AMKmotion
First steps
Connecting AMKmotion drives to third-party controllers
- TwinCAT 2
- TwinSAFE PLC terminal EL6900

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Translation of the "Original Dokumentation"

AMKmotion

MEMBER OF THE ARBURG FAMILY

Imprint

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Change	**Letter symbol**
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Product	Firmware version (Part no.)	Hardware version (Part no.)
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Reservation: We reserve the right to modify the content of the documentation as well as the delivery options for the product.

Publisher: AMKmotion GmbH + Co KG
Gaußstraße 37-39
73230 Kirchheim unter Teck
Germany

Phone +49 7021 50 05-0
Fax +49 7021 50 05-176

E-mail: info@amk-motion.com

Registration court: AG Stuttgart, HRA 230681, Kirchheim unter Teck,
Tax Id no.: DE 145 912 804

Complementary: AMKmotion Verwaltungsgesellschaft mbH, HRB 774646

Service: Phone +49 7021 50 05-190, Fax -193

For fast and reliable troubleshooting, you can help us by informing our Customer Service about the following:

- Type plate data for each unit
- Software version
- Device configuration and application
- Type of fault/problem and suspected cause
- Diagnostic messages (error messages)

E-mail service@amk-motion.com

Internet address: www.amk-motion.com

Content

1 About this documentation

1.1 Structure of this document

Content	Title	Chapter no.
Validity, usage and purpose of this document	Imprint	-
	About this documentation	1
Safety	For Your safety	1
Practical information for carrying out (step by step instructions) • General about third-party controllers • TwinCAT PLC • TwinSAFE with FSoE master terminal EL6900	AMK drive with third-party controller	3
	Beckhoff TwinCAT PLC	4
	Functional safety via FSoE with Beckhoff TwinSAFE PLC	5
Abbreviations and definitions	Glossary	-

1.2 Keeping this document

This document must permanently be available and readable at the place where the product is in use. If the product is used at another place or changed the owner, the document must be passed on.

1.3 Target group

Any person that is qualified and intends to work with this product must read, understand and follow this document:

- Parameterization
- Startup

1.4 Purpose

The document describes the connection of third-party controllers to the AMK drive system either with a TwinCAT 2 controller or / and functional safety.

- Compact power supply KE (EtherCAT field bus)
- Compact inverter with controller card (KW-R06 resp. KW-R07 is shown in the examples)
- Beckhoff TwinCAT PLC
- Beckhoff TwinSAFE-PLC EL6900

KW-R07 / -R17 / -R27 and iC / iX / iDT5 (with functional safety)

The startup of the functional safety is not part of this document.

Any information about functional safety (e. g. properties, parametrization, diagnostic messages) can be found in the Software description Safety manual; functional safety (Part no. 203446).

This document is addressed to any person who handles the product. It gives information about the following topics:

- Safety messages which are absolutely necessary to take care of during handling the product
- Startup and operation

1.5 Display conventions

Display	Meaning
	This symbol points to parts of the text to which particular attention should be paid.
'Text'	Parameter names, e.g. ID2 'SERCOS cycle time' Diagnostic message, e.g. 1042 'Mains phase fault' Name, e.g. Call up the function 'Delete PLC programme'
0x	0x followed by a hexadecimal number, e.g. 0x500A

Display	Meaning
	The red hand symbol indicates the button or menu item to click on. The red hand symbol indicates the option to be selected.
 RMB	Click the right mouse button

1.6 Appendant documents

Device descriptions

Part no.	Title
28932	Servo drives KE/KW
202744	Controller cards KW-R06 / -R16 / -R07 / -R17
204918	Controller cards KW-R24(-R) / -R25 / -R26 / -R27
203445	Decentralized drive technology iC / iX / iDT5

Functional descriptions

Part no.	Title
204979	Software description AIPEX PRO V3 (PC software for startup and parameterization)
203446	Safety manual; functional safety
203704	Parameter description KW-R06 / -R16 / -R07 / -R17, KW-R24(-R) / -R25 / -R26 / -R27, iC / iX / iDT5, KE (CAN / Ethernet)
204019	Basic knowledge AMK PLC programming in structured text
204072	AIPEX PRO add in gateway for TwinCAT
204364	Functional safety, application examples
204539	Initial startup KE/KW
204737	Initial startup of decentralized drives

Third-party descriptions

Producer	Title
Beckhoff	Documentation EL6900
Beckhoff	Documentation EL1904
Beckhoff	Documentation EL2904

Further files

Part no.	Title
nnnnnn	AMK device description file AMK_ECsoe_vvv_nnnnnn.xml (vvv - version; nnnnnn - Part no.) You can get the device description file • from the AMK homepage http://www.amk-antriebe.de/download.aspx -> Configuration files (therefore, a registration is necessary)

2 For your safety

2.1 Basic notes for your safety

- At electrical drive systems, hazards are present in principle that can result in death or fatal injuries:
  - Electrical hazard (e. g. electric shock due to touch on electrical connections)
  - Mechanical hazard (e. g. crush, retract due to the rotation of the motor shaft)
  - Thermal hazard (e. g. burns due to touch on hot surfaces)
- These hazards are present while starting up and operating the unit, and also during servicing or maintenance work.
- Safety instructions in the documentation and on the product warn about the hazards.
- Personnel must have read and understood the safety instructions before installing and operating the product. In the documentation about the product the usage warnings pertain to direct hazards and must therefore be followed directly when operating or handling the product by the operator.
- AMKmotion products must be kept in their original order, that means it is not allowed to do a significant constructional change on hardware side and software is not allowed to be decompiled and change the source code.
- Damaged or faulty products are not allowed to be integrated or put into operation.
- Do not start the system in which the AMKmotion products are installed (begin of intended use) until you can determine that all relevant standards, laws, and directives have been complied with, e. g. low voltage directive, EMC directive, and the machinery directive, and possible further product standards. The plant manufacturer is responsible for the compliance with the laws, directives, and standards.
- The devices must be installed, electrically connected and operated as shown in the device description documentation. The technical data and the required environmental conditions must be observed at all times.

2.2 Safety rules for handling electrical systems

In particular on drive systems, the instructions pertaining to safety and the following five safety rules have to be kept in the specified sequence:

1. Switch off electrical circuits (also electronic and auxiliary circuits).
2. Secure against being switched on again.
3. Determine that there is no voltage.
4. Ground and short circuit.
5. Cover or close off neighboring parts that are under voltage.

Reverse the measures taken in reverse order after completing the work.

2.3 Presenting safety messages

Any safety information is configured as follows:

⚠ SIGNAL WORD	
	**Type and source of risk** Consequence(s) of non-observance **Steps to prevent:** • ...

2.4 Class of hazard

Safety and warning messages are graduated into classes of hazard (according to ANSI Z535). The class of hazard defines the potential risk of harm and is described by a single word, if the safety information is ignored. The signal word is followed by a safety alert symbol (ISO 3864, DIN EN ISO 7010). In accordance with ANSI Z535, the following signal words are used to define the class of hazard.

Safety alert symbol and signal word	Class of hazard and its meaning
⚠ DANGER	DANGER indicates a hazardous situation which, if not avoided, **will** result in death or serious injury
⚠ WARNING	WARNING indicates a hazardous situation which, if not avoided, **could** result in death or serious injury
⚠ CAUTION	CAUTION, used with the safety alert symbol, indicates a hazardous situation which, if not avoided, **could** result in minor or moderate injury
NOTICE	NOTICE is used to address preventions to avoid material damage, but not related to personal injury.

2.5 Used safety alert symbols

Safety symbol	Meaning
	Generic warning!
	Warning against dangerous electrical voltage!

2.6 Requirements for the personnel and their qualification

Only authorized and qualified personnel may work on and with the AMKmotion drive systems.

Specialised personnel must:

- Perform mechanical and electrical work that is described in this documentation, such as mounting and connecting
- Observe all information in the documentation accompanying the product in order to work with the product safely and in an error-free manner
- Understand and know hazards that occur when handling the product
- Know connections and functions of the system
- Be familiar with the control concept in order to operate the drive system
- Be authorized to switch circuits and devices on and off, ground and label them
- Observe local specific safety requirements

2.7 Warranty

- All information in the documents accompanying the product must be complied with for a safe and trouble-free operation.
- The assertion of warranty claims is excluded if the information in the documents is not observed completely.
- Hardware and firmware may not be modified except by personnel authorized by AMKmotion and after consultation with AMKmotion.
- The company AMKmotion GmbH + Co KG is not liable for damages from unintended use, incorrect installation or operation, exceeding rated values and non-observance with the environmental conditions.

2.8 Always to observe!

⚠ DANGER

Danger to life!

The controller cards KW-R07 / KW-R17 / KW-R27 are safety modules according to the Machinery directive MRL 2006/42/EG. Before the cards are put into operation, the executing person must have read and understood the device description and the safety manual. During the startup, all information in these documentation must be taken into account.

⚠ DANGER

Danger to life from touching electrical connections!

Electrical terminals and connectors carry voltages that may cause death or serious injury upon contact.

Steps to prevent:

- Prior to any work on the device: Observe the 5 safety rules.
- Measure the terminal voltages. There may be no voltage present.
- Plug and pull connections only when there is no voltage.
- For devices that are connected to a DC bus, or generate it yourself, you need to consider the discharge times of the dc bus capacitors mentioned in the converter documentation
- Before commencing work, the connections must be isolated from the voltage supply at both ends! (both ends mean: AC and DC bus supply side)

⚠ DANGER

Danger to life due to unexpected movements!

The drive will be torque-free in the status 'Safe torque off (STO)', in case of mains failure or in case of faulty drive controller. External application of force on the drive axis may result in life-threatening movements (e.g. hanging axes can fall down).

Steps to prevent:

- Install an external, mechanical brake that prevents a movement.
- Install a counterweight in order to maintain the axis in balance.

⚠ DANGER

Motor shaft movement (rotating parts)!

Hair, body parts and clothes can be captured and wrapped by rotating parts and people result suffer fatal injuries.

Hazardous motor movement occurs when the motor shaft moves in an uncontrolled or unintentional manner.

Even the intended drive movement may be hazardous, if persons remain inside the range of movement.

Uncontrolled motor shaft movement occurs when the motor is no longer controllable. may have lethal consequences. Possible causes include the following:

- Faulty wiring, e.g., faulty phase sequence while connecting motor
- Faulty components
- Faulty motor parameters
- Software error

Unintended motor shaft movement is caused by errors in the motor control. may have lethal consequences. Possible causes include the following:

- Operator errors
- Controller or application program faults
- Faulty setpoint specification and scaling
- Improper operating mode

The monitoring devices in the drive system are capable of detecting various fault states. However, the monitoring devices by themselves are not sufficient to completely and reliably prevent uncontrolled movement. Uncontrolled movement cannot be prevented completely, even if it occurs only for a brief period of time before a monitoring device trips and shuts down the drive or switch off power supply.

Steps to prevent:

- Always ensure that the is fully de-energized before commencing work on the .
- Check the limit values for torque, speed, and position, as well as the acceleration and deceleration ramps.
- Specify the maximum permissible process speed and set ID113 accordingly.

⚠ DANGER

Danger to life from touching electrical connections!

The permanent magnets of the rotor induce dangerous voltage at the motor connections when the axis rotates, even when the motor is not electrically connected. If the motor is connected to an inverter, the induced DC voltage is linked to the .

Steps to prevent:

- Make sure that the motor shaft does not rotate.
- Make sure that shock-hazard protection is installed at the motor connections.
- Make sure that the terminals are free of voltage.

⚠ DANGER

Risk of injury from hanging axes

The optional motor brake is a holding brake and does NOT provide sufficient protection for persons.

Hanging axes can fall and lead to severe injury.

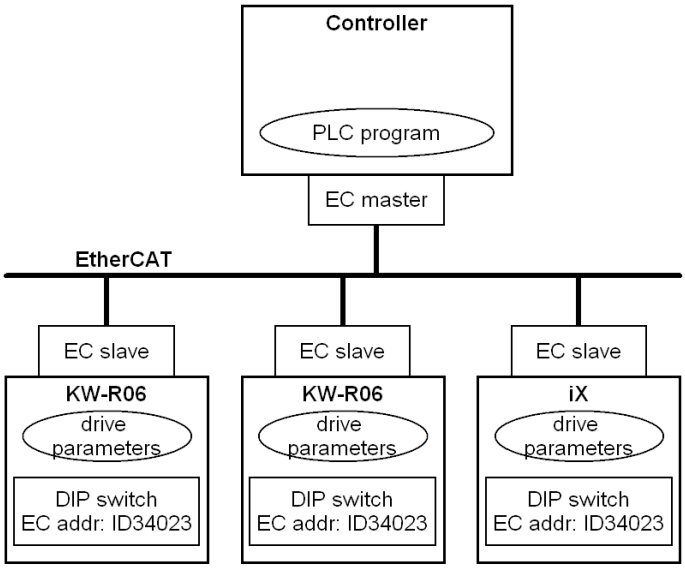
Steps to prevent:

- All hanging axes must be mechanically secured against falling with a fall arrester or a supplementary external brake, for instance.
- People must not stand under hanging loads

⚠ WARNING	
	**Risk of burns when touching hot surfaces!** The casing temperature can be more than 70 °C during and even after operation. Contact causes burns. **Steps to prevent:** • Make sure that the surfaces have cooled down before you touch. • Wear protective clothing such as gloves if hot parts need to be touched. • Fit a warning sign with warning hot surface. • Do not mount any flammable objects near the device.

3 AMK drive with third-party controller

3.1 Prerequisites



The third-party controller is connected to the AMK drives via EtherCAT. The data exchange takes place by SoE protocol (servodrive profile over EtherCAT) acc. to IEC61800-7.

Before connecting the controller, the drive must be started up.
See documents

- Initial startup KE/KW (Part no. 204539)
- Initial startup of decentralized drives (Part no. 204737).

3.2 General procedure

In order to realise the communication between controller and AMK drive, the PLC variables must be linked to the drive parameters.
The device description file describes the AMK EtherCAT slave devices. By means of these information, an EtherCAT configurator (e.g. with AIPEX PRO, TwinCAT) generates the fieldbus configuration.
AMK_ECsoe_vvv_nnnnnn (vvv - version; nnnnnn - Part no.)

When configuring the controller, the device description file is included. On the other hand, the controller configuration is acquainted to the drives.

Parameter	Name	Term in the device description file
ID24	'Configuration list MDT'	MDT
ID134	'Master control word'	Master control word
ID47	'Position command value'	Position command value
ID36	'Velocity command value'	Velocity command value

Parameter	Name	Term in the device description file
ID16	'Configuration list AT'	AT
ID135	'Drive status word'	Drive status word
ID51	'Position feedback value'	Position feedback value 1
ID40	'Velocity feedback value'	Velocity feedback value

Freely configurable parameters

The ID16 'Configuration list AT' defines what parameters are cyclically transferred into the drive telegram (AT) if the ID15 'Telegram types parameter' 'configured telegram' is selected. The configurable parameters are listed in ID187 'List of data AT'.

The ID24 'Configuration list MDT' defines what parameters are cyclically transferred into the master data telegram (MDT) if 'Telegram type parameters' 'configured telegram' is selected in ID15 'Telegram types parameter'. The configurable parameters are listed in ID188 'List of data MDT'.

The configurable parameters will be dynamically read from the EtherCAT salves (ID187 and ID188).

4 Beckhoff TwinCAT PLC

The following chapters will give you a step-by-step description about which configuration is necessary to run AMK drives as EtherCAT slaves with a Beckhoff TwinCAT PLC (EtherCAT master).

4.1 KE(N, S) control signal 'Power ON' (AMK UE - DC bus ON)

Only if you use power supply modules type KE / KEN / KES (exception: KEN 05-xx).

The devices from type AMKASMART iC and AMKASYN KEN 05-xx charge the DC bus automatically. The DC bus is needed to supply the inverters.

The compact power supplies KE / KEN / KES supply the inverters via the DC bus (power supply).

After activating the control signal ID134 'Master control word' bit 14 (0→1) (AMK control signal UE), the DC bus is charged.

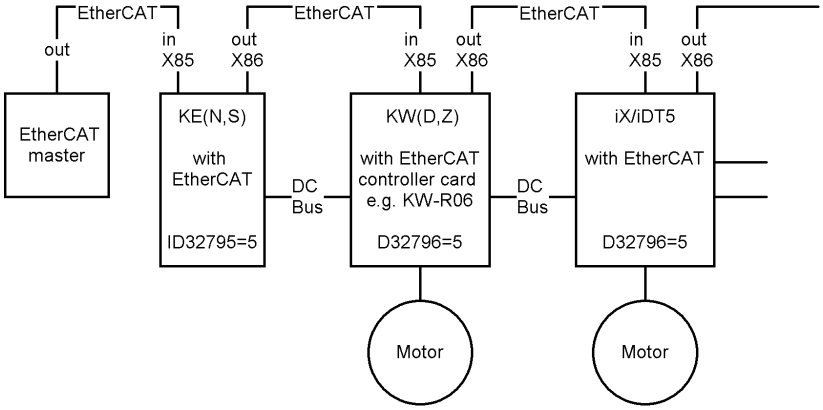
ID135 'Drive status word' bit 15/14 = 10 (AMK status signal QUE) shows that the DC bus voltage meets the admitted range.

4.1.1 Variant 1: Compact power supply KE(N, S) with EtherCAT interface

The compact power supply is integrated within the EtherCAT bus. The EtherCAT master can directly control it.

Parametrisation:

KE(N,S): ID32795 'Source UE' = 5



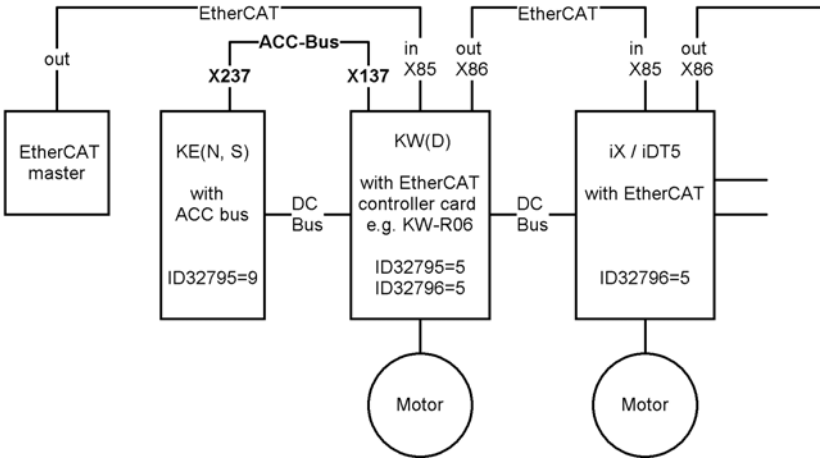
4.1.2 Variant 2: Compact power supply KE(N, S) with ACC bus interface

The compact power supply KE(N, S) is connected to an EtherCAT controller card (e.g. KW-R06) via the ACC bus. Control signals UE are sent to the controller card in the KW(D) inverter via EtherCAT. The controller card will forward it automatically to the KE(N, S) via ACC bus.

Parametrisation:

KW(D): ID32795 'Source UE' = 5

KE(N, S): ID32795 'Source UE' = 9



4.2 KW(D,Z), iC / iX / iDT5 command signal 'Drive ON' (AMK RF - controller enable)

The inverters power supply the servo motors.

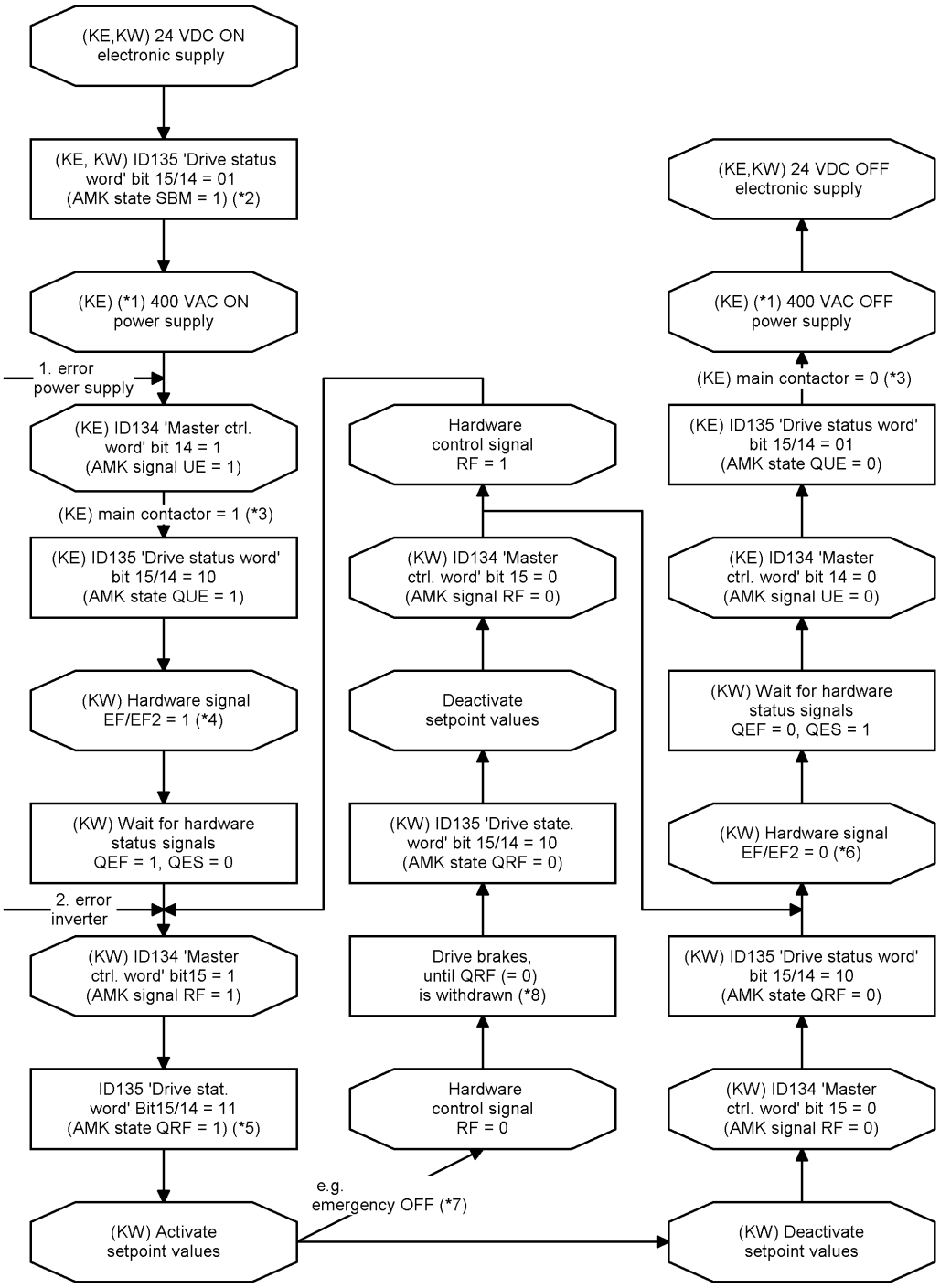
After setting the control signal ID134 'Master control word' bit 15 (0→1) (AMK control signal RF), the motor control is activated.

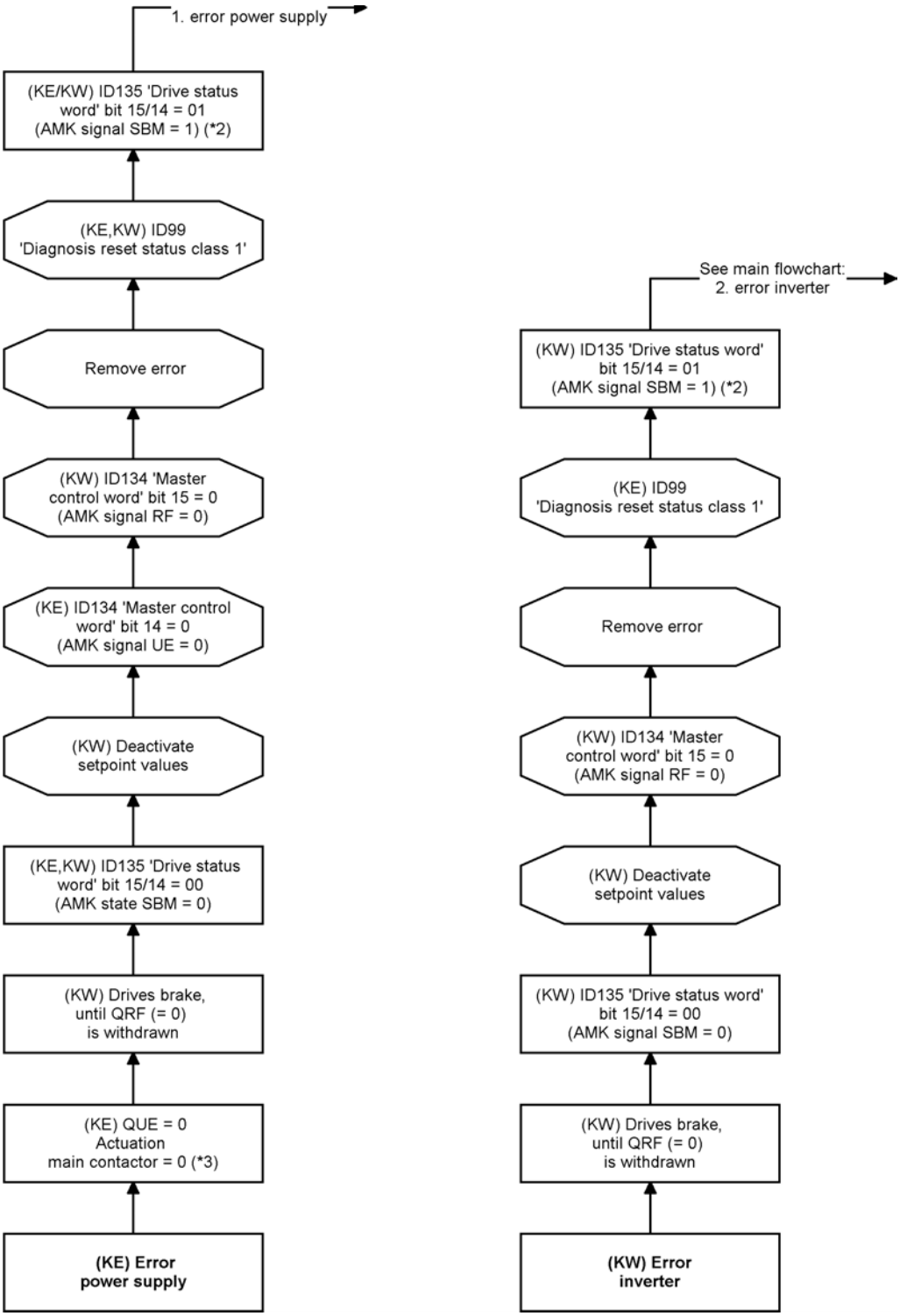
ID135 'Drive status word' bit 15/14 = 11 (AMK status signal QRF) shows that the motor is under control. Position, speed or torque setpoint can be preset depending on the selected operation mode.

