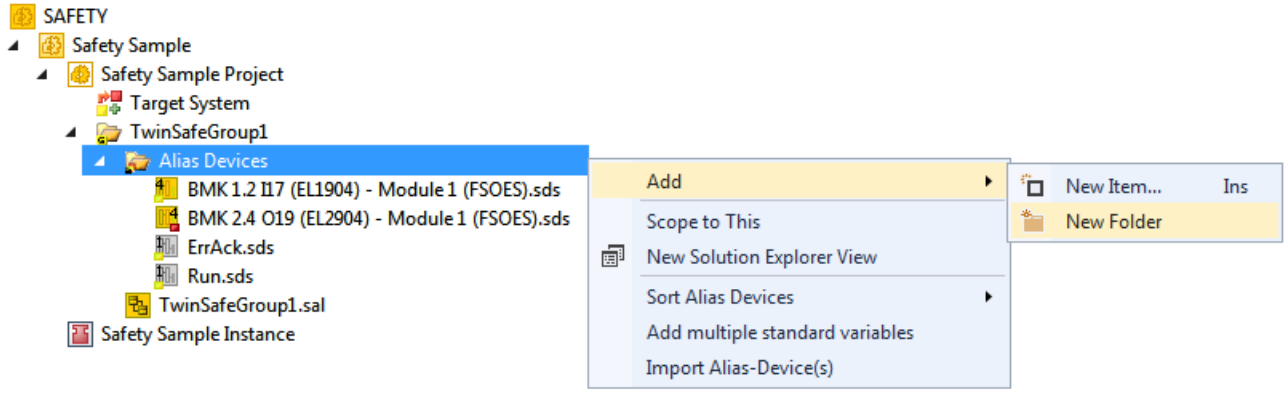


Fig. 136: Adding a subfolder

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

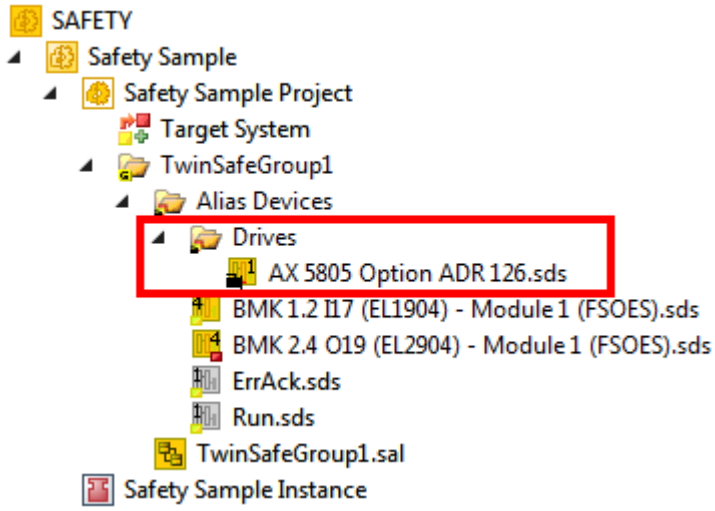


Fig. 137: Subfolder e.g. Drives

4.13.6 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.

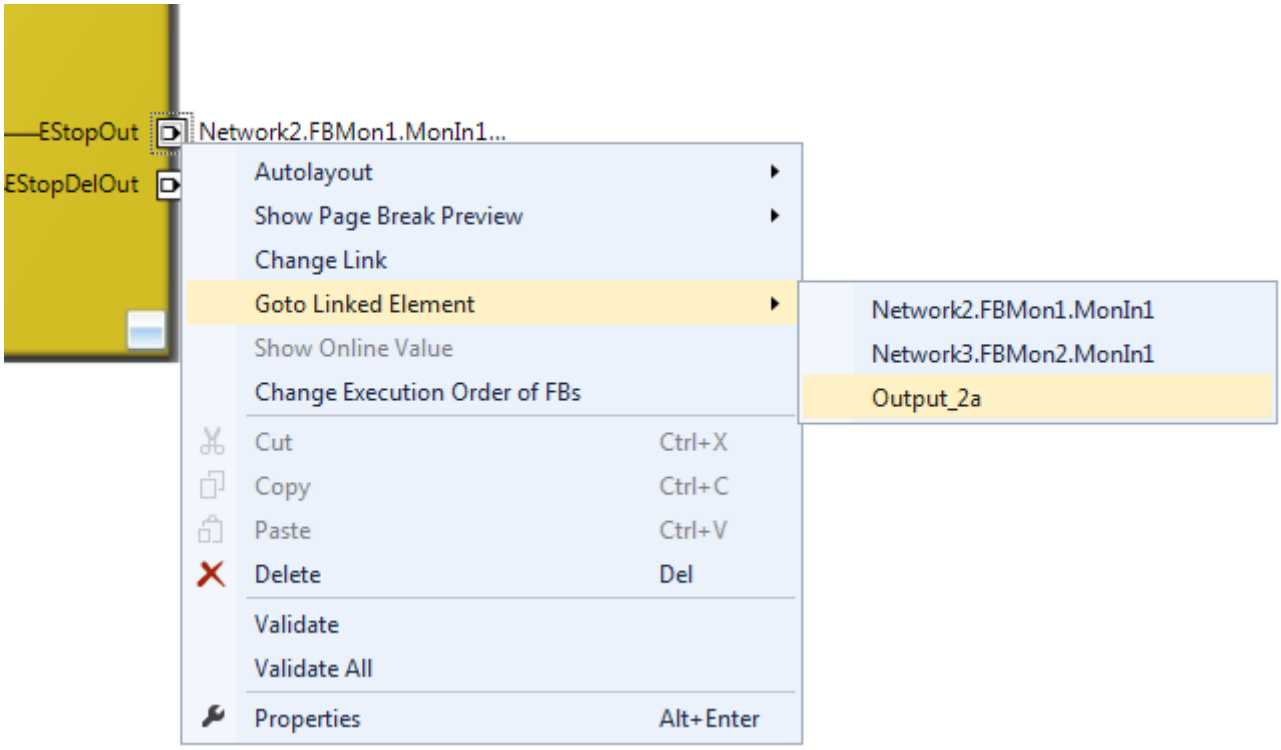


Fig. 138: Goto Linked Element

4.13.7 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*.

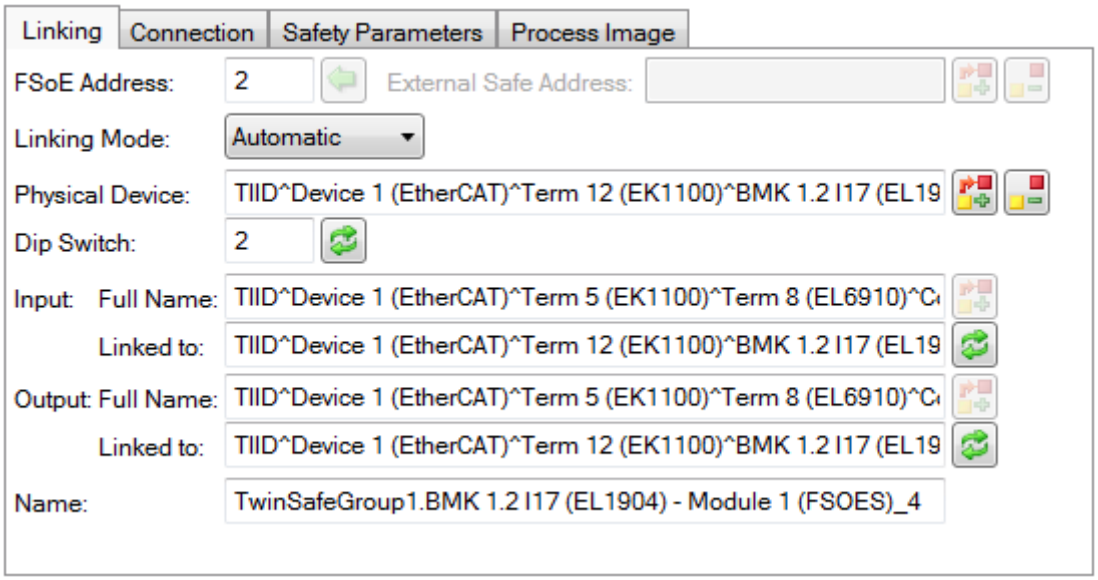


Fig. 139: Path view for safety Alias Devices

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.

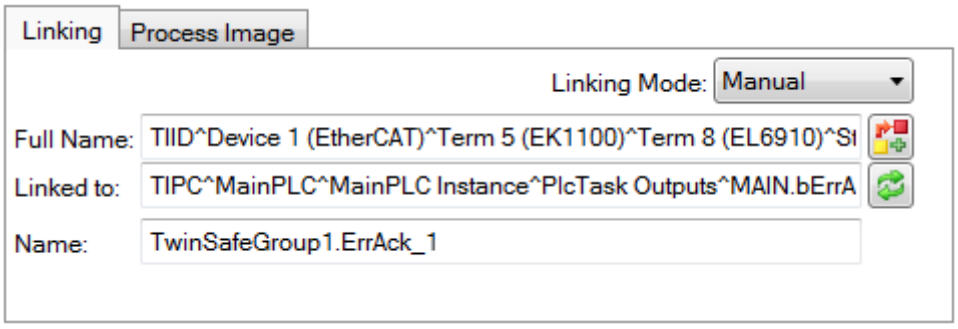


Fig. 140: Path view for Standard Alias Devices

4.13.8 Multiline comments

Comments in the TwinSAFE project may now be multiline.

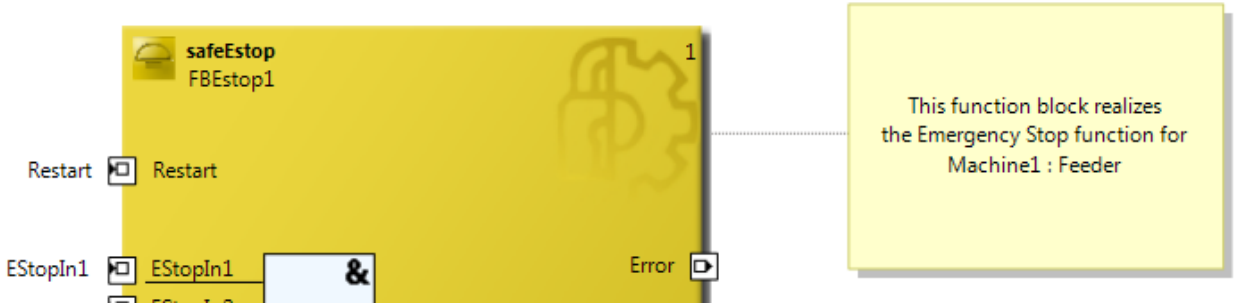


Fig. 141: Multiline comments

4.13.9 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. 142: Properties under Target System

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

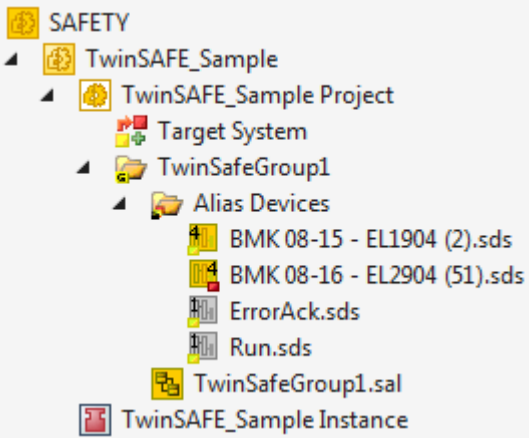


Fig. 143: Take Alias Device Name - Safety Project

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.

