



PNOZ m EF EtherCAT FSoE KUKA KRC5

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Product

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August 2025

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Abbreviations

Abbreviation / term	Description	Source
AN	A pplication N ote	 AN content (1002400)">www.pilz.com > AN content (1002400)
PNOZ	Pilz E-STOP positive-guided (DE: P ilz N OT-AUS- Z wangsgeführt)	 PNOZ">www.pilz.com > PNOZ
PSS	Programmable control system (DE: P rogrammierbares S teuerungssystem)	 PSS">www.pilz.com > PSS
PSS u2	PSS universal, 2 nd generation	 PSS u2">www.pilz.com > PSS u2
POU	P rogram O rganisation U nit	
NC	N ormally C losed	
NO	N ormally O pen	
FSoE	F ail S afe o ver E therCAT	
CoE	C AN application protocol o ver E therCAT	
MDevice	M ain D evice	
SubDevice	S ubordinary D evice	
FSoE MInstance	FS o E M ain I nstance	
FSoE SubInstance	FS o E S ubordinary I nstance	
ESI-Datei	E terCAT S lave I nformation	 ESI">www.ethercat.org > ESI

Definition of Symbols

► Information that is particularly important is identified as follows:



CAUTION!

This refers to a hazard that can lead to a less serious or minor injury plus material damage and also provides information on preventive measures that can be taken.



NOTICE

This describes a situation in which the product or devices could be damaged and also provides information on preventive measures that can be taken. It also highlights areas within the text that are of particular importance.



INFORMATION

This gives advice on applications and provides information on special features.

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1 Useful documentation

Reading the documentation listed below is necessary for understanding this Application Note. The availability of the software used, and its safe handling are also presupposed for the user.

1.1 Documentation from Pilz GmbH & Co. KG

No.	Description	Item No. /Download
1	Pilz international homepage, download section	www.pilz.com
2	Operating Manual PNOZmulti 2 Communication interfaces 1002971-EN-xx	 1002971">www.pilz.com > 1002971
3	Operating Manual PNOZ m EF EtherCAT FSoE 1006493 -EN-xx	 1006493">www.pilz.com > 1006493
4	Operating Manual PNOZ m B1 1003790	 1003790">www.pilz.com > 1003790
5	System description PNOZmulti system expansion 1002217-EN-xx	 1002217">www.pilz.com > 1002217
6	Aplication Note PNOZ m EF EtherCAT FSoE mit TwinCAT 3 und CODESYS 3.5 1006828-EN-XX	 1006828">www.pilz.com > 1006828

1.2 Documentation from other sources of information

No.	Description	Item No. / Download
1	Beckhoff Information System	Beckhoff Information System
2	Official CODESYS-help page	CODESYS Online Help
3	Communication between KRC5 (EL6695-1001 secRev04) und Beckhoff PLC	SS5081 / KUKA Xpert

2 Used hardware and software

2.1 Pilz products

No.	Descriptions	Order number	Version	Number
1	PNOZ m B1	772101	V1.11	1
2	PNOZ m EF EtherCAT FSoE	772123	V1.0	1
3	Industrial PI 4	A1000003	--	1
4	PNOZmulti Configurator	--	V11.5	--

2.2 Third-party products

No.	Descriptions	Order number	Version	Number
1	Beckhoff CX5020 with TwinCAT 3	--	--	1
2	Beckhoff EK1100	--	--	1
3	Beckhoff EtherCAT-Bridge KUKA	EL6695-1001	ab Revision 04	1
4	KUKA KRC5 Robot control system	--	--	1
5	Beckhoff TwinCAT 3	--	v3.1.4024.	--
6	CODESYS	--	V3.5.20 Patch 4	--

2.3 Structure of the application (schematic)

2.3.1 Setup without external EtherCAT Main Device

The description can be found in [chapter 6.1](#), [chapter 7](#).

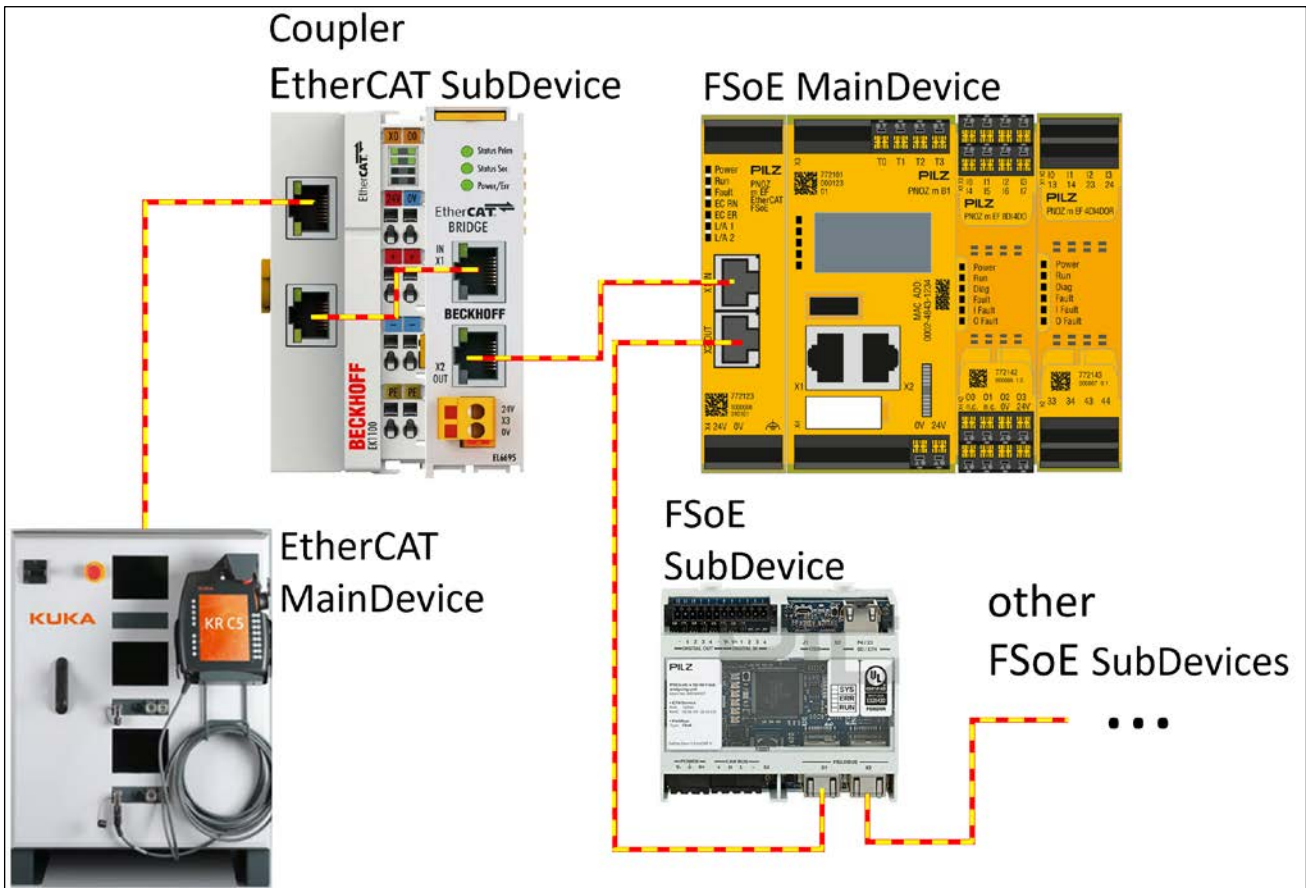


Figure 1: Application without external EtherCAT Main Device

2.3.2 Setup with external EtherCAT Main Device

The description can be found in [chapter 6.2](#), [chapter 7](#) and [chapter 8](#)

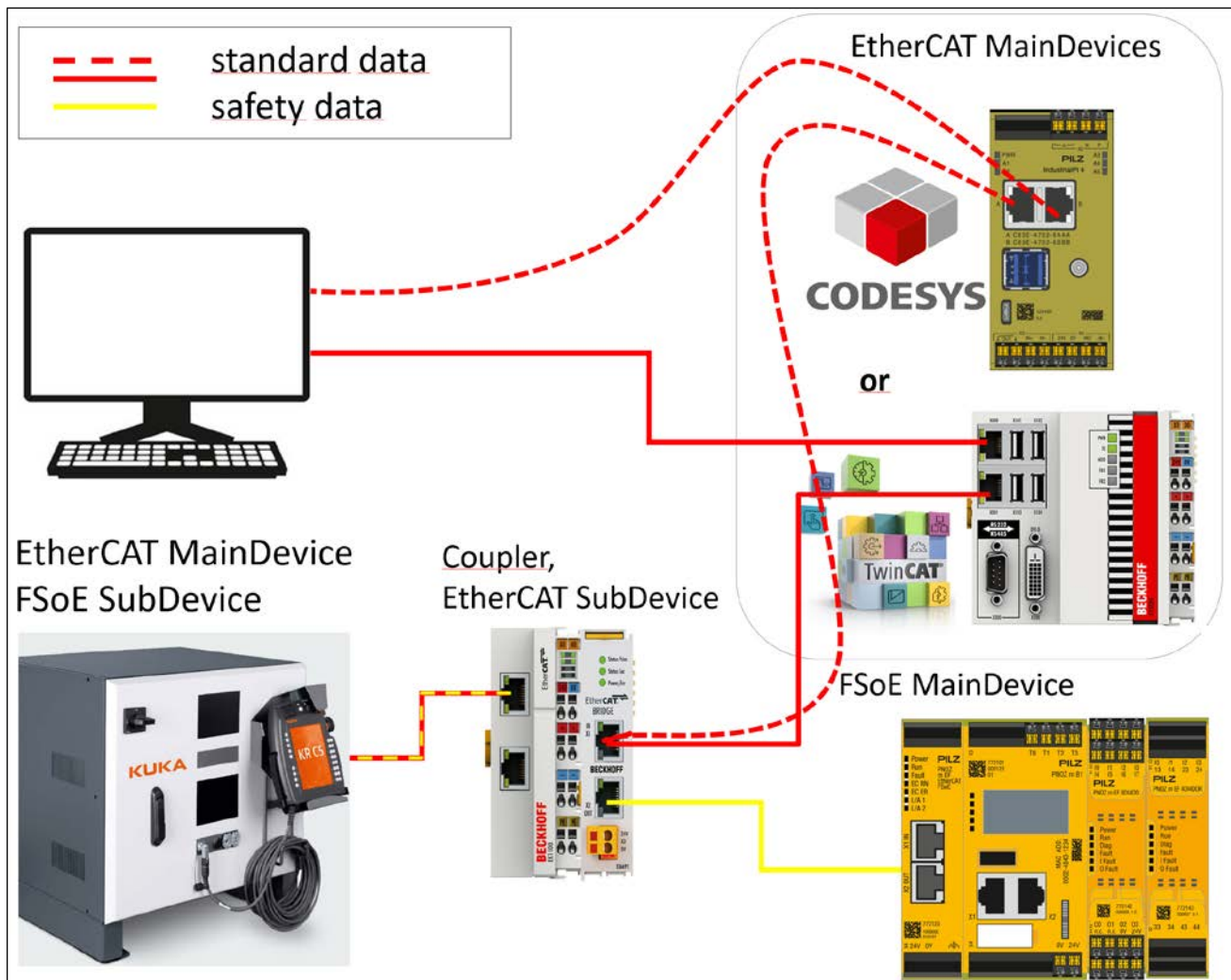


Figure 2: Application with external EtherCAT Main Device

3 Preface

With the aid of the respective development environment, this application note basically describes the commissioning of the module PNOZ m EF EtherCAT FSoE with the KUKA robot controller KRC5 as EtherCAT MainInstance, in [chapter 6.1](#), [chapter 7](#) and PNOZ m EF EtherCAT FSoE with the KUKA robot controller KRC5 on a Beckhoff TwinCAT 3 or CODESYS PLC in [chapter 6.2](#), [chapter 7](#) and [chapter 8](#). The basic step-by-step procedure for a successful basic configuration is shown here, mostly in pictures.

This description is equally applicable to the KUKA robot controllers KRC4 and KRC5. Unless otherwise stated, the functions and processes described apply equally to both controller generations.

**NOTICE**

The "PNOZ m EF EtherCAT FSoE" module can only be connected to the PNOZ m B1.

A detailed explanation of the safety functions employed in the failsafe application and their evaluation in terms of functional safety are not part of this document.

This document is not technical documentation for general use of the software "TwinCAT3" from Beckhoff, "CODESYS" from the CODESYS Group and "Work Visual" from KUKA.

**INFORMATION**

The ETG (EtherCAT Technology Group) has replaced the terms Master and Slave.

This change has already been taken into account in the application note; the screenshots for the tools still contain the previous terms.

Old terminology	New name	New terminology
Master device	MainDevice	MDevice
Slave device	SubordinaryDevice	SubDevice
Master instance	FSoE MainInstance	FSoE MInstance
Slave instance	FSoE SubordinaryInstance	FSoE SubInstance

Figure 3: Terminology adjustment

4 Properties of the module PNOZ m EF EtherCAT FSoE

4.1 MDevice / SubDevice

The module PNOZ m EF EtherCAT FSoE is part of an EtherCAT network and acts as a SubDevice, and simultaneously as an FSoE MInstance and FSoE SubInstance.

In the EtherCAT network, the data is received and sent in the module PNOZ m EF EtherCAT FSoE (SubDevice). The module PNOZ m EF EtherCAT FSoE provides standard and failsafe data.

For more information, please refer to the operating manual.



NOTICE

As the module PNOZ m EF EtherCAT FSoE has no MDevice functionality, it is necessary to integrate an MDevice into the network.

The MDevices in this application note are:

- KUKA robot controller KRC5,
- Beckhoff TwinCAT3 PLC or
- CODESYS PLC.

4.2 FSoE MInstance / FSoE SubInstance

The module PNOZ m EF EtherCAT FSoE can be configured as FSoE MInstance and FSoE SubInstance.

- ▶ Up to 60 connections can be configured as an FSoE MInstance, a maximum of 512 Bits of failsafe input and 512 Bits of failsafe output data can be transmitted.
- ▶ Up to 4 connections can be configured as FSoE SubInstance.



NOTICE

System limits of the module PNOZ m EF EtherCAT FSoE

Number of Connections	min. per Connection	max. per Connection	max. per FSoE MInstance
60 FSoE MInstance to FSoE SubInstance	8 Bit Fail-Safe Inputs	16 Byte Fail-Safe Inputs	512 Bit Fail-Safe Inputs
4 as an FSoE SubInstance	and 8 Bit Fail-Safe Outputs	and 16 Bytes Fail-Safe Outputs	and 512 Bit Fail-Safe Outputs

Figure 4: PNOZ m EF EtherCAT FSoE – Overview of system limits

4.3 Network topology

The MDevices, the SubDevices, the FSoE MInstance and the FSoE SubInstance are all distributed across two networks. These are connected to each other via the EtherCAT Coupler and the EtherCAT Bridge KUKA EL6695-1001. From the perspective of the MDevice, the FSoE MInstance is a SubDevice.

The structure is shown schematically in the [chapter 2.3](#).

5 Properties of the module EL6695-1001 EtherCAT Bridge

5.1 FSoE MInstance / FSoE SubInstance

The EtherCAT Bridge FSoE can be used to establish safe communication between a third-party controller (e.g. PLC) and a KRC5. The third-party controller is the FSoE MainInstance and the KRC5 is the FSoE SubInstance.

5.2 Hardware configuration

The EtherCAT Bridge FSoE consists of a bus coupler and the EtherCAT Bridge terminal. The controller that is connected to the bus coupler is the primary controller. The controller that is connected to the bridge terminal is the secondary controller. Which controller is configured as primary or secondary depends on the bus line in which the bridge terminal is installed.