Parametrisation:

ID32796 'Source RF' = Code 5

4.3 Switch-on and -off flow chart KE/KW

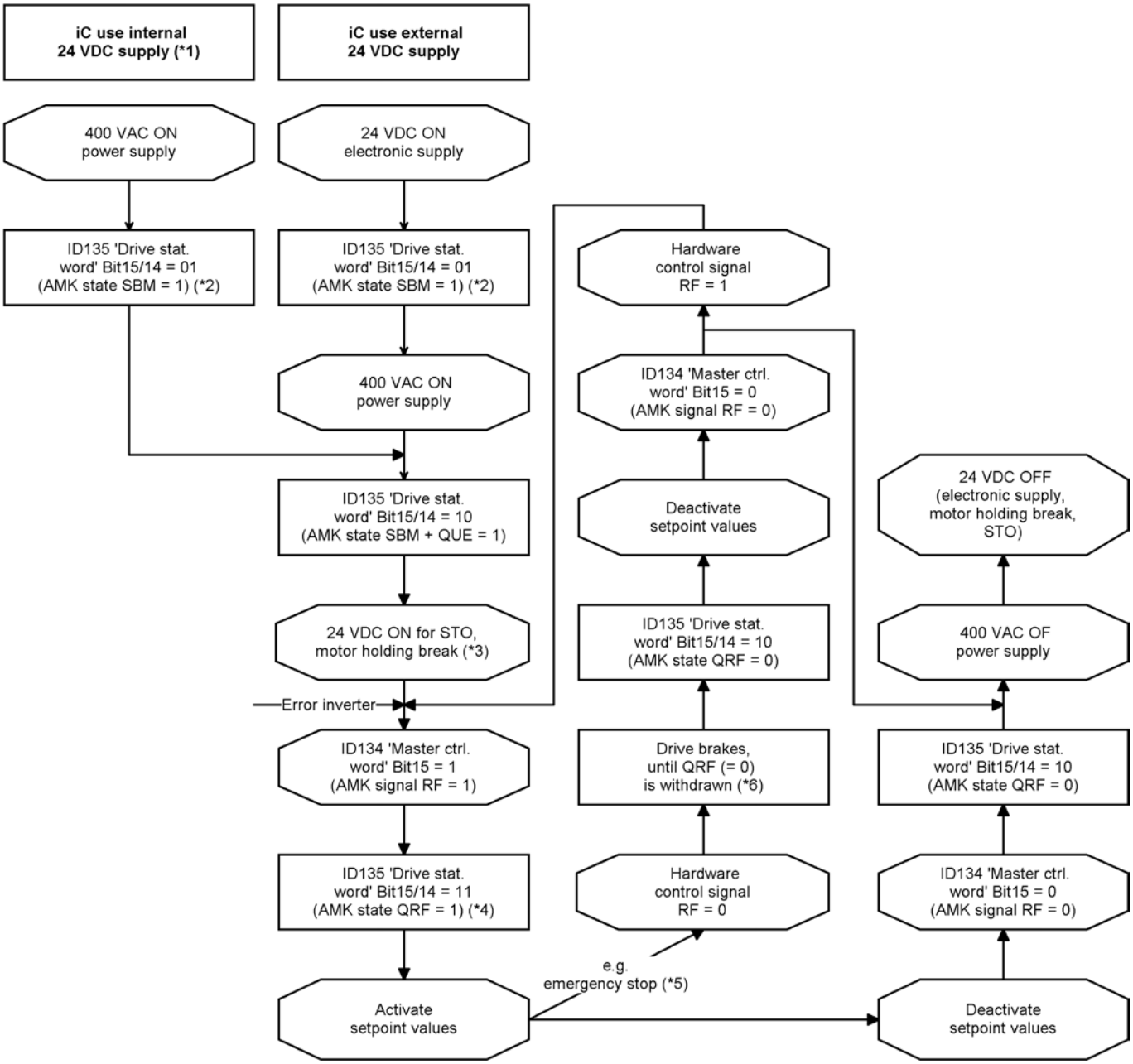


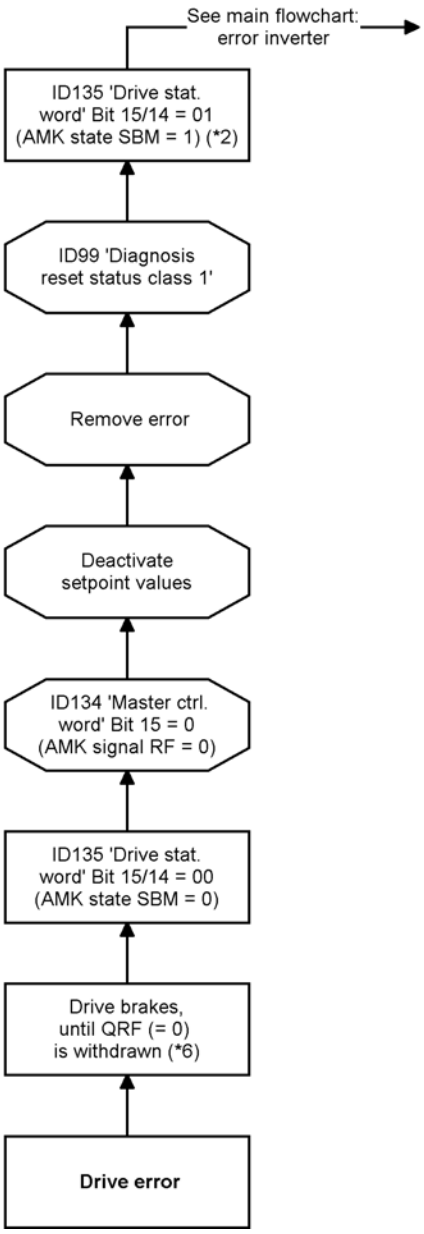


*1	Close emergency OFF circuit (if existent).
*2	The module specific 'System ready' messages (SBM = 1) from the KE and KW modules signal the error-free states. The monitoring of these messages takes place in the higher-ranking controller. Time to SBM > 2 s.
*3	If present, the required external main contactor is actuated by the KE. The delay time until the contactor is actuated via terminal X20 (EH1/EH2) depends on the DC bus capacities connected to the KE.
*4	Only devices with EF logic: Hardware signal EF/EF2 must be applied at the latest at that time.
*5	Delay time until QRF is set depends on the connected motor resp. whether the data set must be newly calculated because of a modification of drive specific parameters.
*6	Only devices with EF logic: Reset hardware signal EF/EF2 if the motor has to be in a safe torque-free state afterwards.

*7	RF will be disabled via BE. BE is linked with PLC signal, see ID32796 'Source RF'.
*8	Motor is braked to a standstill after the ramp ID32782 'Deceleration ramp RF inactive'.
*9	Pulse ≥ 1 ms.
*10	Each inverter generated a DC bus error.

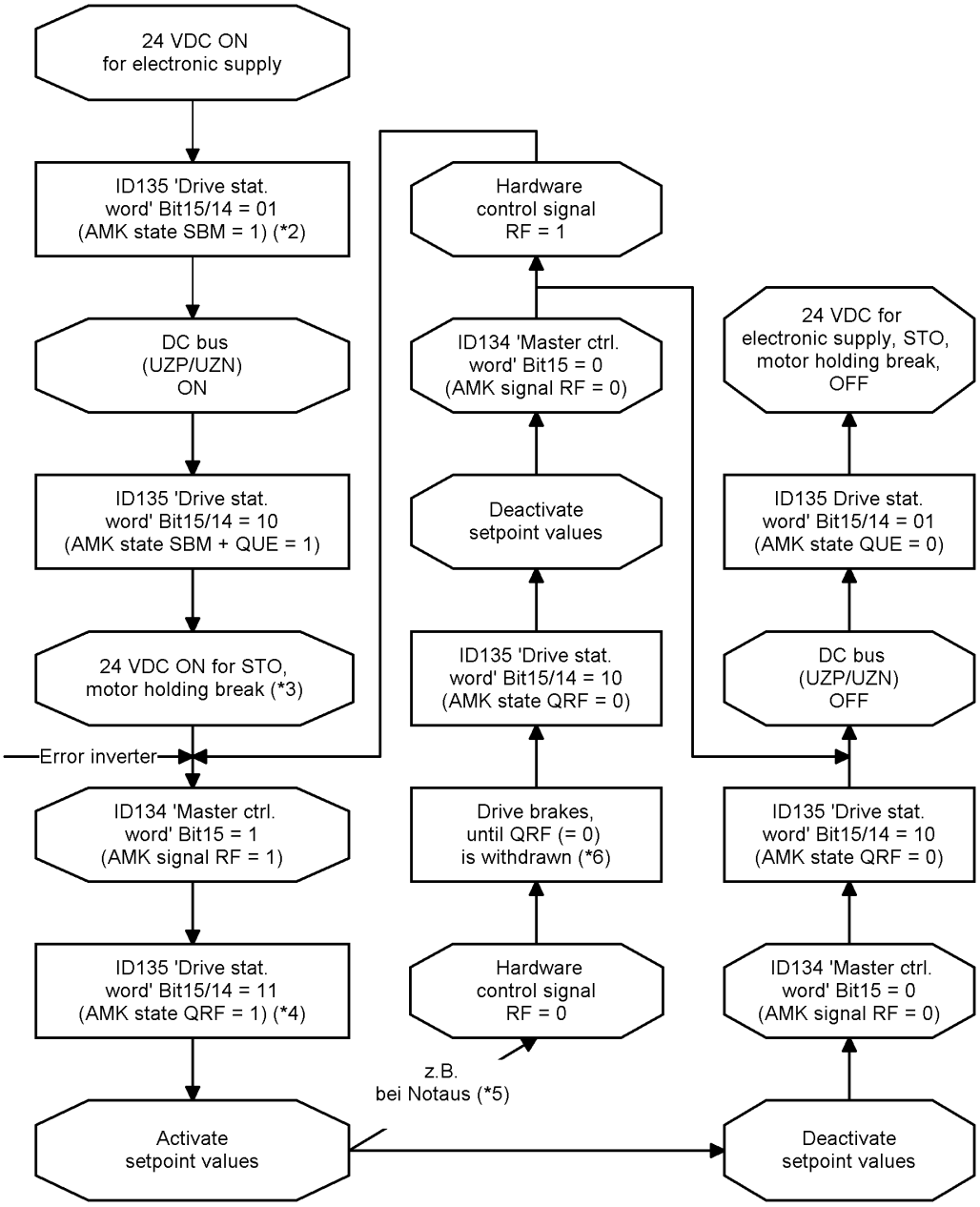
4.4 Switch-on and -off flow chart iC

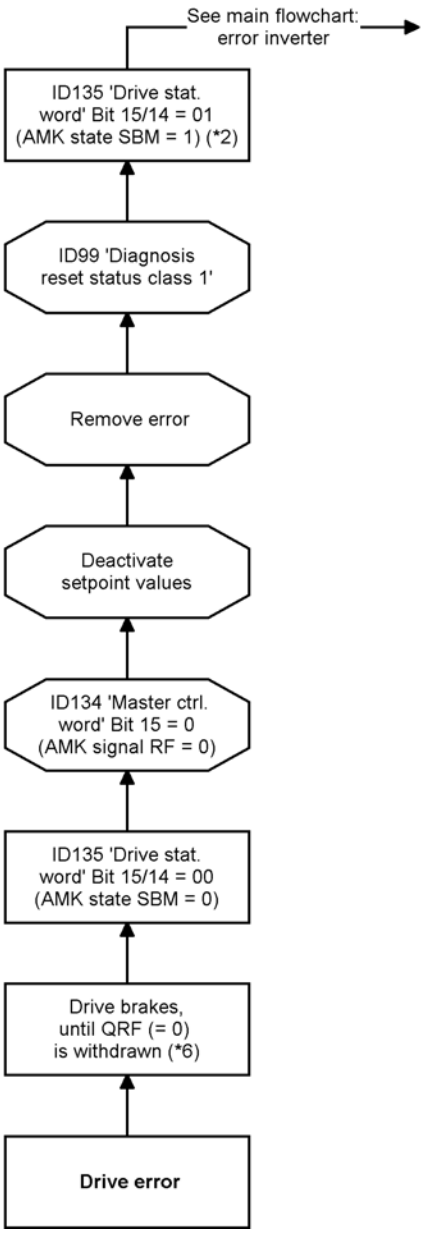




*1	Hint limitations! After power on the internal 24 VDC supply is available after < 3 s.
*2	The module specific 'System ready' messages (SBM = 1) from the modules signal the error-free states. The monitoring of these messages takes place in the higher-ranking controller. Time to SBM > 2 s.
*3	24 VDC supply must be applied at the latest at that time. Open / close motor holding brake will be automatically controlled trough the RF signal.
*4	Delay time until QRF is set depends on the connected motor resp. whether the data set must be newly calculated because of a modification of drive specific parameters.
*5	RF will be disabled via BE. BE is linked with PLC signal, see ID32796 'Source RF'.
*6	Motor is braked to a standstill after the ramp ID32782 'Deceleration ramp RF inactive'.
*7	Pulse ≥ 1 ms.
*8	(iC) Charging time after power on < 50 ms
*10	Maximum 1 power on circuit per minute.

4.5 Switch-on and -off flow chart iX / iDT5





*1	Hint limitations! After power on the internal 24 VDC supply is available after < 3 s.
*2	The module specific 'System ready' messages (SBM = 1) from the modules signal the error-free states. The monitoring of these messages takes place in the higher-ranking controller. Time to SBM > 2 s.
*3	24 VDC supply must be applied at the latest at that time. Open / close motor holding brake will be automatically controlled trough the RF signal.
*4	Delay time until QRF is set depends on the connected motor resp. whether the data set must be newly calculated because of a modification of drive specific parameters.
*5	RF will be disabled via BE. BE is linked with PLC signal, see ID32796 'Source RF'.
*6	Motor is braked to a standstill after the ramp ID32782 'Deceleration ramp RF inactive'.
*7	Pulse ≥ 1 ms.
*8	(iC) Charging time after power on < 50 ms
*10	Maximum 1 power on circuit per minute.

4.6 Integrating the AMK device description file into TwinCAT

Die Gerätebeschreibungsdatei beschreibt die AMK EtherCAT Slave Geräte. Mit Hilfe dieser Informatinen erstellt ein EtherCAT-Konfigurator, z.B. unter AIPEX PRO bzw. TwinCAT, die Buskonfiguration.

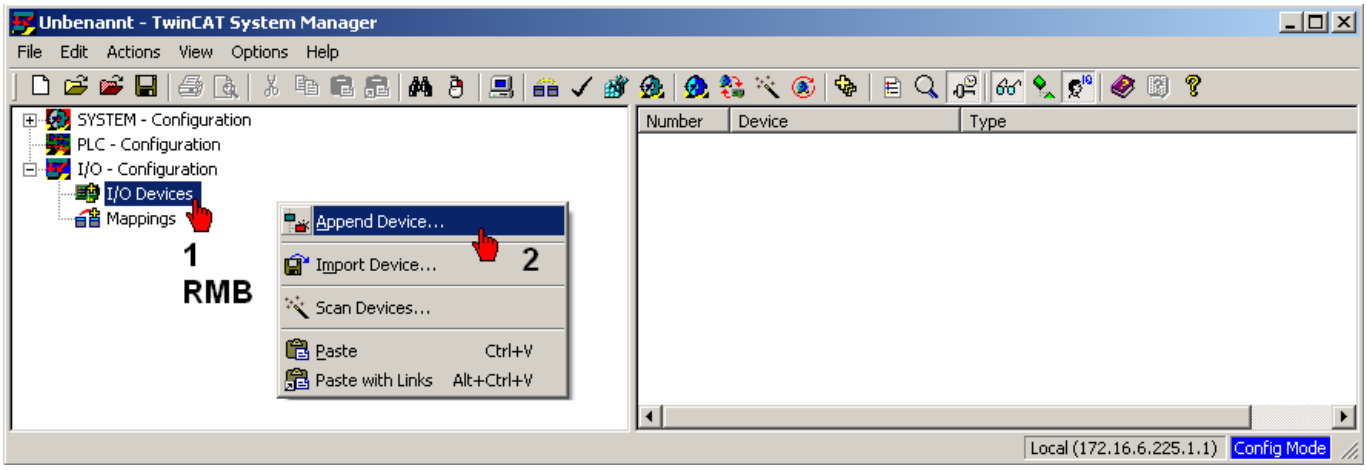
Copy the up-to-date AMK device description file AMK_ECsoe_vvv_nnnnnn.xml (vvv - version, nnnnnn - Part no.) to the windows folder C:\TwinCAT\Io\EtherCAT.

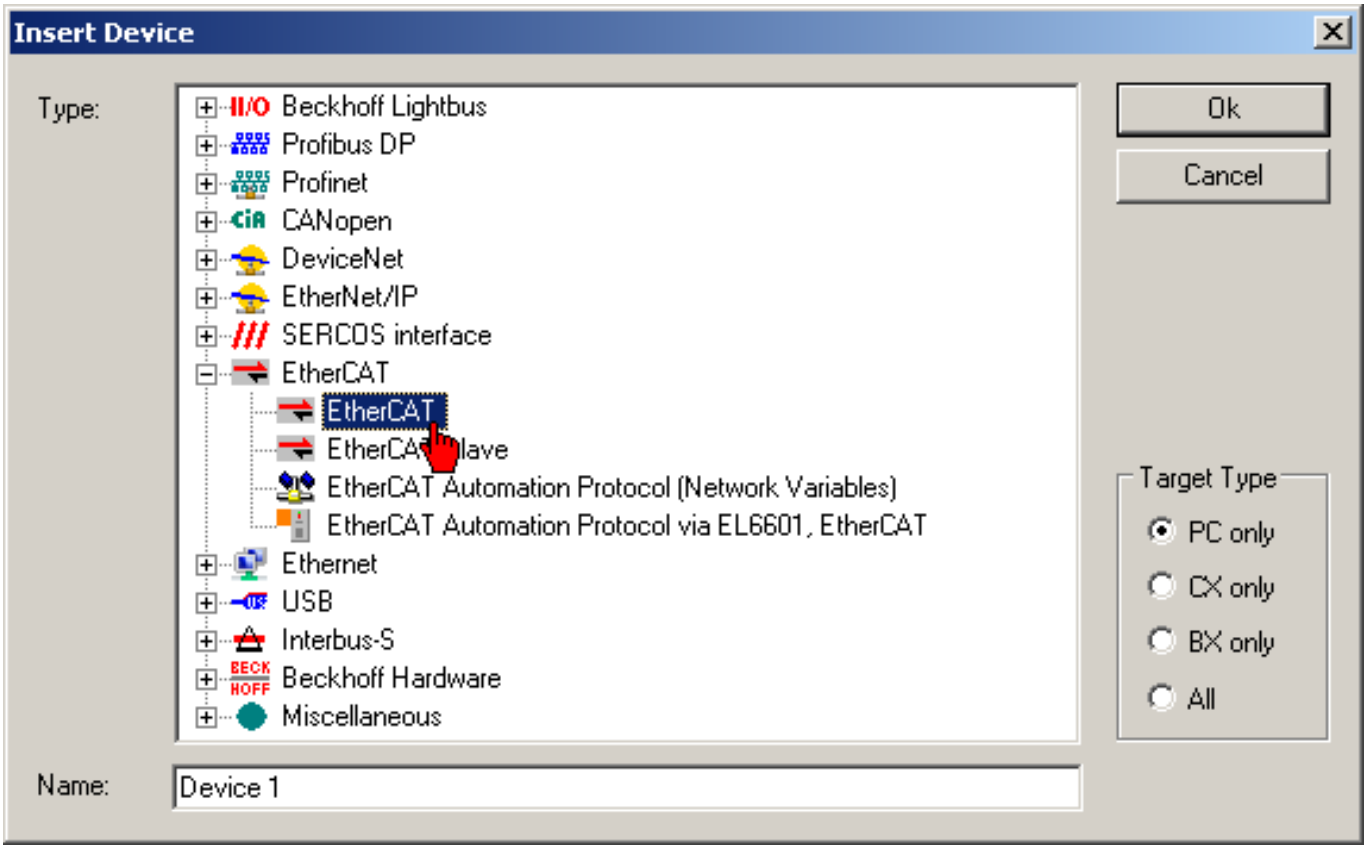
The present configuration file is available from the download window of the AMK homepage (http://www.amk-antriebe.de) or from the AMK Documentation CD (Part no. 47153).

4.7 Creating a TwinCAT project

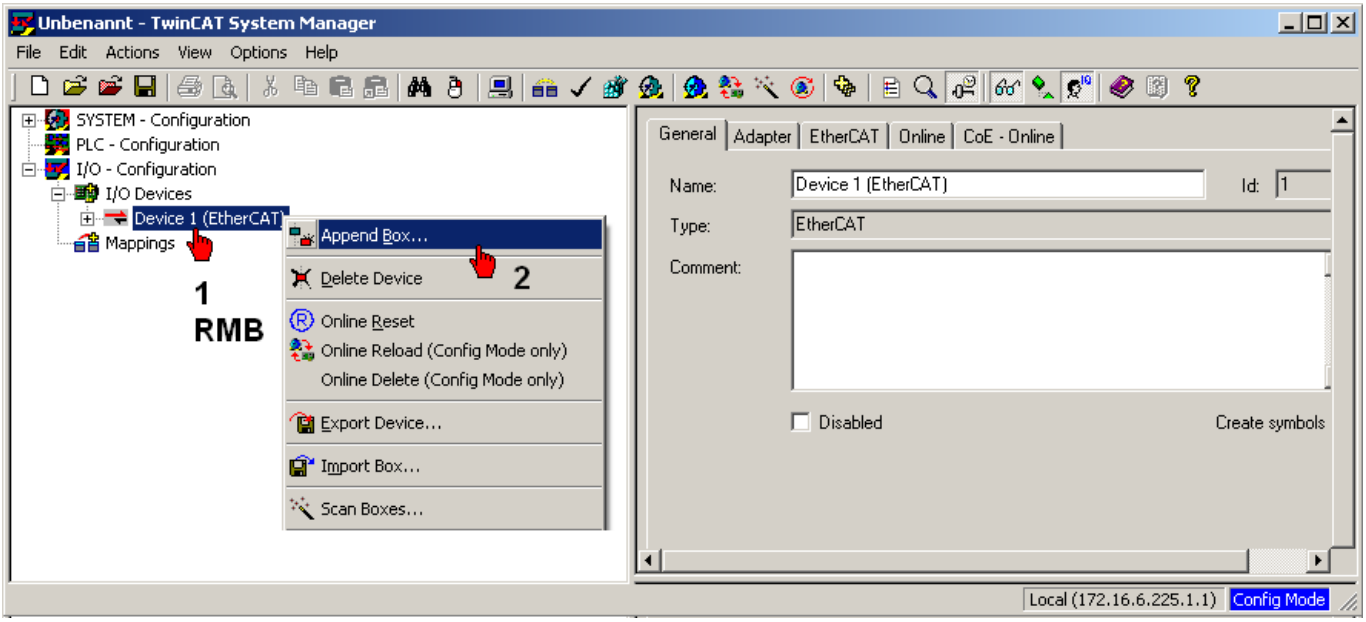
4.7.1 Create an offline TwinCAT project with AMK drive

- Start the 'TwinCAT System Manager'
- Open a new project
- Append an EtherCAT bus to the 'I/O Devices'



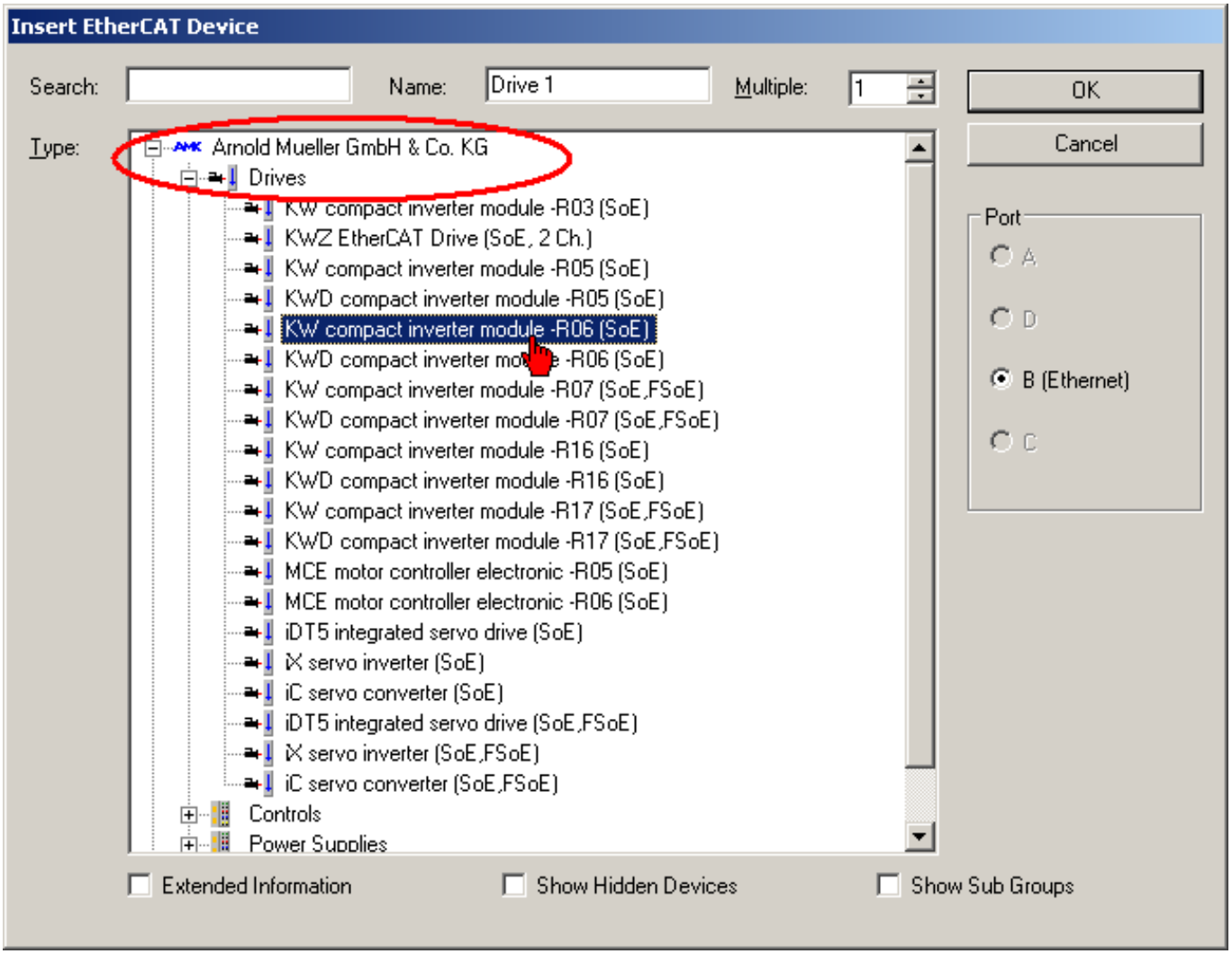


To the EtherCAT bus, you can add EtherCAT slave devices (boxes).
Repeat the following steps until your project is completely emulated.



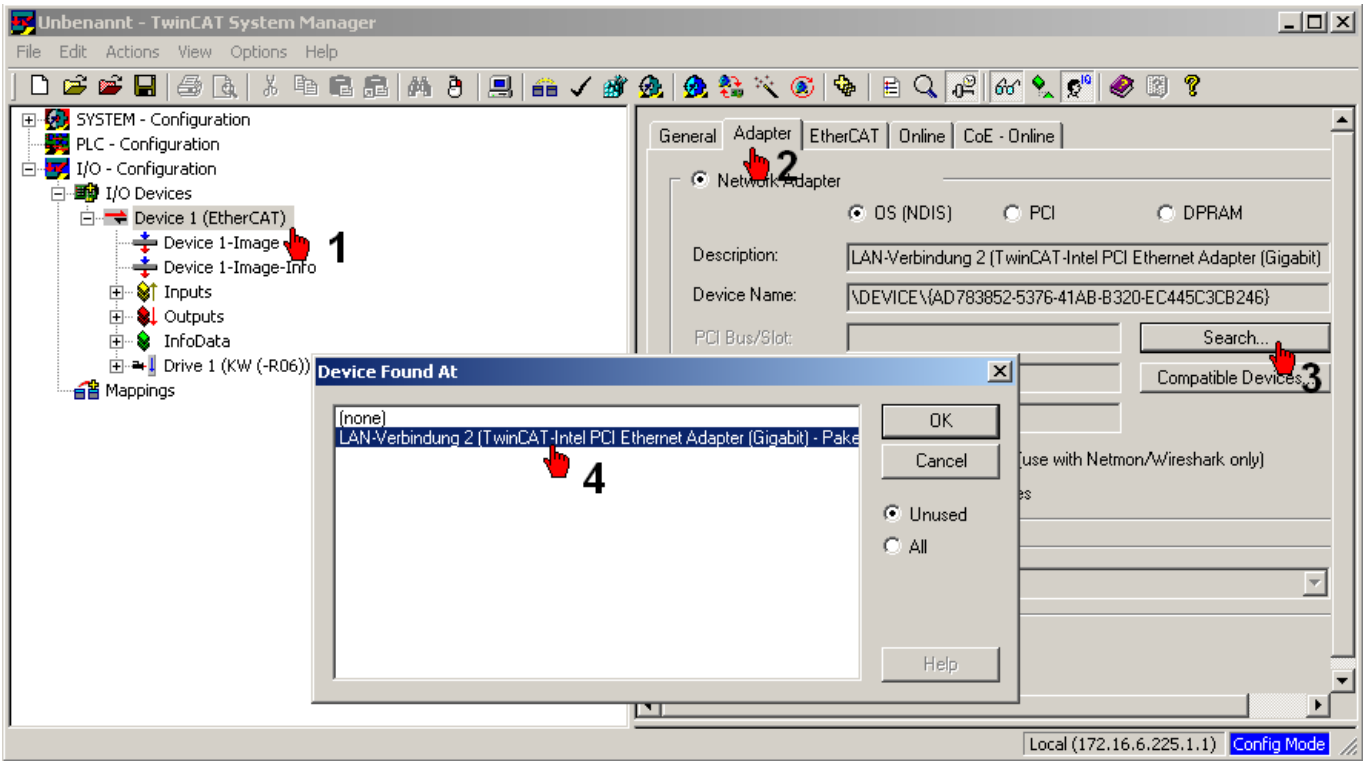
To execute the following step, the AMK EtherCAT configuration file must be integrated within TwinCAT.
Siehe 'Integrating the AMK device description file into TwinCAT ' auf Seite 21.