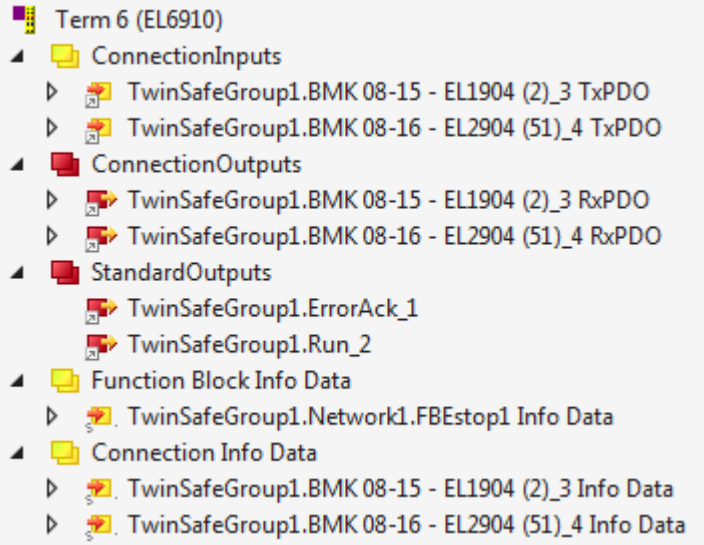


Fig. 144: Take Alias Device Name - TwinSAFE logic process image

4.13.10 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)

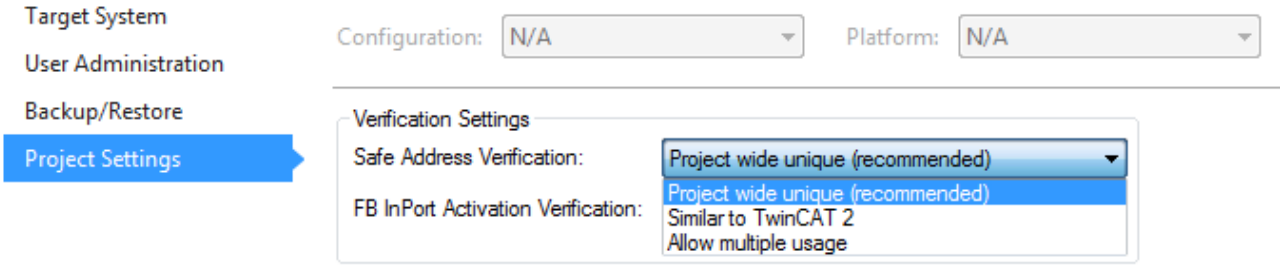


Fig. 145: Safe Address Verification

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.

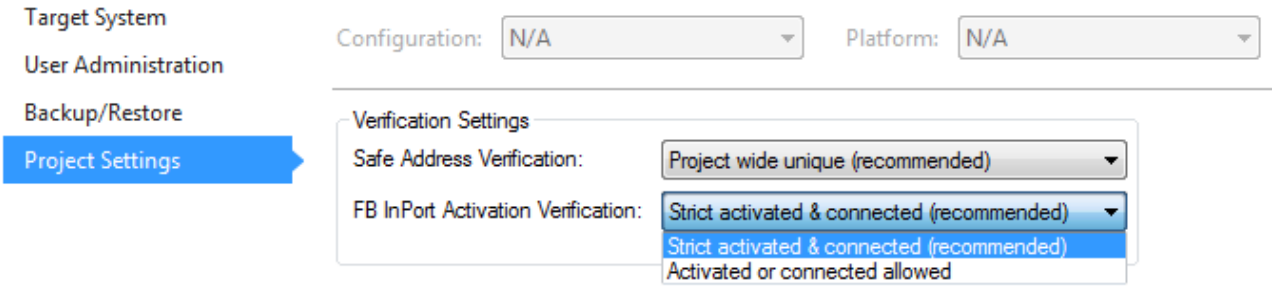


Fig. 146: FB InPort Activation Verification

NOTE

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.

4.13.11 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.

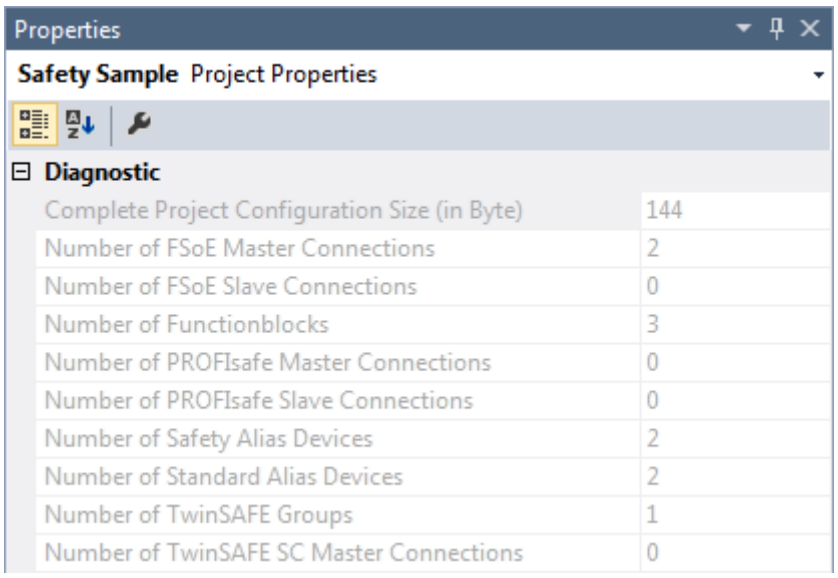


Fig. 147: Project Properties - Diagnostic

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.

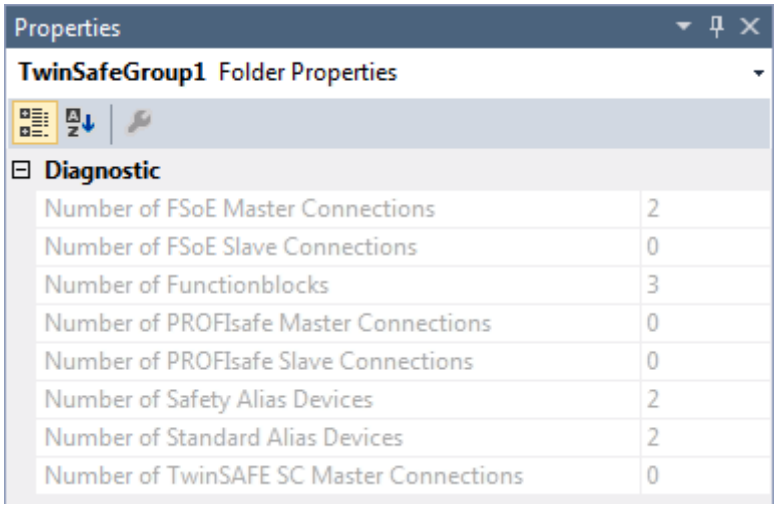


Fig. 148: Group Properties - Diagnostic

4.13.12 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).