NOTICE

Safe communication is only possible with the EtherCAT bridge terminal EL6695-1001. If the EtherCAT bridge terminal EL6695-0000 from Beckhoff is used, only **non-safety**-related I/O data can be exchanged.

To use safe communication via FSoE, the robot controller must be connected on the primary side of the EtherCAT Bridge terminal EL6695-1001.

The EtherCAT Bridge EL6695-1001 must have at least revision 04, HW05 and FW08.

► Outputs on the primary side are inputs on the secondary side and vice versa.

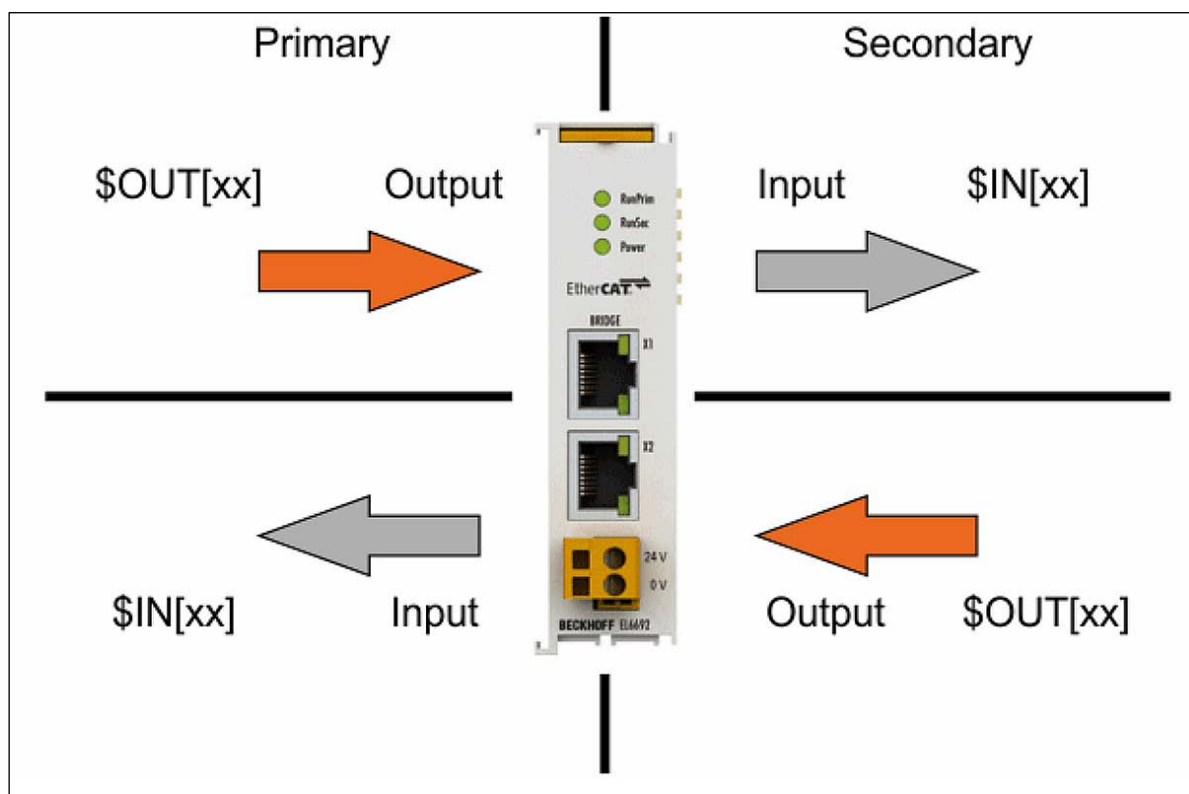


Figure 5: Primary and secondary side

6 Configuration in "WorkVisual"



INFORMATION

The device description files must be obtained from the manufacturer and imported into the development environments

The device description file for the bridge terminal EL6695-1001 with the name Kuka_EL6695prim.xml can be obtained from KUKA.

Information on processes in WorkVisual can be found in the WorkVisual documentation.

6.1 Application without external EtherCAT MDevice



NOTICE

The primary side must be connected to the secondary side via the network (patch cable), see Figure 1.

- ▶ To ensure that the configuration works without an external EtherCAT Main Device, the KRC4 EL6695-1001 is connected to the PNOZ m EF EtherCAT FSoE on the secondary side, where the safety program then runs.
- ▶ The PNOZ m EF EtherCAT FSoE module is an FSoE MainInstance but an EtherCAT SubInstance.
- ▶ The KRC4 EL6695-1001 must be integrated into "WorkVisual" on the primary and secondary side and configured in the same way.
- ▶ The safe signals are thus mapped from the secondary side to the primary side and vice versa.

6.1.1 Configuration without FSoE SubDevice

6.1.1.1 Bus configuration

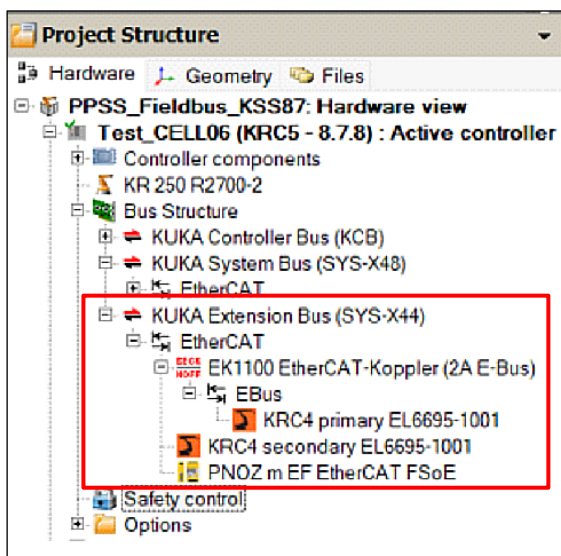


Figure 6: Configuration of the modules on the KUKA Extension Bus

- ▶ Restart after error should be set to automatic.

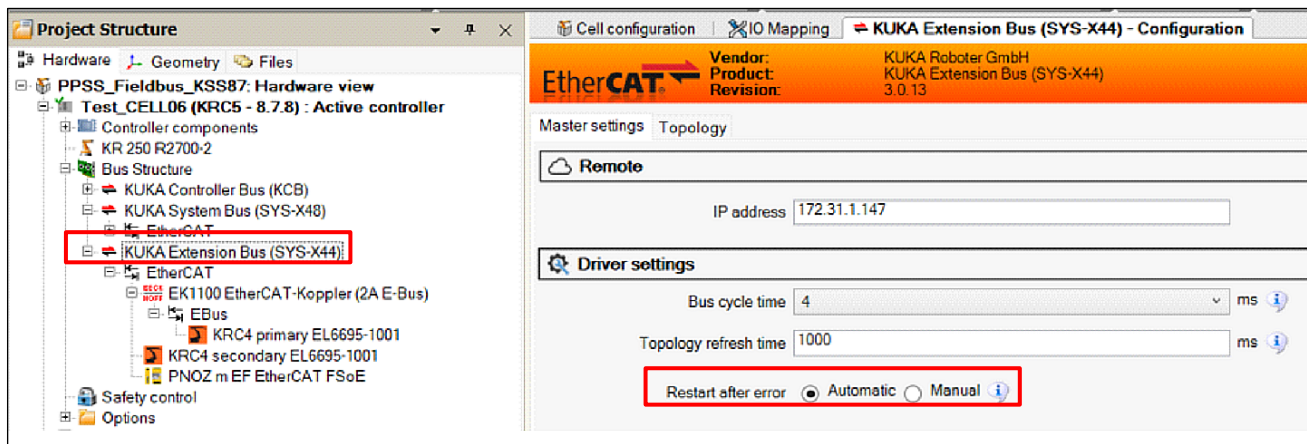


Figure 7: EtherCAT Main Instance settings

- ▶ No adjustment is normally necessary in the topology.

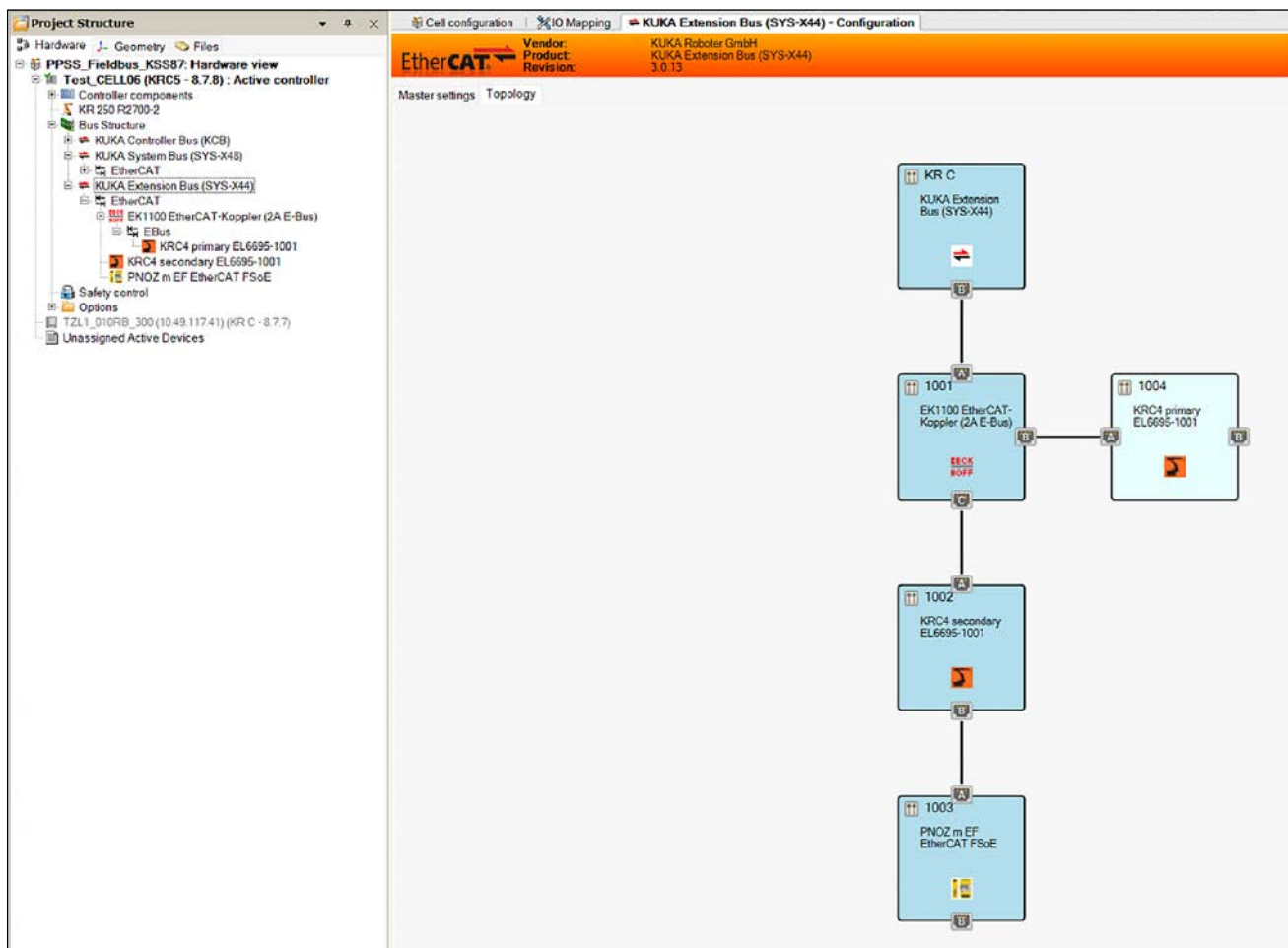


Figure 8: EtherCAT topology

- ▶ Set FSoE address for the robot controller (default: 8504dez)

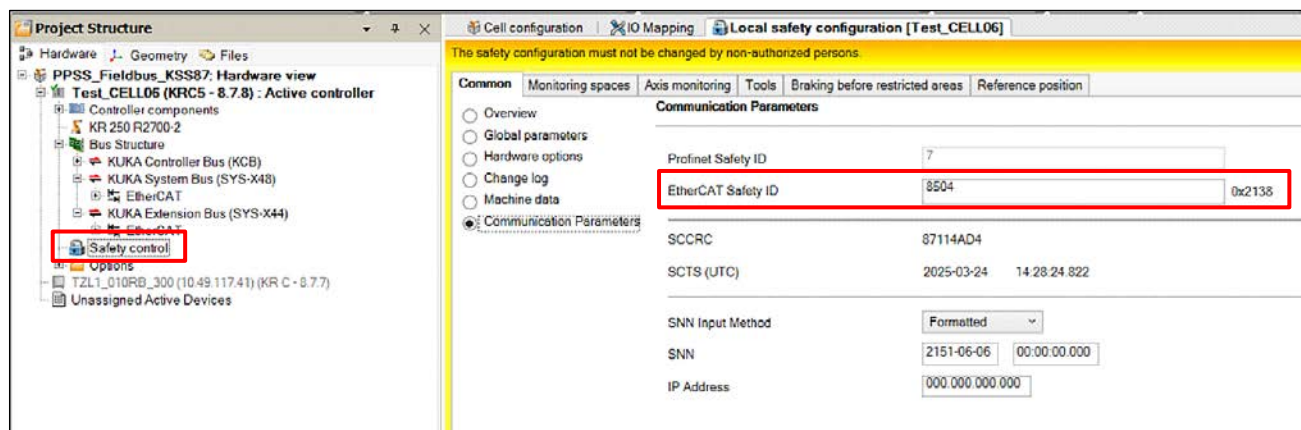


Figure 9: FSoE address robot controller

6.1.1.2 Settings for KRC4 primary EL6695-1001

- ▶ The settings for the KRC4 primary EL6695-1001 and KRC4 secondary EL6695-1001 must match.
- ▶ Tick the box as shown in the figure below
 - EL6695 SYNC Inputs
 - Safety inputs (8 Byte)
 - Std. In (4 Byte)
 - Safety outputs (8 Byte)
 - Std. Out (4 Byte)