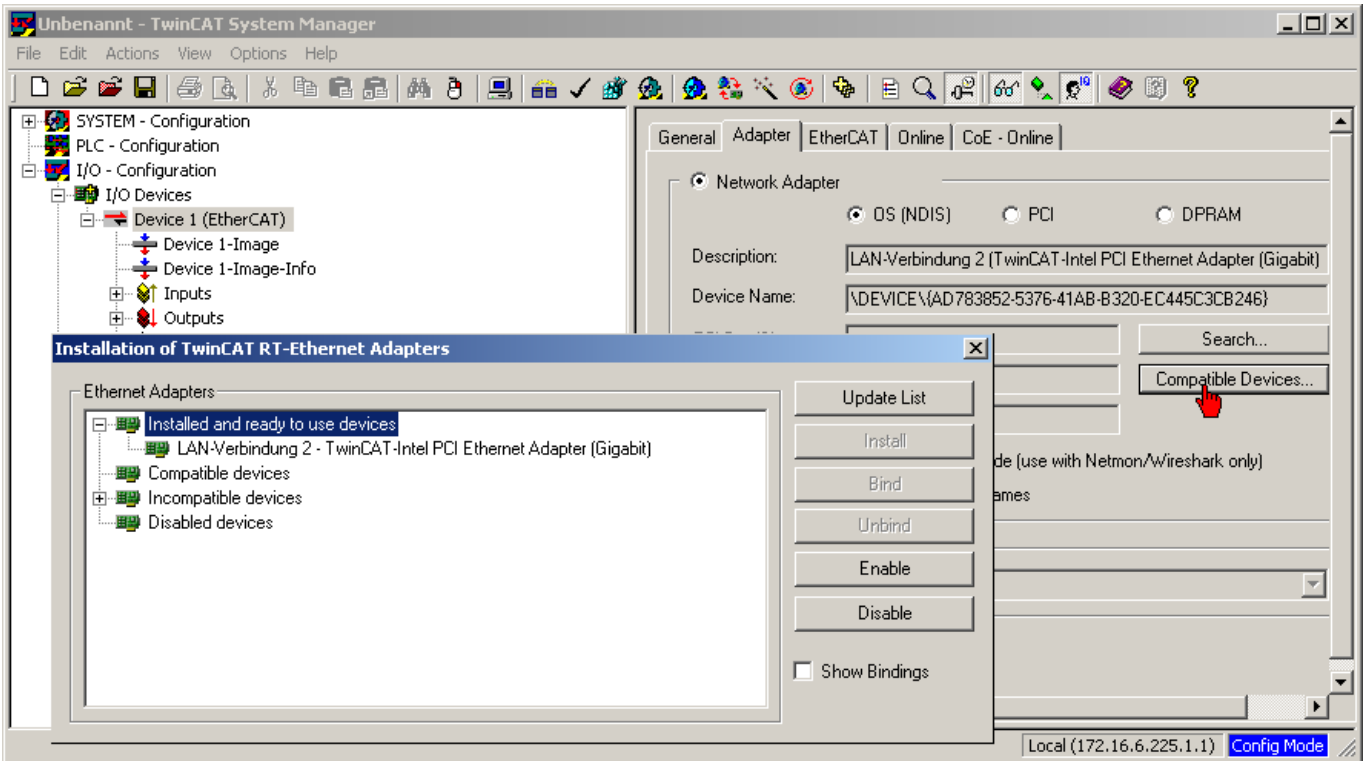
Below 'AMK Arnold Mueller GmbH & Co. KG', the AMK EtherCAT slave device types are listed. Numbers is brackets show the EtherCAT revision.
You will find the device type printed on the front plate of the controller card (e.g. KW-R06)



4.7.2 Activating the EtherCAT network

Activate the TwinCAT adaptor in your PC system



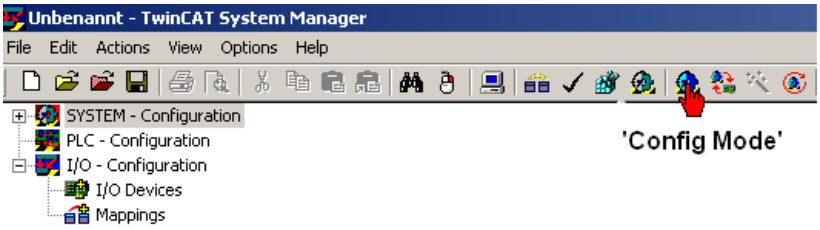


4.8 Reading AMK drives with TwinCAT online

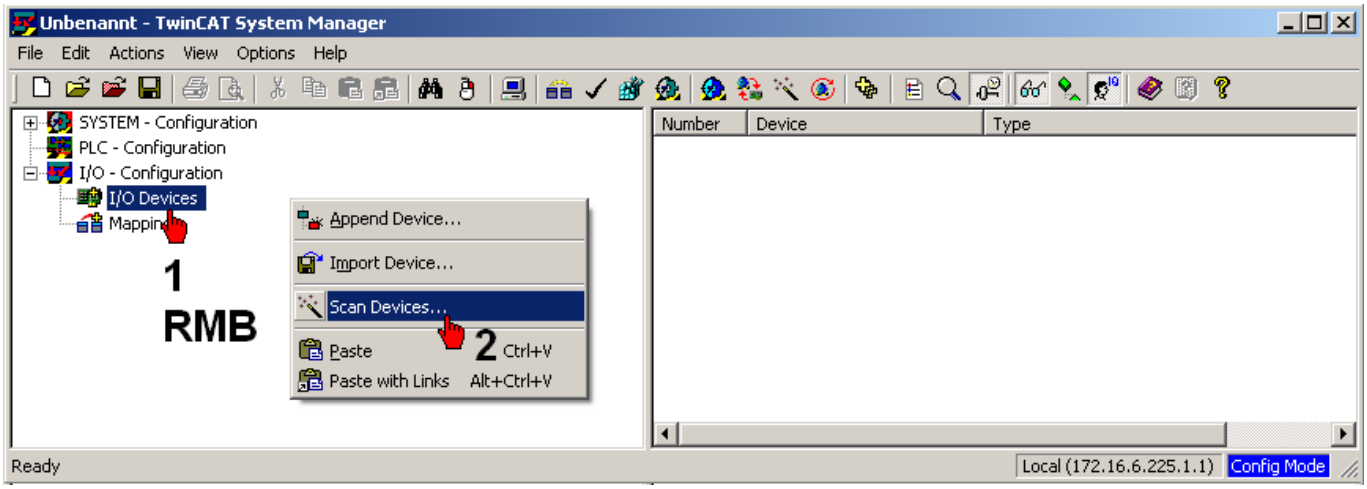
At first, integrate the AMK EtherCAT configuration file.

Siehe 'Integrating the AMK device description file into TwinCAT ' auf Seite 21.

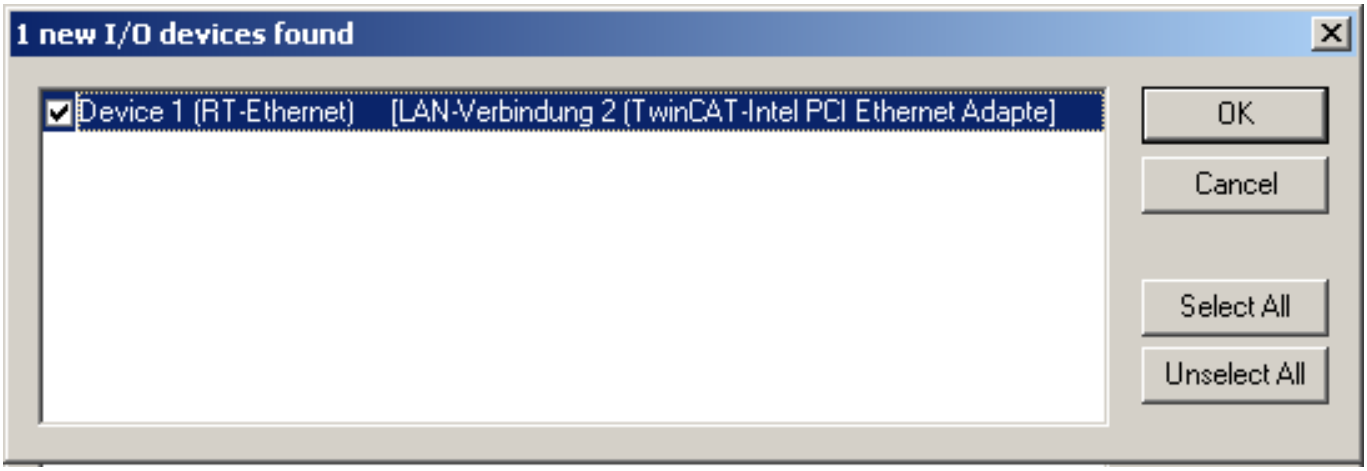
- Establish a physically EtherCAT connection between EtherCAT master and slaves
- Connect the EtherCAT master and slaves to the 24 VDC power supply
- Start 'TwinCAT System Manager'. Open a new project
- Start 'TwinCAT Config Mode'



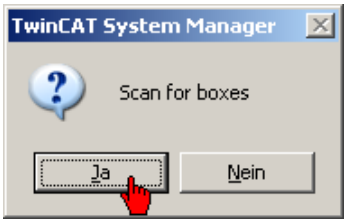
Start 'Scan Devices...'



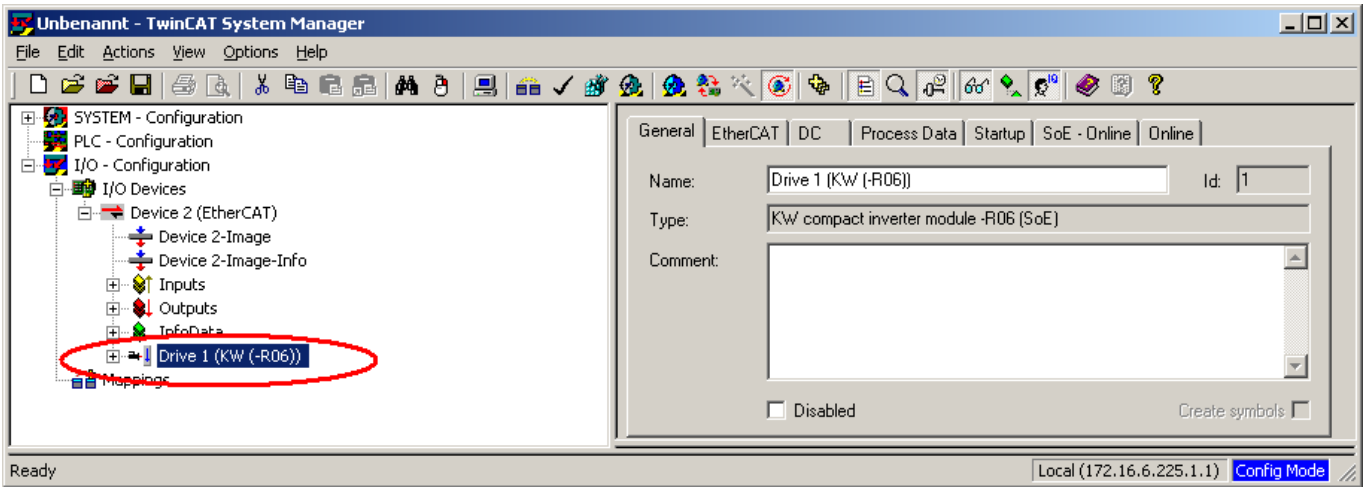
Select the TwinCAT adaptor to which the EtherCAT slaves are connected



Start 'Scan for boxes' (box = EtherCAT slave)



In this example, two EtherCAT slaves are read (drive 1 + drive 2)



Integrate the PLC project.

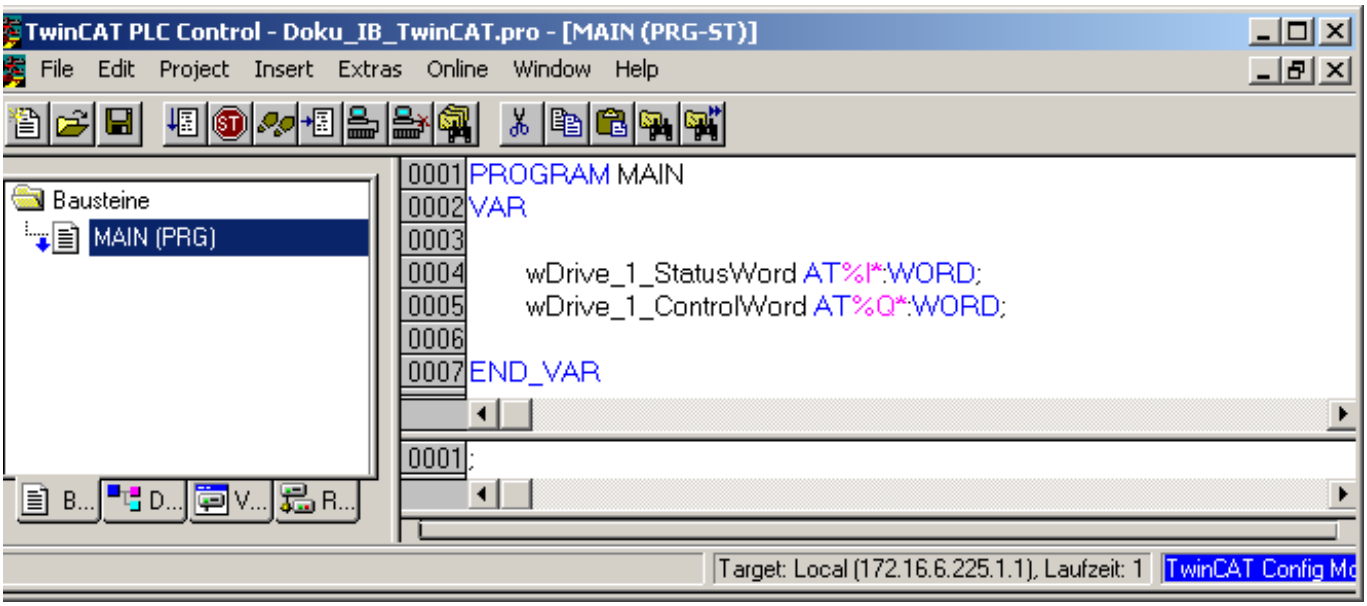
Siehe 'Integrating the PLC project' auf Seite 27.

4.9 PLC project

Start 'TwinCAT PLC Control'. Open a new project

On no account, you may rename the program block MAIN (PRG).

Create your PLC program



For example, in- out variables from type WORD are generated. Following this variables will be linked with each 'DriveStatus' and 'ControlWord' inside the TwinCAT System Manager.

Variables with designation 'AT' exist only within a project and cannot be linked to the Hardware. The addresses are extended by 'I' for inputs (AT%I) or 'Q' for outputs (AT%Q).

The variables can be addressed automatically by using the extension '*' or fixed by declaring the variable type (X = bool, W = word or D = double word).

Example:

diVelocityFeedback AT%I* : DINT; (automatic addressing)

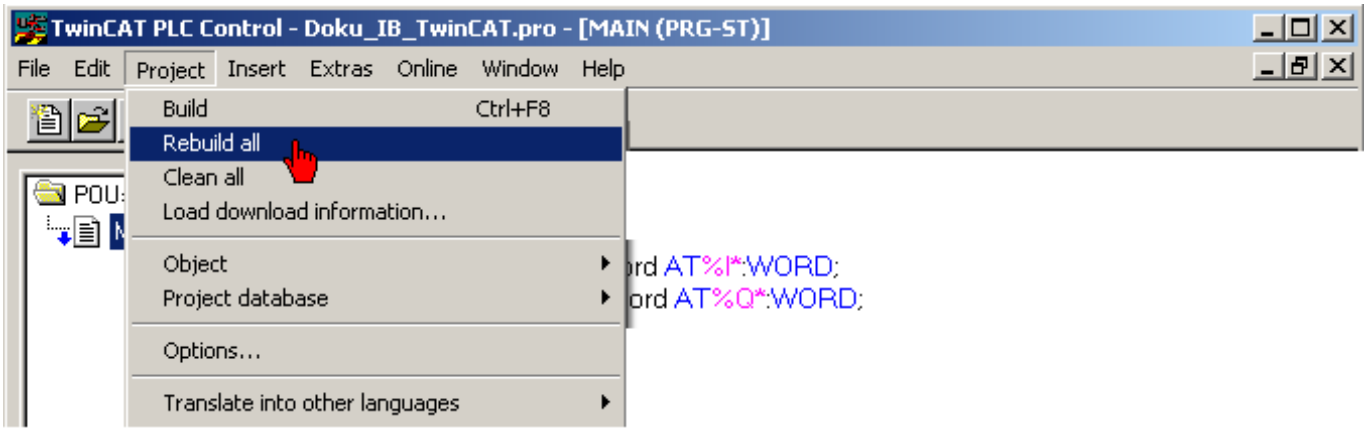
OR

boInput1 AT%IX0.0 : BOOL; (fixed addressing)

4.9.1 Create the PLC configuration

When compiling the project, a XML-type file with extension *.tpy is generated automatically. This file contains the defined variables as well as common project information. After an error-free compilation, the PLC project must be saved.

Subsequently, the XML file (*.tpy) must be read with the 'TwinCAT System Manager'. Siehe 'Integrating the PLC project' auf Seite 27.

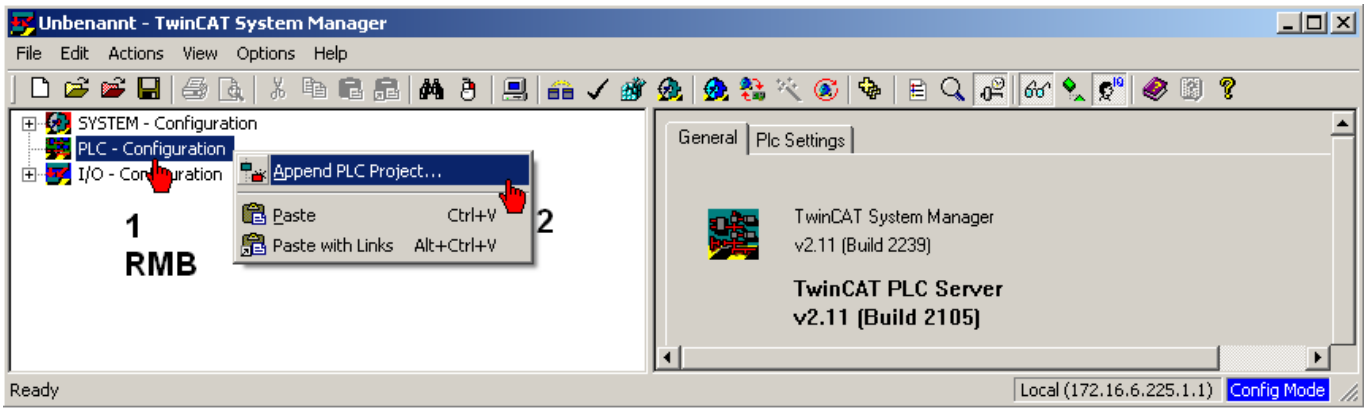


Before you log on to the PLC hardware, the 'run mode' of the 'TwinCAT System Manager' must be started.

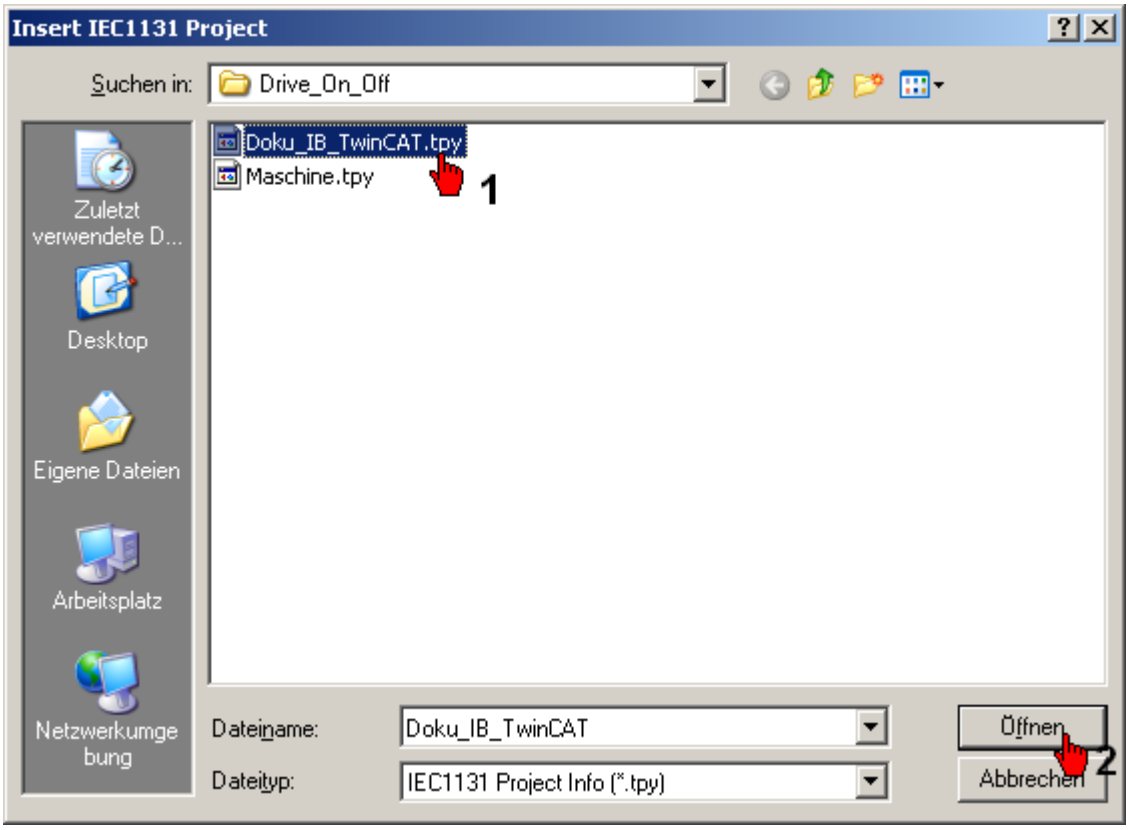
4.9.2 Integrating the PLC project

The following describes how to append an existing PLC project.

Compile and save the CoDeSys PLC project before appending it



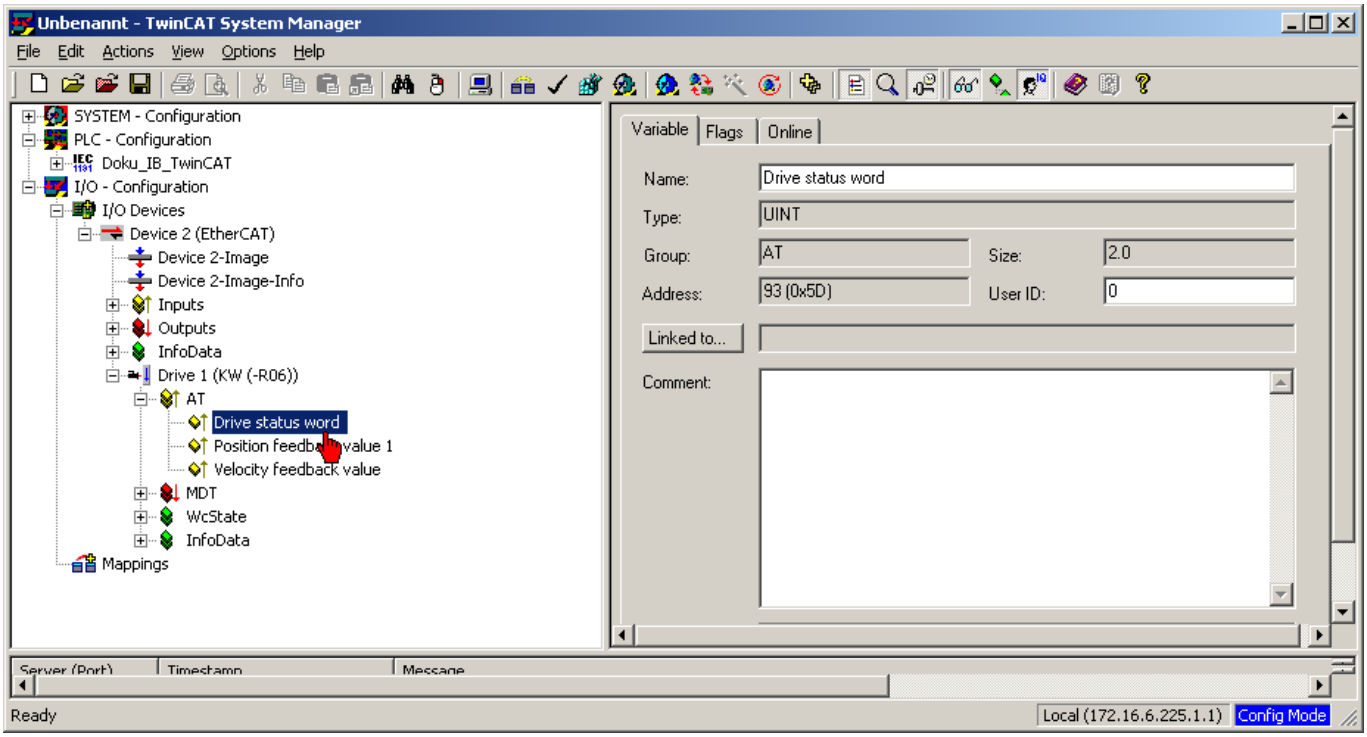
Select the PLC configuration file *.tpy.



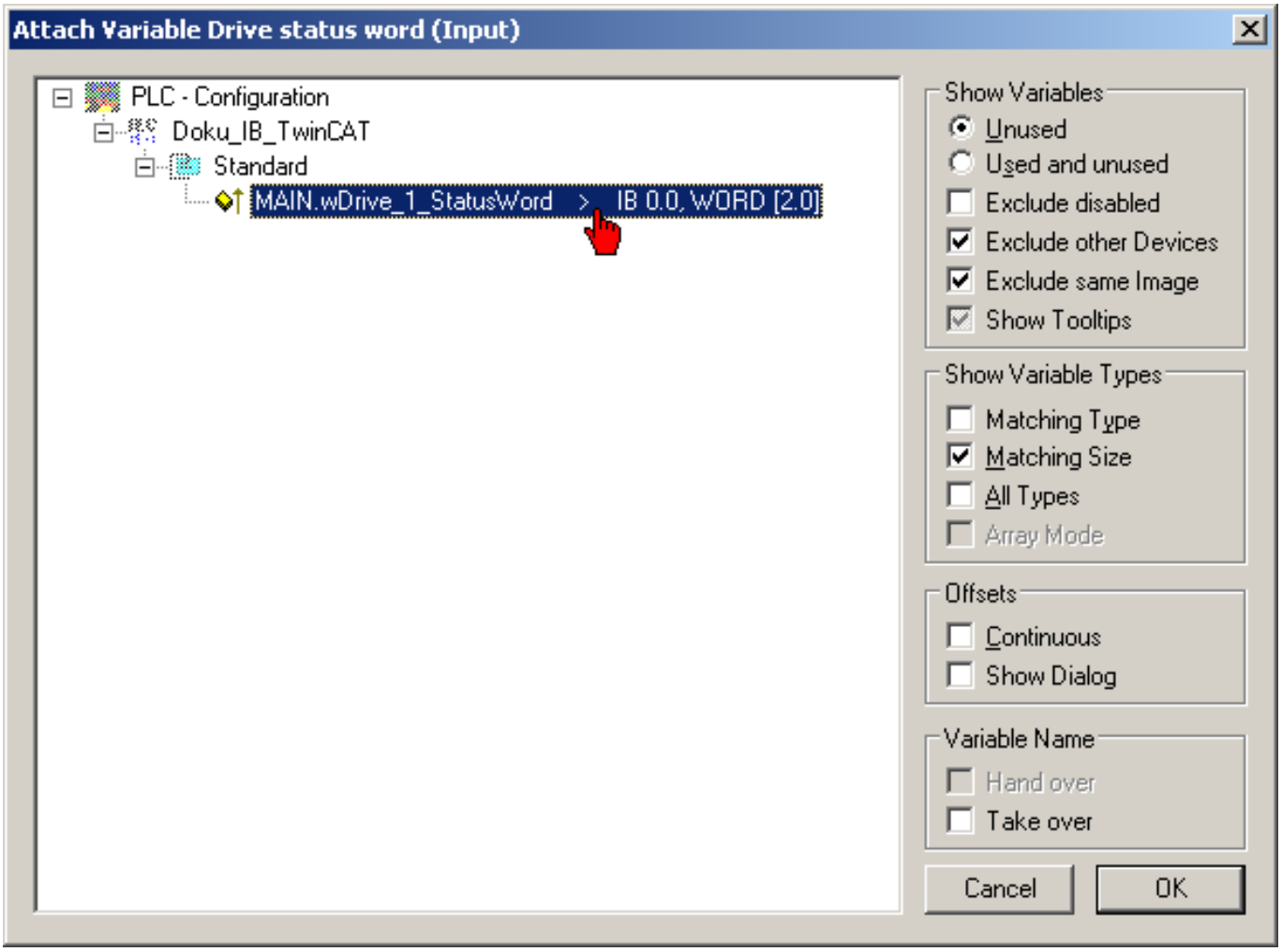
4.9.3 Linking PLC variables

The following describes how to link a TwinCAT variable to a PLC variable.

Double-click to a TwinCAT variable to open the 'Attach Variable' window



Double-click to the respective PLC variable to link it to the TwinCAT variable



4.9.4 Extending the data exchange

The following describes how to extend the drive telegram (AT) resp. the master data telegram (MDT).