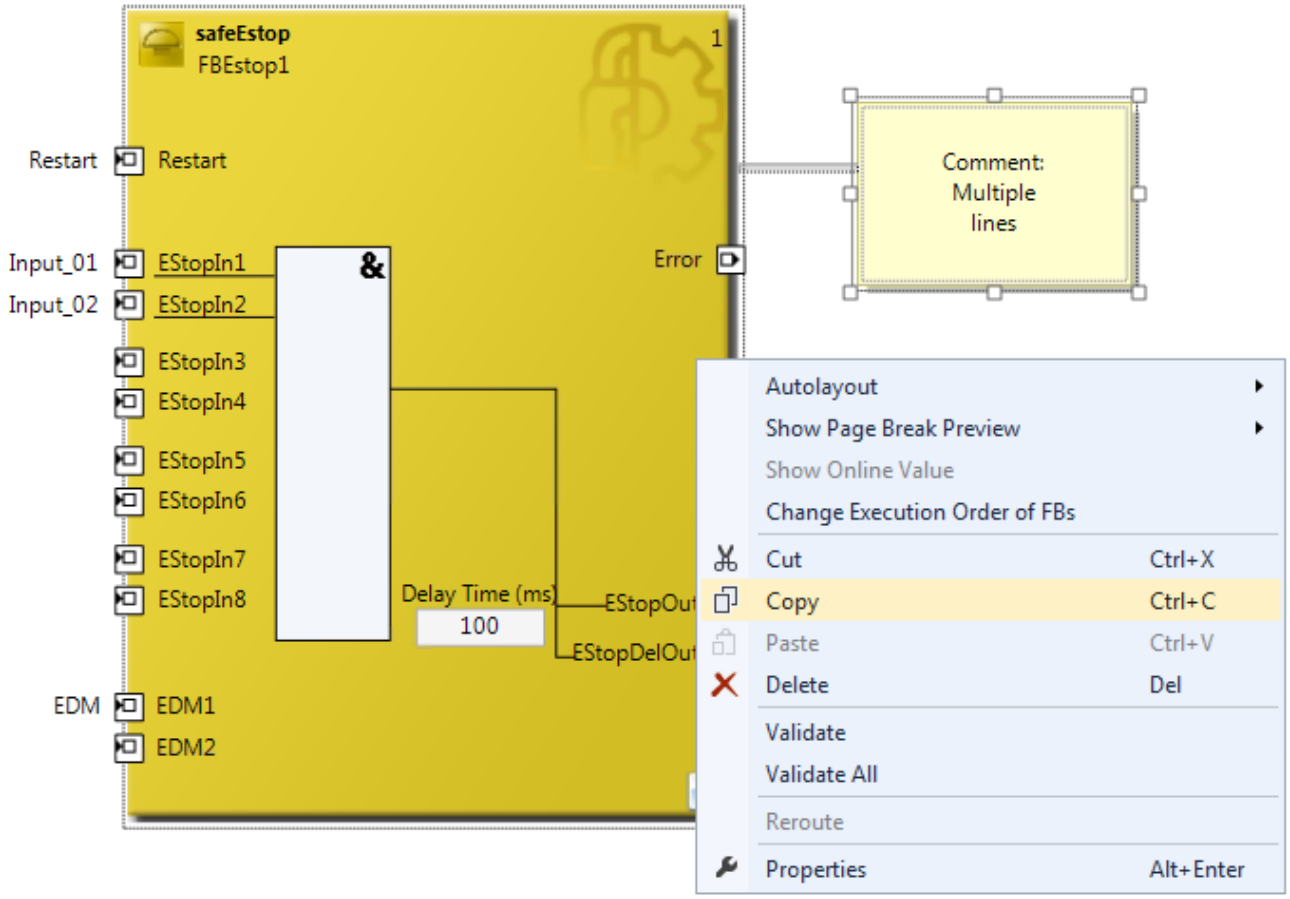


Fig. 149: Copying the data

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

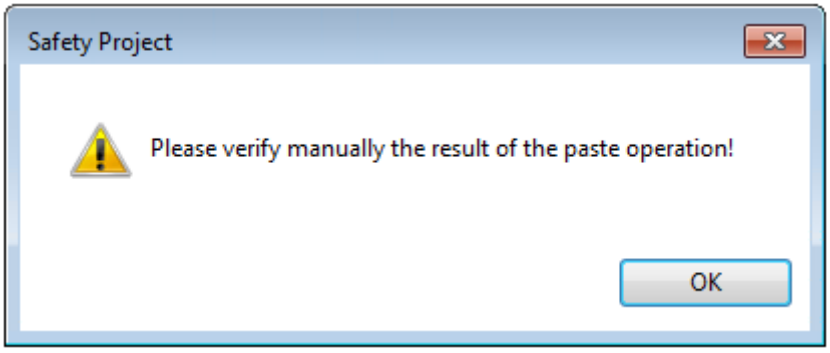


Fig. 150: Message box after inserting the data

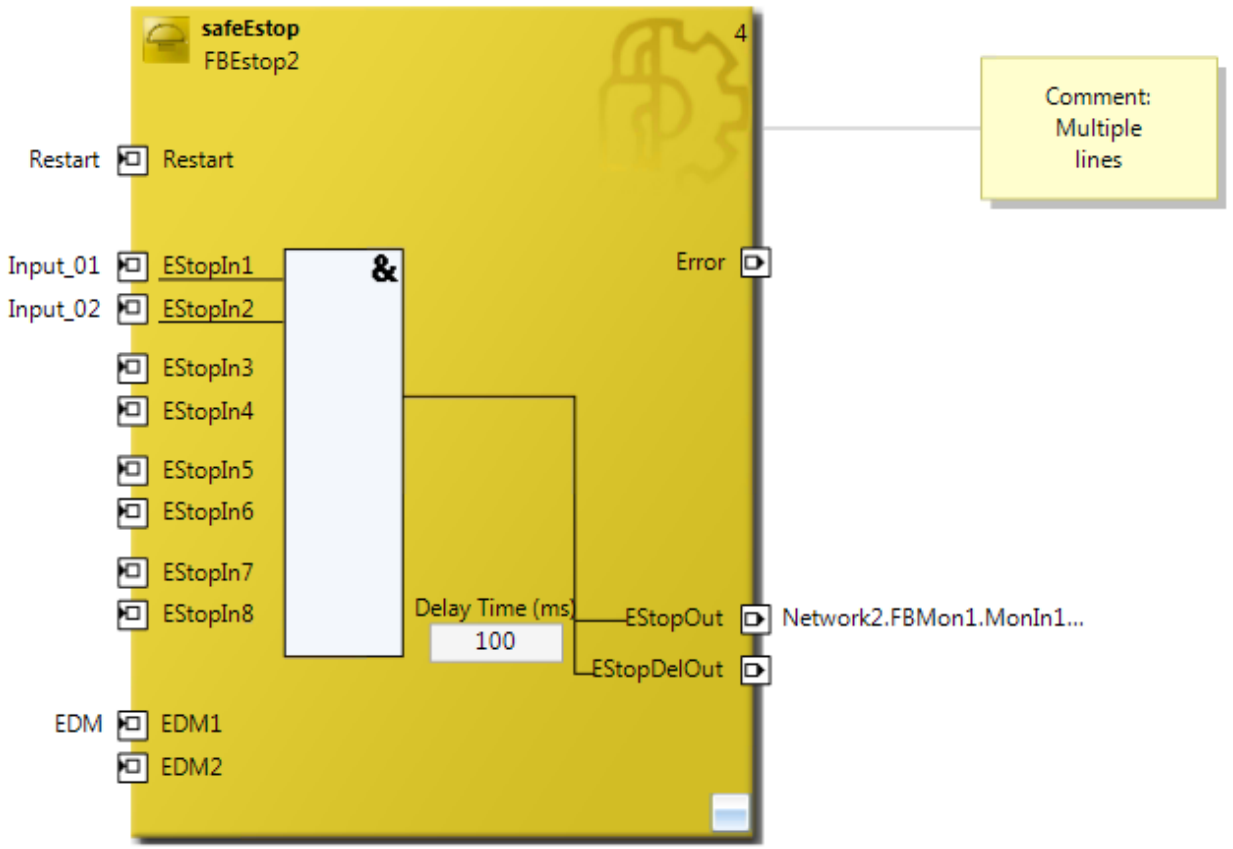


Fig. 151: Inserted data

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.

4.13.13 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.

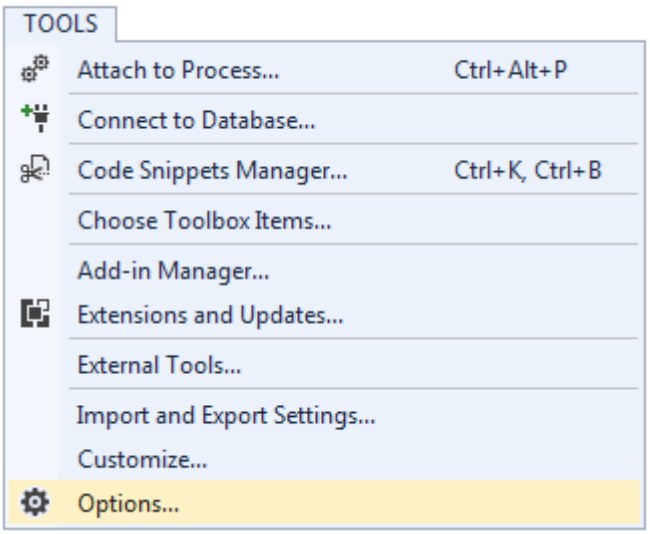


Fig. 152: Visual Studio - Menu Tools / Options

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.

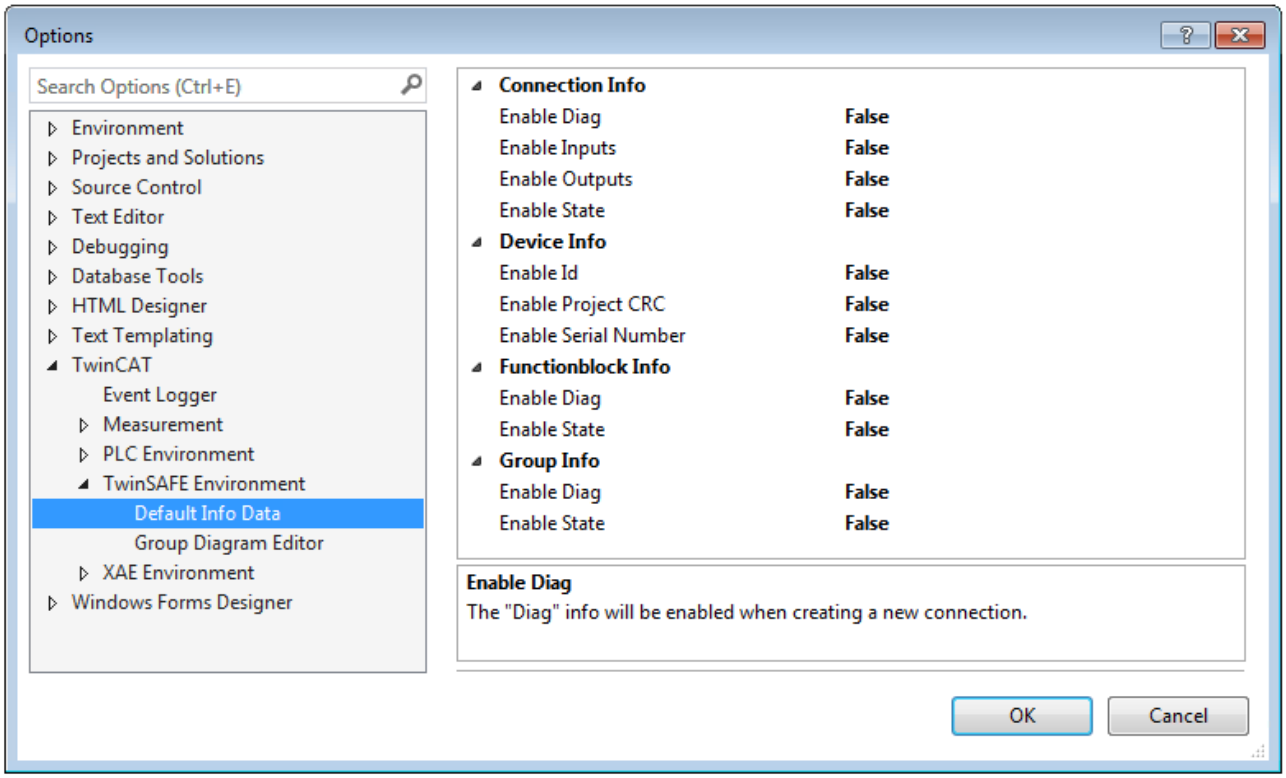


Fig. 153: Global setting - Default Info Data

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.

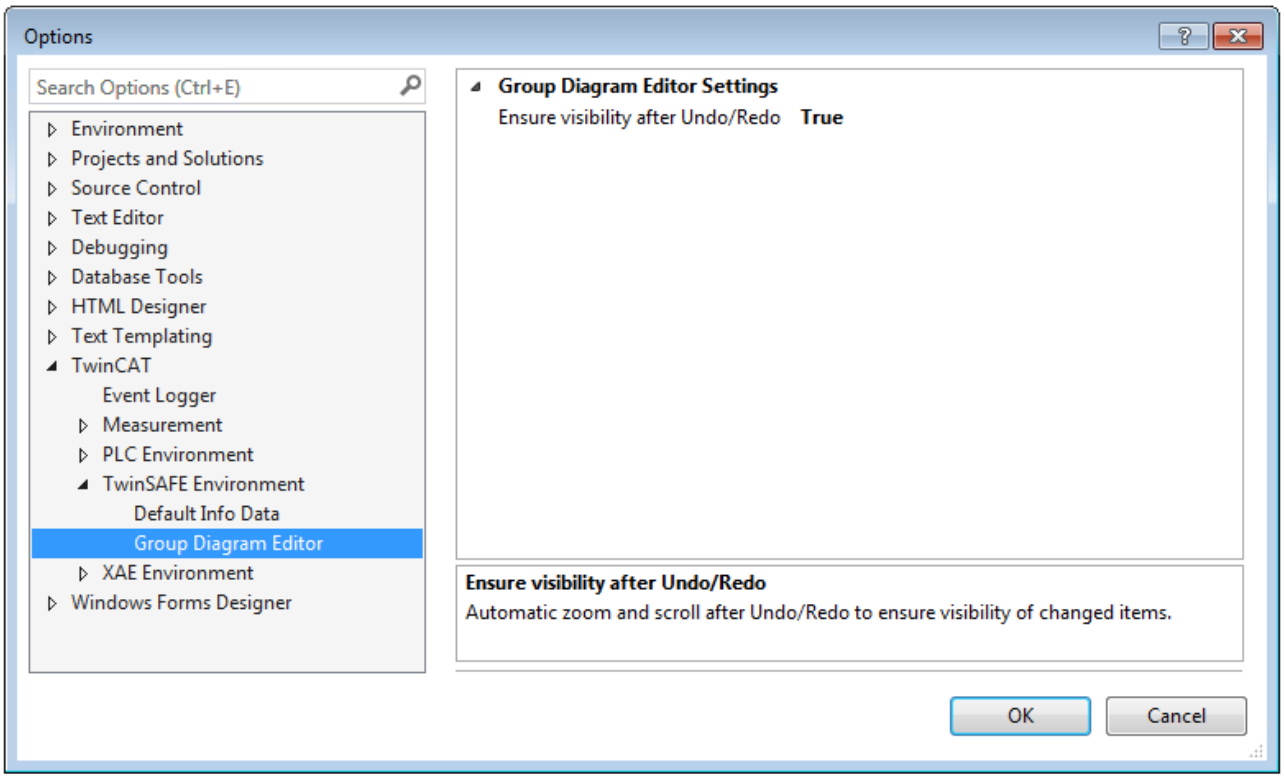


Fig. 154: Global Setting - Group Diagram Editor

4.13.14 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.

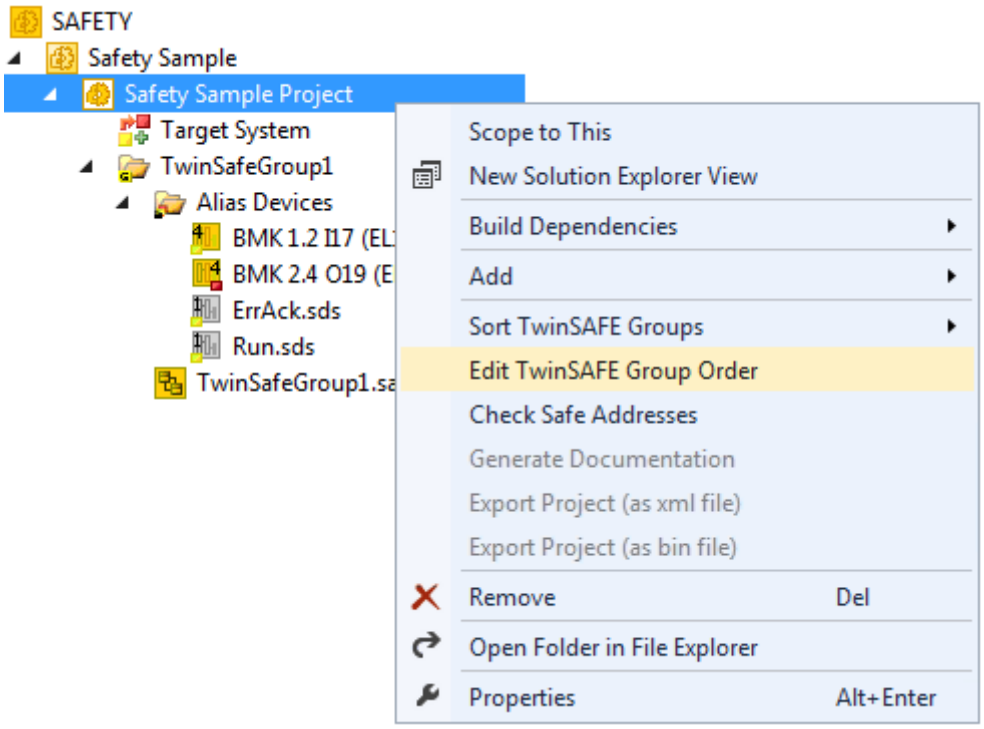


Fig. 155: Context menu - Edit TwinSAFE Group Order

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.