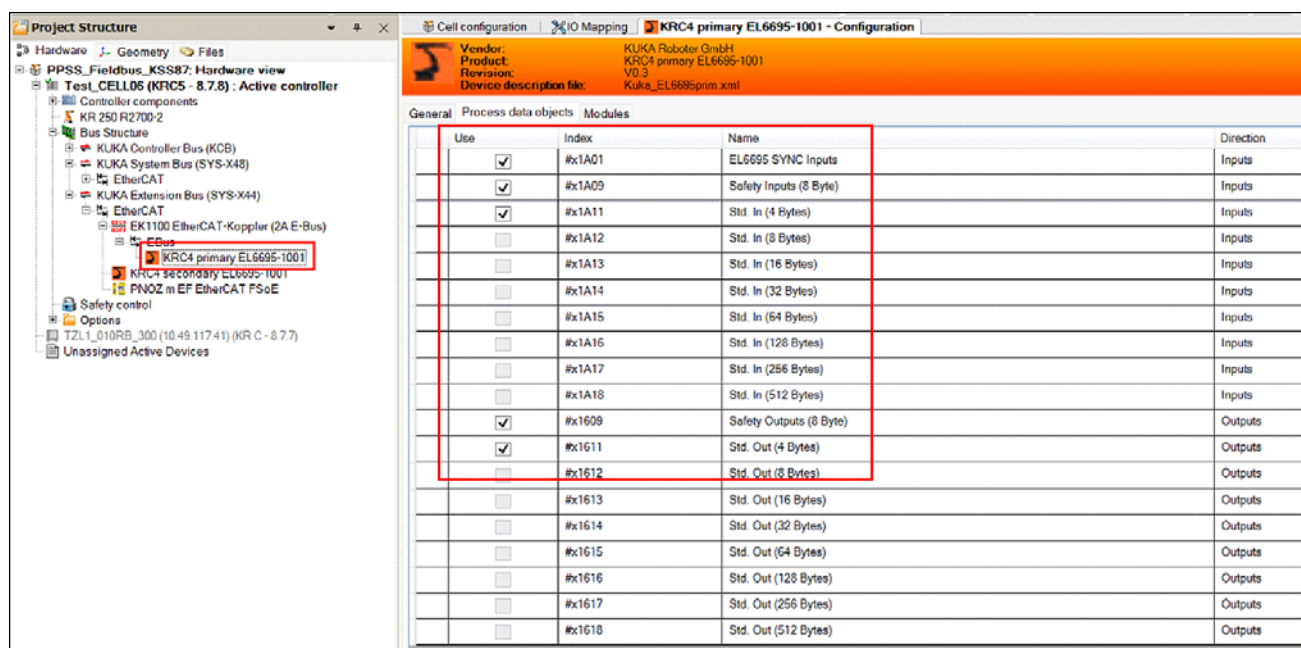


Figure 10: "Primary" settings

6.1.1.3 Settings for KRC4 secondary EL6695-1001

- ▶ The settings for the KRC4 secondary EL6695-1001 and KRC4 primary EL6695-1001 must match.
 - Slot 001: Sync Inputs Compact
 - Slot 002: Safety Data Bitf (8 Byte) Safety Robot
 - Slot 003: Default IO Std. IO 4 Byte

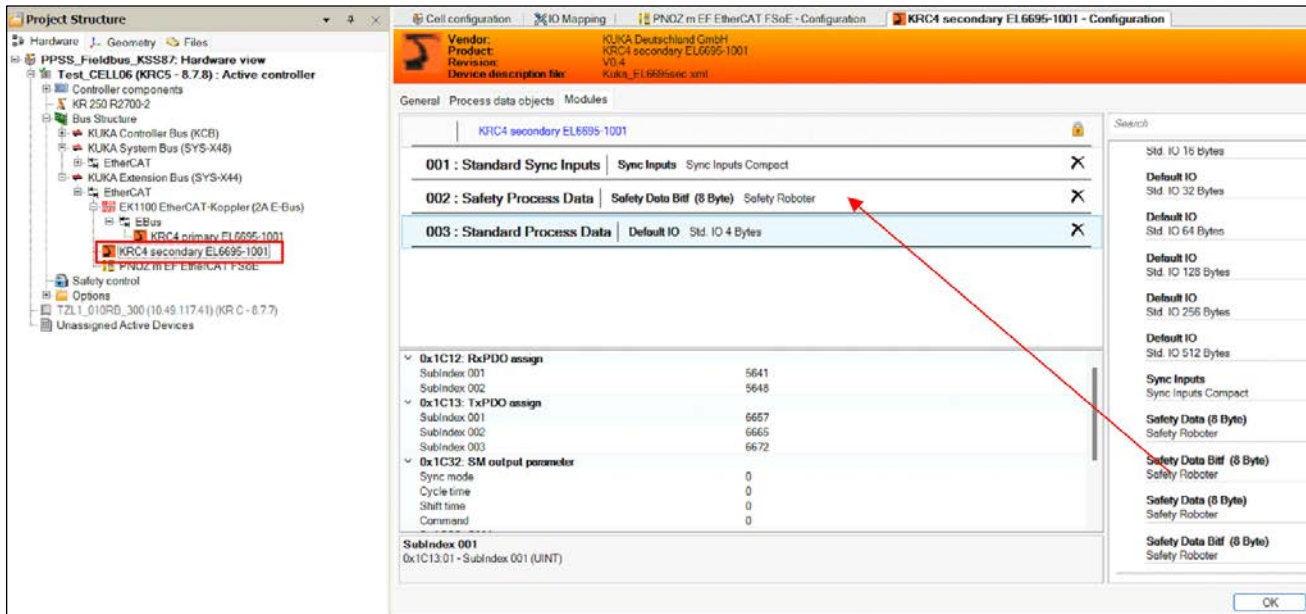


Figure 11: "Secondary" settings

6.1.1.4 Settings for the PNOZ m EF EtherCAT FSoE

- ▶ The size of the inputs and outputs on the PNOZ m EF EtherCAT FSoE must match the settings for the KRC4 secondary EL6695-1001 (Slot 002: Safety Data Bitf (8 Byte) Safety Robot).
- ▶ Insert the corresponding Pilz FSoE Master module:
 - Slot 001: FSoE_M_8BYTE_IN_8BYTE_OUT

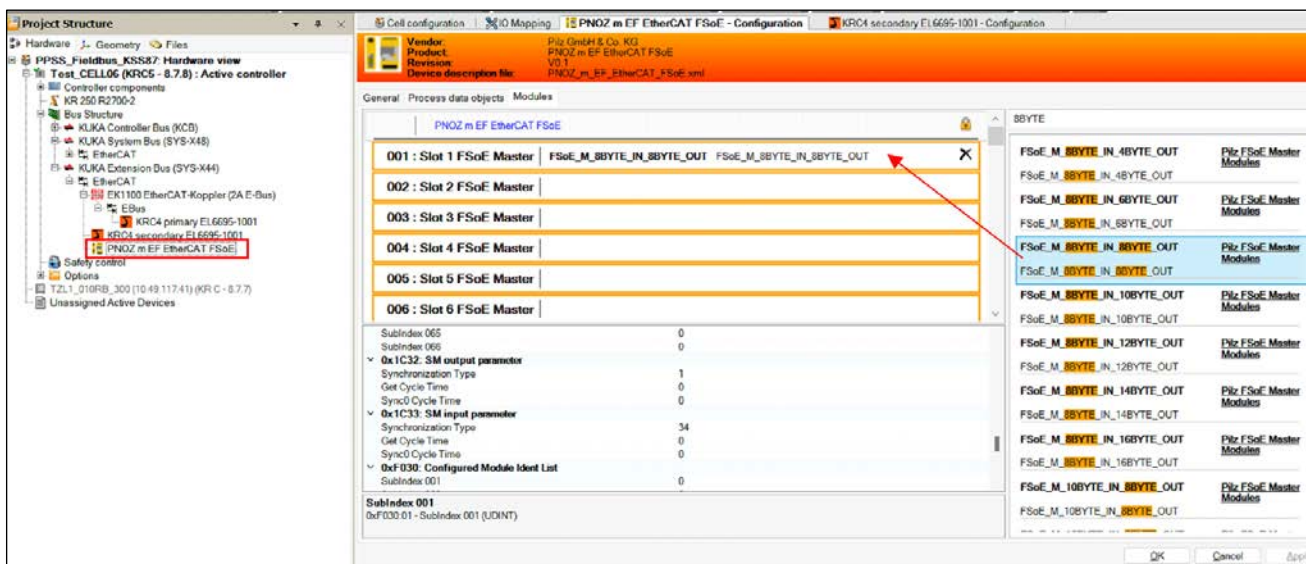
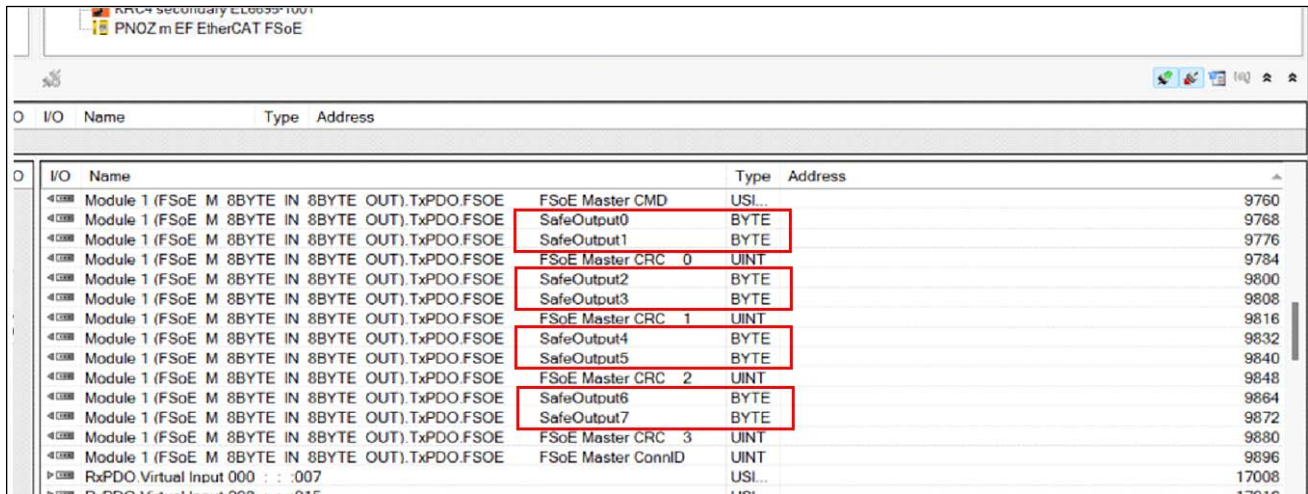


Figure 12: Modules PNOZ m EF EtherCAT FSoE

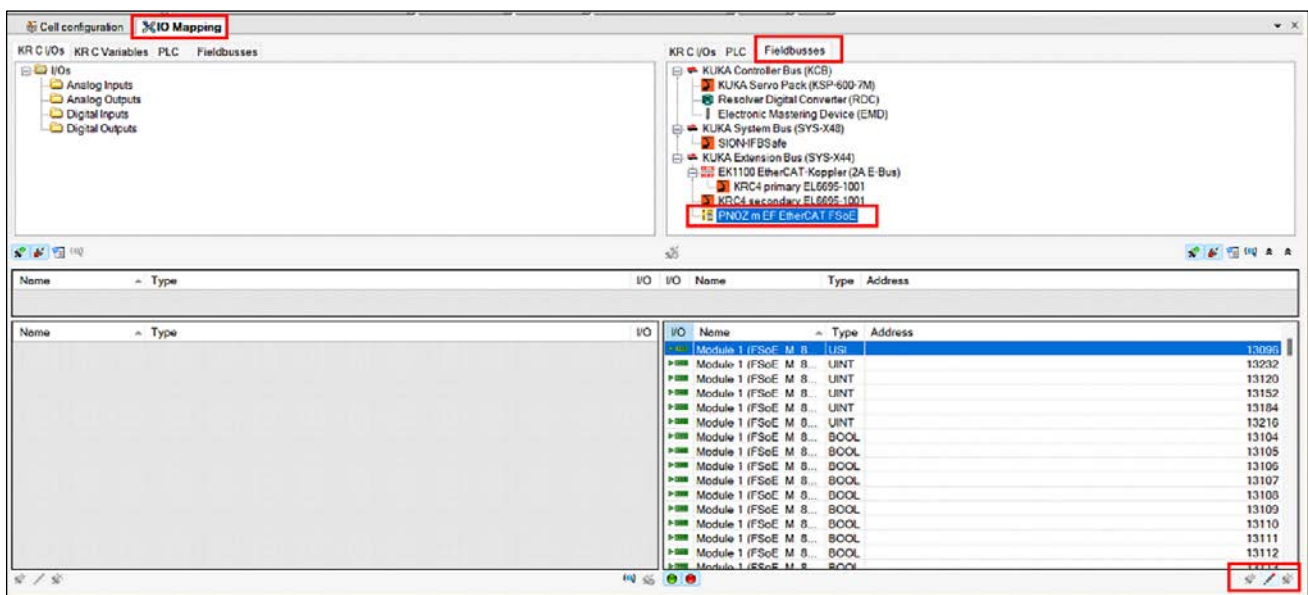
- For simpler IO mapping, all 6 SafeOutputX and 6 SafeInputX BYTES must be split into BITS on PNOZ m EF EtherCAT FSoE module 1.



I/O	Name	Type	Address
Module 1 (FSoE M 8BYTE IN 8BYTE OUT).TxPDO.FSoE	FSoE Master CMD	USI...	9760
Module 1 (FSoE M 8BYTE IN 8BYTE OUT).TxPDO.FSoE	SafeOutput0	BYTE	9768
Module 1 (FSoE M 8BYTE IN 8BYTE OUT).TxPDO.FSoE	SafeOutput1	BYTE	9776
Module 1 (FSoE M 8BYTE IN 8BYTE OUT).TxPDO.FSoE	FSoE Master CRC 0	UINT	9784
Module 1 (FSoE M 8BYTE IN 8BYTE OUT).TxPDO.FSoE	SafeOutput2	BYTE	9800
Module 1 (FSoE M 8BYTE IN 8BYTE OUT).TxPDO.FSoE	SafeOutput3	BYTE	9808
Module 1 (FSoE M 8BYTE IN 8BYTE OUT).TxPDO.FSoE	FSoE Master CRC 1	UINT	9816
Module 1 (FSoE M 8BYTE IN 8BYTE OUT).TxPDO.FSoE	SafeOutput4	BYTE	9832
Module 1 (FSoE M 8BYTE IN 8BYTE OUT).TxPDO.FSoE	SafeOutput5	BYTE	9840
Module 1 (FSoE M 8BYTE IN 8BYTE OUT).TxPDO.FSoE	FSoE Master CRC 2	UINT	9848
Module 1 (FSoE M 8BYTE IN 8BYTE OUT).TxPDO.FSoE	SafeOutput6	BYTE	9864
Module 1 (FSoE M 8BYTE IN 8BYTE OUT).TxPDO.FSoE	SafeOutput7	BYTE	9872
Module 1 (FSoE M 8BYTE IN 8BYTE OUT).TxPDO.FSoE	FSoE Master CRC 3	UINT	9880
Module 1 (FSoE M 8BYTE IN 8BYTE OUT).TxPDO.FSoE	FSoE Master ConnID	UINT	9896
RxPDO Virtual Input 000 : : 007			17008

Figure 13: Splitting SafeOut and SafeIn Bytes into Bits

- Splitting is achieved via the signal editor (select PNOZ m EF EtherCAT FSoE on the **right-hand side**).