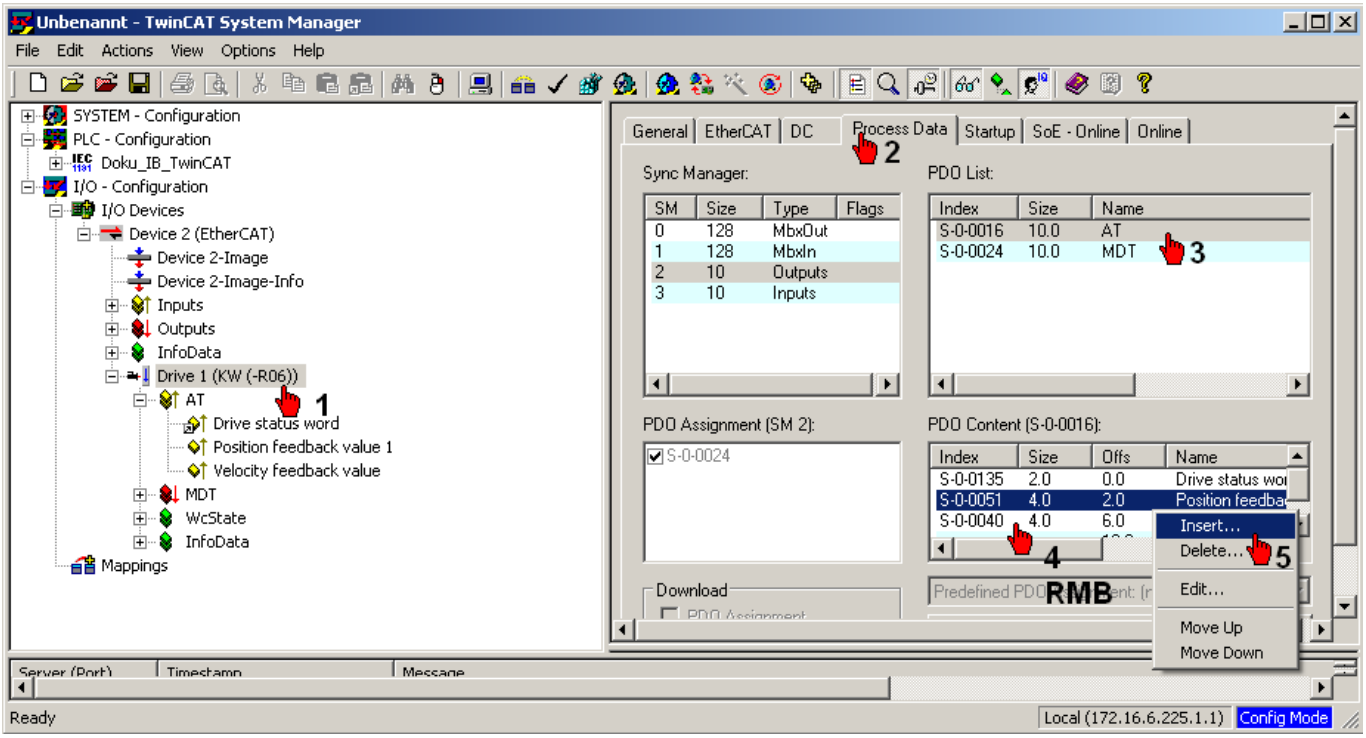
Freely configurable parameters

The ID16 'Configuration list AT' defines what parameters are cyclically transferred into the drive telegram (AT) if the ID15 'Telegram types parameter' 'configured telegram' is selected. The configurable parameters are listed in ID187 'List of data AT'.

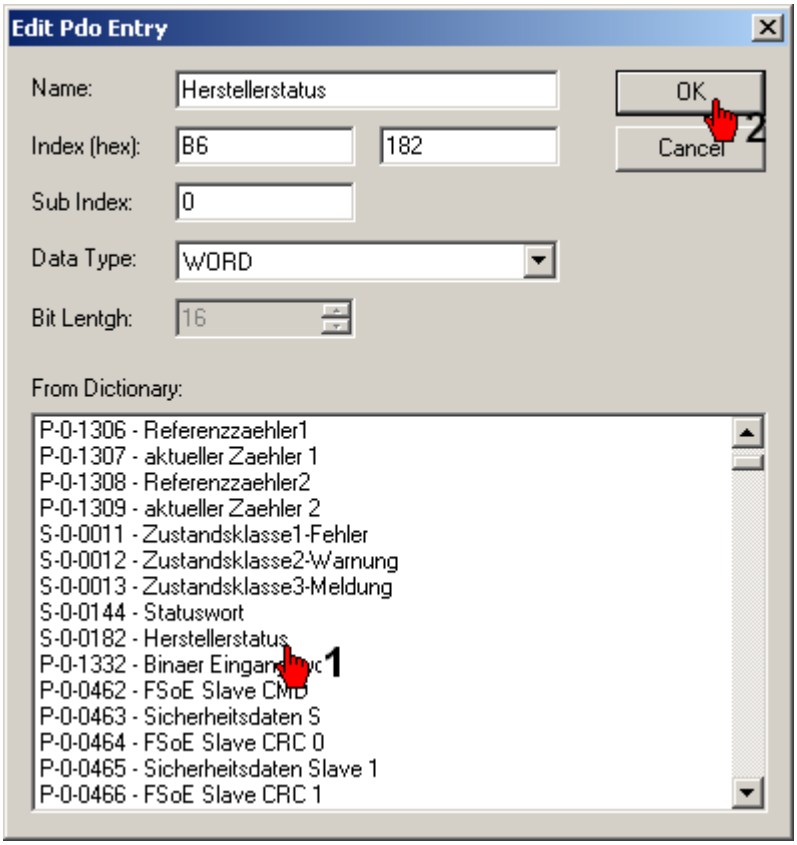
The ID24 'Configuration list MDT' defines what parameters are cyclically transferred into the master data telegram (MDT) if 'Telegram type parameters' 'configured telegram' is selected in ID15 'Telegram types parameter'. The configurable parameters are listed in ID188 'List of data MDT'.

The configurable parameters will be dynamically read from the EtherCAT salves (ID187 and ID188).

The example shows how to exchange the drive telegram (AT) with the ID182 'Diagnosis manufacturer status'.

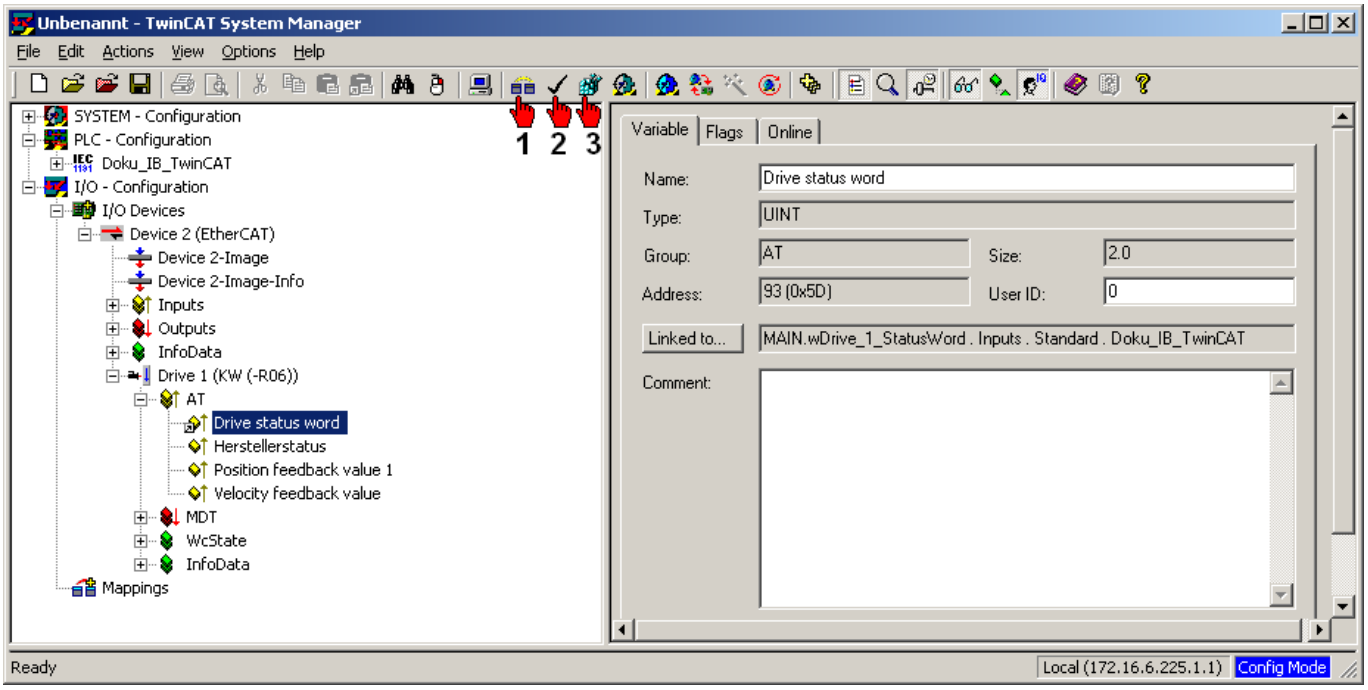


Select the parameter



4.9.5 Generating a configuration and starting the run mode

1. Generate mappings
   Generates the mapping between two process images
2. Check configuration
   Checks the present configuration for plausibility
3. Activate configuration
   Saves and activates the present configuration



4.10 Information about error sources

4.10.1 Revision of the device description file

By default, the check of the revision number of the connected devices is de-activated in the TwinCAT EtherCAT master.
The following check can be activated:

- RevisionNo ≥ >min. Rev-No.<

By means of this setting, an EtherCAT device with a higher revision can run within a configuration defined with a lower version.

Example: KW-R07
<Type ProductCode="#x01000603" **RevisionNo="#x01030105"** UseLrdLwr="1">KW (-R07) (FSoE)</Type>

RevisionNo= 0x 0103 0105
| |
| Software version KW-R06 AER5-6_105_1032_203194
Revision xml AMK_ECsoe_103_202967.xml

4.10.2 TwinCAT with standard PC

The drive generates the diagnostic message 2561 'System diagnostics: Failure of the master'

Possible cause of error:
In state 'operational', the EtherCAT master does not send any or just sporadic frames of setpoints and actual values.

Without full system utilisation, standard PCs will reduce their processor cycle. Because of this reduction, the real time does not run constantly and generates an error.

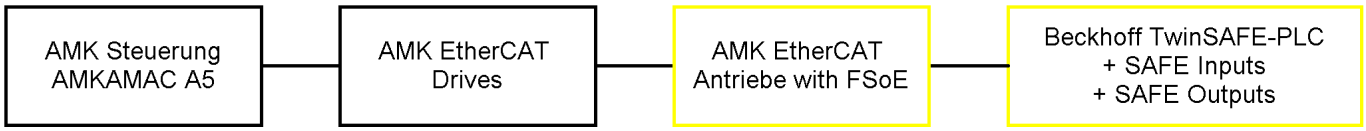
Start the auxiliary program 'LowPrioProc.exe' - repeatedly if necessary - until the PC reaches 100 % system utilisation. By means of the auxiliary program, the system utilisation is increased artificially and a constantly running real time is achieved.

You will find the auxiliary program under C:\TwinCAT\LowPrioProc.exe.

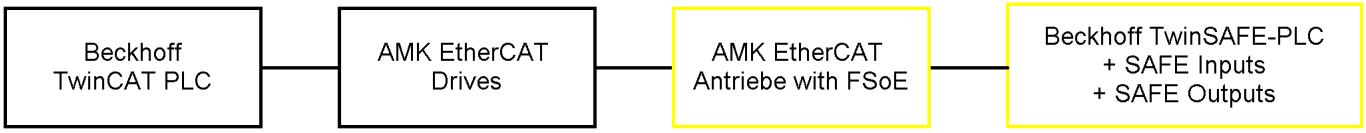
5 Functional safety via FSoE with Beckhoff TwinSAFE PLC

Following variations are described:

Variant 1: AMK controller and TwinSAFE PLC



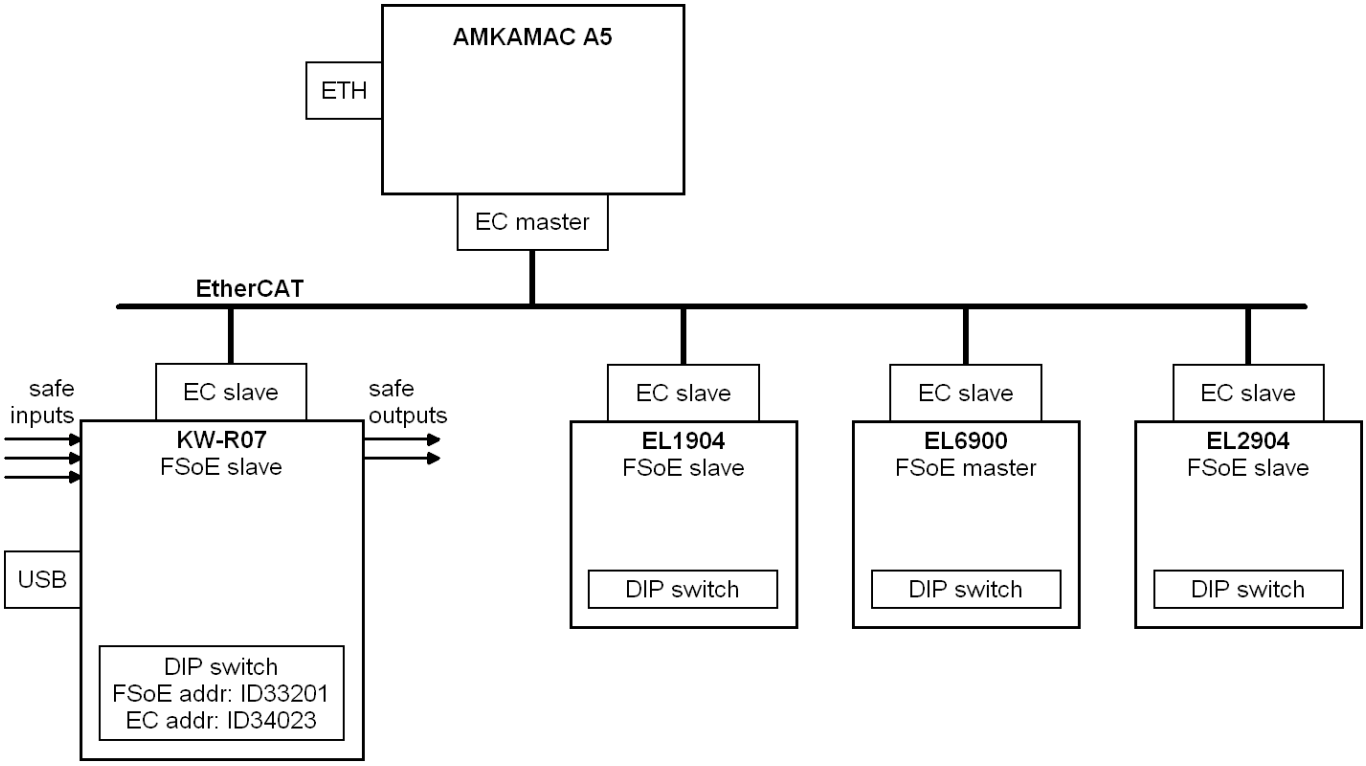
Variant 2: TwinCAT PLC and TwinSAFE PLC



5.1 General overview AMK controller and TwinSAFE PLC

The overview diagram shows a FSoE configuration. The following components are used:

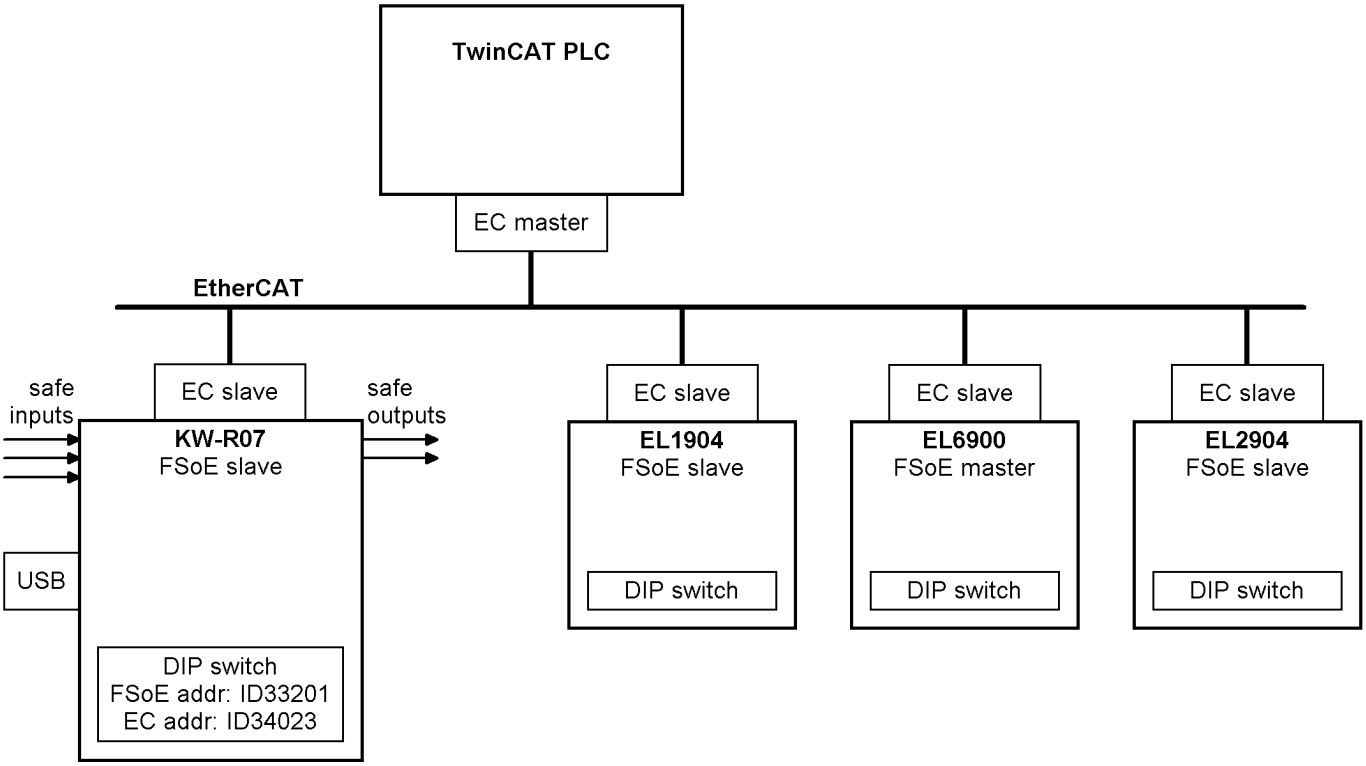
- AMKAMAC A5 controller
- Controller card KW-R07 / -R17 / -R27 with functional safety (KW-R07 is used with this example)
- SafePLC EL6900 with safe input and output terminals



5.2 General overview TwinCAT PLC and TwinSAFE PLC

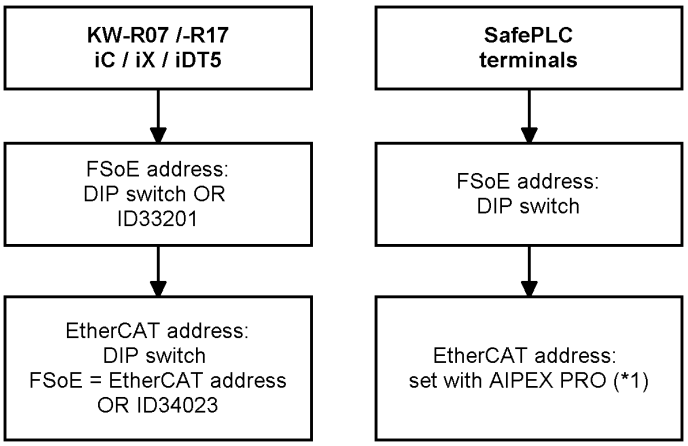
The overview diagram shows a FSoE configuration. The following components are used:

- TwinCAT PLC
- Controller card KW-R07 / -R17 / -R27 with functional safety (KW-R07 is used with this example)
- SafePLC EL6900 with safe input and output terminals



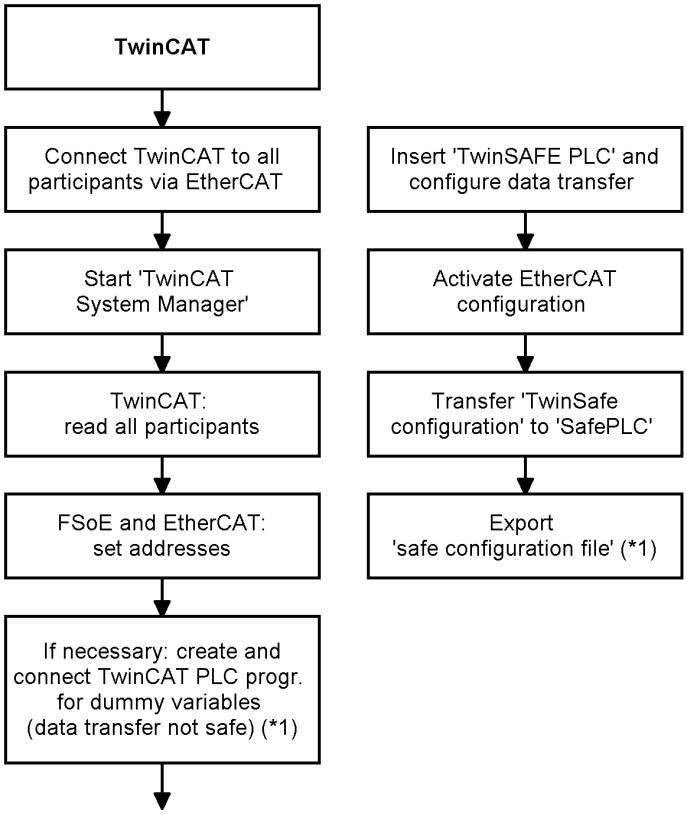
5.3 Procedure (overview)

Step 1: addressing



*1 Not applicable at TwinCAT PLC and TwinSAFE PLC combination.

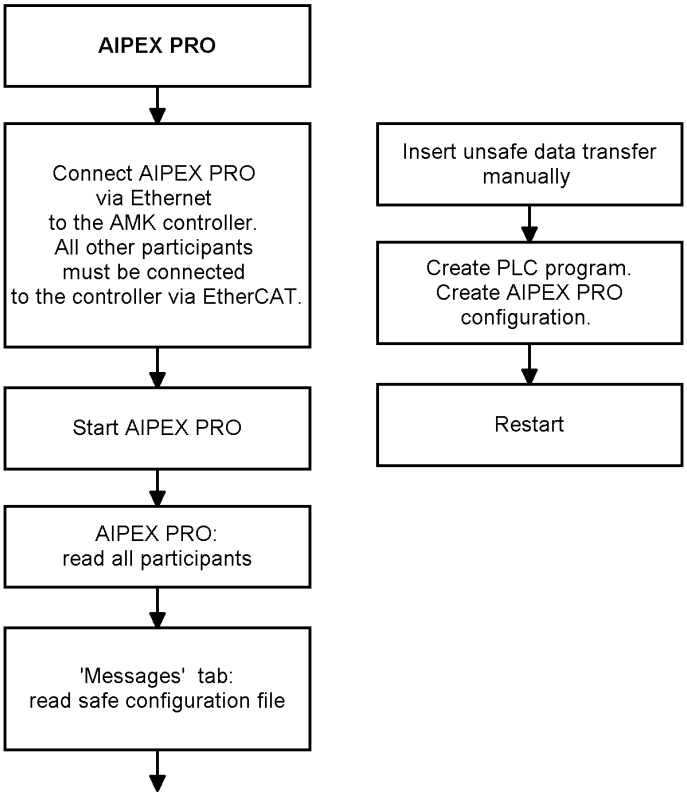
Step 2: TwinSAFE configuration



*1 Not applicable at TwinCAT PLC and TwinSAFE PLC combination.

Step 3: AIPEX PRO configuration (*1)

*1 Not applicable at TwinCAT PLC and TwinSAFE PLC combination.



5.3.1 Create and transmit SafePMT parameter set

- AMK controller cards KW-R07 / KW-R17 / KW-R27:
  See document Safety manual; functional safety (Part no. 203446) Chapter Startup, subtopic Parameterisation
- AMK Decentralised drive technology iC / iX / iDT5:
  See document Safety manual; functional safety (Part no. 205016) Chapter Startup, subtopic Parameterisation and Supplement to the Safety Manual 2013/18 when using iC / iX / iDT with Functional Safety Part no. 204446 Chapter Startup, subtopic Parameterisation

5.3.2 Step 1: addressing

The EtherCAT and FSoE addresses of the different participants must stringently be set equal in the AMK drives and in TwinCAT System Manager. The addressing of the AMK drives will be done with the AMK software AIPEX PRO.