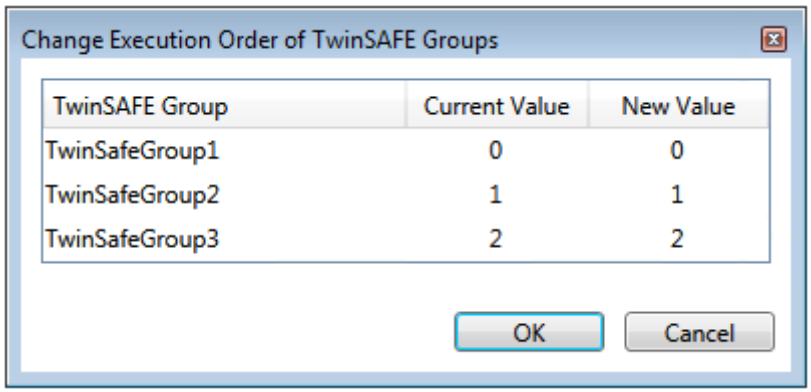


Fig. 156: Execution order for TwinSAFE groups

Sorting of Alias Devices

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

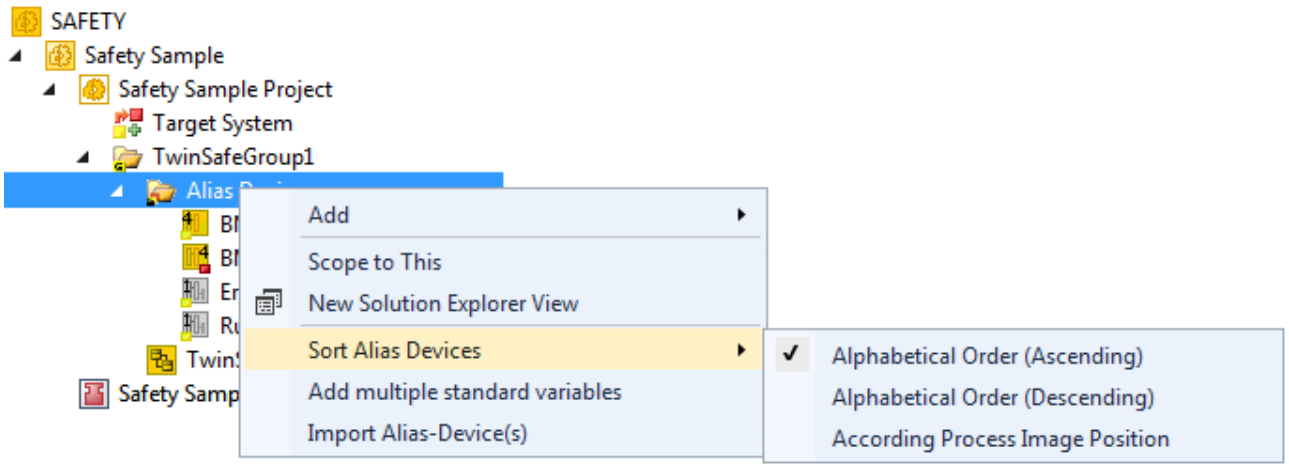


Fig. 157: Sorting of Alias Devices

Sorting of FBs (execution order)

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

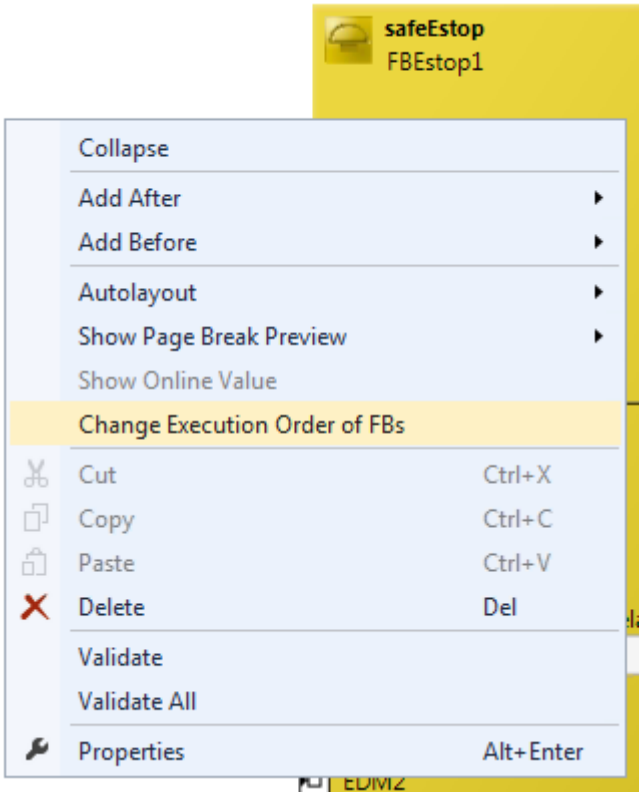


Fig. 158: Context Menu - Change Execution Order of FBs

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.

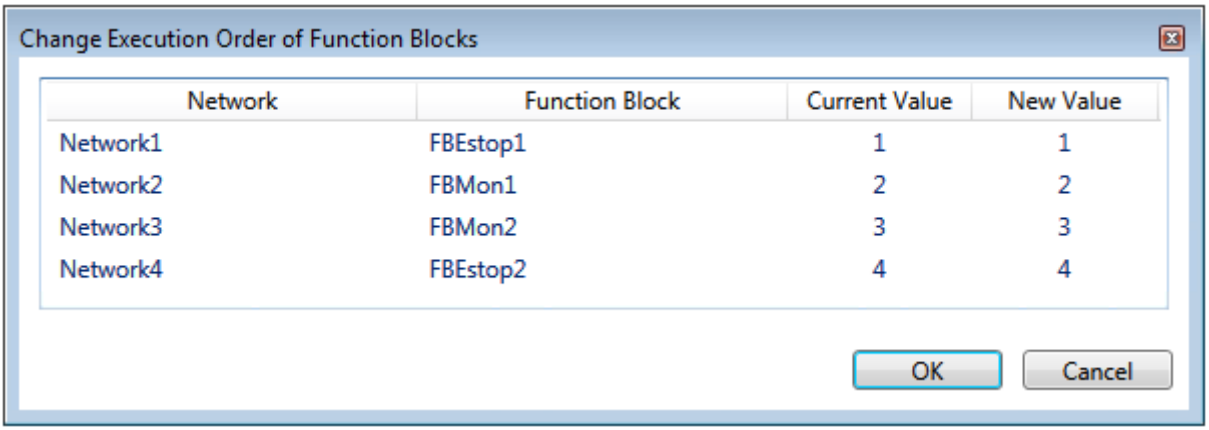


Fig. 159: Execution order FBs

4.13.15 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*.

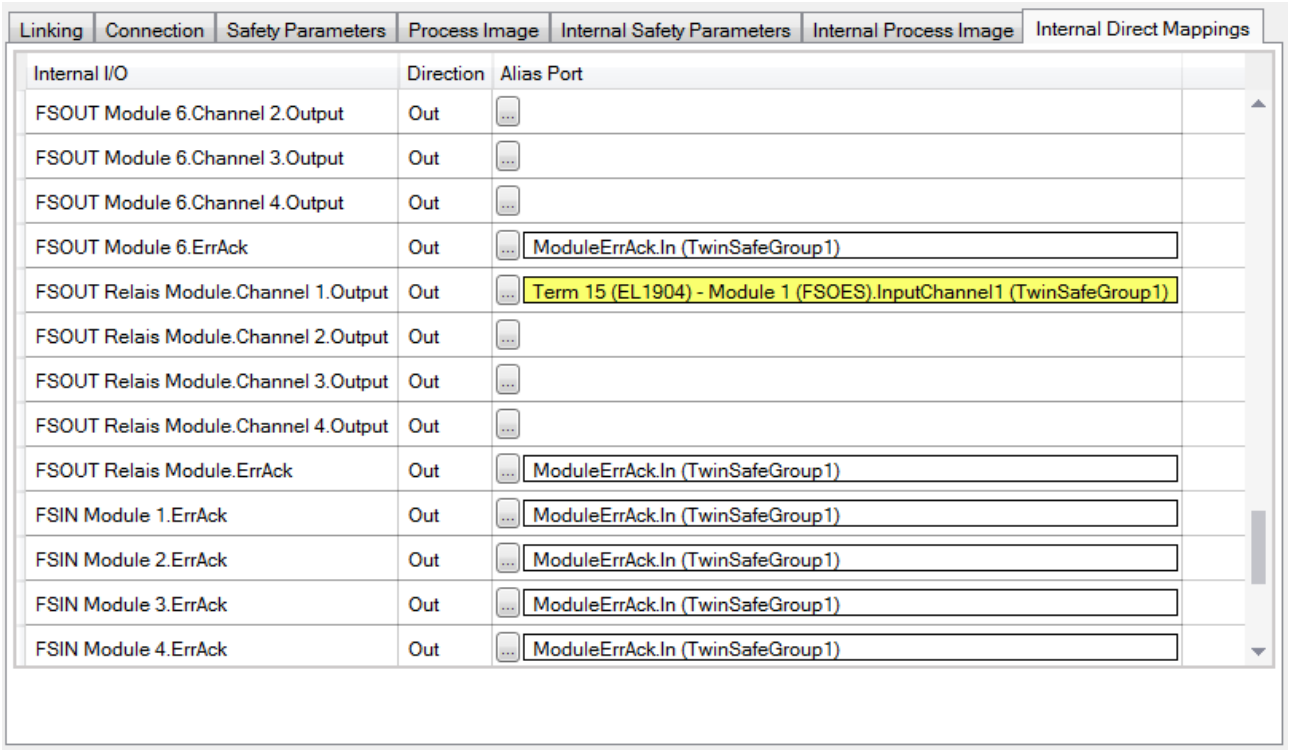


Fig. 160: Dialog - Internal Direct Mapping

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*.

4.13.16 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	Desciption	Available in
Store Project CRC in Slave	Only active when FSoE Connection Type is set to Master. The CRC of the local project is stored on the target slave and can be used for the backup/ restore mechanism. Now, besides the EL1904 and EL2904, TwinSAFE logics are also supported for storing the CRC.	EL69xx, EL1904, EL2904, EP1908
Store Slave Project CRC in Master	Only active when FSoE Connection Type is set to Master. 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.	EL691x, EK1960, EJx9xx and newer products
Store Master Project CRC in Slave	Only active if FSoE Connection Type is set to Slave. 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.	EL691x, EK1960, EJx9xx and newer products
Read Project CRC from Master	Only active if FSoE Connection Type is set to Slave. 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.	EL691x, EK1960, EJx9xx and newer products