Name	Type	I/O	Name	Type	Address
Module 1 (FSoE M 8...	UINT		Module 1 (FSoE M 8...	UINT	13096
Module 1 (FSoE M 8...	UINT		Module 1 (FSoE M 8...	UINT	13092
Module 1 (FSoE M 8...	UINT		Module 1 (FSoE M 8...	UINT	13120
Module 1 (FSoE M 8...	UINT		Module 1 (FSoE M 8...	UINT	13152
Module 1 (FSoE M 8...	UINT		Module 1 (FSoE M 8...	UINT	13184
Module 1 (FSoE M 8...	UINT		Module 1 (FSoE M 8...	UINT	13216
Module 1 (FSoE M 8...	BOOL		Module 1 (FSoE M 8...	BOOL	13104
Module 1 (FSoE M 8...	BOOL		Module 1 (FSoE M 8...	BOOL	13105
Module 1 (FSoE M 8...	BOOL		Module 1 (FSoE M 8...	BOOL	13106
Module 1 (FSoE M 8...	BOOL		Module 1 (FSoE M 8...	BOOL	13107
Module 1 (FSoE M 8...	BOOL		Module 1 (FSoE M 8...	BOOL	13108
Module 1 (FSoE M 8...	BOOL		Module 1 (FSoE M 8...	BOOL	13109
Module 1 (FSoE M 8...	BOOL		Module 1 (FSoE M 8...	BOOL	13110
Module 1 (FSoE M 8...	BOOL		Module 1 (FSoE M 8...	BOOL	13111
Module 1 (FSoE M 8...	BOOL		Module 1 (FSoE M 8...	BOOL	13112
Module 1 (FSoE M 8...	BOOL		Module 1 (FSoE M 8...	BOOL	13113

Figure 14: Signal selection

▶ Right mouse button → "Split Signal"

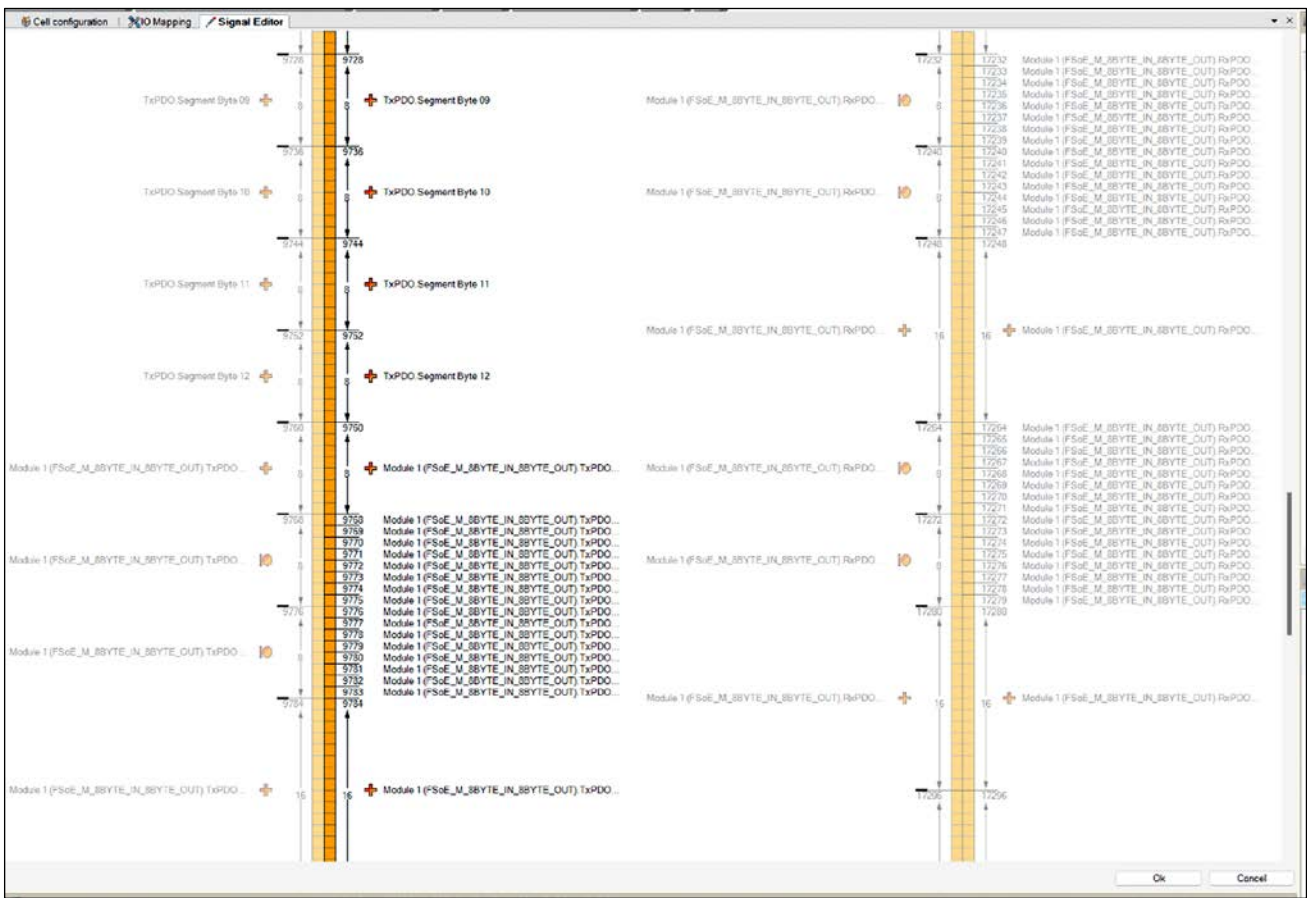


Figure 15: Signal editor

- ▶ Connect fieldbus inputs and outputs of KRC4 secondary EL6695-1001 and PNOZ m EF EtherCAT FSoE via "IO mapping".
- ▶ Selection left KRC4 secondary EL6695-1001 / right PNOZ m EF EtherCAT FSoE.
- ▶ Sort via the "Address" column, so that the signals are in the correct order. Then connect one to one.

The screenshot displays the 'IO Mapping' interface in the WorkVisual software. The left pane shows a hierarchical tree of components, with 'KRC4 secondary EL6695-1001' highlighted. The right pane lists available fieldbuses, including 'PNOZ m EF EtherCAT FSoE'. Below these panes, two tables are shown for mapping I/O signals. The 'I/O' table lists modules and their addresses, while the 'IO' table lists specific input and output signals. A red arrow indicates the selection of 'KRC4 secondary EL6695-1001' from the tree.

Name	Type	Address	I/O	Name	Type	Address
Module 2 (Safety Data...	USI	9320		Module 1 (FSoE M. 8...	USI	17165
Module 2 (Safety Data...	UNT	9456		Module 1 (FSoE M. 8...	UNT	17296
Module 2 (Safety Data...	BOOL	9329		Module 1 (FSoE M. 8...	BOOL	17169
Module 2 (Safety Data...	BOOL	9337		Module 1 (FSoE M. 8...	BOOL	17177
Module 2 (Safety Data...	BOOL	9333		Module 1 (FSoE M. 8...	BOOL	17173
Module 2 (Safety Data...	BOOL	9330		Module 1 (FSoE M. 8...	BOOL	17170
Module 2 (Safety Data...	BOOL	9336		Module 1 (FSoE M. 8...	BOOL	17176
Module 2 (Safety Data...	BOOL	9328		Module 1 (FSoE M. 8...	BOOL	17168
Module 2 (Safety Data...	BOOL	9332		Module 1 (FSoE M. 8...	BOOL	17172
Module 2 (Safety Data...	BOOL	9342		Module 1 (FSoE M. 8...	BOOL	17182
Module 2 (Safety Data...	BOOL	9340		Module 1 (FSoE M. 8...	BOOL	17180
Module 2 (Safety Data...	BOOL	9341		Module 1 (FSoE M. 8...	BOOL	17181
Module 2 (Safety Data...	BOOL	9338		Module 1 (FSoE M. 8...	BOOL	17178
Module 2 (Safety Data...	BOOL	9339		Module 1 (FSoE M. 8...	BOOL	17179
Module 2 (Safety Data...	BOOL	9343		Module 1 (FSoE M. 8...	BOOL	17183
Module 2 (Safety Data...	BOOL	9334		Module 1 (FSoE M. 8...	BOOL	17174
Module 2 (Safety Data...	BOOL	9335		Module 1 (FSoE M. 8...	BOOL	17175
Module 2 (Safety Data...	BOOL	9331		Module 1 (FSoE M. 8...	BOOL	17171
Module 2 (Safety Data...	BOOL	9362		Module 1 (FSoE M. 8...	BOOL	17202

Name	Type	Address	I/O	IO Name	Type	Address
Module 1 (Sync Inputs) Compact IxPDO Input	BOOL	9316		Module 1 (FSoE M. 8BYTE IN 8BYTE OUT) RxDPO FSoE	USI	17136
Module 1 (Sync Inputs) Compact IxPDO Output	BOOL	9317		Module 1 (FSoE M. 8BYTE IN 8BYTE OUT) RxDPO FSoE	USI	17144
Module 1 (Sync Inputs) Compact External device not connected	BOOL	9319		Module 1 (FSoE M. 8BYTE IN 8BYTE OUT) RxDPO FSoE	USI	17152
Module 2 (Safety Data Bit (8 Byte)) Inputs Bit FSoE Command	USI	9320		Module 1 (FSoE M. 8BYTE IN 8BYTE OUT) RxDPO FSoE	USI	17160
Module 2 (Safety Data Bit (8 Byte)) Inputs Bit FSoE Inp D 0 NHIL	BOOL	9328		Module 1 (FSoE M. 8BYTE IN 8BYTE OUT) RxDPO FSoE	BOOL	17168
Module 2 (Safety Data Bit (8 Byte)) Inputs Bit FSoE Inp D 0 AF	BOOL	9329		Module 1 (FSoE M. 8BYTE IN 8BYTE OUT) RxDPO FSoE	BOOL	17169
Module 2 (Safety Data Bit (8 Byte)) Inputs Bit FSoE Inp D 0 FF	BOOL	9330		Module 1 (FSoE M. 8BYTE IN 8BYTE OUT) RxDPO FSoE	BOOL	17170
Module 2 (Safety Data Bit (8 Byte)) Inputs Bit FSoE Inp D 0 ZS	BOOL	9331		Module 1 (FSoE M. 8BYTE IN 8BYTE OUT) RxDPO FSoE	BOOL	17171
Module 2 (Safety Data Bit (8 Byte)) Inputs Bit FSoE Inp D 0 PE	BOOL	9332		Module 1 (FSoE M. 8BYTE IN 8BYTE OUT) RxDPO FSoE	BOOL	17172
Module 2 (Safety Data Bit (8 Byte)) Inputs Bit FSoE Inp D 0 EXT	BOOL	9333		Module 1 (FSoE M. 8BYTE IN 8BYTE OUT) RxDPO FSoE	BOOL	17173
Module 2 (Safety Data Bit (8 Byte)) Inputs Bit FSoE Inp D 0 T1	BOOL	9334		Module 1 (FSoE M. 8BYTE IN 8BYTE OUT) RxDPO FSoE	BOOL	17174
Module 2 (Safety Data Bit (8 Byte)) Inputs Bit FSoE Inp D 0 T2	BOOL	9335		Module 1 (FSoE M. 8BYTE IN 8BYTE OUT) RxDPO FSoE	BOOL	17175
Module 2 (Safety Data Bit (8 Byte)) Inputs Bit FSoE Inp D 0 NME	BOOL	9336		Module 1 (FSoE M. 8BYTE IN 8BYTE OUT) RxDPO FSoE	BOOL	17176
Module 2 (Safety Data Bit (8 Byte)) Inputs Bit FSoE Inp D 0 BSO	BOOL	9337		Module 1 (FSoE M. 8BYTE IN 8BYTE OUT) RxDPO FSoE	BOOL	17177
Module 2 (Safety Data Bit (8 Byte)) Inputs Bit FSoE Inp D 0 SHS1	BOOL	9338		Module 1 (FSoE M. 8BYTE IN 8BYTE OUT) RxDPO FSoE	BOOL	17178
Module 2 (Safety Data Bit (8 Byte)) Inputs Bit FSoE Inp D 0 SHS2	BOOL	9339		Module 1 (FSoE M. 8BYTE IN 8BYTE OUT) RxDPO FSoE	BOOL	17179

Figure 16: IO mapping KRC4 to PNOZ m

- ▶ Selection left PNOZ m EF EtherCAT FSoE / right KRC4 secondary EL6695-1001.
- ▶ Sort via the "Address" column, so that the signals are in the correct order. Then connect one to one.

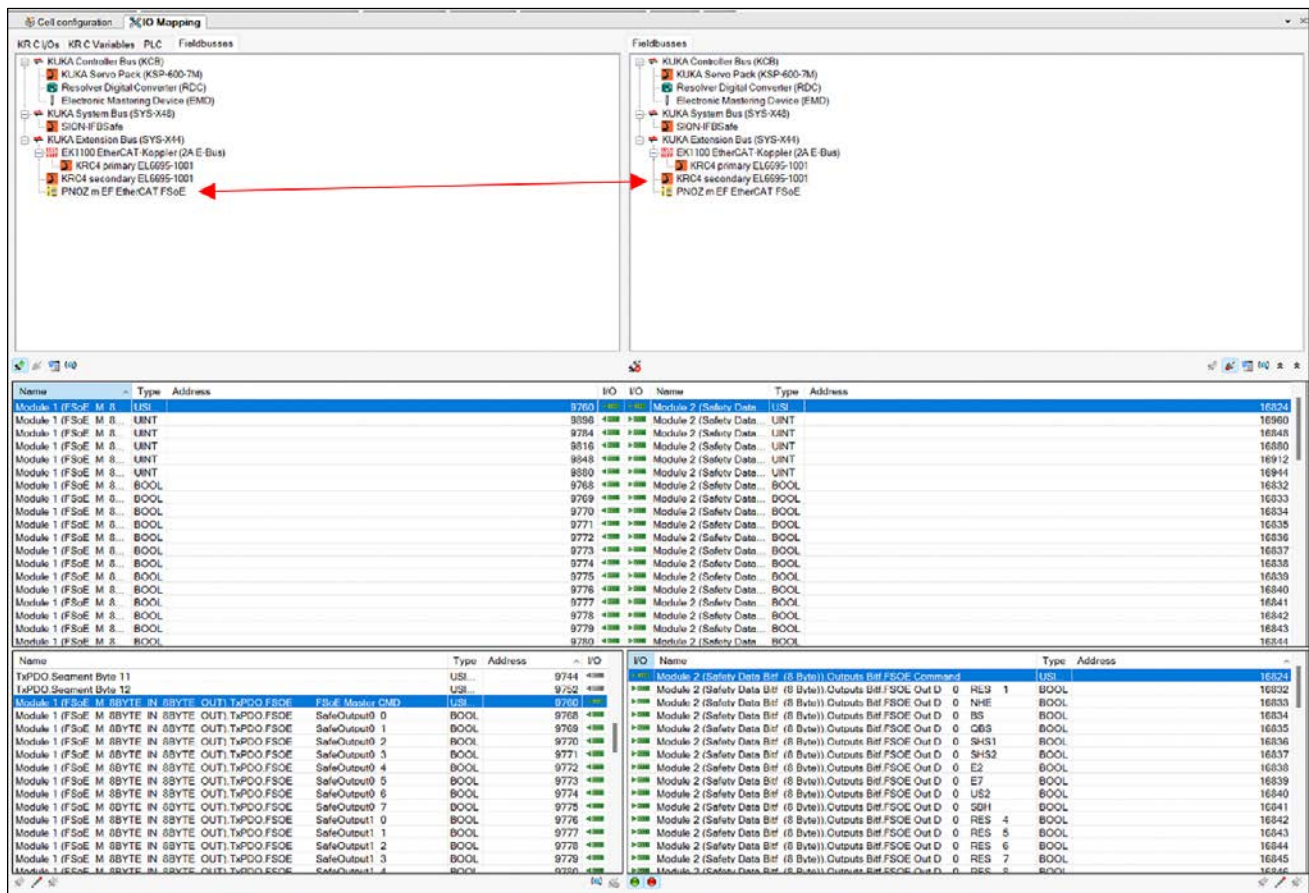


Figure 17: IO mapping PNOZ m to KRC4

6.1.2 Additional configuration with FSoE SubDevice (PSEN rd1)

- ▶ Add sensor PSEN rd1 to the KUKA Extension Bus (SYS-X44) after the PNOZ m EF EtherCAT FSoE.

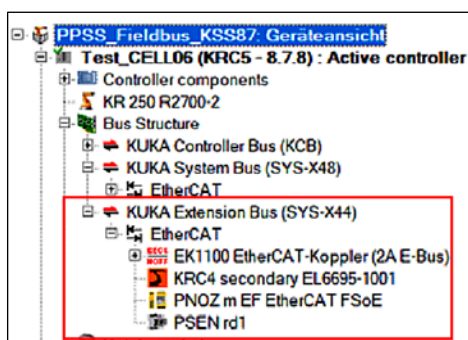


Figure 18: Inserting the safe radar sensor

- No adjustment is normally necessary in the topology.