FSoE addressing

- AMK controller card KW-R07 / KW-R17 / KW-R27:
  See document Safety manual; functional safety (Part no. 203446) chapter Startup, subtopic FSoE addressing
- AMK Decentralised drive technology iC / iX / iDT5:
  See documentSafety manual; functional safety (Part no. 205016) Chapter Startup, subtopic FSoE addressing and Supplement to the Safety Manual 2013/18 when using iC / iX / iDT with Functional SafetyPart no. 204446 Chapter Startup, subtopic FSoE addressing
- SafePLC and safe input and output terminals:
  See manufacturer-specific descriptions

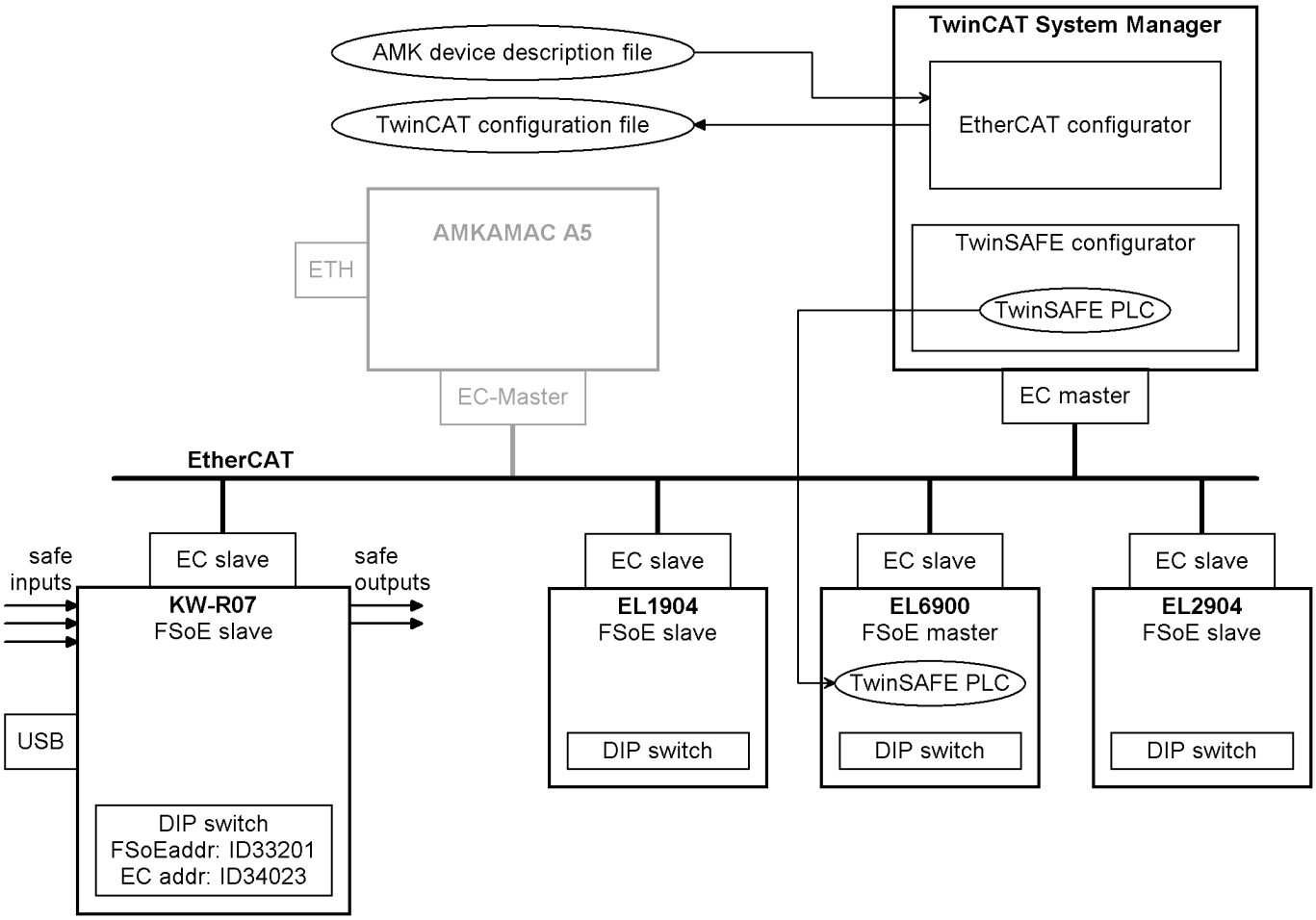
EtherCAT addressing

- AMK controller card KW-R07 / KW-R17:
  See document Controller cards KW-R06 / -R16 / -R07 / -R17 (Part no. 202744) chapter Startup - operation - maintenance - service, subtopic Addressing bus participants
- AMK controller card KW-R27:
  See documentController cards KW-R24(-R) / -R25 / -R26 / -R27 (Part no. 204918) chapter Startup - operation - maintenance - service, subtopic Addressing bus participants
- AMK Decentralised drive technology iC / iX / iDT5:
  See document Decentralized drive technology iC / iX / iDT5 (Part no. 203445) chapter Startup - operation - maintenance - service, subtopic Addressing bus participants

See document ' Software description AIPEX PRO V3' (Part no. 204979) chapter: Directmode, subtopic Function Communications

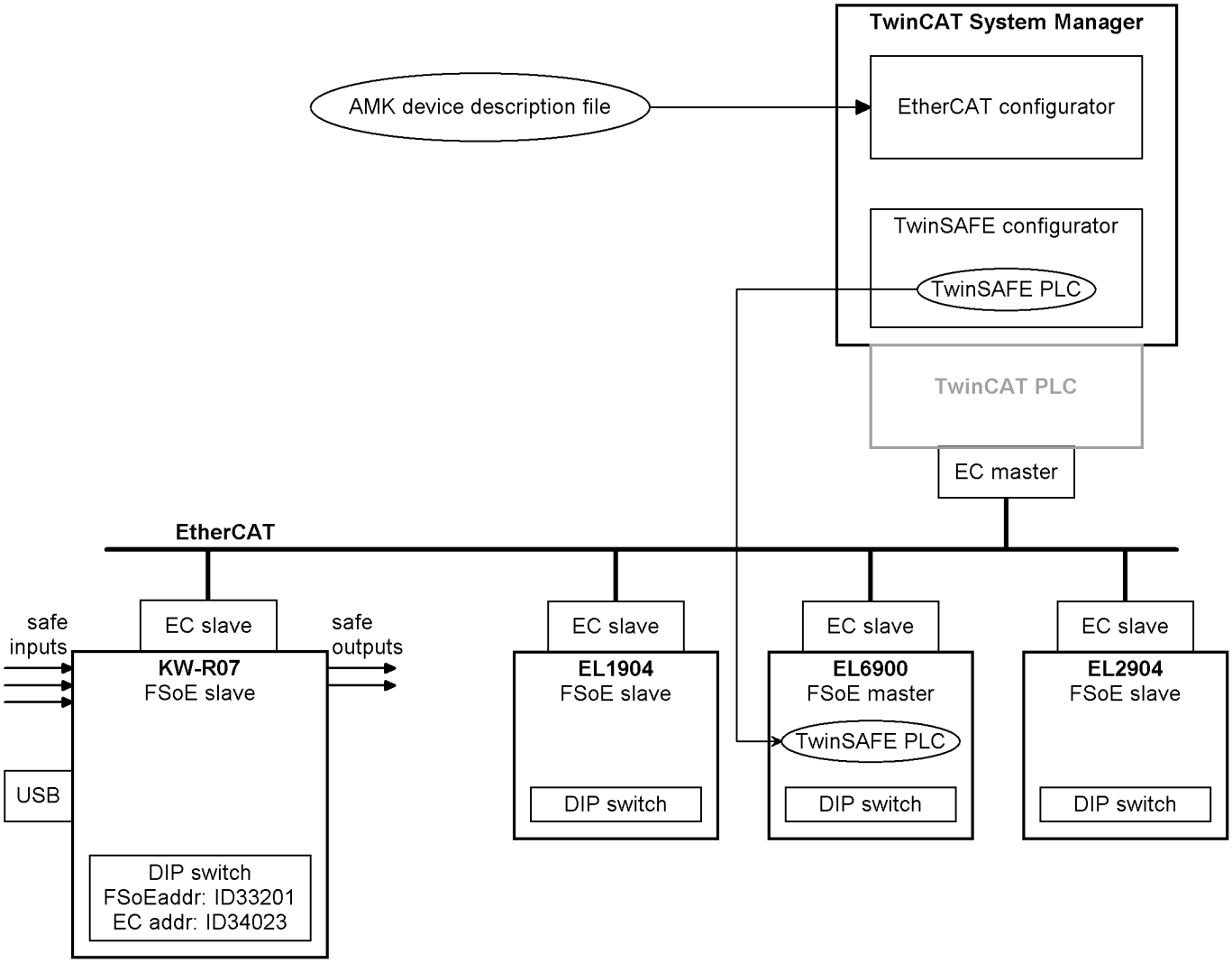
5.3.3 Step 2: TwinSAFE configuration

Hardware overview with AMK controller and TwinSAFE PLC



EC - EtherCAT connection

Hardware overview with TwinCAT PLC and TwinSAFE PLC

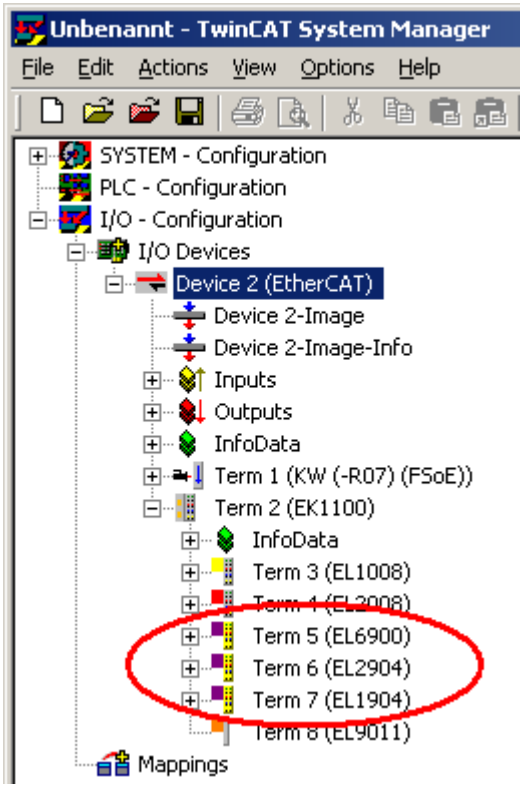


Step 2.1: Creating a TwinCAT project

Hardware prerequisites 'System structure with TwinCAT PC': Siehe 'Hardware overview with AMK controller and TwinSAFE PLC' auf Seite 37.

A TwinCAT project can be created offline or read online:
Siehe 'Creating a TwinCAT project' auf Seite 21.

Example: controller card KW-R07 with SafePLC EL6900 and safe inputs and outputs



Step 2.2: Creating a TwinCAT PLC project

For realising a standard data exchange between TwinSafe PLC and PLC controller, you have to create a TwinCAT project with variables.

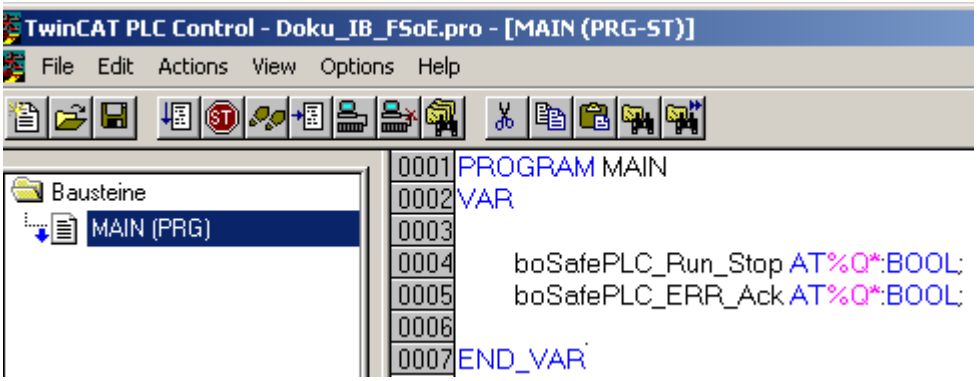
AT%Q = output variables (point of view PLC controller)

AT%I = input variables (point of view PLC controller)

Siehe 'PLC project' auf Seite 26.

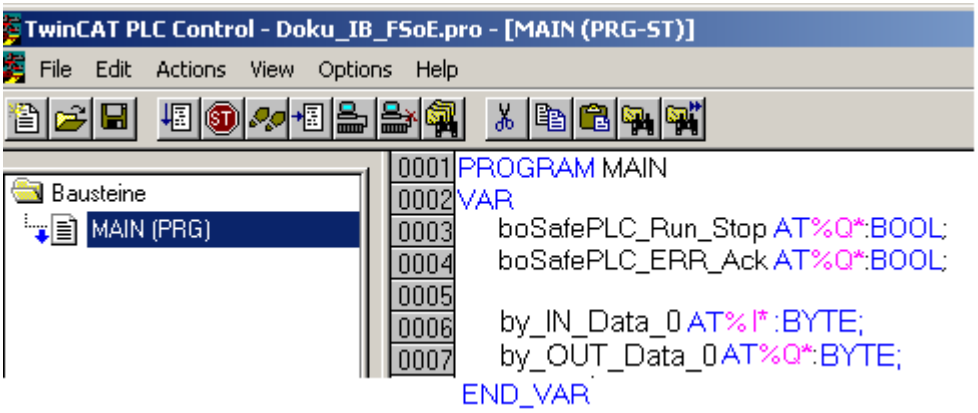
First the variables must be creating inside the TwinCAT PLC project. Further you can use them with the TwinCAT System Manger.

The variables *boSafePLC_Run_Stop* and *boSafePLC_ERR_Ack* are subsequently used to start / stop the SafePLC. The commanding is done by the PLC controller.



Not applicable at TwinCAT PLC and TwinSAFE PLC combination.

For realising a standard data exchange between TwinSafe PLC and AMK controller, you can create more variables.
The variables by_IN_Data_0 and by_OUT_Data_0 can used freely.



Step 2.3: TwinCAT addressing

The EtherCAT and FSoE addresses of the different participants must stringently be set equal in the AMK drives and in TwinCAT System Manager. The addressing of the AMK drives will be done with the AMK software AIPEX PRO.

Hardware addressing: Siehe 'Step 1: addressing' auf Seite 36.

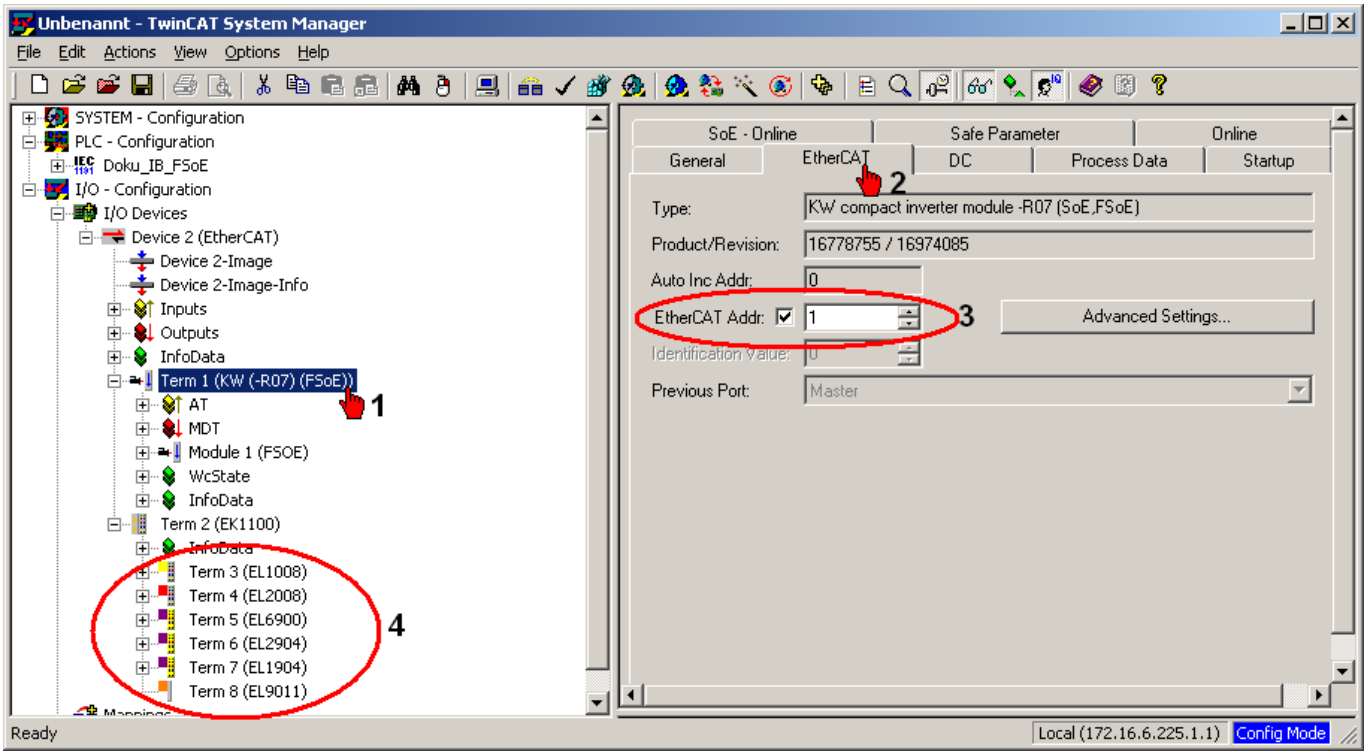
EtherCAT addressing

The physical addressing of the AMK drives can be done by means of AIPEX PRO or with the DIP switch S1 on the controller card.

The EtherCAT addressing of the TwinSAFE PLC as well as the safe input and output terminals is done with the AIPEX PRO direct mode.(*1)

(*1) Not applicable at TwinCAT PLC and TwinSAFE PLC combination.

Enter the preset EtherCAT addresses of any participant.

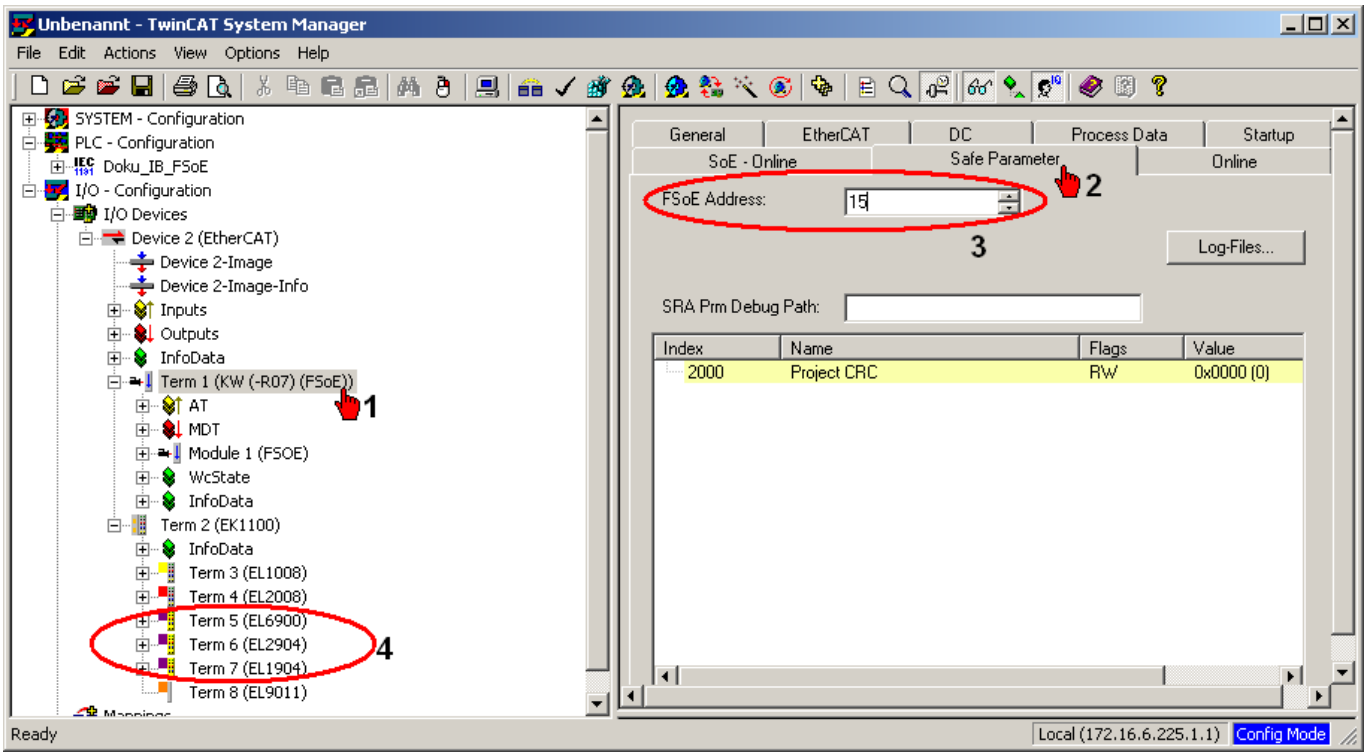


FSoE addressing

The physical addressing of the safety board can be done by means of AIPEX PRO of with the DIP switch S1 on the controller card.

The FSoE addressing of the SafePLC as well as the save input and output terminals is done directly by DIP switch on the hardware.

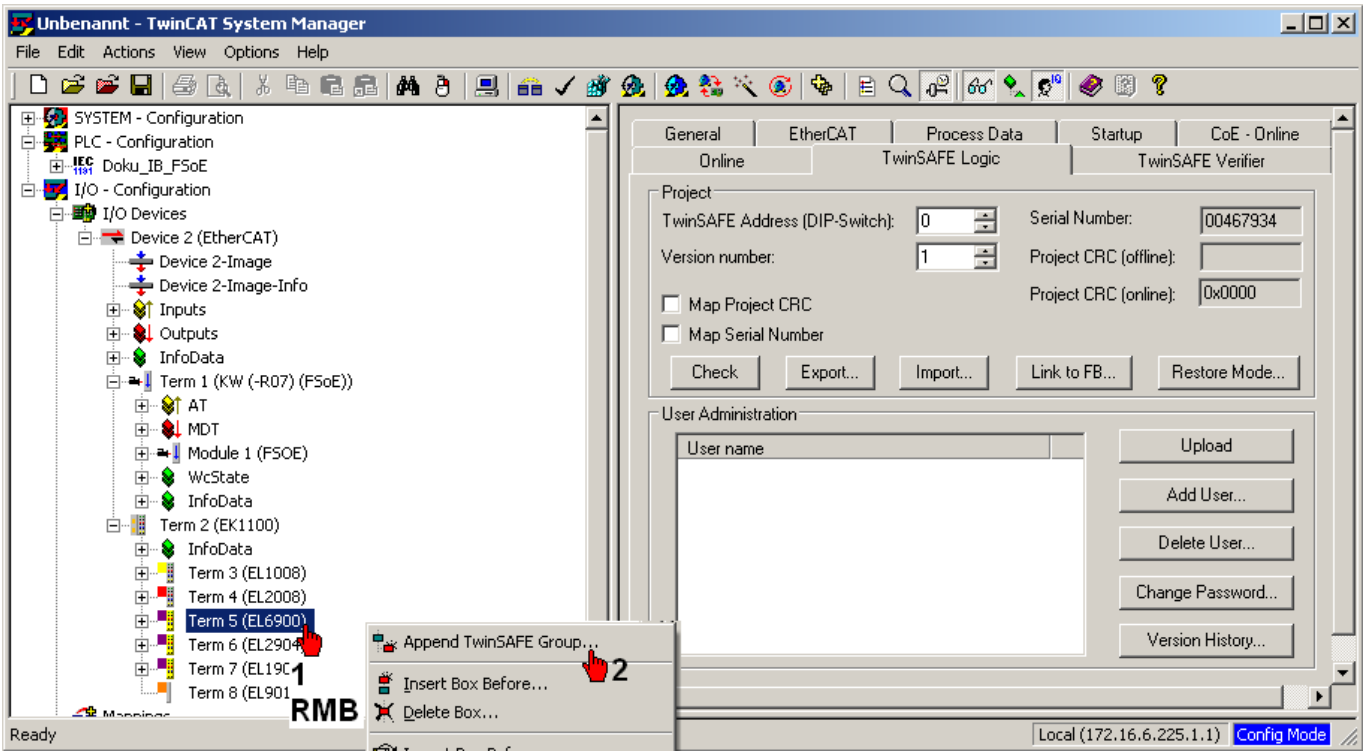
Enter the preset FSoE addresses of any participant.



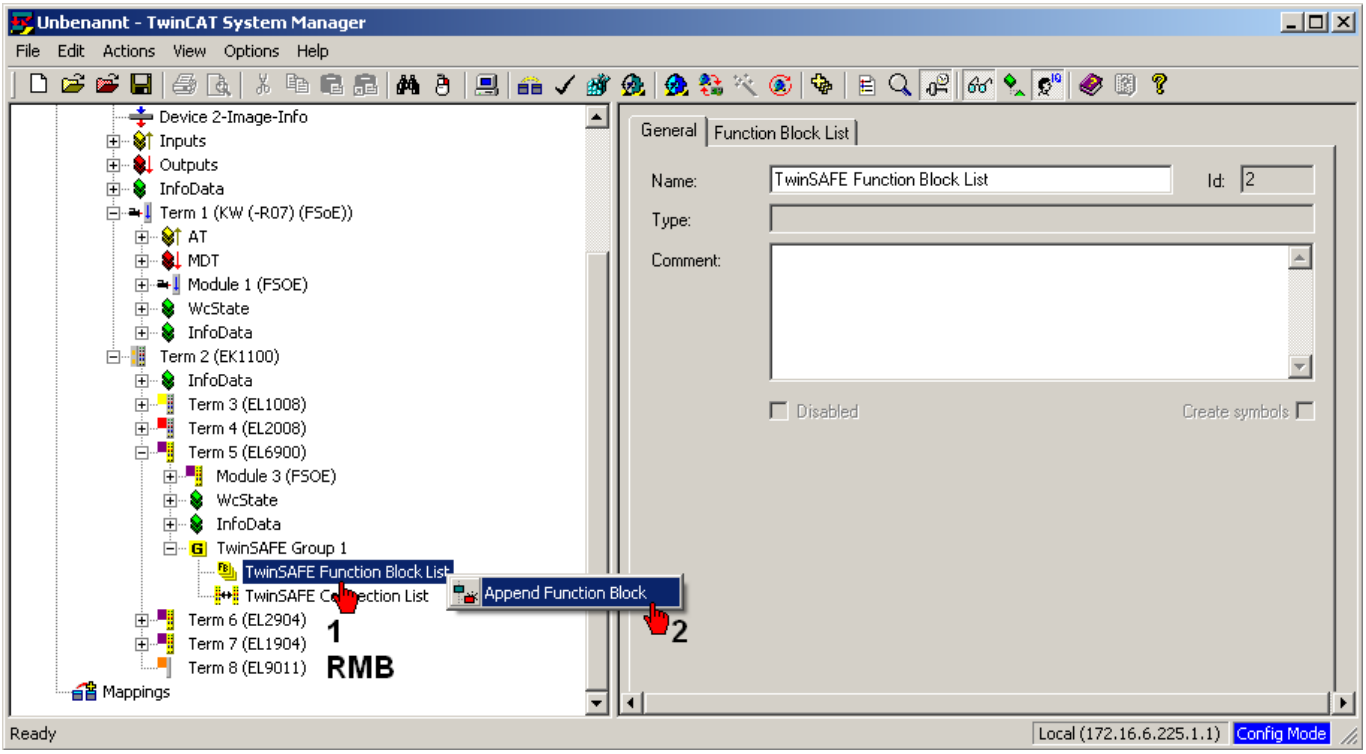
Step 2.4: TwinSAFE Group

The TwinSAFE Group is a group of TwinSAFE clamps (inputs and outputs) witch are logically linked via EL6900.

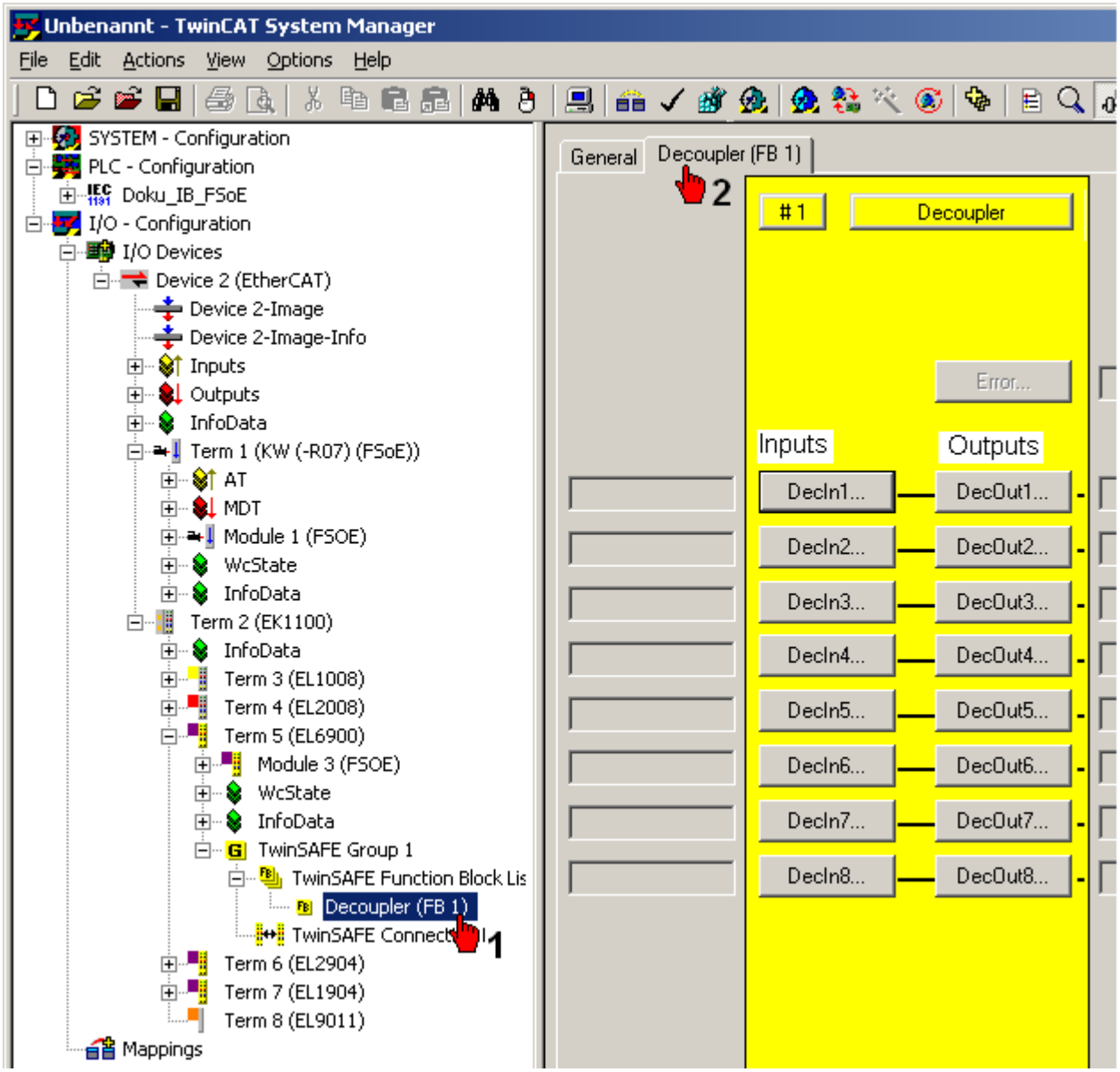
Appending 'TwinSAFE Group'



Appending function block 'Decoupler'



By means of the function block 'Decoupler', for example safe inputs can be linked to particular bits of the FSoE control word.

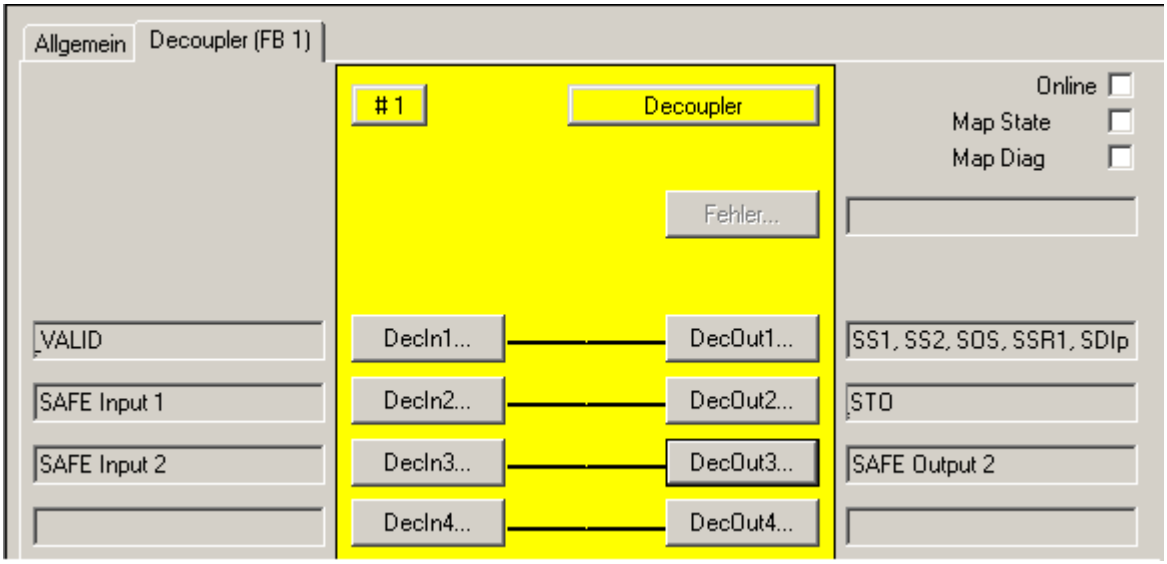


Configuration example

Used are two 'Decoupler' function blocks.