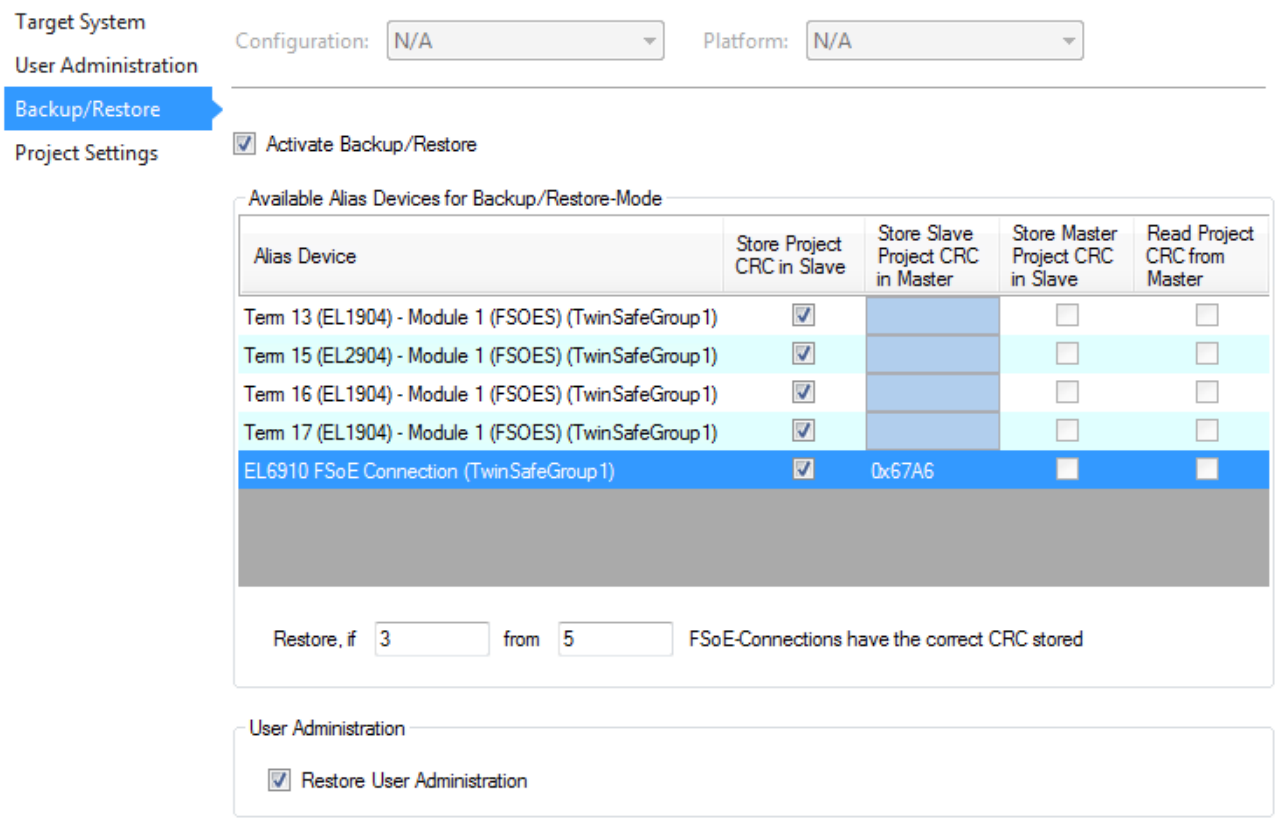


Fig. 161: Backup/Restore settings

4.13.17 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. 162: 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.

NOTE

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.

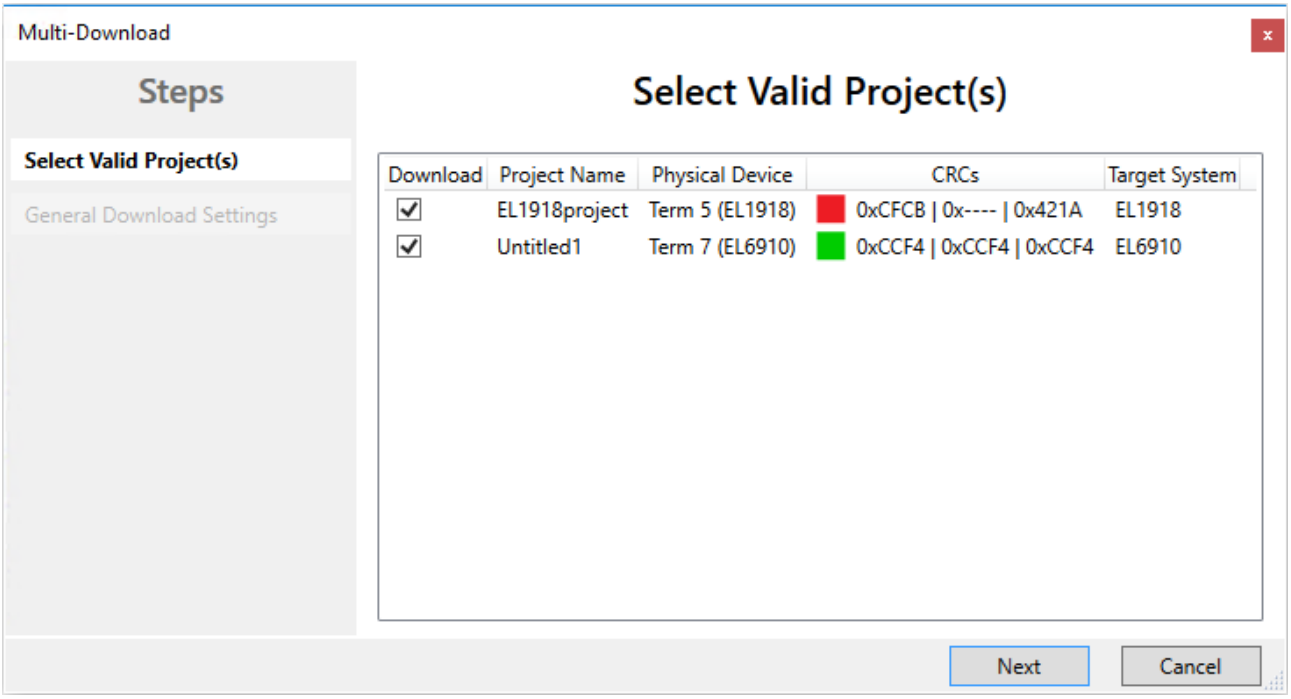


Fig. 163: Multiple Download - Selection of projects

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.

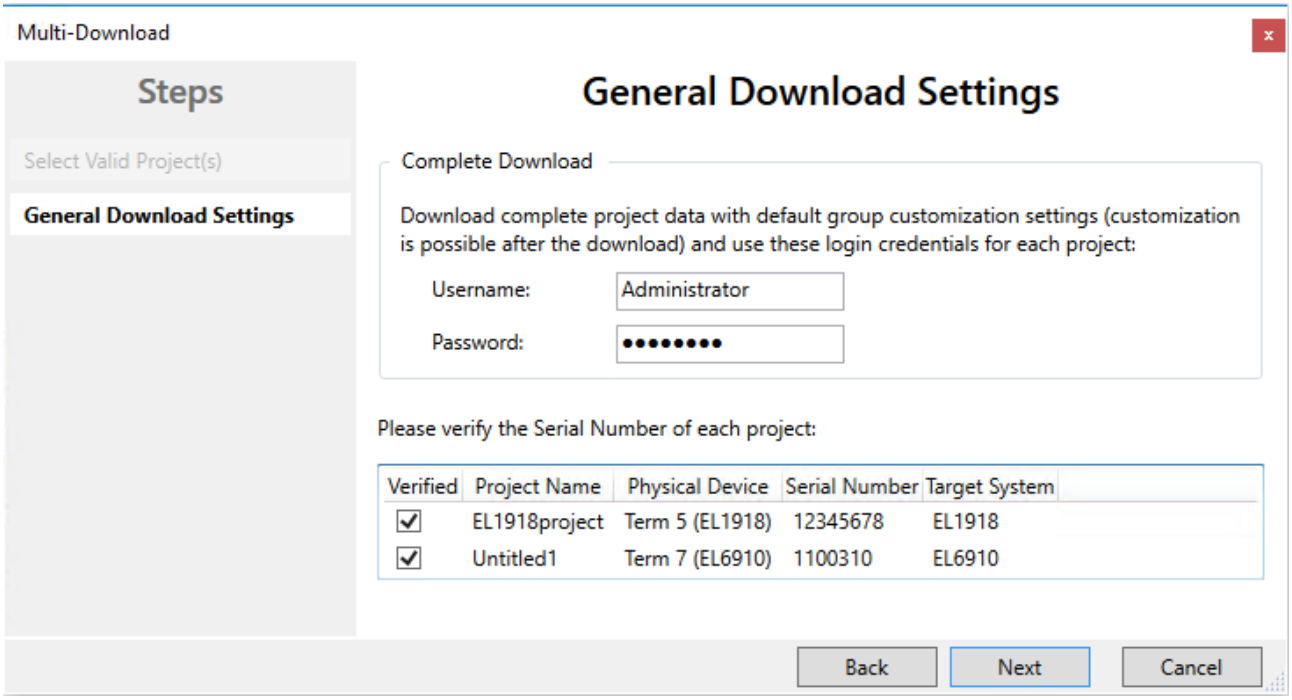


Fig. 164: Multiple Download - general settings

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.