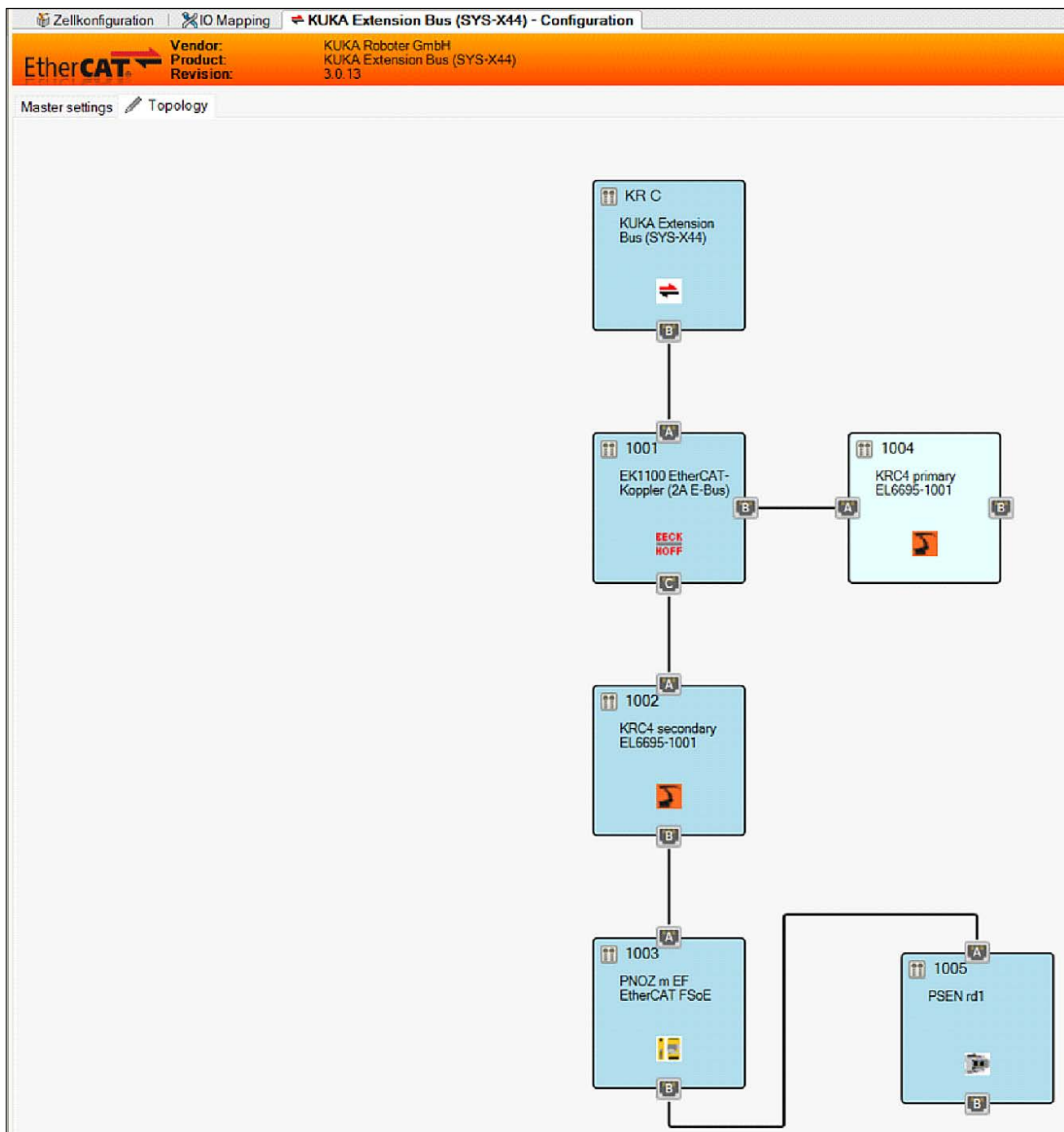


Figure 19: EtherCAT topology

- ▶ Vendor ID / Product Code check should be deactivated.

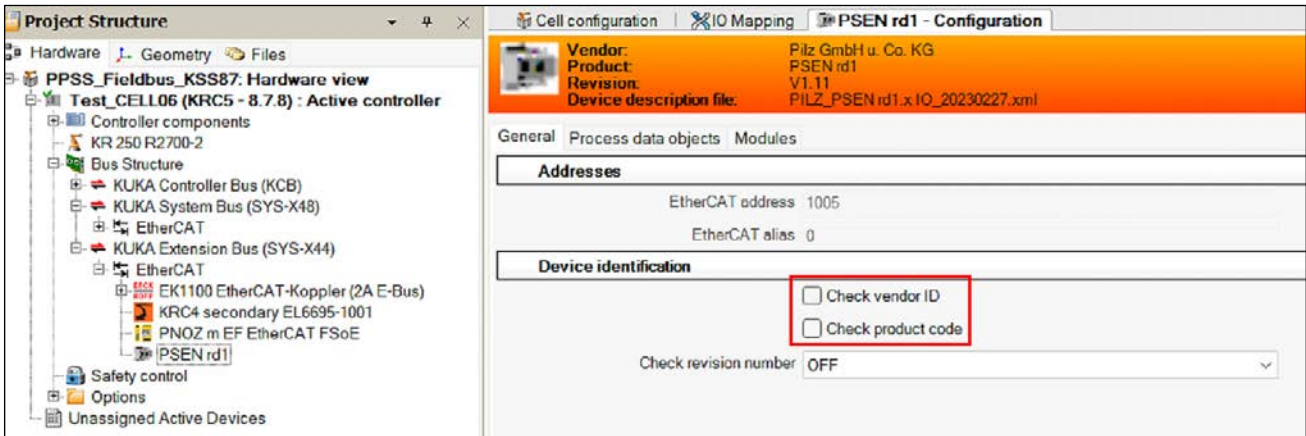


Figure 20: Deactivating device identification

- ▶ The settings (size of the IOs) for PNOZ m EF EtherCAT FSoE must match the settings on the PSEN rd1.
- ▶ Slot 002: FSoE_M_2BYTE_IN_2BYTE_OUT

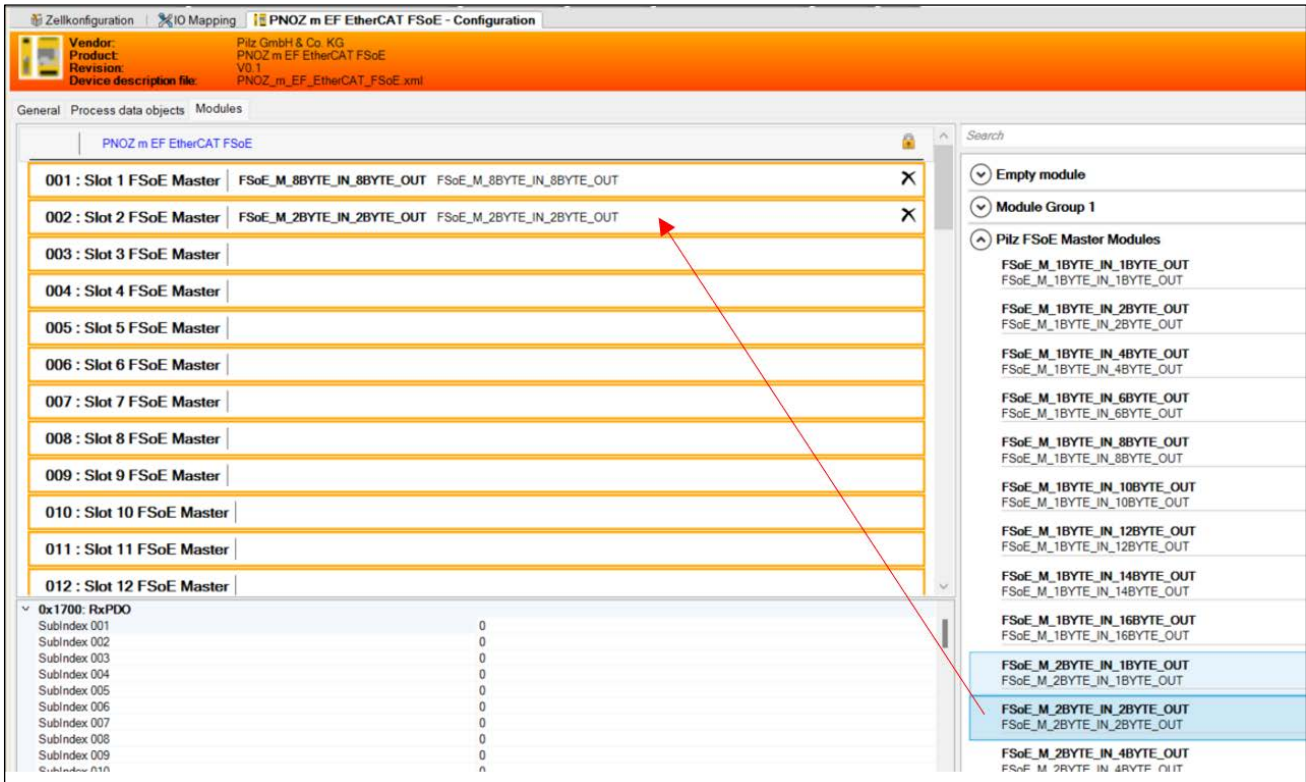


Figure 21: Modules PSEN rd1

- ▶ For simpler IO mapping, both SafeOutputX and both SafeInputX BYTES must be split into BITS on PNOZ m EF EtherCAT FSoE module 2.
- ▶ This is achieved via the signal editor.

Name	Type	Address	I/O
Module 1 (FSoE M 8BYTE IN 8BYTE OUT).TxPDO.FSOE	SafeOutput7 0	1800	← [1800]
Module 1 (FSoE M 8BYTE IN 8BYTE OUT).TxPDO.FSOE	SafeOutput7 1	1801	← [1801]
Module 1 (FSoE M 8BYTE IN 8BYTE OUT).TxPDO.FSOE	SafeOutput7 2	1802	← [1802]
Module 1 (FSoE M 8BYTE IN 8BYTE OUT).TxPDO.FSOE	SafeOutput7 3	1803	← [1803]
Module 1 (FSoE M 8BYTE IN 8BYTE OUT).TxPDO.FSOE	SafeOutput7 4	1804	← [1804]
Module 1 (FSoE M 8BYTE IN 8BYTE OUT).TxPDO.FSOE	SafeOutput7 5	1805	← [1805]
Module 1 (FSoE M 8BYTE IN 8BYTE OUT).TxPDO.FSOE	SafeOutput7 6	1806	← [1806]
Module 1 (FSoE M 8BYTE IN 8BYTE OUT).TxPDO.FSOE	SafeOutput7 7	1807	← [1807]
Module 1 (FSoE M 8BYTE IN 8BYTE OUT).TxPDO.FSOE	FSoE Master CRC 3	1808	← [1808]
Module 1 (FSoE M 8BYTE IN 8BYTE OUT).TxPDO.FSOE	FSoE Master ConnID	1824	← [1824]
Module 2 (FSoE M 2BYTE IN 2BYTE OUT).TxPDO.FSOE	FSoE Master CMD	1840	← [1840]
Module 2 (FSoE M 2BYTE IN 2BYTE OUT).TxPDO.FSOE	SafeOutput0	1848	← [1848]
Module 2 (FSoE M 2BYTE IN 2BYTE OUT).TxPDO.FSOE	SafeOutput1	1856	← [1856]
Module 2 (FSoE M 2BYTE IN 2BYTE OUT).TxPDO.FSOE	FSoE Master CRC 0	1864	← [1864]
Module 2 (FSoE M 2BYTE IN 2BYTE OUT).TxPDO.FSOE	FSoE Master ConnID	1880	← [1880]

Figure 22: Splitting SafeOut and SafeIn Bytes into Bits

- ▶ Connect fieldbus inputs and outputs of PSEN rd1 and PNOZ m EF EtherCAT FSoE via IO mapping.
- ▶ Selection left PSEN rd1 / right PNOZ m EF EtherCAT FSoE.
- ▶ Sort via the "Address" column, so that the signals are in the correct order. Then connect one to one.

The screenshot displays the 'IO Mapping' window in the WorkVisual software. The left pane shows the 'KR C I/Os' tree with 'PSEN rd1' selected. The right pane shows the 'Fieldbusses' tree with 'PNOZ m EF EtherCAT FSoE' selected. A red arrow indicates the mapping from 'PSEN rd1' to 'PNOZ m EF EtherCAT FSoE'. Below the trees, two tables are visible, showing the mapping of signals and their addresses.

Name	Type	Address	I/O	Name	Type	Address
Module 1 (2-byte Proc...	USINT	13248		Module 2 (FSoE M 2B...	FSoE Slave CMD	13248
Module 1 (2-byte Proc...	BOOL	13250		Module 2 (FSoE M 2B...	SafeInput 0	13250
Module 1 (2-byte Proc...	BOOL	13251		Module 2 (FSoE M 2B...	SafeInput 1	13251
Module 1 (2-byte Proc...	BOOL	13252		Module 2 (FSoE M 2B...	SafeInput 2	13252
Module 1 (2-byte Proc...	BOOL	13253		Module 2 (FSoE M 2B...	SafeInput 3	13253
Module 1 (2-byte Proc...	BOOL	13254		Module 2 (FSoE M 2B...	SafeInput 4	13254
Module 1 (2-byte Proc...	BOOL	13255		Module 2 (FSoE M 2B...	SafeInput 5	13255
Module 1 (2-byte Proc...	BOOL	13256		Module 2 (FSoE M 2B...	SafeInput 6	13256
Module 1 (2-byte Proc...	BOOL	13257		Module 2 (FSoE M 2B...	SafeInput 7	13257
Module 1 (2-byte Proc...	BOOL	13258		Module 2 (FSoE M 2B...	SafeInput 8	13258
Module 1 (2-byte Proc...	BOOL	13259		Module 2 (FSoE M 2B...	SafeInput 9	13259
Module 1 (2-byte Proc...	BOOL	13260		Module 2 (FSoE M 2B...	SafeInput 10	13260
Module 1 (2-byte Proc...	BOOL	13261		Module 2 (FSoE M 2B...	SafeInput 11	13261
Module 1 (2-byte Proc...	BOOL	13262		Module 2 (FSoE M 2B...	SafeInput 12	13262
Module 1 (2-byte Proc...	BOOL	13263		Module 2 (FSoE M 2B...	SafeInput 13	13263
Module 1 (2-byte Proc...	BOOL	13264		Module 2 (FSoE M 2B...	SafeInput 14	13264
Module 1 (2-byte Proc...	BOOL	13265		Module 2 (FSoE M 2B...	SafeInput 15	13265
Module 1 (2-byte Proc...	BOOL	13266		Module 2 (FSoE M 2B...	SafeInput 16	13266
Module 1 (2-byte Proc...	BOOL	13267		Module 2 (FSoE M 2B...	SafeInput 17	13267
Module 1 (2-byte Proc...	BOOL	13268		Module 2 (FSoE M 2B...	SafeInput 18	13268

Figure 23: IO mapping PSEN rd1 to PNOZ m

Configuration in "WorkVisual"

- ▶ Selection left PNOZ m EF EtherCAT FSoE / right PSEN rd1.
- ▶ Sort via the "Address" column, so that the signals are in the correct order. Then connect one to one.