Decoupler (FB1)

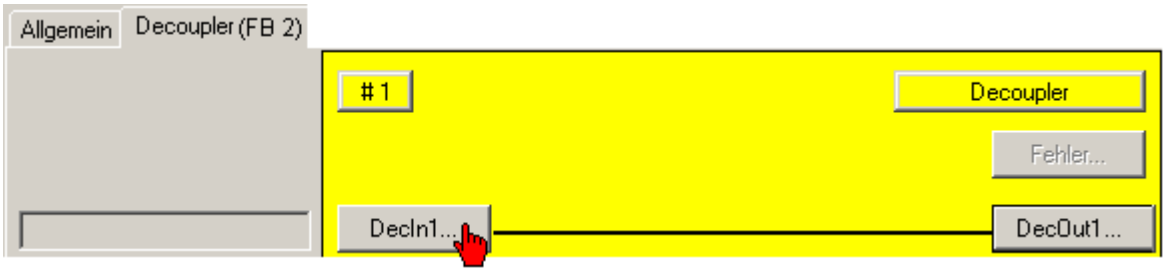
- Input DecIn1:
  By means of the 'system ready' message of the functional safety (status word, bit 28 VALID), the safety functions except STO are set to 1 (= inactive)
  status word, bit 28 = 1 → control word, bit 1 - 6, 9 - 16 = 1
- Input DecIn2:
  SAFE Input 1 triggers 'Safe torque off (STO)'.
- Input DecIn3:
  SAFE Input 2 sets SAFE Output 2

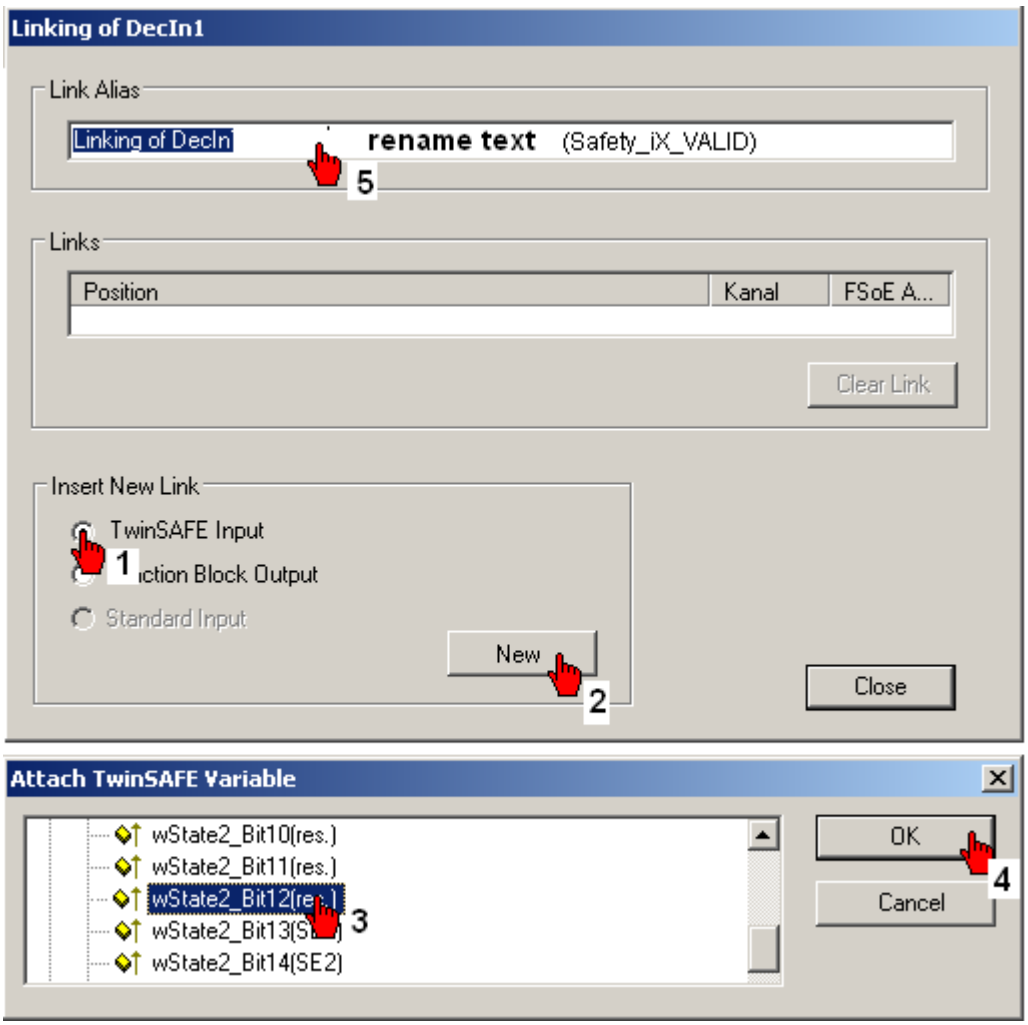


Not applicable at TwinCAT PLC and TwinSAFE PLC combination.

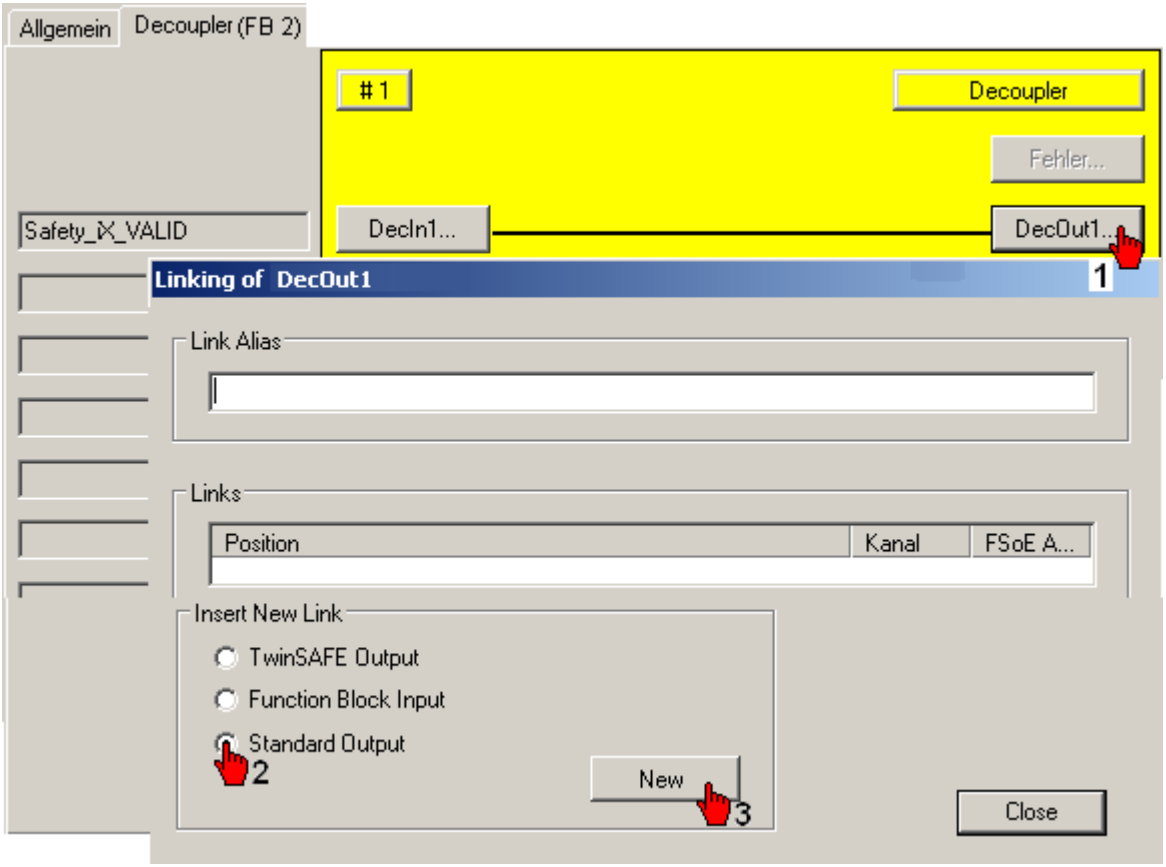
Decoupler (FB2)
This example shows the preparation for a standard data exchange between TwinSAFE PLC and AMK PLC.
Therefore, the BYTE-type variable by_IN_Date_0 was defined inside the TwinCAT PLC project.
The TwinSAFE PLC will send the status of wState2_Bit12 (VALID Bit) with the variable by_IN_Date_0 to the AMK controller.
If you evaluate the VALID bit with the AMK controller, you can check the working state of the FSoE slave and FSoE master.

Enter a TwinSAFE status variable at the Decoupler input DecIn1.

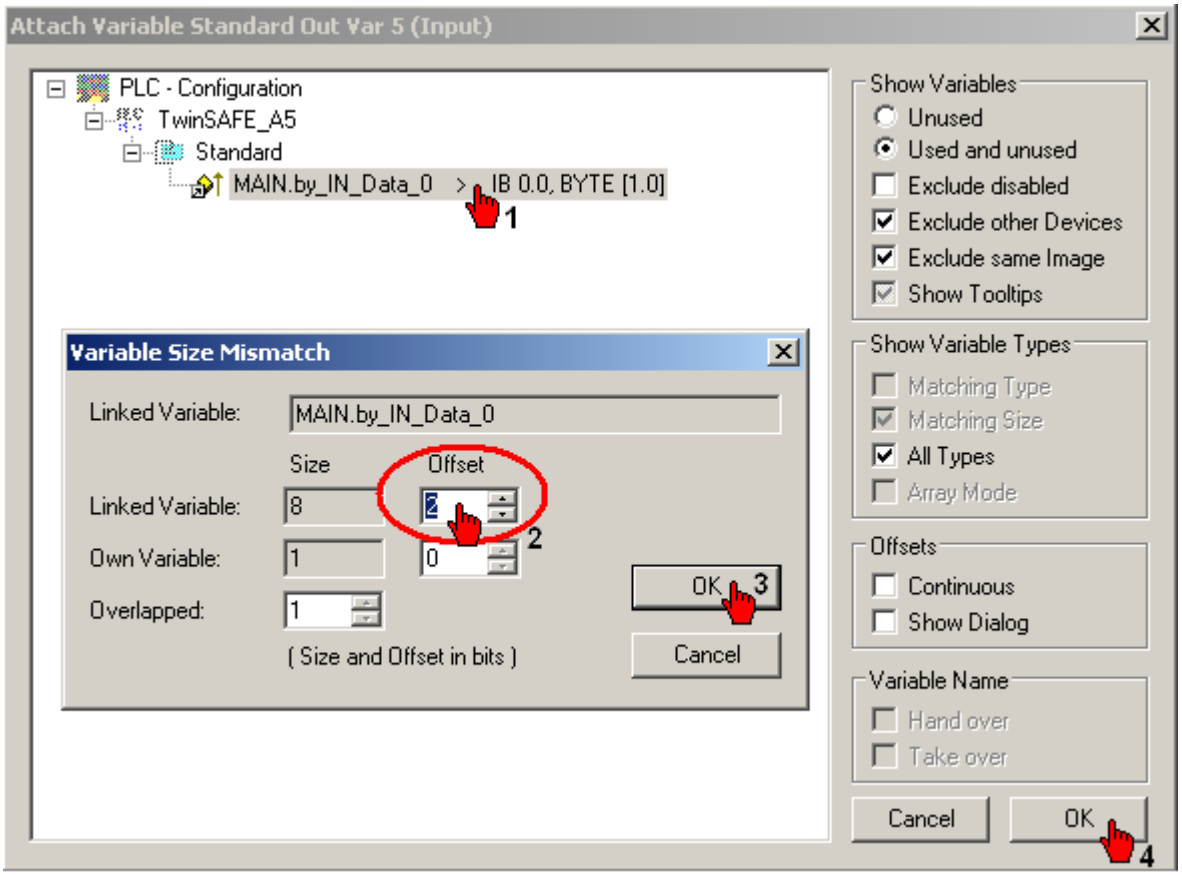



Linking of DecIn1
Link Alias
Linking of DecIn
rename text
(Safety_iX_VALID)
5
Links
Position
Kanal
FSoE A...
Clear Link
Insert New Link
TwinSAFE Input
1
Standard Input
New
2
Close
Attach TwinSAFE Variable
wState2_Bit10(res.)
wState2_Bit11(res.)
wState2_Bit12(res.)
3
wState2_Bit14(SE2)
OK
4
Cancel

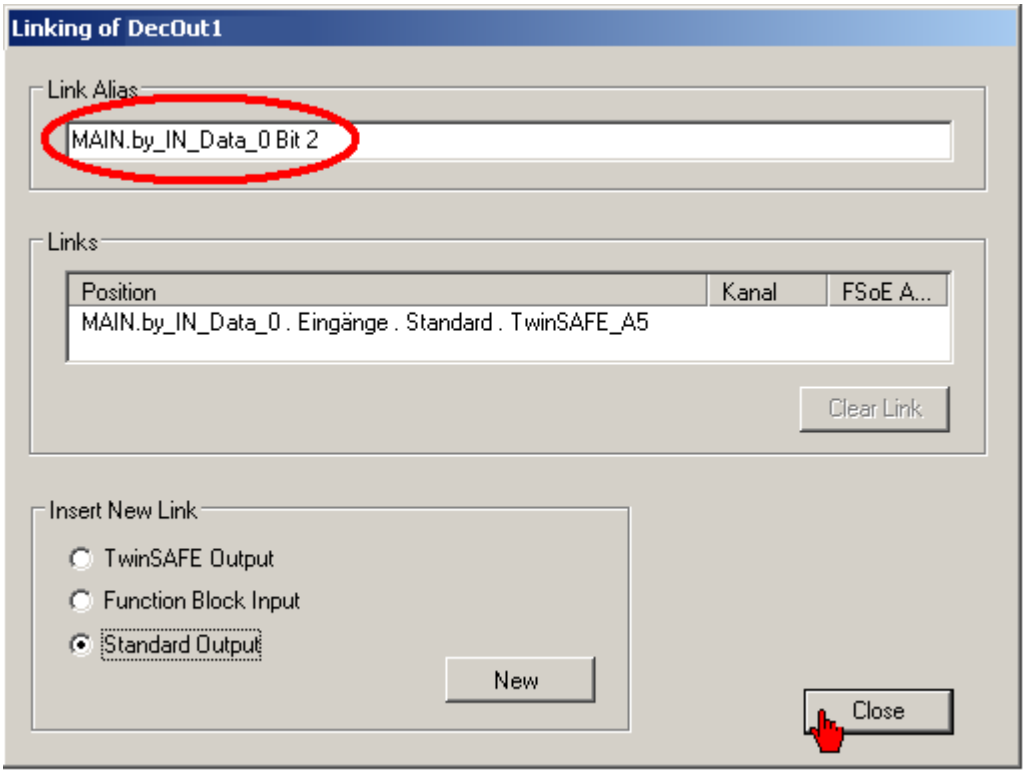
Link TwinSAFE status variable with standard output (by_IN_Date_0).



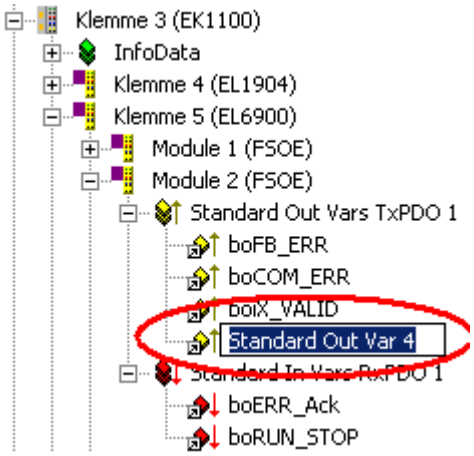
Bit addressing



Symbolic name

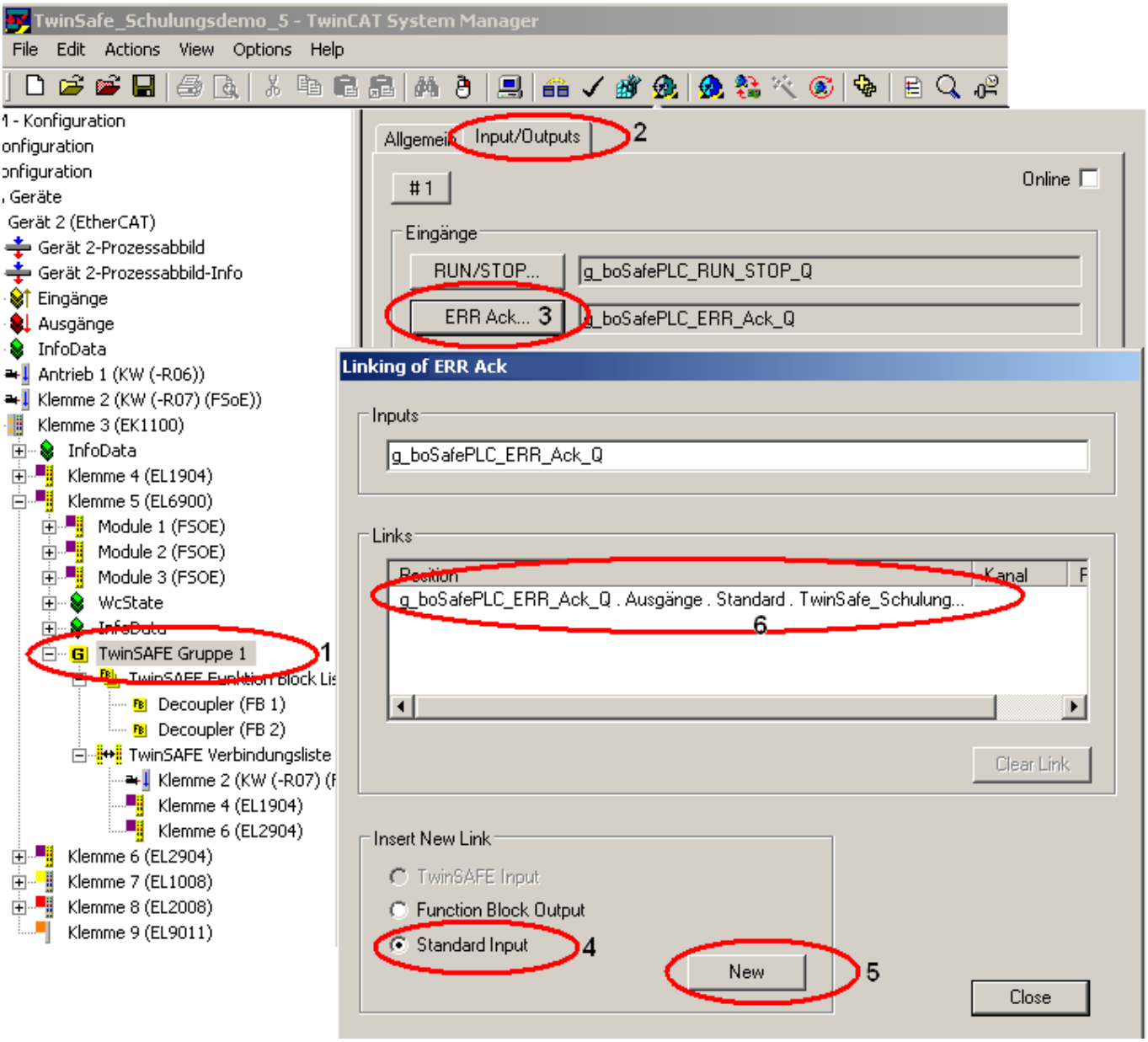


You can find the used variables in the device tree. Below the clamp 'EL6900' – 'Module 2 (FSOE). TwinCAT use standard names like 'Standard Out Var 1', 'Standard Out Var 2' … . Rename the standard variable names to a clear name. This variable name will further be also used for the TwinCAT ‘configuration file’. This 'configuration file' will be read from AIPEX PRO to create the EtherCAT configuration file.



5.3.3.1 Step 2.5: TwinSafe PLC Start / Stop / ErrAck

The example shows how the TwinCAT variables are linked to an AMK controller. Thus the AMK controller can start the TwinSAFE PLC.



ERR Ack = low - high - low edge

RUN/STOP = low - high edge

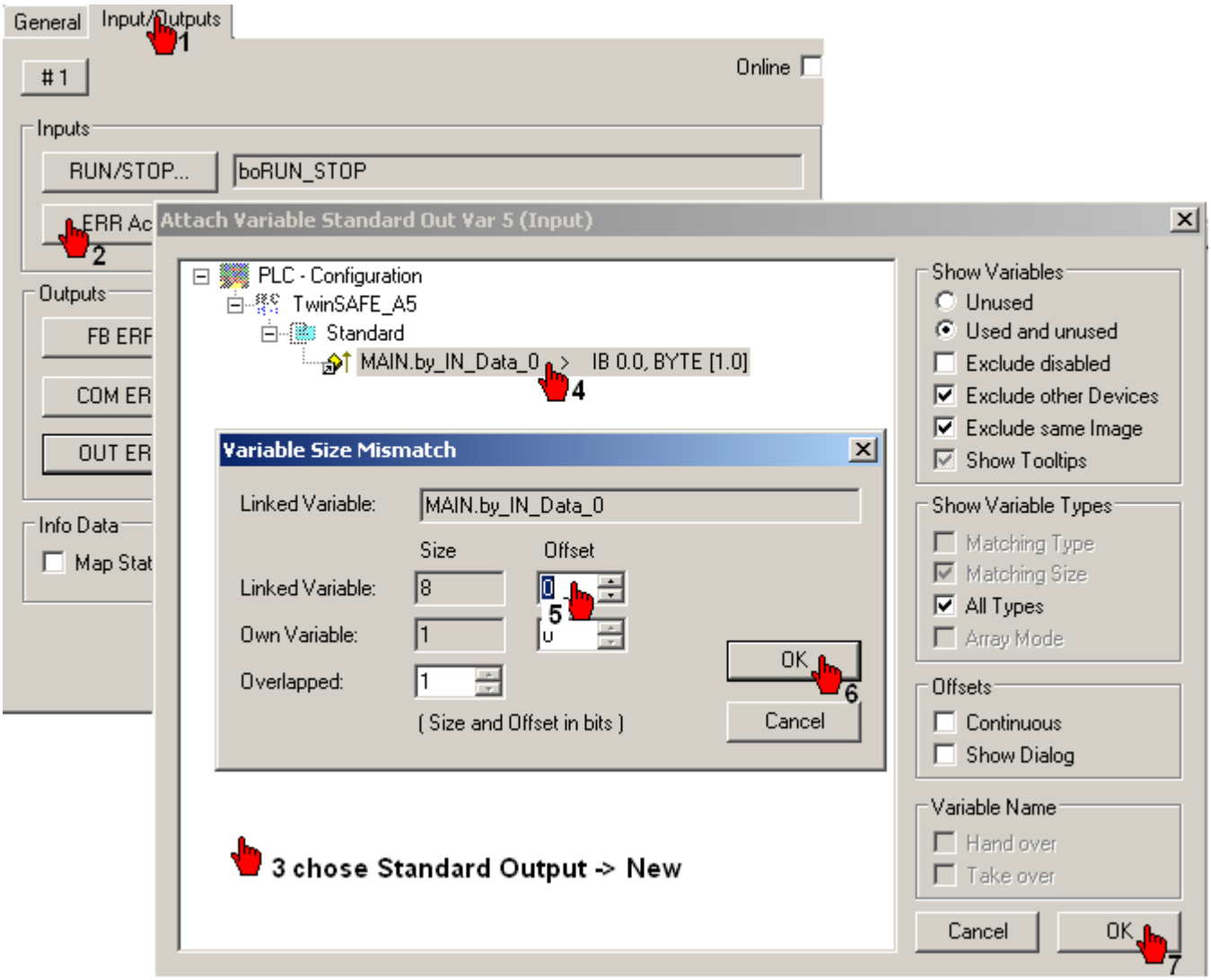
Not applicable at TwinCAT PLC and TwinSAFE PLC combination.

The example shows the preparation for a standard data exchange between AMK controller and TwinSafe PLC. With the variables, the TwinSAFE PLC can be controlled with the AMK controller. The TwinCAT PLC (dummy) variables (by_IN_Data_0 and by_OUT_Data_0) will be linked with the TwinSAFE PLC control and status in- and outputs. The bit numbers will be entered with an offset value.

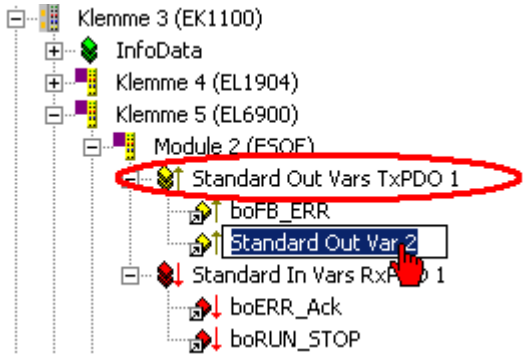
Example:

Signal / Status	Variable
ERR Ack	by_OUT_Data_0 Offset 0 (bit 0)
RUN / STOP	by_OUT_Data_0 Offset 1 (bit 1)

Signal / Status	Variable
FB ERR	by_IN_Data_0 Offset 0 (bit 0)
COM ERR	by_IN_Data_0 Offset 1 (bit 1)

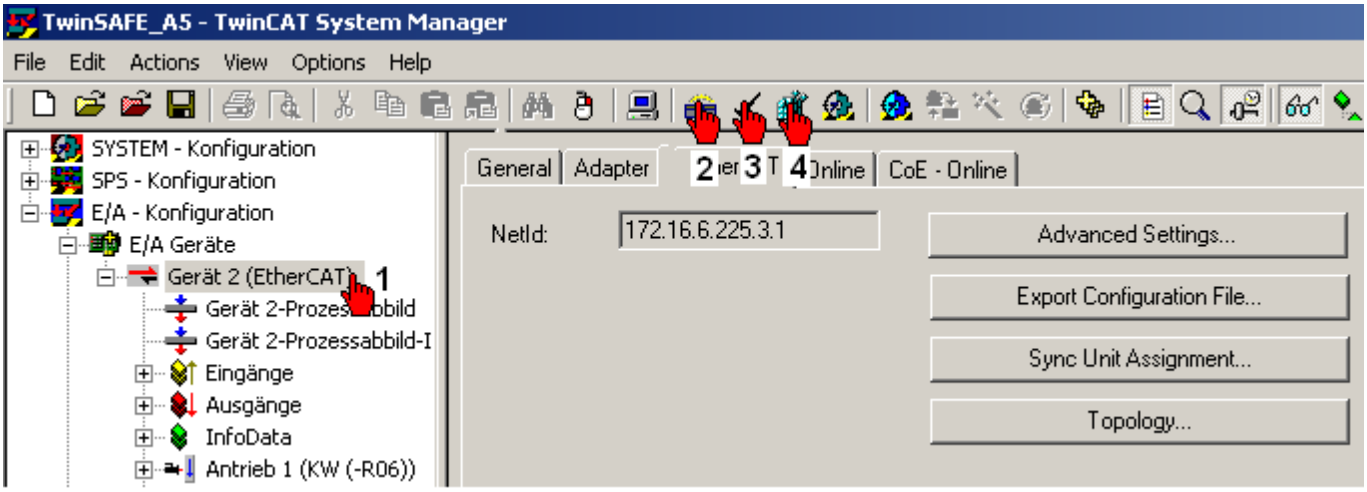


You can find the used variables in the device tree. Below the clamp 'EL6900' – 'Module 2 (FSOE). TwinCAT use standard names like 'Standard Out Var 1', 'Standard Out Var 2' … . Rename the standard variable names to a clear name. This variable name will further be also used for the TwinCAT ‘configuration file’. This 'configuration file' will be read from AIPEX PRO to create the EtherCAT configuration file.