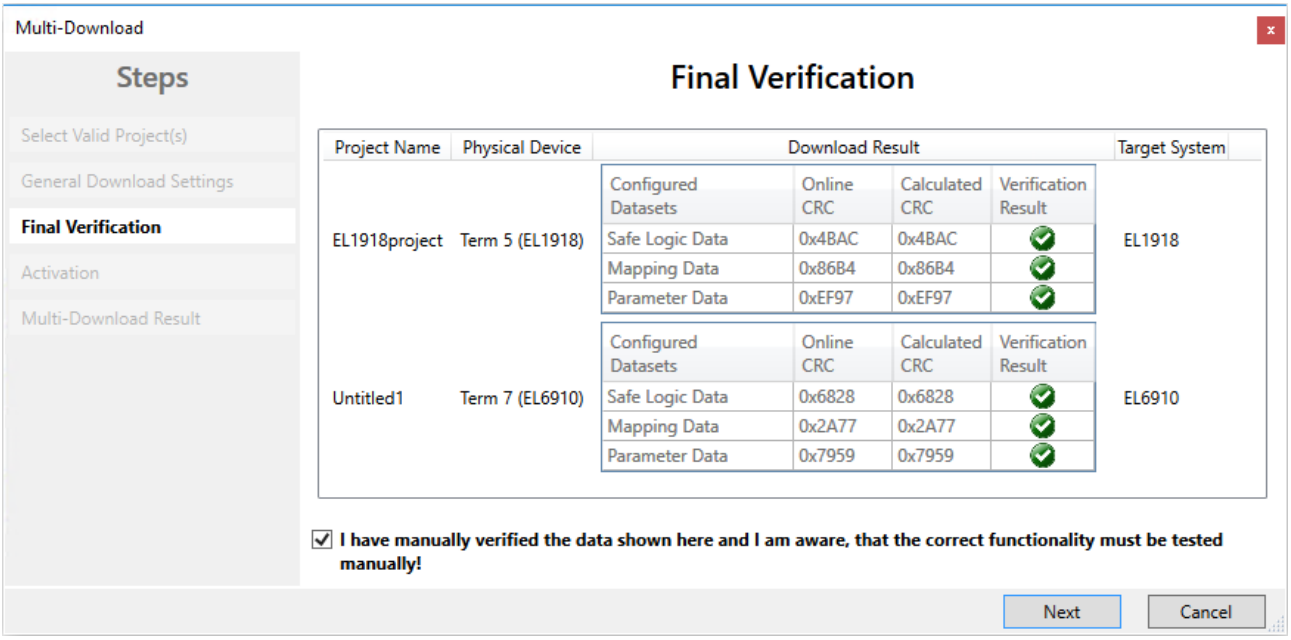


Fig. 165: Multiple Download - Final Verification

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

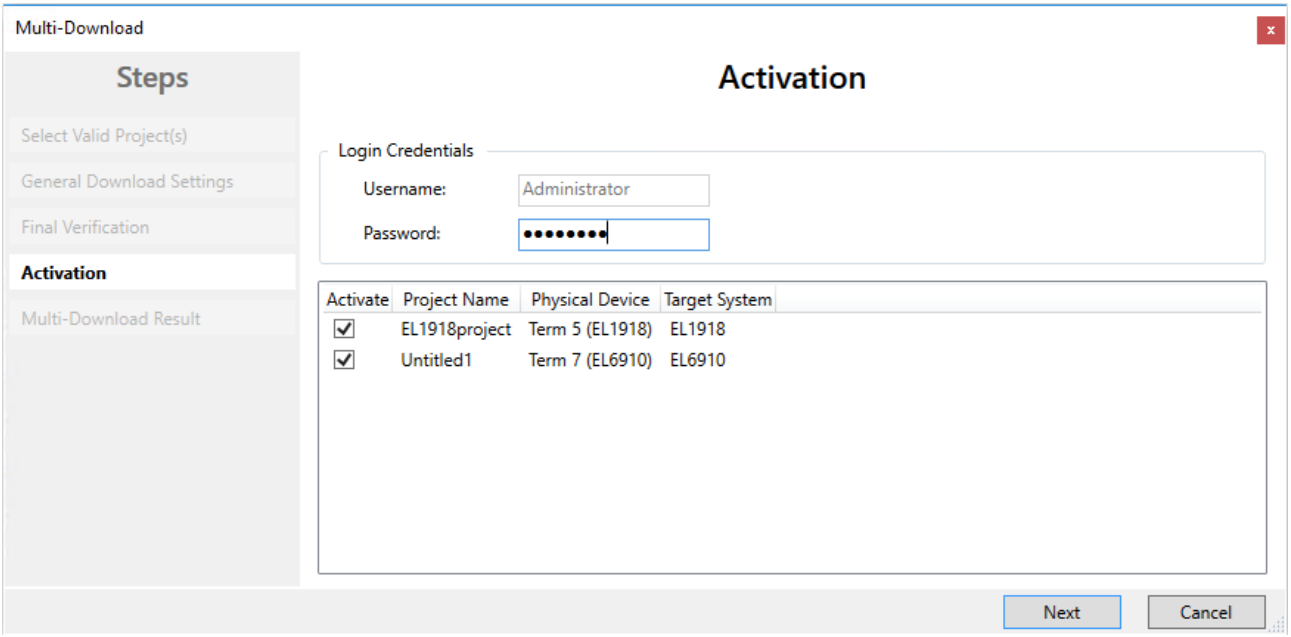


Fig. 166: Multiple Download - Activation

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

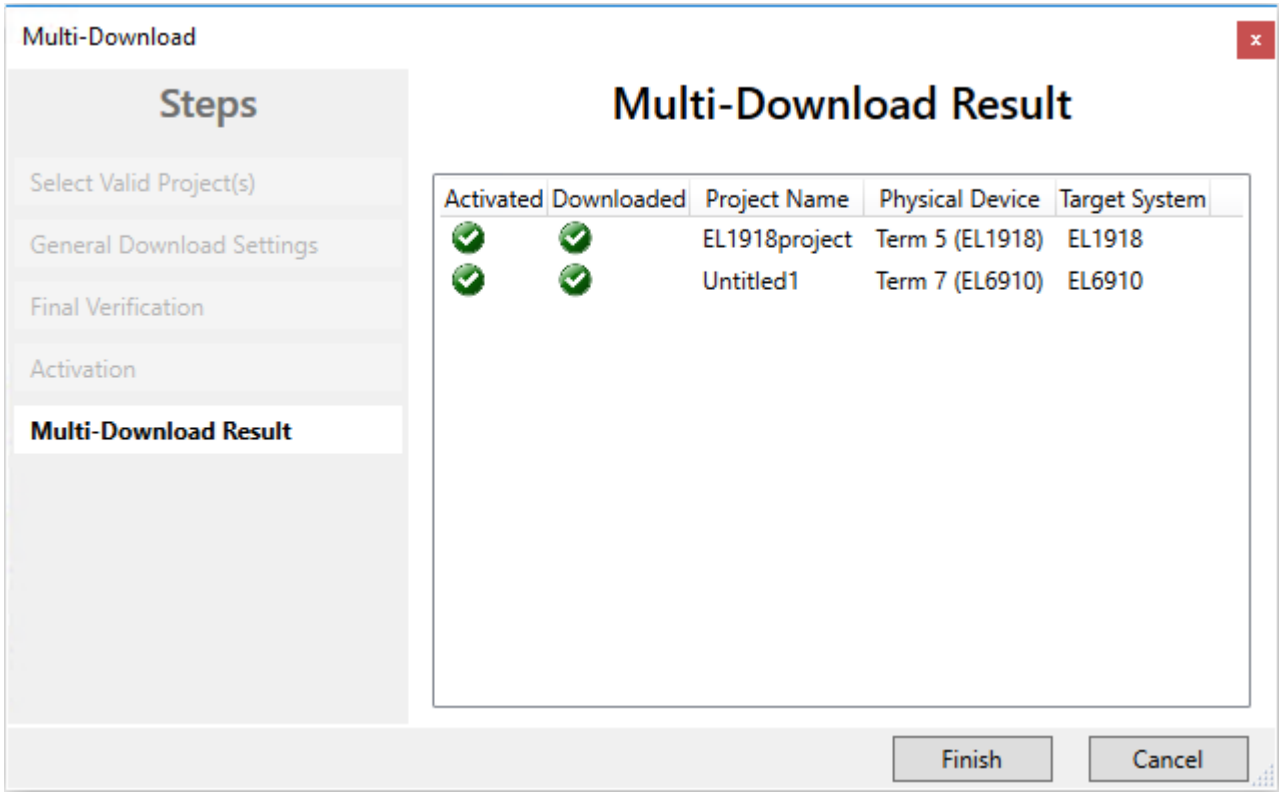


Fig. 167: Multiple Download - Result

4.14 Diagnostics

4.14.1 Diagnostic LEDs

Fig. 168: 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

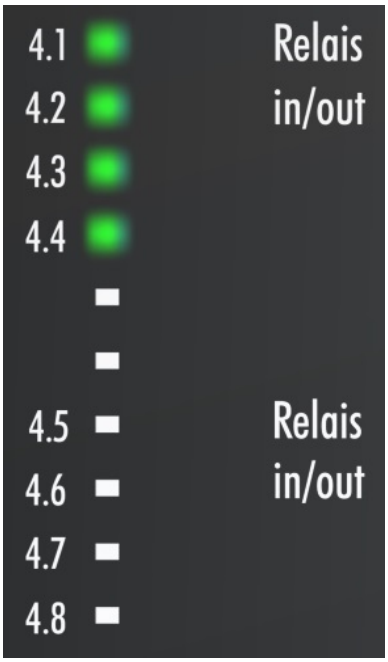
The U_S LED lights up as soon as the 24 V_{DC} voltage is present at the U_S connection.

LED Up

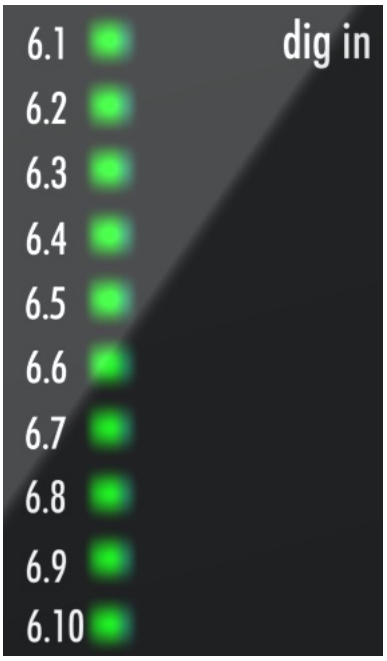
The U_P LED lights up as soon as the 24 V_{DC} voltage is present at the U_P connection.

4.14.2 Status LEDs

Relais LEDs



Digital inputs

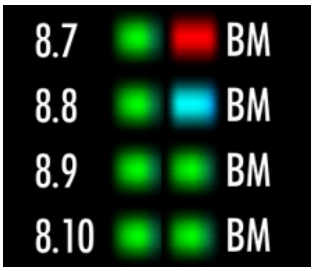


Digital outputs

Inputs 17 - 20

LED left green - Digital Mode On

LED right blue - Bumper Mode On



4.14.3 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 µC2	RO	0_{dec}
F984:02	Temperature C1	Temperature µC1	RO	0_{dec}
F984:03	Firmware CRC C1	CRC of the firmware on µC1	RO	-
F984:04	Vendor data CRC C1	CRC of the vendor data on µC1	RO	-

Index F985$_{hex}$: Device Info Data C2

CoE object F985$_{hex}$ currently displays internal temperature and voltage values for the TwinSAFE component.

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

Diagnostics history

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

Index F100$_{hex}$: FSLOGIC status

The CoE object F100$_{hex}$ shows the current status of the TwinSAFE component.

Index	Name	Meaning	Flags	Default
F100:01	Safe Logic State	Status of the internal logic: 0: OFFLINE 1: RUN 2: STOP 3: SAFE 4: ERROR 6: START 8: PREPARE 10: RESTORE 11: PROJECT-CRC-OK	RO	0$_{bin}$
F100:02	Cycle Counter	Life cycle counter, which is incremented with each TwinSAFE logic cycle.	RO	0 $_{bin}$

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

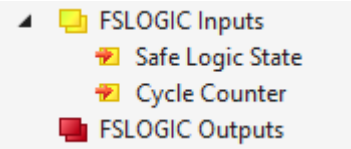


Fig. 169: Diagnostic object: FSLOGIC Status (F100$_{hex}$) at the process image of the der TwinSAFE component (imntvg22.png)

4.14.4 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.

4.14.5 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 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. 170: 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.

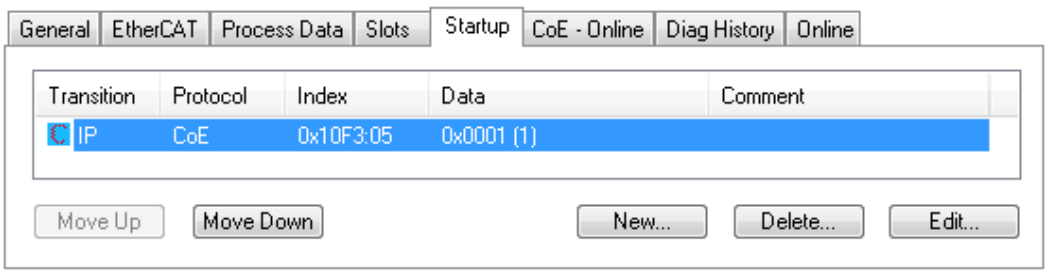


Fig. 171: Startup list

4.15 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.

4.16 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.

4.17 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.