The screenshot shows the 'IO Mapping' window in WorkVisual. The left pane shows the 'KRC I/Os' tree with 'PNOZ m EF EtherCAT FSoE' selected. The right pane shows the 'Fieldbuses' tree with 'PSEN rd1' selected. A red arrow indicates the connection between these two signals. Below the trees is a table with columns: Name, Type, Address, I/O, Name, Type, Address. The table lists various signals and their addresses, sorted by address. The bottom section of the table shows the connection between the PNOZ m EF EtherCAT FSoE signal and the PSEN rd1 signal.

Name	Type	Address	I/O	Name	Type	Address
Module 2 (FSoE) M 2	USI	1896	I/O	Module 1 (2-byte Proc...)	USI	13304
Module 2 (FSoE) M 2	BOOL	1904	I/O	Module 1 (2-byte Proc...)	BOOL	13312
Module 2 (FSoE) M 2	BOOL	1905	I/O	Module 1 (2-byte Proc...)	BOOL	13313
Module 2 (FSoE) M 2	BOOL	1906	I/O	Module 1 (2-byte Proc...)	BOOL	13314
Module 2 (FSoE) M 2	BOOL	1907	I/O	Module 1 (2-byte Proc...)	BOOL	13315
Module 2 (FSoE) M 2	BOOL	1908	I/O	Module 1 (2-byte Proc...)	BOOL	13316
Module 2 (FSoE) M 2	BOOL	1909	I/O	Module 1 (2-byte Proc...)	BOOL	13317
Module 2 (FSoE) M 2	BOOL	1910	I/O	Module 1 (2-byte Proc...)	BOOL	13318
Module 2 (FSoE) M 2	BOOL	1911	I/O	Module 1 (2-byte Proc...)	BOOL	13319
Module 2 (FSoE) M 2	BOOL	1912	I/O	Module 1 (2-byte Proc...)	BOOL	13320
Module 2 (FSoE) M 2	BOOL	1913	I/O	Module 1 (2-byte Proc...)	BOOL	13321
Module 2 (FSoE) M 2	BOOL	1914	I/O	Module 1 (2-byte Proc...)	BOOL	13322
Module 2 (FSoE) M 2	BOOL	1915	I/O	Module 1 (2-byte Proc...)	BOOL	13323
Module 2 (FSoE) M 2	BOOL	1916	I/O	Module 1 (2-byte Proc...)	BOOL	13324

Figure 24: IO mapping PNOZ m to PSEN rd1

6.2 Application with external EtherCAT MDevice

- ▶ Right-click on the terminal "KRC4 primary EL6695-1001" and select "Settings..." in the context menu.
- ▶ Activate the safe inputs and outputs in the "Process data objects" tab.
- ▶ Safety inputs (8 Byte) and safety outputs (8 Byte) must always be ticked at the same time.

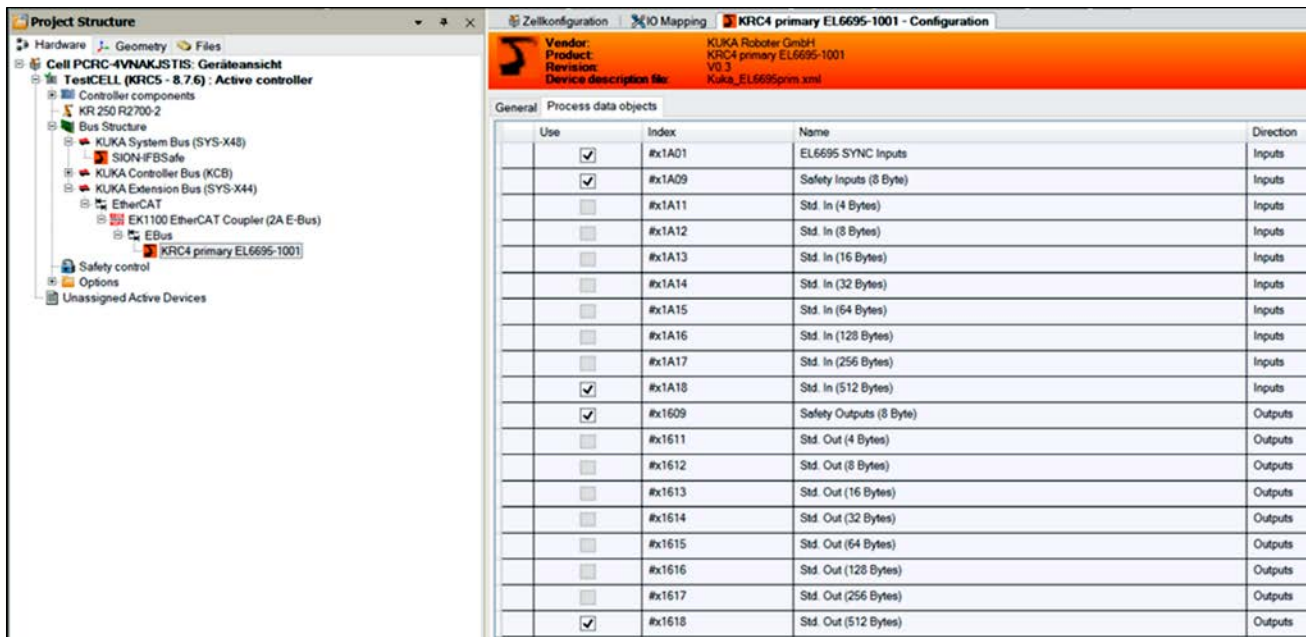


Figure 25: Activation of the safety-related and non-safety-related inputs and outputs

- ▶ In the "Safety configuration" (Safety control) tab, select the Communication parameters range and set the FSoE address.
- ▶ If more than one FSoE SubInstance is used, the EtherCAT Safety ID (FSoE address) must be changed. This must be unique in the system and must match the partner controller. KUKA recommends setting the FSoE address in the range of 8000-9000. In this case, the FSoE address is - 8504 (see figure below).

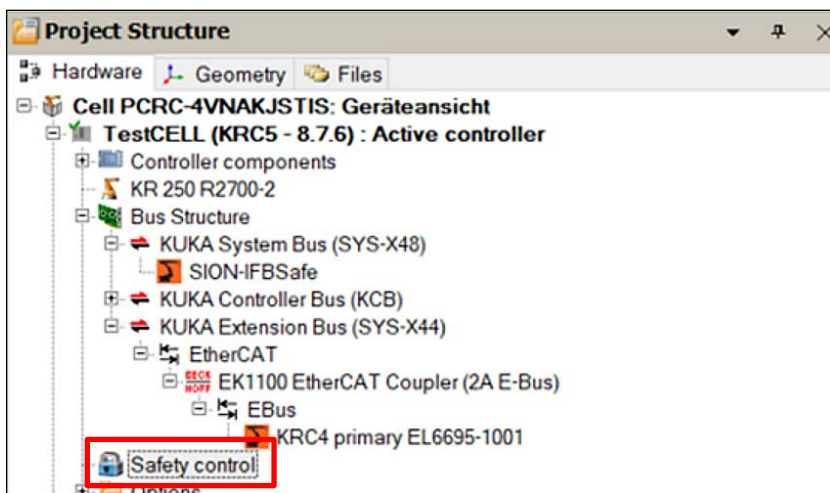


Figure 26: Safety settings

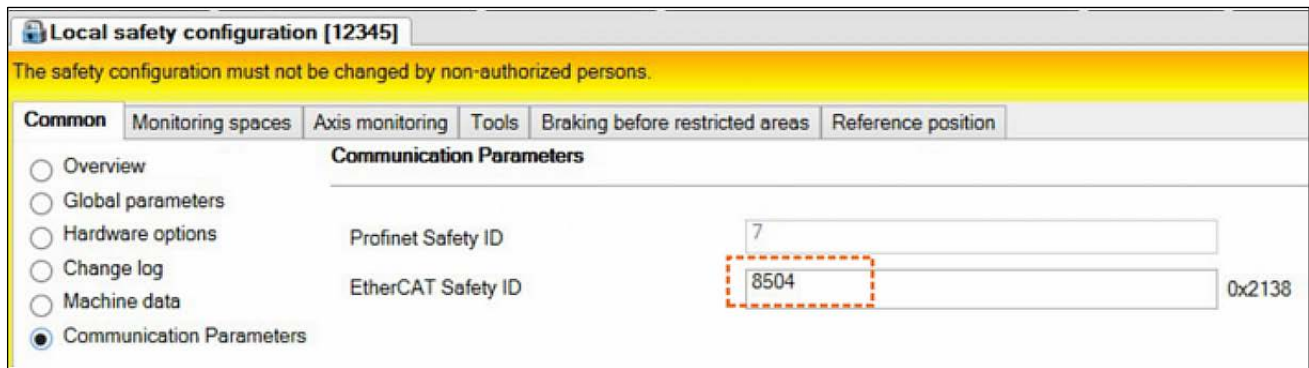


Figure 27: Setting the EtherCAT FSoE address of the KRC4

- ▶ Standard FSoE address of the robot controller - **8504**.
- ▶ More information on the connection to the robot controller is available in the document KUKA Xpert_SS5081_Guide_EL6695-1001.pdf, see [chapter 1.2](#).

7 Configuration in "PNOZmulti Configurator"



INFORMATION

In this application note, a TwinCAT 3 PLC is used as the MDevice. Alternatively, the procedure with CODESYS V3.5 is also described.

Other MDevices that can read and process ESI files with FSoE elements can also be used.



NOTICE

Only one communication module can be used to the left of the base unit. If the module PNOZ m EF EtherCAT FSoE is inserted, no further communication module can be inserted. Exception: PNOZ m EF SafetyNET

Modbus TCP and TCP/IP can also be used via the integrated ETH interface on the PNOZ m B1.

The module provides standard EtherCAT functionality similar to the PNOZ m ES EtherCAT. For more details, see the documentation for the module PNOZ m EF EtherCAT FSoE.

- ▶ Create new PNOZmulti project
- ▶ Insert base unit PNOZ m B1, PNOZ m EF EtherCAT FSoE and additional expansion modules on the right if required.

The screenshot displays the 'Hardware Configuration' window of the PNOZmulti Configurator. The left sidebar lists available modules, including Base Units (PNOZ m B0, PNOZ m B0.1, PNOZ m B1, PNOZ m B1 Burner), Compact Units, Connection Modules (PNOZ m EF PDP Link, PNOZ m EF Multi Link, PNOZ m EF SafetyNET, PNOZ m EF EtherCAT FSoE), Virtual I/O Modules/Interfaces, Input Modules, and Output Modules. The 'PNOZ m EF EtherCAT FSoE' module is selected. The main area shows a visual representation of the configured hardware, including a base unit and the selected expansion module. Below this, a 'Module Description' section provides details for the 'PNOZ m EF EtherCAT FSoE' module, including its product number (772123) and certifications (CE (EU), TÜV (International)). The 'Fieldbus Interface' is listed as 'EtherCAT, FSoE'. On the right, a 'Configured Hardware' table lists the modules and their properties.

	Module Name	Version	Equ...	Locati...	I	O
-1	PNOZ m EF EtherCAT FSoE	v1.0	a2			
	EtherCAT				128	128
	FSoE				0	0
0	PNOZ m B1	v1.11 (FW 0111)	a1		0	0

Figure 28: Hardware configuration

7.1 Import ESI files

- ▶ An ESI file must be installed for **all** FSoE SubInstances that are to be used.
- ▶ Open FSoE configuration, right-click on the module PNOZ m EF EtherCAT FSoE.

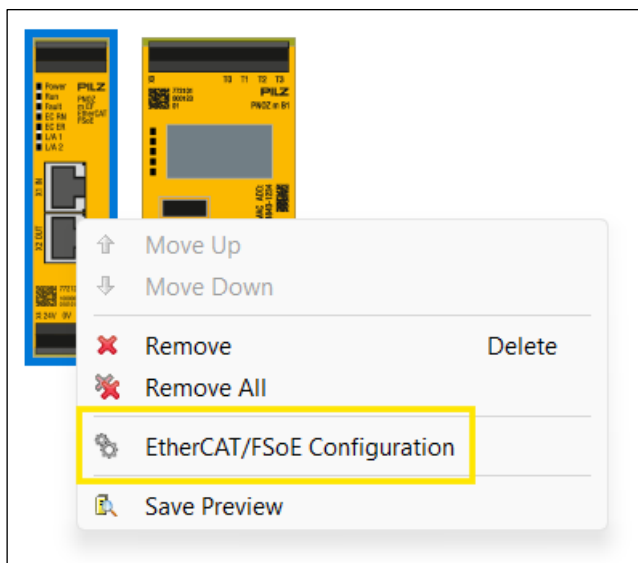


Figure 29: Starting the FSoE configuration

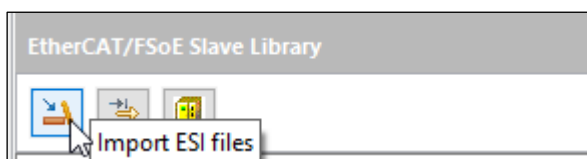


Figure 30: Import ESI file

- ▶ Once the ESI file has been imported successfully (provided there is FSoE data containing the BOOL data type), the device appears in the library.

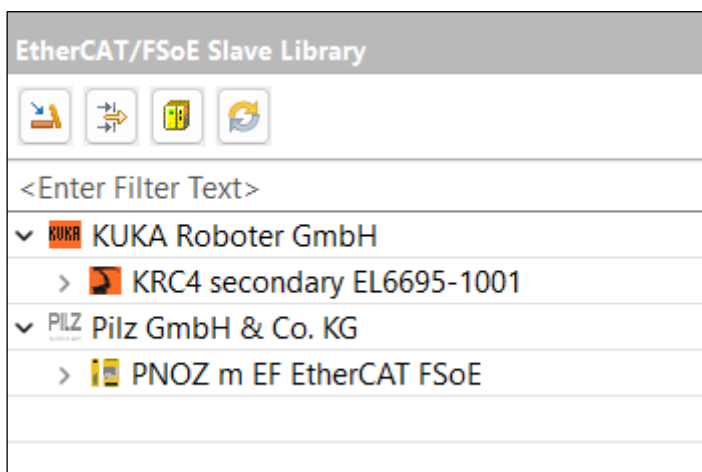


Figure 31: EtherCat/FSoE SubInstance Library

- ▶ The imported ESI files are stored in the directory C:\ProgramData\Pilz\PNOZmulti Configurator_v11.X.X\AppData\Esi Library and can also be deleted there if required.

7.2 FSoE configuration

- ▶ All FSoE SubInstances to which a connection is to be established are selected in the FSoE configuration.
- ▶ The FSoE SubInstances that are available after the ESI import are displayed in the library on the right-hand side.
- ▶ Devices can be added from the library via drag and drop.



NOTICE

The module PNOZ m EF EtherCAT FSoE only supports the BOOL data type. Only ESI files that contain the BOOL data type are supported. If there is no BOOL data type in the ESI file, it will still be imported, but it will be greyed out and a message will be displayed. If the ESI file contains at least one variable with the data type BOOL and a non-supported data type, a message will also be displayed.

⚠ AKD2G Single Axis - SRA Parameters configured via Wo

This module is only partially supported by PNOZmulti.

- ▶ In the KUKA ESI file, there are two modules in the library for selection. In this case it is important to use the module "Safety Data Bitf (8 Byte)", ModuleIdent 0x104.