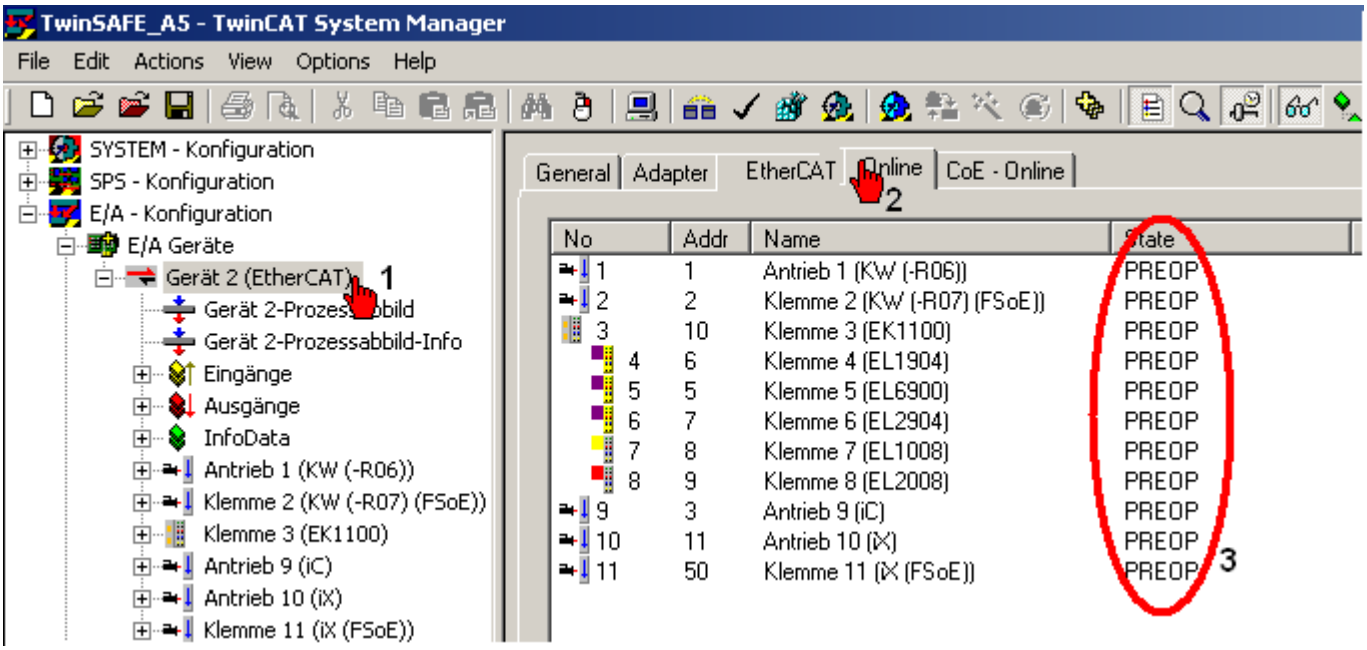


Step 2.6: Activating and transferring configuration

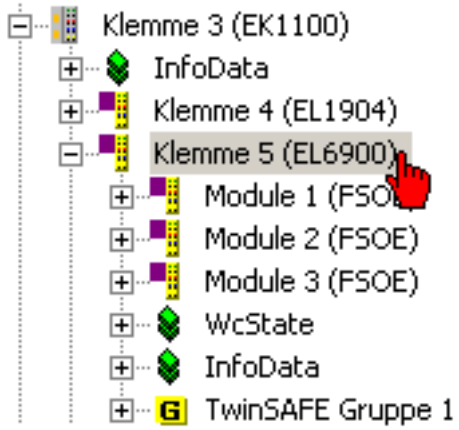
1. Chose EtherCAT bus
2. Generate allocation
   (Generate allocation between 2 process images)
3. Check configuration
   (Plausibility check)
4. Activate configuration
   (Save and activate current configuration)



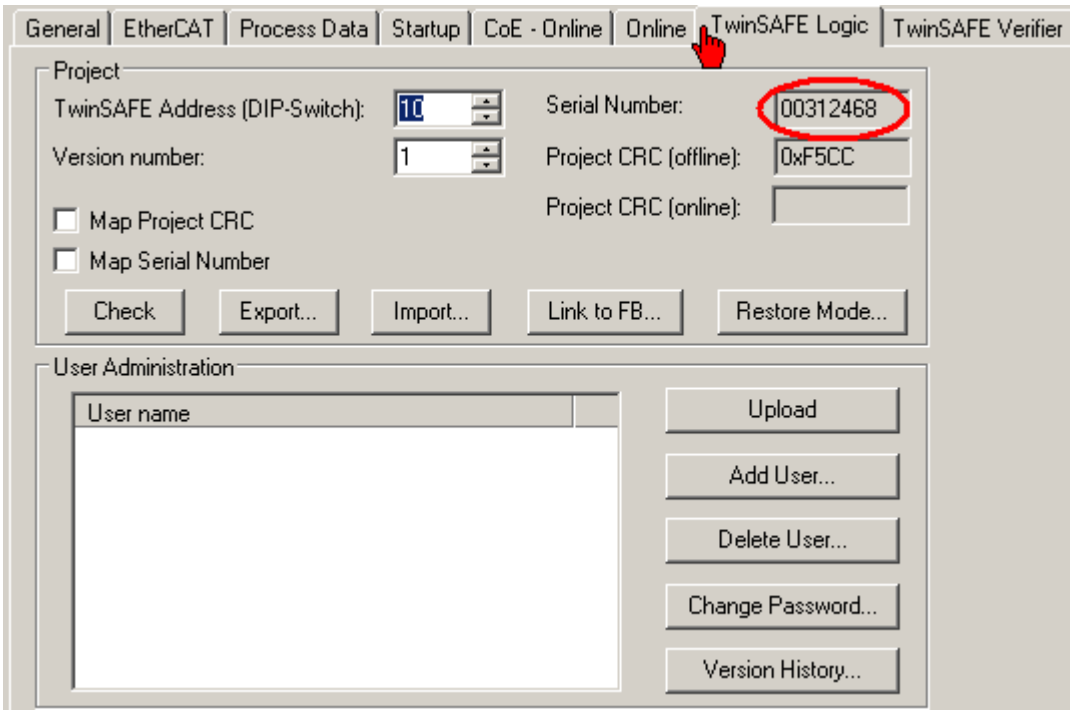
Check whether the 'pre-operational' state is reached.



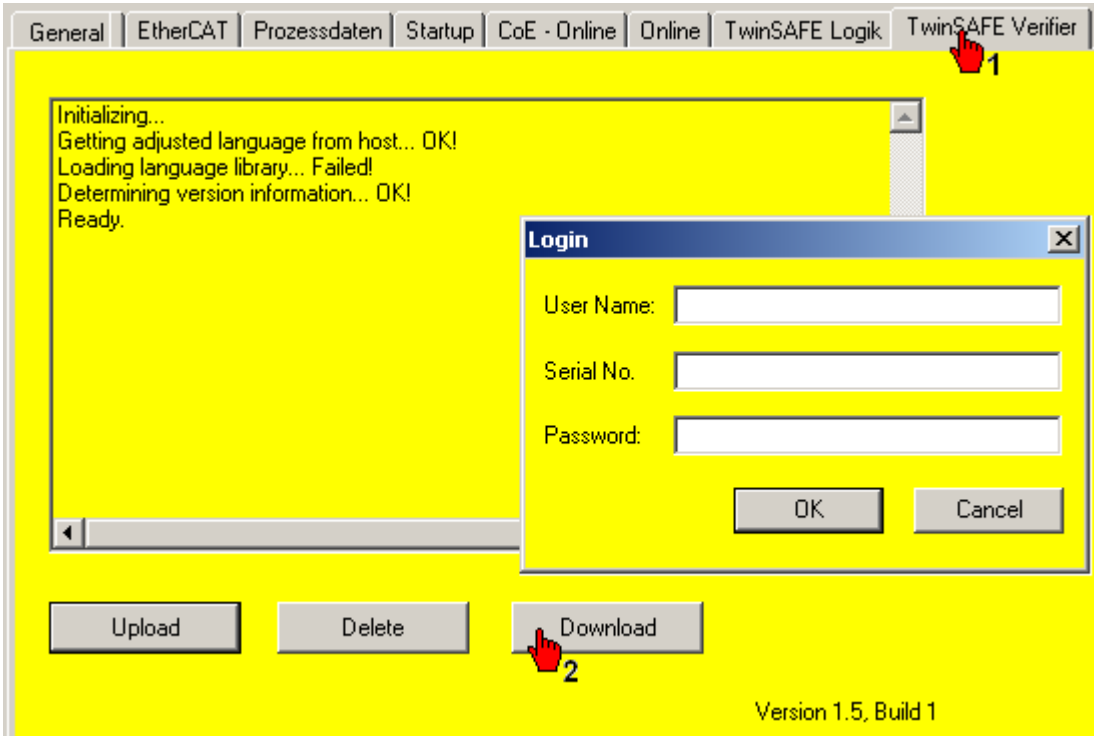
Generate the safety configuration and transfer it to the SafePLC EL6900.



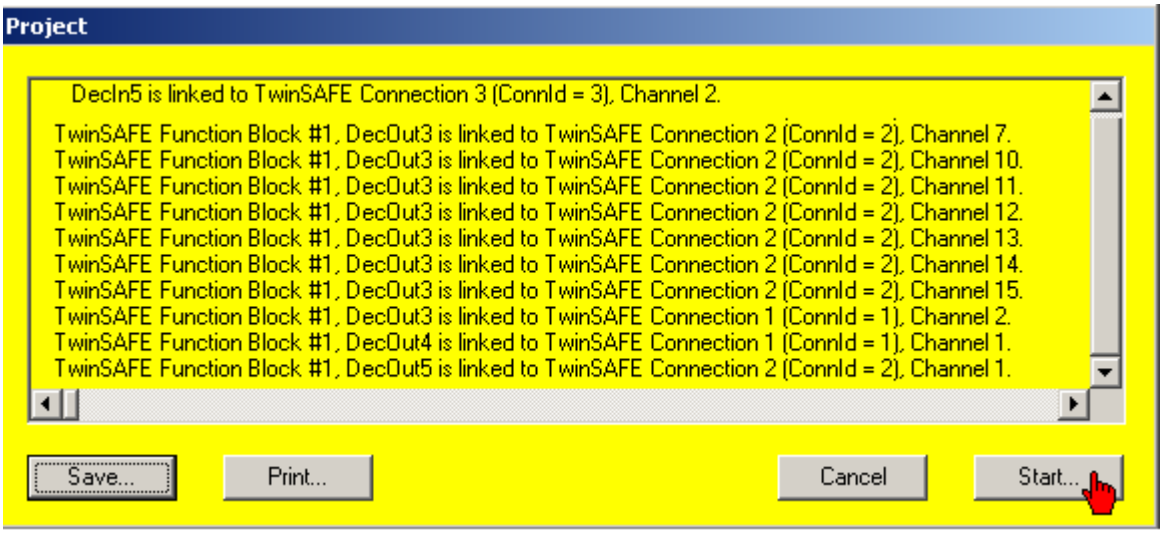
The specific serial number is used for entering the password!



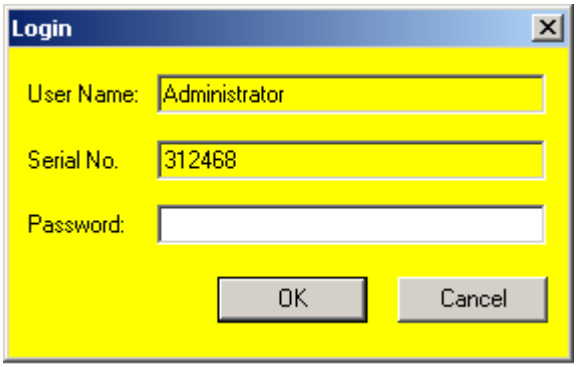
User name: Administrator
Serial No.: see previous image
Password: TwinSAFE



The procedure is finished by pressing the 'Start' button.



Following enter password: TwinSAFE

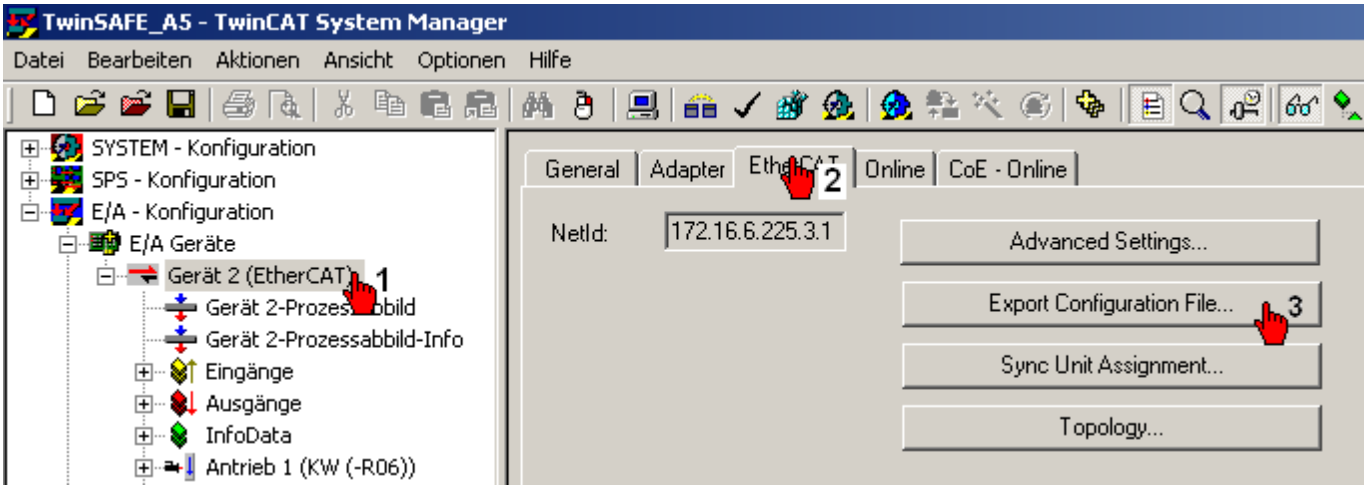


Restart system

Step 2.7: Exporting the TwinCAT configuration file

Not applicable at TwinCAT PLC and TwinSAFE PLC combination.

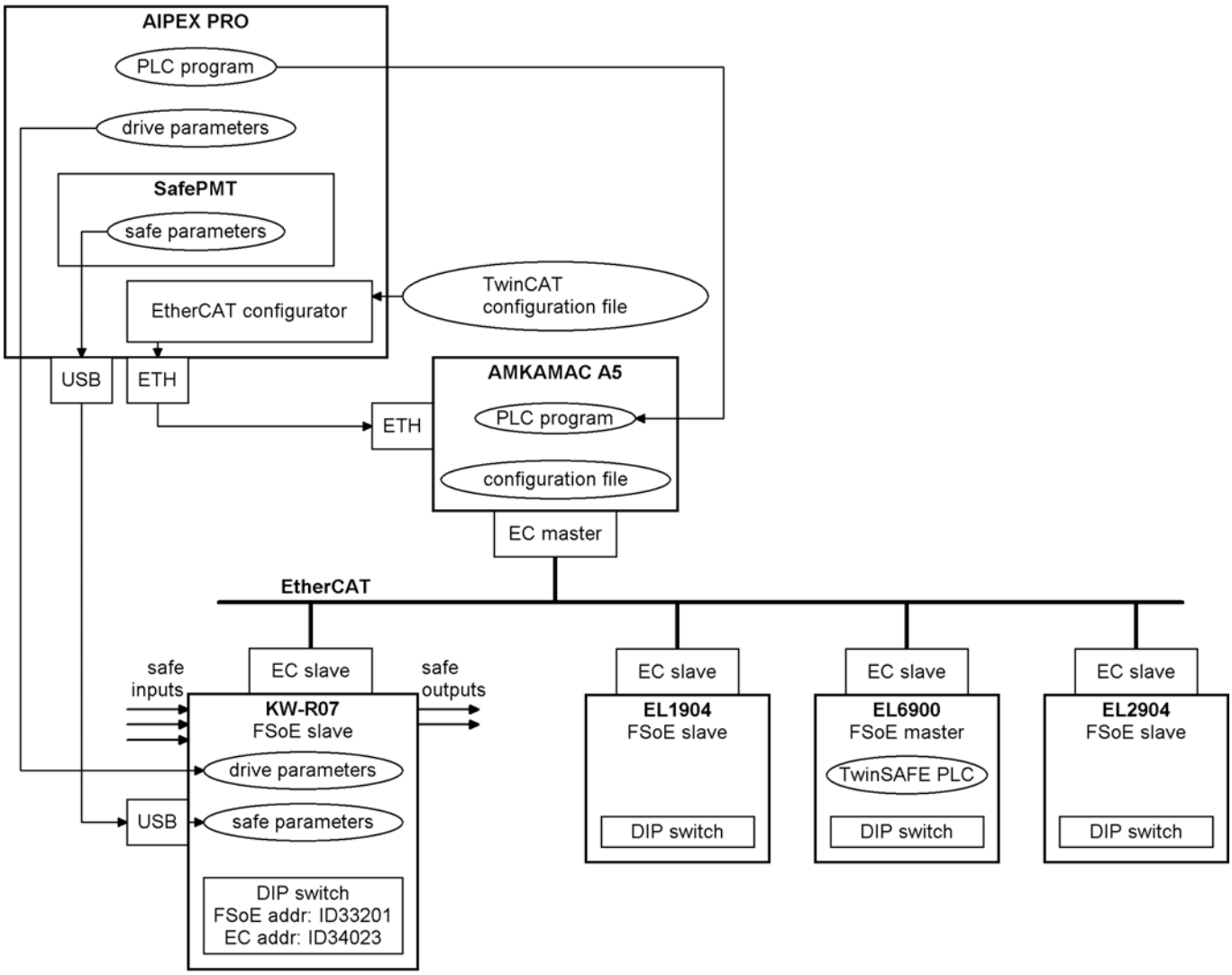
With the subsequent step, the safe configuration file is read in by the AMK controller.



5.3.4 Step 3: AIPEX PRO configuration

Hardware overview with AIPEX PRO PC

Not applicable at TwinCAT PLC and TwinSAFE PLC combination.



EC - EtherCAT connection

ETH - Ethernet connection

Step 3.1: Creating an AIPEX PRO project

Reading the project

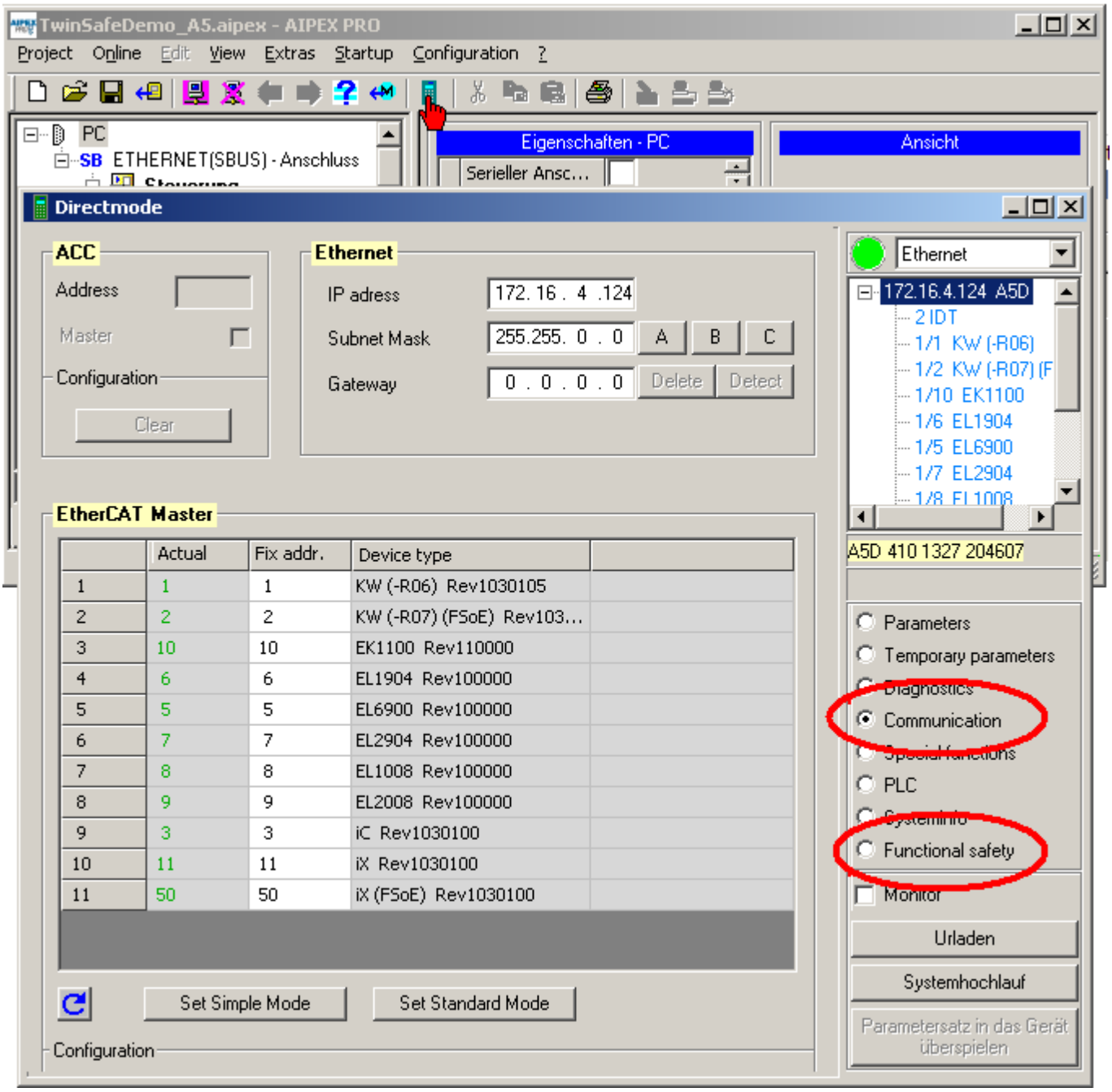
Hardware prerequisites 'System structure with AIPEX PRO PC':
Siehe 'Hardware overview with AIPEX PRO PC' auf Seite 54.

Create an AIPEX PRO project and append all present participants:
See document First steps Initial startup KE/KW (Part no. 204539), chapter Creating an online project for initial motor startup.

Check addressing

The EtherCAT and FSoE addresses of the different participants must stringently be set equal in the AMK drives and in TwinCAT System Manager. The addressing of the AMK drives will be done with the AMK software AIPEX PRO.

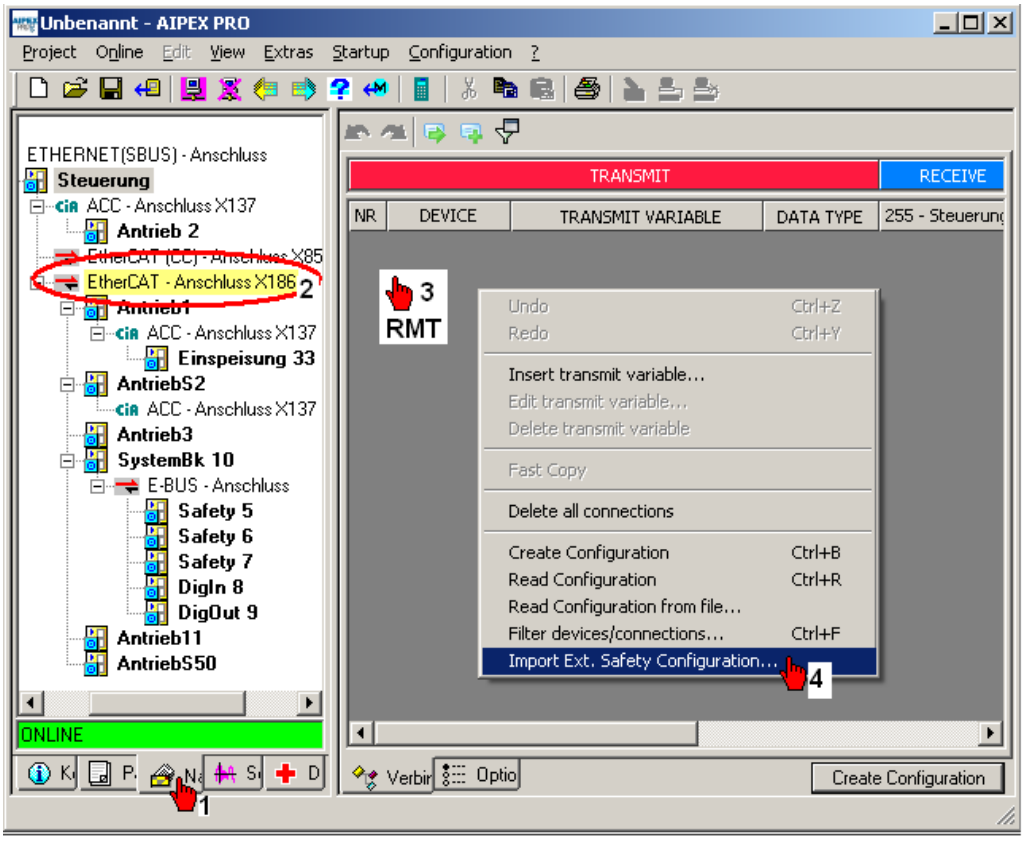
The present addressing can be rechecked in the AIPEX PRO Directmode.
Menu 'Communication' = EtherCAT addresses
Menu 'Functional safety' = FSoE addresses

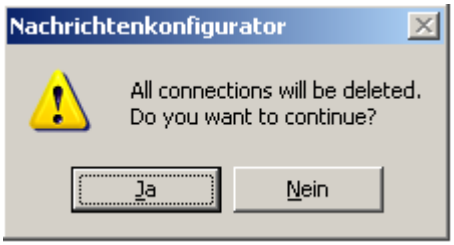


Reading the TwinCAT configuration file

Read in the before-exported TwinCAT safe configuration file.Siehe 'Step 2.7: Exporting the TwinCAT configuration file' auf Seite 53.

Subsequently, the unsafe data exchange must be configured manually.





Existing network configuration available

All manual created links get cancelled and must be following manual done new.

All automatically configured links can be rebuild with the AIPEX PRO function menu 'Configuration' 'Create configuration'

Step 3.2: Creating an AIPEX PRO PLC project

See document Software description AFL - AMK Function Library, part 1 (Part no. 203905).

5.3.4.1 Standard data transfer between TwinSAFE PLC and AMK controller

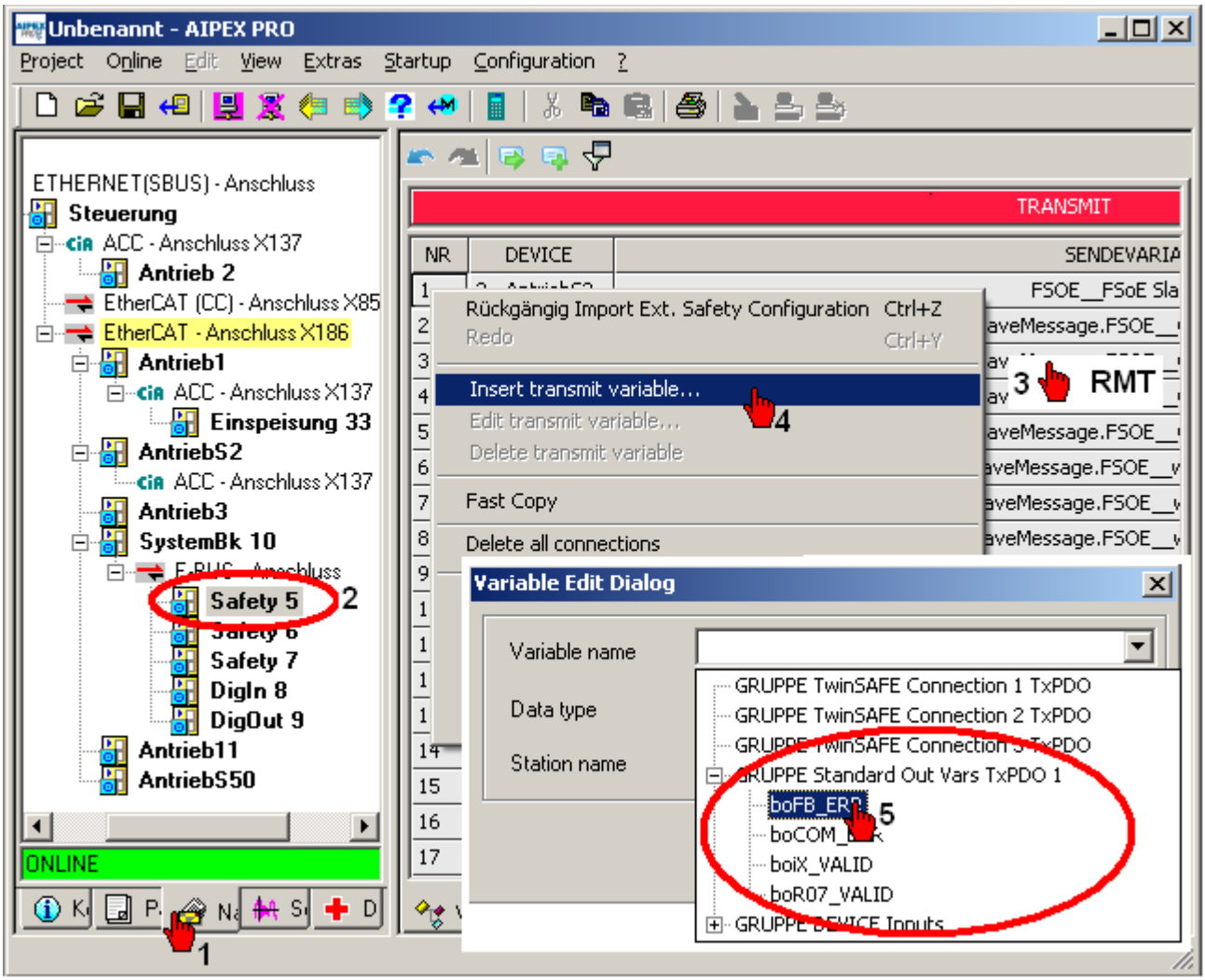
5.3.4.1.1 AIPEX PRO network configuration

A standard data transfer between TwinSAFE PLC and AMK controller must be create manually.