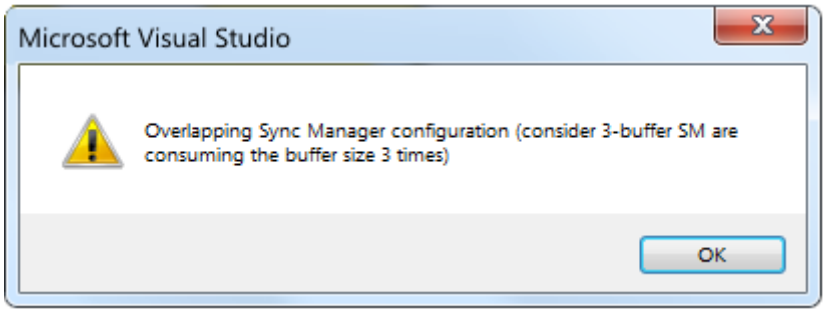


Fig. 172: Overlapping Sync Manager

Adapting the Sync-Manager configuration

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

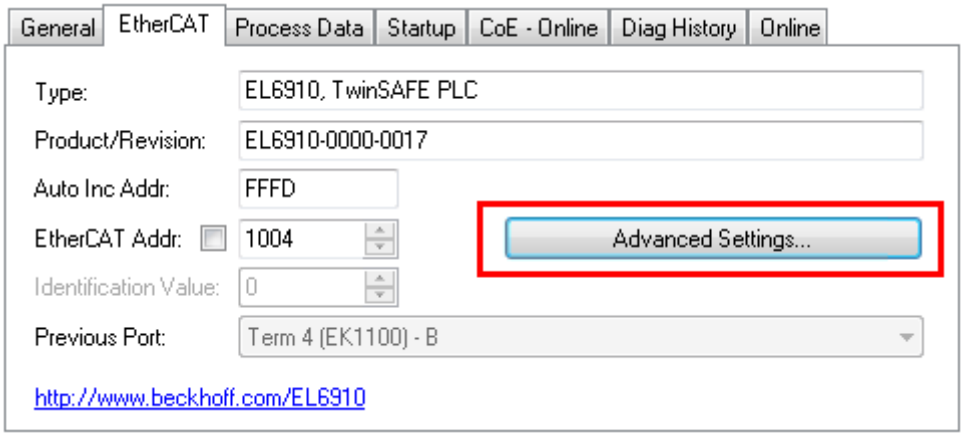


Fig. 173: EtherCAT Advanced Settings

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

Start SM3 >= Start SM2 + 3* Length SM2

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

Start SM3 + 3* Length SM3 <= 0x3000

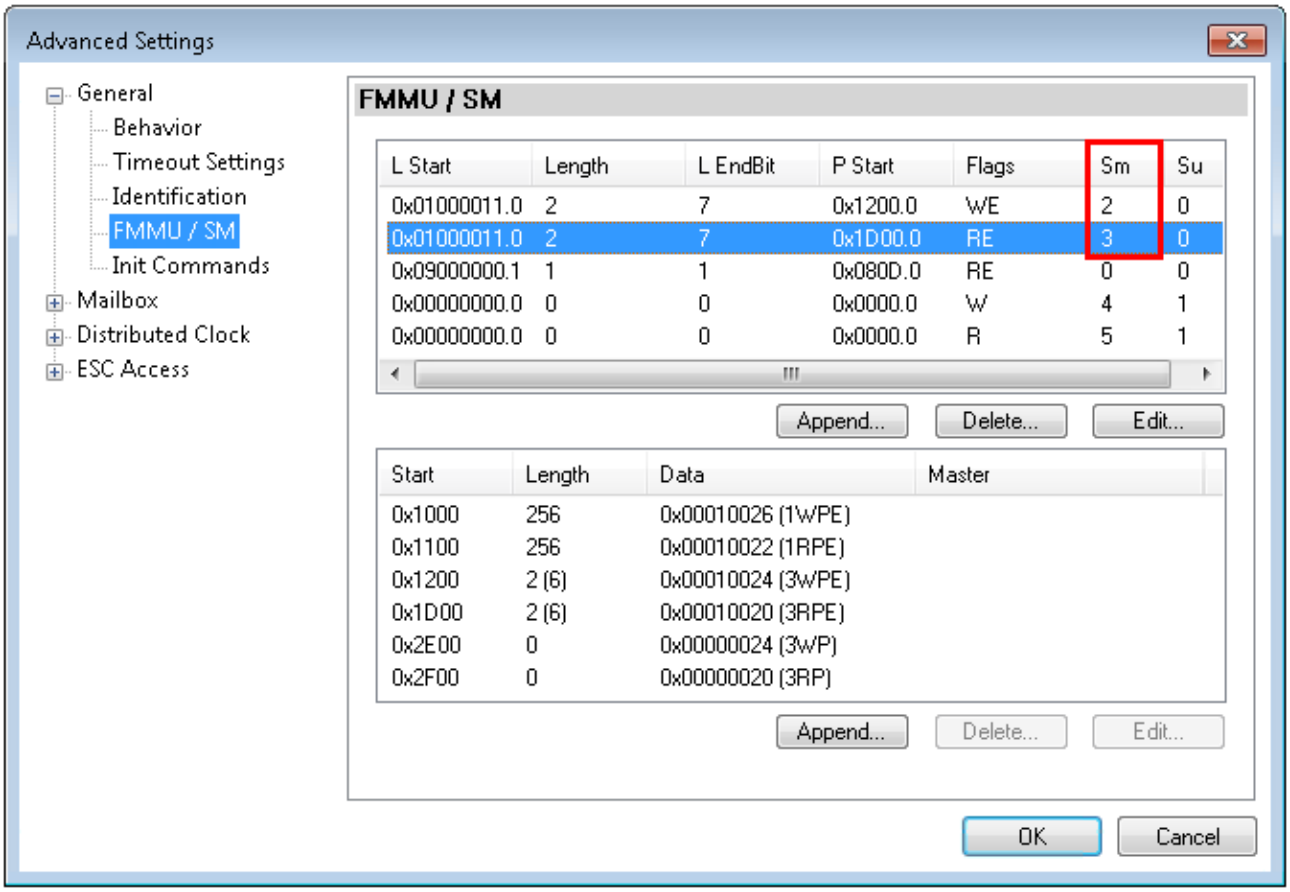


Fig. 174: Sync Manager settings

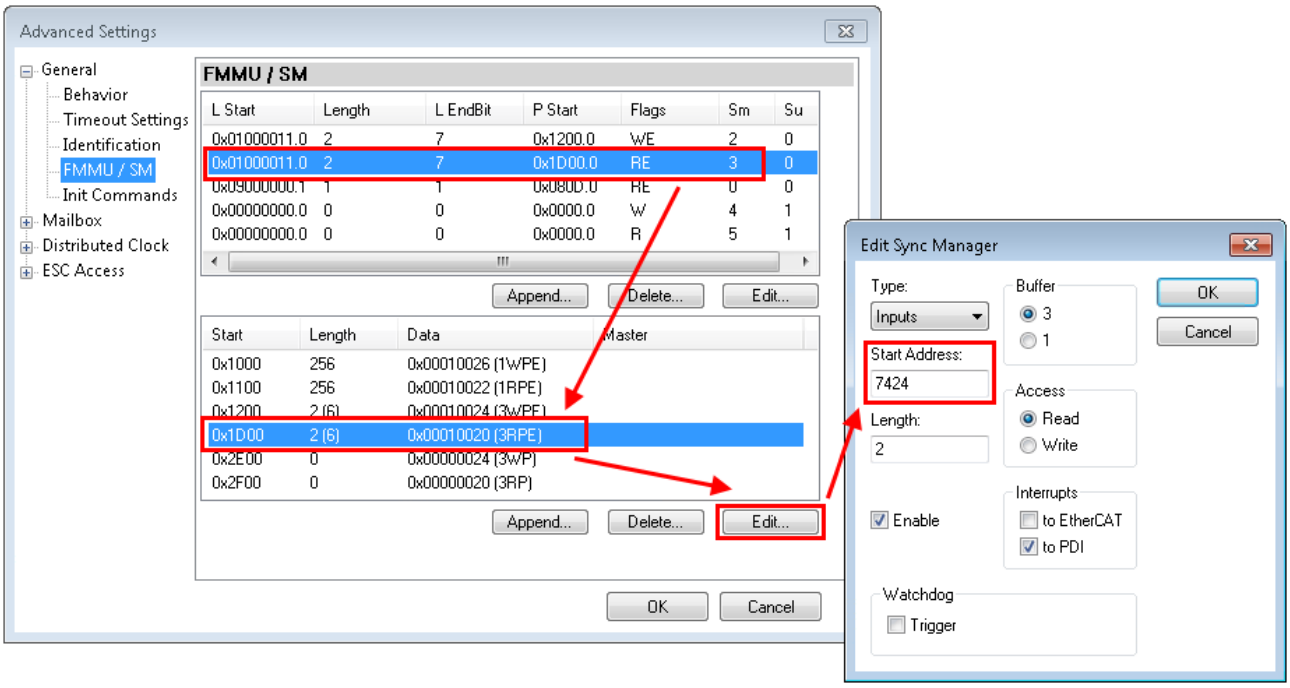


Fig. 175: Setting the start address for SM3

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.

4.18 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.

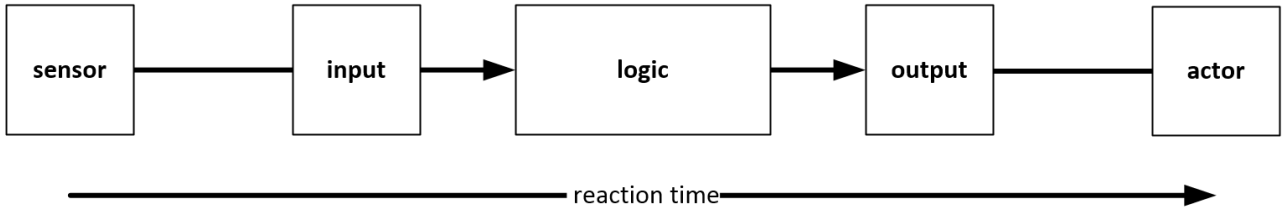


Fig. 176: Reaction time of local signals

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:

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

4.19 TwinSAFE reaction times

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

Typical reaction time

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

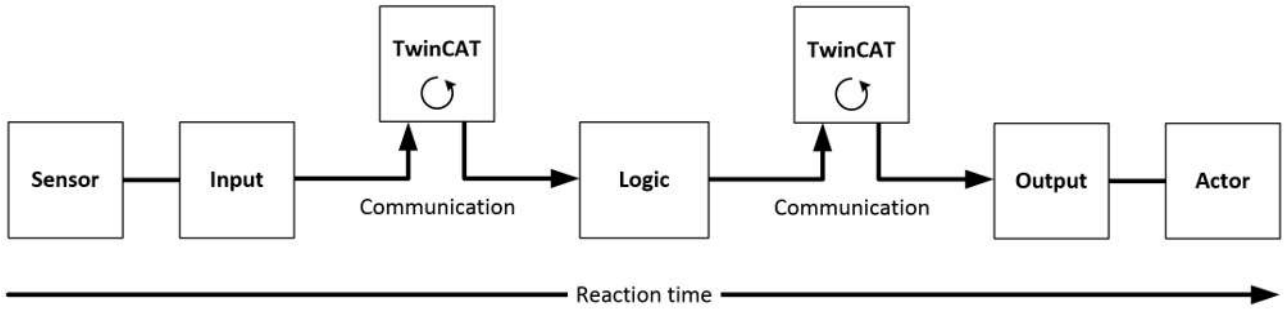


Fig. 177: Typical reaction time

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

This results in the following equation for the typical reaction time:

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

with, for example

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

Worst-case reaction time

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

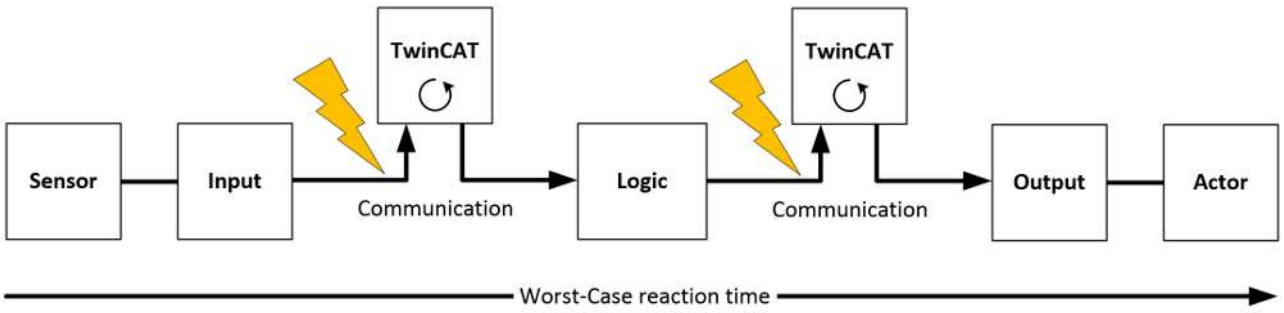


Fig. 178: Worst-case reaction time

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

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

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

with, for example

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

4.20 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 [▶ 32].

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 0xFEA0:09)	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.

4.21 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.

4.22 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 [▶ 120]).

4.22.1 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!

4.23 Service life

The TwinSAFE compact controllers have a service life of 20 years.

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

The TwinSAFE controllers carry a data code, which is composed as follows:

Date Code: CW YY SW HW

Legend		Example: Datecode 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 DateCode are lasered on the front of the device. Postal address and model name are lasered on the back.

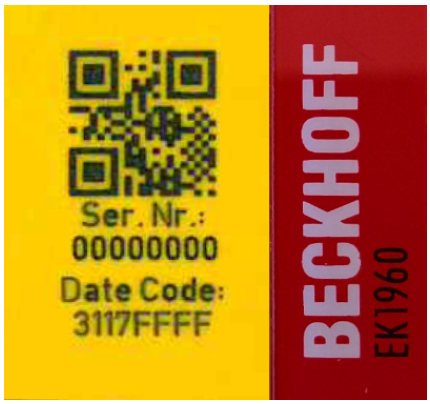


Fig. 179: EK1960: Laser image - serial number / data code

Fig. 180: EK1960: Laser image on the back side

4.23.1 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.

4.24 Firmware update of TwinSAFE products

For TwinSAFE products there is the option of performing a firmware update via the EtherCAT interface. The complete firmware of the TwinSAFE component is deleted and replaced by a new version.

The latest firmware can be downloaded from the Beckhoff website or requested from Beckhoff Support. The versions are available in an encrypted form and can only be loaded onto the matching TwinSAFE product. An incorrect firmware file is rejected by the respective TwinSAFE product.

Prerequisite for a firmware update

⚠ DANGER

Put the machine into a safe state!

A firmware update stops the current processing of the firmware of the TwinSAFE product. It is essential that you switch the TwinSAFE system to the safe state before you start an update.
All safe outputs must be in a safe, de-energized state. If hanging or pulling loads are present on the machine or the TwinSAFE system, these must also be brought into a safe state through external safety measures if necessary.