EtherCAT/FSoE Slave Library



<Enter Filter Text>

KUKA Roboter GmbH

KRC4 secondary EL6695-1001

Safety Roboter, 0x104

Safety Roboter, 0x102

Properties View

Vendor	KUKA Roboter GmbH
Name	Safety Roboter
Device	KRC4 secondary EL6695-1001
Type	Safety Data Bitf (8 Byte)
Module Ident	0x104
ESI File	kuka_el6695sec.xml
ESI File Version	----
I/O	FSoE_M_8BYTE_IN_8BYTE_OUT

Figure 32: Selecting the safety module

Application Note PNOZ m EF EtherCAT FSoE KUKA KRC5
1006932-EN-02

PILZ | 28/38

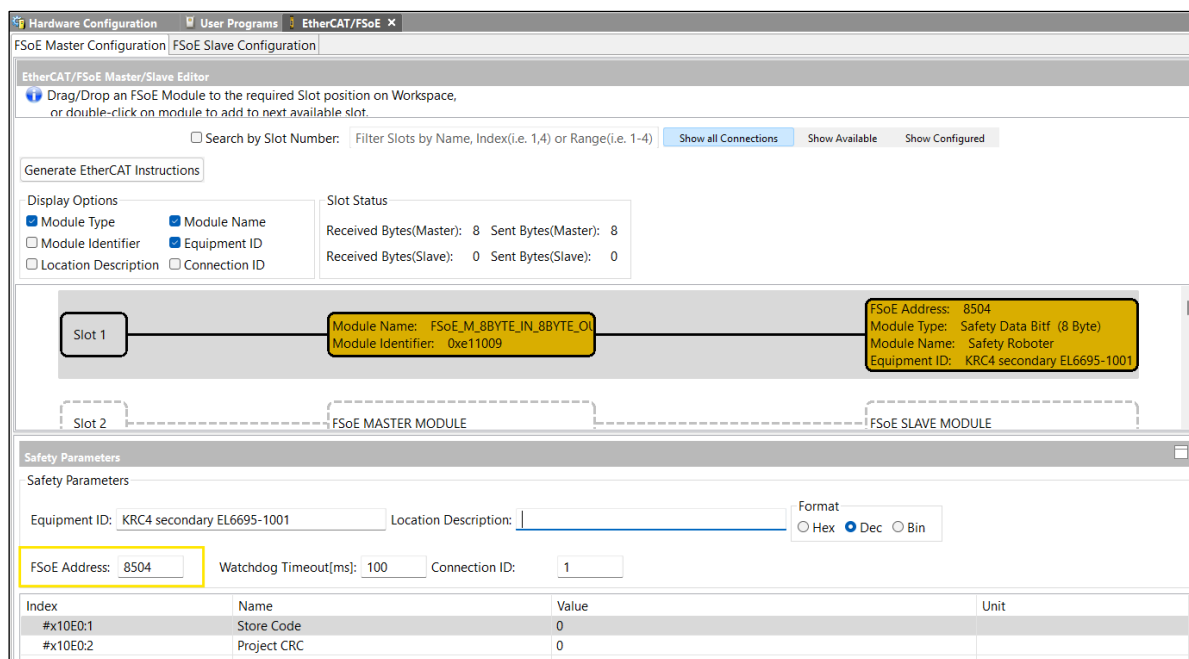


Figure 33: Adding the FSoE connections

- ▶ The FSoE address must be entered here and must match the address set on the FSoE SubInstance. The standard FSoE address for the robot controller is 8504 (see [Figure 27](#)).
- ▶ The FSoE address may only occur once in the EtherCAT network.
- ▶ The PNOZmulti Configurator creates the connection ID automatically and checks whether it is used once.
- ▶ The watchdog timeout must also be set for each connection. The default value is 100ms



CAUTION!

The EtherCAT cycle time (set in the MDevice) has a direct impact on the watchdog timeout and therefore the reaction times!
Please read the documentation for the module PNOZ m EF EtherCAT FSoE.

8 Configuration of the controllers

8.1 Configuration in "CODESYS V3.5"



INFORMATION

The device description files must be obtained from the manufacturer and imported into the development environments

The device description file for KUKA EtherCAT-Bridge EL6695-1001 with the name Kuka_EL6695sec.xml can be obtained from KUKA.

An ESI file is also required for the module PNOZ m EF EtherCAT FSoE. This can be downloaded from www.pilz.com > 3001165A01.

Information on more detailed processes in CODESYS V3.5 can be found in the CODESYS V3 documentation.

8.1.1 Import ESI file

- ▶ The ESI file can be installed in the device repository.

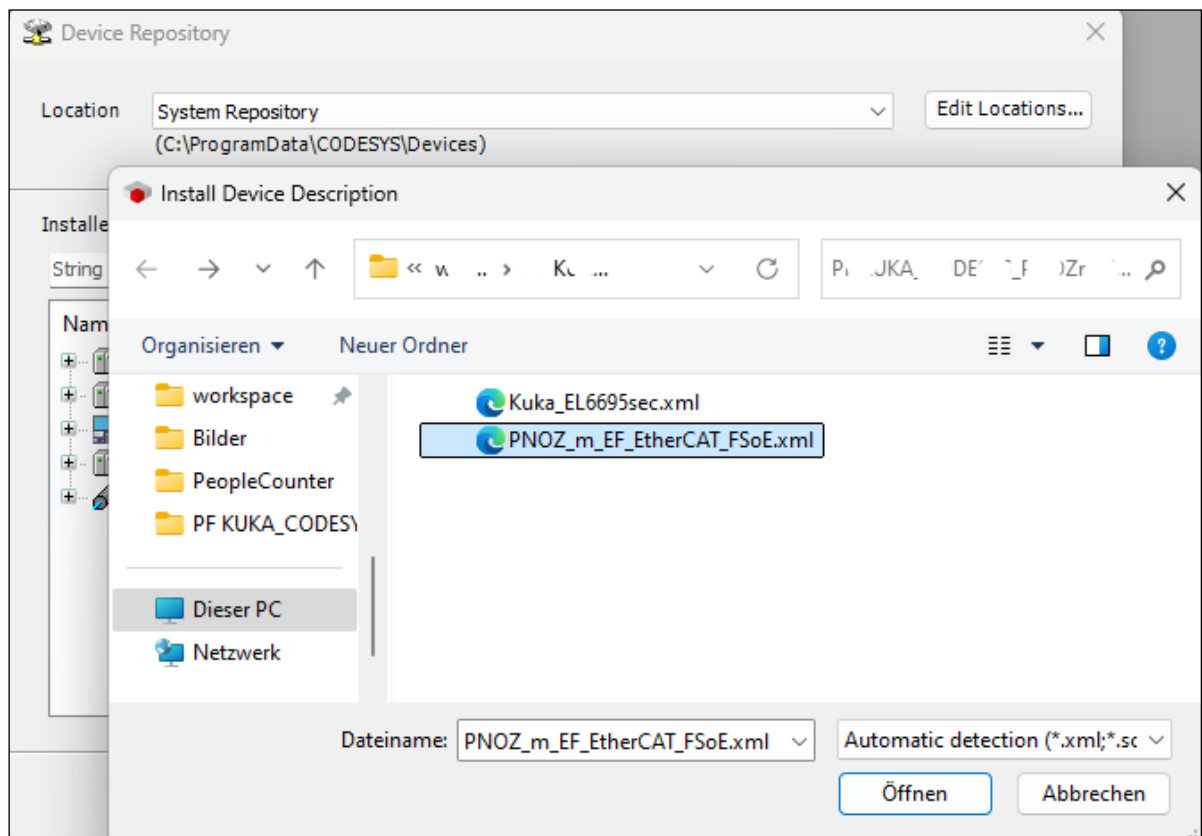


Figure 34: Installing the ESI file

8.1.2 EtherCAT configuration

- ▶ All EtherCAT devices in the network must be created in the MDevice.
- ▶ The device scan can perform the task automatically, but it is recommended that all the devices are created manually.
- ▶ Right-click on Device > "Attach device..." to add the EtherCAT MDevice to the project tree.

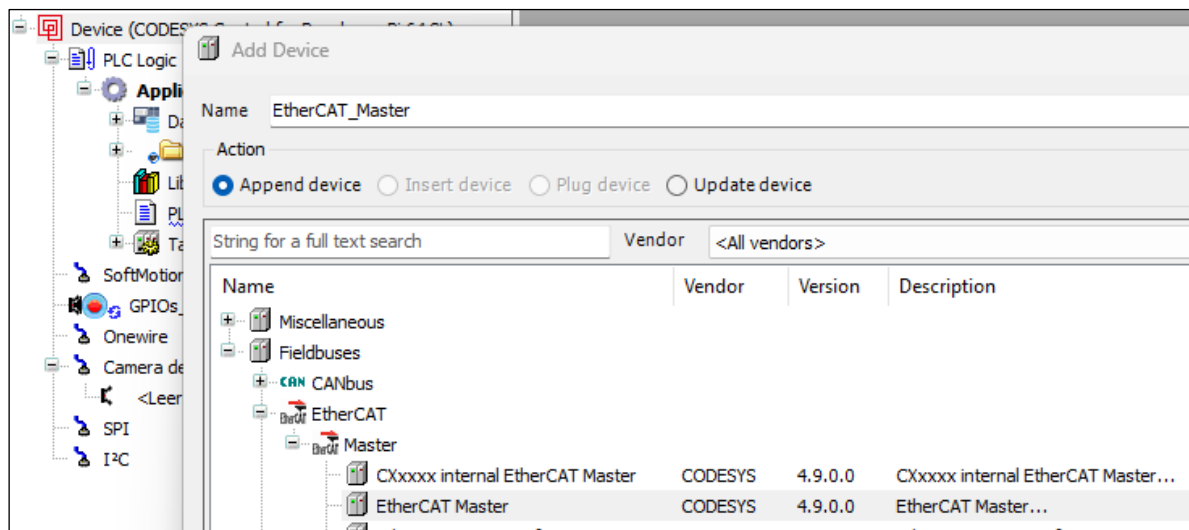


Figure 35: Attaching the MDevice

- ▶ Right-click on EtherCAT MDevice > "Attach device..." to add the EtherCAT SubDevices to the project tree.

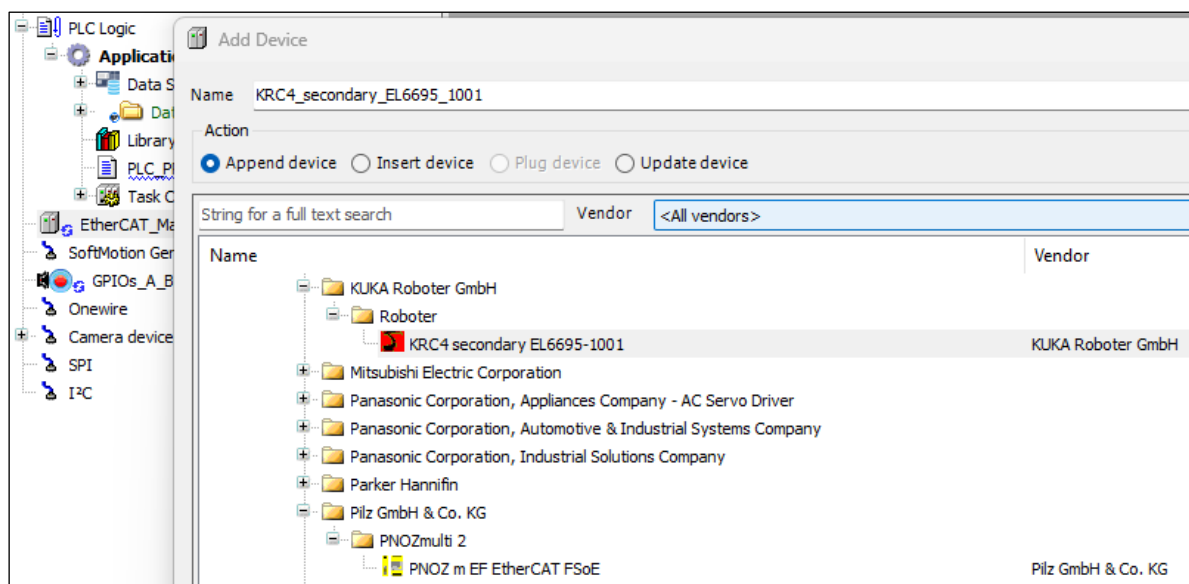


Figure 36: Attaching the SubDevices

8.1.3 Slot configuration

- ▶ Once all the EtherCAT subscribers have been configured, the identical configuration to that in the EtherCAT/FSoE tab in the PNOZmulti Configurator must now be created in the Slots tab.
- ▶ Make sure that the modules are configured in the same order with the identical length.

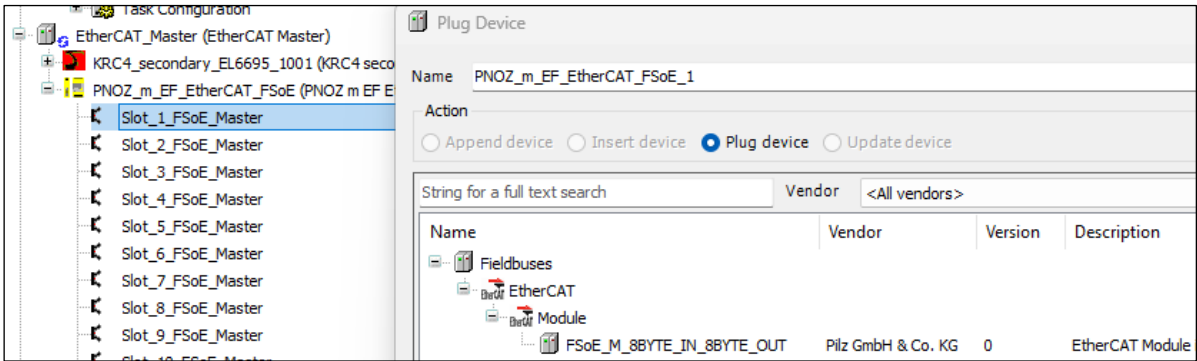


Figure 37: Slot configuration

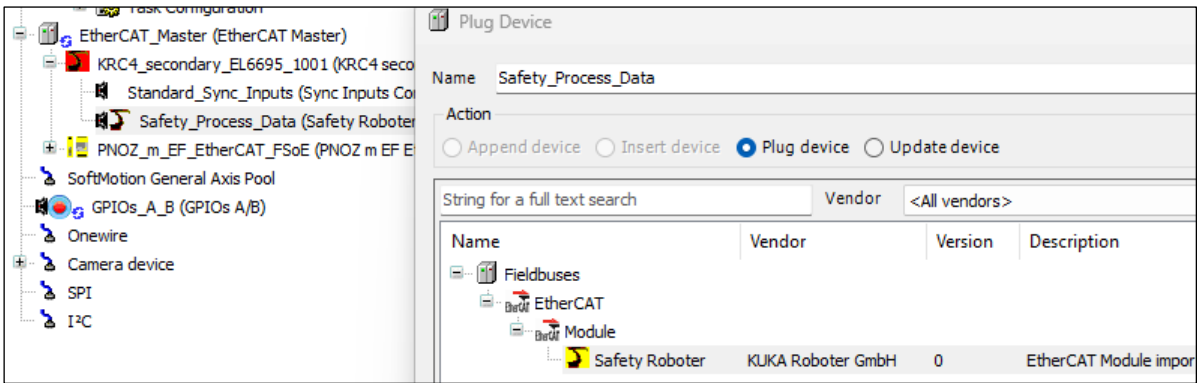


Figure 38: Safety process data, robot

8.1.4 Copying the FSoE data

8.1.4.1 Type 1: Internal CODESYS mapping

- ▶ CODESYS version 3.5.20 Patch 4 added a simple, internal type that enables mapping between devices in the EtherCAT network.
- ▶ Once the devices in the project have been scanned and created, the EtherCAT Master is called and the "Safety FSoE connections" tab is clicked.
- ▶ After that, FSoE SubDevice connections can be selected for all configured FSoE MDevice connections via the drop-down menu.
- ▶ These must match the expected process data size for the configured FSoE MDevice connections to be displayed in the drop-down menu. This completes the whole configuration, and the project can be loaded!