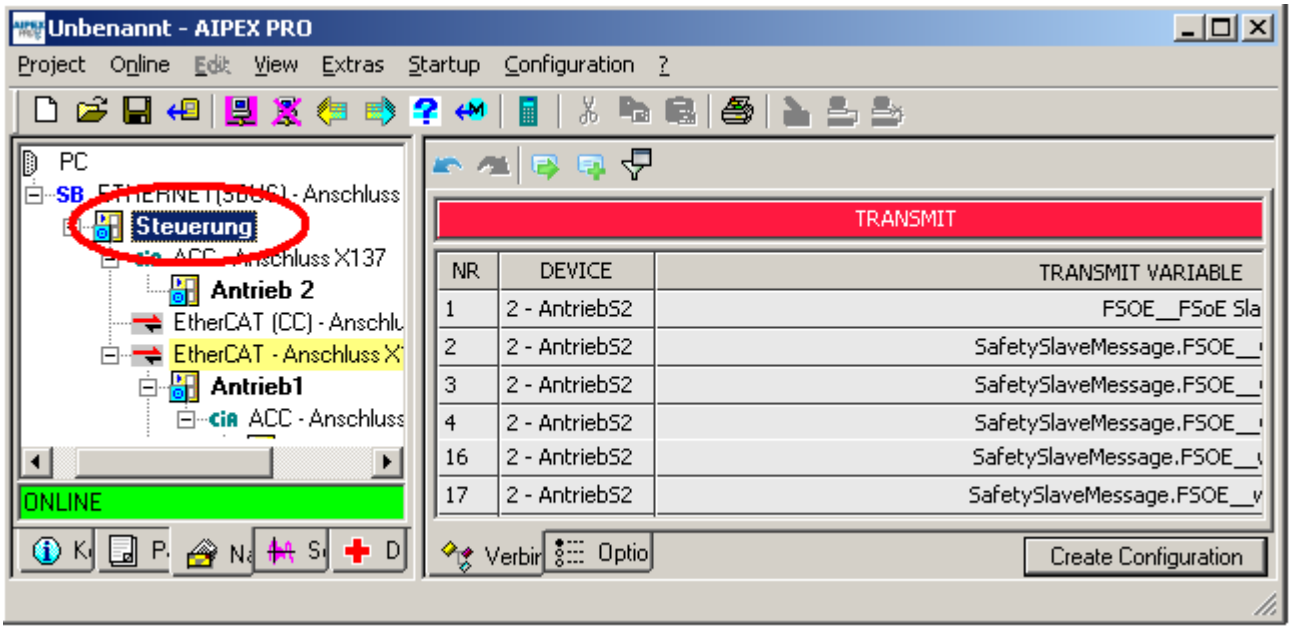
Data transfer TwinSAFE PLC to AMK controller

Click in the device tree onto the TwinSAFE PLC EL6900 (at the example Safety 5, transmitter).

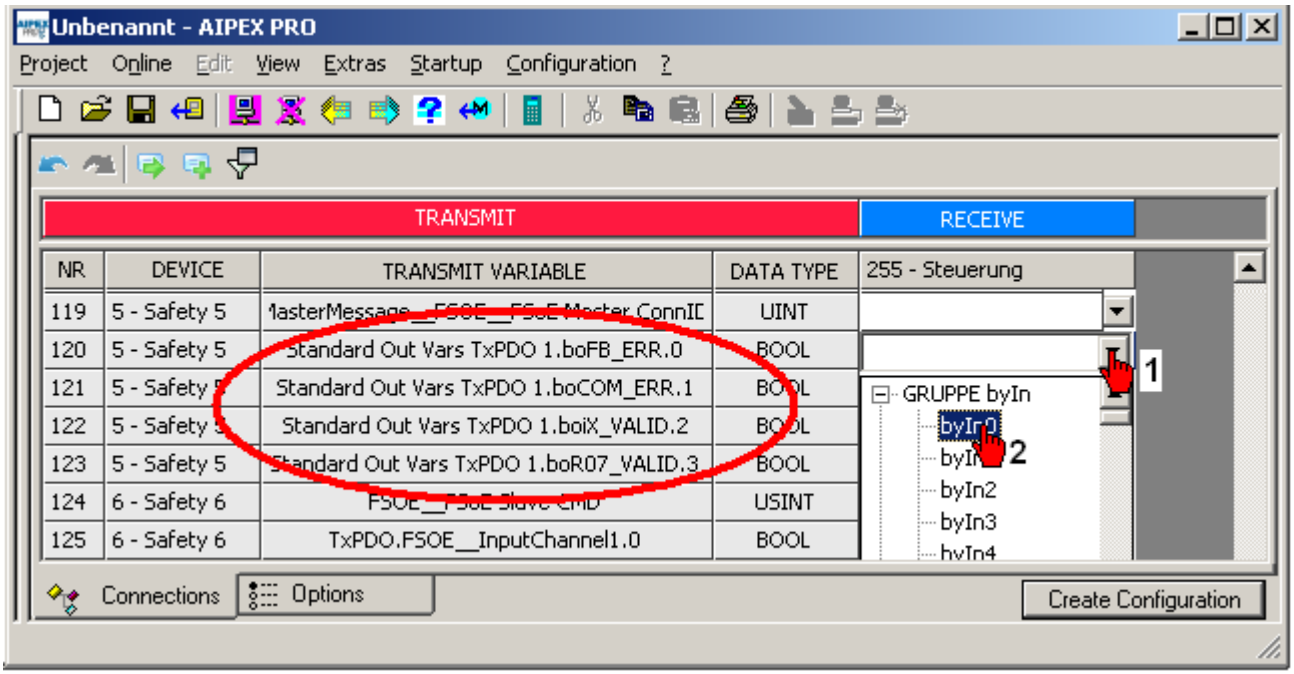
You will find which are defined in TwinCAT inside the group 'Standard Out Vars TxPDO'. Click onto your first variable. Return this process for all variables.



Click in the device tree onto the AMK controller (at the example Steuerung, receiver).



The standard data transfer is done inside the asynchronous task. Link your first TwinCAT variable (at the example Standard Out Vars TxPDO 1.boFB_Err.0) to a free AMK PLC variable (at the example byIn0). The following TwinCAT PLC variables will be linked automatically.



Data transfer between AMK conroller and TwinSAFE PLC

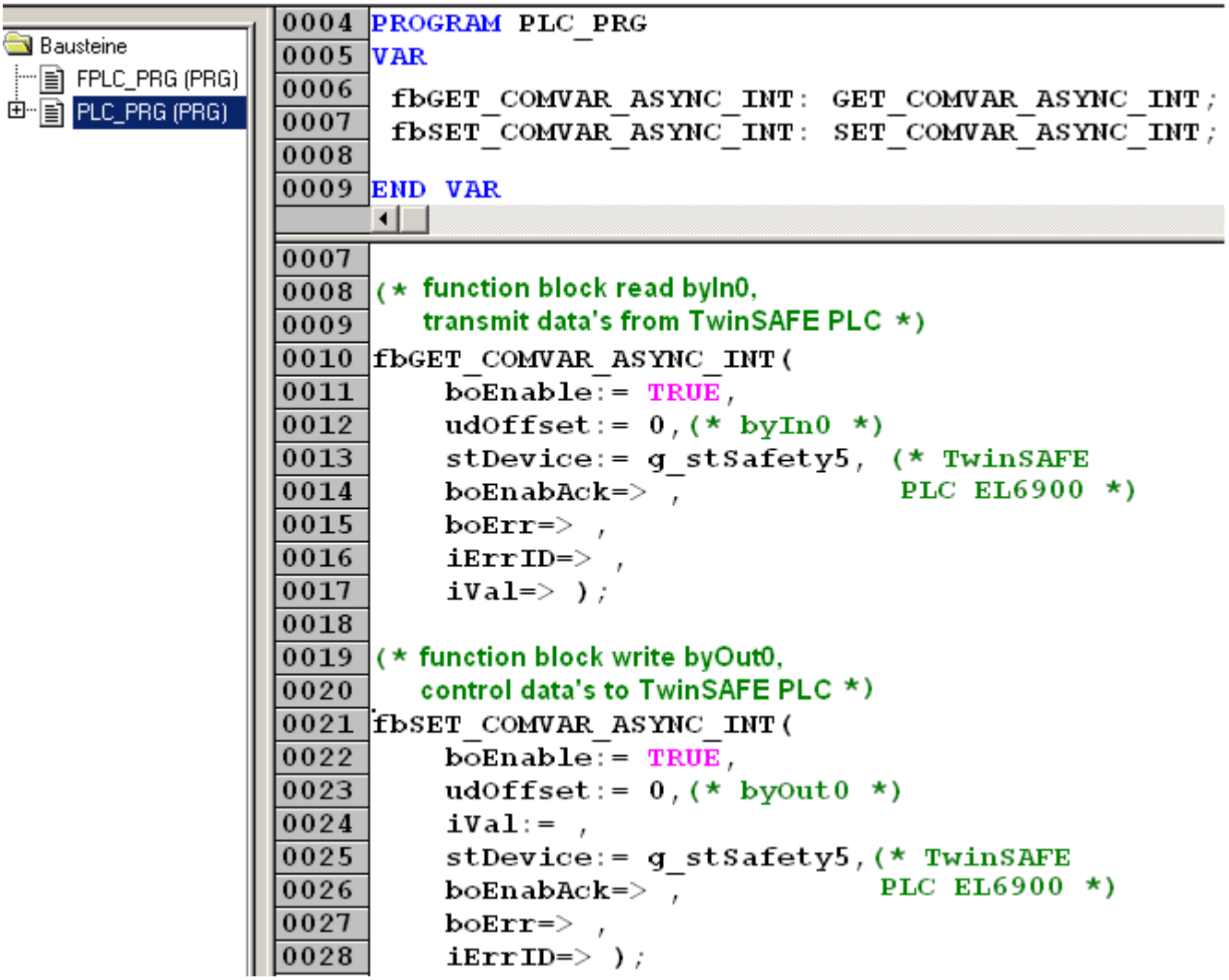
Make now reverse order. Click at first at the device tree onto the transmitter (AMK controller).

Insert the next free byOutx transmit variable (at the example: byOut0).

As next step click onto the receiver (TwinSAFE PLC EL9600). Link your first TwinCAT variable to the byOutx (at the example: byOut0). The following TwinCAT PLC variables will be linked automatically with the byOut0.

5.3.4.1.2 Read and write asynchronous data's with the AMK PLC project

Use the AMK function blocks GET_COM_VAR_ASYNC_INT to read data's and SET_COM_VAR_ASYNC_INT to write data's. The function blocks are called inside the asynchronous task (PLC_PRG).



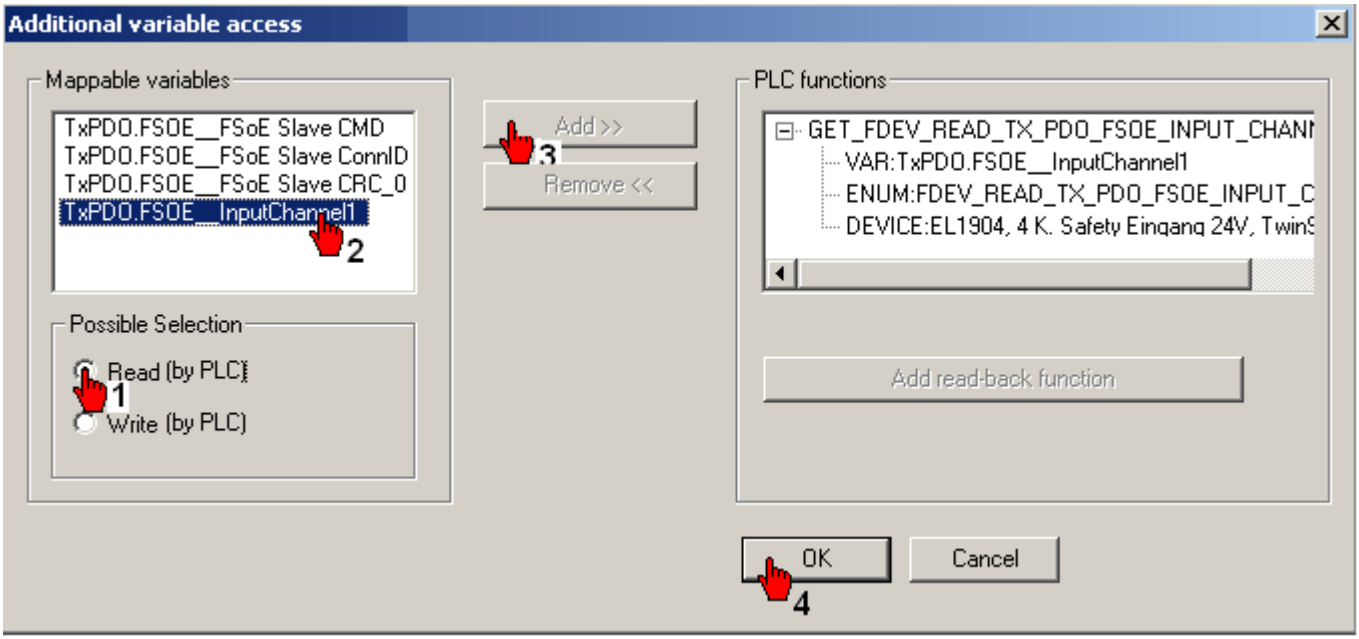

```
0004 PROGRAM PLC_PRG
0005 VAR
0006   fbGET_COMVAR_ASYNC_INT: GET_COMVAR_ASYNC_INT;
0007   fbSET_COMVAR_ASYNC_INT: SET_COMVAR_ASYNC_INT;
0008
0009 END_VAR
```

```
0007
0008 (* function block read byIn0,
0009    transmit data's from TwinSAFE PLC *)
0010 fbGET_COMVAR_ASYNC_INT(
0011     boEnable:= TRUE,
0012     udOffset:= 0,(* byIn0 *)
0013     stDevice:= g_stSafety5, (* TwinSAFE
0014     boEnabAck=> ,             PLC EL6900 *)
0015     boErr=> ,
0016     iErrID=> ,
0017     iVal=> );
0018
0019 (* function block write byOut0,
0020    control data's to TwinSAFE PLC *)
0021 fbSET_COMVAR_ASYNC_INT(
0022     boEnable:= TRUE,
0023     udOffset:= 0,(* byOut0 *)
0024     iVal:= ,
0025     stDevice:= g_stSafety5,(* TwinSAFE
0026     boEnabAck=> ,             PLC EL6900 *)
0027     boErr=> ,
0028     iErrID=> );
```

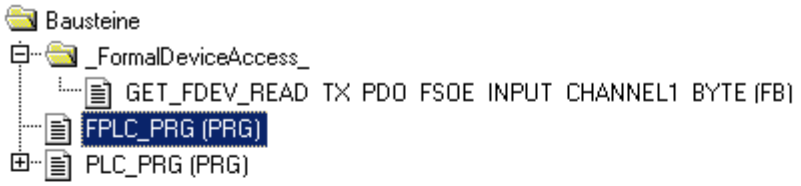
5.3.4.2 Read synchronous data's with the AMK PLC project

5.3.4.2.1 State Safety Inputs (EL1904)

The state of the safety inputs can be read cyclic with an AMK function block from type _FormalDeviceAccess_ .
Click onto the Safety Inputs Interface at the device tree. Follow exactly as represented.



Call an instance of the automatically generated function block.




```
0004 PROGRAM FPLC_PRG
0005 VAR
0006     fbGET_FDEV_READ_TX_PDO_FSOE_INPUT_CHANNEL1_BYTE:
0007         GET_FDEV_READ_TX_PDO_FSOE_INPUT_CHANNEL1_BYTE;
0008 END_VAR
```

```
0001
0002 (* function read the state of the input channels *)
0003 fbGET_FDEV_READ_TX_PDO_FSOE_INPUT_CHANNEL1_BYTE(
0004     boEnable:= TRUE,
0005     stDevice:= g_stSafety6, (* EL 1904 *)
0006     boEnabAck=> ,
0007     boErr=> ,
0008     iErrID=> ,
0009     ReadTxPdoFsoeInputChannel1=> );
```

5.3.4.2.2 Image of FSoE control and status data’s

Image of FSoE control data's reflected to the AMK standard parameter.
ID33211 'Safety data master 0' include bit 0..15 of FSoE control data's
ID33213 'Safety data master 1' include bit 16..31 of FSoE control data's

Image of FSoE status data's reflected to the AMK standard parameter.
ID33231 'Safety data slave 0' include bit 0..15 of FSoE status data's
ID33233 'Safety data slave 1' include bit 16..31 of FSoE status data's

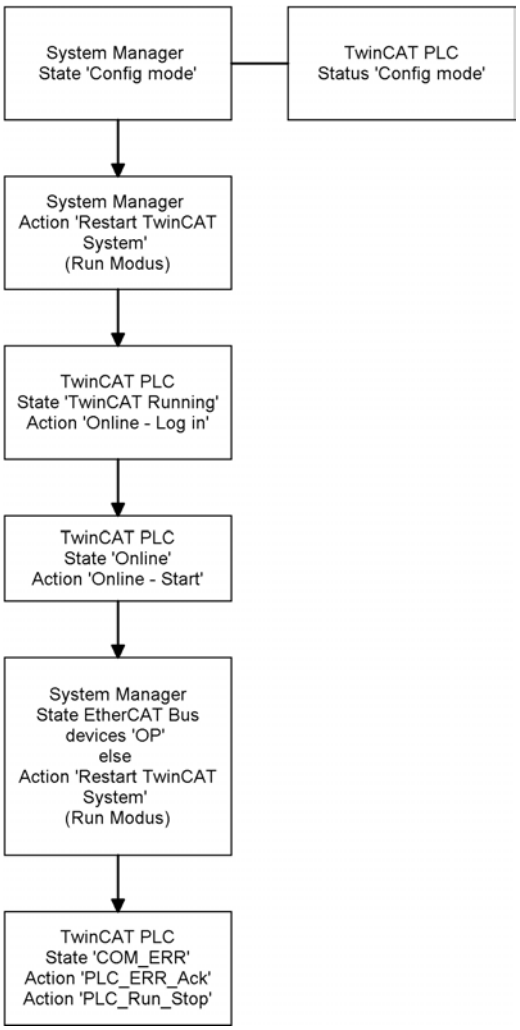
The state of the images can be cyclic read with an AMK function block typ _FormalDeviceAccess_ .
Create the function block in the same way as exampled with the Safety Inputs (EL1909).

Click onto the FSoE drive Interface at the device tree. Open the dialog field [Erweiterte Variablenzugriffe...]. Generate for each standard parameter witch you want to read with the PLC a PLC function (GET_FDEV function_ ...).
Repeat this process for all FSoE drives. Is a GET_FDEV function_ ... for a standard parameter available, only the DEVICE will be expanded with the FSoE drive name.

5.3.4.3 Start TwinSAFE PLC

Prerequisite:

- Complete configuration done
- Restart done



5.4 Information about error sources

The EtherCAT and FSoE addresses of the different participants must stringently be set equal in the AMK drives and in TwinCAT System Manager. The addressing of the AMK drives will be done with the AMK software AIPEX PRO.

If you modify the TwinCAT configuration, you have to transfer it to the SafePLC (EL6900).
The appending configuration file has always to be linked to the AIPEX PRO project, compiled and transferred to the AMK controller.

A new safe configuration file will completely overwrite the existing one.
Manually added links will be lost.

After any modification of the configuration, a restart becomes necessary.

After any restart, the SafePLC (EL6900) must be separately restarted .

Within the SafePMT parameter set, the commanding by FSoE master must be selected (Prm7 = 0)

Diagnostic message 3606, Info1:70, Info2:6

Error messages of the FSoE handling

The FSoE watchdog has expired, i.e. no new FSoE frame was received within the watchdog time

If you get the diagnostic message 3606, Info1:70, Info2:6 you have to increase the FSoE Watchdog time (recommended 200 ms).

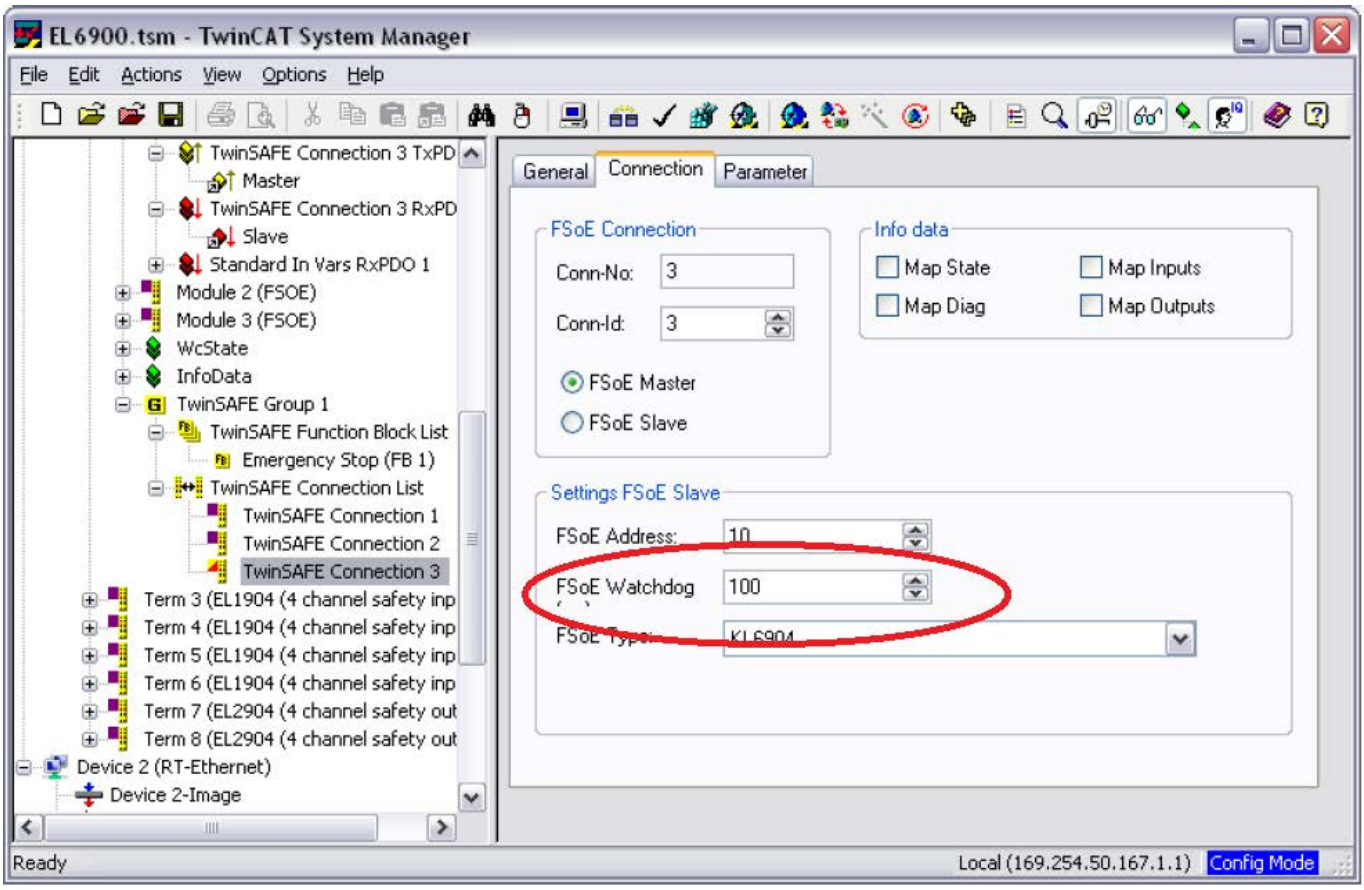
Cause:

The FSoE master sends data (control word) via the EtherCAT master to the FSoE slave. The FSoE slave must be respond (status data) within the configured time FSoE Watchdog.

Factors that affect the transmission time:

- FSoE Slave, read control word
- FSoE Slave, process data
- FSoE Slave, write status word
- Overload EtherCAT bus
- Bad frames

Picture: 'Settings FSoE Salve' with TwinCAT System Manager



Glossary

A

A4 / A5 / A6
AMKAMAC controller A4 / A5 / A6

ACC
AMK CAN Communication (CAN bus interface with standard CANopen protocol DS301 and additional hardware synchronization signal)

AIPEX
AMK startup and parameterizing software (PC software): Programming, parameterization, configuration, diagnosis, oscilloscope, status information

AT
Drive telegram from slave to master

B

BA
Binary output

BE
Digital input

C

CAN
Controller Area Network

D

DI
Digital input

DO
Digital output

E

EMV
Electromagnetic compatibility

EMC
Electromagnetic compatibility

EnDat 2.1
Motor encoder interface protocol of the company Heidenhain

EtherCAT
Real-time Ethernet bus

EnDat 2.2
Motor encoder interface protocol of the company Heidenhain

F

FL
Command (Causes a new system run-up)

FSoE
Fail-Safe over EtherCAT

I

iC
AMKASMART decentralized inverter with power supply

ID
Parameter identification numbers acc. to SERCOS Standard

iDT
AMKASMART Servo motors with integrated inverter

I-encoder
Incremental encoder, optical encoder with sine and cosine track and zero pulse

iX
AMKASMART decentralized inverter

K

KWD
AMKASYN compact double inverter to control two motors

KW-Rxx
AMKASYN controller card for installation into compact inverter

KW
AMKASYN compact inverter

KEN
AMKASYN compact power supply without recovery

KES
AMKASYN compact power supply with sinusoidal voltage and current

KWZ
AMKASYN compact two-axes inverter to control two motors

KE
AMKASYN compact power supply with recovery

KE/KW
Modular AMK drive system (contains compact power supply KE, compact inverter KW with controller card and applicable option card)

M

MDT
Master Data Telegram from master to slave

Modulo
Modulo processing of position setpoint and actual values

N

NK
Cam switch

O

Operational
In state operational, data are transferred cyclically via fieldbus

P

PDK_xxxxxx_abcdefgh
Product documentation; xxxxxx - AMK part no. , abcdefgh - name

Pre-operational
In pre-operational state, the controller can access the bus participants via the service channel. No cyclic data is exchanged.

PRG
Program

Q

QUE
Acknowledgment DC bus on; shows that DC bus is loaded

QBR
Acknowledgment motor holding brake

QRF
Acknowledgment controller enable; the drive is controlled in the activated operation mode

R

RF
Command 'Controller enable'; the drive is energized and will be controlled depending on the selected operation mode. Controller enable can only be set if the device is error-free (SBM = TRUE) and acknowledgement DC bus on is set (QUE = TRUE).Acknowledgement controller enable (QRF) is set.

S

SA
Safe output

SafePMT
Safe parameter editor

SBM
System ready message; shows that the device is error-free In case of error. SBM will be reset

SE
Safe input

SoE
Servodrive Profile (SERCOS) over EtherCAT (Acc. to IEC 61800-7-300)

STO
Safe torque off (Safety function acc. to DIN EN 61800-5-2)

T

TwinCAT
Automation software

U

UZN
DC bus voltage pole negative

UZP
DC bus voltage pole positive

Your opinion is important!

With our documentation we want to offer you the highest quality support in handling the AMKmotion products.
That is why we are now working on optimizing our documentation.
Your comments or suggestions are always of interest to us.
We would be grateful if you take a bit of time and answer our questions. Please return a copy of this page to us.

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or
fax no.: +49 7021/50 05-199

Thank you for your assistance.
Your AMKmotion documentation team

1. How would you rate the layout of our AMKmotion documentation?

   (1) very good (2) good (3) satisfactory (4) less than satisfactory (5) poor

2. Is the content structured well?

   (1) very good (2) good (3) moderate (4) hardly (5) not at all

3. How easy is it to understand the documentation?

   (1) very easy (2) easy (3) moderately easy (4) difficult (5) extremely difficult

4. Did you miss any topics in the documentation?

   (1) no (2) if yes, which ones:

5. How would you rate the overall service at AMKmotion?

   (1) very good (2) good (3) satisfactory (4) less than satisfactory (5) poor

AMKmotion GmbH + Co KG
Phone : +49 7021/50 05-0, fax: +49 7021/50 05-199
E-Mail: info@amk-motion.com
Homepage: www.amk-motion.com