⚠ DANGER

Monitor the machine state!

It is necessary that you have control over the machine, i.e. you can see it and thus ensure that it is in a safe state and that a firmware update can be carried out without endangering the operators or other personnel.

NOTE

Avoid communication interruptions during the download

Please avoid disconnecting the EtherCAT connection while downloading the firmware under any circumstances. If a communication error does occur, the TwinSAFE product may subsequently be unusable and must be sent to the Beckhoff Service.

⚠ WARNING

Default project for TwinSAFE I/O components with local logic function!

After a firmware update, any implemented default project starts automatically. An EK1960, for example, would start up as a TwinSAFE I/O slave after a firmware update.

NOTE

Firmware update of TwinSAFE logics

If a firmware update is performed for a TwinSAFE logic component, e.g. on a TwinSAFE logic EL6910, the safety-related user program must be reloaded to the TwinSAFE logic after the update. After the update the user administration is set to the default settings.

EtherCAT communication

When an EtherCAT component is updated, it is switched to BOOTSTRAP mode. This can have an effect on the EtherCAT communication with other EtherCAT devices.

Performing the firmware update

Click the button (1) in the TwinCAT system to enter Config mode. Confirm the query with OK (2). After that a further window appears which must be confirmed with Yes (Ja) (3). Deactivate the "Free Run" with No (Nein) (4). The system is now in Configuration mode.

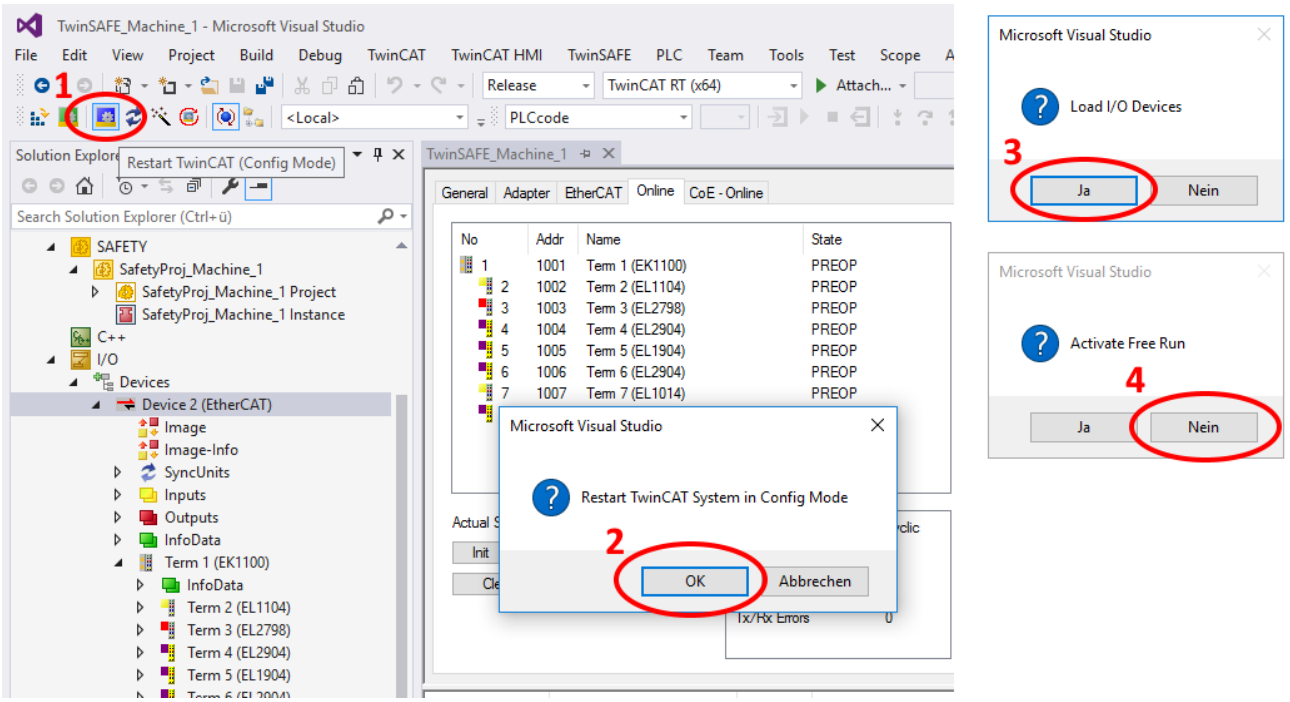


Fig. 181: Firmware update of TwinSAFE products - Part 1

To perform the firmware update, select the "Online" tab (6) for the "EtherCAT Device" (5). If you want to update several components, you can select the corresponding components (7) together; for individual components, select only these. Subsequently, click with the right mouse button inside the selected area and select the command "Firmware Update..." (8) in the command overview.

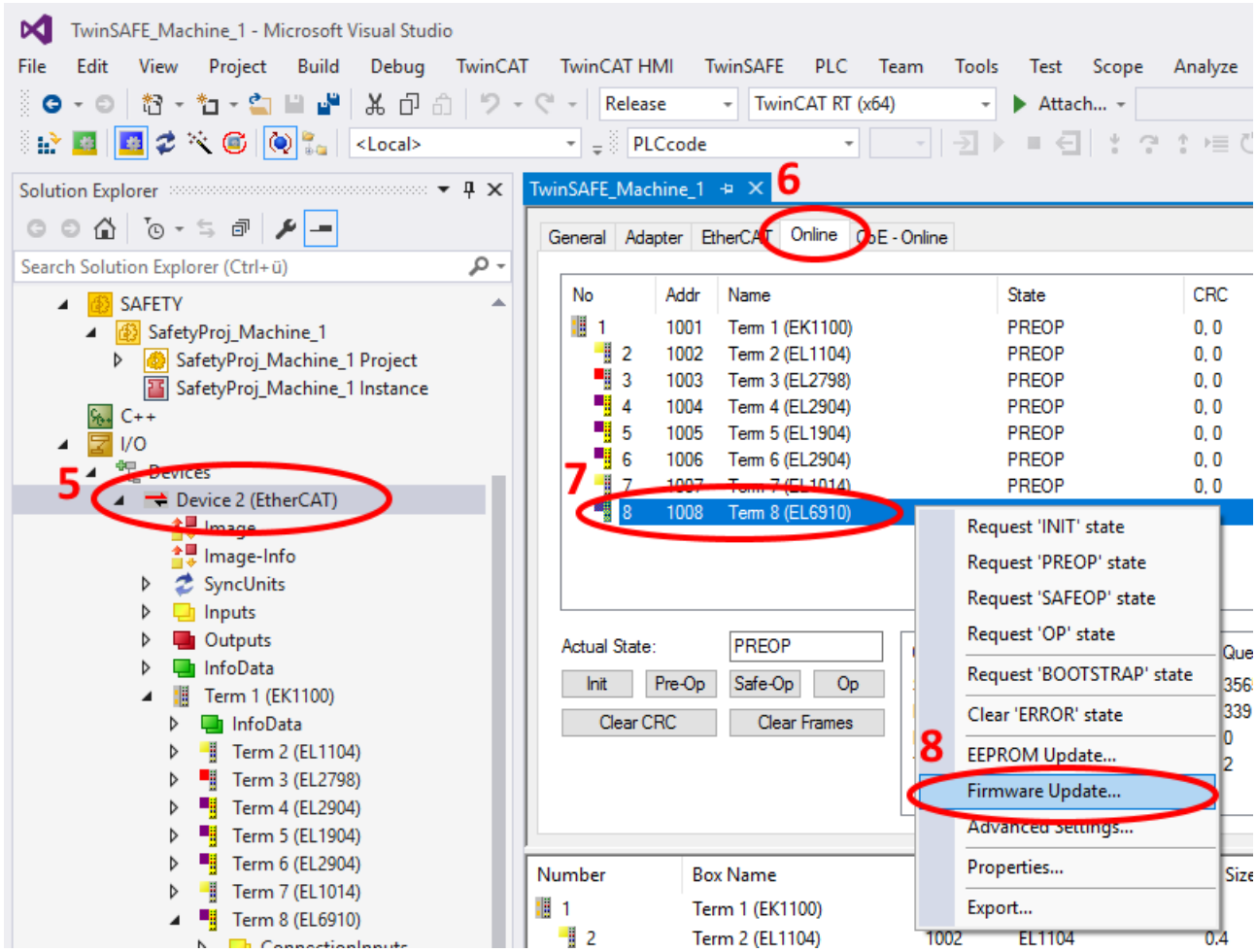


Fig. 182: Firmware update of TwinSAFE products - Part 2

In the place where you have stored the desired firmware version, select the firmware file (9) and click "Open" (10). Confirm the window that then opens with "OK" (11); the firmware update is then performed. After successful completion you must click OK (12) in the concluding "Function Succeeded" window. You can then switch the system back to Run mode and use the TwinSAFE system.

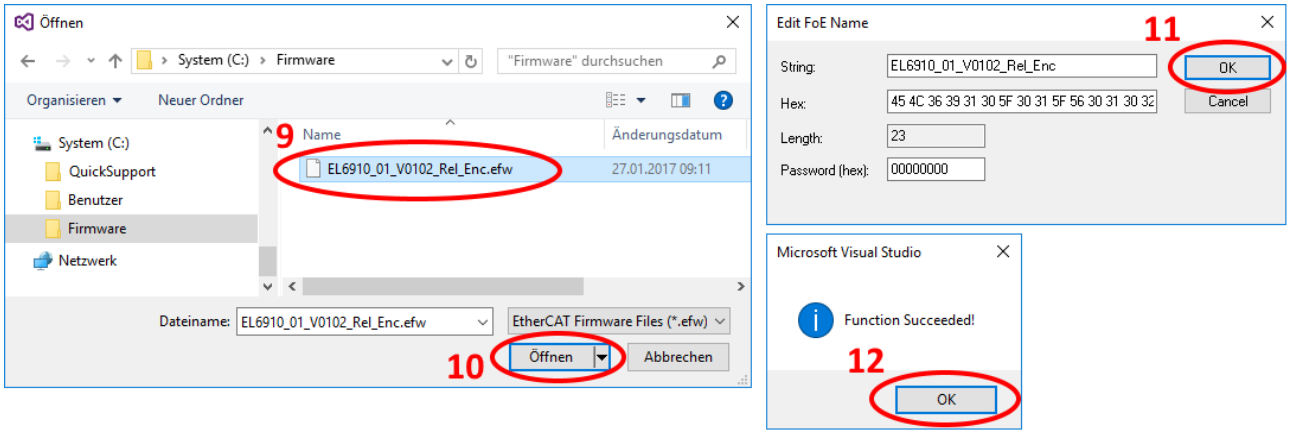


Fig. 183: Firmware update of TwinSAFE products - Part 3

5 Appendix

5.1 Support and Service

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

Beckhoff's branch offices and representatives

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

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

You will also find further documentation for Beckhoff components there.

Beckhoff Headquarters

Beckhoff Automation GmbH & Co. KG

Huelshorstweg 20
33415 Verl
Germany

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

Beckhoff Support

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

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

Hotline:	+49(0)5246/963-157
Fax:	+49(0)5246/963-9157
e-mail:	support@beckhoff.com

Beckhoff Service

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

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

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

5.2 Certificates

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

Product Service

CERTIFICATE

No. Z10 17 04 62386 036

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

Factory(ies): 62386

Certification Mark:

Product: **Safety components**
TwinSAFE-Compact-Controller

Model(s): **EK1960**

Parameters:

Supply voltage:	24VDC (-15%/+20%)
Protection class:	IP 20
Ambient temperature:	-25°C ... +55°C

Tested according to:
EN ISO 13849-1:2015 (up to Cat 4, PL e)
EN 61508-1:2010 (up to SIL 3)
EN 61508-2:2010 (up to SIL 3)
EN 61508-3:2010 (up to SIL 3)
EN 61508-4:2010 (up to SIL 3)
EN 62061:2005/A2:2015 (up to SILCL 3)

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

Test report no.: BV90899T

Valid until: 2022-04-20

719811

Date, 2017-04-21 (Christian Dirmeier)

Page 1 of 1

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

TÜV®

A1 / 04.11

List of figures