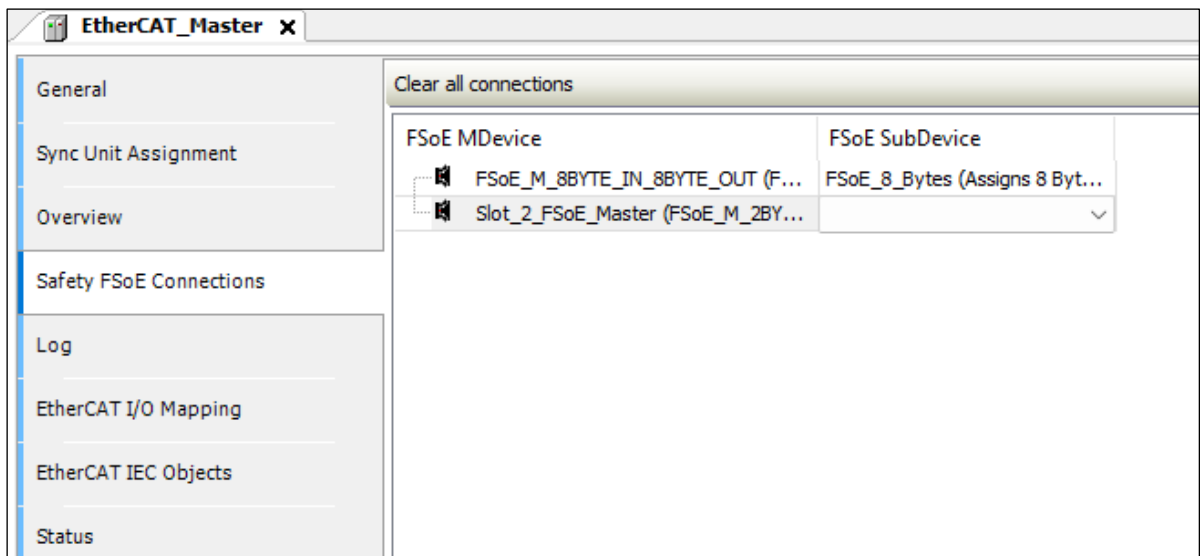


Figure 39: Safety FSoE connections in the EtherCAT Master

- ▶ If you now want to read the values of the transferred process data in CODESYS, the desired addresses must be polled in the main task. However, this does not yet work reliably (as of v3.5.20.50) and sometimes data can only be queried on the MDevice (Tx or Rx) or only on the SubDevice (Tx or Rx).

8.1.4.2 Type 2: CODESYS addresses

- ▶ For CODESYS versions prior to 3.5.20 Patch 4, this type can be used for mapping.
- ▶ For the FSoE MInstance to receive the data from the FSoE SubInstances, a mapping must be created for these in CODESYS.
- ▶ With CODESYS, this is achieved via the user program.
- ▶ Addresses can be read from the "Module I/O image" of the individual components. This is displayed by double-clicking on the respective FS module under the "Module I/O image" tab.
- ▶ The important addresses here are always the CMD addresses, as they indicate the start of an FSoE frame. This must be carried out for all SubDevices.

Variable	Mapping	Channel	Address	Type	Unit	Description
16#1600 RxPDO						
FSOE_FSoE Slave CMD			%QB20	USINT		FSOE_FSoE Slave CMD
FSOE_SafeInput0			%QB21	BYTE		FSOE_SafeInput0
FSOE_SafeInput1			%QB22	BYTE		FSOE_SafeInput1
FSOE Slave CRC_0			%QW12	UINT		FSOE Slave CRC_0
FSOE_SafeInput2			%QB26	BYTE		FSOE_SafeInput2
FSOE_SafeInput3			%QB27	BYTE		FSOE_SafeInput3
FSOE Slave CRC_1			%QW14	UINT		FSOE Slave CRC_1
FSOE_SafeInput4			%QB30	BYTE		FSOE_SafeInput4
FSOE_SafeInput5			%QB31	BYTE		FSOE_SafeInput5
FSOE Slave CRC_2			%QW16	UINT		FSOE Slave CRC_2
FSOE_SafeInput6			%QB34	BYTE		FSOE_SafeInput6
FSOE_SafeInput7			%QB35	BYTE		FSOE_SafeInput7
FSOE Slave CRC_3			%QW18	UINT		FSOE Slave CRC_3
FSOE Slave ConnID			%QW19	UINT		FSOE Slave ConnID
16#1A00 TxPDO						
FSOE Master CMD			%IB32	USINT		FSOE Master CMD
FSOE_SafeOutput0			%IB33	BYTE		FSOE_SafeOutput0

Figure 40: I/O image PNOZ m FSoE MainInstance

Variable	Mapping	Channel	Address	Type	Unit	Description
16#160A Outputs Bitf						
FSOE Command			%QB40	USINT		FSOE Command
FSOE Out D_0_RES_1			%QX41.0	BIT		FSOE Out D_0_RES_1
FSOE Out D_0_NHE			%QX41.1	BIT		FSOE Out D_0_NHE
FSOE Out D_0_BS			%QX41.2	BIT		FSOE Out D_0_BS
FSOE Out D_0_QBS			%QX41.3	BIT		FSOE Out D_0_QBS
FSOE Out D_0_SHS1			%QX41.4	BIT		FSOE Out D_0_SHS1
FSOE Out D_0_SHS2			%QX41.5	BIT		FSOE Out D_0_SHS2
FSOE Out D_0_F2			%QX41.6	BIT		FSOE Out D_0_F2
FSOE Out D_0_F3			%QX41.7	BIT		FSOE Out D_0_F3
FSOE Out D_0_F4			%QX41.8	BIT		FSOE Out D_0_F4
FSOE Out D_0_F5			%QX41.9	BIT		FSOE Out D_0_F5
16#1A0A Inputs Bitf						
FSOE Command			%IB54	USINT		FSOE Command
FSOE Inp D_0_NHL			%IX55.0	BIT		FSOE Inp D_0_NHL
FSOE Inp D_0_AF			%IX55.1	BIT		FSOE Inp D_0_AF
FSOE Inp D_0_FF			%IX55.2	BIT		FSOE Inp D_0_FF
FSOE Inp D_0_ZS			%IX55.3	BIT		FSOE Inp D_0_ZS
FSOE Inp D_0_PE			%IX55.4	BIT		FSOE Inp D_0_PE

Figure 41: I/O image addresses KUKA KRC4 SubInstance

- ▶ Example of copying the FSoE I/O data with the I/O addresses read out above:

```

1  PROGRAM PLC_PRG
2  VAR
3  //NOTE: The following addresses must be customized individually.
4  // SubInstance1 - RxPDO: 8 BYTE --- TxPDO: 8 BYTE
5  MainInstance_Slot1_OUT AT %QB20 : STRUCT_FSOE_8BYTE; //PNOZ m FSoE Slot1 Outputs
6  MainInstance_Slot1_IN AT %IB32 : STRUCT_FSOE_8BYTE; //PNOZ m FSoE Slot1 Inputs
7  SubInstance_OUT AT %QB40 : STRUCT_FSOE_8BYTE; //KUKA FSoE Outputs
8  SubInstance_IN AT %IB54 : STRUCT_FSOE_8BYTE; //KUKA FSoE Inputs
9  END_VAR

10 // SubInstance 1
11 SubInstance_OUT := MainInstance_Slot1_IN;
12 MainInstance_Slot1_OUT := SubInstance_IN;

13 //SubInstance 2

```

Figure 42: Copying the FSoE I/O data

- ▶ More information on the configuration and diagnostics of the module PNOZm EF EtherCAT FSoE can be found in the application note "PNOZ m EF EtherCAT FSoE with TwinCAT 3 and CODESYS 3.5", number 1006828.
- ▶ Link www.pilz.com > AN 1006828

8.2 Configuration in "TwinCAT"



INFORMATION

The device description files must be obtained from the manufacturer and imported into the development environments

The device description file for KUKA EtherCAT-Bridge EL6695-1001 with the name Kuka_EL6695sec.xml can be obtained from KUKA.

An ESI file is also required for the module PNOZ m EF EtherCAT FSoE. This can be downloaded from www.pilz.com > 3001165A01.

Information on processes in TwinCAT 3 can be found in the TwinCAT 3 documentation.

8.2.1 Import ESI files

- ▶ An ESI file must be installed for all FSoE SubInstances that are to be used.
- ▶ All ESI files must be copied to the TwinCAT directory, the default path is: *C:\Program Files (x86)\Beckhoff\TwinCAT\3.1\Config\Io\EtherCAT*
- ▶ After inserting an ESI file, TwinCAT must be restarted or updated via the menu: *TwinCAT – EtherCAT Devices – Reload Device Descriptions*
- ▶ In the EtherCAT Device window, expand the tree "KUKA Roboter GmbH>Roboter" and select the terminals "KRC4 secondary EL6695-1001" and then under "PILZ GmbH & Co. KG > PNOZmulti 2" select "PNOZm EF EtherCAT FSoE".
- ▶ Scanning and using the online data is not recommended, as this can lead to problems with the configuration.

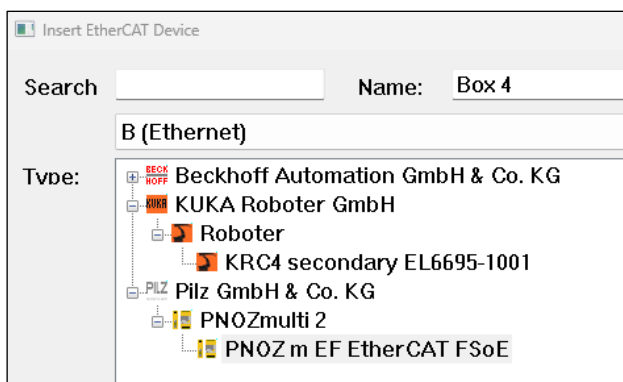


Figure 43: Insert EtherCAT SubDevice

8.2.2 Slot configuration EL6695-1001

- ▶ Double-click to open the properties of the terminal and select the Slots tab.

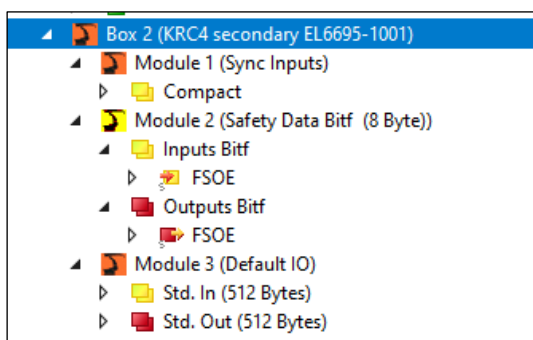


Figure 44: Safety and standard inputs and outputs

- ▶ Select the Safety Process Data slot. This sends the secure signals and is active by default.
- ▶ In the new ESI, there are two modules to choose from for the "Safety Process Data" slot. In this case it is important to use the module "Safety Data Bitf (8 Byte)", Modulldent 0x00000104.
- ▶ The safe inputs and outputs are displayed bit by bit on the secondary side. Each bit also has an abbreviation for the function. The abbreviation is based on the documentation. This enables simpler wiring, as the function of each individual input and output is made clear.

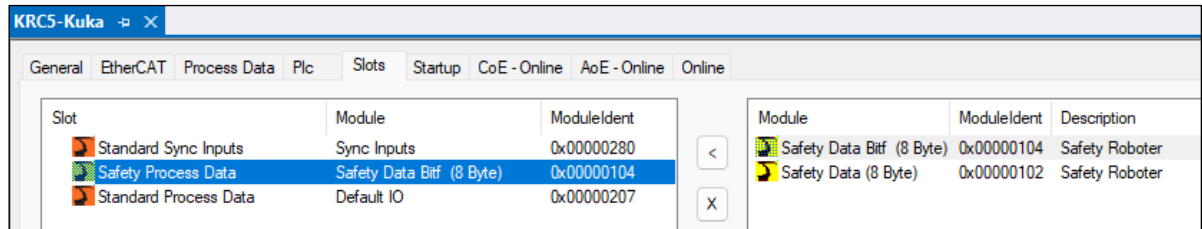


Figure 45: EL6695 Safety Process Data slot

- ▶ The module "FSOE_M_8BYTE_IN_8BYTE_OUT", Modulldent 0x00E11099 must be used in this case, so that the slot configuration on the PNOZ m EF EtherCAT FSoE matches the configuration on the EL6695-1001.

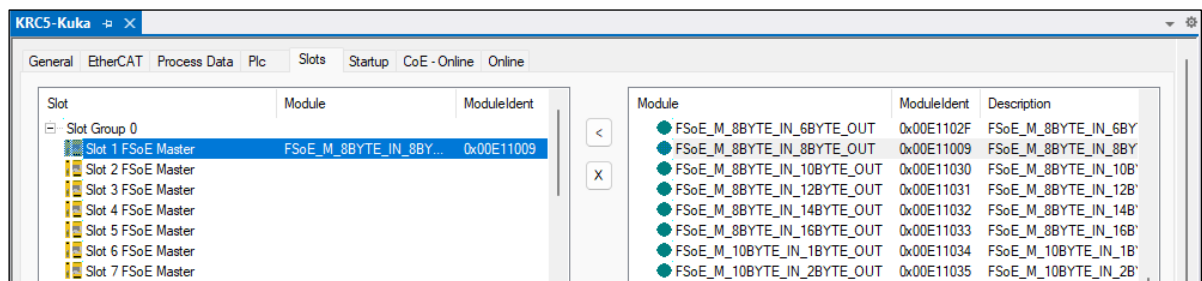


Figure 46: PNOZm EF EtherCAT FSoE Safety Process Data slot

8.2.3 Mapping the FSoE data

- ▶ In order for the FSoE MInstance to receive the data from the FSoE SubInstances, a mapping must be created for these in TwinCAT.

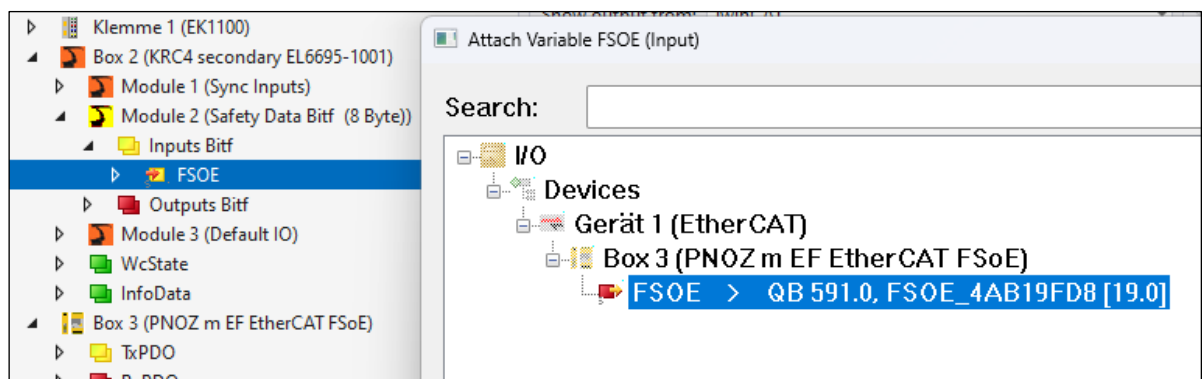


Figure 47: Variable linking of the FSoE data

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